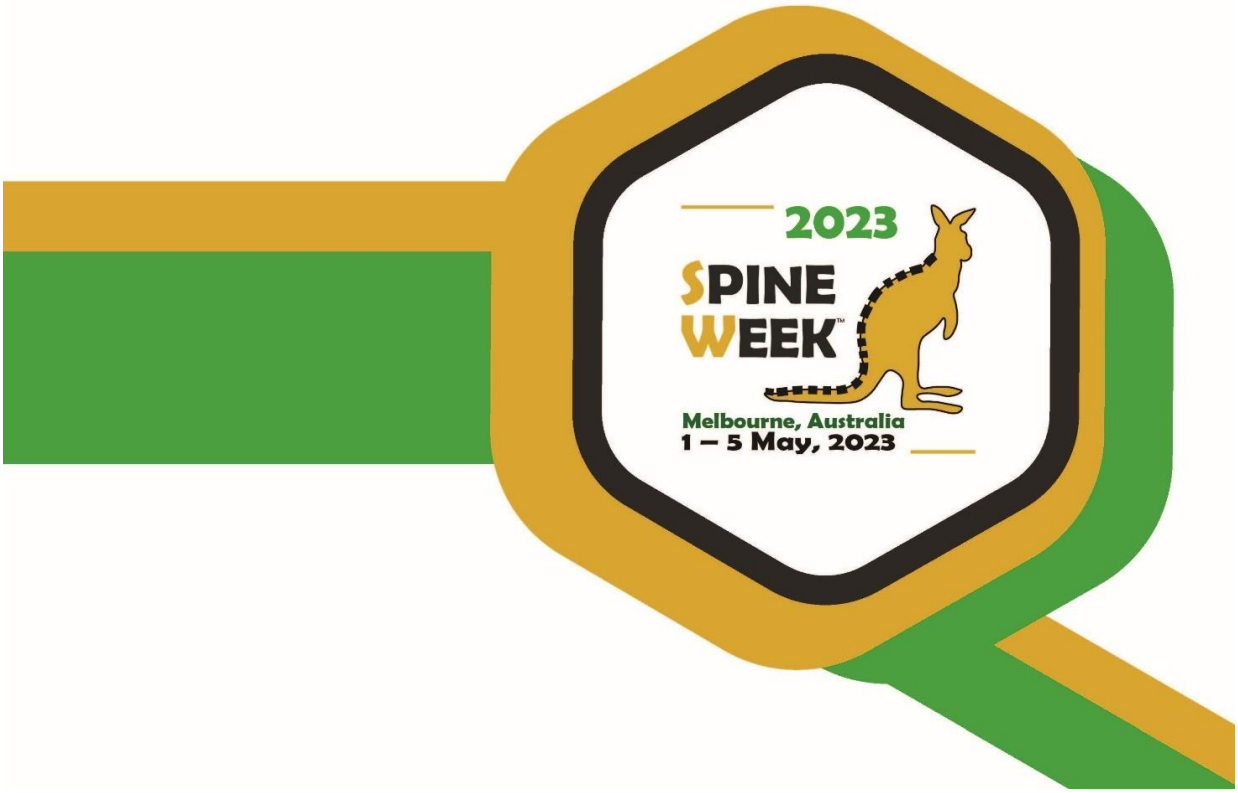
Abstracts of KSSS Invited Talks



I1
Redefining of lumbar interbody fusion

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Introduction: During the spine surgery, owing to the iatrogenic instability of spinal column, many methods of fusion technique were developed for giving stability. Among the fusion method, interbody fusion was used very much these days. There are many techniques to perform the fusion, posterior, anterior and lateral method according to the approach method to disc space.
Methods: Posterior method includes PLIF and TLIF, which is divided by medial or lateral side of facet joint. Direct method to disc space were ALIF and lateral approach. ALIF can get more segmental angle by cut the ALL (anterior longitudinal ligament). The lateral approach has many names according to merchandise as XLIF, DLIF, OLIF. Both the XLIF and DLIF approach to disc space using penetrate the Psoas muscle and preparing disc space and insert the cage. In OLIF method the Psoas muscle is retracted to posteriorly and can assess to disc space. But, the other author declare, the OLIF procedure using the Kamvin's triangle to insert the cage to disc space via posterior approach.
Results: There are many methods for acquire lumbar interbody fusion, but the fusion rate slightly different.
Conclusions: The terminology of interbody fusion was not clearly defined, so we need more discussion about that.

I2

Tip and pitfall of using cage for achieving both indirect decompression and segmental angle restoration

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Introduction: Conventionally, lumbar interbody fusion encompasses both anterior and posterior procedures for treating degenerative lumbar diseases. However, in recent years, with the advancement of surgical instruments such as retractors, neuromonitoring, and navigation systems, lateral lumbar interbody fusion (LLIF) has been developed as a minimally invasive surgery. Oblique lateral interbody fusion (OLIF) and extreme lateral interbody fusion are the representative surgical techniques of LLIF. Many reports have demonstrated excellent clinical and radiographic results for these techniques, which have been rapidly popularized in recent years.
Methods: Indirect decompression by LLIF has been addressed in several reports that showed significant improvements in the average of radiographic parameters such as cross-sectional area of the dura mater and/or foraminal area. Unfortunately, it is difficult to predict how much indirect decompression will be achieved and which patients may still require direct decompression. When performing lumbar fusion, the restoration of segmental angle is another important goal for regional and global balance. Because it is known that making the appropriate lumbar lordosis is critical for obtaining good clinical outcomes and preventing adjacent segment disease, making a normal segmental angle is of importance. Achieving these two goals together, indirect decompression and restoration of the segmental angle, appear to be contrary to each other because the anteriorly located cage can be better for restoring segmental angle, whereas the posteriorly located cage might be favorable for achieving the indirect decompression effect.
Conclusions: Therefore, we would like to investigate the tip and pitfall using a cage to achieve both indirect decompression and segment angle restoration along with a literature review.

Key words: Spine fusion, Indirect decompression, Segmental angle restoration, Cage

I3

Technical tip for getting the larger lumbar correction “with physiologic curve”

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Introduction: Pedicle subtraction osteotomy (PSO) is a closing wedge osteotomy technique performed through a posterior open access and resection across the vertebral body, pedicles and bony structures. It has a potential for sagittal correction up to 40° and for long-term fusion upon fixation.[1)]
Methods: Technical tip for getting the larger lumbar correction along with physiologic curve in anterior column realignment procedure (ACR) as follows;
The identification and separation of the plane between the ALL and anterior structures are mandatory in ACR. Discectomy and contralateral annulus release are essential to ensure symmetrical distraction, proper bilateral decompression, and deformity correction and to isolate and facilitate a safe division of the ALL and remaining annulus. The ALL and remaining annulus are released with surgeon’s preferred method. A paddle distractor or spreader may be used inside the disk space to confirm adequate release of the ALL. If tension persists, ALL or contralateral annulus must be still intact or the posterior portion of the annular release will be incomplete. Sequential trials are performed, and then trials are initiated once the anterior release has been completed and are utilized to accommodate hyperlordotic cages. [2-5)]
Results: Anterior column realignment procedure is better to obtain physiologic lumbar curve compared to PSO. Ultimately, to obtain a physiologic lumbar curve, we should use cantilever force on the lumbar curve following efficient release of each lumbar segment on the condition that the spine has flexible potential.
Conclusion: In summary, for getting the larger lumbar correction along with physiologic curve, we need to perform efficient anterior and posterior release considering degenerative state of disc and facet joint to use effective cantilever force for sagittal deformity correction. During the all the procedure, consideration for osteoporosis should be necessary.

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I4
Strategies of prevention for surgical complications

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Introduction: Anterior column realignment (ACR) is a powerful tool to increase lumbar lordosis by lengthening the anterior column. Minimally invasive lateral ACR can achieve large corrections at a single segment. However, according to the recent literature, the rate of complications is reported from 18 to 47%. These complications included transient and permanent motor/ sensory deficit, hip flexion weakness, bowel perforation, and vascular injury. Of the lumbar plexus nerves, the genitofemoral nerve is especially at risk as it crosses the L2-3 and L3-4 disc spaces while coursing posterior to anterior. As it reaches the caudal end of the L4 vertebral body, it runs anteriorly along with the sympathetic plexus, which runs along the anterolateral border of the lumbar vertebral bodies. The sympathetic plexus lies along the lateral border of the ALL and, thus, may be at risk during release of the ALL. The aorta lies anteriorly along the left border of the lumbar vertebral body and bifurcates into the right and left common iliac arteries approximately 18 mm cephalad to the L4-5 disc space. Arising from the aorta are 4 paired lumbar segmental arteries, which course laterally around the vertebral body, avoiding the disc space. The inferior vena cava lies anteriorly along the right border of the lumbar vertebral body and is formed by the convergence of the right and left common iliac veins with in approximately 2 mm of the L4-5 disc space. Whereas the great vessels lie in close proximity to the ALL and are therefore at risk during an ACR, there is an adipose-lined anatomic plane that allows for safe dissection dorsal to the great vessels.
Methods: We systemically reviewed the current studies and journals to find the strategies to prevent surgical complications of anterior column realignment (ACR) surgery.
Results: The surgeon should scrutinize the relation of the vessels relative to the spine, including looking for a safe plane for dissection anterior to the spine. Contraindications to the procedure include a fused disc space ate the level and prior retroperitoneal vascular injury. To prevent injury, the anterior vascular structure, it is imperative to develop the adventitial plane directly anterior to the anterior longitudinal ligament and annulus. The lumbar plexus passes through the psoas, which adds anatomic risk of neurological injury from lateral MIS approaches. The risk can be mitigated with intraoperative neuro-monitoring. MIS retractor can allow for direct stimulation of the dilators and the posterior blade as they are positioned, allowing the surgeon to make adjustment if low stimulation threshold indicated proximity to a motor nerve. Transient hip flexion weakness is expected form a lateral, transpsoas approach. The direct anterior incision carries the risk of incisional hernia, and the anterolateral incision occasionally results in denervation of a portion of the abdominal wall. This creates a patulous and occasionally uncomfortable abdominal wall on the side of the approach. This condition is not a hernia and cannot be repaired with additional surgery. Adequate visualization of the ALL and annulus is critical for the safety of the ACR procedure. Patients with abnormal vascular anatomy, extensive calcification of the aorta, or previous anterior spinal or retroperitoneal surgery are likely not good candidates for ACR.
Conclusions: A thorough understanding of patient's anatomy and optimization of patient selection helps to increase the probability of a safe surgery and postoperative alignment goals.

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I5

Does radiographic restoration after surgery promises the better clinical outcome?

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Introduction: Over the last 20 years, a lot of research has been done on sagittal plane alignment and the importance of sagittal radiographic parameters has gradually increased in adult spinal deformity (ASD). It has been demonstrated that sagittal spinopelvic alignment plays critical role in determining the final outcome in ASD. Sagittal plane malalignment is poorly tolerated and correlates with suboptimal health status.

Methods: It was well known that sagittal plane parameters such as, pelvic incidence minus lumbar lordosis (PI-LL), pelvic tilt (PT), sagittal vertical axis (SVA) plays critical role after surgery as in other adult spinal deformity surgery. However, recent studies have challenged this presumed impact of sagittal spinopelvic malalignment on health status and demonstrated weak correlations with health-related quality of life when limiting ASD to de novo DLS.

ASD encompasses a complex group of pathologies that covers a broad spectrum of spine disorders including de novo DLS, adult form of idiopathic scoliosis, fixed sagittal imbalance such as ankylosing spondylitis and iatrogenic flat back. Depending on the type and severity of deformity, it may range from asymptomatic to severe pain and disability. Unlike other spinal deformity, DLS patients complains not only back pain, but also radiating pain and claudication.

Results: Unlike other ASD, the main reason for these results were brought by older age group, severe leg radiating pain and stenosis symptoms in DLS. When they limited to DLS, mean age of patients group was mid 70's comparing with mid 50's in ASD group. Also, it may mean treating the stenosis symptoms may be more important than correcting the sagittal alignment in DLS. So, simple decompression and short segmental fusion were recommended to specific DLS patients rather than long segmental fusion with deformity correction.

Conclusions: In general, sagittal profiles are important when treating DLS, but it can't be only major predictors after surgery.

I6

Comparative analysis of lower most fusion level L5 vs S1 vs Ilium

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Introduction: When performing long fusion for degenerative scoliosis correction, the distal fusion level is performed up to the sacrum if pathology exists in the L5-S1 segment, otherwise, up to L5. However, if fusion is performed up to L5, there is a possibility of degeneration of the L5-S1 segment, and if fusion is performed up to the sacrum, there is a possibility of loosening and failure of the distal screw. This can be improved by extending the fusion to the Ilium. Therefore, in this study, using finite element analysis, the possibility of screw loosening and failure after surgery according to the fusion distal end level were analyzed by observing bone-screw interface stresses as well as screw stresses, respectively.
Methods: A three-dimensional intact lumbar-pelvis model was created using CT data of a 57-year-old male. Three surgical models were constructed by pedicle screws and iliac screws insertions (Type 1: L1-L5 fusion, Type 2: L1-S1 fusion, and Type 3: L1-Ilium fusion.) Bone and implant interfaces were assigned 'Tie contact condition', to assume a fusion state. In order to realize physiological loading condition, the acetabulum was completely fixed and a 10Nm pure moment of flexion, extension, axial rotation, and lateral bending was applied at the superior endplate of L1 with a follower load of 400N.
Results: On the bone-screw interface, Type 1 showed the highest stresses in all loading conditions (Flexion: 26.68MPa/Extension: 22.51MPa/Axial rotation: 38.07MPa/Lateral bending: 18.52MPa). On the screw, Type 3 showed the highest stresses in all loading conditions (Flexion: 144.22MPa/Extension: 149.27MPa/Axial rotation: 188.55MPa/Lateral bending: 131.56MPa). These peak stresses were all located near the neck of the distal level screw. Compared to the normal model, the ROM of the L5-S1 segment increases (Flexion: 33%/Extension: 42%/Axial rotation: 22%/Lateral bending: 20%) in Type 1, decreases in Type 2 (Flexion: 82%/Extension: 86%/ Axial rotation: 8%1/Lateral bending: 95%), and decreases in Type 3 (Flexion: 92%/Extension: 91%/Axial rotation: 86%/Lateral bending: 97%).
Conclusions: The results of the bone-screw surface stresses suggests that the possibility of screw loosening decreases as the fusion range increases. In addition, according to the results of the stresses measured on the screw, it can be expected that the possibility of screw failure near the neck of the distal level screw increases as the fusion range increases.

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I7
Proximal curve progression after surgery

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Introduction: Surgical options for degenerative lumbar scoliosis (DLS) comprise simple decompression, long level fusion, including the entire deformity and short level fusion, that comprises decompression and fusion only for main neurologic pathology level within deformity, especially for balanced spine without serious axial back pain. Progression of curve after entire segment fusion or short level fusion can occur according to various factors.
Methods: From comprehensive review of published clinical reports and suggested guidelines, we summarized various factors of curve progression after DLS surgery.
Results: Simple decompression for DLS with clinical symptoms, has been reported unacceptable due to aggravation of deformity and instability, resulting in the worsening of symptoms again. For decompensated or severe deformity more than 40^{o}, long level fusion includes entire deformity and/or above is mandatory. Short level fusion, that is instrumentation within the deformity, restricted to neurological pathology segment can be another option to save mobile lumbar segments.
Conclusions: Factors contribute to progression of coronal deformity after surgery has been reported as follows. Angle of scoliosis, degree of rotation at apical segment, lateral translation of apical vertebra, tilting of L5, L5 height against intercristal line and osteoporosis, age factors. Also, degree of degeneration of intervertebral disc and facet joints above the UIV (upper instrumented vertebra) has been reported as prognostic factors. For the selection of fusion level, UIV below stable vertebra or upper end vertebra, whether fusion comprises the apical segment or not has reported as major factors for progression of deformity. Sagittal angle and balance can be another factor for progression of coronal deformity. In contrast, still there are debates for correlation of clinical results of short level fusion with progression of coronal deformity.

I8

Proximal sagittal curve progression after surgery of degenerative lumbar scoliosis

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In the case of degenerative lumbar scoliosis, some patient will decrease their thoracic kyphosis to compensate for the loss of lumbar lordosis. This method of compensation requires good flexibility of the thoracic spine and the motor strength to maintain the hypokyphosis.
Recognizing preoperative thoracic compensation may have implications for postoperative standing alignment because increased reciprocal thoracic kyphosis occurs after lumbar deformity correction and this may diminish the global correction. In addition, an increased thoracic kyphosis causing reciprocal change occurs in almost 40% of patients after corrective surgery for adult spinal deformity. The presence of preoperative thoracic compensation in adult spinal deformity patient is the primary determinant of postoperative reciprocal thoracic kyphosis and these patients are more likely to have proximal junctional kyphosis.
Identifying patients with preoperative thoracic compensation can aid in planning deformity surgeries as the reciprocal kyphosis that occurs postoperatively can be anticipated and accounted for when setting the final alignment target. In some patients where reciprocal kyphosis is anticipated, the operating surgeon may consider surgical instrumentation that extends higher into the upper thoracic spine to prevent potential loss of correction.

I9

Lumbar spinal stenosis with sagittal imbalance: when do we operate? We do not have to operate early

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Introduction: Complex lumbar stenosis presents concurrently with other spinal deformities such as spondylolisthesis, scoliosis, or lumbar kyphosis (flatback deformity). These lesions may be idiopathic, degenerative, or surgery induced. The long duration of degenerative changes and antalgic posture in the patient with spinal stenosis, stooping for relieving pain results in decrease of lumbar lordosis, can make the muscular degeneration, structural changes and weakness accelerate, leading to pelvic compensation.
Methods: There is no report about natural course of sagittal imbalance with spinal stenosis. but by some reports of natural course of Sagittal imbalance of lumbar kyphosis, even if spinopelvic parameter progressed. however clinical symptoms are not significantly changed.
In the study of the relationship between sagittal alignment and clinical symptoms, there are so many reports that increased SVA, PT, PI-LL mismatch, TPA(T1SPi+PT), T1SPi correlate with clinical disability. however, there are contrary reports that sagittal alignment parameter is not correlated with clinical symptoms, so changes in the sagittal alignment should not be decisive in the surgical indication.
The surgical goal in the treatment of stenosis differs from that of sagittal imbalance, the natural course of spinal stenosis is known that substantial proportion of patients do not deteriorate will remain unchanged, or even improved by medical. severe baseline symptoms, block stenosis and degenerative spondylolisthesis tend to require surgical treatment. but the surgical aiming in the sagittal imbalance is correction, secondary relieving axial symptom, demanding careful consideration in the old patient. And this corrective surgery can give rise to higher complication than any other comparatively simple surgery of stenosis.
In case of needed surgery for the treatment of spinal stenosis, we should try to get a larger lumbar lordosis as much as we can. Only the getting increase of the lower lumbar lordosis can make better global sagittal alignment in the treatment of the patient with spinal stenosis accompanied by flexible, minor sagittal imbalance.
Conclusions: there is no evidence of advantages that earlier operation for corrective surgery for the treatment in the patient with spinal stenosis accompanied by sagittal imbalance can reduce operative risk, complication rate, to get a better clinical and radiological results than later operation. Unhappily there is no definite operative indication for the treatment of sagittal imbalance yet, surgery should not be made according to radiologic parameters but by carefully determining the patients' clinical symptoms and disability level.

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I10

Debate: Lumbar spinal stenosis with sagittal imbalance: when do we operate? We should operate early. Seize the day!

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Introduction: The natural progression of conservatively treated lumbar degenerative flatback is well-known. The surgical outcome of lumbar stenosis is also well-established. However, there is a debate about when to operate on a patient with lumbar spinal stenosis with sagittal imbalance.
Methods: We tried to prove that surgical treatment should be performed as soon as possible after diagnosis through a literature review and case reports we have had.
Results: The treatment of degenerative flatback, as well as lumbar stenosis, usually begins with nonsurgical treatments, and they are typically physical therapy and epidural steroid injections. Surgical treatment can substantially improve posture, quality of life, and pain if these steps do not show a suitable resolution for the disease. However, deterioration of the deformity during conservative treatment further expands the scope of surgery or the number of fusion levels. Sagittal imbalance progresses in patients more rapidly than we expected. These are why we must perform surgical treatment as soon as possible.
Conclusions: We emphasize the need for early surgery to prevent disease progression, reduce the extent of segmental fusion, and improve the quality of life for patients.

I11

Prevention and management for perioperative delirium in elderly spine surgery

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Introduction: Delirium is a clinical syndrome characterized by an acute reversible failure of brain's cognitive functions. It usually occurs in older adults when there is pre-existing neurocognitive impairment and also following an infection or a trauma. In this study, we summarize what is known regarding prevention and management for perioperative delirium.

Main body: Recent prevention strategies can be classified into three categories; pharmacologic, depth of anesthesia and behavioral interventions. In pharmacologic aspect, Ketamine, dexmedetomidine, acetaminophen, steroid and anti-psycotics(haloperidol, quetiapine) were studied, but they were not effective in preventing and treating delirium. A growing body of evidence has implicated anesthetic depth as a possible contributor to perioperative delirium. In several trials, there was no significant difference in delirium incidence in the light sedation group compared with the heavy sedation group. One of the most consistently effective delirium prevention strategies involves a multicomponent intervention that targets modifiable risk factors. The Hospital Elder Life Program (HELP) founded by Sharon K et al. is a multidisciplinary program designed to prevent cognitive and functional decline in older hospitalized patients. HELP services include cognitive orientation, social support, sleep protocol implementation, assistance with nutrition and mobilization. A recent meta-analysis involving 14 studies demonstrated significant reductions in delirium incidence, risk of falls and health-care costs.

Conclusions: Non-pharmacologic, multicomponent interventions are not likely to increase the risk of harm and have repeatedly been shown to reduce the incidence and impact of delirium. With improving scientific and technological advances and the establishment of multidisciplinary neuroscience collaborations, the time is ripe to improve delirium understanding and management.

Acknowledgements: Support or funding must be mentioned in a separate paragraph. This is an optional heading.

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I12
Vertebral artery injury

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Introduction: Vertebral artery (VA) injuries during cervical spine surgery are rare with a reported incidence of 0.3% to 0.5%. The VA enters the vertebral foramen most commonly at C6 and courses from anterior and lateral to medial and posterior with respect to the vertebral body up to C3. The VA has a more variable course in the atlantoaxial region. VA injury can be a catastrophic iatrogenic complication of cervical spine surgery. Although the incidence is rare, it has serious consequences including fistulas, pseudoaneurysm, cerebral ischemia, and death. It is therefore imperative to be familiar with the anatomy and the instrumentation techniques when performing anterior or posterior cervical spine surgeries.
Aim: To provide a review of VA injury during common anterior and posterior cervical spine procedures with an evaluation of the surgical anatomy, management, and prevention of this injury. To discuss and share our experience of VA injury.
Materials and Methods: A systematic review of medical articles related to VA injury in cervical spine surgery was conducted up to and including journal articles published until 2021.
Results: Overall, the risk of VA injury during cervical spine surgery is low. In anterior cervical procedures, lateral dissection puts the VA at the most risk, so sound anatomical knowledge and constant reference to the midline are mandatory during dissection. With the development and rise in popularity of posterior cervical stabilization and instrumentation, recognition of the dangers of posterior drilling and insertion of transarticular
screws and pedicle screws is important. Anomalous vertebral anatomy increases the risk of injury and preoperative magnetic resonance imaging and/or computed tomography (CT) scans should be carefully reviewed. If a VA injury occurs, rapid action is required to prevent exsanguination or catastrophic neurologic injury. Every attempt should be made to repair the VA because the contralateral artery may not provide sufficient blood flow in spondylotic population. If repair is not possible and contralateral circulation is deemed adequate, endovascular coiling or primary ligation should be performed. Tamponade should be avoided as the definitive treatment because of well-known complications.
Conclusion: VA injury during cervical spine surgery is a rare but serious complication. It can be prevented by careful review of preoperative imaging studies, having a sound anatomical knowledge and paying attention to surgical landmarks intraoperatively. When a VA injury occurs, prompt recognition and management are important.

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I14

Intraoperative painful experiences: Dural tear & neurologic deficit

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The incidence of dural tear (DT) in cervical spine surgery has been reported to range from 0.13% to 4% and it occurs relatively infrequently. If DT is not properly treated, CSF leak can occur and serious complications such as meningitis, spinocutaneous fistula, and pseudomeningocele can occur. Repair is frequently technically impossible due to the narrow space of DT that occurred during surgery through the anterior approach.

It is known that the risk of DT is significantly increased in the case of revision anterior surgery, corpectomy, or OPLL. The risk of DT with anterior approach surgery in OPLL cases was reported to be as high as 4.3-32%. In cervical OPLL, it is known that the risk of DT increases especially in the case of broad base OPLL, kyphotic and thick OPLL mass, and lateral curved irregular OPLL.

The most preferred treatment for dura tears is direct repair. First, all rootlets are reduced and then sutures are performed. If there is not enough decompression, it may be difficult to reduce the rootlet. The reverse Trendelenberg position can be used to perform repairs more easily.

If direct suturing is difficult due to narrow space, conventionally, DT is corrected by inserting fat cells into the defect site, but it can also be managed using Surgicel, fibrin glue, or Tachosil. If a dura defect occurs and it is difficult to treat it with suture alone, reconstruction should be performed using autologous fascia or artificial dura. After treatment, the leak can be confirmed through the Valsalva maneuver.

After surgery, it is recommended to maintain a sitting position rather than bed rest like a lumbar, and it is advantageous to prevent recurrence by inserting a lumbar drain for 4-5 days and prescribing stool softners and antiemetics.

I15
Cervicothoracic junctional approach

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Introduction: Surgical approaches to the cervicothoracic junction often involve difficult dissection resulting from the close proximity of major vascular structures. The great vessels, the sternum, and the clavicle often limit accessibility during the procedure. The three most common indications for surgical intervention at the cervicothoracic junction are infections, neoplasms, and fractures. To adequately explore the anterior spine from C4 to T4 requires a midsternotomy with extended anterior cervical incision. This approach most adequately provides the extensive cranial-caudal exposure required in dealing with infections, neoplasms, and fractures at the cervicothoracic junction.
Methods: The posterior surgical approaches, as the laminectomy or the arthro-pediclectomy, fail to expose the anterior spinal elements. Thus, further surgical approaches have been proposed: postero-lateral, antero-lateral (thoracotomies) and purely anterior.
Results: Care must be taken when using anterior or antero-lateral approach so as not to injure the recurrent laryngeal nerve or the brachiocephalic vessels. When using the sternal splitting approach, it is important to keep in mind that it adds marked morbidity risk with the potential for a sternal wound infection. The transthoracic approach uses a proximal thoracotomy with removal of the third or fourth rib. Exposure to the first four thoracic ribs is adequate with this technique, but access to the lower cervical vertebrae can be difficult. Other complications associated with this approach are the added morbidity related to lung manipulation and the potential for Horner's syndrome resulting from damage to the sympathetic chain. In general, neurologic results depend largely on the patient's preoperative status and their underlying disease process. Postoperative complications, such as shoulder dysfunction, hardly ever occur, and swallowing dysfunction is usually short lived. A positive outcome is that some patients can achieve as much as a 20° correction of kyphosis.
Conclusion: The CTJ represents a unique region in the spine because of its biomechanical properties. It is also a difficult region to access anteriorly because of the vital structures ventral to the CTJ. The development of new surgical techniques and new instrumentation has allowed better access and fixation to the CTJ.

I16
Retropharyngeal hematoma and management

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Introduction: Retropharyngeal hematoma is rare but one of the most serious complication in cervical spine anterior approach surgery. Edema and/or hematoma can result in serious airway compromise in these patients. Patients having multilevel corpectomies and certain anterior/posterior procedures are at higher risk. We reviewed retropharyngeal hematoma related complication and how to avoid serious results.
Methods: The studies all suggested that maintenance of the endotracheal tube overnight in high-risk patients may prevent the need. Riew and colleagues reported a study of 256 patients in which the authors used prospective criteria to determine whether it was safe to extubate patients after anterior cervical procedures. They suggested that it may be safe to extubate patients who undergo an anterior cervical procedure that lasts less than 3 hours with a retraction time of less than 2.5 hours. If the patient is difficult to intubate or is morbidly obese, or both, they should be kept intubated overnight unless the procedure is less than 90 minutes in length. These authors also reported four patients in this series who developed symptomatic airway obstruction 30 to 48 hours postoperatively secondary to hematoma formation, suggesting that vigilance in observing for airway complications needs to last up to 3 days postoperatively.
Results: It is important that preoperative preparation about high-risk patient such as long level surgery, high BMI and expect longer operative duration. Postoperative serial lateral x-ray check up and patient respiratory symptom evaluation is also important.
Conclusions: It is important to secure the airway in many ways to check up early symptoms and radiological evaluation to avoid airway obstruction.

References:
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I17
Dysphagia and dysphonia

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Introduction: Dysphagia and dysphonia are common complications after anterior cervical spine surgery (ACSS); However, there are few reliable clinical studies regarding prevalences, risk factors, measuring tools of dysphagia and dysphonia.
Aim: To introduce the risk factors of anterior cervical spine surgery on swallowing and vocal function and how to prevent dysphagia and dysphonia.
Methods: Medical records through the pubmed of 19 most reliable papers between 2012 and 2019 were retrospectively reviewed. We summarized and present the etiology, risk factors, measurement tools and how to avoid dysphagia and dysphonia including our own experiences.
Results: Risk factors are age(>60yrs), blood loss (> 300mL), female, larger less smooth plate, operative levels, increased op time, excessive esphageal retraction pressure, revision surgery, smoking and postoperative prevertebral soft tissue swelling. We present the sequential peri-intraoperative steps for reducing dysphagia and dysphonia.
Conclusions: ACSS is a safe surgical procedure but careful investigation and management are needed for reducing dysphagia and dysphonia. Also, team approach is inevitable to manage those problems.

I18
Postoperative surgical site infection

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Introduction: Postoperative surgical site infection (SSI) after cervical spine surgery is uncommon condition, regardless of approach side and metal implantation. However, its morbidity and mortality is relatively higher, respectively 20% and 0.1~10%.
Aim: To clarify an incidence, risk factors, complications, and other important issues regarding surgical site infection after cervical spine surgery.
Materials and Methods: In reviewing literature about postoperative SSI after cervical spine surgery (anterior and/or posterior surgery), we categorized several components, including incidence, morbidity and mortality, risk factors, complications, and others.
Results: The incidence of postoperative SSI is less than 1% in anterior cervical surgery and to 3% in posterior cervical surgery. The SSI is more prone in implanting hardware such as metal plate and PEEK cage. SSI has relatively higher morbidity and mortality rate, respectively approximately 20% and up to 10%. In particular, SSI after anterior cervical surgery has more possibility of morbidity and mortality, rather than one of posterior cervical surgery, since SSI after anterior surgery is greater associated with injury of vital organ or lethal complications. Several risk factors attributing SSI after cervical surgery have shown, including diabetes, prolonged surgical time, obese patient, malnutrition, and others.
Conclusion: We should keep in mind that surgical site infection after cervical spine surgery is uncommon, but completely lethal condition. Thus, addressing the risk factors preoperatively and focusing intraoperative and postoperative factors is critical for minimizing presence of postoperative surgical site infection.

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I19

Pseudoarthrosis diagnosis and management

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Introduction: Establishing a solid fusion after anterior cervical fusion surgery is not only a desirable endpoint of the intervention, but also provide reassurance and potential explanation for any ongoing symptoms. Pseudoarthrosis after anterior cervical fusion surgery may be a cause of postoperative symptoms and additional surgery. Therefore, understanding the most appropriate detection method of the pseudoarthrosis and how to manage symptomatic pseudoarthrosis is important.
Methods: Review of the literature and case presentation
Results: 2.6% (0-15.2%) overall incidence of pseudoarthrosis after anterior cervical discectomy and fusion (ACDF) was previously reported. However, recently it has been frequently pointed out that the incidence was underestimated. Furthermore, additional surgeries at the index level are three times more common when pseudoarthrosis is detected at the index level. Therefore, pseudoarthrosis is a major complication after ACDF and effort to minimize it is critical. For radiological diagnosis of pseudoarthrosis, flexion-extension radiographs using the interspinous process method (< 1mm motion difference, magnified 150%) can be used as the initial method of choice. Computed tomography (CT) is a useful method, especially when radiographical evaluation is indeterminate. Bone bridging outside the graft on CT may be more reliable and accurate for evaluation of fusion than bone bridging inside the graft. The pseudoarthrosis can result in symptoms including neck pain and reoperation might be indicated for symptomatic pseudoarthrosis without improvement with at least 6 months of non-operative treatment. In surgical planning for the revision surgery, various factors including patient comorbidities, symptoms, location of pathology, underlying deformity, and prior postoperative complications should be considered. Posterior revision surgery is preferred to anterior revision surgery with regard to avoidance of wound complications related to anterior scar tissue and higher fusion rates. However, advantages of anterior revision surgery are lower rates of wound complications, access to anterior pathology and graft or implant migration, exploration of the pseudoarthrosis site, and correction of kyphosis. Therefore, the decision for the revision approach must be individualized based on the underlying pathology. Additionally, strategies for prevention of the pseudoarthrosis may include choice of fusion grafts, additional local bone graft outside the cage, plate augmentation, and fusion related medication.
Conclusions: Pseudoarthrosis is one of the critical complications after anterior cervical fusion surgery with regard to higher incidence than previously expected and higher additional surgery rate. Related symptoms as well as potential reoperation plan might be considered based on radiological diagnosis using the interspinous process method with <1mm motion difference and CT scan. Effort to prevent the pseudoarthoris should be exercised and anterior or posterior revision surgeries for the pseudoarthrosis are chosen individually based on the underlying pathology.

I20

Pears and pitfall in endoscopic decompression technique

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Introduction: The surgical management of lumbar disc herniation has changed over time. In 1934, Mixter and Barr1 performed the first open lumbar discectomy and in 1997, microendoscopic discectomy was introduced as a minimally invasive spinal surgery (MISS). MISS has been used to treat LDH, and includes such approaches as microendoscopic discectomy and percutaneous endoscopic lumbar discectomy. MISS techniques have evolved over time in an effort to allow for sufficient decompression through smaller incisions, in order to preserve the normal anatomy. PELD, has been developed to achieve better visualization of the disc and is carried out under local anaesthesia. However, despite these improvements in surgical techniques and instrumentation, complications such as reoperations and infections still remain a problem.
Methods: During endoscopic procedures, a potential working cavity needs to be created for better visualization and the application of the endoscopic instruments.
Results: It enables surgeons to have a good and wider field of vision with high magnification. Ordinary arthroscopic and spine instruments can be used during this procedure without the need for special endoscopic instruments. A greater surgical range of motion with free movement, handling, and angulation of the surgical instruments and the arthroscope without crowding of the instruments is enabled as the devices are not all restricted in a single portal.
Conclusions: BELD has an advantage of allowing for continuous irrigation with a separate portal for outflow. We need to ensure that the irrigation fluid is not stagnant and is maintained continuously. Furthermore, more attention must be paid to keeping pressures low when opening the epidural space.

I21

Practical surgical technique of biportal endoscopic decompression

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Introduction: Recently, biportal endoscopy has been used, and the surgical field of view is clear and wide, and the instrument can be used freely. Therefore, the author would like to introduce a surgical treatment method using a biportal endoscope for degenerative spinal stenosis.
Main body: The biportal endoscope enables independent movement of surgical instruments through two portals, so it can be manipulated freely, and a wider field of view can be secured. The endoscope has the economic advantage of being able to use the existing arthroscopic and spinal surgery instruments as they are without purchasing new equipment.
The operation is performed under general (or spinal) anesthesia if possible and is performed in the prone position. After positioning the patient, the surgical site is marked on the c-arm image. To make two portals, one of the portals is used as a viewing portal and the other as a working portal. Each portal is made about 0.5~1cm in size, and the location of the portal is slightly different for each surgeon.
After making the two portals, the cobb elevator is inserted through the working portal, and the muscles are dissected from the spinous process and lamina to create working space. When creating working space, it is important to dissect the muscle well, and since a lot of bleeding can occur during dissect, hemostasis should be done using RF after making a space. Many surgeons use the 0-degree endoscope a lot, but if you get used to the 30-degree endoscope, it is quite advantageous to see the ipsilateral and the contralateral side. Laminectomy is performed in the same way as conventional microscopic surgery. Removal is mainly performed using a burr and punch, and single laminectomy and bilateral decompression are performed (unilateral laminectomy and bilateral decompression). Bone bleeding occurs a lot during laminectomy, and hemostasis is mainly done using bone wax. The yellow ligament that comes out after laminectomy is removed. Before removal of the yellow ligament, the upper, lower, and outer borders are first peeled off using a probe, and then removed. When the yellow ligament is removed, a lot of bleeding occurs due to the exposure of the epidural blood vessels. In this case, hemostasis is performed using RF. In general, the yellow ligament on the ipsilateral side is removed first, and then the yellow ligament on the contralateral side is removed.
Conclusion: The biportal endoscope has the advantage of being able to freely use the instrument because it operates through two portals, and the endoscopy has a clear and wide field of view, which is more advantageous than the existing microscope. In addition, although it has the advantage of less pain immediately after surgery due to less soft tissue damage, it showed similar clinical results compared to microscopic surgery. Therefore, biportal endoscopic surgery is considered to be a good surgical technique that can replace microscopic surgery in the future.

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I22

Endoscopic biportal spine surgery in patients with cervical herniated disc disorder

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Background: There have been considerable attempts at endoscopic approaches for the surgical treatment of cervical spinal stenosis and disc herniation. However, few reports have been existed on the trials of foraminotomy and discectomy using a two-portal endoscopy.
Purpose: This report describes short-term clinical results of posterior percutaneous biportal endoscopic discectomy or foraminotomy in patients with cervical disc herniation.
Methods: 150 patients, who had a diagnosis of herniated disc and related symptom, underwent the operation. This technique was provided with a 30° oblique arthroscope and conventional instruments for cervical spine surgery. Through the dorsal approach, the viewing portal was inserted by 10-20° to facet joint, and a working portal was inserted into it by about 20 degrees. With this method, effective removal of the herniated tissue and sufficient foraminotomy is possible through direct access to the paracentral and subarticular region by cutting the facet joint from medial border of the facet to lateral half via dorsal approach. In a right lesion, standing on the right side of the patient, we gripped the working or distal portal with the left hand to reduce laminar bone loss. We evaluated the short-term results of subjects, about one or two weeks postoperatively. Primary outcome was analyzed by using visual analogue scale (VAS) on posterior neck and upper extremity pain, and secondary outcome measure was a motor power change of affected myotomes.
Results: 150 patients (male=84, female=66, median age=59 years) had 11 months symptomatic duration on median value. And the level of disc was C3/4 of 6, C4/5 of 17, C5/6 of 65, C6/7 of 55 and C7/T1 of 7. The VAS was significantly decreased after the operation: 7 to 1 on posterior neck VAS, and 8 to 1 upper extremity VAS on median value. ($p<0.05$) The motor power of cervical myotomes improved more than one grade on MRC grading. ($p<0.05$) No significant complication was found.
Conclusion: Two-portal endoscopic approach can be performed efficiently and safely in patients with cervical disc herniation because of the wide and familiar field of visualization. This technique may be one of the effective and optimal minimal-invasive procedure for cervical disc disorder.

Keywords: Minimal invave, Cervical disc herniation, Biportal endoscopic, Arthroscope

I24

Biportal endoscopic transforaminal lumbar interbody fusion with arthroscopy

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Introduction: Interbody fusion is a common surgical technique for diseases of the lumbar spine. Biportal endoscopic-assisted lumbar interbody fusion (BE-LIF) is a novel minimally invasive technique that has a long learning curve, which can be a barrier for surgeons.
Methods: We analyzed the learning curve in terms of operative time and evaluated the outcomes of BE-LIF. A retrospective study of fifty-seven consecutive patients who underwent BE-LIF for degenerative lumbar disease by a single surgeon from January 2017 to December 2018 was performed. Fifty patients underwent a single-level procedure, and 7 underwent surgery at two levels. The mean follow-up period was 24 months (range, 14-38). Total operative time, postoperative drainage volume, time to ambulation, and complications were analyzed. Clinical outcome was measured using the Oswestry Disability Index (ODI), Visual Analog Scale (VAS) score for back and leg pain, and modified Macnab criteria. The learning curve was evaluated by a nonparametric regression locally weighted scatterplot smoothing curve. Cases before the stable point on the curve were designated as group A, and those after the stable point were designated group B.
Results: Operative time decreased as the number of cases increased. A stable point was noticed on the 400th day and the 34th case after the first BE-LIF was performed. All cases showed improved ODI and VAS scores at the final follow-up. Overall mean operative time was 171.74 ± 35.1 min. Mean operative time was significantly lower in group B (139.7 ± 11.6 min) compared to group A (193.4 ± 28.3 min). Time to ambulation was significantly lower in group B compared to group A. VAS and ODI scores did not differ between the two groups.
Conclusions: BE-LIF is an effective minimally invasive technique for lumbar degenerative disease. In our case series, this technique required approximately 34 cases to reach an adequate performance level.

I25
Biportal endoscopic TLIF: Extraforaminal approach

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Introduction: Biportal endoscopic spinal surgery is an emerging technique in lumbar degenerative diseases. The indication is gradually expanding, and transforaminal lumbar interbody fusion (TLIF) is also being performed through biportal endoscopy. The aim of this study is to introduce biportal endoscopic extraforaminal lumbar interbody fusion (BE-EFLIF), which inserts cage through a more lateral side than the conventional corridor of TLIF. In addition, we described the advantages of 3D printed porous titanium cage with large footprints insertion through multi-portal approach, and preliminary results of this technique.
Methods: This retrospective study included 12 consecutive patients who underwent BE-EFLIF for symptomatic single-level lumbar degenerative disease. Clinical outcomes, including visual analog scale (VAS) for back and leg pain and Oswestry disability index (ODI) were collected at preoperative and postoperative 1, 3, and 6 months. In addition, perioperative data and radiographic parameters were analyzed. And we described the surgical steps of BE-EFLIF using 3D printed titanium cage with large footprints through multi-portal approach.
Results: The mean age of the patients was 68.3 ± 8.4 years, and mean follow-up period was 7.6 ± 2.8 months. Mean operation time was 188.3 ± 42.4 minute, mean amount of surgical drainage was 92.5 ± 49.6ml, and there were no transfusion cases. All patients showed significant improvement in VAS and ODI postoperatively, and these were maintained for 6 months after surgery ($P < 0.001$). The anterior and posterior disc heights significantly increased after surgery ($P < 0.001$), and the cage position was ideally placed in all patients. There was no early cage subsidence and other complications.
Conclusions: The BE-EFLIF using 3D printed porous titanium cage with large footprints is a feasible option for minimally invasive lumbar interbody fusion. This technique is expected to reduce the risk of cage subsidence, and improve the fusion rate.
Acknowledgements: The authors have no conflicts of interest.

I26
Lateral cage insertion in L5/S1 anterior interbody fusion

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Introduction: More recently, a less invasive lateral lumbar interbody fusion (LLIF) technique has been reported using cages inserted through the lateral transpsoas or anterior psoas approach. According to reports, this method, which has been widely utilized in the treatment of numerous lumbar disorders, has the advantages of a short operating time, less bleeding, a large bone graft area, a high rate of fusion, a short hospital stay, and reduced rates of complications.
However, because the iliac wing prevents access to the disc space, the L5-S1 interspace has historically been thought to constitute a relative contraindication to LLIF.
Methods: The iliac crest may frequently block access to the L5S1, however on rare occasions, the intercrestal line may cross the mid to lower l5 body and allow access. However, because there is a chance of iliac plexus or iliac vessel injury, it can be a risky procedure. In sagittal radiographs, we identified the high iliac crest, which blocks more than half of the L5 body, and we attempted to place a lateral cage in patients with the high iliac crest.
Results: The patients are placed in the lateral decubitus position to achieve lateral hyperflexion to expose the surgical site, the iliac crest is centered over the table break, and the hip is extended to rotate the iliac crest anteriorly. Some patients had lateral cage insertion in the L5-S1 disc space with the Pivox instrument and in a hyperflexed lateral position. If the surgical corridor allows, it is possible to implant the cage laterally into the high iliac crest despite some difficulty (Figure 1.).
Conclusions: If the iliac vasculature are located anteriorly and there is a corridor between psoas muscle and iliac vasculature, entire covering of L5 body can be overcome by patient positioning and specialized surgical instrument in L5-S1 lateral cage insertion.

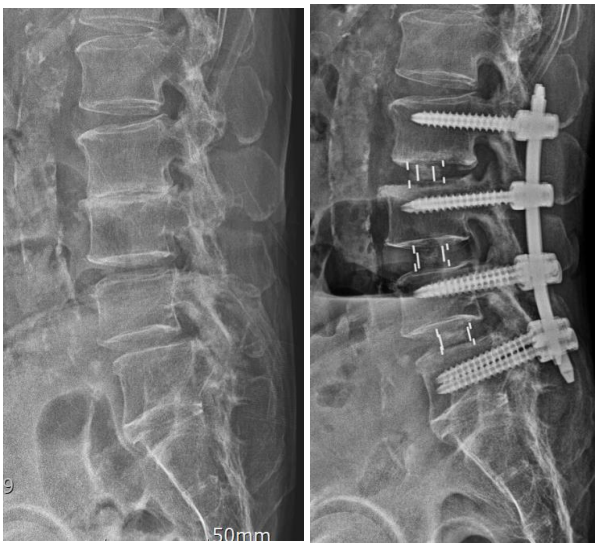

Fig 1. The iliac crest is covering the entire L5 body preoperatively (left). The lateral cage insertion was accomplished (right)

I27

Microscope assisted direct decompression in anterior lumbar interbody fusion

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Introduction: Lumbar interbody fusion is an effective surgical strategies for treating patients with lumbar degenerative diseases, herniated disc, infections, instability and spinal deformities. There have been several techniques such as anterior lumbar interbody fusion (ALIF), posterior/transforaminal interbody fusion (PLIF/TLIF). And recently, minimally invasive (MI) approaches such as, minimally invasive anterior approach, lateral lumbar interbody fusion (LLIF), have been described by some authors. The oblique lumbar interbody fusion (OLIF) is one of the variations of LLIF. Recently, operators can perform various MI surgeries through these approaches and some instruments, such as tubular retractor, percutaneous pedicle screw, microscope, and endoscope. In our literature review, there were no study on clinical outcomes of microscope assisted direct decompression during either OLIF or ALIF. So we used microscope for discectomy, end plate preparation, direct decompression of nerve root and removal of herniated disc before the insertion of the interbody cage during OLIF or ALIF. The purpose of this study is to report the clinical and imaging outcomes of microscope assisted direct decompression during OLIF or ALIF.

Methods: Twelve patients who received microscope assisted direct decompression during OLIF or ALIF for lumbar spinal stenosis were enrolled. The OLIF was performed for the lesion upper than the L4-5 or in the case of multi-segment disease. The ALIF was performed for the lesion at the L5-S1. After anterior-approaching surgery, percutaneous fixation of pedicle screw was performed and we did not perform an additional decompression posteriorly in all cases. For the clinical outcomes, we evaluated short form 36(SF - 36), Oswestry disability index (ODI) score and visual analog scale (VAS) pain score. For the imaging outcomes, we obtained postoperative lumbar magnetic resonance imaging (MRI).

Results: The OLIF was performed for 9 patients and the ALIF was performed for 3 patients. In the clinical outcomes, SF - 36 was improved from 25.40 to 69.83 and ODI score was also improved from 69.83 to 16.50. VAS pain score of back was improved from 4.3 to 1.6 and VAS pain score of leg was improved from 7.5 to 2.2. In the imaging outcomes, all patients had severe stenosis before surgery. After surgery the severity of the stenosis was reduced to mild state in 9 cases and moderate state in 3 cases postoperatively.

Conclusions: We could obtain the good clinical outcomes and effective decompression through microscope assisted direct decompression during OLIF or ALIF.

I28

Anterior column support in severely collapsed osteoporotic vertebrae: Intervertebral cage augmentation

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Introduction: We have reported the surgical outcomes of an anterior column support procedure, the intravertebral cage augmentation technique for the osteoporotic spine.
Methods: Introduction of one of surgical procedures for minimal invasive anterior column stabilization using transpedicular intravertebral cage augmentation and case presentation.
Results: Our experiences have shown that the introduced anterior column support procedure, the intravertebral cage augmentation technique, could be a useful option for osteoporotic patients with a severely collapsed vertebra causing neurologic deficits or intractable back pain. Radiographically, the corrected heights and kyphotic angles had been well sustained at the final follow-up visit, although all 10 patients had severe osteoporosis. Such well sustained corrected angle was more clearly observed at thoracolumbar lesions.
Conclusions: The introduced technique is a valuable surgical option for obtaining anterior column support in osteoporotic patients with severely collapsed Kummel disease who require decompression and stabilization procedures using only a posterior approach.

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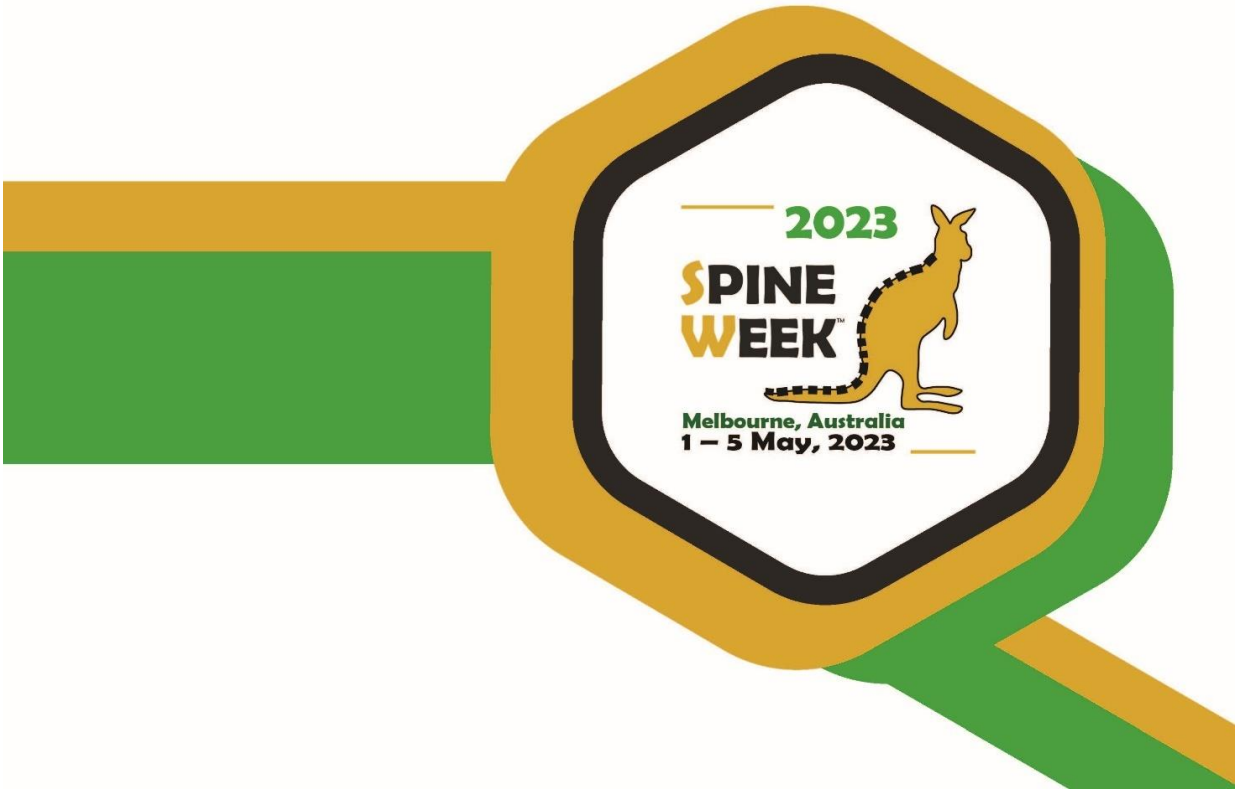
Abstracts of Oral Presentations



O1

Assessing changes in spine biomechanics for progressive AIS: A method using MRI and artificial intelligence

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Introduction: Adolescent idiopathic scoliosis (AIS) is a 3D deformity of the spine. While AIS aetiology has been linked to biomechanical, biochemical, and genetic factors, progression of the deformity is associated with biomechanical drivers. Attempts have been made to explore the progressive changes in joint biomechanics, but no prior study has explored the 3D change in vertebral centroids of individual patients, as their AIS spinal deformity progresses with growth. Using magnetic resonance imaging (MRI) of AIS patients, this study sought to develop a reliable and quick method to extract the 3D location of the vertebral centre of mass in the AIS spine, with a view to future evaluation of change in biomechanical loading over time.

Materials and Methods: MRI data (3T, T1-weighted, 0.5mm cubic voxels) for an AIS patient who was imaged sequentially (4 months apart) over three occasions during the course of their pre-operative treatment (HREC #14/88/AM03) was utilised. The dataset included the major structural curve - T5 to T12. A previously published artificial intelligence (AI) algorithm (convolutional neural network)[1] was used to automatically create a binary 3D DICOM stack (same resolution as MRI) of the thoracic vertebrae. The stack was auto-segmented in Amira (Vsn6.0.0, Thermo Fischer Scientific, USA), the reconstruction smoothed and surface artefacts removed using Geomagic Wrap (2022, 3D systems, USA), and the vertebral body isolated using anatomical landmarks on the posterior vertebral surface (Fig 1a).

Results: Using the AI algorithm[1], a 3D dataset of a thoracic spine spanning T5-T12 could be reconstructed, smoothed and cleaned (Fig 1a). Following image processing, the vertebral body centroids (centre of volume) were calculated and registered to the centroid of T12 in Scan 1 (Fig 1a). The 3D location of all vertebral centroids were tracked between scans, showing change in position with progressive deformity (Fig 1b,c). Using this AI-based workflow, 3D anatomy for a thoracic spine can be reconstructed from 3D MRI and biomechanically relevant landmarks created in approximately 90-120 minutes.

Discussion and Conclusions: 3D reconstruction of vertebral anatomy from MRI is typically carried out using manual segmentation, which is time-consuming and impractical for large datasets. But the use of MRI is preferable for paediatric populations due to the lack of ionising irradiation. The current study presents a reliable and highly promising state-of-the-art AI approach to enable exploration of the biomechanical drivers of AIS progression in the developing spine.
The study methods demonstrate the enormous potential for AI and deep learning techniques to enhance our fundamental understanding of AIS deformity progression, and to improve clinical imaging technologies used in patient treatment.

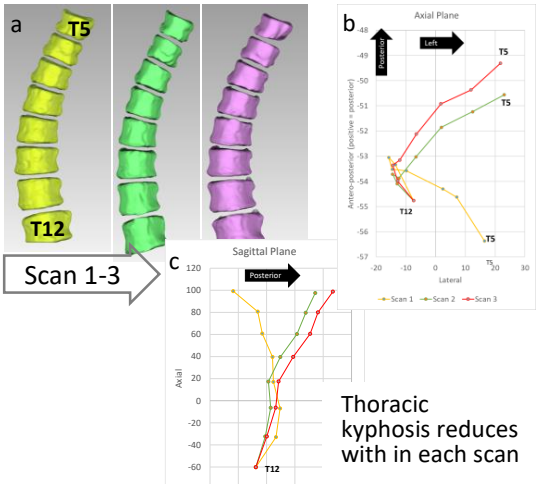

Fig 1 3D reconstructions; Vertebral centroids in the axial (b) and sagittal (c) plane

Reference:

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O2

Refinements of a parametric virtual workflow to design spinal orthoses for adolescent idiopathic scoliosis

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Introduction: Thoracic-lumbar-sacral orthoses (TLSO) are the current gold standard for conservatively managing adolescent idiopathic scoliosis. The most significant clinical challenge surrounding this treatment is patient non-compliance which is the leading cause of treatment failure. This can be linked to the labour-intensive process of manufacturing TLSO with a turn around time of up to 8-12 weeks. Virtual workflows and 3D-scanning paired with 3D-printing offer a novel ability to rapidly design and manufacture TLSO. Published work has emerged for manufacturing smaller devices including ankle-foot orthoses and cervical collars. A complete methodology is yet to be developed for spinal orthoses due to the complexity of the geometry and requirements for applying biomechanical correction. This research aimed to translate the traditional manual methods of designing a TLSO into a virtual environment.

Methods and Results: An initial virtual workflow was developed using computer-aided design (CAD) software with guidance from a trained orthotist and bracing manuals. It was vital that each manual process was correctly translated into the virtual environment. 3D surface scanning using an Artec Eva (Artec 3D, Luxembourg) replaced the traditional casting process to capture the patient's external torso anatomy and create a virtual mould. For the TLSO design, various CAD software was utilised based on the modelling requirements of each step in the manual process. The initial virtual workflow included Geomagic Wrap (3D Systems, USA) for cleaning artefacts within the 3D scan, Blender (Blender Foundation, Netherlands) for applying the corrective biomechanical loading condition, Meshmixer (Autodesk, USA) to create the TLSO profile and geometry, before re-using Geomagic Wrap to add attachment features. Four virtual 3D TLSO models were designed using sequential 3D scans of a patient receiving bracing treatment within QCH Spine Outpatient Clinic. Each TLSO was re-designed three times and a linear deviation analysis was completed for a preliminary analysis of the virtual workflow. Although this workflow was completely virtual, the transferring of CAD models between software caused the workflow to be laborious with low repeatability.

A second virtual workflow was developed with the aim of streamlining the modelling processes and increasing repeatability. The processes that applied biomechanical correction, created the TLSO profile/geometry and the attachment features were repetitive with potential for automation. The second workflow was designed using Rhinoceros 3D (Robert McNeel & Associates, USA) including Grasshopper which enabled the of use of parametric design algorithms that simplified repetitive processes from the initial workflow to a single design software. The original four sequential 3D scans were used to design TLSO models using the refined parametric algorithm. This was repeated three times with a linear deviation analysis for comparison of the two workflows. The repeatability and time taken to design a TLSO model was significantly improved using the refined parametric workflow.

Discussion and Conclusion: As early-bracing and time-efficient methods are critical for treatment success, the parametric approach is a novel tool for increasing an orthotist's productivity and ability to work remote from the patient. This pilot study provides a foundation for further development and analysis of virtual workflows for spinal orthoses.

O3

Risk factors for errors in pedicle screw placement in minimal invasive computer assisted spine surgery

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Introduction: Pedicle screw (PS) placement is the cornerstone in spinal reconstructions, and computer assistant navigation reduces PS misplacements[1,2]. Yet, the exact PS position has never been compared to the trajectory intended in the navigation. Our study examines associated risk factors for PS deviation using CAN in minimally invasive spine surgery (MISS).
Methods: 175 patients who underwent MISS with CAN between 2015 and 2021 were included. In these patients the position of the navigated yamshidi needle was stored on the navigation system as the intended screw position. Intraoperative 3D scans were fused to the postoperative CT-scan using SpineMap® 3D Software (Stryker©). The deviation of the real PS position from the intended position stored on the navigation system was defined as the technical error. The primary endpoint was the discrepancy between the planned and the real PS position presented as PS angle deviation (PAD) in degrees and adjacent PS deviation (APD) in mm. Age, gender, body mass index (BMI), back tissue depth (BTD) and osteoporosis were considered patient factors. The use of cement, PS loosening, surgical time (ST) and estimated blood loss (EBL) were considered surgical factors. Number of PS inserted, PS dimensions, and navigation type were considered technical factors. All were considered as possible outcome-affecting variables[3]. Analyses were conducted on GraphPad Prism 9.4.0. Mann-Whitney and Kruskal-Wallis tests were performed. Linear and logistic regression analysis was used to determine the possible effect on the primary endpoint.
Results: In total, 952 out of 1054 PS placed could be measured. Mean PAD was 5.32° (±3.70), and mean APD was 2.97mm (SD ±1.83). Patient factors associated with increased deviation were BMI and BTD. Surgical factors associated with increased deviation were longer ST, higher EBL, PS loosening and more PS placed. Technical factors associated with increased deviation were PS dimensions and the use of a spinous process navigation tracker. Regression analysis showed BMI, BTD, PS loosening shorter PS, thicker PS, as significant risk factors for higher deviation rates.
Discussion: Our results show that technical errors in PS placement with spinal navigation may be affected by certain patient, surgical, and technical risk factors. Although, the results may not be causative, it lets us be more mindful for possible errors with CAN. We encourage further research into this topic.

O4

Machine learning algorithms can accurately distinguish pathological gait patterns in patients with Lumbar spine conditions and Parkinson's disease when compared to normative controls

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Introduction: Patterns of changes to spatiotemporal gait metrics in gait-altering conditions in different pathologies are colloquially termed gait 'signatures' as these are known to be characteristic of the pathology. This data can be interpreted by machine learning (ML) models which have recently emerged as an adjunct to clinical medicine. Previous studies have shown that ML models can distinguish patients with pathological gait patterns such as Parkinson's disease from normative controls with a high degree of accuracy. However, there is still a clear need for research involving a multi-pathology classification problem to ascertain whether ML algorithms maintain this accuracy when posed with gait patterns belonging to different pathologies. In addition, there is not a clear consensus on the combination of ML techniquese or ML models best suited to analysing spatiotemporal gait data.
Aims: This study aims to investigate whether machine learning models can distinguish patients with Parkinson's disease, and those with lumbar spine conditions from each other, and from normative controls, based on spatiotemporal gait data gathered by an inertial measurement unit. The study also aims to investigate the ML model best suited to this purpose.
Patients and Methods: This was a prospective observational study involving 32 patients with Parkinson's disease, 115 patients with lumbar spine conditions and 167 'normative' subjects. Spatiotemporal gait metrics were gathered from all subjects using the MetaMotionC inertial measurement unit and data obtained were used to train and evaluate the performance of 10 machine learning models. Principal component analysis was the feature selection techniques used. Classification models included Artificial Neural Networks and a new model, Catboost. Data balancing techniques such as ADASYN and Random Undersampler were used to help balance the datasets.
Results: ML algorithms can accurately distinguish pathological gait in Parkinson's disease and Lumbar spine conditions from gait patterns of normative controls. Several models demonstrated accuracies greater than 91%, with the most successful model having a 95% classification accuracy among the three classes, with an $\boldsymbol{F_1}$ score of 0.93.
Conclusion: ML algorithms can accurately distinguish pathological gait from normative controls in Parkinson's Disease and Lumbar Spine conditions. Catboost classifiers, with feature selection are the preferred ML techniques for this purpose as they produce the highest performing model. The accuracies of these models are expected to increase further with more data.

O5

Viscoelastic lumbar disc prosthesis and monosegmental ALIF: What is the impact on the centers of rotation of the adjacent segment?

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Introduction: The preservation of adjacent segments is one of the main objectives of lumbar disc arthroplasty, while segmental arthrodesis is considered a factor of potential deterioration. Previous studies suggest the importance of an exploration of the mean centers of rotation (MCR) to better understand the functional consequences of segmental arthrodesis or disc prosthesis.

Patients and Methods:

- 3 groups have been included 15 control cases without spinal pathology (40 years (38 -54)) 61 patients with LP ESP viscoelastic disc prostheses (mean age 42 years (34-54), minimum follow up 5 years (5-6)) and 58 ALIF (mean age 51 years (36 - 62), minimum follow-up 6 years (6-8)).
- Operated patients and case controls were homogeneous for BMI and sagittal balance parameters (pelvic incidence, sacral slope, lumbar lordosis)

Lateral view of the flexion and extension of the lumbar spine were performed standing and analyzed using Spineview® software for ROM and MCR. The MCR was localized thanks its co-ordinates. *X* is ex- pressed as a percentage of the length of the vertebral end plate, and *Y* as a percentage of the height of the posterior wall. (figure1)

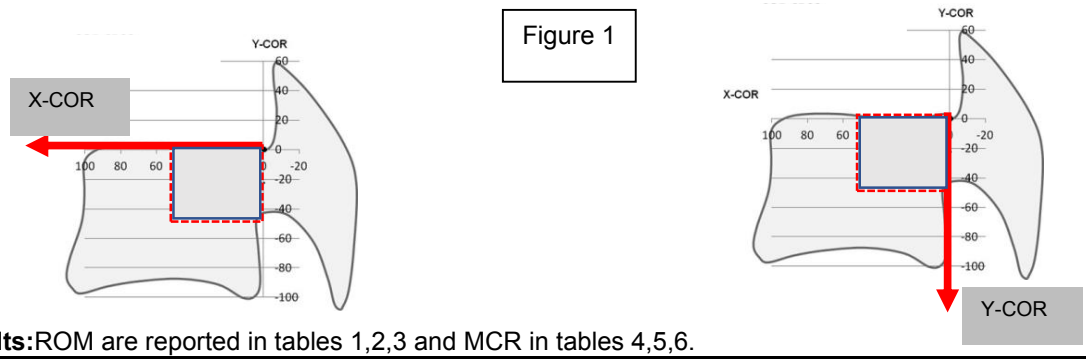

Figure 1

Results:ROM are reported in tables 1,2,3 and MCR in tables 4,5,6.

Table 1. ROM according to the disk replacement procedure

Type	L5S1 LP ESP			L4L5 LP ESP		
	L5S1	L4L5	L3L4	L5S1	**L4L5**	L3L4
N	39	39	39	22	22	22
ROM M (SD)	6,7 (3,4)	6,9 (4,7)	7,9 (4,8)	8,6 (5,4)	6,8 (4)	8,3 (4,9)

Table 2. ROM according to the ALIF procedure

Type	ALIF L5S1			ALIF L4L5		
	L5S1	L4L5	L3L4	L5S1	**L4L5**	L3L4
N	35	35	35	23	23	23
ROM M (SD)	0	8,8 (5,6)	7,3 (3,7)	5,6 (3,2)	0	9,4 (5,9)

Table 3. ROM in control group

	L5S1	**L4L5**	**L3L4**
N	15	15	15
ROM M (SD)	8,4 (6,5)	13,5 (7,2)	11,1 (5,2)

Table 4. MCR for LP ESP and ALIF in L5 S1 segment

Type	L5S1 LP ESP		L5 S1 ALIF	
	L5S1	L4L5	L5S1	L4L5
mean x-MCR values	**26.1%**	**36.8%**		**19.1%**
	± 31.5	± 17.9		± 16.5
mean y-MCR values	**15,70%**	**-15%**		**9,70%**
	± 31,5	± 33.9		± 21,6

Table 5. MCR for LP ESP and ALIF in L4L5 segment

Type	L4L5 LP ESP			L4 L5 ALIF		
	L5S1	**L4L5**	L3L4	L5S1	**L4L5**	L3L4
mean x-MCR values	**30,20%**	**24.7%**	**31.1%**	**34,90%**		**11.5%**
	± 22,2	± 29.2	± 20.9	± 19,1		± 19.1
mean y-MCR values	**-0,61%**	**2,86%**	**-7,90%**	3,61%		**7,86%**
	±46.1	±26.2	±24.7	±26.2		±16.9

Table 6. MCR for control group

	L5S1	**L4L5**	**L3L4**
mean x-MCR values	**39.4%**	**32,50%**	**24%**
mean y-MCR values	**23,90%**	**5,50%**	**-2%**

Conclusion: MCR are less precise than the analysis at multiple points in the motion cycle, but this qualitative analysis allows comparisons with previously published papers about normal lumbar spine functional mobility. This study has limitations (sample size, only 5 years follow-up, heterogeneity for operative indications between disk replacement cases and ALIF). Nevertheless, when comparing to LP ESP disk prosthesis, significant modifications can be observed for ALIF with a tendency for superior and posterior MCR migration at superior adjacent level with potential influence on posterior facets.

O6

New findings pave the way: Structure-function characterization of the transition zone in the intervertebral disc

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Introduction: The current understanding of the relationship between the structure and function of the transition zone (TZ), a region at the interface on the nucleus (NP) and annulus (AF) of the disc (IVD), is little. There is no study to fully characterize the mechanical properties of the TZ, compared to the adjacent regions, and the precise nature of the structural integration between the NP and AF via TZ region is not yet known. The current study aims to understand the viscoelastic and failure mechanical properties of the TZ region under physiological radial loading and to present a structural model for the integration between the NP and AF at the fibre level.
Methods: 36 NP-AF blocks of tissue (t = 1mm) were harvested from the anterior region of ovine IVDs. Samples from the NP, TZ and IAF (inner AF) were subjected to cyclic dynamic loading up to 70% of their initial length (n = 24) at three different strain rates (1, 3, and 5%s^{-1}) and another 8 TZ samples were subjected to tensile failure tests. Tissue blocks (n = 4) were partially digested to identify the structural organization of elastic and collagen fibres at the NP, TZ, and IAF including the integration mechanisms between the NP and AF.
Results: We observed different viscoelastic behaviours for different regions of interest and various strain rates. A Friedman test revealed a significant effect of region (NP, TZ, and IAF) and strain rates on stiffness, $\chi 2$ (11) = 80.694, $p < 0.001$, W = 0.917. The relevant mean rank was the highest for the IAF, followed by TZ and NP regions with a growing trend as strain rates increased from 1 to 5%s-1. From the failure mechanical test, we found that the overall effect of strain magnitude on TZ stiffness was significant ($p < 0.001$; one-way ANOVA) (Figure 1). Our structural analysis revealed similar organizations for both collagen and elastic network from the NP towards the AF and identified three mechanisms of adaptation, direct penetration and entanglement between the TZ and IAF fibres at the NP-AF interface (Figure 2).
Conclusions: The results of the current study revealed the mechanical and structural contribution of the TZ fiber network to the overall mechanical properties of IVD in the radial direction. We found a gradual increase in stiffness from the NP toward the IAF with the stiffness differences between the IAF and TZ increased for higher strain rates and magnitudes. From a structural point of view, we identified three common integration mechanisms between the TZ and IAF region, which likely support the existence of a continuous radial fibrous network across the IVD. The findings of the current study strongly suggest that new IVD tissue-engineered and computational models should take into account the gradual transition of structural complexity and mechanical properties of the TZ.

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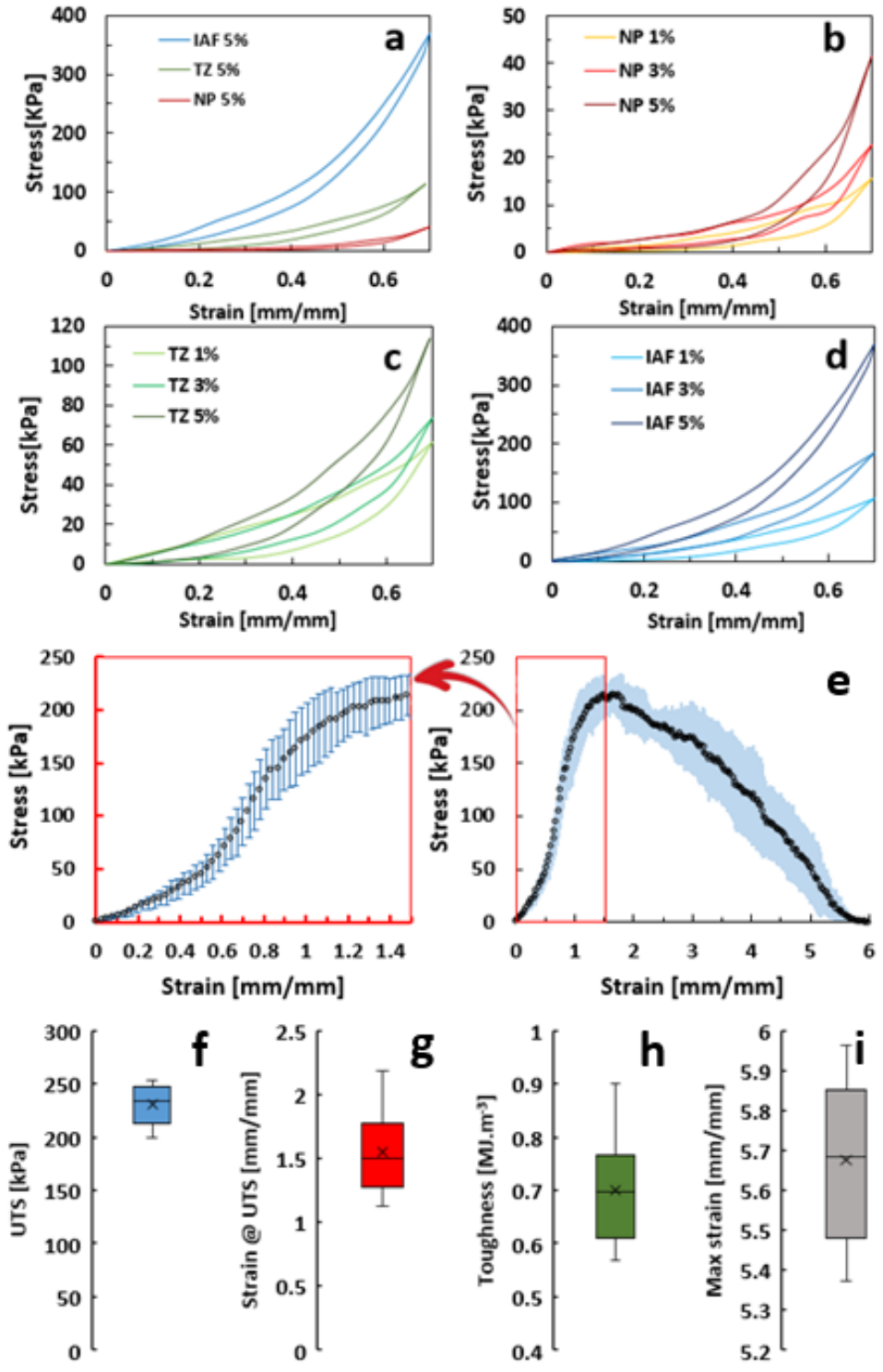

Figure 1 – (a) Cyclic mechanical behavior (mean stress-strain in the radial direction) of the TZ, NP, and IAF regions at 5%s^{-1} strain rate. Cyclic mechanical behavior (mean stress-strain in the radial direction) for (b) NP, (c) TZ, and (d) IAF regions at 3 strain rates. (e) stress-strain curve for full mechanical behavior of the TZ region of IVD with the shaded region indicating the relevant variances across 8 different samples. Zoomed working range of the TZ. Mean (95% CI) of selected TZ mechanical properties, including (f) ultimate tensile strength, (g) strain at TZ ultimate tensile strength, (h) toughness (MJ. m^{-3}), and (i) maximum strain.

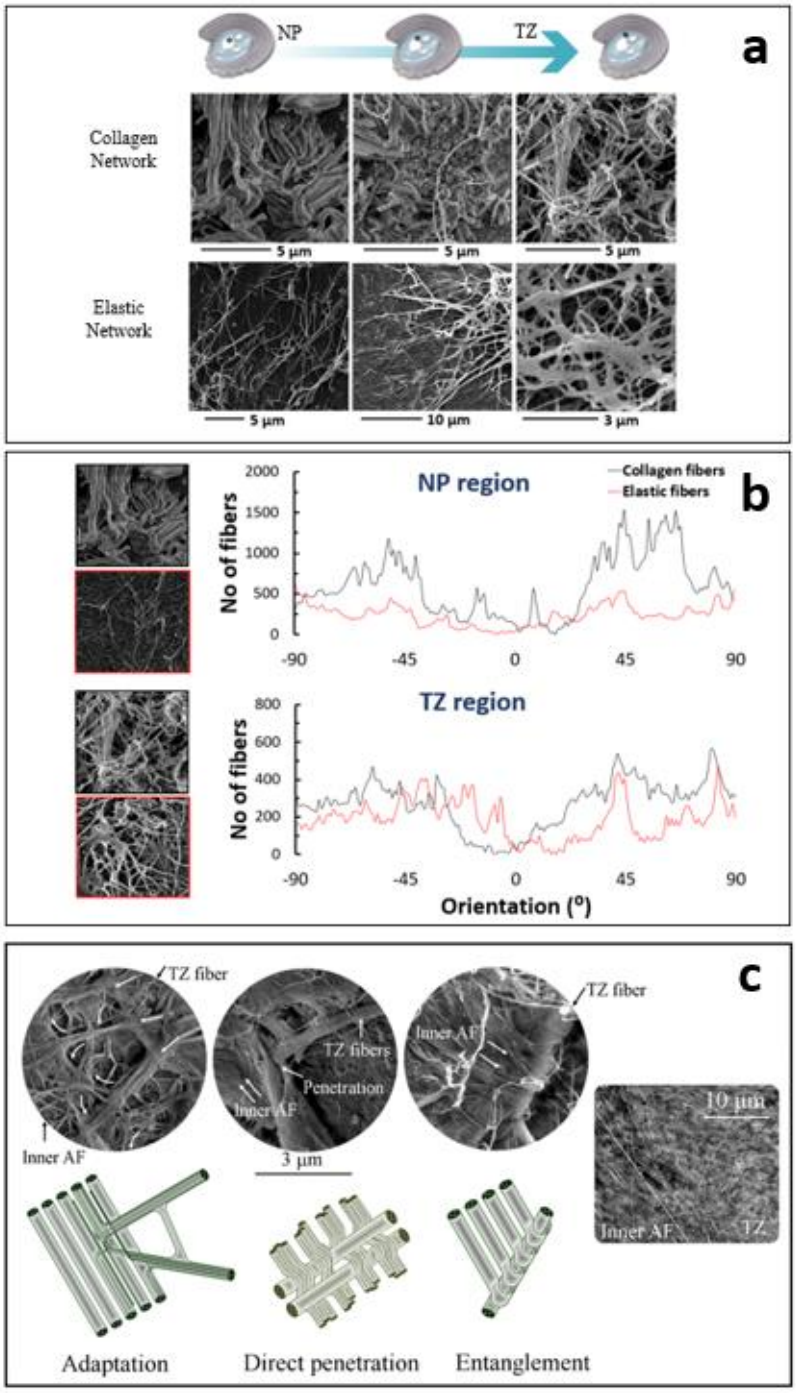

Figure 2 – (a) Structural organization of collagen and elastic compartments in an IVD from the NP (left) toward the TZ region (right). (b) Distribution of collagen and elastic fibers network in the NP and TZ regions of the IVD. (c) SEM images and relevant schematic drawings indicate the three (most common) integration mechanisms between the TZ and IAF at the fiber level.

O7

Is graft material still necessary in 3D titanium interbody fusions? A preclinical evaluation in sheep

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Introduction: 3D printed titanium cages have quickly become an implant of choice for spine surgeons due to complex porous features for bone ingrowth and greater surface area for minimizing subsidence. Surgeons are increasingly tempted to implant these cages without bone graft material, but strong supporting evidence still does not exist, and it is unclear how increased endplate surface area, resulting in a smaller graft aperture, influences fusion results. Here, we evaluate the effect of interbody endplate surface area and bone graft packing on spinal fusion.
Methods: Twelve two-level interbody fusions (L2-3 & L4-L5) were performed in adult sheep using 3D printed titanium interbody cages with bilateral pedicle screw fixation. Interbody cage designs evaluated had either a standard-aperture (low endplate surface area), small-aperture (medium endplate surface area), or no-aperture (high endplate surface area) packed with autologous iliac crest bone graft (ICBG). A fourth group was implanted without ICBG, utilizing the no-aperture cage. Fusions were evaluated at 16 weeks via manual palpation, microCT, and histology endpoints.
Results: Standard, small, and no-aperture cages packed with ICBG all resulted in strong fusion results (80%, 100%, and 83%, respectively) at 16 weeks by manual palpation, and these results were not significantly different. Implantation without ICBD resulted in a significantly lower fusion rate (33%, $p<0.05$). MicroCT and histological results supported those seen by manual palpation, with new bone bridging across the vertebral endplates for spines graded as fused by manual palpation.
Conclusions: Similar fusion results for standard, small, and no aperture cage designs when packed with ICBG suggest that aperture size does not appear to influence fusion results in the sheep model. Significantly decreased fusion results when ICBG graft was not used suggests that graft material plays an essential role in interbody fusion in this model.

O8

Engineering the perfect mattress: The influence of age and anthropometry on lying biomechanics

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Introduction: During sustained supine lying, pressure acting in muscle interfacing the sacrum causes localized occlusion of blood vessels, prompting repositioning to restore blood flow. Increasingly soft mattresses aid to reduce pressures but promote a 'hammocking' effect, where large magnitudes of mattress deformation distort the spine towards an uncomfortable posture. The aim of this study was to apply a multi-geometry 3D finite element (FE) model of the supine lying pelvis in a multi-variate parametric analysis, to explore the influence of age, anthropometry, mattress technology and mattress stiffness on soft tissue compressive stresses and substrate indentation. By understanding the relationships between these parameters, the objective was to identify personalized strategies to minimize pressure and mattress deformation.

Methods: A previously validated finite element (FE) model was used to estimate the influence of mattres properties on the magnitude of compressive stress interfacing the sacrum. Subject-specific anatomy and tissue parameters were developed using a 3D imaging (MRI) of prone lying and biomechanical assessment of a young healthy male subject (Age: 19, Weight: 62 kg, Height: 177.7 cm). The model geometry was developed using 3D reconstruction of MRI scans to develop unloaded geometry of the bone, subcutaneous adipose and skin, and other soft tissue (i.e. muscle and organs). The material properties for the adipose and skin, and muscle were described using a hyperelastic 1st order Ogden function. To parameterize the model, the dimensions of the geometry were scaled proportional to the height and weight of a 5th, 50th, and 95th percentile male. The Ogden material parameters for muscle were scaled proportional to the estimated increase in intramuscular adipose tissue (IMAT) to reflect stiffening of muscle tissue with age (20, 50 and 80). The quasi-static, axisymmetric FE model simulated the pelvis under gravitational load, in frictional contact ($\mu = 1$) with soft and firm spring, and foam mattresses.

Results: The FEM predicted that older individuals (age=80) had deep tissue pressures (Mean±SD) 42±52% higher than younger individuals (age=20), with 19±10% greater mattress deformation. However, foam mattresses were effective for older individuals, decreasing mattress deformation and pressures by 28±8% and 3.4±8.4% respectively in comparison to spring mattresses.

Heavier/larger body sizes (95th percentile) had 26±28% lower pressures than smaller body sizes (5th percentile), however, the weight of heavier body sizes caused 55±17% greater deformations. Heavier body sizes had a reduction in mattress deformation of 26±9% by using a foam mattress instead of spring, while pressure remained similar.

Conclusions: FEM predictions indicate older populations experience increased pressure and spinal distortion when lying supine, however, foam mattresses substantially reduced mattress deformations and deep tissue pressures. This suggests that increases in IMAT with age, which effectively stiffens the muscle, caused a concentration of pressure towards the sacrum, while the foams non-linear characteristics redistributed pressure away from the sacrum. Foams aided in reducing spinal distortion in larger/heavier individuals, without increasing pressure. Mattress customisation and use of foam mattresses with suitable stiffness may aid in improving biomechanical parameters in supine lying, improving sleep and recovery.

O9

Intrathecal pressure, spinal cord compression and oedema in a pig model of contusion spinal cord injury

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Introduction: Dural decompression is a potential treatment for SCI patients with persistent dural compression of the spinal cord. It may improve spinal cord tissue perfusion via reduced local intrathecal pressure (ITP). Clinically, injury-site ITP reductions have been observed with dural decompression of severely swollen spinal cords. In pigs, elevated pressure within the spinal cord parenchyma has been observed for 7 days following contusion SCI. The aim of this study was to characterise ITP at, and across, the injury site, for 14 days post-injury, in a domestic pig model, and to explore the relationship between ITP, intrathecal occlusion, and indicators of oedema and inflammation.

Methods: The study was approved by the Institutional animal ethics committee. Animals received analgesia, anaesthetics, and veterinary care across all procedures. Anaesthetised female domestic pigs (26-34 kg), received a T10 contusion SCI with a custom device that released a 50 g impactor from 10 cm (n=3) or 20 cm (n=5) onto the exposed dura. A further two animals (P01/P02) received minimal SCI due to technical issues but their outcomes are retained for comparison. Three days prior to SCI, intrathecal catheters were surgically placed to allow insertion of miniature ITP sensors at T10 and ~150 mm caudal/cranial. Animals were anaesthetised at 3, 7, 10 and 14 days post-SCI for ITP measurements and magnetic resonance (MR) imaging. Hind limb motor function was assessed at 8 and 13 days post-SCI. Animals were transcardially perfused at 14 days post-SCI and spinal cord tissue was histologically analysed to measure lesion volume, spared white matter, blood-spinal cord barrier permeability and microglia/macrophages. Statistics were not completed due to low animal numbers.

Results: All SCI animals displayed hind limb motor deficits, with differences in stepping and weight bearing between the groups; bladder and bowel function was retained. Pre-injury (T10: 4.8±1.0 mmHg) and ~1hr post-injury mean ITP (T10: 4.4±0.8 mmHg) were consistent across animals and spinal levels (Fig 1A). No systematic changes in mean ITP were observed across the time course or between injury groups, either at the injury site (Fig 1A), or across the caudal and cranial locations; although, in some animals, injury-site ITP measurements were confounded by extradural compression of the thecal sac and cord. Post-SCI MR showed injury-site signal hyperintensity, and intrathecal occlusion resulting from cord swelling and haematoma overlying the T10 laminectomy site was common; occlusion typically reduced at day 7 and 14 post-SCI (Fig 1B-D). Histological lesion volume was 20% greater, and 30% less white matter was spared, in the 20-cm group than in the 10-cm group (Fig 2A,B). Barrier permeability and activated microglia/macrophage presence was elevated at the injury epicentre for both injury groups (Fig 2C,D).

Conclusions: The apparent discordance between mean ITP changes, extradural compression, and histologic evidence of cord oedema at 14 days post-injury, was unexpected. Injury site ITP measurements may have been confounded by the extradural compression around T10 and inconsistent effects of anaesthesia on physiological variables that may influence ITP dynamics (e.g. BP, respiration) on measurement days.

Acknowledgements: This study was funded, in part, by North American Spine Society [CFJ/AVL]; Conquer Paralysis Now [CFJ/AVL]; Depuy Synthes [CFJ/AVL]; The Hospital Research Foundation [CDG]; National Health and Medical Research Council (Australia) [CFJ].

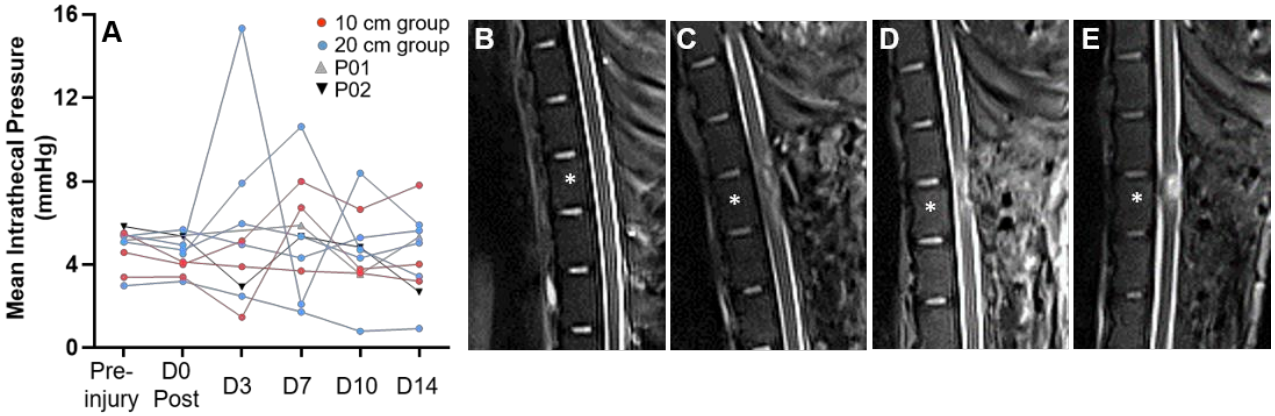

*Figure 1: Injury site intrathecal pressure for each animal pre-injury and post injury at day 0, 3, 7, 10 and 14 (A). Exemplar sagittal T2 SPACE MR images of the lesion site (T10 *) taken pre- injury (B), and at 3 (C), 7 (D) and 14 (E) days post SCI, from a 20 cm animal.*

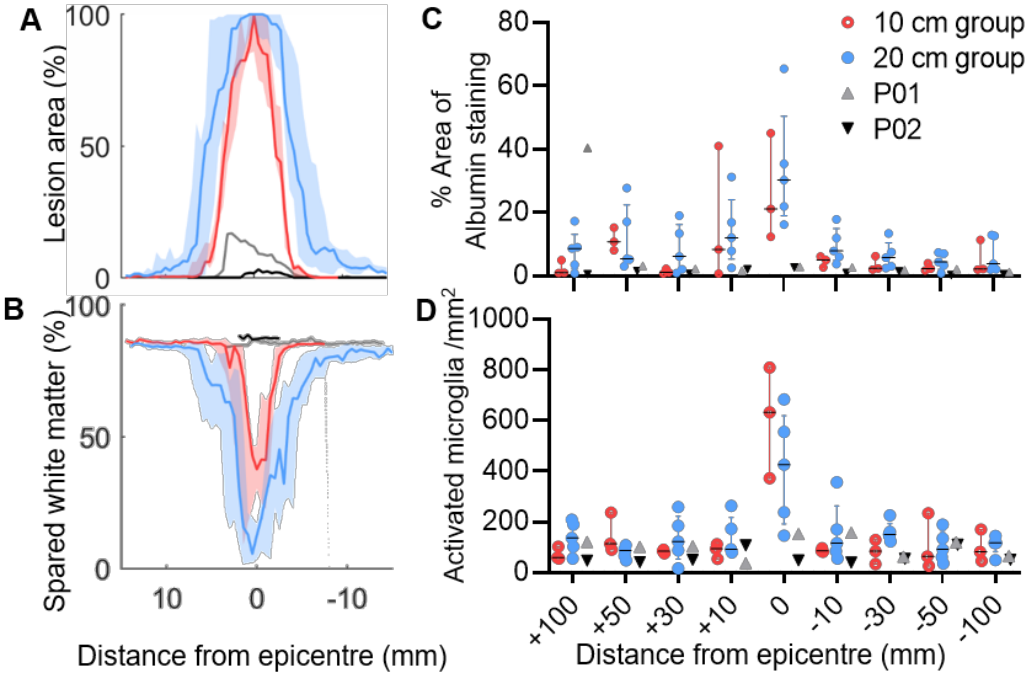

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Figure 2: (A) Lesion area as a percentage of the spinal cord area for each section (luxol fast blue / haematoxylin eosin stained sections); and, (B) Spared white matter as a percentage of spinal cord area (eriochrome cyanine / neurofilament stained sections). Area under the curve represents percentage volume. Solid lines: median; shaded areas: range. (C) Percentage area of albumin staining, and (D) Number of activated IBA1+ cells/mm², at the injury epicentre and at 10, 30, 50 and 100 mm cranial and caudal for all animals.

O10

Spinal cerebrospinal fluid flow following traumatic spinal cord injury: An investigation using phase-contrast magnetic resonance imaging in the pig

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Introduction: Traumatic spinal cord injury (SCI) can cause spinal cord swelling and subarachnoid space (SAS) occlusion. This occlusion may change pulsatile cerebrospinal fluid (CSF) flow, which could have implications for acute clinical management. The aim of this study was to investigate SAS occlusion and spinal CSF flow dynamics during two weeks post-SCI in a pig model.

Methods: A T10 contusion SCI was induced in female domestic pigs (23 – 34 kg) via a controlled weight-drop (50 g) from 10 cm (n=5) and 20 cm (n=5). Post-SCI motor function was assessed at 8- and 13-days post-SCI using the Porcine Thoracic Injury Behavioral Scale (median and range reported). Magnetic resonance imaging (MRI) was performed pre-SCI, and 3, 7, and 14 days post-SCI. SAS occlusion length (cranial-caudal) was measured on high resolution T2-weighted scans. Axial phase contrast (PC)-MRI were acquired at C2/C3, T8/T9, T11/T12 and L1/L2 levels (Figure 1) and post-processed using Segment software (Medviso). The region delineating the border of the flow signal was manually defined on each PC-MRI phase image and mean CSF velocity was determined for each cardiac phase. CSF velocity patterns over one cardiac cycle were not consistent pre-SCI and post-SCI so peak positive (cranial direction) and negative (caudal direction) mean velocity were measured. Linear mixed-effects models with post-hoc pairwise comparisons (Bonferroni) were developed to assess the association between (1) weight-drop height and day post-SCI on SAS occlusion length; and, (2) spinal level, day post-SCI and SAS occlusion length on peak mean CSF velocity.

Results: Median motor function score was lower in the 20 cm group, indicating worse hind limb function. The 20 cm and 10 cm group showed no improvement and minor improvement, respectively, from day 8 (20 cm: 3 [2 – 4]; 10 cm: 6 [4 – 7]) to 13 (20 cm: 3 [2 – 4]; 10 cm: 7 [5 – 8]). The 20 cm animals had larger SAS occlusion length (36.7 ± 14.4 mm) than the 10 cm animals at day 3 (17.8 ± 9.2 mm) ($p = 0.002$), and SAS occlusion decreased on day 14 (20 cm: 29.7 ± 17.1; 10 cm: 6.3 ± 5.5 mm) in both groups ($p < 0.001$). At all spinal levels, peak cranial and caudal mean velocity decreased at day 3 (cranial: $p < 0.001$; caudal: $p = 0.007$) post-SCI, and increased from day 3 to 14 (cranial: $p = 0.019$; caudal: $p = 0.023$) (Figure 2). SAS occlusion length was not associated with peak cranial ($p = 0.964$) or caudal ($p = 0.629$) mean velocity.

Conclusion: Although SAS occlusion length was not associated with peak mean velocity after SCI, the CSF velocity patterns over the cardiac cycle changed, and peak mean velocity decreased on day 3 and returned towards baseline at day 14 following SCI. This suggests that pulsatile motion of the CSF, spinal cord and surrounding tissues are altered in the acute post-SCI period. Additional quantitative evaluation of these data is ongoing.

Acknowledgments: This study was funded, in part, by project grants from North American Spine Society, Conquer Paralysis Now, and Depuy Synthes.

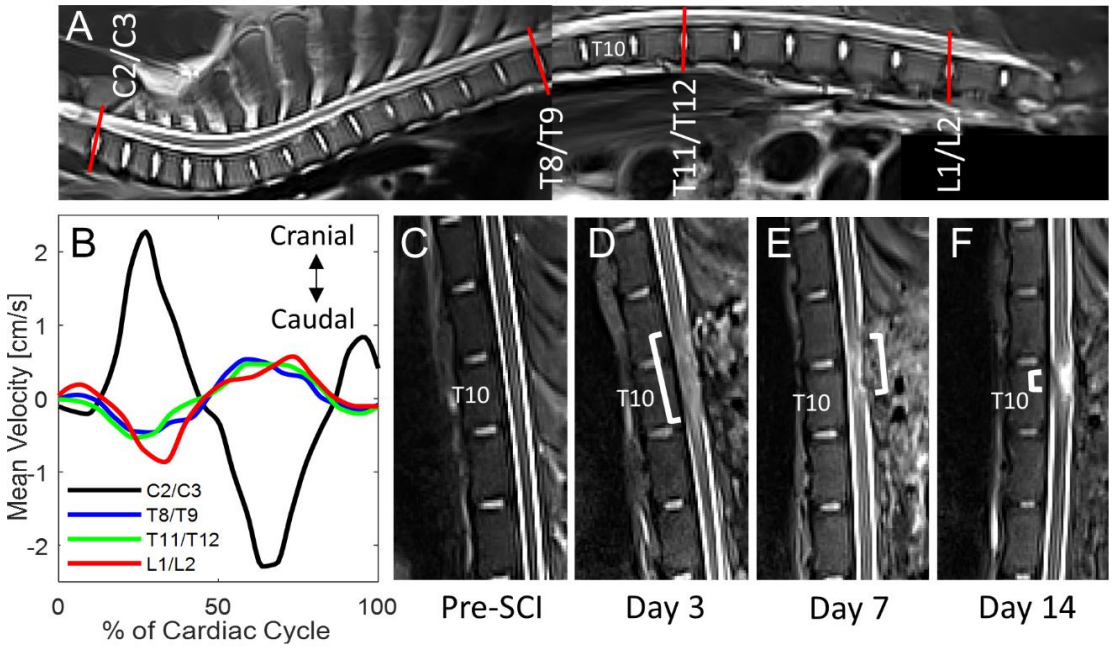

Figure 1: (A) Sagittal T2- weighted MRI of the pig cervical to lumbar spine with labelled spinal levels and planes of the phase-contrast MRI (PC-MRI) images. (B) Exemplar pre-injury CSF mean velocity across one cardiac cycle at four spinal levels. (C-F) Representative mid-sagittal, high-resolution T2- weighted MRIs of a T10 SCI with subarachnoid space occlusion (illustrated with a white bracket) in a 20 cm injury animal.

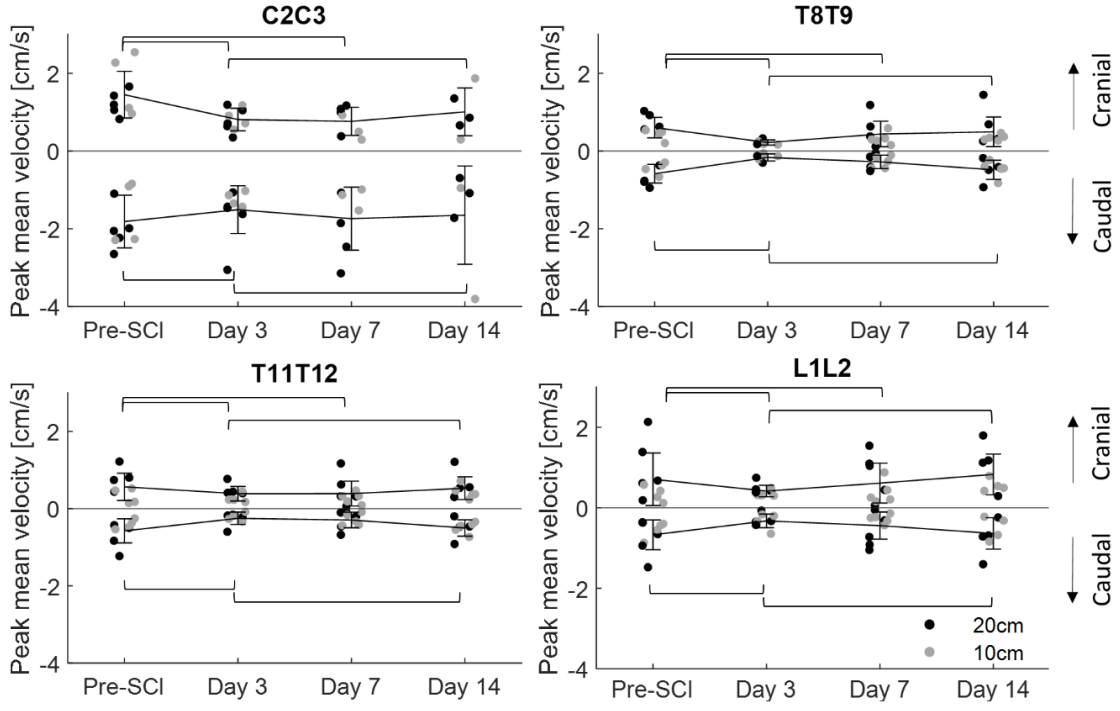

Figure 2: Peak mean velocity (cranial-caudal) pre-SCI, and at 3, 7 and 14 days post-SCI in animals with a 20 (black) cm or 10 cm (grey) weight-drop height SCI. Significant difference (brackets) between time-point correspond to linear mixed effects models with Bonferroni post-hoc pairwise comparisons ($p \leq 0.05$). Each data point is from one animal, and error bar is the mean ± one standard deviation.

O11

What do surgeons hear and feel when breaching cortical walls? Biomechanical investigation of acoustic and torsional biomarkers for cortical wall perforations

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Introduction: Freehand pedicle screw insertion is performed without intraoperative image guidance; thus, the procedure is reliant on intricate knowledge of vertebral landmarks and bone anatomy in conjunction with sense perception. Distinct audible vibration patterns created during pilot hole drilling are used to deduce whether the bit has perforated cortical walls. Tactile feedback during screw insertion, which is the feeling of torque in the hands, is used to determine if screws have breached cortical bone. This study quantified these auditory and tactile cues, which aid surgeons in assiduous attempts to circumvent iatrogenic cortical breach. Furthermore, it aimed to confirm high amplitude acoustic emission (AE) and insertion torque (TI) are directly correlated to cortical breach.
Methods: *In vitro* experimental testing was conducted on 18 ovine femora. Pilot holes were drilled at 1250 rpm, into bones utilising a Hall PowerPro drill and 4.5 mm surgical drill bit. A_E was captured at a frequency of 48 kHz by a custom sound sensor module. A laser timer was implemented to detect the time of far cortex breach. This setup for bicortical drilling enabled sound capture and determination of the exact time the bit plunged through the cortex, breaking the beam. Distance between the inner cortical walls was measured and pedicle screws (6.5 mm x 45 mm) were inserted at 6.0 rpm following predrilled trajectories using a specialised mechanical system. Throughout insertion, screw depth and T_I were digitally recorded. Data regarding time at A_E local maxima (t_{MaxAE}) and time of laser break (t_{Laser}) as well as distance between screw T_I peaks (d_{Peaks}) and distance between cortical walls (d_{Walls}) were collated.
Results: In total 54 insertions were investigated, with typical acoustic and torsional response curves evident in Figure 1. Two-sample T-test revealed no statistically significant difference between t_{MaxAE} and t_{Laser} (p = 0.837). The observed effect size was small (d = 0.040), indicating the magnitude of difference between averages was minor. Pearson's Coefficient signalled a significant, strong positive relationship (r = 0.995, p < 0.001). Analysis determined no statistically significant difference between d_{Peaks} and d_{Walls} (p = 0.899). The effect was small (d = 0.025), and Pearson's Coefficient signalled a significant, strong positive correlation (r = 0.857, p < 0.001).
Conclusions: High A_E and T_I occur at the moment of cortical wall penetration; thus, these variables could be used to accurately identify breach. Strong signal variations provoked by changes in local tissue properties, such as density and microarchitecture, facilitate rapid detection of different material environments. The ability to recognise various bone states is valuable when drilling and screwing in vertebrae. Using A_E and T_I parameters, continuous monitoring of cortical walls routinely performed by surgeons via haptic and auditory perception may be supplemented by advanced tool sensing. This would promote less subjective interpretations of cortical wall integrity, which is paramount for successful procedures. Application of such signal processing-based techniques may be particularly important in modern robotic systems, where rigid arms provide steadier control, however, concurrently reduce or distort tactile and auditory cues as a result of vibratory and mechanical feedback.

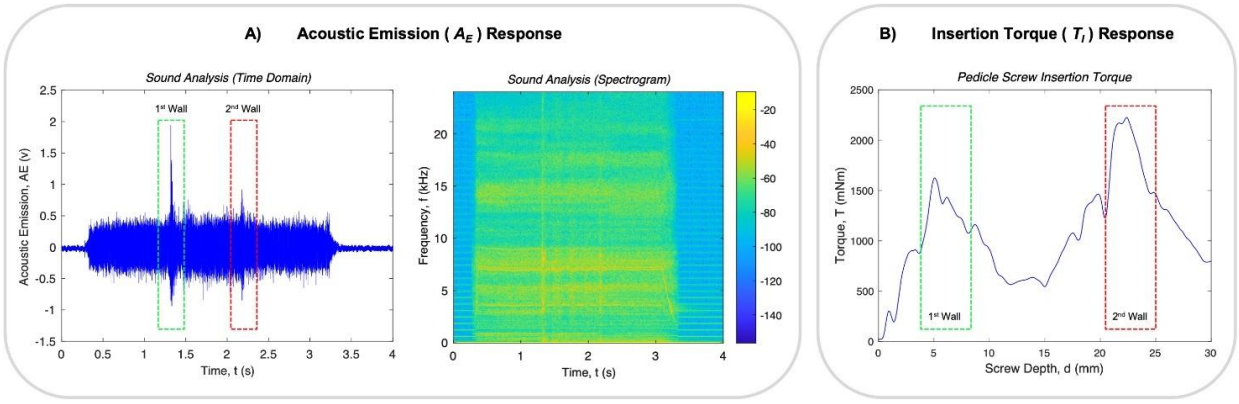

Figure 1 – Cortical Breach During A) Bone Drilling B) Screw Insertion (Specimen 5, Insertion 1)

O12
Development of the paediatric australian spine registry (pASR)

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Introduction: The Paediatric Australian Spine Registry (pASR) at the Queensland Children's Hospital (QCH) is an Australian first for paediatric spine deformity. With the growing need to have infrastructure for monitoring the management techniques employed, a large dataset will provide the evidence to influence future clinical decision making. The pASR is an additional arm of the already established adult Australian Spine Registry (ASR). We present the progress and challenges to date in establishing the first Australian pASR.
Methods: Development began with consultation between the QCH spine orthopaedic surgeons, the ASR, and software providers (SMAIO). The minimal dataset to be collected was refined and communicated to the infrastructure development team. Hospital and University Ethics and Governance approvals were established for QCH and Queensland University of Technology (QUT), with Governance approvals pending for Monash University, Victoria, where the ASR is based. Data collection for the pASR will occur similarly to the ASR except that participation is opt-in with parental consent as opposed to opt-out for inclusion in the registry. The pilot cohort inclusion criteria will consist of adolescents over 10 years having a surgical intervention for their progressive spine deformity (spine fusion with anterior or posterior approach, vertebral body tethering). Data from approximately 100-150 patients per year will be collected from the QCH site. PROMS will be collected onsite or via email with parental assistance and entered into the pASR by research staff.
Results: The refinement of the minimal dataset of the pASR was a challenge and is crucial for surgeon and clinical team engagement as it minimises the time spent in outcome reporting. Categories of information that will be collected includes background, clinical encounters, treatment details, and complications. Data overcollection results in registry fatigue and complications in analysis due to the additional dimensions of data. Data labels on the software must be consistent with current practises for the prevention of misinterpretation, inaccurate data entry, or data incompleteness. Additional data points will need to be added on the software due to the differences between adult and paediatric spinal deformities. Tailoring the software requires patience between all of those involved and a significant amount of time for conversing with the team overseas. As a pilot trial, it is important to test these processes to obtain user feedback and assess the feasibility to add to the minimal dataset. A test platform for the database pilot launches in early 2023.
Conclusions: Development of registries requires surgeon and staff engagement and compliance, stable funding, and sophisticated software developments. Enthusiastic surgeon support along with clinical team engagement towards a common goal will see the registry develop and thrive to achieve its goals.

Acknowledgements: Funding for S. Ho from QCH SERTA Grant, Registry establishment costs supported by Orthopaedic Department, QCH.

O13

Safety and efficacy of continuous epidural analgesia after posterior instrumented fusion for adolescent idiopathic scoliosis

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Introduction: Scoliosis is a tridimensional deformity of the spine. Surgical correction of idiopathic scoliosis is considered for curves above 50 degrees, however management of post-operative pain remains a challenge. Heightened pain increases postoperative morbidity, length of hospitalisation and decreases patient satisfaction. Patient controlled analgesia (IV-PCA) is a widely accepted analgesic modality, however it is commonly associated with increased patient narcotisation. Continuous epidural analgesia (CEA) is an alternative modality which facilitates effective pain relief and simultaneously improves patient alertness. The purpose of this study is to assess the safety and efficacy of CEA, following posterior spinal fusion for adolescent idiopathic scoliosis (AIS).
Methods: Since its inauguration in 2015, the Queensland Children's Hospital (QCH) has provided CEA following surgical correction of AIS as part of its standard post-operative care. A retrospective review of theatre records identified all patients who had posterior spinal instrumented fusion (PSIF) to correct an AIS deformity between January 2020 to July 2022. Patients' hospital and theatre medical records were retrospectively reviewed. Quantitative metrics known to relate to safety and efficacy of CEA were selected. Safety was assessed by any temporary, epidural related neurological changes. Improvement following cessation or down-titration of epidural dosing was accordingly recorded to differentiate between epidural related deficits, or a true cord pathology. Efficacy parameters included days to mobilise, open bowels, return to full diet, length of stay and number of patient whom had significant nausea or vomiting requiring medication.
Results: 90 consecutive patients were identified. All patients received two epidurals, determined by the segmental levels of fusion, ensuring appropriate and adequate analgesia coverage. The mean (SD) age was 14.3 (2.9) years. 69 were female. For this preliminary study, a subset of the patient cohort (27 patients) were analysed, and descriptive metrics (mean, standard deviation) calculated. Days to mobilise 1.3 (0.47), days to open bowels 4.4 (1.4), days to return to full diet 2.68 (1.63), length of stay 5.2 days (1.01), significant nausea or vomiting 48% and epidural associated neurological deficits 14.8%. All reported cases of neurological deficit had resolution of symptoms following the cessation, or down-titration of epidural. There were no post-operative complications concealed as a result of the epidurals. Post-operative pain scores on day 1 were assessed at rest and with movement. The scale was categorised as mild, medium or severe. 22 of 27 patients had scores recorded for pain at rest. 27.3% of this cohort had no pain, 22.7% mild, 36.4% moderate and 13.6% had severe pain. With movement, 17 of 27 patients recorded scores. 17.6% had no pain, 35.3% mild, 29.4% moderate and 17.6% had severe pain.
Conclusions: Continuous epidural analgesia is a safe and effective post-operative analgesic modality with good postoperative outcomes following PSIF in adolescents. It enables patients to be alert and active participants in their rehabilitation. This pilot study aims to support CEA as a component of post-operative care following AIS correction surgery. The evidence provided by this project may encourage increased utilisation and uptake at facilities which currently use IV-PCA following PSIF for scoliosis.

O14

The clinical and radiographic degenerative spondylolisthesis classification and its predictive value

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Introduction: A new classification has been introduced for degenerative spondylolisthesis (DS) with four sub-types. Type A: advanced disc space collapse without kyphosis; Type B: disc partially preserved with translation of 5 mm or less; Type C: disc partially preserved with translation of more than 5 mm; and Type D: kyphotic alignment. This study aimed to analyse the long-term functional and radiographic outcome following degenerative spondylolisthesis surgery.
Methods: A retrospective trial of our prospective database was performed using the Australian spine registry. Data on demographics, preoperative, 6 months, 12 months and 24 months postoperative patient reported outcome measures (PROMs) applying the Oswestry Disability Index (ODI), EQ-5D-3L scores were collected. All pre- and postoperative EOS scans were analysed and measurements of the L4/5, and L1/L5 lordosis, pelvic incidence, pelvic tilt, sacral slope, coronal list and degree of spondylolisthesis (slip) were measured. In addition the type of fusion (PLIF vs. TLIF) was noted. Based on the preoperative findings all x-rays were classified applying the CARDS classification as described above.
Results: Between 2018 and 2021 a total of 62 patients at a mean age of 67.8±11.6 years were included. A majority of patients were female (60.3%). Preoperatively, the L4/5 lordosis was 19.6±8.6°, lumbar lordosis was 42.9±11.8°, pelvic incidence was 59.2±9.4°, pelvic tilt was 22.6±6.4° and sacral slope was 35.7±7.6°. The preoperative slip was 4.6±3.2mm and a coronal list of -22.5±50.2mm was found. There were 38.9% of CARDS type B and C and 11% of type A and D were observed in 11.1%. Postoperatively, L4/5 lordosis changed significantly to 26.3±9.6° (p=0.024). No changes in pelvic incidence, tilt, sacral slope and coronal list were observed.
The preoperative ODI was 41.9±12.2 which changed significantly to 21.2±15.2 at 24 months and EQ-5D-3L scores 57.4±20.9 changed significantly to 76.8±24.0 at 24 months.
The CARDS classification ODI for Type A was was 44±8.5 changing to 17±9.9 at 24 months; Type B 43.3±6.5 to 26.4±20.1; Type C 39.7±18.6 to 23±21.2; Type D 44±14.1 to 10.0±5.7. Similar improvements were observed for the EQ- 5D-3L which were Type A 77.5±3.5 to 89.5±0.7; Type B 51.4±21.0 to 67.0±22.2; Type C 61.7±19.3 to 54.5±62.9; Type D 60.0±14.1 to 82.5±4.9.
Conclusion: This study shows that the CARDS classification predicts the improvement in functional outcome and change in lumbar lordosis well. It will help to simplify the diagnosis and operative planning, especially for A and D types who benefit more from single level fusion.

O15

Outcomes of the direct lateral and anterolateral approach in spinal surgery: Results from the British spinal registry

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Introduction: Direct lateral and anterolateral approaches in spinal surgery have gained popularity in recent years. These approaches may be utilised to treat various adult deformities, degenerative cases and trauma. They are usually combined with various posterior approaches but may also be performed in isolation. Current literature suggests good outcomes in patients who underwent spinal fusion using direct lateral or anterolateral approaches. We embarked on a first registry-based study to explore the patient-reported outcome measures (PROMS) in this group of patients to provide evidence to guide future treatments potentially. This is a retrospective observational cohort study.
Methods: Patients who had undergone direct lateral or anterolateral spinal surgery were selected from the British Spine Registry (BSR) from June 2012 to June 2021, a total of nine years. These patients have undergone surgery for spinal deformities, degenerative conditions or trauma. Pre- and post-operative EQ-5D 5L index, Visual Analogue Scale (VAS) (back and leg) and Oswestry Disability Index (ODI) were obtained. Follow-up PROMS ranged from 6 weeks to 2 years.
Results: 777 patients who had undergone direct lateral or anterolateral approaches in spinal surgery were recorded on BSR. The mean age was 60 years old. The EQ-5D 5L index increased post-operatively for spinal deformities and degenerative conditions. VAS for back and leg decreased post-operatively for spinal deformities and degenerative conditions. ODI decreased post-operatively for spinal deformities and degenerative conditions. Only three trauma patients recorded on BSR had undergone direct lateral or anterolateral. Unfortunately, there were no PROMS recorded for these patients.
Conclusions: The first registry-based study found that the direct lateral and anterolateral approaches provide good post-operative clinical outcomes in the recorded PROMS. The results demonstrate that patients have improved EQ-5D 5L Index, VAS (back and leg) and ODI.

O16

Risk factors for distal construct failure in posterior spinal instrumented fusion for adolescent idiopathic scoliosis: A retrospective cohort study

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Introduction: We observed an increased rate of distal construct failure (DCF) in posterior spinal instrumented fusion (PSIF) in adolescent idiopathic scoliosis (AIS) when the pedicle screw in the lowest instrumented vertebra (LIV) was not parallel to the superior endplate of the LIV. This has not been well studied in the literature. We hypothesise a more inferiorly angled LIV screw predisposes to failure.
Aim: The purpose of this study is to evaluate risk factors for DCF in AIS managed with PSIF, and to find the critical angle that predisposes to failure.
Patients and Methods: A retrospective cohort study was performed on all patients (256) who underwent PSIF for AIS at the Starship Hospital spine unit from 2010 to 2020. On a lateral radiograph, the angle between the superior endplate of the LIV was measured against its pedicle screw trajectory. Data on patient demographics, preoperative coronal Cobb angle, Lenke classification, instrumentation density, rod protrusion from the most inferior screw, implants and reasons for revision were collected. DCF was defined as non-union of the lowest level, pull out or loosening of the most distal screws, or distal rod disengagement.
Results: Of 256 patients, 10.9% (28) required at least one revision. The rate of DCF was 4.6% of all cases (12 of 260) and 25.7% of revisions were due to DCF. The mean trajectory angle of DCF patients compared to all others was 13.3° (95%CI 9.2° to 17.4°) vs 7.6° (7° to 8.2°), p=0.0002. The critical angle established is 11°, p=0.0076. Lenke 5 and C curves, lower preoperative Cobb angle, titanium only rod constructs and one surgeon had higher failure rates than their counterparts. 9.6% of rods protruding less than 3mm from its distal screw disengaged.
Conclusion: Excessive inferior trajectory of the LIV screw increases the rate of DCF and a screw trajectory greater than 11° predisposes to failure. This is one factor that can be controlled by the surgeon intraoperatively and by avoiding malposition of the LIV screw, a quarter of revisions can potentially be eliminated.

O17

Two year outcomes of the Nemost growth rod for early onset scoliosis

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Introduction: Early onset scoliosis is a challenging clinical scenario with many surgical options to consider. Complications are common regardless of implant choice. We began using a new growth rod at our institution in June, 2017. This is a 'ratchet-like' system called Nemost that allows ongoing spinal growth after implantation without the need for further surgery. This study is a description of our 2-year outcomes using this device.
Aims: The purpose of this study was to assess the 2-year clinical and radiographic outcomes of a novel growth rod in paediatric patients with early onset scoliosis.
Patients and Methods: All patients undergoing scoliosis correction with Nemost with minimum 2-year outcomes were identified in the surgical database of a single paediatric institution. Patient charts were reviewed for demographic data and clinical outcomes. Pre-operative, post-operative and 2-year radiographs were reviewed to assess curve measurements and spinal growth.
Results: 31 patients had the Nemost growth rod with 2-year outcomes. The average age at surgery was 10 years (range 7-13). The most common primary diagnosis was CP (9 patients) and 18 (58%) of the patients were non-ambulant. Mean pre-op Cobb angle was 87°, 46° post-op and 50° at most recent follow-up for a mean correction of 43%. Mean thoracic height (T1-12) increased from 177 mm pre-operatively to 204 mm post-correction and to 214 mm at 2 years. Mean total spine height (T1-S1) increased from 275 mm pre-operatively to 327 mm post-correction and to 339 mm at 2 years. 23 patients had at least 1 cm of ongoing lengthening of their growing rod from implantation to most recent review. There were 18 major complications in 12 patients including 17 unplanned return to theatre cases of which 3 were deep infections requiring washout.
Conclusions: The majority of spinal deformity correction occurred with initial implantation of the Nemost growth rod which was maintained out to 2 years. This growth rod demonstrated ongoing spinal growth in 74% of patients. In this series of 31 patients, 39% experienced at least one major complication. Many complications have resulted in modifications of the original technique to improve safety and prevent future similar complications. This is the largest clinical series of this implant outside of the original centre where it was designed.

O18

Effect of Non-fusion Anterior Scoliosis Correction (NFASC) on thoracic and lumbar sagittal parameters in Adolescent Idiopathic scoliosis (AIS) patients? Is it detrimental

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Introduction: Nonfusion anterior scoliosis correction (NFASC) is a novel technique for correcting adolescent idiopathic scoliosis (AIS). NFASC has been successful in correcting coronal deformity in patients with AIS, however, there is a paucity of literature on its effect on sagittal parameters. We present our series of 40 AIS patients with a minimum follow-up of 2 years.
Methods: Data from 40 AIS patients treated with NFASC at a single Centre with a minimum of 2 years of follow-up were analyzed. Coronal cobbs' angle, Thoracic kyphosis (TK), Lumbar Lordosis(LL), Pelvic Tilt(PT), and Pelvic Incidence(PI) preoperatively, immediate post-op, and at final follow-up were measured. A Post hoc analysis following repeated measures ANOVA test was used to examine statistically significant trends.
Results: 40 AIS patients (39 female,1 male). The mean age was 14.57 ±1.98 years (13-18 years). The mean Risser score and Sanders's score were noted to be 4.22 ± 0.6 and 7.15 ±0.59 respectively. The cohort included 14 Lenke type 1, 3 type 3, 18 type 5, and 5 type 6. On average 7.3 vertebrae were instrumented. Mean pre-operative (pre-op) thoracic and thoracolumbar/lumbar cobbs were 51.05 ±7.1 °and 50.96 ±12.07° respectively. Mean pre-op, immediate post-operative(post-op), and at 2 years Thoracic kyphosis was 27.20 ±8.20, 30.83 ±5.85, and 31.09 ±6.06 respectively. Mean pre-op, immediate post-op, and at 2 years lumbar lordosis were 48.92 ±8.41, 47.23 ±7.58, and 48.32 ±6.06 (P>0.05) respectively. 72.5% of patients had a physiological sagittal profile after NFASC, while 27.5% had a physiological profile before NFASC. There was no significant change in Pelvic incidence and Pelvic tilt preoperatively and at 2 years follow-up (P>0.05).
Conclusions: Non-fusion anterior scoliosis correction surgery offers fusion-less correction with a positive influence on TK without having any detrimental effect on LL. As a result, most of the patients achieved normal physiologic kyphosis, whereas some maintained their pre-op alignment. There was no kyphotic effect on the lumbar spine. NFASC offers fusion-less correction of deformity with a positive effect on sagittal parameters.

O19

Surgical management and denosumab for aneurysmal bone cysts of the spine in an Australian tertiary paediatric centre

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Background: Aneurysmal bone cysts (ABC) are rare osteolytic, benign but often locally aggressive tumours of the long bones or vertebrae. For spinal ABC, surgical management, embolisation or sclerotherapy alone often carry high morbidity and/or high recurrence rates. Interruption of receptor activator of nuclear factor-kappa B ligand (RANKL) signalling holds promise as an effective therapeutic strategy for these tumours.

Aims: To review the approach to surgical management and evaluate the efficacy and safety of denosumab for ABC of the spine in children.

Methods: Retrospective review of 7 patients treated with denosumab using a standardised protocol for ABC of the spine in a tertiary paediatric centre. Surgical intervention was only conducted if there was spinal instability or significant neurological impairment. Denosumab 70 mg/m^2 was given 4-weekly for at least 12 months, followed by 2 doses of zoledronate 0.025 mg/kg, to prevent rebound hypercalcaemia.

Results: All patients achieved stability of the spine and resolution of neurological impairment, if present. Four patients achieved metabolic remission and have ceased denosumab without recurrence; the other three have showed clinical and radiological improvement and continue on treatment. Two patients developed symptomatic hypercalcaemia 5-7 months after cessation of denosumab, requiring additional bisphosphonate treatment.

Conclusions: We present our algorithm for the surgical and medical management of paediatric spinal ABC. Denosumab produced a radiological and metabolic response in all patients, with complete remission in most. Follow up time was not long enough to evaluate the endurance of response after cessation in some patients. Incidence of rebound hypercalcaemia in this paediatric cohort was high, prompting a change to our protocol.

O20

A novel approach for thoracic wall reconstruction using a 3D-printed prosthesis with hinged fixation to the vertebral column

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Objective: To describe a new surgical technique for thoracic wall reconstruction using a custom-made expandable prosthesis manufactured with three-dimensional (3D) printing technology.
Summary of Background Data: Malignant tumours can arise from the thoracic wall and vertebral column. Complete tumour resection improves patient survival but remains technically challenging. An ideal surgical approach aims to establish appropriate tissue margins, address thoracic wall defects, and preserve pulmonary mechanics.
Methods: A 54-year-old man was diagnosed with a large pleura-based mass arising from the left hemi-thorax with extension into the posterior paraspinal region. A two-stage procedure was performed. Stage one established the medial margins of the tumour which was attached to the vertebral bodies from T6 to T9. Stage two consisted of resection of the tumour including the lateral vertebral bodies T6-9 and 5th to 10th ribs. The chest wall defect was reconstructed using 3D printed structural prosthesis attached laterally to the residual T5-10 ribs and medially to the spinal instrumentation via a mobile articulation. No post-operative complications or respiratory sequela were noted at 18 month follow up.
Conclusion: Utilising a 3D-printed prosthesis articulating with spinal instrumentation to repair the composite defect of the chest wall can optimise respiratory function and maintain normal breathing mechanics.

O21

The effect of head-end constraint on cervical spine kinematics, facet mechanics, and failure mode, during axial loading

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Introduction: Cervical facet dislocation (CFD) is a devastating neck injury that is often associated with spinal cord injury. It can occur during head-first impacts when the spine is compressed by the following torso. The translation and rotation constraints imposed on the head by the contacting surface may influence injury risk and mechanism. The aim of this study was to evaluate the cervical spine kinematics, facet deflections, and facet surface strains during compressive axial loading, for three head-end constraint conditions that differ in their risk of initiating CFD.
Methods: Seven osseoligamentous cervical spines (occiput-T1, 62±8 yrs, four male) were prepared. Specimens were mounted in a testing machine (Instron 8874) in an inverted posture, with T1 fixed to the upper actuator. The occiput was fixed to an end-condition assembly to separately impose three head-end constraints: unconstrained (UC) allowed sagittal plane rotation (to 50° flexion) and translation; rotationally-constrained (RC) allowed only sagittal plane translation; and, fully-constrained (FC) allowed neither rotation nor translation. Specimens were tested non-destructively in each constraint condition by applying a two-second axial displacement ramp to ~200 N of axial force. Six specimens then underwent supraphysiologic loading in either the RC or UC condition by applying an axial displacement ramp of ~40 or ~90 mm (scaled to specimen length), respectively, over two seconds. Forces and moments were measured at the occipital and T1 ends with six-axis load cells. Markers fixed to each vertebral body were tracked with stereo calibrated high-speed cameras to measure intervertebral kinematics. The bilateral C6 inferior facets were instrumented with motion capture markers (Optotrak) and triaxial rosette strain gauges to measure facet deflections, and principal and shear surface strains, respectively. Descriptive statistics were obtained.
Results: In the non-destructive tests, the magnitude of axial displacement and C6 facet maximum principal surface strains tended to decrease with increasing head-end constraint (UC→RC→FC), but C6 facet deflections were not appreciable (Table 1). The four specimens that underwent supraphysiologic loading in the RC condition adopted a “forward head posture”, characterized by upper neck extension and lower neck flexion, resulting in three bilateral CFDs (2×C6/C7; 1×C7/T1). Peak axial load to CFD was 719±215 N at an axial displacement of 28±9 mm (Figure 1). One specimen from each supraphysiologic loading group did not receive an injury, while the other UC specimen suffered a distractive injury at 58 mm of axial displacement. Detailed analysis of intervertebral kinematics during the supraphysiologic tests is ongoing.
Conclusions: During axial loading, the RC head-end constraint produced the same neck posture that was observed in the few previous experiments that reliably produced subaxial CFD. This “ducking” or “buckling” posture produced CFD at the transition from upper-neck extension to lower-neck flexion in three specimens. Once completed, this study will be the first to characterise facet joint mechanics and neck kinematics during CFD. It is anticipated that this data will assist with the development of improved neck injury criteria and prevention devices.

Acknowledgements: Funding: ARC Discovery Project (DP190101209)

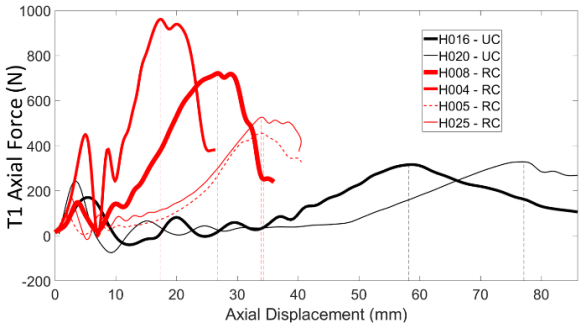

Figure 1. T1 axial force vs actuator displacement for each specimen failed with the UC or RC head-end constraint. Vertical lines indicate displacement corresponding to peak axial load.

Table 1. Mean (±SD) axial displacement and facet measures from the non-destructive tests with each head-end condition.

End Condition	Axial Displacement (mm)	C6 Peak Facet Deflection (°)	C6 Maximum Principal Strain (με)
Unconstrained	61.4±10.2	0.08±1.12	551±295
Rotationally constrained	19.7±6.8	0.03±0.89	409±202
Fully constrained	3.8±0.5	-0.32±0.18	250±176

O22

Estimating canal occlusion with specimen-specific computer models of subaxial cervical spine kinematics

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Introduction: Cervical spinal column injury is frequently associated with devastating spinal cord injury (SCI), often caused by cord compression resulting from occlusion of the canal space. Previous attempts to estimate canal occlusion during dynamic trauma have used invasive sensors, expensive high-speed x-ray systems, or optical measurement techniques that are limited to use with short spinal segments. Kinematic computer models of experimental data offer a non-invasive, three-dimensional method of estimating spinal canal occlusion in simulations of spinal trauma. Therefore, the aims of this study were to develop a method for estimating canal occlusion using specimen-specific C6/C7 computational models and intervertebral kinematics from laboratory tests, and to investigate the change in canal occlusion during combined intervertebral motions that are associated with spinal column injury.
Methods: Twelve C6/C7 motion segments (70±13 yr, nine male) underwent high-resolution CT scanning, from which specimen-specific osseous models were generated and the sagittal-plane anatomical landmarks for calculating canal pinch diameter (CPD, an accepted metric of canal occlusion) were identified (Figure 2). Specimens were subjected to non-destructive quasi-static anterior shear (AS; 1 mm), right axial rotation (AR; 4°), flexion (F; 10°), and left lateral bending (LB; 5°) motions using a six degree-of-freedom materials testing machine. Each motion was superimposed with: 1) 50 N compression (neutral condition; head-weight only); 2) 300 N compression (compressed condition; neck muscle contraction); and, 3) 2.5 mm distraction (inertial intervertebral separation). Intervertebral kinematics were measured via motion-capture markers attached to the vertebral bodies. Kinematic data were applied to the computer models, and the change in CPD (relative to the beginning of each test) was calculated at the peak of each motion/axial condition combination. Descriptive statistics (mean ± SD) were obtained.
Results: A substantial reduction in CPD, indicating increased canal occlusion throughout the imposed motion, was observed only for the anterior shear motions (Figure 3). The change in CPD was minimal during lateral bending and axial rotation, especially when superimposed with distraction, but increased during flexion motion. Interrogation of the model animations demonstrated that this increase did not correspond with greater canal patency, but was an artefact of the CPD method. Similarly, CPD indicated reduced patency for the distracted condition, compared to neutral and compressed, but this was due to the larger vertical component of the CPD vector in this condition.
Conclusions: The results of the current study indicate that intervertebral anterior shear motions are most likely to cause canal occlusion, increasing the risk of cord compression and SCI. However, artefacts related to the CPD method suggest that it may not be an ideal metric of canal patency, so other measurements should be investigated. Once refined, these models could be generated for multi-level experimental models of cervical spine trauma to estimate canal occlusion throughout the injury event.

Acknowledgements: Funding: ARC Discovery Project (DP190101209).

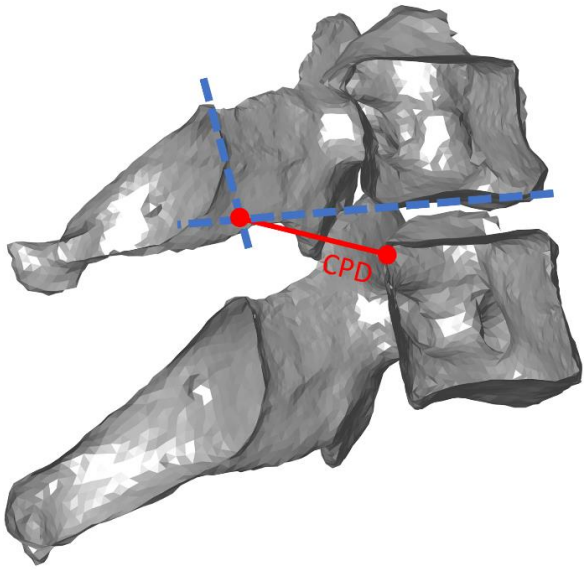

Figure 2. An annotated computer model demonstrating how canal pinch diameter was estimated.

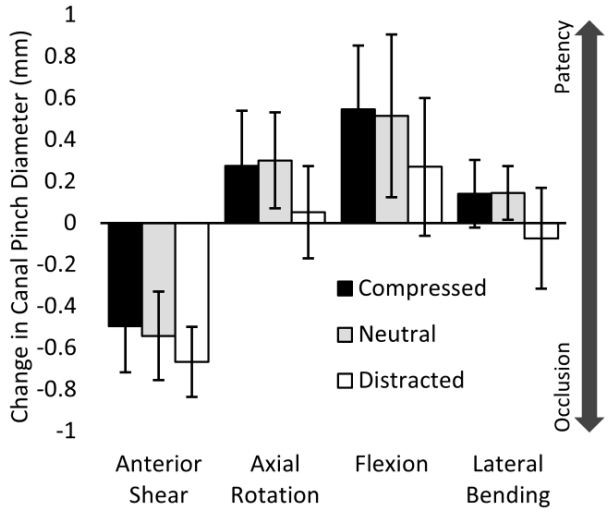

Figure 3. Mean (±SD) change in canal pinch diameter for each motion/axial condition combination.

O23
A dynamic experimental model of cervical facet dislocation

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Introduction: Cervical facet dislocation (CFD) has devastating consequences and is most often a result of head-first impacts, in which the head's motion is arrested and the following torso compresses the neck. The injury mechanisms are not well understood, and further investigations are required for injury prevention. Subaxial CFD has been reliably produced under quasistatic compression when the occiput translated anteriorly, causing an eccentric posture. Previous dynamic models have rarely produced or investigated this posture, and have been unable to reliably produce CFD. The aim of this study was to develop a dynamic, cadaveric cervical spine model of head-first impacts and measure impact kinematics and kinetics.
Methods: Osteoligamentous cervical spines (C0-T1) were inverted and mounted at the occiput (C0) to an end-condition assembly, which permitted three head-end constraints to be applied: head flexion and anterior translation (unconstrained; UC), head translation (rotationally constrained; RC), or fully constrained (FC;

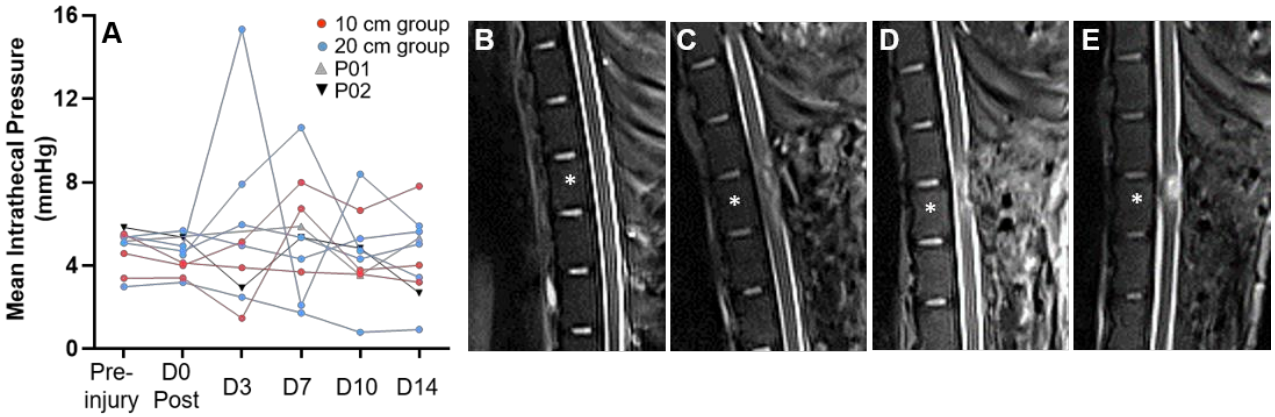

Figure *1: Injury site intrathecal pressure for each animal pre-injury and post injury at day 0, 3, 7, 10 and 14 (A).*). The caudal end was fixed to a load cell on a linear rail, which constrained T1 to move in vertical translation only. The spines were aligned on the end-condition assembly in a neutral, intermediate or maximum eccentric posture, which were determined in a preconditioning protocol. The impact event was performed by raising the 16 kg carriage (50th percentile male upper torso mass), and releasing it onto the caudal load cell to achieve an impact velocity of 1 – 3 m/s. A damping material at the impact site mimicked the cadaveric head response to head-first impacts. Cranial and caudal loads were measured by 6-axis load cells. Carriage displacement was measured by a magnetic encoder. Kinematics were obtained by tracking retroreflective pins embedded at each spinal level, using a motion capture system. Three specimens were subjected to sequential 1 m/s RC impacts in the three initial eccentricities. The third specimen was then subjected to 1 m/s neutral eccentricity impacts in the UC and FC condition, and then a 3 m/s RC impact at the maximum eccentricity.
Results: The 1 m/s impacts in the neutral posture were sub-injurious as the spine returned the carriage's energy, prior to motion of the end-condition assembly. With the spine at maximum eccentricity and RC, 1 m/s impacts produced bilateral CFD (N=1/3) and posterior ligament rupture, prior to failure of the T1 potting (N=1/3). Bilateral CFD (C6/7) was produced in the third specimen in the 3 m/s RC impact at the maximum eccentricity. For 1 m/s impacts, the structural response between end-conditions were similar for the same initial posture (Figure 2). In the neutral posture impacts, the spine underwent extension in the upper levels and flexion in the lower (within physiological limits); however, with maximum eccentricity, C1 – C7 underwent flexion during the impact event.
Conclusions: The preliminary results indicated that the response of the spine is dependent on the combined initial posture and head-end condition, and not the latter alone. Further experiments will be performed with the aim of developing the first dynamic, cadaveric cervical spine model that can reliably produce CFD.

Funding: Australian Research Council Discovery Project (DP190101209).

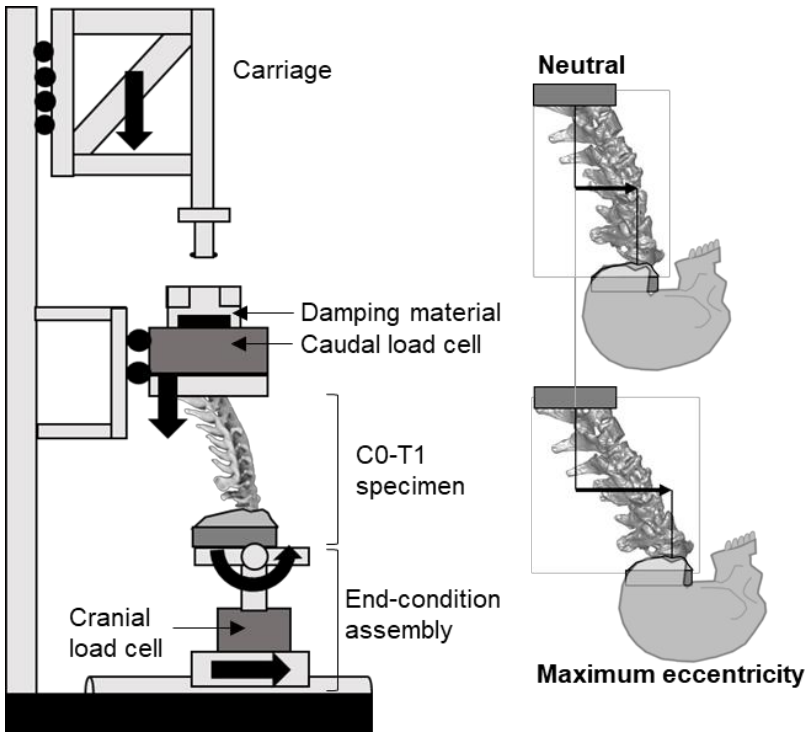

Figure 4: Diagrams of the cervical spine head-first impact model (left) and the neutral and maximum eccentricity postures (right).

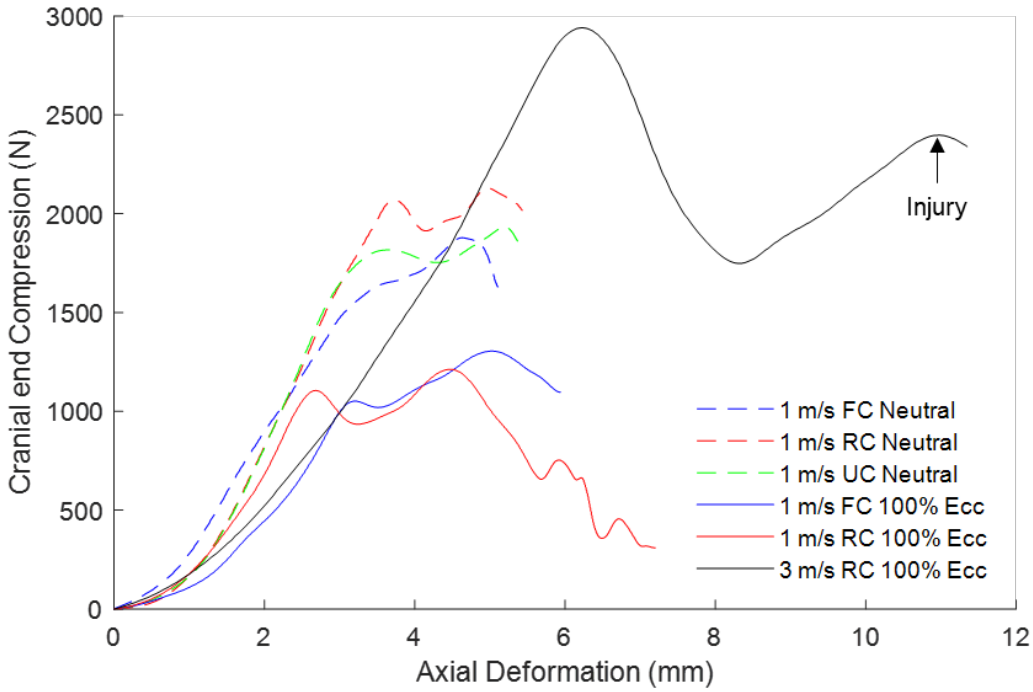

Figure 5: Exemplar cranial end compression vs axial deformation for the FC, RC and UC condition in the neutral or maximum eccentricity (100% Ecc) posture.

O24

Anatomic viability of C2 translamina screw fixation is variable between ethnicity and sex: An anatomic study of 200 computed tomography scans comparing New Zealand Maori and European anatomy

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Introduction: Safe and effective C2 fixation presents a surgical challenge and demands detailed understanding of the anatomy and variations within a surgeon's population. Translamina offer a less demanding screw fixation method and eliminates the risk to the vertebral artery.
The lower limit of the inner diameter of the C2 lamina for a translamina screw is 3.5 mm. Surgically significant variation has been described between Asian and American groups previously. New Zealand (NZ) has significant ethnic variation of which NZ Maori make up 16.5 % and NZ European make up 64.1 %.
Patients and Methods: Ethical approval through the Waikato ethics committee. Computed tomography (CT) scans were acquired from the Waikato trauma database between 2018 and 2020. Patients were excluded if lamina morphology was distorted by trauma. Measured parameters for the C2 lamina included the smallest inner transverse diameter, the smallest outer transverse diameter, spinolamina angle and lamina length using previously validated methods.
Statistical analysis was performed using excel and comparisons made. Statistical significance defined as a p value of <0.05. Reliability measurements were undertaken.
Results: A total of 193 scans analysed following exclusion of 7. Overall, 38 % were Maori, 62 % European, 37 % female and 63 % male. Average age of the NZ Maori was 40 years (16 – 65) and European, 44 years (16 – 84) with 64 % and 63 % male respectively. All measurements demonstrated good or excellent reliability.
NZ Maori had larger inner and outer diameters of the C2 lamina by 0.2 and 0.3 mm respectively and this was statistically significant. This difference between the ethnicities was greater in males, 0.4 and 0.5 mm respectively and was reduced in females, 0.1 and 0.1 mm (Table 1).

Table 1: Mean axial CT measurements of 193 included participants

	Maori	European	Male	Female	Maori male	European male	Maori female	European female
Inner diameter (mm)	3.8	3.6	3.9	3.3	4.1	3.7	3.3	3.4
P value		0.04		<0.01		<0.01		0.5
Outer diameter (mm)	6.9	6.6	6.9	6.4	7.2	6.7	6.3	6.4
P value		0.03		<0.01		<0.01		0.6
Spinolamina angle (°)	47°	46°	46°	46°	47°	45°	47°	46°
P value		<0.01		0.2		<0.01		0.7
Maximum screw length (mm)	32	31	32	30	33	32	30	30
P value		0.14		<0.01		0.4		0.09

The mean inner transverse diameter of the C2 lamina in all participants was 3.7 mm. Overall 42 % of participants had an inner transverse diameter of <3.5 mm. The mean outer diameter was 6.7 mm, mean spinolamina angle was 46° and mean laminar length was 32 mm. Participants of European decent had a higher rate of C2 lamina that were not suitable for translamina screw fixation compared to Maori, 47 % and 34 %. This difference was greater in males and less in females of each ethnicity (Table 2).

Table 2: Percentage of C2 lamina with parameters representing viability of translamina screws

	Overall	Maori	European	Maori males	European males	Maori females	European females
Inner diameter	42%	34%	47%	23%	45%	52%	57%

< 3.5 mm							
Outer diameter < 5.5 mm	12%	9%	16%	3%	15%	24%	20%

Maori males demonstrated greater spinolamina angles compared to European males, 47° vs 45° which was statistically significant. Both Maori and European females demonstrated angles of 46°. Lamina length did not demonstrate a difference between groups and was on average 31 mm.

Conclusions: Based on having an inner diameter <3.5 mm, both NZ Maori and NZ European populations have high rates (34% and 47%) of C2 lamina that is not suitable for translamina screw fixation. Bony anatomy is more favourable for translamina screws in Maori and in males. Significant, surgically relevant difference exists between Maori and European C2 anatomy.

Acknowledgement: Dr Benjamin Petry is acknowledged for completing repeat reliability measurements.

O25

Interbody fusion using controlled release of E-Coli derived rhBMP-2 in a skeletally mature ovine model

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Introduction: Lumbar arthrodesis is a commonly surgical procedure in the treatment of numerous spinal diagnoses including degenerative disc disease, spinal stenosis, spondylolisthesis, and other deformities. A bony fusion is essential for restoring segmental stability, preventing, or correcting deformity and, when combined with decompression for disorders such as spondylolisthesis with spinal stenosis, has been shown to provide improved long-term outcomes. Lumbar intervertebral fusion is achieved by creating an environment conducive to the formation of a continuous osseous bridge across the involved spinal segments. Autologous iliac crest bone graft (ICBG) is often considered the gold standard although not without shortcomings. This study evaluated an E-Coli derived rhBMP-2 encapsulated within poly (DL-lactic acid-co-glycolic acid) (PDLLGA) with a porous osteoconductive scaffold of beta tricalcium phosphate in an ovine interbody fusion model**.** The encapsulation of rhBMP-2 was designed to reduce the local drug concentration and prolong the duration of action with the aim of minimising osteolysis associated with a burst of the drug shortly after implantation.
Methods: 80 endplate sparing lateral interbody fusions were performed at L45 (4.5 mm x 10 mm x 22 mm PEEK cage) with bilateral posterior titanium pedicle fixation (4.5 mm x 25 mm screws, 5.5 mm rods) in 4–5-year-old ewes. Four groups were evaluated: Iliac crest autogenous cancellous bone and 3 dose levels of rhBMP2. Time points of 1 month (n=4 per group), 3 and 6 months (n=8 per group) were evaluated using anteroposterior and lateral Faxitron radiographs, micro computed tomography (38 microns), and robotic range of motion (ROM) in flexion/extension, lateral bending, and axial rotation was measured using a robotic 6° axis musculoskeletal simulator, simVITRO (Simulation Solutions and Cleveland Clinic, Ohio) non-destructively to ±7.5 Nm. Radiographic data was analysed with non-parametric statistics while a 2-way ANOVA was used ROM data.
Results: Autograft performed consistent with this model with progression in fusion based on radiographic and ROM endpoints. The 1-month data showed the lack of osteolysis in the rhBMP-2 groups at the 3 doses with new bone formation within the aperture based on radiographic endpoints. 3 and 6 months rhBMP-2 treated animals demonstrated progressive bone formation/remodeling and early fusion with the highest dose by 3 months. No differences were detected between rhBMP-2 doses and autograft for ROM at 6 months.
Conclusions: The use of PEEK cages allowed bone formation and osteolysis to easily be evaluated. Controlled release of rhBMP-2 gives reduced risk of osteolysis, early signs of bone formation facilitating fusions in an endplate sparing ovine interbody fusion model.

Acknowledgements: This study was supported by LocateBio.

O26

Bone on the back table: Effects of autograft handling on spinal fusion

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Introduction: Autograft is often considered the gold standard graft material for spinal fusion, purportedly due to its osteogenic properties. Autograft consists of adherent cells and a non-adherent cellular milieu (i.e. bone marrow) within a cancellous bone scaffold. However, the bone forming potential of each component is not well understood. During surgery, autograft may be left out on the back table for prolonged time periods, which may adversely influence osteogenic potential. Furthermore, there has recently been controversy over the role of cells in allogeneic cell bone matrices, which begs additional questions about the role of cells in autograft.
Methods: Posterolateral spinal fusions were performed using the Boden model; 40 NZW rabbits were assigned to viable, partially devitalized, devitalized, 90min dried, or 90min hydrated iliac crest (n=8 per group). Partially devitalized and devitalized grafts were rinsed with saline, removing non-adherent cells. Devitalized graft was additionally freeze/thawed to lyse adherent cells. For 90 minutes prior to implantation, graft was left on the back table to simulate intraoperative handling, while hydrated graft was immersed in saline. Fusion was assessed at 8 weeks via manual palpation and microCT.
Results: Spinal fusion by manual palpation was 58%, 86%, and 88% for viable, partially devitalized, and hydrated autograft, respectively, which were not statistically different. All three fusion rates were significantly higher ($p<.001$) than the devitalized and dried groups (both 0%).
Conclusions: Viable autograft resulted in significantly higher fusion rates compared to devitalized autograft. Thus, the cellular component of autograft is important for fusion. Similar results for viable and partially devitalized autograft suggest that adherent graft cells, not the non-adherent cellular milieu, are the more important cellular component for fusion. When autograft is left out dry on the back table, fusion performance drops significantly. However, graft performance can be maintained by immersing the graft in saline.

O27

Do 3D printed templates improve the accuracy and safety of pedicle screw insertion in complex spinal kypho-scoliotic deformities? A Comparative Cohort study

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Introduction: Surgical treatment of severe complex spinal deformities involves inherent difficulties such as anatomic anomalies, dysmorphic or absent pedicles, vertebral rotations and rib deformities. In India, these deformities are often neglected and present at a very late, much more deformed state when their treatment becomes even more challenging. Pre-operative imaging (including 3D reconstructed CT images) provide limited morphometric information, cannot show full scale spine and cannot be directly used on the operating table. Various techniques have been introduced to assure safe and accurate pedicle screw placement. One such promising and safe tool is 3D printed bone models and patient-specific drill templates.

Aim: To evaluate the safety of 3D printed ABS thermoplastic bone models for freehand placement of pedicle screws and accuracy of patient-specific screw guides with pre-drawn, pre-validated trajectory in management of complex kypho-scoliotic deformity.

Methods: Of the 40 cases, 20 were operated with the help of 3D models/jigs [Fig1,2] and 20 were operated with free hand technique. Primary outcomes were measured in terms of screw violation, assessed by post op CT scan [Fig3] and secondary outcome were measured in terms of surgical time, blood loss, radiation exposure (no. of c-arm shoots required) and complications. Two-sample test of proportion for pedicle screw placement, T-test with equal variance for other parameters were statistically analyzed.

Results: The mean cobbs of the scoliotic curves were 98.1˚±19.4°. Each group had matched 30% cases of Congenital scoliosis, 60% Adolescent Idiopathic Scoliosis, 10% post tubercular kyphosis [Fig4]. 3D printed group over freehand group had significantly less medial violation, surgical time and fluoroscopic shots [Table 1]. There was no neurological deficit in any of the cases with no difference in the mean blood loss between the groups. We found significant (p=0.04) difference between 2 groups regarding perfect screw placement in favour of 3D printed jigs. There was no superior or inferior violation in any of our patients in either group. Mean Blood loss was higher in free hand group, however it was not statistically significant (p-value: 0.3). There were a total of 42 fluoroscopic shots required in 3D printing group (2.1/patient) while 113 fluoroscopic shots were obtained in freehand group, which was significantly higher.

Conclusion: The use of 3D printed models/ guides provided statistically significant higher rate of accurate screw positioning and higher number of inserted screws, particularly at apical levels, providing more accurate morphometric information and facilitate surgical correction of complex severe spinal deformity.

Fig 1- 3D printed bone model for detailed deformity assessment

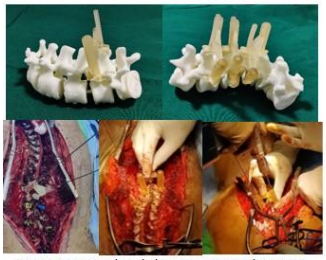

Fig 2- 3D printed pedicle screw jigs and its intra operative usage for guide wire placement

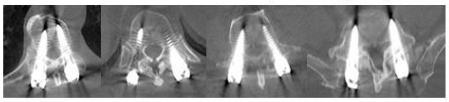

Fig 3- Post op CT scan images to assess violation

	Group 1- Non 3D printing	Group2- 3D printed bone model	Group3- 3D printed jigs	P value
Cobb's angle	96.4˚±15.8°	105.6˚±20.9°	98.9˚±19.2°	
Total Screws Placed	234	126	64	0.6
Correctly Placed (Grade 1)	192 (82.05%)	110 (87.3%)	57 (89.06%)	0.03
Incorrectly Placed (Grade 2/ 3)	42	16	7	0.03
Medial violations (Total) Grade 2: <4 mm Grade 3: >4 mm	18	6	3	0.005
Lateral violation (Total) Grade 2: <4 mm Grade 3: >4 mm	24	10	4	0.76
Surgical Time (mins.)	298.5 (59.3)	235.5 (55.7)	259.8 (5.3)	0.03
Surgical Blood Loss (ml)	840 (533.3)	630 (227.6)	630 (227.6)	0.3

Table 1- Statistics regarding pedicle screw placement and its medio-lateral violation

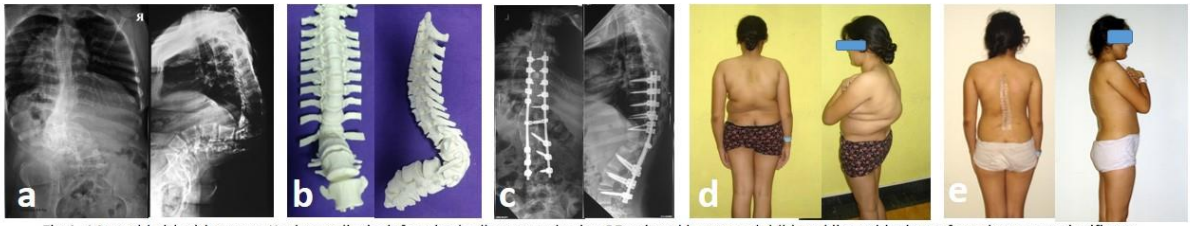

Fig 4- 14yrs old girl with severe Kypho-scoliosis deformity (a,d) operated using 3D printed bone model (b) and jigs achieving safe and accurate significant correction (c,e)

O28

Effect of non fusion anterior scoliosis correction surgery on pulmonary function in lenke type 1 adolescent idiopathic scoliosis patients treated with mini open thoracotomy approach

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Introduction: Existing literature is teeming with studies that have evaluated pulmonary function tests (PF) after spinal fusion and have shown conflicting results. There is a paucity of literature on the effect of non-fusion anterior scoliosis correction (NFASC) surgery over PF in Lenke 1 Adolescent Idiopathic Scoliosis (AIS) patients. The current study aims to find the effect of the mini-open thoracotomy approach for NFASC on PF in AIS patients.
Methods: 26 Lenke type 1 AIS patients with a minimum follow-up of 2 years were evaluated. Percent-predicted values of forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), and total lung capacity (TLC) were evaluated preoperatively and at follow-ups at 6 months, 1 year, and 2 years. Data was presented as mean ±Standard deviation. Paired t-test was used for statistical analysis. A 'P' value of <0.05 was considered statistically significant.
Results: The cohort included 25 females and 1 male with a mean age of 13.5 years at the time of surgery. The mean Sanders score was 7.1±0.6 and the mean Risser score was 4.2±0.5. The mean pre-op main thoracic (MT) cobbs were 52.1°±6.7°. Baseline TLC %, FEV1 %, and FVC % recordings were 93±15,82±10 and 88±13 respectively. At 6 months post-surgery there was a significant improvement in FEV1 (88±12) while TLC (94±10) and FVC (90±9) were improved. At 1 year follow up there was a significant improvement in FEV1 (91±8), TLC (98±15), and FVC (91±7). At 2 years follow up FEV1, TLC and FVC remain stable.
Conclusions: Our study showed an improving trend in PF up to 1-year post-surgery and after that PF remained stable at 2 years post-surgery. We conclude NFASC via mini-open thoracotomy does not have a detrimental effect on PF in AIS patients at 2 years follow-up.

O29

Does truncal balance restoration in idiopathic scoliosis depend on choice of lowest instrumented vertebra and cobb correction?

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Introduction: Spinal balance restoration is an important goal of scoliosis surgery. Aligning the thoracic cage with the pelvis (trunk balance) is an important aspect of this. Radiological assessment of trunk balance is done by apical vertebral translation and trunk shift on standing radiographs. Clinical photographic measurements have been recently described. Objective assessment of shoulder balance with clinical photography has started new dis cussions on choice of upper instrumented vertebra based on shoulder asymmetry (and not purely on structural proximal thoracic curve). Trunk shift and waist asymmetry, which indicate trunk imbalance, have not been hitherto considered in making decisions about choosing lower instrumented vertebra (LIV).
Aim: To study the improvement of clinical truncal balance outcome postoperatively and analysing the impact of surgeon-controlled factors like LIV selection, cobb correction and implant density on the restoration of trunk balance.
Materials and Methods: Thirty-three patients with idiopathic scoliosis were operated between September 2014 to December 2018. The mean thoracic cobb was 66.9 + 17.5 degrees. Truncal balance was assessed radiographically by measuring the trunk shift ratio (at the level of apical vertebra in relation to CSVL) on whole spine anteroposterior standing radiograph. Posterior photographs of patients were taken in a standardised manner. Three photographic parameters (measured on Surgimap software) were used to assess the trunk balance namely, Trunk Shift at apex of posterior axillary folds (MDA), Trunk Shift at deepest point of waistline (MDT) in relation to the central natal vertical line and Lateral Trunk Height was an indirect measure. Ratios of measures from concave to convex side was taken and this ratio was compared from pre-operative to post-operative, to avoid errors of calibration**.** Correction of trunk balance was analysed against various LIV, thoracic cobb correction, apical vertebra to LIV correction and implant density. ANOVA (Analysis of Variance), Paired t test and Pearson correlation were used as statistical tools and analysis was done using SPSS 22.
Results: There was a significant postoperative improvement in all truncal balance parameters. In Lenke 1 curves, there was significant difference in trunk shift radiographic (p=0.03) and trunk shift photographic at waistline (p=0.04) among different LIV. There was a statistically significant association between thoracic cobb correction and improvement in all trunk balance parameters. No significant association was found between implant density and truncal balance correction. The apical vertebra to LIV cobb correction correlated significantly with correction of trunk balance at waistline (MDT).
Conclusion: Clinical trunk balance parameters showed improvement consistently with thoracic curve cobb correction. Implant density can be minimized whenever appropriate to reduce cost as well as improve outcome. Waist asymmetry, which is of prime concern to the patients, can be restored better with optimal correction of the curve between the apical thoracic vertebra and LIV. In patients with a significant trunk imbalance, choosing a distal LIV improves the cosmetic outcome.

O30

Posterior-only two-stage vertebral column resection in severe and rigid scoliosis: Case series

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Introduction: The treatment of severe and rigid scoliosis poses a great challenge for spine surgeons. Various kinds of correction methods are developed. There is an on-going debate regarding one- and two-staged procedures for the correction of such deformities. Two-staged procedures have various advantages over single stage procedure. We discuss a few cases of two-staged deformity correction surgeries.
Materials and method: Patients who underwent two-staged deformity correction surgery between 2000-2022 were found and the necessary data segregated. Appropriate measurements and Cobb's angles were measured on pre-operative and post-operative X-rays using Surgimap software (v2.3.2.1). Clinically, shoulder balance and the correction of scoliotic humps were calculated pre-operatively and post-operatively. Patient satisfaction was measured by SRS-22r (Scoliosis Research Society) questionnaire.
Results: We found 11 patients (7 males, 4 females) with average age 14.2 (+/- 1.7) years who underwent spinal deformity correction surgery in two stages. According to etiology, 8 curves were congenital, 2 were adolescent idiopathic type and 1 was syndromic. The average pre-operative Cobb's angle was 119.4 (+/- 12.2) degrees. Flexibility index was 12.7 (+/- 5.3) %. Both the parameters indicate the severity and rigidity of the deformity curves. Preoperatively, shoulder balance was 'n' in 3, '-' in 4 and '+' in 4 patients. Post-operatively, shoulder balance was 'n' in 8 and '-' in 3 patients. The average correction achieved was 49.7% with an implant density of 68.5 (+/-12.2) %. The mean hump correction was 34.9%. Mean SRS score was 4.59 (+/-0.2).
We faced two post-operative complications. One patient had a post-operative infection and was operated for implant removal. The curve, thus, progressed leading to compressive myelopathy at the apex, which was surgically treated by decompression and in-situ fusion. The patient recovered thereafter. Another patient had a post-operative infection and subsequent wound dehiscence. Prolonged I/V antibiotics were administered, and the patient underwent full thickness flap surgery for wound coverage. At present, the patient has no further complaints and all surgical wounds have healed.
Discussion: Various methods are available for correction of severe rigid deformities. Posterior spinal fixation and different osteotomies, including vertebral column resection are usually required. Congenital curves also associated with low body weight and various nutritional deficiencies. In such cases, single staged surgery has certain disadvantages such as massive blood loss, complications related to prolonged anaesthesia, vision loss, superior mesenteric artery syndrome, lung atelectasis and neurological deficit. Long surgical time also exposes the wound to higher risk of post-operative infections. Moreover, surgeon fatigue and loss of concentration may add to the aforementioned problems. Intraoperative blood loss of about 1.5-2.0 litres has been reported, out of which 60% of it occurs in the vertebral column resection (VCR) osteotomy.
Prolonged hospital stays, increased cost and double the use of anaesthesia are a few disadvantages of staged procedure. Nevertheless, the benefits of staged procedure outweigh its disadvantages.

O31

Pediatric non-glial intramedullary spinal cord lesions: Clinicoradiological profile, pathology and surgical outcome

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Introduction: Pediatric intramedullary spinal cord lesions are rare, constituted mostly by glial neoplasms like astrocytomas and ependymomas. Our aim was to study the clinicoradiological profile, pathology and surgical outcome of the rarer spectrum of non-glial intramedullary mass lesions of the spinal cord in children.
Methods: The medical records and images of 19 consecutive children (aged 14 years or below, mean 8.05 years, male: female = 10:9) with histopathologically confirmed diagnosis of non-glial intramedullary spinal lesions who had undergone surgery at our institute were retrospectively analysed. The data included demography, clinicoradiological profile, surgical details, histopathology and functional outcome (modified McCormick grade), with a minimum follow up duration of 2 years.
Results: There were 7 dermoids, 4 primitive neuro-ectodermal tumors, 2 neurenteric cysts, one each of epidermoid, diffuse leptomeningeal glioneuronal tumor, tuberculoma, lipoma, hemangioblastoma and teratoma. The pre-operative radiological diagnosis was incorrect in all PNETs, one neurenteric cyst and one teratoma with chronic inflammation. Two patients had co-existent lesions in the brain. One patient with tuberculosis who presented late with poor functional status deteriorated, and remained as such on long term follow up. All other patients had improvement in functional outcome. Gross total excision was done in all patients; one patient with an infected epidermoid cyst had recurrence after 9 years and underwent re-surgery with resultant improvement in neurological status. Two patients with dermoid were lost to follow-up at 3 and 5 years of surgery, with good outcome at available last follow up. Common post-operative complications included transient deterioration in motor power and wound related complications.
Conclusions: Compared to glial neoplasms, non-glial lesions were mostly developmental in nature and amenable to gross total resection without adverse neurological sequelae. In general, pre-operative neurological status co-related well with post-operative outcome and hence early gross-total surgical excision is recommended in all pediatric patients with such rare intramedullary spinal cord tumors.

O32

Functional results following microsurgical resection of intradural extramedullary spinal tumors

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Introduction: Intradural extramedullary spinal tumors cause significant functional and neurological morbidity. The preferred treatment is surgical resection.
Methods: Ten patients with intradural extramedullary spinal tumors underwent surgical resection between September 2020 to November 2021. Of the 10, 7 were female, mean age was 50 years, location was lumbar in 5 (50%), thoracolumbar in 3 (30%), thoracic in 2 (20%). All patients had back pain as a presenting symptom, only 4 had neurological manifestations. Extent of resection was total in all patients. All patients underwent standard microsurgical procedures consisting of laminectomy, durotomy and tumor resection followed by watertight dural suturing and fibrin glue application. Diagnosis was confirmed by histopathological examination. Functional outcomes were studied using Frankel grade and modified McCormick scale. Mean follow up was 16.6 months.
Results: All tumors were benign, individual diagnoses were 6 schwannoma, 2 meningioma, 1 mature cystic teratoma and 1 arteriovascular malformation. Pre operative neurology was normal (Frankel E) in 5 patients, Frankel D in 2, Frankel C in 2, Frankel B in 1. Pre operative modified McCormick scale was I in 5, II in 2, IV in 2, V in 1. 2 patients had one grade deterioration in neurological status post operatively; this did not improve at 23 months follow up in 1 patient who had mature cystic teratoma, whereas the other patient improved to normal functional status. Post operative Frankel grade was E in 7, D in 3. Post operative modified McCormick Scale was I in 7, II in 2 and III in 1. There were no cases of tumor recurrence at follow up.
Conclusions: Total excision of intradural extramedullary benign tumors provides improved functional outcome. All patients achieved ambulatory status post surgery. Teratoma resection carries an added risk of neurological injury.

O33

Management of aggressive vertebral haemangioma: A systematic review and a proposed management algorithm

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Study design: Systematic review.
Introduction: Vertebral haemangiomas are the most common benign tumors of the spine. Its incidence in literature is quoted to be 10 to 12% with thoracic spine being documented as commonest location. Vertebral haemangiomas have been classified into Typical and Aggressive vertebral haemangioma [AVH]. Management options for AVH are many and clinician face dilemma in choosing the right treatment option whenever they are confronted with symptomatic AVH.
Aim: We hypothesis that management of AVH can be based on the clinical presentation of the patient and a suitable treatment modality can be chosen based on the clinical presentation of patient. Aim of our systematic review is to identify various treatments documented in the literature and formulate a management algorithm for AVH based on clinical presentation and to identify radiological differentiating pointers between them.
Materials and Methods: The Systematic review was conducted according to PRISMA guidelines and was registered with 'PROSPERO' vide (reference number: CRD42021266613). We reviewed English literature for last two decades from the year 2001 to 2020. Relevant articles were identified as per laid down criteria from medical databases – pubmed, ovid medline and science direct. The keywords "Vertebral" AND haemangioma, "Aggressive" AND haemangioma, "Atypical" AND haemangioma, "Spinal" AND haemangioma and their combination MeSH terms were searched for analysis. Search was limited to articles published in the and full text article written in English were only selected. Studies conducted before the year 2000, studies quoting the number of patients less than 5, systematic reviews, meta-analysis, case reports, grand rounds, expert comments, studies with follow-up less than one-year, non-spine studies and duplicates were excluded. Abstracts of all the articles obtained with electronic database search were reviewed. After inclusion, first and second author went through full text of each included article.
Results:139 studies identified through databases, were narrowed down to eight studies following PRISMA guidelines.99 patients with 88 AVH had undergone treatment in the study cohort. Majority of patients with AVH had presented with backpain alone (20.1%) followed by back pain- myelopathic symptoms (79.9%). Patients with back pain alone had improved with either CT guided alcohol ablation or with percutaneous vertebroplasty. Patients with backpain-myelopathic symptoms had improved following surgery. In patients presenting back pain - myelopathic symptoms due to soft tissue tumour mass causing compression over thecal sac had benefitted from posterior decompression and intralesional vertebroplasty. Patients presenting with recurrence following posterior decompression and
intralesional vertebroplasty or initial presentation due to anterior bony impingement to thecal sac had improved following Anterior Corpectomy and reconstruction with prior preop arterial embolization of the feeding vessel.
Conclusion: Management of AVH can be based on patient's clinical presentation. Patient presenting with AVH and back pain can be managed with either Percutaneous Vertebroplasty or CT guided alcohol ablation. Patients presenting with AVH and neurological symptoms could be managed with surgery–Intralesional vertebroplasty with posterior decompression. Patients presenting with multiple recurrence following posterior decompression and intralesional vertebroplasty or due to bony impingement to thecal sac could be managed with Anterior corpectomy and reconstruction surgery with prior arterial embolization of feeding vessel.

O34

Locally aggressive chondroblastoma of the dorsal spine mimicking parachordoma

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Introduction: Chondroblastoma is a benign cartilaginous neoplasm with a male preponderance usually arising in the epiphyses of long bones with metaphyseal expansion and cortical thinning. It usually presents in young patients undergoing maturation and it rarely localises in the spine. The Treatment majorly involves local curettage or resection. Herein, we report a 30-year-old male presenting with acute onset paraplegia secondary to dorsal compressive myelopathy who was initially diagnosed with parachordoma mimicking a locally aggressive chondroblastoma.
Materials and methods: 30-year-old male with mid to lower dorsal pain since 9 years, aggravated over 2 months presented with acute onset paraplegia secondary to dorsal compressive myelopathy & biopsy was suggestive of Parachordoma. Symptoms worsened and he was lost to followup and repeat biopsy was suggestive of chondroblastoma which was managed with global decompression & fusion in 2 stages
Results: Histopathology was suggestive of chondroblastoma of D7,8,9 vertebra as the lesion had progressed. Post operative, the patient showed significant recovery with a gross motor power improvement of 2-3/5. There was an eventual sensory recovery with improved anal tone and retrieval of bladder control as well. At 18 months follow up the patient shows no clinic-radiological evidence of recurrence.
Conclusion: AE1/AE3 positive tumors with a non-metastatic picture should alarm a surgeon regarding the possibility of a locally aggressive, yet slow growing chondroblastoma. Regular follow up is necessary to monitor disease progression with timely spaced biopsies during such diagnostic dilemmas.

O35

Minimally invasive posterior thoracolumbar corpectomy: Technical note and case series

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Introduction: Certain pathologies in the thoracolumbar spine require corpectomy such as tumors, trauma, and infection, especially when there is significant involvement of the anterior and middle columns. Further, their management may include anterior reconstruction, which may pose certain specific challenges due to the presence of ribs and other adjacent critical structures. Conventional posterior open approaches for thoracolumbar corpectomy have many drawbacks including extensive paraspinal muscle dissection, prolonged retraction resulting in ischemia, and muscle injury. The application of minimally invasive techniques may provide distinct advantages to overcome these pitfalls.

Methods: The authors present their experience in performing minimally invasive posterior thoracolumbar corpectomy (MIS PTLC) in 25 patients along with a technical note. The corpectomies were performed with an expandable 22 mm diameter tubular retractor and paramedian incisions. Adequate exposure was obtained to allow placement of an expandable interbody cage with grafting between the adjacent vertebral bodies. In total, 12 clinical cases of spinal Koch's, 9 burst fracture, 2 primary spinal tumors, 1 spinal metastasis were treated using this minimally invasive approach. Clinical evaluation was performed both before and after surgery, using the Visual Analog Scale (VAS) pain scores. Patient functional outcome was measured using the modified Odom's criteria.

Results: There were no major perioperative complications. No patient required surgery for the same level during the follow up period which ranged from 1 to 3 years. Good clinical and radiological outcomes were obtained with statistically significant results in all patients. Faster functional recovery was observed with early ambulation on day 1 post-surgery with a total hospital stay of 4-5 days.

Conclusions: MIS PTLC seems to be an effective technique for treatment of thoraco-lumbar fractures due to various pathologies in a carefully selected subgroup of patients with good medium to long-term outcomes. A larger study would possibly highlight the effectiveness of this procedure.

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O36

Approach to soft tissue reconstruction for complex spinal wounds

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Introduction: Increase in complex spine surgeries have also increased the incidence of post-op wound related complications. Wound dehiscence, exposed hardware, CSF leak etc. represent majority of such complications. Interdisciplinary management of such complications is the key to favourable outcome of these patients. We present our experience and approach with complex wounds involving cervical, thoracic and lumbar spine areas where both therapeutic and prophylactic soft-tissue reconstructions have been performed.
Aim: To achieve stable soft tissue coverage for complex spinal wounds and exposed hardware therein with well vascularized tissue for reliable long-term solution.
Materials and Methods: All the patients in which soft tissue reconstruction was done between January 2016 till September 2019 either prophylactically for revision surgeries or for complex wounds with/without exposed spinal implants in the cervical, thoracic and lumbar spinal region were included in this study. These included patients admitted under the Department of Orthopaedic Surgery as well as Neurosurgery.
Results: At the time of writing this abstract, total 24 patients were operated for flap reconstruction (21 for complex wounds with/without exposed hardware and 3 for impending exposure/ planned re-surgery). Out of the 3 prophylactic procedures, 2 patients underwent placement of tissue expanders in bilateral paraspinal region to facilitate effective closure after revision surgery and one patient underwent Latissimus-Dorsi (LDMC) flap cover for impending implant exposure. Trapezius flaps, LDMC flaps and local soft tissue flaps were utilized in the reconstruction of complex wounds in the cervical, thoracic and lumbar regions, respectively of the 21 patients that underwent therapeutic soft tissue reconstruction. Two patients who underwent prophylactic surgery went on for successful revision spinal instrumentation surgeries and one is awaiting adequate tissue expansion for revision surgery. None of the patients had any major complications (total flap loss, CSF leak). One patient had exposed screw-head through the flap suture-line that was managed with local rotation skin flap cover.
Conclusion: Complex spinal wounds with/without exposed hardware are amenable for soft tissue reconstruction with the help of flaps based on regional muscles. Latissimus Dorsi muscle is the most commonly used muscle for reconstruction of most of the thoraco-lumbar defects. However, Trapezius muscle is more apt for the use in reconstruction of complex wounds near the cervical spine and foramen magnum. Use of prophylactic tissue expanders, where wound healing related problems are expected due to multiple previous scars and tight/ scarred paraspinal skin, is a viable alternative.

O37

Minimising blood loss in major spine surgery. A prospective randomized study of high dose tranexamic acid compared to control

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Introduction: The value of Tranexamic acid (TXA) has been well established in minimising blood loss in cardiac, gynecologic and arthroplasty surgeries. Its use in spine surgeries has also been established with reasonable safety margins. The doses used conventionally are at 1-5 mg/kg. There are reports of benefits of high dose of TXA at 50-100 mg/kg and this study was done to assess the efficacy and safety of the high dose TXA.
Methods: A prospective comparative study from a single institution. The patient cohort of 100 patients (age range 3 to 76 years old) with spinal disorders undergoing spinal corrective surgeries was included. The patients were divided into two groups: The High dose TXA group (Total of 50 patients, including 8 scoliosis) and the control group of low dose TXA (total of 50 patients, including 9 PVCR patients). Minimally invasive procedures like microdiscectomy and MIS fracture fixations were excluded from the study group. Before skin incision, the patients in the TXA group received an intravenous loading dose of 30 mg/Kg over a 20-minute period, followed by a maintenance infusion of 10 mg/Kg/h until skin closure was completed. The patients in the control group received a bolus dose of TXA at 1 gm prior to the skin incision. Statistics included estimated intraoperative blood loss, RBL, blood transfusion requirements, coagulation parameters, complete blood count, liver function, and renal function. All patients in this study were also carefully monitored for consciousness level, breathing status, chest tightness or pain, and urine output after surgery. These were done to detect the presence or absence of pulmonary embolism, myocardial infarction, seizures, and acute renal failure. The analyzed outcome measures included estimated intraoperative blood loss, real blood loss (RBL; blood loss/blood volume×100%), blood transfusion requirements, coagulation parameters, complete blood count, liver function, and renal function. Lower limb vein thrombus, symptomatic pulmonary embolism, symptomatic myocardial infarction, seizures, and acute renal failure were also recorded.
Results: There were no significant differences in the demographic or surgical traits between the two groups. The blood loss of the patients in the High dose TXA group was 455 ml± 156 mL, whereas that of the control group patients was 1650 ±560 mL. The difference was statistically significant ($p<.05$). he blood transfusion requirements for the patients in the high dose TXA group were significantly less than that in the control group ($p<.05$). Blood loss, RBL, and blood transfusion requirements were all significantly lower in the TXA group, compared with the control group among both PVCR patients and non-PVCR patients. There were no differences in liver and renal functions between the TXA and control groups. There was no lower limb vein thrombus, symptomatic myocardial infarction, symptomatic pulmonary embolism, seizures, or acute renal failure reported in the TXA group.
Conclusions: In our study, high doses of TXA have been shown to effectively control blood loss and reduce the transfusion requirement. No adverse drug reaction was recorded in the study. The high doses were safe in the study group and has significant cost savings and blood saving.

O38
Complex revision spine surgeries: How to do it right?

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Introduction: Spine surgery produces excellent clinical outcomes in properly selected patients. Still, there is a cohort of patients who fail to achieve resolution of pain following index surgery, opting for revision surgery.
Revision spine surgery is becoming an important part and parcel of spine surgeons' armamentarium nowadays, but when faced with complexities like hardware failure, sagittal/coronal malalignment, infection, osteoporosis, it is still considered a nightmare one should avoid.
Aim: To analyse the outcome after various complex revision spine surgeries and enumerate essential tactics for obtaining optimum results.
Materials and Methods: Prospective single centre study. Patients who failed to improve after primary spine surgery and with conservative measures thereafter due to implant failure, infection, adjacent segment degeneration were included. Patients with only recurrent disc herniation were excluded. Perioperative (blood loss, surgical time, hospital stay, complications), clinical (ODI, VAS score and nurick grade) and radiological parameters(fusion/instability) were evaluated. Neuromonitoring was used in all cases.
Results: 21 patients (M: F=5:1) with mean age of 46.8 years and follow-up period of 10.2 months were evaluated. Mean blood loss was 405ml, mean surgical time was 170 minutes and mean hospital stay was 4.6 days. 3 patients underwent revision surgery in cervical spine,4 in dorsal spine and 14 in thoracolumbar /lumbar spine. Causative factors were as under: cage retropulsion/backout- 6, Adjacent segment degeneration- 5, Pedicle screw breakage/backout with collapsing deformity-6, Spondylodiscitis with/without huge abscess-4. Significant improvement was noted in clinical parameters (mean pre/post-operative VAS= 7.2/3.1, pre/postoperative ODI= 78.3/16.8, nurick grades=4/2). Fusion was noted in all but 2 patients, who were also asymptomatic. There was no neurological deficit or dural tear in any patients.
Conclusion: Revision spine surgery is a complex interplay between patients' and surgeon expectations. Patient selection is the most important factor governing outcomes in revision surgery along with other pearls like use of ultrasonic bone scalpel leading to marginal reduction in surgical time and dural tears, thorough decompression by developing proper plane between duramater and overlying fibrosis along with removal of adhesions all around the involved roots, adequate instrumentation (universal pedicle screw removal/rescue scews) and meticulous hemostasis. Even the most complex of revision spine surgeries yield optimum outcomes if done in suitable patient and with proper principles followed.

O39

Clinical and radiological outcomes of high grade developmental spondylolisthesis treated surgically. Does reduction matter?

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Introduction: High-grade spondylolisthesis presents a significant surgical challenge and traditional surgery has ranged from in situ fixation to major reconstructive surgery with high rates of morbidity.
Aim: The objective of this study is to evaluate the clinical and radiological outcomes of surgical treatment of high grade developmental spondylolisthesis.
Patients and Methods: This study is a retrospective analysis of 49 patients with high grade developmental spondylolisthesis (defined as slippage > 50%) who underwent surgery at our institution in the period between 2008 to 2018. All surgeries were done in the Ortho Spine Unit comprising of 3 surgeons. The patients were divided into two groups: Group A, who underwent bilateral decompression, reduction and Group B, postural reduction and surgical decompression from symptomatic side by the standard TLIF technique. Patient's demographic, preoperative, and postoperative data were collected. The radiological parameters assessed were Meyerding's grade, Pelvic incidence, Sacral slope, Pelvic tilt, Lumbosacral angle, lumbar lordosis and Pelvis balance for all cases. Preoperative and postoperative clinical outcomes were evaluated using Visual Analog Scale (VAS) and the Oswestry Disability Index (ODI). Complication rates were collected during the follow-up period.
Results: Based on inclusion criteria, 49 patients were selected (reduction group A,18, postural reduction group B, 31) with a minimum follow-up of 2 years with longest follow up being 10 years. There was no significant difference in demographics or radiological data between groups. Following surgery, there was a significant improvement in the median ODI and median VAS scores in both the groups (p-value:<0.01)], however there was no significant difference between the two groups on comparing the function outcomes. Both techniques were efficient in relieving pain and improving disability at last follow-up visits. Among the radiological outcomes, a significant decline following surgery in Pelvic Tilt among both the surgical group (p-value: <0.01). LSA increased significantly among both the surgical group (p-value: <0.01). In both groups, the changes in SS and LL were not significantly changed. However, the differences were not statistically significant between the two groups. 44.4% in postural reduction group as compared to 75.0% in reduction group improved from an unbalanced to a balanced pelvis postoperatively.However, there was no statistically significant association observed (p, 0.13). 98 % patients achieved solid fusion. There was one case of pseudoarthrosis and one case of S1 screw breakage in reduction group for which revision surgery was performed. There were no cases of permanent neurological deficit at the last follow up.
Conclusion: The present study showed that both the techniques achieve the same changes in sagittal parameters with good functional outcomes and fusion rate.

O40

Effect of in-situ fusion in lumbar spondylolisthesis on clinical outcomes and spino-pelvic sagittal balancing: A case series of 138 patients

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Introduction: Reduction of the slipped vertebra can give better alignment of the lumbosacral junction in terms of spino-pelvic parameters. However, these surgeries involve an increased risk of neurologic complications during the corrective procedure, most commonly attributed to nerve root injuries. Fusion in situ has given good long-term results, where active reduction of the slipped segment to attain anatomical alignment is avoided. The objective was to study the effect on sagittal balance, radiographically and clinical outcomes after in-situ fusion of lumbar Spondylolisthesis.
Methods: Prospective study of 138 patients with lumbar spondylolisthesis lesser than or equal to grade 3 (as per the Myerding's classification) from 20 to 80 years of age, excluding traumatic and pathological etiologies along with conservatively managed patients was done. VAS, SF-36 and ODI scores were measured for clinical outcomes. Lumbosacral spine antero-posterior, lateral flexion-extension views were taken, pre-operatively, at 6 and 12 months of follow up. The spino-pelvic sagittal parameters including pelvic tilt, pelvic incidence, sacral slope and lumbar lordosis were calculated. In-situ fusion, most commonly Transforaminal interbody fusion, was done and statistical analysis using chi-square test and p value was analysed.
Results: The mean Pelvic tilt changed from a mean of 23.85 degrees to 18.25 degrees which was statistically significant. VAS score improved from a median of 8 to 2 at 12 months post-operatively, ODI score from a mean of 39.07 to 7.92 and SF-36 scores showed a statistically significant improvement. 23 patients had pseudarthrosis, 4 patients had neurological deficit whereas 4 patients had superficial infection and were managed accordingly. This study also compared the clinical outcome scores between the patients who had complications against the ones who did not, and showed no statistically significant difference. The neurological deficits were transient and recovered along with patients who had superficial infections by the end of final follow up. Patients with pseudarthrosis had better clinical outcome scores and were not revised by the end of 12 months.
Conclusion: In-situ fusion can provide significantly better clinical outcome with minimal complications due to improved spino-pelvic sagittal balance as evidenced on measurements of Pelvic tilt, attributed to positioning and increased disc height via interbody cage. The need for reduction to achieve near normal anatomical alignment, can be avoided, thus preventing inadvertent neurologic complications. However, a longer follow up study may be needed to validate the effects of this study.

O41

Effects of Posterior Spinal Fusion Surgery on Gait Biomechanics in Patients with Adolescent Idiopathic Scoliosis

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Introduction: Scoliosis is a complex multidimensional spinal deformity which affects spinal anatomy, quality of movement, walking and trunk symmetry. These alterations are especially exaggerated in Indian patients who present at a very late and much more deformed state. Posterior spinal fusion (PSF) is performed to stop curve progression, to reduce back ache and to restore asymmetric torso. In this study, we aimed to investigate the effects of posterior spinal fusion surgery on spatio-temporal and lower and upper body kinematics in severe Adolescent Idiopathic Scoliosis (AIS) patients during gait.
Methods: This study included 15 patients (mean age 16.3 years) with thoraco-lumbar/lumbar AIS (cobb angle MT 78.62 ± 8.10, TL/L 60.52 ± 7.42). Spatio-temporal parameters and upper and lower body kinematics were evaluated preoperatively and after 6 months of surgery using instrumented 3D gait analysis (BTS, Italy). Student T test was applied to find significant differences between pre and post operative gait parameters.
Results: Gait speed, cadence, stride length were improved significantly after 6 months of surgery. Step width, gait profile score (GPS) and gait deviation index (GDI), were not changed significantly postoperatively. No significant changes in mean angle of knee flex extension, hip Ab-adduction, hip flex-extension, ankle dorsiplantarflexion, spine flex extension were observed postoperatively.
Conclusion: Posterior spinal fusion with deformity correction improved gait pattern and gait biomechanics in cases of Adolescent Idiopathic Scoliosis.

O42

Do all adult spinal deformity (ASD) patients need complex deformity correction surgery? A propensity matched prospective comparative analysis of outcomes of operative versus non-operative treatment of adult spinal deformity in Indian scenario

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Introduction: Adult spinal deformity (ASD) is a diverse range of defects of the lumbar spine or the thoracolumbar spine that arises in adult patients. Specific ASD diagnosis comprises iatrogenic spinal abnormality, adult spinal scoliosis and primary degenerative sagittal imbalance. Global disparities exist in both the assessment and treatment of adults with spinal deformity across countries of varying incomes, which represents an area requiring further investigation. On an extensive literature search, it was found that there are studies done in Western countries assessing the level of disability and functional outcomes of patients who are diagnosed and treated for ASD, however such studies in Indian population are scarce. Hence, this study was planned to evaluate the adult patients of ASD, undergoing operative or non-operative treatment.
Methods: 40 ASD patients who are treated with a mean follow up of 24 months. Baseline data collected including demographic details, comorbidities, treatment given, spinopelvic parameters, SF36 questionnaire and SRS-22 questionnaire. The same data collected at each successive follow up. Appropriate statistical tests were applied.
Results: The mean ODI score, SRS-22r as well as SF-36 scores were comparable between study groups at baseline. At 6- month, 1-year and 2-year follow-up, all the three parameters in the operative group were noted to be significantly improved in the operative group versus non-operative group (p0.05). The mean pelvic tilt (PT) did not show significant change at 2-year follow in both study groups ($p>0.05$), and the mean PT was comparable between the study groups at 2-year follow-up ($p>0.05$). Figure 1
Conclusions: We recommend non-operative treatment for patients' content with current spine-related health with the understanding that improvement is unlikely regardless of radiological parameters of sagittal or coronal imbalance. If a patient is not satisfied with current spine-related health and has an expectation of improvement, surgery is preferred and is likely to provide improvement, although complications are common.

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Table 5.5: Comparison of baseline with 2-year follow-up mean radiological parameters in study groups

Parameter assessed	Operative group (n=20)	Non-operative group (n=20)	P value (intergroup)
Mean pelvic tilt in degrees			
Mean baseline value	22.3 ± 7.72	24.1 ± 7.88	0.54
Mean value at 2-year follow-up	17.75 ± 5.5	26.52 ± 7.45	0.11
P value (baseline vs 2-year)	0.14	0.32	
Mean PI-LL mismatch in degrees			
Mean baseline value	23 ± 12.66	24.4 ± 12.38	0.24
Mean value at 2-year follow-up	11.72 ± 3.4	25.72 ± 11.07	0.01*
P value (baseline vs 2-year)	0.01*	0.28	
Mean maximum TL/L Coronal Cobb's Angle in degrees			
Mean baseline value	28.42 ± 10.45	29.85 ± 10.03	0.42
Mean value at 2-year follow-up	11.1 ± 7.57	30.50 ± 10.19	0.01*
P value (baseline vs 2-year)	0.01*	0.31	
Mean magnitude for coronal alignment in mm			
Mean baseline value	29.81 ± 10.93	29.67 ± 11.08	0.21
Mean value at 2-year follow-up	21.8 ± 8.97	30.05 ± 10.90	0.01*
P value (baseline vs 2-year)	0.03*	0.13	
Mean thoracic kyphosis (T4-T12) in degrees			
Mean baseline value	46 ± 16.47	45.65 ± 10.34	0.62
Mean value at 2-year follow-up	38.27 ± 6.41	46.25 ± 10.37	0.01*
P value (baseline vs 2-year)	0.01*	0.42	
Global positive sagittal malalignment (% with C7-S1 SVA >5cm)			
Mean baseline value	26.5± 9.84	27.5±7.09	0.24
Mean value at 2-year follow-up	15.2 ± 4.43	28.95±5.50	0.01*
P value (baseline vs 2-year)	0.01*	0.57	

Table 5.6: Comparison of ODI in Study groups at various time-points

Time point of assessment	Operative group (n=20)	Non-operative group (n=20)	P value (intergroup)
Baseline (pre-treatment)	31.25 ± 11.02	30.87 ± 15.88	0.39
6 months	21.45 ± 7.8	29.95 ± 16.31	0.01*
1 year	17.25 ± 6.76	31.8 ± 8.98	0.01*
2 years	16.46 ± 5.77	32 ± 8.78	0.01*
P value (intra-group)	0.01*	0.37	

Table 5.7: Comparison of SRS-22r (total score) between study groups at various time-points

Time point of assessment	Operative group (n=20)	Non-operative group (n=20)	P value (intergroup)
Baseline (pre-treatment)	3.32 ± 0.69	3.42 ± 0.65	0.19
6 months	3.86 ± 0.66	3.47 ± 0.68	0.01*
1 year	3.95 ± 0.58	3.5 ± 0.57	0.01*
2 years	4.09 ± 0.70	3.51 ± 0.69	0.01*
P value (intra-group)	0.01*	0.47	

Table 5.14: Comparison of SF-36 score (mental component) between study groups at various time-points

Time point of assessment	Operative group (n=20)	Non-operative group (n=20)	P value (intergroup)
Baseline (pre-treatment)	48.24 ± 6.06	47.22 ± 5.89	0.29
6 months	52.30 ± 5.77	47.89 ± 11.32	0.03*
1 year	53.7 ± 10.23	48.19 ± 11.39	0.02*
2 years	53.72 ± 11.87	48.97 ± 12.07	0.01*
P value (intra-group)	0.04*	0.16	

Table 5.13: Comparison of SF-36 score (physical component) between study groups at various time-points

Time point of assessment	Operative group (n=20)	Non-operative group (n=20)	P value (intergroup)
Baseline (pre-treatment)	36.79 ± 6.59	37.12 ± 6.31	0.42
6 months	44.35 ± 6.98	36.43 ± 6.42	0.01*
1 year	46.07 ± 9.32	36.91 ± 10.03	0.01*
2 years	46.06 ± 9.34	36.75 ± 9.73	0.01*
P value (intra-group)	0.01*	0.29	

Figure 1

O43

Is thoracolumbar interfascial plane block better than local anaesthetic infiltration in lumbar fusion for postoperative pain management? A randomized controlled trial

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Introduction: Posterior lumbar spine fusion surgeries are associated with severe postoperative pain necessitating a multimodal analgesic regime. Wound infiltration with local anaesthetic is an accepted modality for postoperative analgesia in spine surgeries. Thoracolumbar interfascial plane (TLIP) block is a novel technique being evaluated for providing analgesia in lumbar spine surgeries. This study aimed to compare the analgesic efficacy of TLIP block compared to that of wound infiltration with local anaesthetic in terms of time to request the first dose of rescue analgesic.
Methods: Seventy-one patients scheduled for posterior lumbar spine fusion under general anaesthesia were included in this double-blinded randomised controlled trial (Refer consort diagram Fig 1). Preoperatively, patients were randomly allocated to receive either a TLIP block (TLIP group) or wound infiltration (LI group). The primary endpoint was the time of the first request for rescue analgesia. Secondary endpoints were the total tramadol consumption and pain and comfort scores measured at various time points in the 48-h postoperative period. The trial was terminated after second interim analysis as the analgesic benefit of TLIP was evident both clinically and statistically.
Results: Demographics like age,sex and weight of patients were comparable. Mean duration of the surgery was comparable between the groups (147 min in LI group and 152 min in TLIP group (p=0.18). The median (interquartile range) duration of the time of the first request for rescue analgesia was 1440 (1290, 2280) min in the TLIP group and 340 (180, 360) min in the infiltration group; P value <.001. The mean tramadol consumption was significantly higher in the infiltration group compared to the TLIP group, with a P value <.001.
Conclusion: TLIP block provided better postoperative analgesia than that provided by wound infiltration with local anaesthetic in lumbar fusion surgeries.

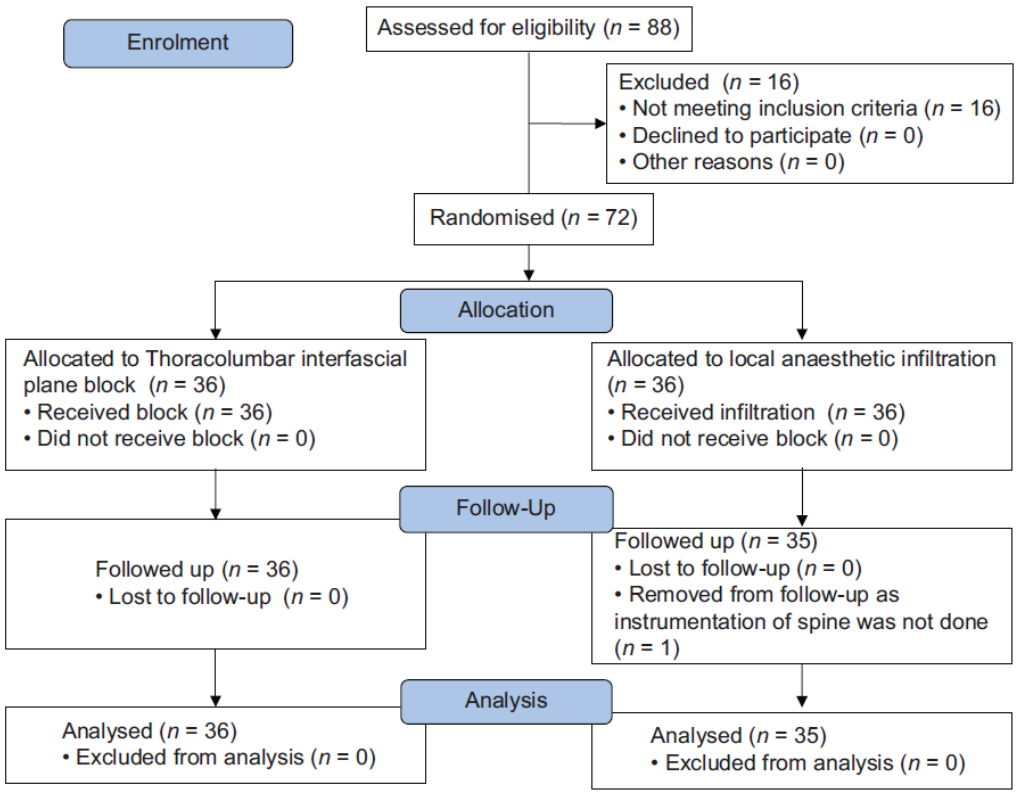

Fig 1 – Consort diagram showing the process of the RCT

O44

Minimally Invasive Surgery Transpedicular Intrabody Cage (MISTIC technique) for management of Kummell's disease

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Introduction: Osteoporotic vertebral compression fractures (OVCF) are common amongst the elderly population and typically occur with minimal or no trauma. Although most patients are treated conservatively, some patients develop avascular necrosis of the fractured vertebrae (also known as Kummell's Disease) and require some form of intervention for symptomatic relief. The treatment of Kummell's disease remains controversial and a wide variety of options have been proposed in the literature. This study aims to introduce a unique and minimally invasive approach to the treatment of KD and the clinical results of this technique.
Material and Methods: 20 consecutive patients underwent surgery using the MISTIC technique at our institute from 2014 to 2016 by a single surgeon. All patients presented with severe thoracolumbar pain that was unresponsive to conservative treatment. Radiographs showed collapse of the vertebral body with kyphotic deformity. Preoperative CT and MRI showed an intravertebral vacuum cleft with fluid collection. Postoperatively, patients were seen at three months, six months and one year post surgery. VAS and ODI scores were collected and patient outcomes were graded as excellent, good, fair and poor using a modified MacNab's criteria. Radiological outcomes were assessed through measurements of the anterior vertebral height (AH), mean vertebral height (BH) and segmental angle (SA) on standing lateral radiograph pre- and post-operatively.
Results: There was significant improvement in the segmental angle (SA), anterior body height (AH) and mean vertebral body height (BH) in the immediate postoperative period and at 12-months follow-up. The SA improved from 15.2 ± 8.7° of kyphosis to 1.2 ± 5.2° ($p < 0.01$) in the immediate postoperative period and that improvement was largely maintained at the final follow-up. The AH increased from 13.3 ± 14.6mm to 22.6 ± 12.2mm ($p < 0.01$) and at final follow-up, it was 21.9 ± 12.6mm ($p < 0.01$). Similarly, the BH increased from 18.5 ± 6.8mm to 25.6 ± 7.6mm ($p < 0.01$) post-surgery and at final follow-up, it was 23.6 ± 4.4mm ($p < 0.01$)
Conclusions: The MISTIC technique offers significant correction of kyphosis and restoration of the vertebral anatomy following surgery. These results were maintained at 12-months post-operation and there was 100% union rate of the fractures. In addition, patients experienced significant relief of pain and improvement in their ODI scores that was maintained at 12 months.
Key words: Kummell's disease, avascular necrosis, minimally invasive surgery, MISTIC, intrabody cage

O45

Analysis of radiological and clinical outcome of per cutaneous kyphoplasty in osteoporotic compression fractures - A single center prospective study

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Introduction: Osteoporotic vertebral compression fractures(OWCF) are a leading cause of disability and morbidity in the elderly. These usually respond to conservative treatment but sometimes chronic pain result from incomplete vertebral healing and progressive collapse. There is a risk of altered spine kinematics as a consequence of junctional kyphosis and development of a pseudoarthrosis. The evidence is very sparce regarding the radiological outcomes and its correlation with clinical outcomes after kyphoplasty. The aim of the present study is to treat patients with chronic pain or non union with kyhoplasty and study the efficacy of pain relief and deformity correction.
Material and Methods: Prospective analytical study was conducted on 32 patients of OWCF (failed conservative treatment) for a period of 2 years from June 2019 to May 2021. All the patients are operated by same surgeon in single center. Biplanar flouroscopy was used and bipedicular approach was followed and PMMA injected (approx 4cc) untill good fillling was seen on Fluoro. Thoracolumbar AO type A1 or A2 fractures included. Pre op, 6 months 1 year and 2 years assessment of Clinical parameters -Visual analogue scale score (VAS) Oswestry disability index (ODI) and radiological parameters --Anterior vertebral body height and Cobb's angle of kyphosis(on standing lateral) radiographs was done. Statistical analysis was done using the SPSS software version 17.0.
Results: 32 Patients with average age of 65 years with average BMD T score-3.4 were analysed. Average surgical time is 40 minutes with negligible blood loss. Average Pre operative ODI and VAS scores are 66and 7.2 respectively, and 2 year post op ODI and VAS scores are 22 and 2 respectively($p<0.05$)**.** Average pre op vertebral height and kyphotic COBB angle are 22 mm and 7.9 deg res respectively and 2 year post op vertebral height and kyphotic COBB angle are 28 mm and 5 degrees respectively($p<0.05$).
Conclusion: Kyphoplasty in patients with failed conservative treatment results in long term pain reduction with statistical significance. There is also significant vertebral body height and kyphotic angle improvement which is sustained at 2 years follow up.

O46

Assessment of efficacy and safety of nandrolone decanoate and alendronate as compared to alendronate alone in patients with osteoporosis

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Introduction: Pharmacotherapies for osteoporosis either reduce bone resorption (antiresorptive agents) or increase bone formation (anabolic agents) along with Vitamin D and Calcium supplementation. Antiresorptive agents for treatment of osteoporosis consists of Selective Estrogen Receptor Modulators (SERMs), bisphosphonates like Alendronate, Risendronate, Ibandronate or Denusomab, Calcitonin. Alendronate significantly increases average bone mass compared to placebo at femoral neck, at total hip and in lumbar spine as measured by BMD. Anabolic agents like Nandrolone decanoate is reported to increase Insulin like Growth Factor (IGF-1), Osteocalcin and reduce the number of osteoclasts. The effects of Nandrolone Decanoate, is to stimulate osteoblasts for bone formation and inhibits osteoclastic activity thus uncoupling the dynamic cycle of bone resorption and bone formation. Alendronate and Nandrolone Decanoate individually are known to be effective in the management of osteoporosis. However, there are no studies comparing the effects of Nandrolone Decanoate along with Alendronate therapy and Alendronate alone.
Aim: The aim of the study was to evaluate efficacy and safety of therapy with Nandrolone Decanoate and Alendronate as compared to Alendronate monotherapy in patients with Osteoporosis.
Methods: Osteoporotic patients with T scores ≤- 2.5 (WHO) either at lumbar vertebrae or hip, fulfilling inclusion criteria were enrolled in the study. Patients were randomised into two groups. Patients in group A were administered injection Deca Durabolin (Nandrolone decanoate) 50 mg intramuscular (I.M.) every 3 weeks for 12 weeks followed by every 4 weeks for next 36 weeks along with Alendronate 70 mg per oral (P.O) every week for 48 weeks. Patients in group B received only Alendronate 70 mg (P.O) for 48 weeks. Follow up was done at 3, 6 and 12 months for clinical evaluation and answering the questionnaire.
Results: 230 patients, mean age of 60 years were enrolled. At end of 1 year, 53 patients were lost to follow up and 177 patients were randomised to group A (n=89) and group B (n=88). Patients in group A had significantly higher improvement in BMD of lumbar spine, frailty score, QOL score as compared to patients in group B. Patients in both groups had improvement in BMD of hip, lean mass, body fat, ODI and VAS score but were not statistically significant on inter-group comparison.
Conclusion: Our results demonstrate that addition of Nandrolone Decanoate to Alendronate therapy increases lumbar spine BMD. Improvement in bone quality also translates into improvement in patient related outcome measures like QOLs and Frailty scores.

O47

Necessity of direct decompression for thoracolumbar junction burst fractures with neurological compromise

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Background: Surgical management of burst fractures is controversial, with many different operative options. From a posterior approach, decompression of the spinal cord can be performed through both indirect and direct methods, the former relying on ligamentotaxis. It is unclear whether indirect decompression with ligamentotaxis is as effective as direct decompression.
Methods: Prospective, randomized controlled data were retrospectively analyzed to include only burst fractures of the thoracolumbar junction. Patients were treated with either direct decompression, involving wide posterior decompression in addition to operative stabilization, or indirect decompression, where decompression was performed solely through ligamentotaxis. Patients were followed up at 6 months with clinical assessment and imaging. Additional clinical assessment was performed at 1 year. For all analyses, $P < 0.05$ was significant.
Results: The study included 46 patients, with 18 patients in the direct decompression subgroup and 28 patients in the indirect decompression subgroup. The average age of the full cohort was 35.1 13.1 years (range, 16e60 years). Most patients had L1 fractures (21/46; 46%), with an AOSpine classification type A4 fracture morphology (17/46; 37%), and were American Spinal Injury Association grade B (18/46; 39%). Both treatments resulted in similar in- creases in canal diameter and decreases in dural sac compromise ($P > 0.5$) at 6-month follow-up. Both treatments resulted in similar grades of neurological improvement (P [0.575) at 1 year.
Conclusions: There were no significant differences in clinical and imaging outcomes when comparing direct decompression with ligamentotaxis. Ligamentotaxis alone may be effective in carefully selected cases.

O48

The study of neurological and radiological outcome of short segment fixation without laminectomy for traumatic thoracolumbar spine fractures with neurological deficit

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Introduction: Among the thoracic and lumbar spinal injuries, 50-60% involve the transitional zone (T11-L2) which forms the thoracolumbar junctional zone. Neurologic injury has been reported to occur in 30 to 90 % of patients with these fractures.

Operative management has been widely accepted as the form of management for unstable thoracolumbar burst fractures, especially when coupled with a neurologic deficit. Controversy persists regarding the need for formal decompression in the form of laminectomy for patients with thoracolumabar fractures with neurological deficit. Some researchers have considered that neurologic recovery benefits from surgical decompression. However, few literatures have had the opposite attitude. We propose short segment fixation with index screw in proper alignment and correction of kyphosis without doing laminectomy.

Aims:

1. To assess the neurological recovery following short segment fixation with index screw without laminectomy in thoracolumbar fractures with neurodeficit.
2. To assess the correction of kyphosis angle and canal remodeling after the surgery by radiological assessment.

Materials and Methods: Study was conducted in a tertiary care government centre with sample size of 30 patients and patients were followed up till 1 year from Jan 2021 till Jan 2022. All patients with traumatic thoracolumbar spine fractures with neurodeficit are included in the study. Patients with intact neurodeficit, pathological fracture, osteoporotic fracture, multilevel spine trauma and patients with history of previous spine surgery are excluded from the study.

After preoperative assessment with neurological examination and categorizing with ASIA impairment scale, radiographs, computerized tomography for canal compromise; patients underwent pedicular screw fixation without decompression by indirect reduction with screws cranial and caudal to the fracture along with index screw placement. Correction of kyphosis was achieved by positioning and rod contouring.Not doing formal laminectomy saved operative time and complications like inadvertent dural leaks and blood loss.

Clinical assessment for neurological improvement was done on post operative day 30, 90 and 180 as an outpatient basis. Assessment of radiological kyphotic angle on radiograph and canal clearance on CT were done at one year.

Results: It was observed that patients with ASIA impairment scale B,C,D showed a significant improvement. 12 patients with ASIA impairment scale D showed complete recovery. Among patients of ASIA scale C, 5 patients showed complete recovery and 5 patients had ASIA scale D at the end of 1 year. 4 patients of ASIA scale B showed improvement to ASIA scale D. All four patients of ASIA scale A showed no recovery.

There was significant canal clearance and remodeling at the end of 12 months after operation seen by computerized tomography. (fig 1 and 2)

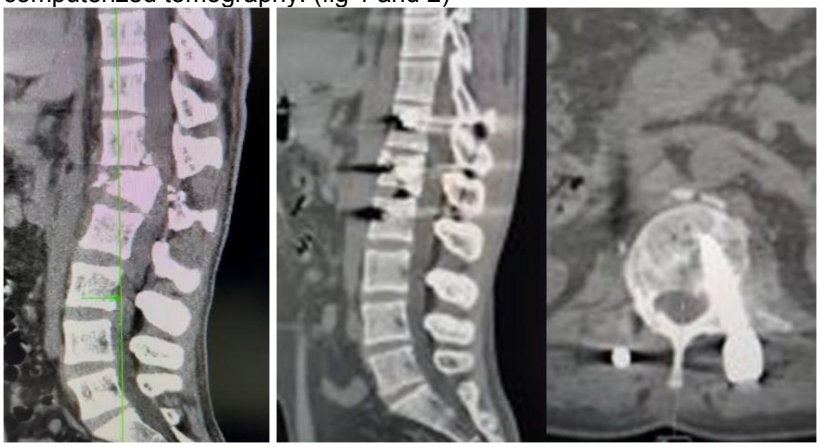

Fig 1 (Preop CT) Fig 2 (Postop CT)

Conclusion: This prospective study shows that adequate achievement of alignment and kyphosis correction is sufficient for patients with partial neurological deficits in thoracolumbar fractures. Patients with ASIA scale A showed no neurological improvement and is consistent with results shown in other studies which involved laminectomy.

O49

Thoracolumbar vertebral burst fractures treated by short segment fixation with index screw and transpedicular intracorporeal bone grafting: A clinico-radiological analysis pre-post interventional study

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Introduction: The treatment of thoracolumbar fractures is controversial. Short segment pedicle screw fixation has been used as a treatment of choice for many years yet it is associated with loss of reduction and undesirable implant failure. In 1994, Dick et al introduced an additional screw in the fractured vertebra leading to the 6 screw construct to treat the thoracolumbar fractures but screws at the fractured site has led to inconsistent effect including collapse of the fractured vertebra leading to reduction in the vertebra height and non-union. While long segment fixation incorporates multiple normal mobile spinal segments leading to spinal stiffness. Transpedicular intracorporeal bone grafting proposed by Liao et al, has a comparative advantage of union of the fractured vertebra but the incidence of vertebral collapse still persists due to non-support of the graft under axial loading. Considering both the additional screw at the fractured site and transpedicular bone grafting have disadvantages as non-union and collapse respectively, combining both the procedures should not only fill the void of the fractured vertebra leading to better union but should also impart mechanically more stable construct due to presence of an additional screw in the fractured vertebra.

Methodology: The pre-operative clinical examination was done and scoring was done using the ASIA score, Denis work score and Denis pain score. The pre-operative radiograph of the thoracolumbar spine was evaluated to identify the fractured vertebra level and to calculate the radiological parameters like sagittal index, vertebral wedge angle, anterior body compression, Gardner's kyphosis angle, regional kyphosis, posterior wall angles, Cobbs angle. CT of the thoracolumbar spine was done and the canal clearance at fractured site was measured in mid sagittal sections, location of void in the vertebral body in axial cuts and status of the pedicles of the fractured vertebra were assessed. MRI was done to assess the posterior ligamentous complex integrity and to identify altered signal intensity of the spinal cord. Finally, TLICS of the patient was done.

Results: There were 50 patients on whom we did transpedicular intracorporeal bone grafting with index screw short segment screw fixation. The average preoperative kyphosis angle was 22.3_ ± 6.6_, which was corrected to 5.6_ ± 4.8 immediately after surgery ($p < 0.001$). At final follow-up, the mean local kyphosis angle was 10.3_ ± 5.2_; loss of correction was 4.7_ ± 2.7_ ($p < 0.001$). The average preoperative anterior body height was 46.6% ± 12.5%, which improved to 85.7% ± 9.4% immediately after surgery ($p < 0.001$). Anterior body height restored by surgery was 39.2% ± 13.3%. Anterior body height at 6-month follow-up was 74.9% ± 12.0%, and the average loss of body height correction was 10.8% ± 7.0% ($p < 0.001$).

Conclusion: The outcomes of this study confirmed that the use of two additional augmenting screws in the fractured body with short-segment pedicle screws and intracorporeal bone grafting is sufficient for most thoracolumbar burst fractures, to attain fracture reduction, maintain alignment achieve union and prevent vertebral collapse.

O50

Comparison of radiological & functional outcome of thoracolumbar burst fractures treated by Short Segment Pedicle screw fixation (SSPF) with monopedicular index screw fixation & bipedicular index screw fixation - A single center retrospective 2 years observational study

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Introduction: Thoracolumbar (T10 - L2) region is uniquely susceptible to injury because when the vertebra is subjected to a significant axial and possibly flexion force vector that brings the failure of the anterior vertebral body in compression and posterior complex in distraction common among youth, due to increasing MVA, occupational hazards & fall from heights.

Aim: To study the radiological and functional outcome of Thoracolumbar burst fractures treated by SSPF with monopedicular index screw fixation & bipedicular index screw fixation operated in a single center over a period of 2 years.

Materials and Methods: 24 Patients were evaluated retrospectively in our study at our institute who were diagnosed with Thoracolumbar Burst fractures & treated by SSPF with all monoaxial monopedicular Index Vertebral screw fixation & bipedicular index screw fixations. Anterior vertebral body height (AVH), mid sagittal height, posterior vertebral height (PVH) & Kyphosis angles were calculated & compared on pre op and post op radiographs / CT scans.

Discussion: Although SSPF approach has high failure rate, it became a preferred approach after renovation by addition of screws into the fractured level (index level). Intermediate Index screw increases the strength of construct, increases the vertebral height, takes the anterior load on vertebra, acts as anti-rotation screw, and helps in achieving better deformity correction, better postoperative Cobb's and offers improved biomechanical stability. Cantileverage with rods on either side with index screw also helps in regaining the lost anterior vertebral height. Several studies were done to ensure biomechanical stability of this short construct, and most studies revealed its low failure rate and high pull out resistance. Adding bilateral index level screws to short-segment fixation increased the stability of the construct by 25%. Cantileverage with rods by placing an index screw leads to tensioning of the longitudinal ligaments, forcing them to act like splints leading to restoration of the fractured vertebra to its near normal shape and height. At the end of consolidation, the initial "bag of bone" vertebral body is converted into a "solid rectangle block".

Results: Both groups showed decent correction of kyphosis on lateral radiographs. However, in cases with bipedicular index screw fixation, CT scan showed better correction and final vertebral body morphology in both coronal & sagittal sections, almost similar to expected preinjury contours, which is accommodated well between the adjacent discs, reducing stress on neighboring vertebra & their screws achieving uniform distribution of stresses along the vertebral column. This also helps in early consolidation, early implant removal & thereby saving the motion segments. Single index pedicle screws fall short in rafting the entire fractured superior end plate.

Conclusion: Bi-pedicular fixation gives better radiological corrections. For better correction of sagittal parameters, and maintenance of the vertebral height we propose, caudally directed monoaxial pedicle screw of adequate diameter which occupies the entire pedicle of fractured vertebra, and adequate length, reaches the anterior column on both sides, acts like a raft screw below the superior end plate, supports subchondral bone and allows more correction by cantilever forces created by distraction maneuver. This three point fixation also prevents collapse and loss of corrected kyphosis.

O51

Dural breach is and indicator to prognosticate neurological recovery in traumatic dorsolumbar spine: Prospective analysis of 48 patients with cauda equina and conus injuries

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Introduction: Senior author, in his previous study, evaluated co-relation between dural intactness and neurological recovery in dorsolumbar fracture spine. Current study is carried out to validate our own previous retrospective case series by considering prospective cases of similar nature.
Aim: To validate previous retrospective study to show co-relation between dural intactness with neurological recovery in a traumatic dorsolumbar spine, by prospective way between 2014- 2018.
Materials and Methods: 48 patients with single-level vertebra fracture over T11–L1 with cauda equinal or epiconal injuries that underwent posterior decompression and stabilization were evaluated prospectively between 2014 and 2018. All patients included had motor incomplete ASIA C neurology in 34 and ASIA B in 14 with either Type B or C (AO/ Magerl classification) of fracture morphology. Patient age ranged from 24-59 years with 41 males and 7 females. Radiologist opinion was taken for identifying preop dural leak with sac on MRI. Intraoperative findings with respect to intactness of dura was noted. 28 cases out of 48 were found to have preop dural injury on MRI with ASIA C- 19 and ASIA B- 9. Out of these 28, 24 were confirmed to have dural tear intraoperatively with ASIA C- 16 and ASIA B- 8 neurology.
20 patients with no dural leaks reported on preop MRI had neurology of ASIA C in 15 and ASIA B in 5, out of which 16 were confirmed not to have any dural injury intraoperatively with ASIA C- 13, ASIA B- 3 neurology. All patient's basic demographic data, neurological status noted at intervals. ROC curve analysis was used to define the cutoff value of lower extremities motor score (LEMS) in functional walkers and non-walkers. All patients were seen at a postoperative follow-up of minimum 12 months.
Results: 48 patients studied here had fractures at T11 – 11, T12- 27 and L1- 10. Out of 24 cases with intraop dural tear, 15/16 ASIA C and 5/8 ASIA B neurology patients showed recovery whereas 16 patients in whom there was no dural tear, neuro recovery took place in 4/13 ASIA C, 1/3 ASIA B. Interestingly neurological recovery happened in all patients with MRI reported as intact dura but had shown intraoperatively a pre-existing breach due to trauma. Also, all the 4 patients in whom dural breach was reported, but was found to be intact intraoperatively did not recover in neurology.
Conclusion: Prospective analysis showed and validated our retrospective study that dural breach in a fracture spine at the cauda equina is a prognostic indicator for neurological recovery.

Reference:

[1]Raghuprasad Varma. Does an intraoperative finding of an intact dural sac help to prognosticate neurological recovery in cauda equinal and epiconal injuries in thoracolumbar fractures? An analysis of 31 patients. *Eur Spine J*; published online 13 September 2014

O52

Better late than never: Clinical outcomes of delayed fixation in thoracolumbar spinal trauma

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Introduction: Spinal cord injury patients are two- to fivefold more likely to suffer premature death than the normal population, with poorer survival rates in middle and low-income nations. Spinal cord injury with delayed presentation after receiving no or inadequate treatment is more commonly seen in developing countries. Various studies have reported that patients undergoing early decompression in spinal cord injury have better outcomes, whereas a few studies have concluded that there is no significant difference in the outcome of whether the patient is operated on early or late. Thus, there is no clear consensus on how early should a spinal cord injury patient be operated on. To understand the behavior of these neglected injuries, we conducted a study analyzing the outcome of delayed fixation with or without decompression in traumatic spinal cord injuries.
Methods: A retrospective analysis of 33 patients with thoracolumbar spinal cord injury who underwent delayed surgery (≥ 72hrs post-trauma) with a minimum follow-up of 1 year (average:32.55 months) was done. The parameters studied included age, sex, co-morbidities, mode of trauma, associated trauma, level and number of vertebrae involved, fracture morphology, thoracolumbar injury classification and severity score (TLICS), maximal spinal cord compression (MSCC), signal changes in the cord, neurological deficit as per the American Spinal Injury Association (ASIA) scale, lower extremity motor score (LEMS), bowel bladder involvement, the time interval between trauma and surgery.
Results: The mean time interval from injury to spine surgery was 24.45 days. At the end of 1-year follow-up, 17(51.5%),12(36.36%), and 3(9.1%) patients had ≥ 1, ≥ 2, and ≥ 3-grade ASIA improvement, respectively. The mean LEMS rose to 33.86 from 17.09 ($P < 0.001$). 8 out of 20 patients with bladder involvement showed improvement. 4 patients succumbed, 22 were ambulatory, and 7 remained non-ambulatory. On comparing various parameters, pre-operative LEMS score (P-value: < 0.001), cord signal changes (P-value:0.002), and presence of cord transection (P-value:0.007) differed significantly in the above-mentioned three groups, while age (P-value:0.442), average TLICS (P-value:0.872), time from injury to surgery (P-value:0.386) did not differ significantly.
Conclusion: It is well-accepted that spinal injuries should be treated within the first 72 hours. However, there indeed are less fortunate patients who present late to the hospital equipped with spine surgery services, owing to multitudes of medical, socioeconomic, and logistic delays. This study highlights that there is still a significant chance of neurological improvement even after delayed surgery. The presence of cord transection, signal changes in the cord, and lower LEMS score at the time of presentation have a significant influence on unfavorable clinical outcomes at the end of 1-year post-surgery.

O53

Outcomes of long segment posterior fusion in patients with ankylosing spondylitis with thoracolumbar fractures

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Introduction: Managing Ankylosing spondylitis related thoracolumbar fractures is a great challenge due to poor condition complicated by comorbidities. Non surgical external immobilization methods are disappointing and they often lead to poor fracture healing, persistent pain and eventually pseudoarthrosis making the subsequent surgical intervention more difficult. There is growing recommendation for surgical stabilization as it has better results. However, the ideal surgical treatment for these injuries remains controversial. As per most of the current literatures, anterior fusion is preferred to get 360degrees fusion. However, the trend is shifting towards posterior surgery due to high rate of complications with anterior surgeries.

Materials and Methods: This is a retrospective, institutional cohort study of patients with ankylosing spondylitis who were treated for thoracolumbar fractures at the Sir Gangaram Hospital, a tertiary care center between 2000 and 2016. Clinical outcomes were assessed in terms of Patient Related Outcome Instruments (PROI) like Oswestry Disability Index [ODI],Visual Analogue Score [VAS] for back and leg pain, American Spinal Injury Association [ASIA] grading for neurology and Euro Qol-5D-5L (EQ-5D-5L) score to assess postoperative health-related quality-of-life. The sagittal profiles (kyphotic angle, anterior vertebral height and posterior vertebral height) were calculated both pre and post operatively on available images.The mean follow up duration was 3 years(10months- 36months).

Results: Solid bony fusion was noticed in thirty five cases (n=35, 92.1%) till final follow-up.

The pre-operative mean sagittal kyphotic angle was 20.47 degrees which was reduced to 9.42 degrees in the immediate postoperative image and 10.55 degrees at final follow-up. The pre-operative mean anterior and posterior vertebral height were 28.1 degrees and 37.69 degrees respectively and were restored to 36.47 degrees 38.97 degrees respectively at final follow-up.

On admission 57.89% of the study patients (n=22) were neurologically intact and rest of them were involved. On the basis of the Wilcoxon Signed Rank Test, the overall neurological recovery at final follow-up in patients who presented with neurologic deficits on admission was statistically significant ($p < 0.05$).

The mean Oswestry disability index (ODI) score on admission was 60.94 which improved to 20.19 at the final follow-up. The mean visual analogue scale (VAS) score for back pain was 6.7 at admission and improved to 0.84 at final follow up. The mean visual analogue scale (VAS) score for leg pain was 1.6 at admission and improved to 0.4 at final follow up. The overall functional outcome at final follow-up was satisfactory on the basis of EU 5Q-5L scoring system. The perioperative mortality within a month was zero, within a year was 5.26% (n=2) and till final follow up it was 13.15% (n=5). The overall morbidity was 47.36% (n=18).

Conclusion: Patients with AS who sustain fractures of the spine provide daunting diagnostic and treatment challenges. Posterior long segment instrumented fusion alone for thoracolumbar fractures in patients with ankylosing spondylitis have excellent clinical and radiological outcome despite the fact that a 360 degree fusion is a must according to most of the current literature.

O54

A perioperative predictive model of early mortality in acute cervical spine injury: A prospective cohort study

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Introduction: Traumatic cervical spine injury is common among spinal cord injuries which requires an intensive, multidisciplinary approach which can affect the immediate postoperative hospital survival rate. By identifying the risk factors leading to early mortality in cervical spine trauma patients, the prognosis of patients with TCSCI can be better predicted.
Aim: The study aims to analyze the variables influencing in-hospital mortality in cervical spine trauma patients treated at a Level I trauma center.
Methods: Prospective study was conducted on the patients presenting with subaxial cervical spine injuries from July 2019 to March 2022. Patients were divided into two groups – Group A, with in-hospital mortality, and Group B, who got discharged from hospital and followed up to hospital discharge or in-hospital death, whichever was earlier. Data for age, gender, mechanism of injury, and ASIA Impairment Scale (AIS), level of injury, fracture morphology, sagittal extent of parenchymal damage to the cord, Mean Canal Compression (MCC), Mean Spinal Cord Compression (MSCC), duration of surgery, blood loss, ASA grading, injury to hospital duration, Injury to surgery duration, duration of ICU stays, hospital stay, and tracheostomy rates were reviewed and analyzed for as potential risk factors for in-hospital mortality.
Results: Out of 105 patients included, 83.8% were male with mean age of presentation was 40.43 ± 12.62 years. C5-C6 was the most common level of injury (34.2%), and fracture-dislocation (AO type C) was the most common fracture morphology (64.7%). 29 cases (27.6%) had in-hospital mortality. In comparison between the two groups (Group A and B), extent of parenchymal damage, MSCC, and MCC had significant differences. AIS, ICU stay, level of injury, and MRI parameters like the extent of Parenchymal damage, MSCC, and MCC were potential risk factors for in-hospital mortality. On multivariate regression analysis, AIS at presentation was the only significant independent parameter for in-hospital mortality.
Conclusions: AIS grading at presentation, duration of ICU stay, level of injury, rate of tracheostomy, and MRI parameters like the extent of parenchymal damage, MCC, and MSCC influence in-hospital mortality in cervical spine trauma patients. However, AIS is the only independent risk factor predicting high mortality in TCSCI patients.

O55

On-site clinician-led bracing algorithm with short clinical feedback loops lead to significant improvements in bracing outcomes

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Introduction: Despite the increasing evidence-base for spinal bracing as a key treatment for adolescent idiopathic scoliosis (AIS), efficacious and widespread implementation remains limited. Common barriers include financial restrictions, brace design exclusivity, blocking patents and induced dependence on off-site involvement. This results in lengthy and incomplete clinical feedback loops which impair clinical outcomes such as immediate in-brace correction – a documented primary predictor of overall brace treatment outcomes. Therefore, a clinical algorithm was designed with rapid and complete feedback loops to optimise the initial in-brace correction and fine tune the brace at the fitting stage. This study examined 10 months of clinical data with the new clinical algorithm (LOCBrace) and compared them to 12 months of bracing data with a Chêneau-derivate to assess if it led to improved clinical outcomes.
Aim: To assess if an on-site clinician-led bracing algorithm improves in-brace correction when compared to an off-site Chêneau-derivate bracing algorithm.
Patients and Methods: AIS patients were treated according to the LOCBrace algorithm. Braces were modelled and manufactured on-site applying Chêneau principles. Baseline x-rays were obtained prior to treatment. Braces were fitted and immediate increase in standing height was used as an indicator for fine tuning. A further x-ray was taken within 72 hours of brace provision measuring Cobb angle in-brace. In-brace correction was measured by Cobb angle as a percentage improvement from baseline. As part of the algorithm, low dose full spinal EOS scans were recommended for the rapid and safe turnaround. Over the course of 10 months, each patient's pre-treatment and immediate in-brace correction was measured (n=61) and compared to preceding 12-month data from the Chêneau-derivate (n=44) to determine the effects of the LOCBrace algorithm on in-brace Cobb Angle correction. For consistency, only patients treated by the same clinician were evaluated in both cohorts. Patients were classified using the Scoliosis Research Society (SRS) inclusion/exclusion criteria.
Results: For patients treated within the SRS inclusion criteria, the average correction was 86.04% in LOCBrace compared to 68.42% in the Chêneau-derivate – a 25.76% greater brace efficacy compared to the Chêneau-derivate. For patients treated outside of the SRS inclusion criteria, the average correction was 75.95% in LOCBrace compared to 55.08% in the Chêneau-derivate - a 37.89% greater brace efficacy compared to the Chêneau-derivate. Overall, the average correction was 76.58% for the LOCBrace and 60.13% in the Chêneau-derivate.
Conclusions: This study suggests that the use of short clinical feedback loops led by on-site clinicians can improve initial in-brace correction results, which is predictive of enhanced bracing outcomes. In-brace correction rates improved over the course of the study due to immediate feedback into the modelling techniques secondary to rapid data collection using x-rays. The LOCBrace algorithm characterised by clinician driven, in-house manufacturing and rapid feedback loops resulted in improved in-brace correction in AIS patients compared to the preceding Chêneau-derivate brace algorithm.

O56

The effect of night-time bracing on the sagittal profile in adolescent idiopathic scoliosis

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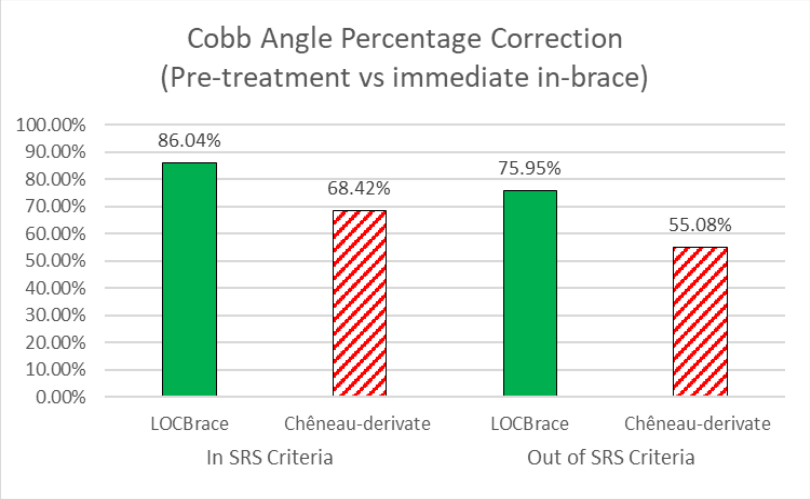
Study Design: Retrospective, consecutive, single-center cohort study.
Introduction: Adolescent idiopathic scoliosis (AIS) is characterized by a coronal scoliosis and a sagittal hypokyphosis. The effect of bracing on the sagittal profile is not well understood. The aim of our study was to assess the change of select sagittal radiographic parameters in AIS patients before and after night-time brace treatment.
Methods: We included AIS patients with a main curve of 25-45° treated with a night-time brace between 2005-2018. Patients with Risser stages 0-4 and both pre- and postmenarchal patients were included if there was an estimated growth potential. Patients with prior scoliosis treatment were excluded. Coronal and sagittal radiographic parameters were recorded prior to night-time brace treatment and post bracing. Patients were braced until surgery or skeletal maturity.
Results: One hundred forty-six patients were included. Eighty-seven percent (n=127) were female and the mean brace time was 25 months [IQR: 17-36]. Global kyphosis increased with a mean of 3° (±11) (p=0.001). Twenty-seven percent (n=36) of the patients were hypokyphotic (T4T12 <20°) pre-brace compared with 19% (n=26) of the patients post-brace treatment (p=0.134). All other recorded radiographic sagittal parameters remained the same after night-time bracing.
Conclusion: This is the first study to indicate that brace treatment in patients with AIS has an effect of the sagittal profile of the spine, reflected in an increased kyphosis. The clinical implications of this finding require further studies.



O57

Nighttime compared to full-time bracing in adolescent idiopathic scoliosis: Evaluating clinical equipoise and feasibility for a multi-center clinical trial

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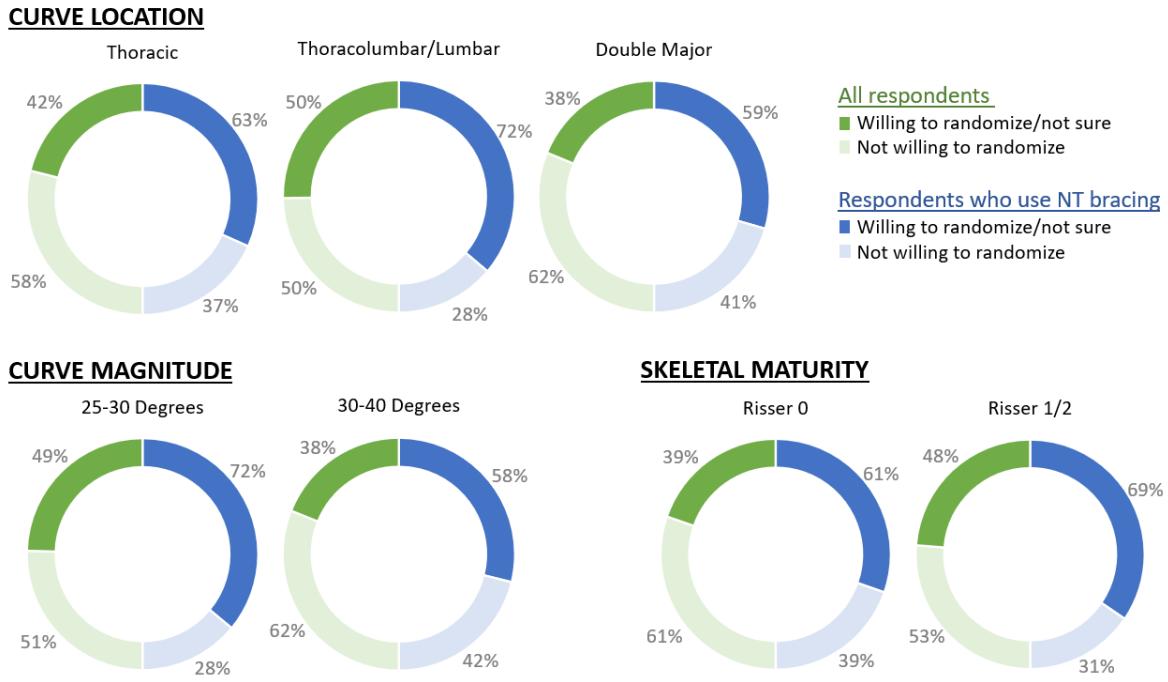
Introduction: Adolescents with idiopathic scoliosis are often prescribed a thoraco-lumbar-sacral orthosis to prevent curve progression and optimally avoid the need for surgery. While most scoliosis braces are prescribed for full-time wear, nighttime braces are designed for part-time use while sleeping. Thus, nighttime braces are a promising treatment option for some patients with idiopathic scoliosis due to the minimal impact on daily life for the adolescent and their family. To date, there is minimal evidence to guide prescription for nighttime bracing. A high-quality, prospective clinical trial is needed to compare the effectiveness of nighttime and full-time scoliosis braces in adolescents with idiopathic scoliosis. Preliminary research is required, however, to ensure the future trial's success and potential to inform routine clinical practice. The aim of this study was to assess (1) clinical equipoise regarding nighttime and full-time scoliosis bracing, and (2) physician willingness to randomize patients to brace type. Study findings will be used to inform the design of a future clinical trial.
Methods: A cross-sectional survey study was conducted with approval from an institutional review board. Members of the Pediatric Orthopedic Society of North America (POSNA) and the International Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) were sent a link to an online REDCap survey. Respondents were eligible if they were pediatric orthopaedic surgeons engaged in non-operative scoliosis management and could communicate in English. Respondents completed an online survey that included 12 hypothetical scoliosis cases. They were asked to indicate their bracing recommendation and their willingness to randomize the hypothetical patient in a clinical trial. The survey also queried respondents regarding their opinions about nighttime and full-time bracing, and asked questions about respondent demographic and clinical characteristics. Descriptive statistics were used to summarize findings.
Results: A total of 53 pediatric orthopaedic surgeons completed the survey. Most respondents were men (77%), had been in practice for >15 years (55%), and dedicate the majority of their practice to pediatric spine (66%). Just over half (53%) currently prescribe nighttime braces. Across hypothetical patient cases, most respondents recommended full-time bracing (between 64-94%), and recommendations varied by curve type, curve magnitude, and skeletal maturity. Specifically, respondents were more likely to recommend nighttime bracing for patients with thoracolumbar curves, those with smaller curve magnitudes, and those at Risser stages 1/2. Surgeon respondents who currently prescribe nighttime braces were more willing to randomize patients to nighttime or full-time braces in a future clinical trial (Figure 1). The most important factors noted for prescribing nighttime over full-time braces were skeletal maturity (53%) and patient willingness to wear the brace (53%).
Conclusions: Most physicians preferred to prescribe full-time over nighttime braces. Physicians were more willing to recommend a nighttime brace for patients with smaller curve magnitudes, Risser stage 1-2, and lumbar/thoracolumbar curves. Physician willingness to randomize increased when patients were more skeletally mature and had small lumbar/thoracolumbar curves. This analysis is preliminary, with plans to include data from one more professional society. Ultimately, results will inform eligibility criteria and feasibility for a future study comparing nighttime and full-time braces.

Acknowledgements: This study was funded by the Gillette Spine Fund.

Figure 1. Percentages of surgeon respondents willing to randomize case patients to nighttime (NT) or full-time bracing in a future clinical trial based on patient characteristics (i.e., curve location, curve magnitude, and skeletal maturity). Percentages calculated for all respondents (n=53, green) and respondents who currently prescribe NT (n=28, blue).



O58

The short-term outcomes of the Boston brace 3D program based on SOSORT and SRS study criteria

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Introduction: Adolescent idiopathic scoliosis (AIS) is characterized by a lateral curvature of the spine with a Cobb angle greater than 10°, accompanied by rotation of the vertebral body. Bracing has been shown to be effective in halting the progression of at-risk curves, and, even improving the Cobb angle by 6° or more (Weinstein 2013; Katz 2010). The Boston Brace 3D is part of a standardized scoliosis program. The orthosis is custom-fabricated from scan, computer-aided design (CAD), and computer-aided manufactured (CAM) thoracolumbosacral orthosis used in the non-operative management of AIS. Aim: To evaluate the outcomes of a scoliosis program utilizing the Boston Brace 3D orthosis for patients with AIS, based on SRS and SOSORT criteria. Design: Retrospective study.

Materials and Methods: *Procedures*: Internal review board (IRB) exemption was obtained by wcgIRB to conduct an electronic medical records search to identify first-time brace wearers fitted between 1 January 2018, and 30 June 2019, at Boston Orthotics and Prosthetics Boston area clinics that met the SRS/SOSORT research guidelines.(10-17 years of age, Cobb angle between 25-40 degrees, Risser 0-1) The initial out-of-brace, in-brace, and last follow-up X-rays (taken at least 12 months after fitting) were compared.

The cohort was separated into curve type, magnitude, Risser, and one-way ANOVA used to compare heterogeneity between means of age, sex, and average break in wear time. Mean and standard deviation change in Cobb angle, in-brace correction, and average wear time reported over the course of the study period.

The sample consisted of 178 patients (150 female and 28 male) with adolescent idiopathic scoliosis, with a primary Cobb angle between 25°-40°, Risser 0-2, fit with a Boston Brace 3D within the established timeline.

Results: 84% of patients presenting with a single curve and 69% of patients with a double curve saw their curves improve (reduced 6° or more) or remain unchanged (±5°). 8 of the 178 patients (4%) have progressed to surgery to date. In general, the patients who wore their brace for more hours per day saw improved results.

Discussion: Our study adds to the body of evidence that orthotic management is effective in stopping scoliotic curve progression and can show reduction of Cobb angle over the course of treatment. It also indicates that wear time is an important factor in the outcome of a bracing program. Limitations include patients lost to follow up, thus not completing the bracing program. Additionally, not all patients had complete objective average hours of wear time data. Future studies should have all included patients with objective wear time data, be prospective, and include quality of life questionnaires at beginning and end of treatment.

Conclusions: The Boston Brace 3D program is effective in controlling (and in some cases improving) curve progression in the non-operative management of adolescent idiopathic scoliosis. The approach is a repeatable system, as shown in this cohort seen by thirteen clinicians across six area clinics following the Boston Brace 3D clinical guidelines.

Table 1. Cobb Angle Changes and Dose Double Curves

Cobb Angle Change	N (%)	Break-In Average Wear Time Hours/Day	Number of Break-In Reads (%)	2nd Average Wear Time	Number of Second Reads	Third Average Wear Time	Number of Third Reads
Improved (6° or more)	32 (25%)	10.2 ± 3.29	28 (88%)	14.91 ± 3.79	20 (63%)	15.6 ± 3.07	17 (53%)
Unchanged (±5°)	56 (44%)	10.98 ± 3.76	41 (73%)	12.72 ± 5.02	35 (63%)	13.29 ± 4.61	29 (52%)
Progressed (6° or more)	39 (31%)	7.6 ± 3.64	33 (85%)	7.84 ± 4.45	23 (59%)	7.67 ± 4.59	17 (44%)

Table 2. Cobb Angle Changes and Dose Single Curves

Cobb Angle Change	N (%)	Break-In Average Wear Time Hours/Day	Number of Break-In Reads (%)	2nd Average Wear Time	Number of Second Reads	Third Average Wear Time	Number of Third Reads
Improved (6° or more)	14 (27%)	11.02 ± 3.63	13 (93%)	15.6 ± 3.42	13 (93%)	15.5 ± 3.62	10 (71%)
Unchanged (±5°)	29 (57%)	10.47 ± 3.79	23 (79%)	13.97 ± 4.14	27 (93%)	14.1 ± 4.13	16 (55%)
Progressed (6° or more)	8 (16%)	6.94 ± 3.07	7(88%)	10.66 ± 3.58	5 (63%)	8.2 ± 3.87	5 (63%)

JHW AND LRH are both full time employees of Boston Orthotics & Prosthetics.

O59

It is worth treating adolescent with idiopathic scoliosis when bone maturity passed US Risser 2: Bracing can improve curves and aesthetic

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Hypothesis: Bracing can help Risser 3-4, 30-45° adolescents with idiopathic scoliosis (AIS) to achieve 1) curve reduction (with reduced risks in adulthood) and 2) improved aesthetics.
Study Design: Retrospective analysis of prospective clinical data (2003 to 2021).
Introduction: The SRS (Richards 2005) developed criteria that provided the minimum standards for bracing research, but 1) they could not be standard for clinical practice, and 2) research should test new hypotheses. The SOSORT-SRS research criteria (Negrini 2014) state that, when surgery is avoided, the aim of treatment is to achieve at the end of growth a curve below or as close as possible to 30° Cobb to minimize risks in adulthood (progression, pain).
Methods: Inclusion: IS, age 10-18, EU Risser 2-4 (corresponding to US Risser 3-4), primary curve 25-45°, females > 1-year post menarche, first consultation at our Institute. Exclusion: still in treatment. Treatment: brace (SPoRT concept) ≥18 hours/day w/o Physiotherapic Scoliosis Specific Exercises (PSSE) (SEAS school). Controls: patients with same Cobb, ATR and TRACE at baseline but starting at EU Risser 0 or 1. Outcome measures: °Cobb, °ATR, TRACE index (aesthetics). Observations: start and end of treatment; in and post brace. Statistics: paired t-test for continuous variables, one-way ANOVA for multilevel categorical variables and Chi-square for proportions. Propensity score matching for treatment effect and linear and logistic regression modelling. Level of significance $p<0.05$.
Results: Out of the 1,542 subjects fulfilling the inclusion criteria, 1,089 reached the end of treatment. Females represented the 82.6% of the sample, mean age 14.50 (SD 1.40) and major Cobb angle was 34.14(SD 6.02). In the propensity score matched cohort the average Cobb angle at start was 0.30 higher than in younger patients starting treatment at US Risser 0 to 2. This very small difference was not significant as 95% CI was -0.35-0.96 and $p=0.368$. The treatment effect of bracing was very similar in the two groups.
Conclusion: Bracing provides curves' reduction and aesthetics improvement of 25-45° Risser 3-4 AIS more than controls.

O60

The effect of Risser stage on the risk of curve progression in patients with adolescent idiopathic scoliosis treated with night-time bracing

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Introduction: Risser stage is widely used as a marker for skeletal maturity (SM) and thereby an indirect measure for the risk of progression of AIS. The SRS recommends bracing for Risser stage 0-2 as Risser stage 3 or above is considered low-risk. Very few studies have assessed the risk of progression in Risser 3-4.
Aim: To determine if Risser stages 3-4 provides a meaningful cut-off in terms of progression risk in patients with adolescent idiopathic scoliosis (AIS) treated with night-time bracing.
Patients and Methods: AIS patients treated with night-time brace from 2005 to 2018 with a Cobb angle between 25-40 degrees and Risser 0-4 were included. We recorded age and menarchal status at initiation of treatment. Curve progression (≥6 degrees increase) was monitored until surgery or SM.
Results: One hundred thirty-five patients were included (Risser 0-2: n=86, 3-4: n=49). Overall, radiographic progression occurred in 52% and 35% progressed beyond 45 degrees. Twenty-six percent of the patients underwent fusion surgery at SM and additionally 8% more underwent fusion surgery within 2 years after SM. Progression rate in the Risser 0-2 group was 60% and 37% in the Risser 3-4 group (p=0.012). Univariate logistic regression analysis of progression showed statistically significance in Risser group (OR: 0.38, 95%CI: 0.18-0.78), premenarchal status (OR: 4.37, 95%CI: 1.92-9.72) and age (OR: 0.63, 95%CI 0.47-0.84). However, in multivariate logistic regression analysis only premenarchal status showed a statistically significant association with progression (OR: 2.68, 95%CI: 1.08-6.67).
Conclusion: Risser stage does not provide a clinically meaningful differentiation of progression risk as the progression rate was high in the Risser 3-4 group. Risk assessment should be optimized using other more reliable measures of skeletal growth potential.

O61

Bracing interventions can help adolescents with idiopathic scoliosis with surgical indication: A systematic review

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Introduction: There is a common agreement that bracing is appropriate for curves between 20 and 40° Cobb during growth, but for larger curves experts' opinions are not consistent.
We designed this systematic review to report the updated evidence about the effectiveness of bracing in scoliosis patients with curves ≥40° and a residual growth period.
Methods: We included Randomized Controlled Trials, Non-Randomized Controlled Trials, prospective and retrospective observational studies, case series addressing the effect of bracing in patients with idiopathic scoliosis during growth with curves ≥40° Cobb published from 2000 onwards.
We considered Cobb angle changes at the end treatment:
• average worst Cobb angle before and after treatment;
• percentage of patients with improvements (reduction >5° Cobb), progression (increase >5°) or stability (±5°);
• percentage of patients with curves larger than 45°;
• percentage of patients with curves larger than 50°;
• percentage of surgically treated patients.
Results: Nine papers (563 patients, average worst curve of 44.8°) were included: 4 retrospective case series, 2 retrospective and 2 prospective cohort studies, 1 prospective controlled study. The overall quality was good with respect to the type of design.
Due to the characteristics of the studies, a meta-analysis was not performed. Results have been reported narratively including tabulation of data and a summary of the evidence.
Considering the whole sample of studies for which we have complete data (563 patients), 32% of patients improved (>5° Cobb change), 26% were stable and 42% progressed. The rate of improvement ranged from 11% to 78% while the rate of progression ranged from 4% to 64%. Surgical rates were not reported in all studies, but ranged from 0 to 58%, with relevant differences in different studies.
In 3 studies, the number of patients with curves below 45° largely increased after treatment. In one paper, the percentage of patients with curves larger than 45° increased while in another those larger than 50°.
Considering the retrospective studies (332 patients, 44.4° ±3.5° Cobb at baseline), 18.4% of patients improved (>5° Cobb change), 30.1% were stable and 51.5% worsened (Table 2). For prospective studies, both a Per Protocol analysis and an Intention-to-treat (ITT) are available. For the Per protocol (198 patients, 47.8° ±5.2° Cobb at baseline) 61.9% of patients improved, 22.9% remained stable, and 15% progressed while for the ITT (171 patients, 48.2° ±5.2° at baseline) 59% improved, 11% remained stable and 29% progressed.
Conclusions: According to the findings of this systematic review there is very low-quality evidence supporting the use of bracing in severe curves, when patients are motivated and willing to avoid surgery. Nevertheless, we need more research with coherent outcome criteria. From a clinical standpoint, the advantages and limitations of bracing in such a condition should be discussed with the patients and family, compared with those of surgery with the aim of reaching a shared a decision making. Further and better high-quality studies are needed to rule out the current limitations, as well as to explore which brace, and which protocols of treatment, are more effective for patients with severe scoliosis.

O62

Can an immediate increase of standing height, when wearing a corrective scoliosis brace, be predictive of in-brace skeletal correction?

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Introduction: A relationship between spinal distraction and correction of a scoliotic curvature is long recognised. Literature confirms height is lost secondary to scoliosis and that height can be gained following fusion surgery. 5 published mathematical algorithms predict expected height loss secondary to a patient's scoliosis. These are largely based on initial presenting Cobb angle(s). There is a paucity of literature reverse engineering this information to predict how much height should be gained in-brace at a fitting appointment if a brace is successfully correcting the scoliosis. In-brace (Cobb angle) correction is a primary indicator in predicting final success of scoliotic brace treatment and is a primary focus in conservative treatment. Whilst experienced orthotists can predict a brace's efficacy by clinical observation, there are no measurable/quantifiable tools in clinic to confirm the brace is optimum before the in-brace x-ray. This ensures that the radiation exposure is only used for assessing an optimum correction of the spine.
Aims: The first aim is to establish if measured height change, during the fitting appointment, is consistent with expected height loss predicted in current literature. Following this, the study aims to look at correlation between height gain and radiological improvements when wearing a corrective scoliosis brace. We will then aim to consider the suitability of measuring height gain at fitting as a quantifiable clinical tool in determining brace efficacy prior to exposing the subject to radiation.
Patients and Methods: Data collection was from January 2022. Each patient (n=60) had two standing height measurements taken on the same day – one pre and one post fitting (with the brace in situ). We measured two Cobb angles, one baseline and one in-brace. The relationship between these measures were evaluated. Statistical analysis was performed.
Results: The mean age was 12.4 years. Mean Risser 1.49. Mean Cobb at assessment was 38.1°, correcting to 10.1° in-brace. Mean in-brace correction 74.96%. Mean height change at fitting was 1.1cm (range -0.2cm to 3.5cm). Patients who achieved in-brace Cobb angles closest to null had the most significant increase in height. When we remove patients who had correction exceeding 100% in-brace (those who exceed maximal spinal distraction), our linear trendline shows height change at fitting is consistent with the current literature. Our R value shows moderate positive correlation between initial presenting cobb angle and height change (0.4791). Our P-value is 0.0027 ($p<0.05$). Results show all patients who had a height gain above our linear trendline demonstrated a mean correction of 78.1% (range 60-180%).
Conclusion: Assessing novel methods of confirming not only adequate but optimal brace wear is essential. Limiting radiation is a priority in children. We found a positive correlation between original Cobb angle and in-brace height change. We also found that patients who had a height change above the trendline demonstrated above expected in-brace skeletal correction (international standards of 50%). We conclude that measuring height change at fitting can be used to predict brace efficacy and optimise scoliotic correction prior to the initial in-brace x-ray.

O63

Non-operative treatment for adolescent idiopathic scoliosis (AIS) by a combination of Cheneau brace and Schroth - physiotherapeutic scoliosis specific exercises (PSSE), for curves at high risk of progression

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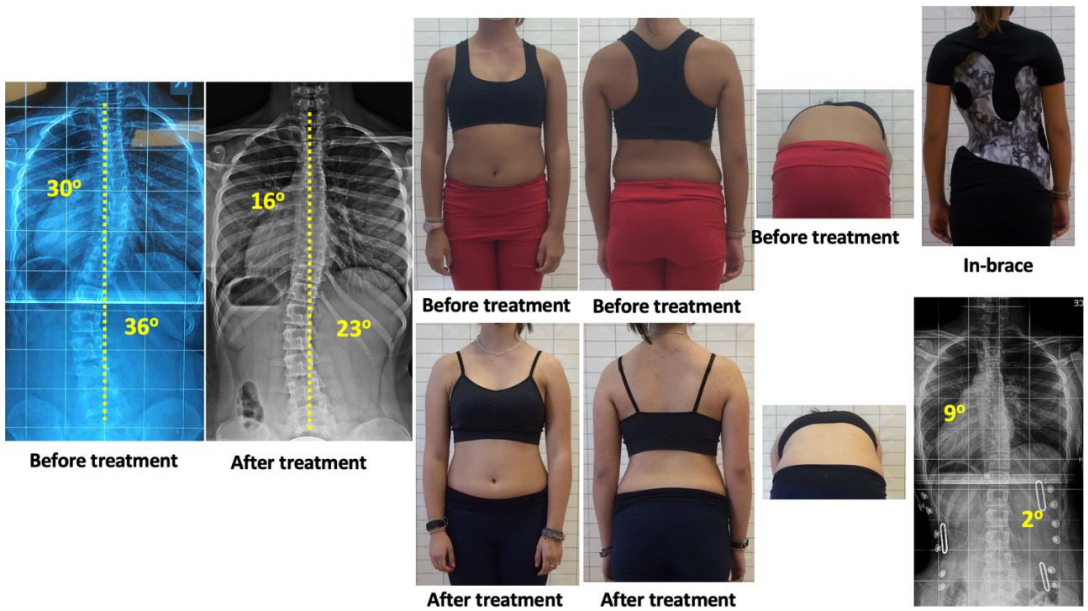
Introduction: According to Scoliosis Research Society (SRS) brace is indicated for scoliotic curves > 25° during growth. Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT) recommends PSSE in conjunction with bracing. Limited studies have investigated the effectiveness of brace and PSSE in curves exceeding 40°. Our aim was to evaluate the efficacy of conservative treatment for AIS, including severe curves with high risk of progression.

Materials and Methods: Prospective study, enrolling all eligible subjects from a prospective database. Modified SRS research inclusion criteria were used (>10 years, Cobb angle > 25°, Risser 0-2, < 1-year post-menarche, no prior treatment), as we included curves more than 40°. 219 patients (192 females-27 males, mean age 12.6 years, Risser 0.58, Cobb Thoracic 37.7°, Lumbar 34.4°) followed treatment with Cheneau brace and Schroth – PSSE exercises. Mean follow-up time was 38.7 months. Compliance was self-reported and a scale from A to C was used to classify as A full-compliant, B partially compliant and C non-compliant. Fail of treatment was defined as progression > 5°. 19 subjects were lost during follow-up (8.7%), so 200 patients were analyzed, using paired t-test.

Results: 112 patients (56%) remained stable, 63 improved Cobb angle >5° (31,5%) and 25 progressed (12.5%). The mean in-brace correction (IBC) was 42.3% for thoracic curves and 50.9% for lumbar curves. Post-treatment thoracic Cobb angle was 34.7° and lumbar 31.7°. A further analysis was made for curves with initial Cobb angle 25° – 40° (162 subjects) and for curves > 40° (38 subjects). For 25° – 40° group, 100 (61.7%) were stable, 49 improved (30,2%) and 13 worsened (8.1%). For >40° group, 15 (39.5%) were stable, 14 (36.8%) improved and 9 (22.7%) worsened. The success rate of the whole group (87.5%) was not significantly lower than the 25° – 40° group (91.9%, p=0.06 but significantly higher than the >40° group (77.3%, p= 0.002). 69 patients (34.5%) were full-compliants (A-A group) and for those the success rate was 95.7% (39 stable, 30 improved and 4 progressed). In total, 3 patients (1.5%) underwent surgical treatment with spinal fusion.

Conclusions: Brace and PSSE Schroth based exercises achieved a success rate of 87.5% in a population with high risk of progression, as our sample included many curves more than 40° at the peak of growth. This can be attributed to high in-brace correction, addition of Schroth – PSSE exercises to bracing and overall good adherence with treatment protocol.



1. Significant clinical and radiological improvement after treatment with Cheneau brace and PSSE – Schroth method exercises

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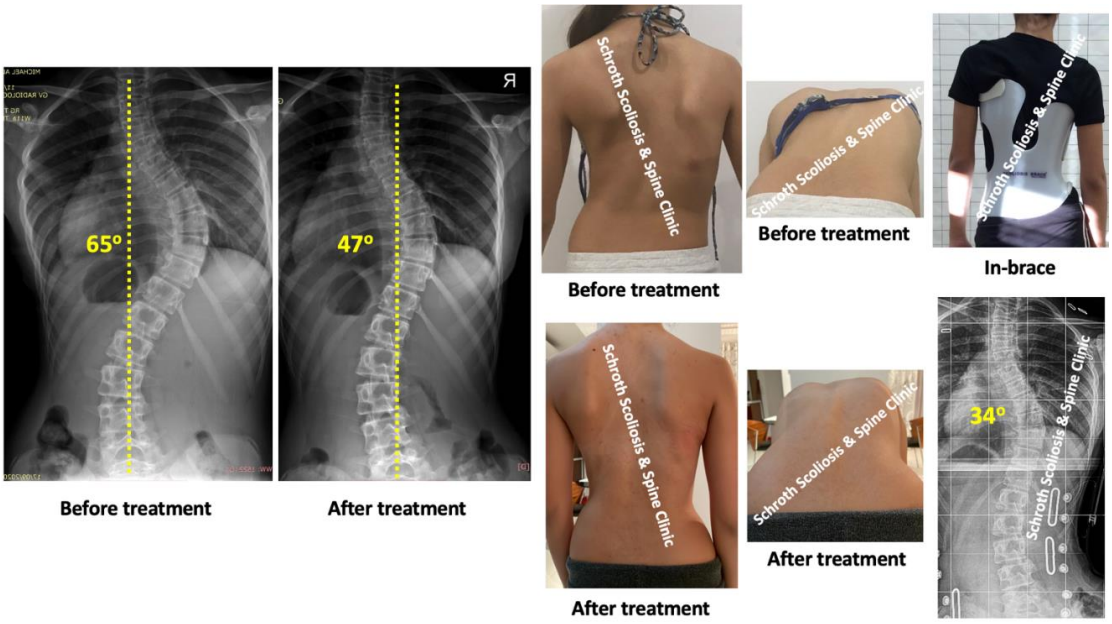

1. Significant clinical and radiological improvement after treatment with Cheneau brace and PSSE – Schroth method exercises

O64

Secondary outcomes on spinal deformity, spinal appearance, health related quality of life, treatment adherence and adverse effects in a multicentre randomised controlled trial on CONservative TReatment for moderate-grade Adolescent Idiopathic Scoliosis (CONTRAIS)

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Aim: Compare effectiveness of first-step interventions before considering full-time bracing for moderate-grade adolescent idiopathic scoliosis (AIS) according to CONTRAIS-trial secondary outcomes.

Methods: Multicentre randomised controlled trial including patients with moderate-grade AIS (Cobbs angle 25-40°, apex Th7 or caudal, <1-year post-menarche, >1-year remaining growth). Interventions included adequate self-mediated physical activity levels combined with either hypercorrective Boston brace night shift (NB), or scoliosis-specific exercise (SSE), or control (PA). Secondary outcomes included between and within-group change baseline-endpoint in Cobb angle, angle of trunk rotation (ATR), pictorial Spinal Appearance Questionnaire (pSAQ), Scoliosis Research Society-22r (SRS-22r), EuroQol 5-Dimensions-Youth (EQ-5D-Y) and Visual Analogue Scale (EQ-VAS), treatment adherence and adverse effects. Follow-up was performed every 6-months until endpoint defined as treatment failure (Cobb angle progression >6º = transition to full-time bracing) or treatment success (reaching skeletal maturity of <1.0 cm height growth over 6 months without curve progression >6º). Intention-to-treat, per-protocol and sensitivity analyses were investigated.

Results: 122/135 (90%) of patients remained in the study until endpoint. Analyses showed statistically significant between-group difference in change for ATR favouring NB group compared to SSE group -2.0º (95% CI = -3.7 to -0.3, p=0.019). Statistically significant within-group ATR increase occurred for SSE 2.1º (95% CI = 0.9 to 3.3, p<0.001), and PA groups 1.6º (95% CI = 0.5 to 2.7, p=0.006). Comparison of EQ-5D-Y dimensions showed a statistically significant between-group difference in mobility (p=0.031) and usual activities (p=0.003) with SSE group reporting slightly higher proportion of moderate problems at endpoint compared to NB and PA groups. There were no other significant between-group differences but within-group change for the Cobb angle showed a statistically significant increase for PA 8.0° (5.7 to 10.4, p<0.001), SSE 7.1º (95% CI = 4.7 to 9.5, p< 0.001), and NB groups 5.7º (95% CI =3.4 to 8.0, p<0.001). The pSAQ displayed a statistically significant worse within-group change for SSE group 1.6 (95% CI = 0.4 to 2.9, p=0.009). NB group had a statistically significant but minor within-group decrease of high-level function (-0.1, 95% CI = -0.3 to -0.1, p=0.018). SRS-22 within-group analysis for SSE group displayed a statistically significant worsening of pain (-0.2, 95% CI = -0.3 to -0.1, p=0.028), self-image (-0.3, 95% CI = -0.5 to -0.1, p = 0.012), mental health (-0.3, 95% CI-0.5 to -0.1, p=0.020) and SRS-22 subscore (-0.2, 95% CI = -0.3 to -0.1, p<0.001). Patient and practitioner ratings showed adequate treatment adherence over time but slightly better in NB and PA groups compared to SSE (p = 0.012). Adverse events were few, mild, transient, and occurred in the initiation of NB and SSE interventions.

Conclusions: SSE for moderate-grade AIS on average resulted in worse outcome in ATR than NB, and slightly higher proportion moderate problems with mobility and usual activities compared to NB and PA.

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O65

Assessing the presentation of adolescents seeking bracing treatment in the UK, using SRS bracing guidelines

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Introduction: Studies have shown that bracing can be successful in the treatment of idiopathic scoliosis. Extensive research has directed the formation of clinical inclusion criteria which document an adolescent's suitability for bracing. The Scoliosis Research Society (SRS) report the criteria for bracing to be: age of 10 years plus, Risser 0–2, Cobb angle of 25–40°, no previous treatment and before menarche or less than one year after menarche. However, it is theorised that the United Kingdom's abolishment of scoliosis screening in schools in the 1990s may be contributory to adolescents receiving their eventual diagnosis when their condition is at a more advanced stage. Thus, the adolescent is more likely to fall out of SRS bracing guidelines.
Aims: This study aims to assess the presentation of all adolescents who attended a private orthotic clinic for the assessment of a scoliosis brace as first-line treatment. All patients were seen within a week of first referral. This study will firstly state the percentage of presenting adolescents who were within SRS guidelines and those who were out of guidelines. The study will assess and compare in-brace corrections between the two groups.
Patients and Methods: We retrospectively reviewed all adolescents that attended our clinic for the assessment of a scoliosis brace from the years of 2017-2022 (n=210). We considered age, Cobb angles, Risser and menarche status where suitable. We studied the criteria they met and where they may have failed, based on the SRS guidelines above. The bracing design employed was changed in January 2022. Due to protected data from the initial bracing design, this study will only review in-brace Cobb angle correction for the 2 groups using the latest brace design – the LOCScoli Brace, which is an asymmetric Cheneau derivative brace. We used the data from all assessments as of January to September 2022 for the latter part of this project (n=64).
Results: Of the 210, 95 (45%) were within and 115 (55%) were out of SRS guidelines on the day of their assessment. Of the 115 who were out of SRS guidelines, 79 (38%) adolescents failed on one criterion and 35 (17%) failed on 2 criteria or above. The in-brace correction of the 2 groups from January 2022 onwards highlight a mean in-brace correction of 86.04% for those within SRS guidelines and 75.95% for those out of guidelines.
Conclusion: Our preliminary data may suggest that the UK is now in a national position where less than 50% of patients attending an orthotic clinic for first-line bracing treatment are within SRS bracing criteria. Our work highlights the possibility of achieving greater than the internationally acceptable Cobb angle correction in what we term as "hyper corrective braces" for patients both within and out of SRS guidelines. This suggests that adolescents falling outside of the recommended guidelines can be treated with a high level of bracing efficacy. Further studies are required assessing the impact of bracing in those with larger curves and/or those who exceed recommendations. The conversation surrounding in-school screening remains essential.

O66

Combined subjective and objective health related quality of life (SO.QOL™) score, and usefulness in a spine population for pre and post intervention assessment

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Background: Quality of Life (QOL) is an individual's perception of their situation in life in the context of culture and community. Health related QOL (HRQOL) is an evaluation of QOL and its relationship with physical and mental health. ***Objective*** measures such as reduced walking speed and activity (daily step count) is a sign of advancing age, multiple disease states, cognitive impairment, and early mortality. ***Subjective*** validated questionnaires that assist in the measurement of health can help in measuring QOL. The authors present a novel tool for HRQOL evaluation that is easy to measure based on a simplified app questionnaire (***subjective***), and mobility metrics as recorded on a patient's smartphone (***objective***).
Methods: SO.QOL is a health measure with a range of 0 (poor health) to 100 (excellent health). The ***objective*** component is based on the SMoS algorithm, including daily step count and walking speed (measured as a weekly average). The ***subjective*** component is based on 5 health measures: i. Patient perception of their overall health status, ii. Personal care, iii. Day-to-Day activities, iv. Pain levels and v. Anxiety/Depression status. The score is delivered via a phone App to simplify data entry and extraction.
Results: Validation of SO.QOL for a spinal population includes normative datasets compared to spine pathology groups including acute disc herniation (ADH), spinal stenosis (SS) and low back pain (LBP). From a cohort of 659 patients presenting to a spine clinic over a 2-year period, the SS group was the most disabled based off SO.QOL scores, then followed by ADH, and finally LBP. All groups scored significantly lower than aged matched normative cohorts.
Conclusions: SO.QOL is a simple and effective health scoring tool which is demonstrably altered in many pathologies and serves as a rapid, App based tool for general health assessment in large populations. The SO.QOL has potential to be used as a screening tool in primary and specialised care settings, in addition to assessment of post intervention disability and recovery.

Conflict of interest: None of the authors have a conflict of interest with regards to devices or companies reported in the manuscript.

Funding: No funding was received for this study.

Consent: All patients consented to collection and analysis of their walking data.

O67
Patient and parent expectations to scoliosis treatment

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Introduction: The patient and parent attention towards AIS treatment has increased the last 10 years, and several papers has published the efficacy of Braces, Scoliosis Specific Exercises (SSE)[1] and Surgery. Brace treatment and SSE treatment requires a high compliance from the patients, and previous study has shown a significant difference in patient satisfaction scores after conservative treatment versus surgery[2].
Material and Method: A questionnaire was designed to investigate patient and their family's expectations toward Scoliosis treatment. The questionnaire were handed out to patient in the outpatient clinic and their parents/grandparents following them to their appointment. The questionnaire included the figures from the Spinal Appearance Questionnaire[3], allowing the patients/family to express which spinal deformity was the biggest concern to them, and which deformity they believed were corrected during brace treatment, surgery and physiotherapy.
Results: 28 AIS patients (24 girl and 4 boys age 12-19 years) and 22 family members were included in the study. The main cosmetic concern to the patients were 81 % shoulder imbalance (Nr 4), 63 % haunch back (Nr 5) and 63 % thoracic rib hump (Nr 1). Parents stated their focus on the lumbar rib hump in 76 % (Nr 2) and the haunch back 64 % (Nr 5). Brace treatment was expected by 78% of the kohort to correct the shoulder imbalance, but only 12 % believed that the haunch back would improve. Surgery was believed by 68 % to correct the shoulder imbalance, and 40 % stated that the haunch back would be improved.
Conclusion: To achieve good patient satisfaction and high compliance during treatment, it is very important to understand the main concern of the patients and explain the efficacy of a given treatment. This study reveals that patient´s primary concern is the shoulder imbalance and haunch back, while the parents focus on lumbar rib hump and haunch back. There is a high expectation that all treatment modalities can correct shoulder imbalance, but a lower expectation toward correction of the haunch back with braces.This might explain the lower patients satisfaction scores, reported in brace treated cohorts compared to surgical treated cohorts. It is important for the treating physicians to ensure that patients/parents are aware of the efficacy of a given treatment, and to explain how the treatment will address the spinal deformity. The patient and parent expectation is an important toll to ensure good compliance during treatment.

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O68

The psychological impact of children spinal deformities on their parents: How to measure with a Rach consistent unidimensional questionnaire

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Introduction: Having a child diagnosed with a chronic condition can be stressful for parents who report higher rates of mood disturbances, anxiety, physical and cognitive problems, and loss of control due to their children's condition. They are also more likely than parents of healthy children to experience higher stress levels and a poorer quality of life. The experience of parents of children suffering from asthma, diabetes or other chronic pathologies is well documented. Still, little attention has been paid to the parents of children and young people with scoliosis who undergo conservative treatment. In reality, careful assessment of the parents' psychosocial status, psychological well-being and functioning is essential given the level of involvement of the latter in treatment management. Currently, there are no questionnaires aimed at assessing the quality of life of this population. This study aims to develop a new Rasch consistent questionnaire for measuring the impact of pathology and treatment on parents of patients with spinal deformities.
Methods: The current ongoing study consists of several stages: a conventional approach content analysis (Phase 1), an opinion poll among clinicians trained in spine deformities (Phase 2), and the Rasch analysis (partial credit model) (Phase 3).
Results: In phase 1, we used a conventional approach content analysis to identify on an online blog addressed to patients with scoliosis and their families the parents’ self-reported problems affecting their QoL. According to the content analysis, we arranged a pool of 55 items. In Phase 2, a group of 24 scoliosis experts rated the items’ appropriateness for measuring the parents’ QoL, and we selected 48 items to create the first version of the questionnaire. In phase 3, we ran a Rasch analysis on the first version of the questionnaire administered to 300 parents. According to the analysis, 21 items did not fit the model of Rasch and were thus excluded. As a result, we created nine new items, and a new questionnaire collection is currently ongoing.
Conclusions: The analysis of the preliminary questionnaire version identified a pool of 27 items that fit the Rasch model, thus providing proper quality-of-life measures in the parents of young persons with spine deformities. In the following study's stages, we will refine the item's pool, and test additional questionnaire features, such as dimensionality.

O69

Investigating the relationship between objective measurements and patient perception in Non-Treated AIS. Study 1: How much radiologic measurements affect the SRS-22 and the TAPS

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Introduction: The impact of AIS on the QoL is a still controversial issue. The relationship between the objective measurements (radiological or topographical) is not clear. Most studies use populations including both treated and untreated patient, while treatment has been shown to change this relationship. This is a study based on a Non-Treated sample of consecutive patients diagnosed with AIS. The aim is to analyze the relationship between objective (Radiologic) and subjective (SRS-22 and TAPS) measurements in a sample formed exclusively by Non Treated AIS patients.
The data are presented separately in a series of studies, for the radiological measurements and for the topographical measurements. This is the study 1 (out of 5) analyzing the relationship between radiological measurements and patient measurements (SRS- 22 / TAPS).
Methods: This is a series of 64 consecutive AIS Non treated patients, all of them completing the SRS-22 the day of the consultation. Inclusion criteria were: Non- Treated AIS, age 10 to 17 years 11 months, a good quality radiograph dated into the three months before the consultation. The patients were mainly retrospectively selected from the prospective database. Few patients were prospectively taken, also consecutively, during the period of the data collection (four weeks between June and July 2022). Mean Thoracic Cobb angle was 30.1º ± 16.3; Mean Lumbar Cobb angle 25.1º ± 12.6. Mean values SRS 22 P 4.35 ± 0.58; MH 3.99 ± 0.60; SI 3.71 ± 0.67; F 4.51 ± 0.43; ST 4.06 ± 0.67. Thirty-eight patients full filed the TAPS, with a mean total TAPS of 3.47 ± 0.64; TAPS Dorsal 3.24 ± 0.80; TAPS FF 3.75 ± 0.79; TAPS Ventral 3.51 ± 0.76. We did look at the correlation between radiological values and SRS-22 and TAPS values. The main characteristics of the study population were described using mean and standard deviation (SD). The variables of interest and the characteristics of the sample have been described using descriptive statistics. The possible relationship between the variables was analyzed using the Pearson and Spearman correlation coefficients. All analyses were performed using R Statistical Software (version 4.1.3).
Results: We did not find any significant correlation between the Thoracic Cobb angle and any of the SRS-22 domains but Function ($r = -0.31$ $p < .05$). There was a moderate negative correlation between the Thoracic Cobb angle and the TAPS total ($r = -0.44$ $p < .05$) and TAPS Dorsal ($r = -0.54$ $p < .05$). Lumbar Cobb angle did not correlate with any of the SRS 22 domains but SI ($r = -0.42$ $p < .05$). Lumbar Cobb angle correlated also with TAPS Dorsal ($r = -0.37$ $p < .05$).
Conclusions: In a population formed exclusively by untreated AIS patients, we have found a moderate correlation between the Cobb angle and the SRS 22 function and Self Image domains, surprisingly, thoracic affecting more Function and Lumbar affecting more Self Image. Thoracic and Lumbar Cobb angle influenced the TAPS dorsal and Lumbar also the TAPS Total, but they did not affect the TAPS Ventral.

O70
Sources of emotional support for scoliosis patients

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Introduction: The emotional impact of Idiopathic Scoliosis (IS) is evident. The diagnosis of scoliosis and corresponding treatment intensify stress levels as patients are often simultaneously navigating an inherently stressful period of life: adolescence. While bracing is an effective treatment in controlling curve progression, it has been linked to feelings of anger, shame, and diminished body image; the psychological impact of bracing helps to explain why adherence is challenging. Peer support has been suggested to increase adherence in braced scoliosis patients, and pursuing social support is an attribute of adherent female scoliosis patients. The purpose of this study was to investigate the sources of emotional support for scoliosis patients and to analyze a program designed to encourage social support, the Scolios-us Mentor Program.
Methods: This study consisted of a cross-sectional survey. The survey included the SRS-22r, BSSQ-Brace, and questions about demographics, mental health, Scolios-us Mentor Program, and general scoliosis experience. The survey was distributed via email to Scolios-us Mentor Program participants and to scoliosis clinicians to provide to their patients. Responses about the Scolios-us Mentor Program and sources of emotional support were analyzed through a series of statistical testing for significant group differences and correlations.
Results: A total of 55 subjects were included in the final analysis, with 31 of those subjects participating in the Scolios-us Mentor Program. The median age was 13 (IQR: 3), and median diagnosis age was 10 (IQR: 4). Our results indicated that scoliosis subjects receive emotional support from several sources, including family (83.6% of subjects), friends (52.7%), support groups (52.7%), and healthcare providers (21.8%). 72.7% of subjects received support from at least two sources. Mental health scores were better for those receiving emotional support from their friends (p=.013), and BSSQ-brace scores trended higher for these subjects but did not reach statistical significance. Increasing importance of social support was associated with joining the Scolios-us Mentor Program (p<.001). No significant differences were noted in BSSQ-Brace or SRS-22r scores between those who participate in the Mentor Program versus those who do not. Interestingly, as program satisfaction increased, BSSQ-Brace scores decreased (p=.012), signifying that the program may be more valuable for those who are experiencing significant brace-related stress (Figure 1). More frequent communication with mentee/mentor trended towards greater program satisfaction but did not reach statistical significance.

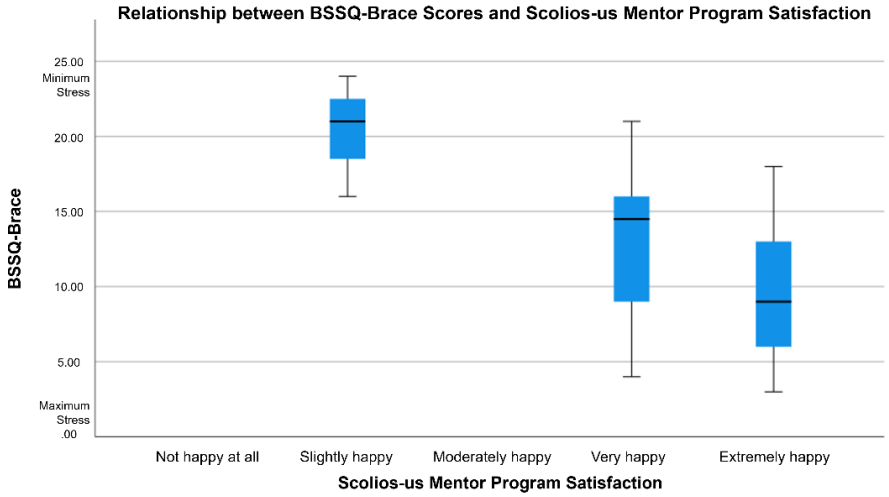

Figure 6: Subjects responded to the question: "Overall, how happy are you with the Scolios-us Mentor Program?" Subjects with increased brace-related stress reported greater satisfaction with the Scolios-us Mentor Program.

Conclusions: Scoliosis patients receive emotional support from different sources, and most receive support from multiple sources. Receiving emotional support from friends may be important for improving mental health and reducing stress while scoliosis patients undergo treatment. The Scolios-us Mentor Program may be a good option for scoliosis patients who value social support and are struggling with brace-related stress.

O71

Cross-cultural adaptation and psychometric properties of the traditional Chinese version of the Italian spine youth quality of life (ISYQOL) questionnaire

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Introduction: Adolescent idiopathic scoliosis (AIS) may adversely affect the health-related quality of life (HRQOL) of teenagers. Therefore, it is important to use validated HRQOL questionnaires to monitor the HRQOL in these individuals. A recently developed Italian Youth Spine Youth Quality of Life (ISYQOL) questionnaire, which contains 13 items applicable to all patients and 7 items for those with a brace, has demonstrated good psychometric properties for measuring HRQOL in children with AIS, and has been translated into multiple languages. This study aimed to culturally adapt this questionnaire to traditional Chinese in Hong Kong and to evaluate its psychometric properties.

Methods: The original ISYQOL was translated into traditional Chinese using the established forward-backward translation method. An expert panel of scoliosis experts and translators was formed to verify the semantic and conceptual equivalence of the translated questionnaire. The backward translated questionnaire was then sent to the original developer for comment prior to refining the questionnaire. Three adolescents with AIS with and three without brace tried the questionnaire to verify their understanding of the translated items. Then, a consecutive sample of 99 female and 34 male conservatively treated volunteers (mean age 13.9$\pm$2.1 years; Table 1) were recruited from a scoliosis clinic in Hong Kong to complete the translated ISYQOL (ISYQOL-TC) and the Chinese version of the Scoliosis Research Society-22 refined (SRS-22r) questionnaires, 9-item Patient Health Questionnaire (PHQ-9), 7-item Generalized Anxiety Disorder scale (GAD-7), and 11-item numeric pain rating scale (NPRS). The participants repeated the ISYQOL-TC and SRS-22r two weeks later to evaluate the test-retest reliability. Cronbach's alpha, Rasch measurement models, and intra-class correlation coefficients ($ICC_{3,1}$) were used to evaluate the internal consistency, unidimensionality, and test-retest reliability of the ISYQOL-TC, respectively. Pearson correlation coefficients were used to quantify the concurrent validity with the SRS-22r, convergent validity with PHQ-9, GAD-7, and NPRS, and discriminant validity with the Simplified Coping Style Questionnaire (SCSQ).

Results: The ISYQOL-TC demonstrated good internal consistency (Cronbach's alpha 0.90 and 0.89 for the items 1-13 (for those without brace, n=76) and items 1-20 (for participants with brace, n=57), respectively). Test-retest reliability was excellent ($ICC_{3,1}$=0.95; standard error of measurement ranging from 1.25 to 1.49; minimal detectable change with 95% confidence ranging from 3.47 to 4.14). The Rasch analysis showed that ISYQOL-TC displayed unidimensionality for the first 13 used in all patients and for all 20 items used with bracing. The ISYQOL-TC showed satisfactory correlation with the SRS-22r total (r=0.65; $P < 0.05$; Table 2). The ISYQOL-TC scores showed significant but weak negative correlations with PHQ-9, GAD-7, and NPRS scores (r=-0.34 to -0.43; $P < 0.05$; Table 4), Conversely, ISYQOL-TC scores did not discriminate between different SCSQ scores.

Conclusions: The ISYQOL-TC is semantically and conceptually consistent with the original ISYQOL. It displayed good internal consistency and test-retest reliability. The ISYQOL-TC total scores were moderately correlated with SRS-22r scores. It also demonstrated satisfactory construct validity. Therefore, ISYQOL-TC is suitable for evaluating HRQOL in teenagers with AIS who read traditional Chinese. Future prospective studies should evaluate the responsiveness of ISYQOL-TC in Chinese teenagers with AIS.

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Table 1. Demographics and clinical data of participants at the first visit (N=133)

	All participants	No brace (n = 76)	Brace (n = 57)
	Mean ± standard deviation (SD)	Mean ± standard deviation (SD)	Mean ± standard deviation (SD)
Age (years)	13.9 ± 2.1	14.2 ± 2.1	13.7 ± 1.8
Sex (n female, percentage)	93 (69.9%)	50 (65.8%)	42 (85.7%)
Height (cm)	153.6 ± 13.1	154.3 ± 13.5	153.9 ± 11.9
Weight (kg)	43.0 ± 4.2	42.9 ± 4.2	43.9 ± 3.8
Number of females (percentage)	n = 99 (74.4%)	n = 49 (64.5%)	n = 50 (87.7%)
Thoracic Cobb angles, mean ± SD	24.5° ± 10.4° (n=118)	24.5° ± 10.9° (n=71)	25.8° ± 9.6° (n=47)
Thoracolumbar Cobb angles, mean ± SD	25.1° ± 9.6° (n=79)	25.1° ± 11.0° (n=44)	25.4° ± 8.5° (n=35)
Lumbar Cobb angles, mean ± SD	32.7° ± 16.5° (n=16)	32.4° ± 18.5° (n=12)	34.7° ± 9.5° (n=4)
Brace wearing	n = 57 (42.9%)	n = 57 (42.9%)	n = 57 (42.9%)
ISYQOL Rasch scores (%)	61.25 ± 15.60	62.85 ± 18.11	59.11 ±11.23
SRS-22r	94.62 ± 8.84	96.06 ± 1.90	92.78 ± 8.08

N= number of…, SD = standard deviation

Table 2. Spearman's rho correlation between ISYQOL scale Rasch scores and SRS-22r scores, SCSQ, PHQ-9, GAD-7, GAD-7 Difficulty level, MAS, PSS and NPRS

ISYQOL domains (%)	SRS-22r domains					
	Function	Pain	Self-image	Mental health	Satisfaction	Total
ISYQOL Rasch scores	0.38**	0.39**	0.59**	0.58**	0.22**	0.65**
	SCSQ-A	SCSQ-P	PHQ-9	GAD-7	GAD -7 Difficulty	NPRS
ISYQOL Rasch scores	0.01	-0.18	-0.38**	-0.42**	-0.34**	-0.43**

ISYQOL = Italian Spine Youth Quality of Life questionnaire; SRS-22r = Scoliosis Research Society-22 revised questionnaire; SCSQ-A = Simplified Coping Style Questionnaire-Active; SCSQ-A = Simplified Coping Style Questionnaire-Passive; PHQ-9 = Patient Health Questionnaire-9; GAD-7 = General Anxiety Disorder-7; GAD-7 Difficulty = General Anxiety Disorder-7 Difficulty level; MAS = Mastery Scale; NPRS = Numeric Pain Rating Scale; *Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

O72

What's sore about scoliosis? A prospective cohort study correlating prom's, radiographic measurements, and surface topography with pain

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Introduction: Up to 77.9% of patients with adolescent idiopathic scoliosis (AIS) report pain, and pain improvement after surgery has been positively correlated with patient reported self-image. Literature has not previously compared the correlations of patient appearance and patient perception of their appearance with pain.

Aim: The primary goal of this study is to correlate surface topographic (ST) measurements, radiographic measurements, and patient reported outcomes measures (PROMs), with Scoliosis Research Society (SRS)-22R pain domain and Patient-Reported Outcomes Measurement Information System Pain Interference (PROMIS-PI) for individuals with AIS.

Patients and Methods: Patients between 11-21 years old with AIS completed the SRS22R and PROMIS 1.0 questionnaires. Patients underwent radiography using EOS scanners and then ST imaging data was obtained from a whole-body surface topographic scanning system. The five variables with the highest univariate correlations to SRS22R pain domain or PROMIS-PI and three discrete variables (sex, scoliosis severity, and primary curve location) were entered into stepwise multivariate linear regression models ($p<0.05$ to enter, $p>0.1$ to remove) to predict SRS-22r pain or PROMIS-PI.

Results: 149 patients with AIS (64.4% female, mean age 14.5 ± 2.0 years, and body mass index of 20.6 ± 4.1 kg/m2) were included in the study. The mean PROMIS-PI was 42.2 ± 10.0 and SRS-22r Pain was 4.4 ± 0.6.

Univariate analysis demonstrated strong correlations between PROMs and SRS22R pain domain and PROMIS-PI, specifically SRS22R self-image and function domains. Some ST and radiographic measurements showed significant, albeit weak, correlations with SRS22R pain domain or PROMIS-PI (table 1). The most correlated ST measurement, anteroposterior centroid displacement, was weakly correlated with SRS22R pain domain and PROMIS-PI.

A stepwise multivariate model with inputs of 3 discrete variables and the five highest univariate correlated variables with SRS-22r pain domain utilized SRS22R self-image domain, body mass index, SRS22R function domain, SRS22R management domain, and sex to create a model strongly correlated with pain ($R=0.711$, $R2=0.505$, $N=138$, table 2).

A stepwise multivariate regression model for PROMIS-PI, with inputs including three discrete variables and the five highest univariate correlated variables only utilized SRS22R self-image domain and SRS22R function domain to create a model strongly correlated with PI ($R=0.687$, $R2=0.463$, $N=124$, table 2).

Conclusion: PROMs, specifically SRS22R self-image and SRS22R function domains, are strongly correlated with the SRS22R pain domain and PROMIS-PI. Most radiographic parameters do not significantly correlate to the SRS22R pain domain or PROMIS-PI. Some ST measurements have a weak but significant correlation with patient reported pain measures of pain.

Patient reported outcomes of pain in AIS may be better explained by patient reported loss of function and self-image than by radiographic or surface topographical measurements.

Table 1. The three highest univariate correlation coefficients between EOS pose ST measurements and SRS pain domain or PROMIS-PI.

Measurement	r-SRS22R Pain Domain	r-PROMIS PI
Maximum AP Centroid Displacement	-0.357**	0.260**
Principal Axis Maximum Rotation	-0.184*	0.221**
Shoulder Volume Asymmetry	-0.077	0.169*

r: Pearson Correlation Coefficient; SRS: Scoliosis Research Society; PROMIS PI: Patient-Reported Outcomes Measurement Information System Pain Interference; AP: Anteroposterior

Table 2. The 5 highest univariate correlations with pain or PI amongst demographic variables, ST, radiographic measurements, and PROM's.

	SRS22R Pain Domain		PROMIS Pain Interference	
	Variable	r	Variable	r
PROMs	SRS Self Image	0.565	SRS Self Image	-0.623
	SRS Function	0.518	SRS Function	-0.557
	SRS Management	0.417	SRS Mental Health	-0.465
	SRS Mental Health	0.379	TAPS	-0.385
			PROMIS Global Health	-0.352
Demographic	BMI	-0.422	N/A	

SRS: Scoliosis Research Society, PROMIS: Patient Reported Outcome Measurement Information System, PROMs: Patient Reported Outcome Measures; r: Pearson Correlation Coefficient; TAPS: Trunk Appearance Perception Questionnaire

O73

Differences in LBP in adults with and without scoliosis: Results of a systematic review

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Introduction: There is a paucity of evidence to differentiate the features of low back pain (LBP) in adults with scoliosis compared to those without scoliosis. Therefore, there is a need to better identify the features of LBP in adults living with scoliosis to distinguish whether scoliosis is the underlying cause of LBP. Understanding the features of LBP in this group would have clinically relevant outcomes related to treatment and prevention of pain. The aim of this study was to check if signs, symptoms, and features of LBP differ between adults with and without scoliosis through a systematic review of the literature.
Methods: We searched CINAHL, EMBASE, PubMed and SCOPUS from database inception to the 30th of September 2022. We included studies that described the features of LBP in adults with scoliosis compared to adults without scoliosis. We also included studies of adults treated during adulthood if they did not receive any treatment in the last six months, and then we only considered baseline information. We also included studies where the authors had excluded participants who had been surgically managed for their scoliosis or LBP during growth. We excluded studies if the scoliosis was not likely related to idiopathic or degenerative scoliosis. We included original peer-reviewed primary research articles with a population of adults with scoliosis, with no limitations for study design.
Results: From 7473 titles we selected 88 abstract and finally included 12 papers. Four papers (4092 patients) were controlled: two were prospective controlled studies, one was a retrospective cohort study, and one was a cross-sectional study. The other eight (1072 patients) papers were not controlled. The overall quality was good, with respect to the type of design. We included the percentage of signs, symptoms, and associated features of LBP in adults with and without scoliosis. Cruralgia was more prevalent in adults with scoliosis, compared to adults without scoliosis, and ranged from 14% to 26% compared to 6.3% to 12% respectively. Inguinal pain was reported in 30% of adults with scoliosis compared to 6% of adults without scoliosis. There is some evidence that adults with LBP with scoliosis can be distinguished from adults with LBP without scoliosis by more advanced age and a greater proportion of women.
Conclusions: There are differences in the reported signs, symptoms, and associated features of LBP in adults with and without scoliosis. Adults with LBP and scoliosis are more likely to be older females, and report pain radiating beyond the LBP, compared to adults without scoliosis. More and better-quality research with coherent outcomes is needed.

O74

Don't hang up the cleats yet: Predicting physical activity levels in scoliosis patients with surface topography

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Introduction: Children with adolescent idiopathic scoliosis (AIS) experience structural spinal deformity, but the impact of AIS on physical activity is not widely studied. Reports of physical activity levels between children with AIS and their peers are mixed, with some reports indicating children with AIS exercise less than their unaffected peers while other reports have found no difference This study utilized surface topographic imaging (ST) to quantify bending and twisting range of motion (ROM) measurements in all three planes, and asymmetry of these bending movements in the coronal and axial planes.

Methods: Patients aged 11-21 completed self-reported measures of physical activity using the Hospital for Special Surgery Pediatric Functional Activity Brief Scale (HSS Pedi-FABS) and PROMIS Physical Activity questionnaires. Radiographic measures were obtained from EOS radiographic imaging. ST imaging data was obtained using a whole-body ST scanning system, while ROM and asymmetry during bending measurements were computed using an automated analysis pipeline. Hierarchical linear regression models were built to analyze the relationship between physical activity, ST, and radiographic deformity while controlling for age and body mass index (BMI).

Results: 149 patients with AIS (mean age 14.5±2.0 years) were included in this study. Using hierarchical regression analysis, Cobb angle was unable to predict either physical activity measure, all factors were non-significant predictors. The model accounted for 1.7% of the variance in physical activity measured through Pedi-FABS as a result of change in Cobb angle (r^2=0.017) and 1.4% of the variance in physical activity measured through PROMIS Physical Activity (r^2=0.014) as a result of change in Cobb angle. When assessing the role of ST ROM measurements in patient reported physical activity levels, age and BMI served as covariates. No covariates were significant predictors and no ST range of motion measurements were significant predictors of physical activity levels for either activity measure. Surface topographic ROM accounted for 3.9% (r^2=0.039) of the variance in physical activity measured by HSS Pedi-FABS and 3.7% (r^2=0.037) of the variance in PROMIS Physical Activity, respectively. Individual breakdowns of ST measurements can be found in Table 1.

Conclusions: Physical activity levels of patients with AIS were not predicted by levels of radiographic deformity or surface topographic range of motion. Although patients may experience severe levels of structural deformity and range of motion limitations, these factors do not prevent them from participating in physical activity at similar levels to their peers.

Table 1, Predicting self-reported physical activity

1A: Predicting HSS Pedi-FABS

Variable	Standardized Coefficient (Beta)	Significance (P)
Cobb Angle	-0.012	0.162
Axial Twisting	-0.025	0.832
Axial Twisting Asymmetry	-0.114	0.337
Lateral Bending	-0.018	0.875
Lateral Bending Asymmetry	-0.031	0.798
Forward Bending	0.006	0.954

1B: Predicting PROMIS Physical Activity

Variable	Standardized Coefficient (Beta)	Significance
Cobb Angle	-0.077	0.386
Axial Twisting	0.018	0.884
Axial Twisting Asymmetry	-0.037	0.762
Lateral Bending	-0.141	0.215
Lateral Bending Asymmetry	-0.112	0.334
Forward Bending	-0.077	0.465

O75

Is thoracic hyper-kyphosis deformity relevant to pain, autonomic nervous system function, disability, and cervical sensorimotor control in patients with chronic nonspecific neck pain?

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Introduction: There is great interest in the sagittal configuration of the thoracic spine as it relates to pain, disability, and cervical spine alignment. However, investigations rarely define limits of hyper-thoracic kyphotic deformity as cut-off values to discriminate between pain populations. Further, the thoracic kyphosis is thought to be a contributor to neck pain, neck disability, and sensorimotor control measures, though this has not been completely investigated in treatment or case control studies.
Methods: This case control design investigated participants with non-specific chronic neck pain. Ethical approval was obtained from the Research and Ethics Committee our University (CA-REC-22-5-20), with informed consent obtained from all participants prior to data collection. Eighty participants with a defined hyper-kyphosis (> 55°) were compared to 80 matched participants with normal thoracic kyphosis (< 55°). Participants were matched for age and neck pain duration. Posture measures included formetric thoracic kyphosis and the craniovertebral angle (CVA) to assess forward head posture. Sensorimotor control was assessed by the following measures: smooth pursuit neck torsion test (SPNT), overall stability index (OSI) and left and right rotation head repositioning accuracy (HRA). A measure of autonomic nervous system function included the amplitude and latency of skin sympathetic response (SSR). Differences in variable measures were examined using the Student's t-test to compare the means of continuous variables between the two groups. Pearson correlation was used to evaluate the relationship between participant's thoracic kyphosis magnitude (in each group separately and as an entire population) and their CVA, SPNT, OSI, HRA, and SSR latency and amplitude.
Results: The distribution of the thoracic kyphosis for both groups is shown in **Figure 1**. Hyper-kyphosis participants had a significantly greater neck disability index compared to the normal kyphosis group ($p < 0.001$) even though both groups were matched for neck pain duration and intensity. Statistically significant differences between the two kyphosis groups for all the sensorimotor measured variables were identified with, decreased efficiency of the measures in the hyper-kyphosis group, including: SPNT, OSI and left and right rotation HRA ($p < 0.001$). Also, there was a significant difference in neurophysiological findings for SSR amplitude ($p < 0.001$), but there was no significant difference for SSR latency ($p = .07$). The CVA was significantly greater in the hyper-kyphosis group ($p < 0.001$). The magnitude of increased thoracic kyphosis correlated with worsening CVA and the magnitude of the decreased efficiency of the sensorimotor control measures and the amplitude and latency of the SSR. **Table 1** shows these correlations.
Conclusion: This case control on chronic neck pain populations, identified that those with hyper-kyphotic deformity also have an increased FHP and that this is related to abnormal autonomic nervous system function. Furthermore, increased thoracic kyphosis is correlated to disturbances of a variety of sensorimotor control measures. Our findings have important implications for the assessment and rehabilitation of patients with hyper-kyphotic deformity of the thoracic spine, increased forward head posture, and chronic non-specific neck pain.

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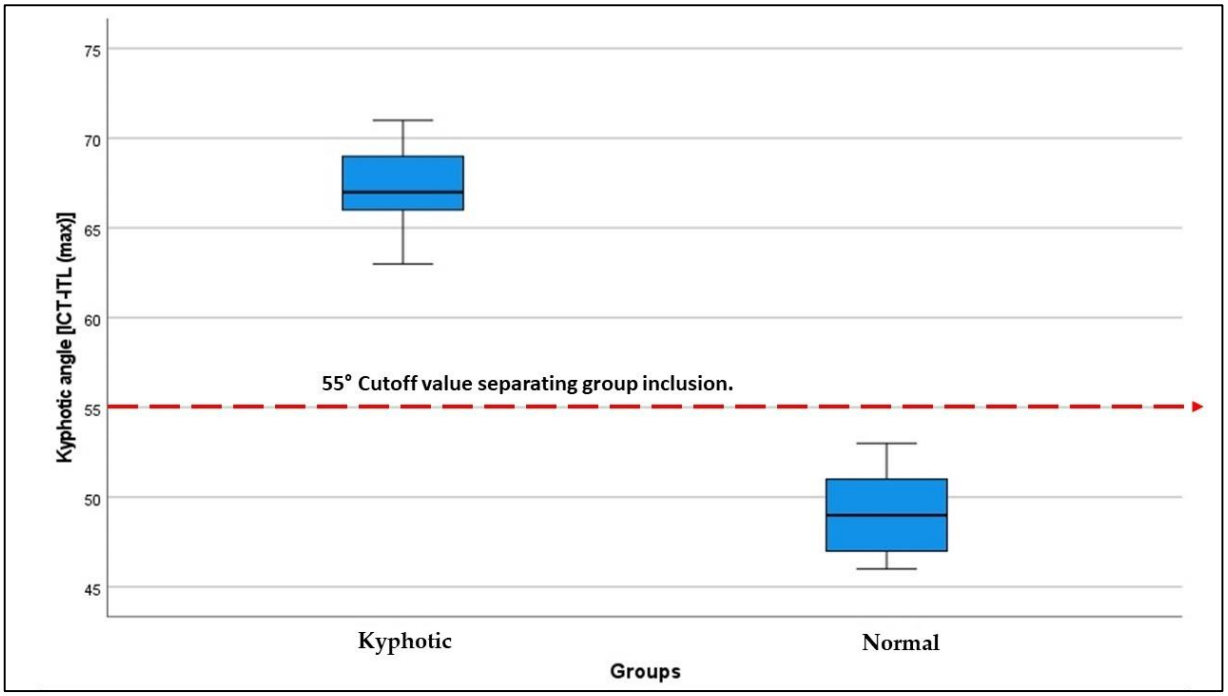

Figure 1. Box and whisker plots of the magnitude of thoracic kyphosis, ICT-ITL (max), in both the hyper-kyphotic (kyphotic, 67° ± 4) and the normal kyphosis (control, 49° ± 3) groups. A statistically significant difference for these variables between groups was forced by study design where 55° (shown as red-dashed line) was the absolute cutoff for kyphosis between groups.

Table 1. Correlations (Pearson's *r*) between the kyphotic angle and measured outcomes in both groups and entire sample.

Correlation between variables	**Kyphotic group *r* (*p* value) n=80**	**Normal group *r* (*p* value) n=80**	**Entire sample *r* (*p* value) n=160**
CVA	-0.7 (<0.001)	-0.51 (<0.001)	-0.61 (<0.001)
NDI	0.58 (<0.001)	0.51 (<0.001)	0.67 (<0.001)
Pain intensity (NRS)	0.30 (0.040)	0.34 (0.043)	0.53 (<0.001)
Smooth pursuit neck torsion test	0.51 (<0.001)	0.50 (<0.001)	0.58 (<0.001)
Overall stability index	0.67 (<0.001)	0.52 (<0.001)	0.59 (<0.001)
Head repositioning accuracy (Right)	0.63 (<0.001)	0.61 (<0.001)	0.74 (<0.001)
Head repositioning accuracy (Left)	0.61 (<0.001)	0.61 (<0.001)	0.71 (<0.001)
Sympathetic skin resistance amplitude	0.67 (<0.001)	0.61 (<0.001)	0.69 (<0.001)
Sympathetic skin resistance latency	-0.3 (0.040)	-0.36 (<0.001)	0-.49 (<0.001)

CVA= Craniovertebral angle; NDI = neck disability index; NRS = numerical rating scale.

O76

Adherence to physiotherapeutic scoliosis specific exercises during adolescence: Voices from patients and their families. A qualitative content analysis

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Introduction: Physiotherapeutic Scoliosis Specific Exercises (PSSE) have shown promising results in the conservative treatment of adolescents with spinal deformities. In fact, PSSEs are effective in avoiding brace prescription or spinal curvatures exceeding a Cobb angle of 29° at the end of growth. Naturally, PSSE efficacy largely relies on patients' adherence to the prescribed program. Adherence in physiotherapy is a multi-dimensional concept that includes appointment attendance, frequency of undertaking prescribed exercises, and correct performance of exercises. Adherence is the result of the interactions of factors related to the treatment, the patients, their families, and the healthcare providers. Therefore, identifying factors that sustain or prevent adherence to PSSE is crucial to maximising the outcome that adolescents can get from their treatment.
Aim: The purpose of this study was to explore the experience with PSSE of adolescents with spinal deformities and their parents, and their insight on how to assess the quality and frequency of the PSSE performed at home. This study constitutes the exploratory phase of the development of a new Rasch-consistent questionnaire to assess adherence to PSSE in adolescents with spinal deformities.
Methods: Data were collected anonymously through an online survey with open-ended questions investigating personal thoughts and experiences about adherence to a home-based PSSE program. Specifically, participants were asked what could hinder and what could facilitate PSSE compliance. The survey was sent to patients and their parents attending an outpatient tertiary referral clinic that specialized in the conservative treatment of spinal deformities. The qualitative formal content analysis was conducted on the collected data via MAXQDA 22.2.1 software.
Results: We sent 2699 emails and received the answers from 110 adolescents (mean age 14.3 ± 4.5 years, 91 female) and 93 parents (mean age 48.7 ± 4.5 years, 75 female). We analysed approximately 7500 words of written text. Forty-one primary codes were detected and ascribed to 5 main categories: "Understanding therapy goals", "Loneliness", "Exercises characteristics", "Time and space organization", and "Helpful tools". In each category, codes were divided into two sub-categories: facilitating and hindering factors. Among the facilitating factors, the most commonly reported were the use of a specifically-developed app, listening to preferred music while performing the exercises, free scheduling of the home sessions, and exercise characteristics (i.e., easy exercises, fun exercises, exercises that do not require specific tools). Among the hindering factors, the most commonly reported were the lack of time, lack of motivation, lack of feedback from the physiotherapist, and exercises characteristics (i.e., boring exercises).
Conclusions: The findings of this qualitative study show that patients and their families are aware of what can help or interfere with adherence to a home-based PSSE program. The possibility of programming the PSSE session according to the patient's schedule is a huge advantage, but it requires careful planning. Further, the lack of company or supervision may discourage patients. Listening to their insight on hindering and facilitating factors can help physiotherapists to develop exercise programs tailored to the specific needs of patients and provide solutions and strategies to common difficulties.

O77

The effect of scoliosis-specific exercises on quality of life in adolescents idiopathic scoliosis vary with program duration and baseline curve severity: A meta-regression

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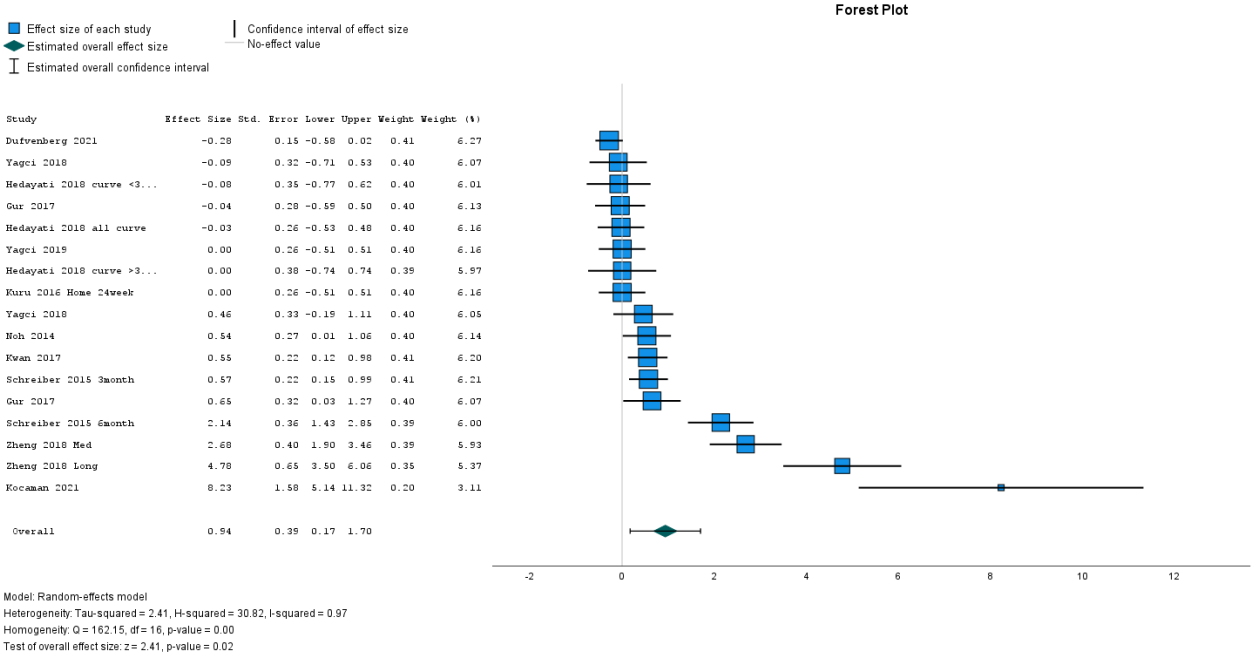
Introduction: SOSORT guidelines recommend Scoliosis-specific exercises (SSE) alone or with bracing for adolescents with idiopathic scoliosis (AIS). Reviews support using SSE but there is variability about the magnitude of their effect on quality-of-life scores. We hypothesized that the effect may vary with the program duration, mean age at baseline or mean initial curve severity among studies. The aim of this review was to determine if these study characteristics influence the effect of SSE on quality-of-life scores in AIS.
Methods: Pubmed was searched from inception to August 2022 to find case series, cohort, controlled trials or systematic reviews on SSE in AIS using the therapy clinical filter. Included studies focused on more than 10 participants with AIS, reported the effect SSE on a quality-of-life score. We excluded studies on participants treated with surgery, other diagnoses, or where adults or juveniles made up most of the sample. After completing 3 extractions with supervision, two evaluators extracted the following information: design, number of participants, baseline age, baseline curve severity, exercise type, treatment description, program duration, and compliance. Quality-of-life scores were extracted for baseline and all follow-ups. Random-effects meta-analysis and meta-regression were used with a restricted Maximum Likelihood (REML) estimator to determine the effect of the three study characteristics on Cohen's d effect size.
Results: Complete data was extracted from 17 SSE groups from 11 studies for TOTAL QOL. A significant large effect size on Total QOL was observed indicating improvement (0.94 95%CI 0.17;1.70) (Fig.1) but heterogeneity was important (I^2 =0.97). In a meta-regression, curve severity related to the effect of SSE on Total QOL more than program duration (Fig 2A) Curve severity explained little of the heterogeneity (I^2 97.1%, R^2 31.7%).
Fifteen SSE groups from 9 studies produced a significant moderate effect size showing Pain improvements (0.64 95%CI 0.18;1.10; I^2 =0.91). In a meta-regression, curve severity related to the effect of SSE on Pain more than program duration (Fig 2B). This model explained little heterogeneity (I^2 84.3%, R^2 35.4%).
Sixteen SSE groups from 10 studies produced a significant small effect size showing functional improvements (0.45 95%CI 0.01;0.89; I^2 =0.91). In a meta-regression, SSE program duration related to the effect of SSE on function more than Curve severity (Fig 2C). This model explained little of the heterogeneity (I^2 85.1%, R^2 45.7%).
Fifteen SSE groups from 10 studies reported improved Self-image with a non-significant small effect size (0.46 95%CI -0.08;1.01; I^2 =0.94). Thirteen SSE groups from 8 studies reported improved mental health with a non-significant small effect size (0.32 95%CI -0.07;0.71; I^2 =0.87). Baseline age did not explain heterogeneity for any QOL scores. None of the study characteristics significantly explained heterogeneity in the meta-regression for self-image and mental health.
Conclusions: Despite heterogeneity in published effects, SSE leads to moderate to large significant effect sizes on Total, Pain and Function QOL scores in AIS. Longer programs and smaller curves at baseline were associated with larger effects but baseline age was not related to effect sizes.

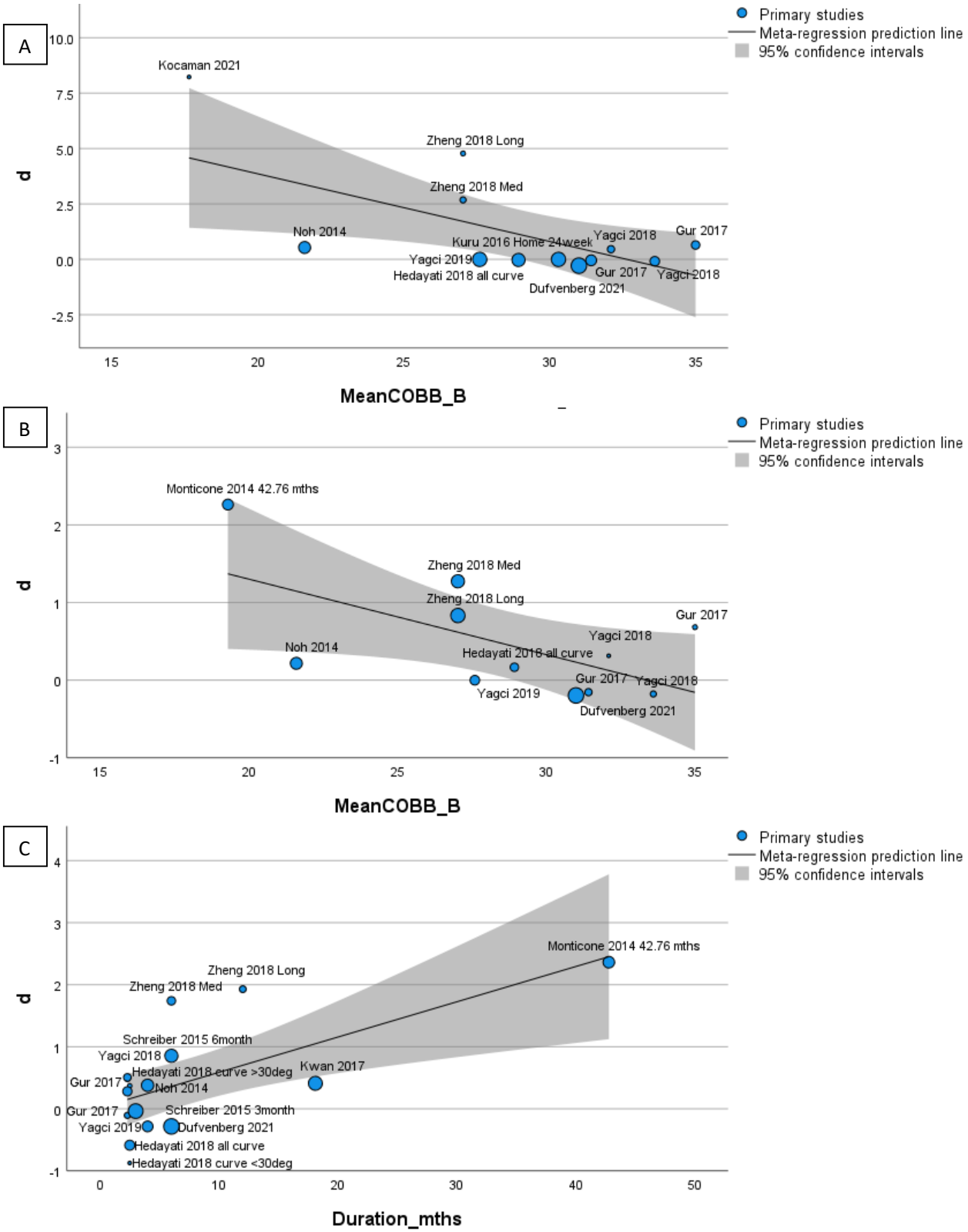
Acknowledgements: C. Cory and J. Concini received Alberta Innovates Health Youth Research Summer Studentships.

Figure 1. Forest plot indicating a large significant meta-analyzed effect size of SSE on Total QOL scores and large heterogeneity (I^2=0.97)



Model: Random-effects model
Heterogeneity: Tau-squared = 2.41, H-squared = 30.82, I-squared = 0.97
Homogeneity: Q = 162.15, df = 16, p-value = 0.00
Test of overall effect size: z = 2.41, p-value = 0.02

Fig 2. Buble plot showing larger effect sizes for A) Total QOL and B) Pain scores in samples with smaller mean Cobb angles and larger effects sizes for C) Function scores in samples with longer SSE program duration.



O78

The effect of scoliosis-specific exercises on curve severity in adolescents idiopathic scoliosis vary with program duration and baseline curve severity: A meta-regression

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Introduction: SOSORT guidelines recommend Scoliosis-specific exercises (SSE) alone or with bracing for adolescents with idiopathic scoliosis (AIS). Reviews support using SSE but there is controversy about the magnitude of their effect on curve severity. The effect may vary with the type of exercises, program duration, mean age at baseline or mean initial curve severity among studies. The aim of this review was to determine if these study characteristics influence the effect of SSE on curve severity in AIS.
Methods: Pubmed was searched from inception to August 2022 to find case series, cohort, controlled trials or systematic reviews on SSE in AIS using the therapy clinical filter. Included studies focused on more than 10 participants with AIS, reported the effect SSE on curve severity. We excluded studies on participants treated with surgery, other diagnoses, or where adults or juveniles made up most of the sample. After completing 3 extractions with supervision, two evaluators extracted the following information: design, number of participants, baseline age, baseline curve severity, exercise type, treatment description, program duration, and compliance. Cobb angle results were extracted for baseline and all follow-ups. We plotted the baseline and follow-up curve severity against mean age at baseline for each SSE sample (Fig.1). Random-effects meta-analysis and meta-regression were used with a restricted Maximum Likelihood (REML) estimator to determine the effect of the four study characteristics on Cohen's d effect size. We first examined covariables as continuous covariables, then dichotomized using 13.5yo, 6m, or 25^0, respectively.
Results: Complete data was extracted from 48 SSE groups (17 Schroth, 9 SEAS, 22 other SSE) from 27 studies. Overall, 1289 participants were included (median=18, range 7; 145). The median sample mean age was 13.5yrs (11.5; 18.14). Mean baseline severity was 26.8^o (10; 35). Median program duration was 6 months (2; 55). Overall, the median difference reported between baseline and follow-up in SSE groups was a mean reduction of 2.4^o and (range -14.1 to 6.3) for an overall significant moderate effect size of -0.66 indicating improvements (95%CI -0.89; -0.43) (Fig.2). Heterogeneity among estimates was important (I^2 =0.91). In a meta-regression using continuous covariables, curve severity but not age, program duration or exercise type (Schroth, SEAS, Other) related to the effect of SSE on curve angles. This model explained little of the heterogeneity (I^2 89%, R^2 7.1%). Using dichotomized study characteristics, program duration ≥6 months (meta-regression estimate= -.481)) and curve severity at baseline of $≥25^o$ (estimate -.870) were significantly related to effect sizes indicating less improvement. This model explained 24.2% of the variance among the effect sizes. Dichotomized baseline age and exercise types did not relate to the effect sizes. Still, heterogeneity remained (I^2=88.7%)
Conclusions: Despite heterogeneity in published effects, SSE leads to statistically significant yet clinically small ($<5^o$) curve reduction in AIS. Longer programs and more severe curves at baseline were associated with smaller effects but baseline age and exercise type were not.

Acknowledgements: C. Cory and J. Concini received an Alberta Innovates Health Youth Research Summer Studentship.

Fig.1 Curve Angle Changes with SSE Depending on Baseline Age, Curve Severity and Program Duration

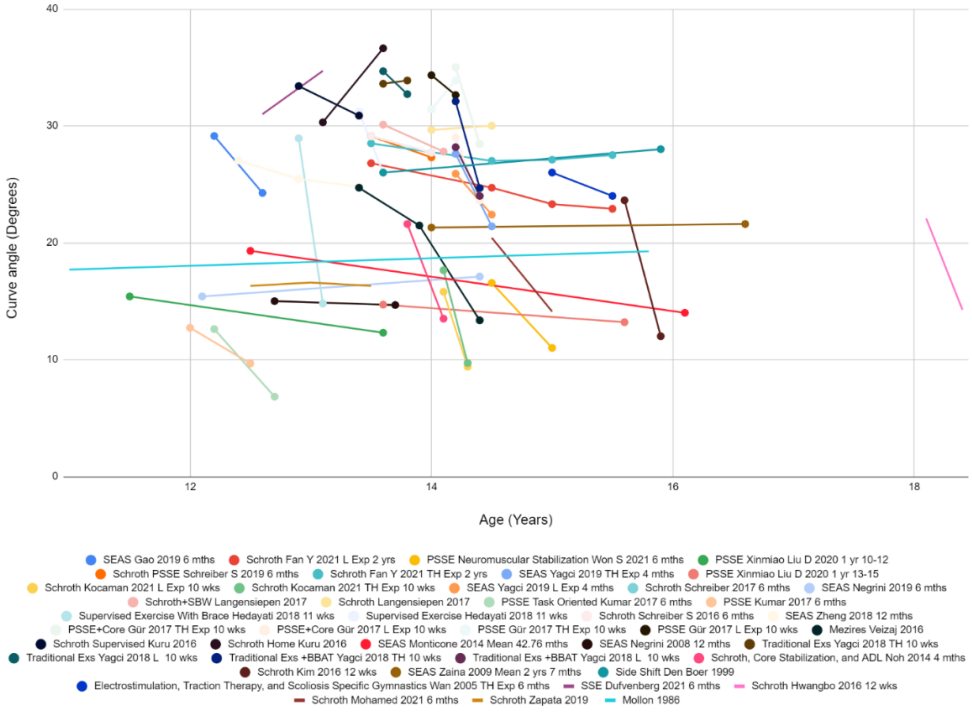
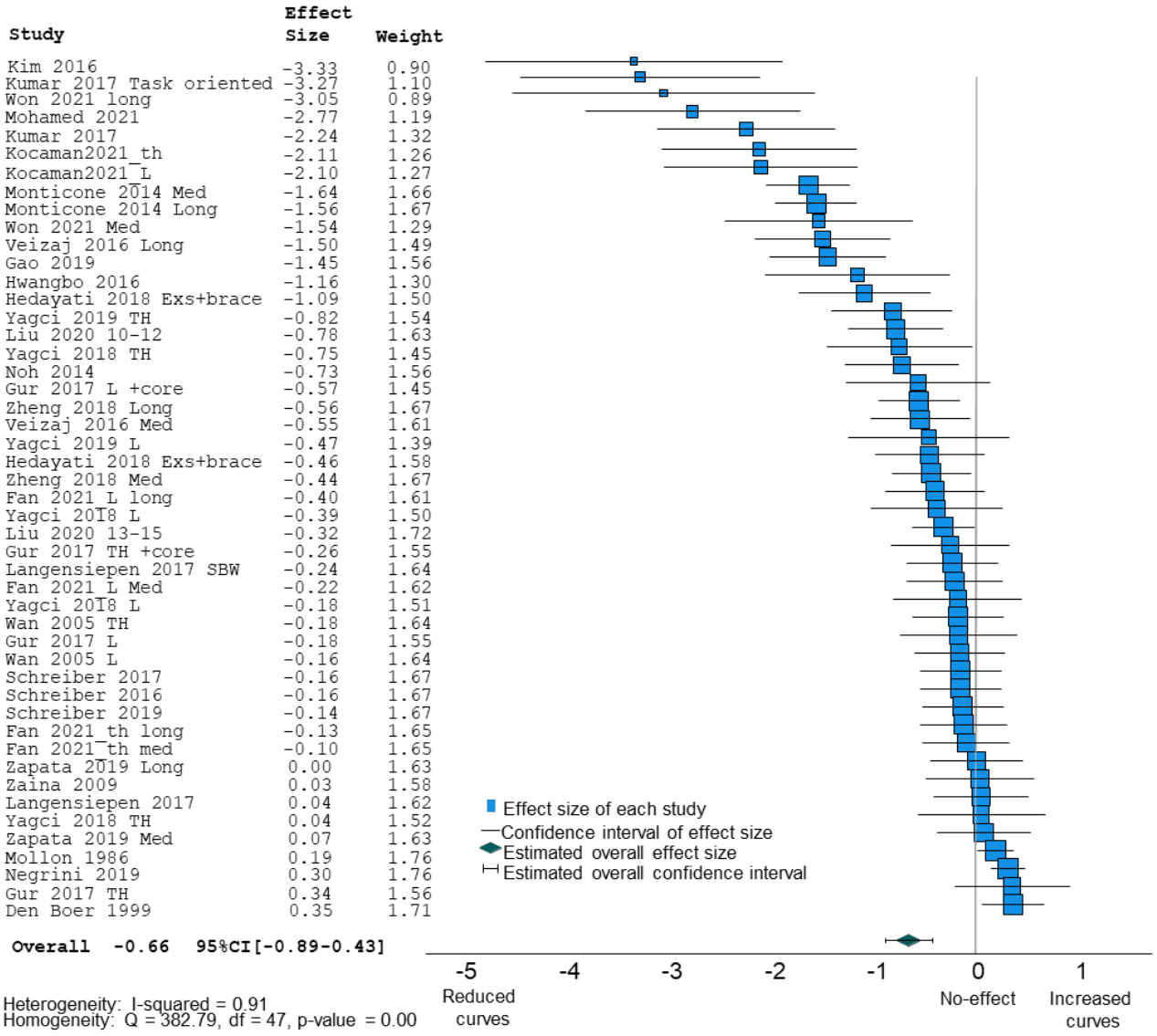


Fig 2. Forest Plot of Cohen d Effect Sizes for Cobb Angles within SSE Groups



Heterogeneity: I-squared = 0.91
Homogeneity: Q = 382.79, df = 47, p-value = 0.00

O79

The effects of physiotherapy scoliosis specific exercise on truncal shift in idiopathic scoliosis: A 12-month follow-up

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Introduction: Truncal shift caused by scoliosis can be measured with a Formetric Scanner using the Maximal Thoracic Apical Deviation (MTAD) measurement. It is a well-documented complaint with regards to body-image in patients with idiopathic scoliosis (IS). Furthermore, thoracic apical deviation is an important measure in pre-operative assessment and post-operative outcomes whereby pre-operatively the focus is on determining fusion segments and post-operatively the focus is to achieve a balanced, central fusion mass without compromising the lumbar motion segments.
Objective: The aim of this retrospective cohort study was to determine the long-term effects of an intensive course of Physiotherapy Scoliosis Specific Exercise (PSSE) on MTAD in patients with IS.
Methods: Consecutive IS patients with a single right-sided thoracic curvature who completed an intensive 4-week course of PSSE were recruited. Data was collected between April 2019 and December 2021. All patients were routinely scanned using a Formetric Scanner pre-, immediately post-, and at 12 months post-treatment. MTAD, measured in millimetres, was documented. Adults (>17 years old) (group 1) and children (group 2) were analysed separately.
Results: In group 1 (n=29) the ages ranged from 18 to 81 with a median age of 34. 90% were female. The average Cobb Angle was 40°. There was a 21.5% improvement in MTAD from 33.2mm pre-treatment to 26.1mm post-treatment ($p<0.05$). At 12 months follow-up, the MTAD was maintained at 26.1mm. This difference was significant compared to pre-treatment ($p<0.05$), but not significant compared to the post-treatment results ($p>0.05$). In group 2 (n=24) the ages ranged from 10 to 17 with a median age of 14.5. 92% were female. The average Cobb Angle was 39.3°. There was a 28.6% improvement in MTAD from 26.4mm pre-treatment to 18.8mm post-treatment ($p<0.05$). MTAD at 12 months follow up was maintained at 18.0mm. This difference was significant compared to pre-treatment ($p<0.05$), but not significant compared to the post-treatment results ($p>0.05$).
Significance and Conclusion: An intensive course of PSSE significantly improved MTAD in both adults and children with IS and the results were maintained at 12 months follow-up. Improving truncal shift may have an effect on patients' body image. Furthermore, the use of PSSE to reduce apical deviation may aid in enhancing surgical decision-making and outcomes. Further research is required into these topics.

O80

Factors that influence how Schroth therapists world-wide implement Schroth for adolescents with idiopathic scoliosis: A qualitative study

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Introduction: Schroth is a type of physiotherapeutic scoliosis specific exercises (PSSE) prescribed to adolescents with idiopathic scoliosis (AIS). The aim of this study was to explore how Schroth therapists navigate the complexity of prescribing exercises for AIS by elucidating the factors that influence exercise prescription in the clinical setting.
Methods: A convenience sample of Schroth therapists world-wide were invited to participate in semi-structured interviews via e-mail to explore the factors that influenced their prescription of Schroth for AIS. Potential participants were eligible if they 1) had completed a survey on Schroth exercise prescription for AIS, 2) treated AIS, 3) were able to communicate in English, and 4) were publicly listed on the Barcelona Scoliosis Physical Therapy School or the International Schroth 3-dimensional Scoliosis Therapy School websites. Interviews were conducted via ZOOM, video recorded, and automatically transcribed. Transcriptions were reviewed by two investigators and then sent to participants for checking. Two investigators analysed the interview transcripts using an inductive thematic approach, with a third investigator available to resolve any disagreements.
Results: Although data saturation was achieved after four interviews, seven participants were conducted. Thematic analysis revealed four inter-related themes describing the factors that influenced Schroth prescription for AIS: 1) *the adolescent as a whole*, which included their physical, emotional, and mental characteristics, preferences, and goals. This theme highlighted how adolescents undergo a complex and critical period of physical and emotional development in the context of their chronic condition whereby they are trying to gain independence; 2) *the adolescent-parent relationship*, which also includes the parent's motivation towards Schroth. This theme emphasised the important role of parents in providing support to adolescents during their journey of undergoing treatment particularly at this critical stage of emotional and physical development; 3) *the systems*, within which Schroth therapy is offered, such as the family's vicinity to the clinic and the presence of financial support provided by the healthcare system. This theme underlined the significance of considering Schroth therapy within a socioeconomic context which was shown to affect clinical decision-making and equitable access to care within the clinic; and 4) *the therapist*, who is the clinical decision-maker but acts within the constraints of their life and clinical experience and training to individualise their prescription of Schroth to the adolescent, relationship to their parent/s, and the health care system in which they operate. The factors that influence Schroth exercise prescription are dynamic across time, such as treatment conducted over time with rapidly developing adolescents, and space such as the country, city, or culture which Schroth therapy takes place. The multi-factorial and dynamic nature of Schroth prescription underscored the complexity of clinical decision-making world-wide.
Conclusion: Schroth therapists prescribing Schroth exercises to AIS consider the complex interplay of intra-, inter- and extra- personal factors in clinical practice. These considerations move beyond the three pillars of evidence-based healthcare, which include research evidence, patient preferences, and clinical expertise, towards a systems-based reflection on exercise prescription.

O81

Trunk Shift Over correction is related to generalised hypermobility

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Introduction: The overcorrected trunk position provides the forces needed to create growth modulation upon the spinal tissues. (Mehta 1984, Stokes et al [1,2]. The ability to do the exercises may have a profound effect upon the effectiveness and outcomes of the technique. It may also define the boundaries of use of the Side Shift technique to scoliosis patients with limited ability to Side Shift. A previous study has validated the use of the Side shift mobility classification [3] demonstrating good Intra-rater, [$\kappa = 0.77$, 95% CI (0.61 – 0.91), $P < 0.01$ reliability and inter-rater reliability [$\kappa = 0.7623$, 95% CI (0.504 - 1.000), $P < 0.01$.

Aim: The aim of this study was to compare the three different catergories of mobility [type 1-flexible, type 2- stiff and type 3- rigid] against the Hypermobility Beighton scale, a generalised standard measure of hypermobility.

Patients and Methods: 58 consecutive patients with a medical diagnosis of AIS were recruited for this study. The patients were categorised. Two different members of the treatment team at the Royal National Orthopaedic hospital were blind to the categorisation of the presenting patients.

Sample size calculations were performed to ensure the study would provide confidence intervals of a desired width. With over 46 patients the study has adequate numbers to detect agreement using the kappa statistic with two-sided 95% confidence intervals of width 0.3.

Results

Table 1 Hyperlaxity score versus Side shift mobility

Side shift mobility types	N	Mean hypermobility score	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Type 1	19	6.26	2.600	.596	5.01	7.52	0	9
Type 2	9	5.33	2.550	.850	3.37	7.29	2	9
Type 3	7	2.14	1.345	.508	.90	3.39	1	4
Total	35	5.20	2.826	.478	4.23	6.17	0	9

A one way analysis of variance (Anova) was calculated on Hyperlaxity score by Side Shift types (see Table 1). This analysis was significant $F(2, 32) = 7.55$, $p<.001$. Posthoc analyses using the Bonferroni post hoc criterion for significance indicated that the average Hyperlaxity score was significantly lower in the Type 3 ($M=2.14$, $SD=1.35$) condition compared to Type 1 ($M=6.26$, $SD=2.6$), $p<.001$. Findings also confirmed that Hyperlaxity score was significantly lower in Type 3 ($M=2.14$, $SD=1.35$) compared to Type 2($M=5.33$, $SD=2.55$) ($p<0.05$). There was no significant difference found between Type 1 ($M=6.26$, $SD=2.6$) and Type 2 ($M=5.33$, $SD=2.55$) ($p>0.05$).

Conclusion: An Analysis of the different categories of the Side Shift Types with Hyperlaxity (hypermobility) demonstrated a significance difference between the different types of Side Shift mobility and generalised Hyperlaxity scores. The average Hyperlaxity score(2/9) for Type 3 (Rigid) was significantly lower than compared to Type 1 (flexible) Side Shift. This indicates that the ability to Side Shift is related to generalised Hyperlaxity scores. The less flexible the subject is, the less is the ability of the subject to Shift the Trunk across the midline.

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O82

The development of United Kingdom National Guidelines for the post operative treatment of AIS. A consensus-based approach from a new Multidisciplinary special interest group

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Introduction: Postoperative therapy for AIS following fusion therapy is a topic with limited known consensus as to what is best practise. We developed a group of experts working within centres of operative care. This group consisted of a mix of therapist occupational and Physiotherapy, Orthotist and Nurses who are closely involved in the provision of care. We followed an adapted Delphi technique/model, with identifying experts, brainstorming, 3 rounds of questionnaires, review and survey distribution. Following this 12 month process we agreed on a timetable and flow of guidelines which we think reflects the needs and opinions and best practice for children following AIS from traditional fusion surgery. We would like to present this as a National Expert consensus on therapeutic/nursing/orthotic guidelines following AIS surgery.
Aim: The purpose of this study was to create a consensus of therapeutic intervention in AIS and Adult scoliosis patients following surgery.
Patients and Methods
The study used a Modified Delphi approach: identifying expert opinion, Brain storming, surveys and 3 rounds of questionnaires. A final document was produced and agreed by the group consensus (90-100%) before dissemination to a wider audience.
Results: Post operative goals for discharge were aimed towards the patient being able;
• Provide pre-operative information given and assessment of post operative needs
• To independently manage bed, chair, pain management, toilet and bath transfers and do stairs by day 5.
• To be able to sit long enough to make the journey home and walk greater than 10 metres unaided by day 5-6.
• 7 days to 6 weeks-postural/curve specific exercises. Functional training (ADL) and exercises
• 6 weeks to 12 weeks- Hydrotherapy and Core/Pilates type; stabilisation- mobility
• 12 weeks to 6 months- swimming- general fitness
• > 1 year - return to all/ normal sports, some Contact, trampoline.
Conclusions: A broad-based consensus was agreed amongst a multidisciplinary group on post operative management of scoliosis. The key post operative factors are pain management, Bowel and bladder management, pre and post operative information and long-term care and exercises. This study has helped to develop a multi-disciplinary National consensus to the approach of post operative management of teenagers with AIS. This study has also help develop shared processes and information from other regional and National Hospitals that treat Scoliosis We hope that this can provide a reference to ensure equitable and consistent treatment within the UK.

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O83

Possible implications of pediatric chest wall surgeries on the risk of development of spinal deformities

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Introduction: The relationship between early childhood thoracic surgery and onset of scoliosis is poorly understood. The clinical guidance regarding the treatment of scoliotic curves for patients that have undergone thoracic surgery is similarly lacking. The clinicians addressing this population can benefit from greater clinical context as to how the co-occurrence of these diagnoses can impact the course of treatment. A meta-analysis of the current body of literature was conducted to clarify the relationship between childhood thoracic surgery and the risk of scoliosis development.
Methods: A review of PubMed digital library was conducted using the search terms “scoliosis,” “thoracotomy,”” sternotomy,” “congenital heart disease,” and “CDH.” 13 studies published 1993-2020 were identified for inclusion.
Results: 9 publications identified a significant correlation between surgical history and scoliosis risk. The range of prevalence of the scoliotic curves varied between 66% and 6.6%, with mean scoliotic prevalence at 36.14%. One study reported outcomes in the non-operative and operative groups described by the same diagnosis as experiencing 55% and 15% incidence of scoliosis, respectfully. Conversely, 3 studies reported insignificant correlation between the surgeries performed and scoliosis risk, with a high of 2.8% and a low of 1.1%.
Conclusions: The current body of literature suggests that early pediatric thoracic surgical procedures increase the risk of developing scoliosis, and that the scoliotic curves may have clinically relevant distinctions from those described by the Idiopathic Scoliosis diagnosis. The estimation of risk is complicated by a significant discrepancy of the prevalence of scoliosis in the post-surgical groups. Additional context as to the correlation between specific diagnoses or procedures and scoliotic curve risk, type, and progression potential can be beneficial to the detection and the improvement of the clinical outcomes for those experiencing scoliosis symptomology. Further exploration of this relationship appears as warranted.

O84

Bracing and physiotherapy in the conservative management of adolescent idiopathic scoliosis during growth: A survey of current practices across the UK and Ireland

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Background: Adolescent Idiopathic Scoliosis (AIS) constitutes approximately 80% of all scoliosis. Curve magnitude progression is most prolific during rapid growth phases (age 10 – 13 years). Literature documents that bracing is effective in halting curve progression in mild to moderate curves (Cobb angle 20˚-40˚(+/- 5˚)). Physiotherapeutic Scoliosis-Specific Exercise (PSSE) is recommended as a treatment to prevent or limit curve progression and the need for bracing in mild curves. When bracing is required, PSSE is suggested to improve brace compliance; facilitate spinal mobility for brace preparation; assist curve stabilisation during brace weaning. These recommendations are made within the Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) 2016 guidelines.
Aim: To survey current conservative treatment practices across the UK and Ireland, and compare to the SOSORT guidelines.
Method: A virtual survey was conducted across all major public healthcare Hospitals as part of a scoping project. A mixture of Extended Scope Practitioners, Nurse Practitioners, Orthotists and Physiotherapists were contacted. A series of questions were asked around whether they offered bracing, whether this was routinely offered, what the criteria was, and what type of brace was provided. A further series of questions were asked around whether PSSE was offered, what type of PSSE was provided, what the criteria was for referring for PSSE and whether PSSE was offered alongside brace treatment.
Results: 20 centres were contacted, 16 responded (80%), 1 each from Ireland, Northern Ireland, Scotland, Wales, and 12 from England. 81% (n=13) of responding centres followed the SOSORT guidelines and criteria for routine bracing of mild to moderate curves. 19% (n=3) of centres offered non routine bracing, dependent upon consultant/clinician preference. 50% (n=8) of centres offered 'Boston type' as their brace of choice, however 38% (n=6) of centres had moved on from Boston and offered 'Chenêau style' bracing. The remaining 13% (n=2) of centres offered a mixture of both, but with a bias still towards the Boston.
Only 13% (n=2) of centres offered PSSE to halt curve progression or to support bracing. However 19% (n=3) of centres had recently trained therapists in Schroth Best Practice PSSE, and were in the process of developing their pathways. 2 centres referred for Schroth PSSE privately.
Conclusion: Most responding centres followed the SOSORT guidelines, using bracing to manage curve progression. Boston bracing is still the most prevalent brace used, but there appears to be a movement towards Chenêau style corrective bracing. Future research could assess the impact of Chenêau style bracing on curve progression versus Boston.
The results of this survey suggest most centres are not using PSSE either as a stand-alone treatment in mild curves or in conjunction with bracing. Future research could assess the impact of increased PSSE with or without bracing on curve progression.

O85

Effect of muscle fatigue of the thoracic erector spinae on neuromuscular control in people with adolescent idiopathic scoliosis

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Introduction: Adolescent idiopathic scoliosis (AIS) alters the spinal alignment which may impair the stability and dynamics of the intervertebral movements. These may also increase the demand of active muscle work for functional task execution. The long-term unbalanced compensatory neuromuscular control between the convex side (AIS_{convex}) and concave side ($AIS_{concave}$) of the spine may contribute further to the asymmetrical activation and histological composition of the paraspinal muscles. To understand the essential role of paraspinal muscle endurance in postural stability, this study aimed to investigate the spinal alignment and neuromuscular control during upper limb elevations and their responses toward fatiguing of paraspinal muscles.
Methods: Electromyographic activity of spinal, axioscapular and scapulohumeral muscles, as well as spinal posture and mobility (translational and rotational) measured by surface tomography were acquired (Figure 1). Data obtained were compared between 15 subjects with AIS and 15 age- and gender-matched healthy controls (HC) during unilateral shoulder flexion and abduction with and without weights (2kg), performed before and after the endurance task (prone isometric chest raise), using repeated measures ANOVA.
Results: Comparable level between the AIS and HC groups was found for endurance task. Activity level of TES and lower trapezius (LTr) at AIS_{convex} was significantly higher than that of $AIS_{concave}$ and the HC group during functional tasks regardless of their fatigue status. Analysis of the fatigue-induced effect revealed significant time-and-group interactions in TES at T9 (TES9), LTr, lateral deltoid (LD) and anterior deltoid (AD) between AIS_{convex} and HC (Figure 2). Both translational and rotational mobility were significantly decreased during the weighted abduction tasks after fatigue at AIS_{convex} (Figure 3). Contrarily, the rotational mobility of the thoracic and lumbar spine was significantly increased during weighted flexion tasks after fatigue at AIS_{convex}.
Conclusions: Our results reveal a comparable level of trunk extensor endurance between the AIS and HC groups. There was a significantly higher muscle activation at the convex side of TES9 than the concave side after fatigue. Increased muscle activation post-fatigue provides no additional active postural stability as expressed in the kinematics of the thoracolumbar spine may potentially contribute to a higher risk of back pain over the convex side in individuals with scoliosis. In addition, muscle activities of LTr, LD and AD of the upper limb kinetic chain at AIS_{convex} were subsequently increased with the fatigue of ES, potentially explaining the higher prevalence of scapular dyskinesis and shoulder pathologies over the convex side in AIS individuals. Findings highlight muscle imbalance and the potential implications in optimising neuromuscular activation and endurance capacity in the rehabilitation for AIS patients. Future research is needed to investigate if endurance training of the convex-sided back extensors could optimise the impaired neuromuscular control in the AIS patients.

Acknowledgements: The authors would like to acknowledge the assistance of Hong Kong Scoliosis Awareness Group for recruitment of the participants and the participants who have joined this study.

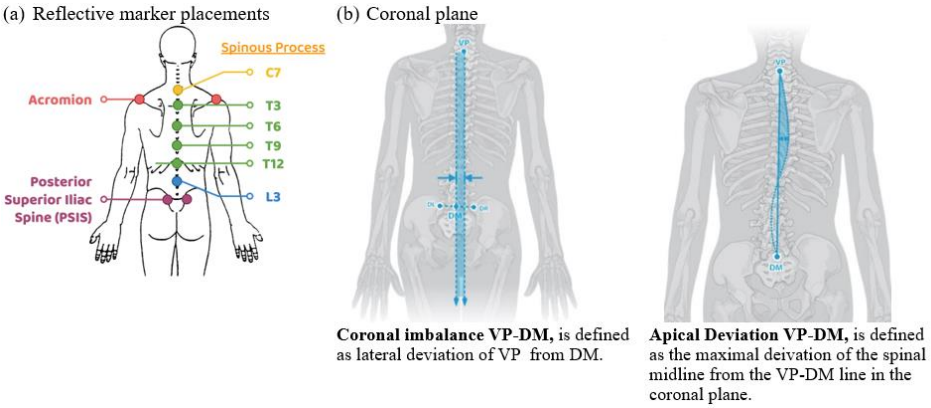

Figure 1. Measurement setup and kinematics of the thoracolumbar spine using the surface tomography system.

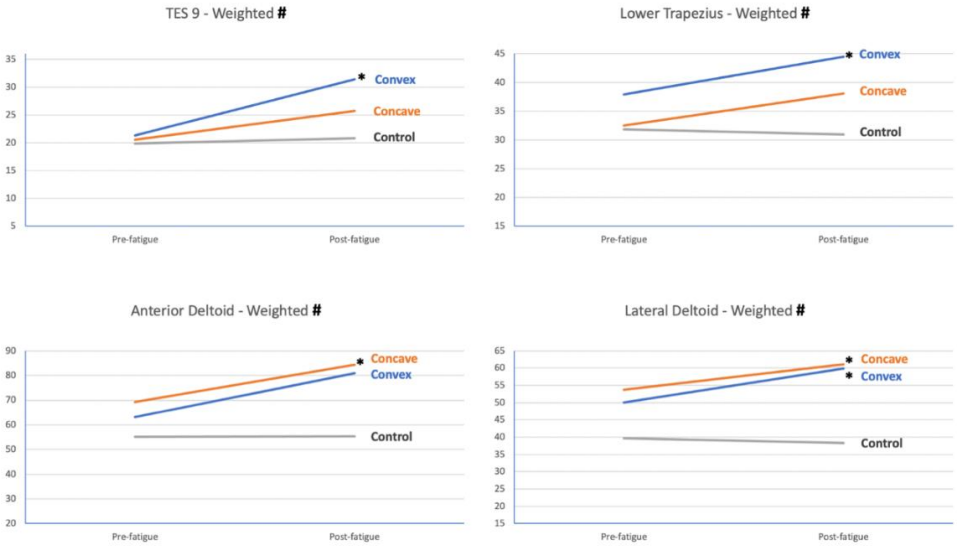

Figure 2. EMG amplitude (in percentage of maximal voluntary contraction, %MVC) during weighted and non-weighted shoulder flexion and abduction tasks, measured at pre-fatigue and post-fatigue intervals.
represents significant time effect between pre- and post-fatigue measurements ($p<0.05$);
* represents significant time-and-group interaction between the specified side of AIS and control group ($p<0.05$).

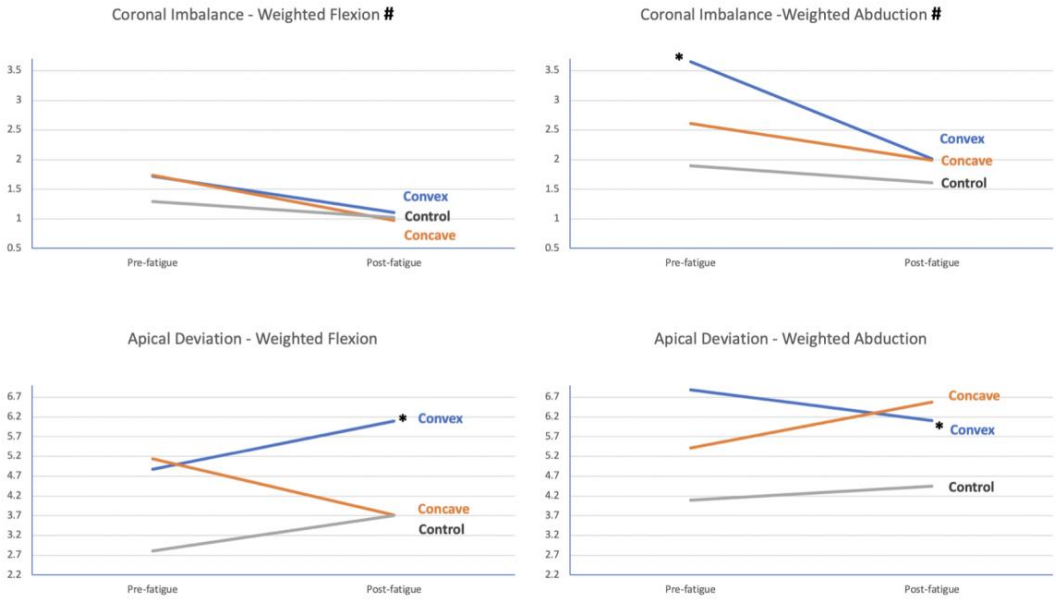

Figure 3. Spinal kinematics expressed in coronal imbalance and apical deviation during weighted and non-weighted should flexion and abduction tasks, measured at pre-fatigue and post-fatigue intervals.
represents significant time effect between pre- and post-fatigue measurements ($p<0.05$);
* represents significant time-and-group interaction between the specified side of AIS and control group ($p<0.05$).

O86

Efficacy, safety and reliability of single posterior approach for unstable thoracolumbar burst fracture treated with anterior reconstruction & posterior instrumentation

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Introduction: Management of unstable thoracolumbar burst fracture is still a controversial issue. Fracture morphology, neurologic status, and surgeon preference play major roles in deciding the appropriate approach. Though the combined anterior and posterior instrumentation provides the most stable repair, but optimizing neural decompression & stable internal fixation using a single approach over the least number of spinal segments is the goal. Moreover, the use of both approaches on a trauma patient may increase morbidity. Anterior reconstruction of spine through only one approach can provide an effective outcome.
Aims & Objectives: The purpose of this study is to evaluate neurological, functional and radiological outcome of the anterior reconstruction of spine by single posterior approach in cases of unstable thoracolumbar burst fractures.
Methods: Eight patients with acute unstable thoracolumbar burst fractures (T-11 to L-4) with neurological deficit in the age group of 16-60 years with McCormack's score six or more and thoracolumbar injury severity score (TLISS) five or more were included. Neurological status, visual analogue scale (VAS), angle of kyphotic deformity, McCormack's score and TLISS score were evaluated.
Results: The mean duration of surgery was 255 minutes. The mean blood loss was 440 ml. Mean improvement of ASIA scale was 1.67 in a patient with incomplete spinal injury whereas patient with complete spinal injury remain same at last 6 months' follow-up. The mean preoperative kyphotic angle was improved from 25 degrees to 5 degrees postoperatively. Visual analogue score improved from 6.1 to 1.7.
Conclusions: Single posterior approach is a safe, cost effective and reliable surgical approach for reconstruction of all the columns of spine. It reduces the operative time, blood loss, the morbidity associated with combined approach with a good outcome.

Keywords: Anterior reconstruction, Posterior approach, Unstable, Burst fracture, Titanium cage

O87

Comparison of three different instrumentation constructs in a prospective cohort of thoracolumbar burst fractures - Does interbody fusion offer any advantage over fractured level instrumentation?

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Introduction: Ideal construct design for posterior instrumented fusion in thoracolumbar burst fractures remains much debated worldwide. Current study presents comparative outcome of three different posterior constructs in such injuries.
Methods: Patients between 18 to 60 years of age and operated for single level thoracolumbar burst fracture (T10-L2) with neurologic deficit were included in the study prospectively between July 2020 to April 2022. Decision of surgical treatment was based on TLICS score of 5 or more. Patients with intact pedicle at fractured level were treated with short-segment with index screws (IS) (Group I). Remaining patients were treated with either short segment fixation with interbody cage (TLIF)(Group II) or long segment fixation (Group III) depending upon a semirandomized model. Patients were followed for minimum 6 months. Outcome was measured in terms of improvement in pain (VAS score), level of activity (ODI score), neurological improvement (ASIA scores), fusion status (Bridewell CT scoring), perioperative complications and radiological outcomes. The three treatment groups were compared and statistical analysis was done. Significance level for p-values was set at <.05.
Results: Total 60 patients were included with 20 patients in each group and mean age of 39 years. At presentation number of patients with ASIA grade A, B, C and D were 31, 6, 14 and 9 respectively. All patients had significant improvement in VAS and ODI scores at final follow-up. No patient showed deterioration in neurology after surgery. At the end of 6 months neurological status were 13 in ASIA A, 4 in ASIA B, 22 in ASIA C, 6 in ASIA D and 15 in ASIA E. 4 patients had traumatic dural tears and were treated with direct repair with augmentation. Two patients in Group 3 required operative debridement for deep surgical site infection. Statistical analysis did not reveal any significant difference between the three groups in terms of ASIA grade improvement, canal clearance, length of hospital stay, VAS or ODI scores, fusion scores and loss of kyphotic correction on follow up. However, estimated blood loss and surgery time were found to be statistically significant when compared between Group I (395$\pm$36 ml & 144$\pm$27 min) and Group III (744$\pm$114 ml & 203$\pm$23 min) ($p<0.05$), as well as between Group II(422$\pm$54 ml &157$\pm$17 min) and Group III ($p<0.05$), although no significant difference was found between Groups I and II ($p=0.151$).
Conclusions: Short segment posterior fixation with instrumentation of fractured vertebra was found to be better than interbody fusion or long segment fixation in terms of estimated blood loss and duration of surgery. Though all three constructs performed similarly with regard to neurological improvement or fusion status.

O88

Effects of teriparatide alone versus percutaneous vertebroplasty on pain control and radiographic outcomes after osteoporotic vertebral compression fracture: A matched cohort study

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Introduction: Vertebroplasty has become common for osteoporotic vertebral compression fracture (OVCF) because of fast relief of pain and improvement of the quality of life. However, complications including refracture or subsequent spine fracture may be expected. Treatment with teriparatide (TPD) has been applied to enhance fracture healing. However, the efficacy of TPD on acute OVCF is not clear. The aim of this study was to investigate the efficacy of 3-month TPD and compare this treatment with vertebroplasty in terms of clinical and radiographic outcomes.
Methods: This is a retrospective matched cohort study. Patients who received conservative treatment with a back brace, analgesic agents, and at least 3-month TPD treatment (20mcg/daily, subcutaneous) for OVCF with at least 1-year follow-up were included. Each enrolled TPD case was matched with 2 vertebroplasty cases using age and gender. 30 TPD cases and 60 vertebroplasty cases were enrolled. Patient-reported pain scores, numeric pain rating scale (NRS), were obtained at diagnosis and 1, 3, and 6 months after diagnosis. Radiographic parameters including middle body height, posterior body height, wedge angle, and kyphotic angle were measured at diagnosis and 6 months after diagnosis. Fracture non-union and subsequent vertebral fracture were evaluated at 6 months after OVCF was diagnosed.
Results: TPD treatment showed inferior pain relief to the vertebroplasty group at 1 month but it did not show the difference at 3 and 6 months after diagnosis. In TPD cases, progression of vertebral body collapse was noted in terms of middle body height and wedge angle at the final follow up but only wedge angle reached statistical significance (p=0.00). Instead, both middle body height (p=0.00) and wedge angle (p=0.00) increased significantly after the operation in the vertebroplasty group. 4 TPD patients were diagnosed with fracture non-union (4/30, 13.3%) but only 1 patient received vertebroplasty due to persistent back pain. Subsequent vertebral fracture within 6 months was significantly higher in the vertebroplasty group (12/60, 20%) than in the TPD group (1/30, 3.3%).
Conclusions: In acute OVCF, 3-month TPD treatment alone showed comparable pain improvement and less subsequent spine fracture than vertebroplasty. Thus, this study suggested that 3-month TPD treatment could be a treatment option for OVCF.

O89

Non-surgical management of flexion distraction type of spinal column injuries, institutional preview

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Thoracolumbar fractures with flexion distraction mechanism of injury, involving all the 3 columns of the spinal vertebrae, are common presentation in FALL FROM HEIGHT and ROAD TRAFFIC INJURIES. These fracture patterns with intact neurology present a surgical dilemma whether to manage conservatively or surgically. When a FRACTURED vertebra having NORMAL NEUROLOGY, with posterior element bony injury, is held in a biomechanically acceptable position and alignment, it unites readily without need for surgical stabilization of the fractured bones for bony union.
Our study comprised of 74 patients treated conservatively, and reported for final follow up for clinical and radiographic assessment. Patients enrolled were treated between 2014 t0 2016, and final follow up of minimaum1 year (1-3 years). 56 male & 18 females, FFH 90% cases (fall from fruit trees majority). Nonoperative support of the spine was continued for 12 weeks (pop jacket in 45, brace in 29), followed by physiotherapy and rehabilitation. Mean kyphosis at the fractured level at presentation was 35degress (15-60), it reduced by initiation of the conservative treatment by about 25degree and finally at one year of follow up, the mean correction of kyphosis was about 30 degrees. The restoration of the anterior vertebral height was about 75% of the normal adjacent vertebrae at initiation of the conservative treatment and it improved subsequently to 80% at end of one year. VAS score at final follow up was 2. No deterioration of neuro or loss of vertebral kyphosis and height was noted in any case. No residual instability at end of one year was demonstrated in stress views of the x-ray at the fracture site.
Conclusion: conservative treatment in selected cases of 3 column bony chance fractures without neurological deficit can be managed successfully with conservative treatment and achieving and maintaining normal bony configuration and stability by virtues of bony healing without instrumentation. The bony chance fractures when maintained in biomechanically desirable and acceptable alignment and immobilization of spine in well contoured orthosis or pop for that, results in

O90

Epidemiological characteristics and factors of early mortality for traumatic cervical spinal cord injury with radiographic abnormality: A multicenter nationwide cohort study

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Introduction: Traumatic cervical spinal cord injury (TCSI) is a relatively common injury in Japan, with the frequency of occurrence increasing each year. However, few reports have focused on cervical spine injuries with fracture or dislocation. The objectives of our study were to investigate the clinical features of TCSI with radiographic abnormality.
Methods: A cohort study was designed using the Japan Trauma Data Bank from January 2004 to December 2019. Of 14,611 patients with TCSI, 5,367 patients with cervical spine fracture and dislocation were extracted and divided into the survival and mortal groups. Patient background, cause of injury, the severity of paralysis, neurological level of injury, and comorbidity were compared. The primary endpoint was acute mortality. Using logistic regression analysis, multivariate analysis was performed.
Results: The survival group consisted of 4,487 patients, and the mortality group consisted of 880 patients. The mean age was 62.0±18.3 in the survival group and 62.6±22.6 years old in the mortality group. Elderly patients over 70-year-old were 1,775 (39.6%) in survivals and 438 (49.9%) in mortalities. Fall at ground level was the most common cause of injury in survivors (44.1%) against mortalities (25.8%). Contrarily, high-energy traumas such as traffic accidents were the leading cause of mortalities (47.3%) against survivors (29.8%). The mortalities group showed more frequencies of bradycardia (47.8% in the mortality group, 5.5% in the survival group), hypotension (60.9% in the mortality group, 8.4% in the survival group), and severe disturbance of consciousness (77.9% in the mortality group, 9.6% in the survival group) at presentation than the survival group. The Injury Severity Score (ISS), which correlates with severity and mortality, was also higher in the mortality group (55.9±23.8) than in the survival group (23.9±14.0). The mortality group had more cervical spine dislocation (59.7% in the mortality group, 38.2% in the survival group) and complete paraplegia above C3 (56.6% in the mortality group, 4.7% in the survival group) than the survival group. The mortality group was more frequently associated with concomitant injuries at all sites than the survival group, especially with head injuries (50.9% in the mortality group, 25.9% in the survival group) and thoracic injuries (42.7% in the mortality group, 18.0% in the survival group). Multivariate analysis of mortality revealed that ages over 70 (Odds ratio: OR 1.79, 95% Confidential interval: 95% CI 1.25-2.58), bradycardia at presentation (OR 3.12, 95% CI 1.98-4.91), hypotension at presentation (OR 2.75, 95% CI 1.84-4.11), severe disorder of consciousness at presentation (OR 7.16, 95% CI 4.69-10.9), cervical spine dislocation (OR 1.56, 95% CI 1.08-2.27), complete paraplegia above C3 (OR 2.86, 95% CI 1.90-4.29), and head injuries (OR 1.48, 95% CI 1.01-2.15) were independent risk factors of mortality.
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O91

Treatment of chronic spinal cord injury. Is there any hope?

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Objective: Here we are presenting the outcome of new treatment option (Adhesiolysis of cord+ Arachnoidectomy+ Dentectomy) of chronic spinal cord Injury.
Methods: This prospective case series was carried out using probability consecutive sampling technique. The study was conducted at Orthopedic Spine Institute, Doctors Hospital & Medical Centre, Lahore from 1stjanuary 2021 to 31stjuly2022. A sample size of 7 Patients presented in our hospital with chronic spinal cord injury (ASIA A and B) recruited in the study and followed prospectively. Patients with sharp injuries, Firearm injuries were excluded from study. All patients had pre-op MRI. All patients operated by a single surgeon. The outcome measures were Neurology, and Improvement in Bowel and bladder control. Patients were followed up at 3 weeks, 6 weeks, 12 weeks, 6 months and 12months postoperative.
Results: The mean age was 24. Mean follow up was 6 months. There was no neurological worsening following surgery. 4 patients with ASIA B improved to ASIA C. 2 patients having improvement in dysesthetic pain. One patient did not improve after surgery. Average operation time was 3hours. Postoperatively remained flat for 72 hours. The average hospital stay was 4 days. There was no wound infection reported in the study.
Conclusion: It is concluded that Adhesiolysis of cord +Arachnoidectomy and Dentectomy is a safe option in chronic Spinal cord injuries, where there is no hope in previous literature. But current data is limited and more work is required to establish this treatment option.

Keywords: Spinal Cord Injury (SCI)Adhesiolysis of cord+ Arachnoidectomy + Dentectomy

O92

Predictors of neurological outcome of acute traumatic central cord syndrome: Outcome of a treatment algorithm

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Introduction: The central cord syndrome is caused by an acute cervical spinal cord injury, resulting in disproportionate limb weakness, sensory loss below the lesion, and bladder dysfunctions. This paper aims to compare the functional and surgical outcomes in the patients managed surgically by anterior or posterior approach and to predict the independent prognostic factors for final neurological outcomes.
Aim: Retrospective analysis of prospectively collected data to investigate the outcome of ATCCS following the new treatment algorithm.
Patients and Methods: This study was a retrospective review of patient with central cord syndrome presented between January 2019 and January 2020. Preoperative radiographic assessment of the patients using plain radiographs, CT, and MRI divided them into two groups. Group 1 Anterior procedure in which Patient having Anterior Compression, Segmental kyphosis greater than 10 degrees, PLL disruption and three column injury managed with ACDF/ACCF and Group 2 in which patient having maintained cervical lordosis,segmental kyphosis lesser than 10 degrees, multisegmental posterior compression, managed with posterior approach and, Laminectomy and fusion performed when there is upto 2 level compression, and Laminoplasty preformed when there is greater than 2 level compression.
Results: Among 24 patients; 18 were males and 6 were females. The mean age group was 44.79 years. A univariate analysis was carried out to look for the factors which are predictive of neurological improvement at the final follow-up. Factors taken into account for carrying out the univariate analysis were Age, AIS scores, Maximal canal compromise (MCC), Maximal spinal cord compression (MSCC), extent of parenchymal damage, early (<24 hours) surgery, and late (>24 hours). Following it a multivariate regression analysis was carried in order to predict the factors which significantly associated with a final neurological recovery. Statistical significance was presumed for a p-value of <0.05. On univariate analysis there is a significant association between low AIS scores (p=0.02), maximal canal compromise (p=0.04), maximal spinal cord compression (p=0.02), and extent of cord parenchymal damage (p=0.02) with poor neurological outcomes. On multivariate analysis Maximal spinal canal compromise, the extent of parenchymal damage, and admission AIS scores are independent risk factors for poor neurological outcomes. In the anterior surgery group, there was a statistically significant increase in mJOA hand component scores at six months (p=0.02), which again became insignificant at the final follow- up similarly, NDI scores were higher in the posterior surgery group than the anterior surgery group at 6 months and at the final follow-up (p=0.01). As compared to the anterior surgery group, the posterior surgery group had a longer surgery duration and more blood loss.
Conclusion: The approach does not affect functional outcomes at the final follow-up, except for the initial improvements in mJOA hand component scores and NDI. Also, the posterior approach is associated with increased surgical time and blood loss compared to anterior as well as greater neck disability scores.

Univariate analysis

Variable	p-value
Age	0.07
Maximal Spinal Cord Compression	0.02
Maximal Canal Compromise	0.04
Extent of parenchymal damage	0.02
Admission AIS scores	0.02
Segmental kyphosis	1.00

Multivariate analysis

variables	RR	p-value
Admission AIS Scores	0.59	0.03
Maximum Canal compromise	1.56	0.01
Extent of parenchymal damage	1.68	0.01

O93

Assessment of biomechanical advantages in combined anterior-posterior cervical spine surgery by radiologic outcomes: Pedicle screw over lateral mass screw

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Introduction: The combined anterior–posterior approach has shown better clinical outcomes for multi-level cervical spondylotic myeloradiculopathy and degenerative kyphosis cases. Traditionally, posterior fixation in the combined approach has been achieved using lateral mass screws. However, with development of insertion techniques and advantages in load-sharing properties from biomechanical studies, cervical pedicle screws have been proposed as an alternative in certain cases.
Aim: To assess the biomechanical advantage of cervical pedicle screw fixation over lateral mass screw fixation in combined anterior-posterior decompression and fusion cases
Patients and Methods: Seventy-six patients who received anterior-posterior combined cervical surgery for myelopathy or radiculopathy or both from June 2013 to December 2020. Patients were divided into two groups: LMS group (Lateral mass screws) and PPS group (Posterior pedicle screws). Lateral cervical spine X-rays were taken for all patients at preoperative, immediate postoperative, 3 months follow-up and 1 year follow-up period. Differences in radiologic outcomes between two groups were assessed statistically. The C2-C7 cervical lordosis and C2-C7 sagittal vertical axis were used for the cervical sagittal balance. Subsidence was defined as a decrease of the vertebral body height. For vertebral body remodeling, the amount of vertebral body width change was checked.
Results: There were 40 patients in LMS group, and the total number of segments was 153. 36 patients belonged to the PPS group, with 152 segments operated totally. At 1 year postoperatively, the numbers of patients whose C2-C7 cervical lordosis was less than 20 degrees decreased larger in the PPS group ($P = 0.001$). The amount of vertical height change from immediate to 1 year post surgery was less in the PPS group than the LMS group ($P = 0.030$). The mean vertebral body width change was larger in the PPS group than in LMS group, during 3 months to 1 year post surgery ($P = 0.000$).
Conclusions: In anterior-posterior combined cervical surgery cases, maintenance of cervical lordosis and protection of vertebral body from subsidence were better in the pedicle screw fixation than the lateral mass screw fixation. More bone remodeling as of resorption occurred in the anterior portion of the vertebral body-allograft spacer constructs when using the pedicle screw fixation method.
Acknowledgements: Nothing to disclose

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O94

Surgical complications and incomplete canal widening of the vertebral body sliding osteotomy to treat cervical myelopathy

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Introduction: Vertebral body sliding osteotomy (VBSO) is a surgical technique that involves anterior translation of the vertebral body with compressive lesions such as ossification of the posterior longitudinal ligament (OPLL), disc, or spurs. Fewer complications, improved lordosis restoration, and faster bone union with VBSO than corpectomy have been reported. However, data on the surgical complications of VBSO are lacking. Furthermore, VBSO achieves cord decompression through canal widening instead of complete removal of compressive lesions; thus, understanding the incidence and risk factors associated with incomplete canal widening is important. We therefore conducted this study to describe the incidence of VBSO-associated surgical complications, and evaluate the incidence and risk factors of incomplete canal widening.

Materials and Methods: Patients who underwent VBSO to treat cervical myelopathy and were followed up for more than 2 years were retrospectively reviewed. C2-C7 cervical lordosis, C2-C7 sagittal vertical axis, and canal occupying ratio (COR) were measured. Patient-reported outcome measures including neck pain visual analog scale, neck disability index, Japanese Orthopedic Association (JOA) scores, and surgical complications were recorded. Patients with preoperative COR <50% and COR ≥50% were compared. Logistic regression analysis was performed to identify factors associated with incomplete canal widening (postoperative COR >20%).

Results: Among the 109 patients, 60 (55.0%) were included in the COR <50% group, and 49 patients (45.0%) in the COR ≥50% group. The most frequent complication was mild dysphagia (7.3%). Dural tears were observed in two patients (1.8%); one occurred during posterior longitudinal ligament resection and the other during foraminotomy. Two patients (1.8%) underwent reoperation due to radiculopathy from adjacent segment disease. Other complications are summarized in Table 1. Incomplete canal narrowing occurred in 21 patients (19.3%; postoperative COR, 24.8 ± 3.8%). Logistic regression analysis demonstrated that high preoperative COR was the only factor associated with incomplete narrowing (95% CI: 1.008–1.122; odds ratio, 1.063; p=0.024). The amount of canal widening was significantly greater in the COR ≥50% group (p<0.001); however, postoperative COR did not demonstrate a significant difference between the two groups (p=0.169). The JOA recovery rate was significantly higher in the COR ≥50% group compared with the COR <50% group (p=0.005).

Conclusion: Although VBSO aims to decrease the complication rate of corpectomy, it was not free of dural tears. Special care would be required during ligament resection around OPLL masses. Incomplete canal widening occurred in 19.3% of patients, and high preoperative COR was the only risk factor for incomplete canal widening. However, greater canal widening occurred in the COR ≥50% group, leading to a higher JOA recovery rate; thus, high COR would not be a contraindication for VBSO. In conclusion, dural tears may still occur despite VBSO minimizing the need for OPLL lesion manipulation, so caution is warranted. Although high preoperative COR is a risk factor for incomplete canal widening, favorable clinical outcomes can be expected in patients with a COR ≥50%.

Table 1. Surgical complications

	Incidence	%
Dural tear	2	1.8
Neurological deterioration	0	0.0
Infection	0	0.0
Reoperation	2	1.8
Graft dislodgement	0	0.0

Dysphagia	8	7.3
C5 palsy	5	4.6

O95

Retrospective comparative study of anterior cervical decompression and fusion and muscle-preserving selective laminectomy in patients with degenerative cervical myelopathy

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Introduction: Muscle-preserving selective laminectomy (MSL) is an alternative to conventional decompression surgery in patients with degenerative cervical myelopathy (DCM). It is less invasive, preserves the extensor musculature, and maintains the range of motion of the cervical spine. Therefore, the preferred treatment for DCM has changed from anterior decompression and fusion (ADF): anterior cervical discectomy and fusion (ACDF) and anterior cervical corpectomy and fusion (ACCF), towards MSL at our institution. Our aim was to compare surgical outcomes between ADF and MSL with patient-reported outcome measures (PROMs), complications, reoperations, and cost-effectiveness.
Materials / methods: This study was a retrospective register-based cohort study. All patients with DCM who underwent ADF or MSL at Uppsala University Hospital from 2008 to 2019 were reviewed. Using analysis of covariance (ANCOVA), changes in PROMs from baseline to the 2-year follow-up were compared between the two groups, adjusting for clinicodemographic parameters, baseline PROMs, number of decompressed levels, and magnetic resonance imaging (MRI) measurements (C2-7 Cobb, C2-7 SVA, modified K-line interval). The PROMs, including the European Myelopathy Score (EMS), the Neck Disability Index (NDI), and the European Quality of Life-5 Dimension Questionnaire (EQ-5D), were collected from the national Swedish Spine Register. Length of hospital stay (LOS), complications, reoperations, and in-hospital treatment costs were also compared between the two groups.
Results: Ninety patients (mean age 60.7 years, 51 men [57%]) were included in the ADF group, and 63 patients (mean age 68.8 years, 41 men [65%]) in the MSL group. The ADF and MSL groups presented similar PROMs both at baseline (13.3 vs 13.1 [EMS], 38.6 vs 38.4 [NDI], 0.32 vs 0.36 [EQ-5D], 47.3 vs 45.6 [EQ-5D health]) and at the 2-year follow-up (14.1 vs 13.3 [EMS], 33.8 vs 31.3 [NDI], 0.43 vs 0.42 [EQ-5D], 58.7 vs 60.7 [EQ-5D health]). The preoperative MRIs presented similar C2-7 Cobb angles (10.7 [ADF] versus 14.1 [MSL], p=0.12) and modified K-line intervals (4.08 versus 4.88, p=0.07), but different C2-7 SVA values (16.2 versus 19.3, p=0.04). The ANCOVA-adjusted comparison of 2-year changes in PROMs presented no significant differences between the groups (EMS: p=0.618, NDI: p=0.904, EQ-5D: 0.085, EQ-5D health: p=0.096). LOS did not differ significantly (4.6 days vs 4.1, p=0.31). The overall complication rate was twice as high in the ADF group (22.2% versus 9.5%, p=0.049), while the reoperation rate was comparable (16.7% versus 7.9%, p=0.146). The average in-hospital treatment cost per patient was 6,870 USD for MSL, 7,737 USD for ACDF, and 14,953 USD for ACCF.
Conclusions: MSL provides similar PROMs after 2 years, a significantly lower complication rate, and better cost-effectiveness compared with ADF.

O96

The surgical results of onstage of laminoplasty and anterior cervical fusion for the patients with multilevel cervical spondylotic myelopathy- postoperative 8 year-follow-up

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Objectives: Expansive open-door laminoplasty (EOLP) is effective for multilevel cervical spondylotic myelopathy (MCSM). When MCSM is combined with one- or two-level segmental kyphosis, instability, or major anterior foci, EOLP with short-segment anterior cervical fusion (ACF) results in good short-term neurological recovery and can preserve postoperative range of motion (ROM). The objective of this study was to evaluate the medium-term clinical outcomes of this procedure and to analyze the risk factors affecting the neurological function at the last follow-up.
Materials and Methods: A total of 73 patients who have received one stage EOLP and ACF from January 2010 to October 2014 were enrolled in this study. These patients exhibited MCSM with combined short segmental kyphosis, instability, or major anterior pathology. The follow-up period lasted at least 8 years. The radiographic outcomes were collected from plain radiographs with dynamic views checked preoperatively and at the last follow-up. Neurological status and visual analog scale scores for neck pain were evaluated. Logistic regression analysis was then applied to determine the correlation between radiographic parameters and rates of neurological recovery.
Results: The mean Japanese Orthopedics Association recovery rate at the last follow-up was 75.4 %. The improvement in functional scores and reduction in neck pain were statistically significant. The most influential risk factor affecting neurologic recovery was preoperative functional status. 5 of them developed radiographic adjacent segment pathology but none of the patients needed further cervical spine surgery during this follow-up period.
Conclusions: EOLP followed by short-segment ACF is a favorable treatment for patients with MCSM with concomitant short-segment kyphosis, instability, or major anterior pathology and had long-term satisfying functional outcomes.

O97

Predictive factors for the aggravation of cervical alignment after posterior cervical foraminotomy

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Introduction: Posterior cervical foraminotomy (PCF) is a common surgical option for cervical radiculopathy that maintains cervical mobility by avoiding the fusion of motion segments. However, PCF has the risk of progression to cervical kyphosis, likely arising from procedure-related injuries on the facet joint and musculature. Age and preoperative hypo-lordosis have been regarded as risk factors for postoperative cervical kyphosis; however, recent studies suggested that hypo-lordosis in patients with cervical radiculopathy may be a temporary finding resulting from a positive Spurling's sign. Therefore, we investigated the risk factors for the aggravation of cervical alignment after PCF and identified their relationships with aggravation in cervical curvature.
Methods: The medical records of 98 patients who underwent PCF for unilateral radiculopathy and followed for > 2 years were retrospectively reviewed. Segmental angle (SA), cervical angle (CA), Pfirrmann grade, foraminal stenosis, and clinical outcomes including neck pain, arm pain, neck disability index (NDI) were assessed. To identify the predictors for postoperative kyphotic changes, the patients were divided into two groups based on postoperative changes in the Cobb angle at C2−C7. Radiological and clinical outcomes were compared between groups C (Control group; CA kyphotic change < 5°) and K (Kyphotic group; CA kyphotic change ≥ 5°). Univariate and multivariate linear regression analyses were used to identify the risk factors for the kyphotic changes in CA. Pearson's correlation coefficient analysis was used to determine the relationships between the risk factors and the kyphotic changes in CA.
Results: Group K was significantly older than group C (P =.002) and had a higher Pfirrmann grade (P =.025) (Fig 1). In group K, neck pain was significantly increased at the last follow-up (P <.001). Univariate and multivariate linear regression analysis revealed that kyphotic changes of CA were significantly related to older age (P =.016, B = 0.420) and higher Pfirrmann grade of operative levels (P =.032, B = 4.560). Previous reported risk factors such as T1 slope and C2-C7 sagittal vertical axis had no significant relationship to kyphotic changes of CA (Table 1). Pearson correlation analysis showed that both age (R = 0.487, P <.001) and Pfirrmann grade (R = 0.249, P =.027) had a significant relationship with the kyphotic changes in CA. ROC curve analysis showed that the cut-off value of Pfirrmann grade was 3.417 for kyphotic changes in CA of ≥ 5° (P =.008, area under the curve = 0.703, sensitivity = 91%, specificity = 59%) (Fig 2).
Conclusions: Our results showed the potential utility of the preoperative measurement of Pfirrmann grade for assessing the risk of aggravation of cervical alignment following PCF. Although preoperative cervical alignment has been used for estimating postoperative kyphotic changes, independent risk factors for kyphotic changes in cervical curvature may be more useful in clinical situations. Collectively, our results suggest that careful consideration should be taken when treating older patients with a Pfirrmann grade of higher than IV for disc degeneration.

Figure 1.

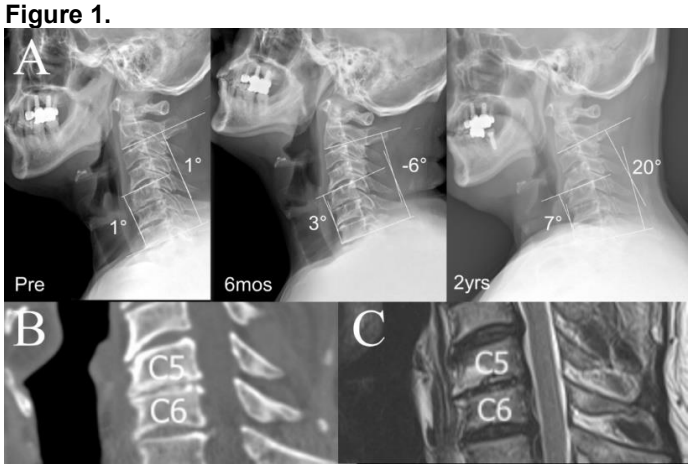
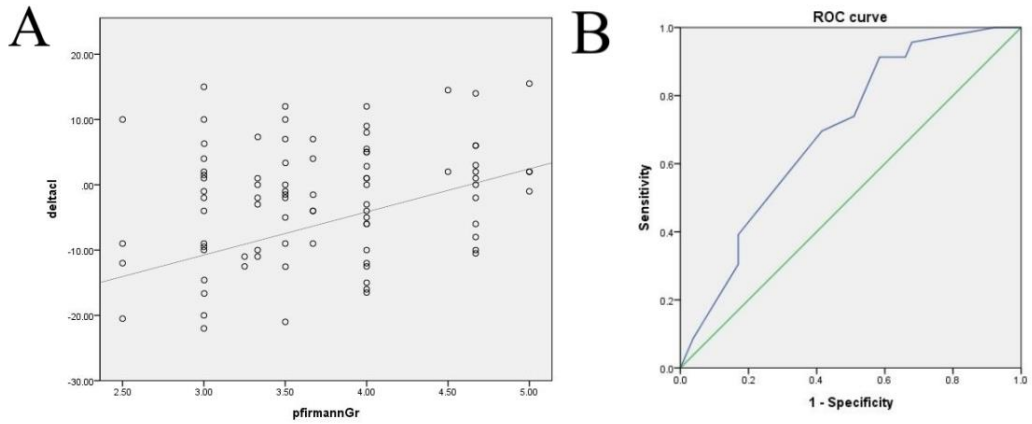


Figure 2.



O98

Change in physical and mental well-being between the short-and mid-term periods after cervical surgery for myelopathy: A retrospective cohort study with minimum 5 years follow-up

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Introduction: The current study aimed to demonstrate the change in mental and physical well-being of the patient with cervical spondylotic myelopathy (CSM) between short-term and mid-term follow-ups. Additionally, we aimed to determine the predictive factors at short-term follow-up for the deterioration of patient well-being after short-term observation.
Methods: This is a retrospective cohort study. Totally, 80 consecutive patients who underwent laminoplasty for CSM and followed up at least 5 years postoperatively were enrolled. The Short Form-36 Physical Component Summary (PCS) and Mental Component Summary (MCS) scores were considered as the parameters of physical and mental well-being. The “deterioration” of PCS and MCS was defined as a decrease of more than minimum clinically important difference (4.0 points). Additionally, a multivariate logistic regression model was used to identify the predictive factors for deterioration after 2 years of surgery.
Results: The mental well-being of the patients who underwent surgery for CSM did not deteriorate after follow-up at 2 years postoperatively ($p=0.912$). Meanwhile, physical well-being significantly declined between 2 and 5 years postoperatively ($p=0.008$). In the regression model, the cJOA score at 2 years postoperatively was significantly associated with PCS deterioration after 2 years of follow-up, independent of age, sex, and PCS score at 2 years postoperatively ($p=0.008$). In ROC analysis, the optimal cutoff value was 13.0 (sensitivity, 86.8%; specificity, 56.1%). Therefore, patients with a cJOA score <13.0 at 2 years postoperatively experienced a deterioration of PCS more frequently than patients with cJOA scores ≥13.
Conclusions: The current results suggest that physicians continue follow-up for patients with a cJOA score <13 for over 2 years. Furthermore, additional intervention may be planned for patients with a cJOA score <13 at the short-term follow-up.

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O99

Do intra-operative neurophysiological changes predict functional outcomes following decompressive surgery for cervical myeloradiculopathy? A prospective study

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Introduction: There is insufficient evidence on the therapeutic relationship between Intraoperative Neuromonitoring (IONM) changes during cervical spinal decompressive surgery for cervical compressive myelopathy (CCM) and neurological outcomes. Thus, in this current study, we prospectively assessed the effect of IONM changes in predicting a postoperative neurological recovery in patients with CCM.
Methods: 28 patients who underwent cervical spine surgery with IONM for compressive myelo-radiculopathy were enrolled. During surgery motor-evoked potential (MEP) and somatosensory-evoked potential (SSEP) at baseline, before, and after decompression was documented. A decrease in latency >10% or an increase in amplitude >50% was regarded as a “positive change”. Patients were subgrouped based on IONM changes into Group A(those with positive changes) and Group B (those with no change or deterioration). Nurick grade and modified Japanese Orthopaedic Association (mJOA) were evaluated before and after surgery. The Spearman correlation coefficient was used to ascertain the strength of the association.
Results: 9 patients (32.1%) showed improvement in MEP. The mean preop Nurick grade and mJOA score of groups A and B were (2.55±0.83 and 11.11±1.65) and (2.47±0.7 and 11.32±1.24) respectively. The mean postoperative Nurick grade of group A and B at six months was 1.55 ± 0.74 and 1.63 ± 0.46 respectively and this difference was not significant. The mean postoperative mJOA score of groups A and B at six months was 14.3 ± 1.32 and 12.9 ± 1.29 respectively and this difference was statistically significant (p-value = 0.011). Spearman correlation coefficient showed a significant positive correlation between the IONM change and the mJOA score at six months postoperatively (r = 0.47; p = 0.01).
Conclusions: The trend of improvement in Nurick grade was observed in patients showing improvement in motor evoked potentials but did not reach statistical significance. Trend pertaining to improvement in mJOA was observed in patients showing improvement in motor evoked potentials was seen only at six months postoperatively whereas there was no significant difference at three months. We recommend serial monitoring of mJOA but also caution other investigators that the benefit of intraoperative monitoring might be observed only around 6 months postoperatively. Also, mJOA is a better indicator of improvement compared to Nurick's grade.

O100

Male patients with longer disease duration of axial spondyloarthritis have less severe disc degeneration

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Introduction: Low back pain is the leading cause of disability worldwide, age-related disc degeneration (DD) is highly prevalent in the population. Axial Spondyloarthritis (SpA) also causes backpain.
Aim: To compare severity of DD in SpA patients versus the population, to determine the effect of Ankylosing Spondylitis Disease Activity Score-C-reactive protein (ASDAS-CRP), Spondyloarthritis Research Consortium of Canada spine score (SPARCC-spine), modified Stoke Ankylosing Spondylitis Spine Score (mSASSS) and Bath Ankylosing Spondylitis Metrology Index (BASMI) on lumbar Pfirrmann score, and to assess demographic determinants for whole spine DD within SpA patients.
Patients and Methods: This study comprises of two prospective cohorts. 967 populational participants and 304 SpA patients were included into the analysis (42.7% male & 57.3% female). Disc and endplate measurements included any disc herniation, Pfirrmann grading, Schmorl's node, High Intensity Zone, and Modic change, and were studied from C2/3 to L5/S1. Age, gender, weight, height, smoking history and presence of current back pain were selected for the calculation of propensity-scores. 219 match pairs were generated using 1:1 nearest neighbour matching. DD severity was assessed by sum of Pfirrmann scores in each segment, then compared using Mann-Whitney U test. SpA patients were stratified into early disease (<3 years) and later disease (≥3 years). Univariate linear regression was then used to detect factors associated with worse lumbar Pfirrmann score. Factors with p-value < 0.05 were then included into the multivariate model.
Results: SpA patients had better DD severity in all three spinal segments ($p<0.001$). Within the SpA cohort, disease activity (ASDAS-CRP) were not associated with DD presence in all segments ($p=0.495$-0.800). mSASSS, SPARCC spine MRI index, and BASMI were significantly higher in subjects with later disease. Male had higher SPARCC ($p<0.001$) and mSASSS ($p<0.001$) than female. In the disease-stage stratified multivariate linear regression for lumbar Pfirrmann score, SPARCC spine MRI index was associated with higher lumbar Pfirrmann scores in early disease ($B=0.196$, $p=0.044$), where mSASSS was associated with lower lumbar Pfirrmann scores in later disease ($B=-0.138$, $p=0.038$). For whole spine DD, male had lower odds (OR 0.622, $p=0.027$), where older age was associated with higher odds (OR 1.095, $p<0.001$). In contrast, whole spine DD was independent from gender ($p=0.109$) in the populational cohort.
Conclusion: Female have a longer delay in diagnosis due to less recognised radiographic progression (mSASSS) in the lumbar spine, which also confers less stability and higher odds of DD in the whole spine. For male SpA patients with longer disease duration-- a generalised increase of ankylosis means the spine is rather 'stable' and do not experience 'increase in motion' or loading as in a high BMI individual.

O101
High grade spondylolisthesis: Reduction versus in situ fusion for adult

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Introduction: There is no uniform agreement about the optimal treatment of high grade spondylolisthesis. Surgery with reduction or in situ fusion is still controversy. The purpose of our study is to assess whether the evaluation of the spino-pelvic balance can be effective in the surgical decision making of the high-grade spondylolisthesis.
Method: A prospective study was designed over 18 patients with lumbar spondylolisthesis with severe neurological symptoms. Study time was January 2017-September 2022 in NITOR Other Private Hospital in Dhaka. Patients were selected for surgery depending on significant lower back pain with or without neurological deficit & no sufficient clinical improvement despite conservative care at least for 3 months.
Results: Evaluation was done comparing their pre & post-operative states including clinical evaluation, X-ray showing gradual fusion, CT scan & MRI. Our choice of surgery was PLIF & TLIF. 8 patients were treated with ‘‘in situ’’ fusion, and 10 with reduction and fusion. A clinical and radiological assessment of the deformity correction was carried out with a minimum follow-up of 2 years. The differences between the pre- and postoperative measures were statistically analyzed using a two-tailed, paired t test. The patients treated with ‘‘in situ’’ fusion showed no statistically significant change at the last follow up relative to pelvic tilt (PT), sacral slope (SS), and grade, while the patients treated with reduction showed significant changes. PT significantly decreased following surgery, while SS significantly increased, this is the indicator of balanced pelvis.
Conclusion: The analysis of the spino-pelvic sagittal balance is the specific determinant by which decision making can be done. In case of the balanced deformities no need of reduction, but in unbalanced deformities correction is needed.

O102

Does platelet rich plasma enhance fusion in transforaminal lumbar interbody fusion? A prospective clinico-radiological comparative study

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Introduction: Several animal studies have shown that PRP is effective in enhancing bone fusion. But the role and efficacy of PRP in spinal fusion surgery remains uncertain. The objective was to evaluate the efficacy of PRP in bone fusion and to compare the clinical and radiological outcome of TLIF (Transforaminal lumbar Interbody fusion) with and without PRP.
Methods: This is a prospective study done in 50 patients who underwent TLIF surgery for various spinal pathologies. Patients were divided into control group (underwent TLIF with interbody cage and local bone grafts alone) and study group (underwent TLIF with interbody cage, local bone grafts and PRP). Functional outcome was evaluated using VAS and ODI. Radiological outcome was assessed by Bridwell's grading system for fusion on CT scan at the end of two years.
Results: Average bone fusion rate was significantly higher in the PRP group compared to control group, however the average duration of fusion was not statistically significant. There was no difference in VAS and ODI at one and two years. There was also no significant difference in lower back pain, leg pain and numbness in both groups at the end of one year.
Conclusion: Although there is no statistical significant difference in functional outcome between the both groups, local application of PRP along with autologous bone grafts increases bone fusion rates with good clinical and radiological outcome.

O103

How paraspinal atrophy affects pain and function in degenerative spinal conditions? An analytical study on degenerative disc disease without instability and in spondylolisthesis

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Introduction: Paraspinal muscle integrity has been implicated to play a critical role in the maintenance of global spinal alignment in turn helping vertebral stabilization and movement. The difference in the impact of paraspinal atrophy in conditions like spondylolisthesis is inconclusive. This study aims to compare the severity of pain and functional deterioration in patients with spondylolisthesis and degenerative lumbar disease without instability and correlate it with paraspinal muscle mass density.
Methods: 40 patients were divided into two groups - Group A with spondylolisthesis and Group B with degenerative lumbar disease without instability. Visual analog score (VAS score) for pain and Modified oswestry disability index score was used for functional assessment. Cross sectional areas of paraspinal muscles (Erector spinae ES, Multifidus MF and Psoas Major PM) to vertebral body ratio were calculated from T2 axial MRI images at L4 and L5 levels and these values and scores were correlated.
Results: Comparing the values in both the groups, the mean CSA to Vertebral body (VB) ratio for the ES muscle was significantly lower in Group B ($p=0.0442$ at L4, $p=0.0103$ at L5) whereas that for the MF muscle and psoas major was not statistically significant. None of the general variables significantly predicted any of the muscle area values. VAS score difference and functional outcome between the groups were insignificant. Mean functional score as per Modified ODI was 38.65 (SD=18.68, range 12-60) in Group A compared to 47.96 (SD=17.36, Range 26.6-71.1) in Group B ($p=0.8717$).
Conclusions: Patients with degenerative spinal conditions suffer from atrophy of all paraspinal muscles. Higher degree of atrophy of their ES muscle is seen in cases of degenerative disc disease without instability compared to spondylolisthesis.

O104

Total en-bloc spondylectomy versus stereotactic ablative body radiotherapy in patients with single spinal metastasis

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Introduction: Total en-bloc spondylectomy (TES) is traditional surgical treatment of primary spinal tumors. TES can achieve low tumor recurrence, but there is also disadvantages including surgical site infection, weakness, and pneumonia. Since the introduction of stereotactic ablative radiotherapy (SABR) which delivers a higher dose of radiation to target tissues while minimizing the dose exposure to normal tissue, therapeutic role of TES in spinal metastasis has been diminished. While previous studies on TES or SABR, respectively, have reported their efficiency achieving good local control rate and improving survival rates, the information is still lacking about comparing the efficacy of the two different types of treatment.
Aim: The purpose of our study is to compare TES and SABR in patients with single spinal metastasis by assessing local recurrence, overall survival.
Patients and Methods: This is a retrospective study from a single tertiary hospital. We included all patients who underwent TES or SABR in patients with single spinal metastasis since 2000. Patients' demographics including performance status, and oncologic information including primary tumor type, the New England Spinal Metastasis Score (NESMS), modified Tokuhashi score were reviewed. Information on recurrence and survival after treatment was checked through review of electronic medical records, picture archiving and communication system, and request of the Ministry of Public Administration and Security of the country. For the between-group comparison, we used only the follow-up data collected up to the 97.7 months in the TES group, which was the longest follow-up period in the SABR group, and we did exact matching of patients with primary origin, NESMS and modified Tokuhashi score. Survival analysis was performed on both all patients and matched patients.
Results: A total of 90 patients were included, with 20 patients receiving TES and 70 patients receiving SABR, with a mean follow-up of 35.4 months. The cumulative 12, 24, 60-month local progression rate among matched patients were 5.6%, 12.8%, 21.5% in TES group, and 31.0%, 43.5%, 43.5% in SABR group, respectively. Kaplan-Meier curve about local progression among matched patients showed no significant difference between TES and SABR group (P=0.133) (Figure 3). Survival analysis of matched patients also showed no significant difference between TES and SABR group for survival period (median [95% CI], month: 55.2 [40.8–69.6] versus 41.0 [0.0–93.4]; P=0.207) (Figure 4). TES group had a higher rate of major complications such as paralysis.
Conclusions: There was no significant difference in survival between the groups receiving TES and SABR in patients with single spinal metastasis. It is expected that the role of SABR will increase in the future.

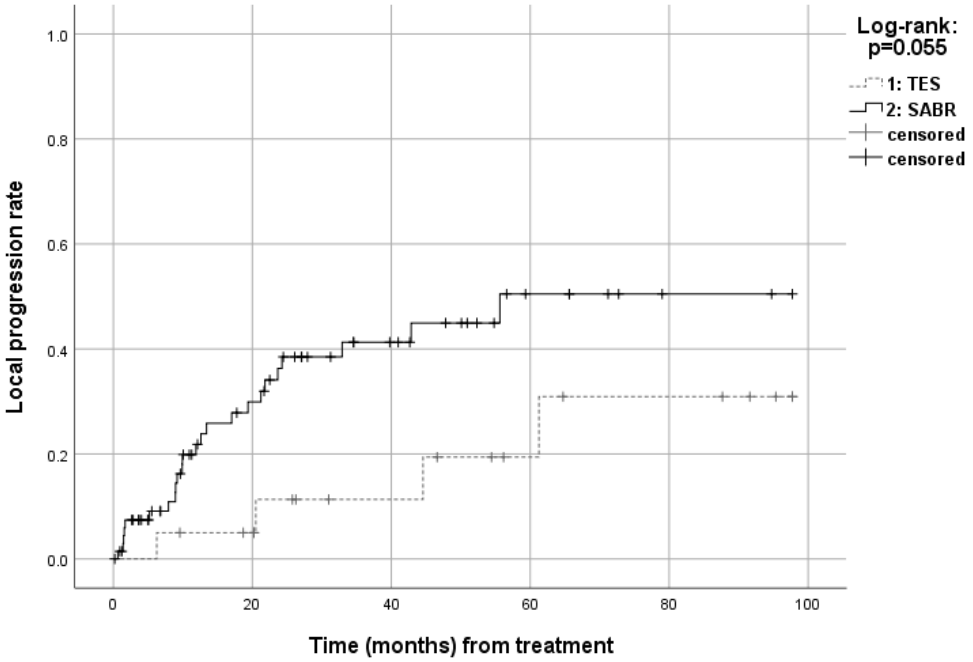

Figure 1. Kaplan-Meier curve for local progression of all patients.

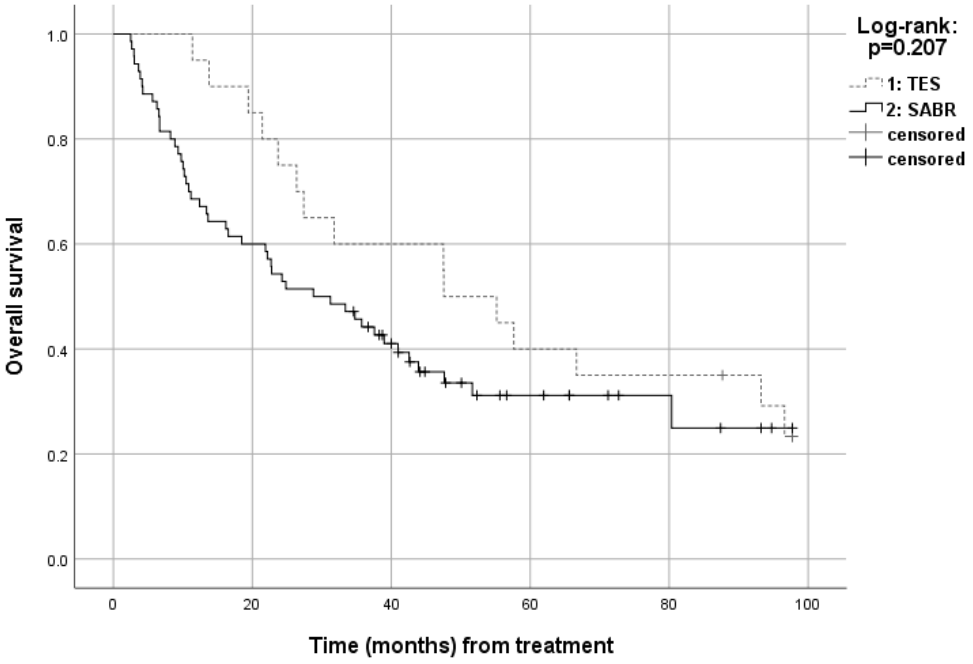

Figure 2. Kaplan-Meier curve for overall survival of all patients.

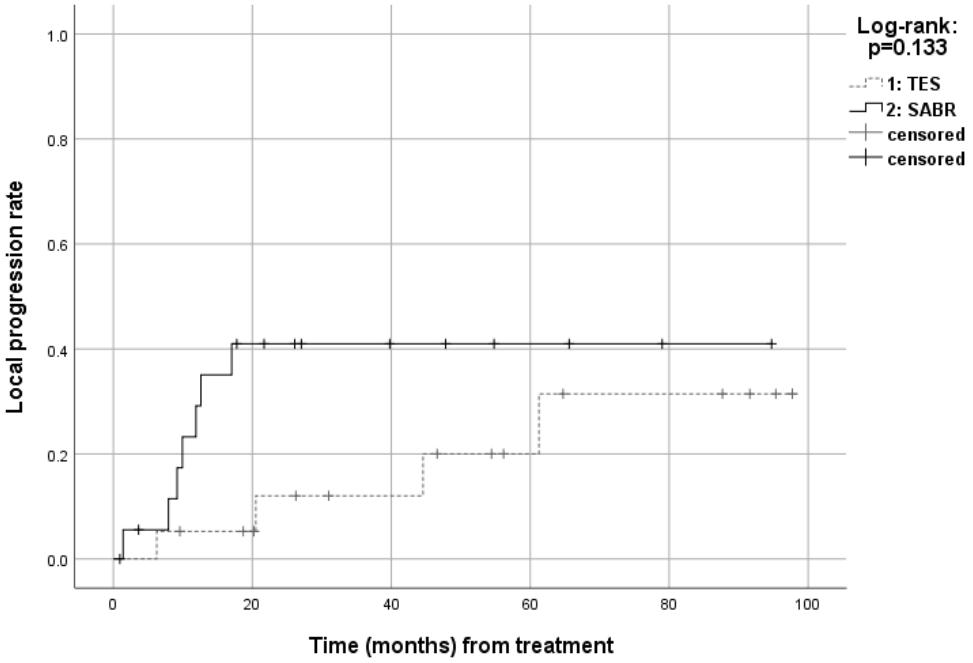

Figure 3. Kaplan-Meier curve for local progression of matched patients.

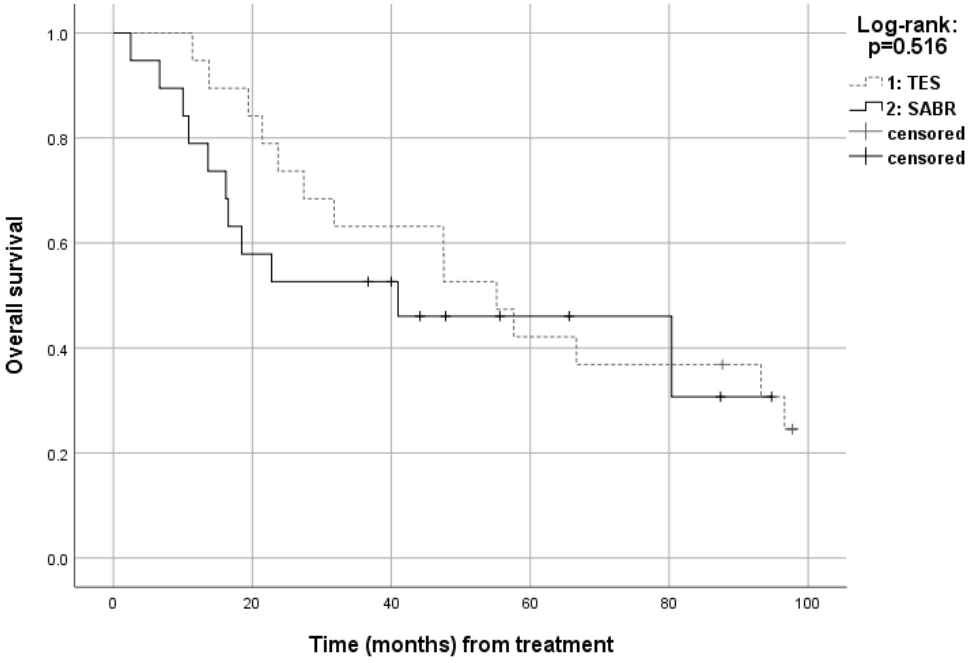

Figure 4. Kaplan-Meier curve for overall survival of matched patients.

O105

The analysis of treatment failure candidate after preoperative radiotherapy for metastatic spinal tumor

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Introduction: Radiotherapy is one of the important treatment options for patients with metastatic spinal tumor. However, it is difficult to say that this is a definite treatment for metastatic spinal tumor, and there are patients who need surgical treatment because severe pain or neurologic deficits occurs even after radiotherapy. Therefore, this study aimed to analyze the patients who underwent surgical treatment after preoperative radiotherapy and check which patients had a high radiotherapy failure rate.
Methods: We included 81 patients who underwent decompression and fusion surgery after radiotherapy for metastatic spinal tumor. Patients who underwent surgery within 6 months after radiotherapy classified as the failure group (group F, n=47), while surgery cases after 6 months after radiotherapy were assigned to the effective group (group E, n=34). Using magnetic resonance imaging (MRI) before radiotherapy, the Bilsky grade, pathologic fracture, and cord compression were checked in both groups. Also, we analyzed the period from radiotherapy to surgery according to Bilsky grade.
Results: In group F, pathologic fracture and cord compression were more frequent than in group E (42/47 vs 20/34, 42/47 vs 23/34, p=0.001, 0.015, respectively). In subgroup analysis, there was a difference in the period from radiotherapy to surgery according to Bilsky grade (Bilsky grade 0, n=17, 14,4±7.5mo; grade 1, n=16, 7.4±6.1mo, grade 2, n=5.7±7.4mo, grade 3, n=12, 1.5±1.1mo).
Conclusion: Although this may be limited information on only patients who underwent surgery, radiotherapy failure is highly likely in patients with metastatic spinal tumor accompanied by Bilsky grade above 2, higher cord compression and pathologic fracture. In these patients, surgical treatment can be considered as the primary treatment.

O106

A comparative factor analysis and new MRI scoring system for differentiating pyogenic versus tuberculous spondylodiscitis

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Background: The differential diagnosis between Pyogenic and Tuberculous spondylodiscitis is crucial. Accurate diagnosis and early treatment are important to prevent further progression of disease and decrease patient morbidity.
Objective: This study aims to compare and analyze the difference of clinical and MRI findings between pyogenic spondylodiscitis (PyS) and tuberculous spondylodiscitis (TS) and to develop and validate a simplified multi-parameter MRI-based scoring system for differentiating TS from PyS.
Methods: We compared the predisposing factors of 190 patients (67 PyS patients and 123 TS patients) whose confirmed diagnosis by laboratory, culture or pathology. The demographics, clinical characteristics, laboratory results, and MRI findings of the patients were collected between 2015 and 2020. The data were analyzed using logistic regression methods. The selected logistic coefficients were transformed into MRI-based scoring system. Internal validation was done with bootstrapping procedure.
Results: The relevant factors for TS vs PyS group, the multivariate analysis demonstrated that facet joint arthritis (OR, 0.19; 95%CI, 0.02-1.28), intraosseous abscess (OR, 18.20; 95%CI, 2.24-147.26), well-defined paravertebral soft tissue extension (OR, 12.67; 95%CI, 1.77-90.55), ALL spreading (OR, 72.47; 95%CI, 6.88-763.93), epidural phlegmon (OR, 0.0037; 95%CI, 0.003-0.042) and thoracic lesion (OR, 116.87; 95%CI, 4.33-3155.81) significantly influenced the differential diagnosis between TS vs PyS group and were used for derivation of the scoring system. The score-based model showed area under ROC of 0.91 (95%CI 40.38-513.42). The developed scoring system ranged from 0 to 24 was cutoff at greater than or equal to ten for TS (OR, 144; 95%CI, 40.38-513.42)
Conclusion: This simplified MRI-based scoring system for differentiating TS from PyS were helpful to guide the appropriate treatment when the causative organism is not identified.
Keywords: Infectious spondylodiscitis; Tuberculous spodylodiscitis; Pyogenic spondylodiscitis; differential diagnosis.

O107

Paradoxical worsening on imaging in the early treatment course of tuberculous spondylodiscitis: Should it be a concern?

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Introduction: Pott's spine is the most common extrapulmonary presentation of tuberculosis. Currently, magnetic resonance imaging (MRI) is the gold standard imaging modality for early diagnosis and monitoring the response to the treatment. Many a time, radiological worsening with clinical improvement of the patient poses a challenge concerning the course of the treatment. Our study intends to document the radiological changes during chemotherapy at serial intervals coupled with clinical and haematological evaluations. It also intends to identify whether there is a need to alter the course of therapy.
Methodology: Prospective, clinico-radiological, observational study. Serial monitoring of patients was performed from diagnosis till 12 months of chemotherapy. Radiological assessment was done with serial MRI images for various radiological parameters. Clinical assessment was performed with Measure Your Medical Outcome Profile version 2 (MYMOP 2) and erythrocyte sedimentation rate (ESR). All patients followed standard 4 drug regime of anti-tubercular therapy.
Results: 52 patients were included in the study. 30 were males and 22 were females. The mean MYMOP2 score at the time of diagnosis was 4.98. It was 3.18 and 0.33 by the end of 1 month and 12 months of chemotherapy respectively. The mean ESR at diagnosis was 64.13 mm at the end of 1hour. After 1 month of chemotherapy it was 48.98 and decreased to 23.08 by 12 months of chemotherapy. The average number of vertebrae involved at the initial presentation was 2.52. At the end of the first month it was 2.78 vertebral bodies. The average number of affected vertebral bodies has decreased from the third month follow up, and a similar trend continued in subsequent visits. The mean percentage of vertebral body hypointensity in T1 images at diagnosis was 74.4 +/- 30.7. At the end of the first month, the mean was 79 +/- 22%. The mean percentage of vertebral body hyperintensity in T2 images at the time of initial diagnosis, the mean was 70.6 +/- 21 %, which increased to 73.6 +/- 23.9 % at the end of the first month. At the time of presentation, the average extent of pre and/or paraspinal abscess was 2.13. At the end of the first month, the average extent was 2.73. The total number of endplates involved at the initial presentation was 105 in 52 patients, out of which 60 endplates have eroded. At the end of the first month, 83 endplates were found to have been eroded. This unforeseen radiological worsening despite clinical improvement of the individual during chemotherapy is termed as "Paradoxical worsening".
Conclusion: The individual's clinical response to the therapy takes precedence over the radiological picture regarding the line of management in the early stages of treatment. Paradoxical worsening should not be a concern; instead, it should be expected. There are only few situations necessitating surgical management.

O108

Remodeling of facet joint after posterior endoscopic cervical foraminotomy: Computer tomographic facet dimension analysis and clinical evaluation with minimum one year follow up

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Objective: Limited literature on the medium term of 2 years clinical and radiological facet dimensions outcomes in posterior cervical endoscopic decompression surgery in patients for cervical disc herniations and foraminal pathologies. [1, 2]
Methods: Retrospective comparative cohort study of 45 patients who underwent one level posterior endoscopic cervical foraminotomy for degenerative cervical spinal conditions were evaluated. Basic demographics, preoperative, post-operative 1 week, 3months and final follow up of patients' clinical outcomes in terms of Visual Analog Scale Pain Score, Neck Disability Index, Japanese Orthopaedic Association Score and MacNab's Criteria and computer tomographic evaluation of 3D CT reconstruction coronal cut cervical resection Area, sagittal cut foraminal cranio-caudal length, ventro-dorsal length and axial cut ventro-dorsal length was evaluated.
Results: Mean follow up for posterior endoscopic cervical foraminotomy is 17.24 (6-45) There are 4 complications (8.8%) in PECF. There means operative time was 59.2(40-80) minutes. The mean 3D coronal cut area was measured as 1047.2 and 604.7 at postoperative day one and final CT scan done postoperative one year, respectively. In final one year CT scan compared to postoperative day one scan, there was statistically significant changes in 1) remodelling of the coronal 3D reconstructed area with mean increment in bony area of 442.6 ± 248 mm2; 2)Sagittal CT cut foraminal cranio-caudal length was 4.45±2.32mm, 2.06± 2.38mm at postoperative day one and final respectively; 3)Sagittal CT cut foraminal ventro-dorsal length there was 3.92± 1.91mm, 3.49± 1.80mm at postoperative day one and final respectively;4) Axial CT cut foraminal ventro-dorsal length was 4.24± 1.72mm, 3.27± 1.57mm at postoperative day one and final respectively; 5)Axial CT cut foraminal mediolateral length was 6.5± 2.56mm, 3.26± 1.93 mm at postoperative day one and final respectively, $p<0.05$.
PECD had better and statistically significant improvement at final follow up for VAS (6.13± 1.59) and NDI (52.44 ± 12.79) and motor power improvement (0.56± 0.81), $p< 0.05$ respectively. Both cohorts had 100% good to excellent outcomes in MacNab criteria.
Conclusions: Despite remodelling in the facet joint with bony ingrowth and partial reformation of facet joint after posterior endoscopic cervical foraminotomy at final follow up, there is continued improved clinical outcomes at final follow up in 1-2 years after decompression.

References:

[1]Posterior endoscopic cervical foramiotomy and discectomy: clinical and radiological computer tomography evaluation on the bony effect of decompression with 2 years follow-up. *European Spine Journal*. 2020/10/19 2020;doi:10.1007/s00586-020-06637-8
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O109

Clinical and radiographic outcomes of late-onset cage subsidence after lateral lumbar interbody fusion

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Introduction: Lateral lumbar interbody fusion (LLIF) can restore disc height and perform indirect decompression of neural elements. However, cage subsidence may lead to clinical problems, including loss of disc height correction, altered spinal alignment, recurrent pain, and vertebral body fracture. The factors leading to subsidence after LLIF are poorly understood.
Aim: The purpose of this study was to evaluate clinical and radiographic outcomes according to the subsidence in a case series with LLIF.
Methods: A retrospective review of consecutive patients who underwent LLIF between 2012 and 2017 was performed. Patients with a follow-up period of less than 1-year were excluded. Subsidence was defined as cage sinking of more than 2 mm from the bony endplate compared to the immediate postoperative status. The timing of cage subsidence was investigated. Clinical (using VAS and ODI) and radiographic outcomes (sagittal parameters) were investigated. The relationships between cage subsidence, intraoperative endplate injury (IOEI), and fusion rate were analyzed.
Results: One hundred sixty-six patients were eligible for this study. They underwent LLIF at a total of 331 levels and their mean follow-up period was 54.5±23.3 months. The subsidence rate per level was 37.5% (124/331). In patients with IOEI, subsidence occurred more frequently compared to those without IOEI (48.5% vs 34.6%, p=0.034). VAS and ODI at the final follow-up were not different between patients with or without the subsidence. Although a segmental sagittal angle was smaller at the level with subsidence, lumbar lordosis was not different between patients with or without subsidence at the final follow-up. The fusion rate at postoperative 1-year was not different. Reoperation was not needed except one patient with a coronal split vertebral body fracture followed by IOEI and progressive subsidence.
Conclusions: The prevalence of subsidence after LLIF was quite high (37.5%) in our series. However, clinical and radiographic outcomes after subsidence were not unfavorable. Patients with intraoperative endplate injury were likely to show late-onset subsidence, however, the fusion rate was not affected. Late-onset subsidence did not seem clinically significant.

O110

Risk factors for conversion to open spinal surgery after percutaneous epidural neuroplasty

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Introduction: Percutaneous epidural neuroplasty (PEN) is a minimally invasive therapy wherein a catheter is directly placed into different spine pathologies, and has reported to be safe and effective. However, prevalence and risk factors of conversion to open spinal surgery has not reported. Thus, the purpose of this study was to evaluate the risk factors for conversion to open surgery after PEN and suggest appropriate indication for PEN.
Methods: From 2019 to 2020, patients undergoing PEN for lumbar spinal stenosis or disc herniation on magnetic resonance imaging (MRI) were included in this study with a minimum 6-month follow-up and computed tomography (CT) scans to evaluate bony spur and hard disc. Radiologic parameters included the degree of central and foraminal stenosis on MRI, presence of spondylolisthesis, hard pathology including facet joint calcification and hard disc on CT. Clinical outcomes included numeric rating scale (NRS) for back pain and leg pain, and Oswestry disability index (ODI).
Results: Among the 63 patients, 7 patients underwent open surgery within 6 months after PEN, and conversion to open spinal surgery was 11.1%. Mean time from PEN to open surgery was 49.7 ± 32.4 days. Risk factors for conversion to open surgery were the grade of central stenosis, calcification of facet capsule or ligamentum flavum, and limited contrast spread within the canal (all p-value < 0.05). Multivariate analysis revealed that independent risk factors were the calcification of facet capsule or ligamentum flavum (Odds ratio (OR) = 8.4, 95% confidence interval (CI); 0.85 – 83.4, p-value = 0.045) and intra-canal contrast spread (OR = 16.3, 95% CI; 2.3 – 114.9, p-value = 0.005). Regarding the clinical outcomes, NRS for back pain and leg pain and ODI at 1 month postoperatively were significantly greater in surgery group than non-surgery group despite similar preoperative values (3.1 ± 2.0 vs. 7.2 ± 3.9 for back pain, 3.0 ± 1.9 vs. 9.0 ± 1.7 for leg pain, 25.8 ± 14.5 vs. 73.3 ± 25.4% for ODI, all p = 0.000).
Conclusions: Conversion to spinal surgery after PEN within 6 months was 11.1%. Calcified of facet capsule and ligamentum flavum and intra-canal contrast spread were the risk factors for conversion to open spinal surgery. Moreover, CT scans will be helpful for selection of patients having indication for PEN.

O111

Minimally invasive spine surgery (MISS): Techniques, technologies & indications for thoracolumbar spine fracture

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Introduction: Over the past few decades, interest in minimally invasive spine surgery (MISS) has increased tremendously due to its core principle of minimizing approach-related injury while providing outcomes similar to traditional open spine procedures. With technical & technological advancements, MISS has expanded its utility not only to simple spinal stenosis, but also complex spinal pathologies such as metastasis, trauma or adult spinal deformity. In this series we have reviewed techniques, technology in MISS & outline the results in comparison with traditional open spinal surgeries.
Material and Methods: In this prospective observational study, a total 21 cases were included from January 2022 to August 2022 through non randomized purposive sampling. All the patients were between 15 to 60 years of age and operated within 10 days of fracture by MISS techniques; short-segment pedicle screw fixation including the fractured vertebral body. Postoperative functional outcome was assessed both clinically by ODI, VAS, ASIA, Denis work scale and radiologically by Cob's kyphotic angle, kyphotic deformation, Beck index, Bridwell criteria. Postoperative follow up was conducted at 6th, 12th and 24th weeks.
Results: The mean age found in 31.42±11.2 years with male predominant (74.19%). Most of the cases were manual workers (51.61%). FFH was the most common cause of injury 80.65%) and L1 was the most common level of injury (54.84%). The mean duration between injury and operation time was 5.45±2.34 days. None of cases deteriorated.
Conclusion: The main goal of MISS is to minimize approach-related soft tissue injury and to preserve normal anatomy, which permit a better quality of life through faster postoperative recovery. Over the past few decades, significant technological and technical advancements have made this goal possible.

O112

What makes them stay? A study on effects of socioeconomic indicators on length of stay and post operative rehabilitation following minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF)

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Introduction: The patient undergoing spine surgery has to comprehend an alphabet soup of terminology, procedure risks and understand rehabilitation goals. This may not be possible for all patients from varied backgrounds and this can have implication on the post-operative outcome. This study investigates the effects of socioeconomic indicators on Length Of Stay (LOS) as well as rehabilitation targets following Minimally invasive Transforaminal Lumbar Interbody Fusion (MIS-TLIF)
Methods: We analysed socioeconomic status (SES) factors at the individual level using room index which is based on the tiered-subsidy housing system in Singapore. Secondly, we use Socioeconomic Disadvantage Index[1] (SEDI) and Socioeconomic Advantage Index[1] (SAI) to compare SES at the neighbourhood level. A recruitment of consecutive patients that underwent single and double level MIS-TLIF procedures from August 2015 to August 2022 across two institutions were included into the study. We derived patient postal codes from records and cross referenced them with national database to derive individual patient room index (Equation for room index: Sum total[number of rooms in a flat × number of such flats per block] / total number of units in a block). SEDI and SAI indices were obtained from a public policy paper by Earnest et al[1]. After comparative analysis, at individual and neighbourhood levels, the analysis was repeated with propensity score matching at 1:1 ratio.
Results: A total of 221 patients were analysed. 115 (*52.0%)* of our total cohort were female patients and overall median LOS was 4 days (Interquartile range: [2.00, 6.00]). When Room index values were compared, no significant differences were noted in terms of LOS (Table 1), intra-operative variables, post-operative complications and follow up compliance. Similarly, when unmatched cohorts stratified by neighbourhood based SES indicators were compared, no significant differences were noted. However, in these unmatched cohorts, there were numerical trends towards shorted LOS in individuals from neighbourhoods with higher SAI (4.00 [3.00, 7.00] vs 3.00 [2.00, 5.00], p=0.092). Congruent numerical trends were noted in individuals in neighbourhoods with higher disadvantage scores having longer LOS (4.00 [3.00, 6.00] vs 3.00 [2.00, 6.00], p=0.156].
After matching cohorts, there was a significantly shorter LOS noted amongst patients living in neighbourhood with higher advantage scores (n=73:73), (4.00 [3.00, 6.25] vs 3.00 [2.00, 5.00], p=0.035). There was also a non-significant trend towards patients with higher neighbourhood advantage scores having lower number of Physiotherapy (PT) sessions needed prior to being discharged (3.83[2.41] vs 2.82 [1.44], p=0.071). We noted a complementary non-significant trend towards patients with higher disadvantage scores having longer LOS after matching (4.00 [3.00, 6.00] vs 3.50 [2.00, 5.70], p=0.297).
Conclusions: Significant differences in cohorts stratified by neighbourhood SES indicators suggest that patients with better neighbourhood advantage indices had shorter LOS and less physiotherapy requirements. These findings were supported by numerical trends amongst patients with higher disadvantage scores having longer LOS. We believe that this paper provides a novel take into studying LOS post TLIF procedures. We surmise that a spine patient, originating from an advantaged neighbourhood may potentially have better understanding of a commonly performed procedure and will likely have a successful outcome in terms of length of stay and improved physiotherapy outcomes We wish that the findings of this paper can be used in understanding the socioeconomic factors involved in successful understanding and subsequent post op care for patients undergoing routine spine surgery.

Table 1: Length of Stay (LOS) compared against neighbourhood and individual indices (Matched and unmatched cohorts)

Unmatched Analysis			
	Room index <4	Room index ≥ 4	p-value
Individual analysis, median [IQR]	3.00 [3.00,5.00]	4.00 [2.00,6.00]	0.892
	SAI ≤ 95.4	SAI >95.4	p-value
Neighbourhood analysis, median [IQR]	4.00 [3.00, 7.00]	3.00 [2.00, 5.00]	0.092
	SEDI ≤ 100.2	SEDI > 100.2	p-value
Neighbourhood analysis, median [IQR]	3.00 [2.00, 6.00]	4.00 [3.00, 6.00]	0.156
Matched Analysis			
n=70:70	Room index <4	Room index ≥ 4	p-value
Individual analysis, median [IQR]	3.50 [2.25, 5.00]	3.00 [2.00, 6.00]	0.413
n=73:73	SAI ≤ 95.4	SAI >95.4	p-value
Neighbourhood analysis, median [IQR]	**4.00 [3.00, 6.25]**	**3.00 [2.00, 5.00]**	**0.035**
n=83:83	SEDI ≤ 100.2	SEDI > 100.2	p-value
Neighbourhood analysis, median [IQR]	3.50 [2.00, 5.75]	4.00 [3.00, 6.00]	0.297

Reference:

[1]Earnest A, Ong MEH, Shahidah N, et al. Derivation of indices of socioeconomic status for health services research in Asia. *Preventive Medicine Reports* 2015;2:326–32.

O113

Radiographic analysis of early changes in upper adjacent segments after fusion surgery: OLIF vs PLIF

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Introduction: Recently, oblique lumbar interbody fusion (OLIF) is one of the most frequently performed lumbar fusion surgery technique. The purpose of this study was to compare the early radiological changes of upper adjacent segment between OLIF without laminectomy and posterior lumbar interbody fusion (PLIF).
Methods: This was a retrospective comparative study. Between 2013 and 2020, a group P (PLIF, n=131) and a group O (OLIF, n=65) were recruited as matched pairs (Table 1). Each patient underwent plain upright whole spine lateral radiography preoperatively, 3days, 1, 3, 6months, and 1year postoperatively. Radiographic outcomes (lumbar lordosis, upper adjacent segmental lordosis, retrolisthesis, and foraminal height) were measured at each time point, and changes in values from the preoperative value were noted and used for study. Patient-reported outcome measures were obtained preoperatively and 1years follow-up.
Results: Group O was superior to group P with respect its capability to restore lumbar lordosis (O: 4.03°±4.38, P: 1.63°±5.11, p=.001) and surgical segmental disc height (O: 5.50mm±3.39, P: 2.71mm±2.18, p<.001) in 1year after surgery (Fig 1). However, group O showed an increase in upper adjacent segmental lordosis at 3days postoperatively (O: 1.8°±4.39, P: 0.08°±3.35, p=.001) and showed a significant increase in the incidence (O: 76.9%, P: 24.6%, p<.001) and degree of retrolisthesis (O: 1.69mm±1.09, P: 0.29mm±0.70, p<.001) of the upper adjacent segment, and a decrease in the foraminal height of the upper adjacent segment (O: -1.43mm±2.12, P: 0.54mm±2.53, p<.001) at 1month postoperatively (Fig 2).
Conclusions: OLIF shows superior ability to PLIF in recovery of lumbar lordosis and surgical segmental disc height. However, it causes radiographic deterioration in retrolisthesis, segmental lordosis, and foraminal height of the upper adjacent segment after surgery. It seems that stress on the upper segment appears to cause several radiological changes in the upper adjacent segment. During fusion surgery, it should be considered that excessive increase in disc height and lumbar lordosis of the surgical segment may cause early degenerative changes due to stress in the upper adjacent segment. Although it was not possible to confirm the clinical difference related to this in short-term follow-up observation, attention should be paid to the difference to be brought about in long-term follow-up observation.

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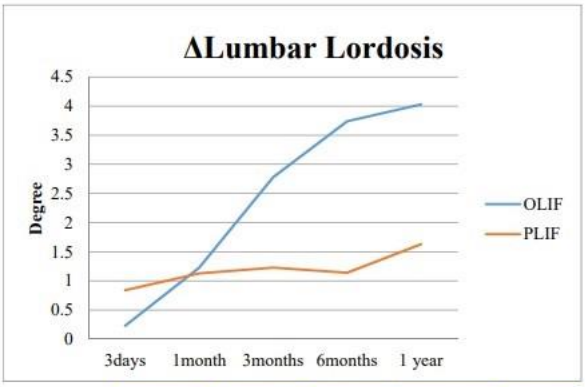
Table 1. Comparison of demographics between Groups O and P

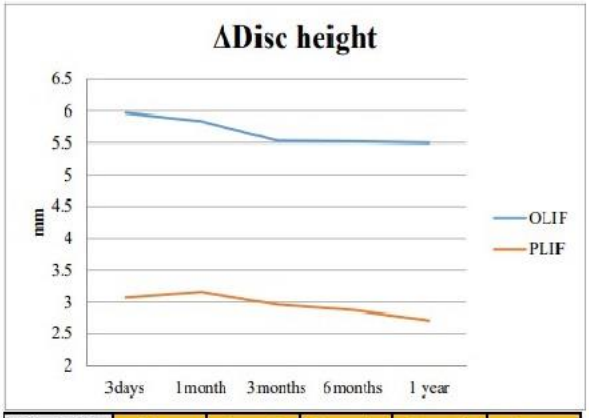
	Group O	***Group P***	***P*-value**
case	65	136	
Age	65.07±8.22	63.41±7.68	0.133
Sex			0.614
male	16	39	
female	49	97	
Smoking			0.880
Non-smoker	33	65	
smoker	32	71	
Level			0.997
L3-4	10	22	
L4-5	35	74	
L3-4-5	20	40	
Lumbar Lordosis	50.75±8.23	48.35±12.78	0.502
Pelvic Incidence	53.47±10.70	51.83±10.64	0.216
Disc height (mm)	7.80±3.16	7.91±2.44	0.487
Upper adjacent Segmental Radiologic Parameters			
Foraminal height (mm)	19.53±2.05	20.1±3.01	0.194
Segmental Lordosis (°)	8.15±3.18	7.75±3.88	0.379
Flexibility (°)	7.64±2.05	7.49±3.88	0.515
Disc degeneration (Pfirrmann Gr.)	2.33±.062	2.44±0.59	0.267
Facet sagitallization (°)	69.16±9.04	71.19±12.62	0.259
Facet degeneration (Weishaupt Gr.)	2.16±0.69	2.36±0.48	0.085
Patient Outcomes			
ODI (%)	48.71±8.23	45.39±10.39	0.81
Back pain VAS	5.47±2.71	5.98±2.69	0.75
Leg pain VAS	8.51±1.16	7.61±1.94	0.63

O, OLIF; P, PLIF; VAS, visual analog scale score; ODI, Oswestry Disability index; Gr., grade;

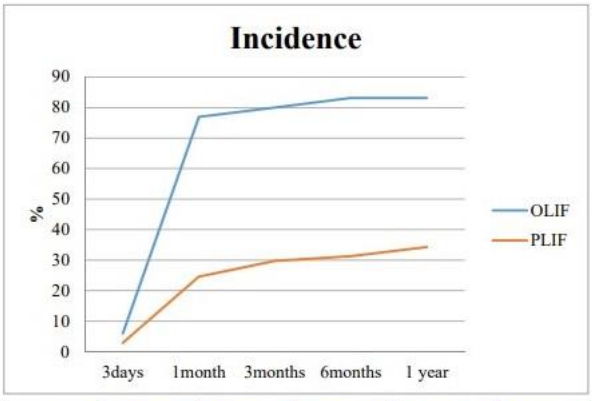
Figure 1. Comparison of postoperative radiological outcomes of between Groups O and P



ΔLL	3days	1month	3months	6months	1 year
OLIF	0.23±4.11	1.23±4.26	2.78±4.32	3.74±4.13	4.03±4.38
PLIF	0.84±6.70	1.13±4.87	1.23±5.71	1.14±5.06	1.63±5.11
p-value	0.609	0.495	**0.036***	**<.000***	**0.001***

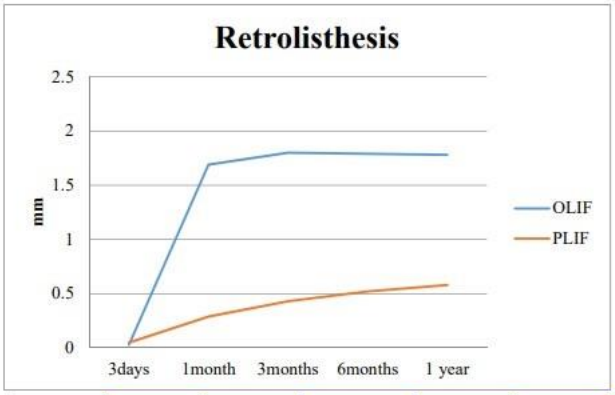


Δdisc height	3days	1month	3months	6months	1 year
OLIF	5.97±3.14	5.84±3.07	5.53±3.53	5.52±3.45	5.50±3.39
PLIF	3.07±2.20	3.16±2.23	2.96±2.32	2.87±2.33	2.71±2.18
p-value	**<.000***	**<.000***	**<.000***	**<.000***	**<.000***

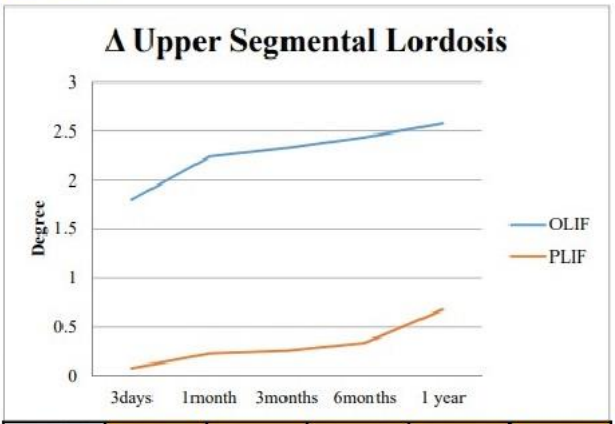


%	3days	1month	3months	6months	1 year
OLIF	6.1	76.9	80	83.1	83.1
PLIF	2.9	24.6	29.8	31.3	34.3
p-value	.12	**<0.00***	**<0.00***	**<0.00***	**<0.00***

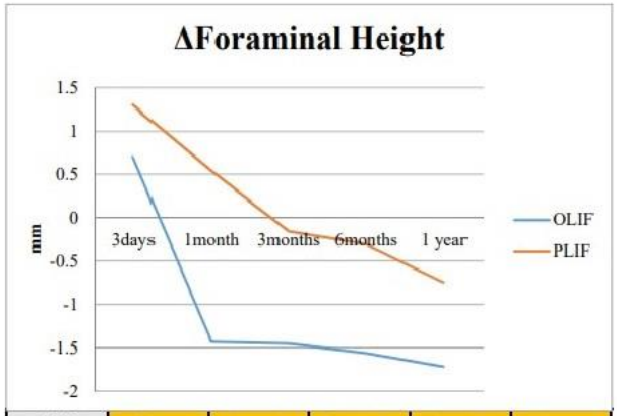
Disc height, surgical segmental disc height, Incidence, incidence of upper adjacent segmental retrolisthesis;
Figure 2. Comparison of postoperative radiological outcomes of upper adjacent segment between Groups O and P



Retro	3days	1month	3months	6months	1 year
OLIF	0.03±0.14	1.69±1.09	1.80±1.33	1.79±1.28	1.78±1.10
PLIF	0.05±0.78	0.29±0.70	0.43±0.75	0.52±0.91	0.58±0.98
p -value	0.305	**<.000***	**<.000***	**<.000***	**<.000***



ΔLordosis	3days	1month	3months	6months	1 year
OLIF	1.8±4.39	2.24±3.55	2.33±3.57	2.44±3.65	2.58±3.17
PLIF	0.08±3.35	0.23±3.75	0.26±3.17	0.34±3.02	0.68±2.63
p -value	**0.001***	**<.000***	**<.000***	**<.000***	**0.001***



ΔFH	3days	1month	3months	6months	1 year
OLIF	0.70±0.78	-1.43±2.12	-1.45±2.82	-1.56±2.07	-1.72±1.81
PLIF	1.3±2.72	0.54±2.53	-0.16±2.42	-0.31±2.47	-0.75±2.72
p -value	0.155	**<.000***	**0.03***	**0.037***	**0.043***

O114

Effect of lumbar spinal stenosis on treatment of osteoporosis: Comparison of three oral bisphosphonate therapies

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Introduction: Many studies have shown that lumbar spinal stenosis (LSS) causes various neurological symptoms and reduces the patient's daily activity, which can negatively affect bone mineral density (BMD) in patients with osteoporosis. The objective of this study was to investigate the effect of LSS on BMD in patients treated with three different oral bisphosphonates (ibandronate, alendronate, risedronate) for newly diagnosed osteoporosis.
Methods: We retrospectively reviewed 1521 consecutive patients treated with osteoporosis. Among them, 346 patients treated with oral bisphosphonates for three years were included in this study. Group I included 178 patients with osteoporosis alone, and group II included 168 patients with both osteoporosis and symptomatic LSS. We compared annual BMD and BMD improvements for 3-years between the two groups. Moreover, the therapeutic efficacies of three oral bisphosphonates in each group were also evaluated.
Results: The mean BMDs were similar in both groups at the initial and 1-year follow-up. However, the mean BMDs at 2- and 3-year follow-up were significantly higher in the group I than those in the group II. Annual and total changes of BMD were significantly higher in group 1 compared to group II ($p < 0.05$ for all). In the group I, BMD change at 1-year and total changes were significantly higher in ibandronate and alendronate than in risedronate (0.34 vs. 0.34 vs. 0.16, $p = 0.002$ for BMD change at 1-year; 0.59 vs. 0.62 vs. 0.35, $p = 0.003$ for total change). In the group II, total change of BMD for 3-year was significantly greater in ibandronate than in risedronate (0.36 vs 0.13, $p = 0.018$ at post-hoc test), while ibandronate and alendronate significantly increased BMD than risedronate at 1-year (0.23 vs. 0.24 vs. 0.07, $p = 0.017$).
Conclusions: This study revealed that symptomatic LSS may interfere with BMD improvement in the treatment of osteoporosis. Among the bisphosphonates, ibandronate was more effective in improving BMD than risedronate in patients with symptomatic LSS. Further trials are needed to validate these results.

O115

A comparison between cortical bone trajectory screws and traditional pedicle screws in patients with single-level lumbar degenerative spondylolisthesis: 5 year results

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Introduction: Traditional pedicle (TP) screw insertion in posterior lumbar fusion has become a surgical treatment option for patients with degenerative lumbar diseases. Cortical bone trajectory (CBT) screw technology as a novel alternative strategy to obtain improved fixation, compared to fixation with the TP screw. We aimed to compare clinical and radiological outcomes, which include the ODI scores, VAS scores, radiographic fusion, and postoperative complications such as the prevalence of adjacent segment disease, between CBT and TP screws in transforaminal lumbar interbody fusion for a minimum follow-up period of 5 years.
Methods: From January 2011 to December 2013, 80 consecutive patients with single-level low-grade degenerative spondylolisthesis underwent TP-TLIF. January 2014 to December 2015, 131 consecutive patients with single-level low-grade degenerative spondylolisthesis underwent CBT-TLIF. Patient-reported clinical outcome measures were obtained at baseline, and postoperatively at 6 months, and 1 year, 2 years, and 5 years and and adverse events after surgery were obtained. Radiologic outcomes such as radiologic ASD, and radiographic fusion were obtained too. All analyses were conducted using SPSS Statistics.
Results: The postoperative VAS score for back pain was significantly lower in the CBT group through 5-year follow-up in the linear mixed model ($p<.0001$, respectively). The VAS score for leg pain was higher in the CBT group at 2 years postoperatively. The ODI scores were not significantly different between the preoperative and postoperative periods between the CBT and TP groups. Adverse events such as iatrogenic dural tear, screw malposition, and iatrogenic nerve root injury that occurred during the intraoperative period were not significantly different between the two groups. The prevalence of a second surgery for symptomatic ASD at postoperative 2 years was significantly different between the two groups. ($p =.044$)
Conclusions: Over a 5-year follow-up, the treatment effect of CBT screws in TLIF was comparable to that of TP screws in TLIF for patients with single-level lumbar degenerative spondylolisthesis. However, when performing CBT screws for TLIF, surgeons should consider screw malposition, breakage, and postoperative prevalence of symptomatic adjacent segment disease requiring surgery.

O116

Correlations between age, pain intensity, disability, and tactile acuity in patients with chronic low back pain

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Introduction: Chronic low back pain is an overwhelming problem for a wide range of people and leads to tactile acuity deficits. We aimed to investigate the correlations among age, pain severity, disability, and tactile acuity in patients with chronic low back pain by using multiple tactile acuity tests.

Methods: A total of 58 participants (36.40 ± 14.95 years) with chronic low back pain were recruited, and tactile acuity tests (i.e., two-point discrimination, point-to-point test, and two-point estimation) were performed on their painful low back areas. A numerical rating scale that ranged from 0 ("no pain") to 10 ("the worst pain") was used as the scoring standard to quantify pain intensity of low back pain, including general pain, maximum pain, and pain unpleasantness during the past 3 months. Disability was measured by using the Oswestry Disability Index (ODI) and the Roland–Morris Disability Questionnaire (RMDQ). The correlations between age, pain intensity, disability, and tactile acuity were characterized with Pearson's correlation coefficients. Subgroup analyses according to the median values of age, pain intensity, and disability were used to compare the intergroup difference in tactile acuity.

Results: Results illustrated significant negative associations among age, pain intensity, disability, and tactile acuity (R^2=0.314 to 0.617, P<0.05). Subgroup analyses revealed that patients with below-the-median values of age (P<0.001), maximum pain (P≤0.013), general pain (P≤0.004), pain unpleasantness (P≤0.006), ODI (P<0.001), and RMDQ (P≤0.001) had better performance in tactile acuity tests than those with above-the-median values.

Conclusions: Our findings confirmed negative associations among age, pain severity, disability, and tactile acuity in patients with CLBP. Severe CLBP was associated with worsening tactile acuity. Specifically, CLBP patients with advanced age, severe pain, and severe dysfunction may experience a significant deterioration in tactile acuity.

O117
Central sensitization is a significant risk factor for the chronic low back pain

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Introduction: Central sensitisation is defined as an increased responsiveness of nociceptors in the central nervous system to either normal or sub-threshold afferent input. To clarify the relationship between central sensitization and chronic low back pain (CLBP), we conducted a longitudinal survey under the spread of COVID-19 infection in Japan.
Methods: Invitations were sent to 771 people who participated in the baseline survey in July 2019 before the spread of the COVID-19 infection in rural areas in Wakayama prefecture, and 227 people (79 men, 148 women, average age at baseline 68.5 ± 9.5 years) who participated in the follow-up survey in October 2020 were included in the analysis. The main evaluation items were (1) presence or absence of CLBP (definition: low back pain that lasts for 3 months or more), (2) central sensitization screening tool: Central Sensitization Inventory (CSI). At the time of follow-up survey, we also asked about whether or not to refrain from going out due to the spread of COVID-19 infection.
Statistics: First, we observed changes in the prevalence of CLBP and CSI scores through the observation period. Second, the participants were divided into the following four groups and the baseline characteristics were compared among the groups; (1) "None group" did not have CLBP through the observation period, (2) "De novo group" did not have CLBP at baseline while it had CLBP at follow-up, (3) "Continued group" had CLBP through the observation period, (4) "Improved group" had CLBP at the baseline while it did not have CLBP at the follow-up. Third, a multiple logistic regression analysis was conducted to elucidate risk factors for the development of CLBP on 167 patients who did not have CLBP at baseline.
Results: The prevalence of CLBP were 59/227 (26%) at baseline and 71/227 (32%) at follow-up. The CSI score was 16.9 at baseline and 17.1 at follow-up. There were 131 participants (60%) in the None group, 32 (15%) in the De novo group, 39 (18%) in the Continued group, and 15 (7%) in the Improved group. There were no significant differences in gender, age, BMI at baseline, and whether or not to refrain from going out among the four groups. The baseline CSI score (mean) was 14.2 in the None group, 17.9 points in the De novo group, 22 points in the Continued group, and 20 points in the Continued group- a significant difference was observed between the None group and the Continued group. The multiple logistic regression analysis revealed that higher baseline CSI scores were a significant risk factor for the development of CLBP.
Conclusion: (1) After the spread of COVID-19 infection, the prevalence of CLBP increased. (2) Higher CSI score was a significant risk factor for the development of CLBP.

O118
Hip-spine syndrome: Which first and which last longer?

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Introduction: It is common to meet the clinical picture that patient with buttock, groin and thigh pain with the presence of degenerative disease of both the hip and the spine. Since the referred pain pattern from lumbar spine and hip joint were similar, suggesting that the pathological changes might be interrelated. Because of the overlap of symptoms, the proper diagnosis and treatment of this pathological condition can present a substantial challenge to even the most skilled specialists. Especially when the lesion site from both were severe enough to warrant surgery, it may be difficult to decide on the optimal order of treatment. The aim of this study was to discuss in patient with complex hip-spine syndrome, accepting hip replacement first or spine surgery first can experience longer duration of pain relief.
Methods: This is a retrospective study. From 2006/9 to 2019/9, patients with complex hip-spine syndrome who underwent lumbar spine surgery or hip replacement or both were included. Group A comprised patients who underwent hip first and then underwent lumbar surgery. Group B comprised patients who underwent lumbar surgery first and then underwent hip replacement. Group C comprised patients who accepted hip replacement first and experienced enough pain relief and didn't need further lumbar surgery. The exclusion criteria including patient who accepted previous spine or hip surgery, symptomatic spinal stenosis, metastasis cases, and patient who accepted both surgery within 3 months. We evaluated the surgical outcome with preoperative and postoperative ODI questionnaire, preoperative and postoperative Visual Analogue Scale (VAS) pain score. In patients who accepted both kind of surgeries (Group A and Group B), we compared the duration between two surgeries. Evaluating which kind of surgeries can provide longer discomfort relief.
Results: A total of 148 patients were included in this study. Group I comprised 48 patients with age 73.8 ± 11.4 years, Group II comprised 28 patients with age 70.8 ± 12.8 years and Group III comprised 72 patients with age 64.6 ± 12.51 years. The patients age was not significantly different between Group I and II but significantly younger in Group III ($p < 0.001$). The duration between surgeries is 55.1 months in Group A and 25.4 months in Group B with significant difference ($p = 0.029$)
Conclusion: In patient with both hip lesion and lumbar spinal stenosis without obvious neurological deficit and no obvious primary pain source, hip replacement provides longer duration of discomfort relief comparing with lumbar spine surgery. Most patients who presented with complex hip spine syndrome experienced resolution or improvement of their pain after hip replacement.

O119

Aging intervertebral disc induces nociceptive signaling in mouse sensory system

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Introduction: Aging is a major risk factor for chronic low back pain (cLBP), which is often associated with disc degeneration. Each disc contains nucleus pulposus (NP) and annulus fibrosus (AF) cells. However, degenerating discs can often be asymptomatic. Hence, it is crucial to elucidate whether degenerating discs cause cLBP and how, which we tested in a preclinical mouse model of natural aging. We previously reported that lumbar disc pathologies in naturally aging FVB mice were associated with sensory innervation of the discs, and and nociceptive signaling demonstrated by increased expression of *TRPA1, $Na_v1.8$, $Na_v1.9$* in the lumbar dorsal root ganglion (DRG). The goal of the present study was to determine whether the patholgically aging discs are a cause of stimulated nociceptive signaling in the DRGs of the aging mice.
Methods: To test whether cLBP is a consequence of age-related disc pathologies, first we did transcriptomic analysis by RNAseq of lumbar NP and AF of 1 week and 12-month (12M) old, and lumbar DRGs from 4M, 11-13M, and 20-24M old mice. The results from bulk RNA-seq analysis were validated by multiplex qPCR analysis. To test the hypothesis that age-related disc pathologies elicit nociception in DRG, we establised a heterochronic *ex vivo* model to co-culture lumbar DRGs and discs. The effects were analyzed by qPCR analysis, or immunostaining followed by fluorescence microscopy.
Results: GSEA of the 1wk and 12M old NP and AF cells buld RNAseq analysis showed significant differential gene expression and increased inflammatory pathways in NP and AF cells. Moreover, age-related increased expression of immune-response related markers was observed in DRGs from aged mice. Analysis of published RNAseq data of human herniated discs and spondylolisthesis-causing degenerated discs validated transcriptomic changes in degenerated discs. Multiplex qPCR analysis.of mouse lumbar NP, AF, and DRG from 4-6M to 24M of age validated the age-related expression of key candidate genes. Expression of inflammatory cytokines (*IL1b, Tnfa*) and neurotrophic factors (*Bdnf, Ngf, Tac2*) increased in NP and AF cells by 24M of age. Moreover, increased expression of *Ngf, Tacr1* validated enhanced sensitization and inflammatory response in aged DRG. Heterochronic culture experiment showed increased expression of nociceptive-related markers, including *Npy* and *Calca* by qPCR analysis in the DRG from the heterochronic group compared to young controls. Immunostaining for $Na_V1.9/1.8$ and NPY validated the effects of secretory factors from aged-mouse disc in enhancing nociceptive signaling in young mouse DRGs in heterochronic group compared to young controls. The old DRG co-cultured with old disc served as positive control. Additionally, DRGs cultured with serum from aged mice controlled for the effects of circulatory signals on the DRG.
Conclusions: In summary, together with the transcriptome analysis, these results indicate that degenerated discs directly regulate nociceptive response in the DRG and induces cLBP.

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O120

Biomechanical comparison of lumbar spine instrumented with stand-alone interbody fixation constructs versus interbody with supplemental fixation

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Introduction: Low fusion rates and cage subsidence have been reported as the main drawbacks of lumbar fixation with static interbody cages.[1] Although several clinical and biomechanical studies have evaluated the efficacy of 360 interbody fixation constructs (Anterior cage plus posterior fixation), no study has reported the biomechanical comparison between such constructs and more novel techniques which use standalone fixation implants. A cadaver validated computational model of lumbar spine was used to compare the biomechanics of spine instrumented with 360 fixations versus standalone cage with screw and cage with lateral plate systems. To compare the mechanical stability of different interbody fixation techniques in lumbar spinal segments with standalone interbody versus static cage with posterior fixation or lateral plate system.

Methods: An experimentally validated Finite element (FE) model of L1-Pelvic segment was used to simulate ALIF and LIF lumbar fixation techniques including: ALIF cage at L5-S1 plus posterior screw-rod fixation (360 construct) versus ALIF standalone (screw through the cage).[2,3] LIF cage at L4-L5 versus LIF cage with integrated two-hole lateral plate system. 4WEB Medical's Truss ALIF (27mm x 25mm), Lateral Truss (22mm X 5mm) cages and 2-hole integrated plate systems were used for simulation of the surgical procedure. For 360 constructs, a generic posterior rod and screw system was used. All models were subjected to a 400N compressive pre-load followed by an 8 Nm moment to simulation Flexion-Extension, Left and Right Bending and Axial Rotation motions. The segmental kinematics and the load sharing at the inferior endplate were compared among the cases.

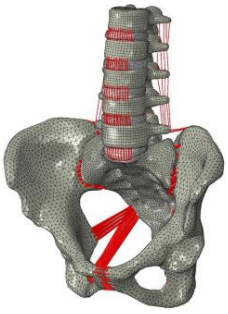


Figure 1. Finite element model of L1-

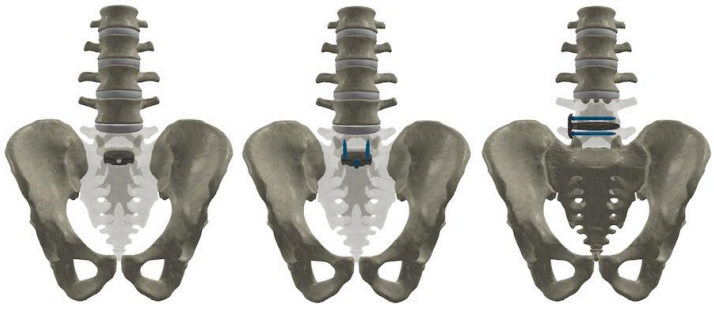
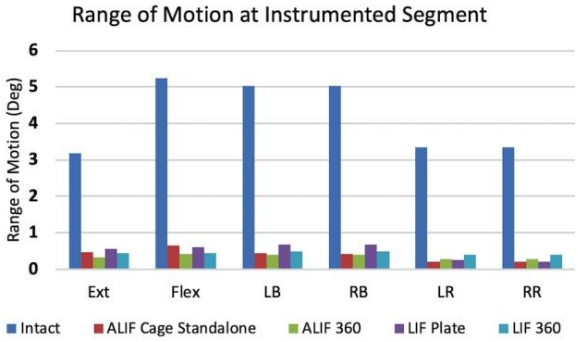


Figure 2. FE model of the spine instrumented with ALIF cage with posterior screw-rod fixation, Stand-alone ALIF cage and Lateral Cage with Plate or Posterior screw and

Results: The segmental motion in standalone ALIF construct was 1.1°(Flex-Ext), 0.9° (LB) and 0.4° (AR) versus 0.8°, 0.8° and 0.6° in 360 ALIF in the same planes of motion. When comparing lateral constructs, the motions were 1.2° (Flex-Ext), 1.4° (LB) and 0.5° (AR) in Lateral cage with plate versus 0.9°, 1.0° and 0.8° in the 360 lateral construct for the same loads. The peak stresses in extension for the LIF stand-alone cage were slightly higher than the posterior instrumented cases. When comparing the mechanical stress on the inferior endplate of the index segment, the Stand-alone ALIF had almost 20% higher peak stress compared to the 360 ALIF construct. In the lateral construct, the cage-plate segment experienced 15% lower stresses on the endplate compared to the 360 lateral construct.



Discussion: Our data suggest that stand-alone ALIF cage with screw through the cage is able to provide kinematic stability in the fixation construct comparable to the cage plus posterior fixation. Although the 360 construct is able to provide slightly more stability in the sagittal plane. Also, the standalone cage resulted in higher stresses at the endplate compared the 360 constructs. The lateral cage with integrated plate had superior stability in axial rotation compared to the 360 lateral construct. The loads on the endplate were also slightly lower compared to the 360-fixation case. Standalone ALIF and LIF with lateral plate are biomechanically efficient alternatives to 360-fixation constructs at least under the controlled conditions analyzed in the present study. Clinical data are required to support the findings and defining the further role and application of stand-alone cages.
Significance: Understanding the biomechanics of various fixation construct can result in better selection of hardware for better clinical outcomes.

Reference:
[1]Mummaneni PV et al., JNS, 2021. [2] Goel VK, et al., *Spine*, 2005. [3] Kiapour et al., JNS, 2021.

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Disclosures: Ali Kiapour (N), Elie MAssaad (N), David Row (5), John Shin (N)

O121

Effect of implant surface roughness and porosity on osteoblastic genes expression in bone marrow mesenchymal stem cells

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Introduction: Achieving optimal spinal fusion in interbody fixation procedures requires a rapid and stable fixation at the bone-implant interface, which may reduce implant-related complications such as subsidence, expulsion and nonunion. Commonly utilized interbody fusion cages are comprised of Polyetheretherketone (PEEK) or Titanium (Ti). Although PEEK interbody spacers have favorable attributes such as biocompatibility and an elastic modulus that is similar to bone[1], PEEK implants generally have a smooth, hydrophobic surface that does not directly bond to bone and promotes fibrous tissue formation[2,3]. Similarly, Ti cages with a smooth surface (SmTi), such as commonly utilized in traditional interbody cages manufactured through a machining process, have demonstrated inferior osteogenesis and bony integration[4] as compared to those with roughened surfaces. Porosity and surface roughness properties of Ti interbody implants have been shown to promote stability and fusion by facilitating improved bone repair and interlocking between the implant and bone interface zone. Specifically, multi-scale Ti surface topography (e.g. those that contain macro-, micro- and nano-scale features), can shorten the bone ingrowth and integration phase. The purpose of ths study was to compare P3D with SmTi and PEEK surfaces for their bone differentiation capability by utilizing transgenic bone marrow stem cells that fluoresce when osteogenesis is initiated. In addition, to evaluate the rate and magnitude of osteogenesis, gene expression was evaluated longitudinally with a comprehensive panel of bone-related genes that include a master transcriptional regulator of bone formation, and early- and late-stage markers for bone differentiation.
Methods: The current study evaluated mesenchymal stem cells obtained from the bone marrow of a transgenic mouse in which the expression of two genes that are critical for the proper mineralization of bone could be monitored fluorescently (Fig 1).

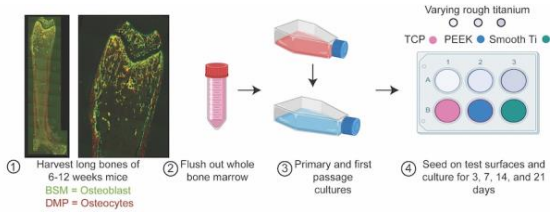

Figure 1. Experimental setup

Bone marrow was harvested from the femur and tibia bones of the Bone Sialoprotein (BSP)-Green Fluorescent Protein (GFP) tpz/Dentin Matrix Protein (DMP)-Red Fluorescent Protein (RFP)chry Bacterial Artificial Chromosome (BAC) transgenic reporter mouse and cultured under non-osteogenic conditions to expand the attached stem cells. The BSP and DMP proteins are located deposited in bone tissues and are involved in hydroxyapatite nucleation and collagen mineralization. The BSP gene is activated in newly formed osteoblasts and DMP expression is limited to mineral embedded osteocytes (figure 1). Low density, first passaged cells from the primary bone marrow stromal culture (BMSCs) were seeded at 1x106 cells/ mL onto three replicate plates: P3D, Ti with smooth surface (SmTi) or PEEK (ultra-low cell attachment plates, Corning Fisher Scientific). From day 7 through 22, cell-constructs were placed under osteogenic conditions (alpha MEM (ThermoFisher Cat# 12571063) supplemented with 10% FBS, 50 µg/ml ascorbic acid and 4 mM ß-glycerophosphate). Media was replenished every 2-3 days. The plates were harvested at days 3, 7, 14 and 22 and evaluated for fluorescence and RNA expression. Cultures were rinsed with PBS and treated with Accutase for 30 minutes at 37°C. The remaining cells were scraped, resuspended and centrifuged. The cell pellets were resuspended in PBS containing 2% FBS, loaded into a disposable cell counting chamber slide (SD100, Nexcelom Bioscience, USA), counted in the Cellometer with phase image using filters for GFPtopaz (P/N: VB-535-402) and mCherry (custom made: VB-625-502) and analyzed with FCS4 Express Flow Cytometry software (De Novo Software, USA). Fluorescence intensity below 1000 was

counted as fluorescence negative. Cells that have entered osteogenesis were identified as being GFPtopaz positive, mCherry positive, and/or GFPtopaz/mCherry double positive at day 22. Cells that did not express fluorescence were defined as not having initiated osteogenesis.

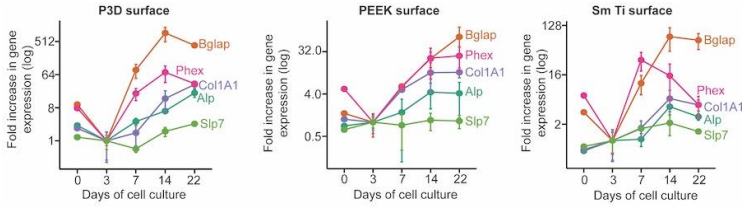

Figure 2. Osteogenic gene expression over time (day 3, 7, 14 and 22) for the BMSCs cultured on (left) P3D, (middle) PEEK and

Results: Significantly greater percentage of BMSC-derived progenitor cells were osteogenic on the P3D Ti surface at day 22 (Fig 2, $p<0.05$) as compared to smooth Ti and PEEK. Osteogenic gene expression was evaluated over time on each surface (Fig 3). On each surface, almost all osteogenic markers increased over time with maximum osteogenic gene expression generally occurring at approximately day 14. The magnitude of gene expression was substantially higher for most markers on the P3D surface as compared to PEEK or SmTi (compare y-axis of all three).

At each time point, the fold-increase for osteogenic expression between P3D and PEEK or SmTi was evaluated (Fig 3). BMSC-derived progenitor cells cultured on P3D resulted in significantly ($P<0.005$) greater increases in the late osteogenic markers Bglap and Phex (indicative of osteocyte formation) by more than 1,000- and 100-fold, respectively, at day 14. At day 22, stem cells cultured on P3D resulted in significantly ($P<0.005$) greater increases in the early osteogenic markers Alp and Col1A1 by more than 15- and 35-fold, respectively, at day 22.

Discussion: The 3D-printed rough Ti surface enabled a significantly greater proportion of the stem cells to enter the osteogenic lineage relative to PEEK and Smooth Titanium surfaces. Stem cells on the P3D surface resulted in significantly greater gene expression compared to PEEK or to SmTi for a broad spectrum of bone related molecules that includes a master regulator of bone differentiation, early bone markers and markers associated with bony mineralization. Faster and more robust late-stage osteogenic differentiation was demonstrated by over a 100-fold increase in osteocalcin and Phex for P3D relative to PEEK and SmTi. These attributes may facilitate a more rapid and stable fixation of bone-implant interface during spinal fusion.

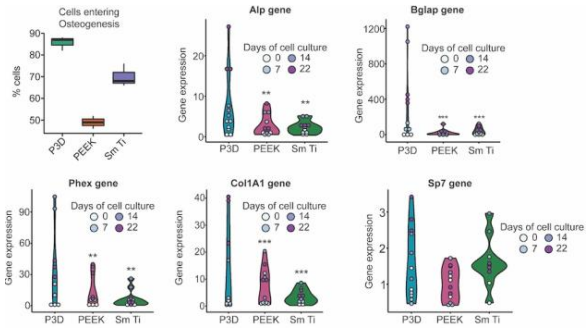

Figure 3. Comparison P3D for markers of osteogenic expression versus PEEK and SmTi at each time point of the growth curve.

Significance: The rough 3D printed titanium surface may facilitate a more rapid and stable fixation of bone-implant interface during spinal fusion.

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[2]Cho, D.Y.+, Neurosurgery, 2002.
[3]Olivares-Navarrete, R.+ Spine, 2015. [4] Klein, M.O.+, Clin Implant Dent Relat Res, 2013.

Acknowledgements: This work was supported by a sponsored research agreement from 4WEB Medical Inc.

Disclosures: Ali Kiapour (N), Xiaonan Xin (N), Elie MAssaad (N), John Shin (N), David Row (5)

O122

Results of biphasic calcium phosphate bone graft with submicron-sized needle-shaped surface topography as standalone alternative to autograft are favorable in a prospective, multi-center, randomized, intra-patient controlled trial

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Introduction: Pseudoarthrosis after spinal fusion is an important complication leading to revision spine surgeries. Iliac Crest Bone Graft is considered the gold standard, but with limited availability and associated co-morbidities, spine surgeons often utilize alternative bone grafts.
Aim: Determine the non-inferiority of a novel submicron-sized needle-shaped surface biphasic calcium phosphate (BCP<µm) as compared to autograft in instrumented posterolateral spinal fusion.
Patients and methods: Adult patients indicated for instrumented posterolateral spinal fusion of one to six levels from T10-S2 were enrolled at five participating centers. After instrumentation and preparation of the bone bed, the randomized allocation side of the graft type was disclosed. One side was grafted with 10 cc of autograft per level containing a minimum of 50% iliac crest bone. The other side was grafted with 10 cc of BCP<µm granules standalone (without autograft or bone marrow aspirate). In total, 71 levels were treated (average 1.4 per patient). Prospective follow-up included adverse events, Oswestry Disability Index (ODI), and a fine-cut (<1mm) Computerized Tomography (CT) at one year. Fusion was systematically scored as fused or not fused per level per side by two spine surgeons blinded for the procedure.
Results: The first fifty patients enrolled are included in this analysis. Average age was 57 years old (27-79 years), with 60% female and 40% male. The diagnoses included deformity (56%), structural instability (28%), and instability from decompression (20%). The fusion rate determined by fine-cut (<1mm) CT for BCP<µm was 76.1% (54/71 levels), which compared favorably to the autograft fusion rate of 43.7% (31/71 levels). Fusion of the BCP<µm side was not contingent upon fusion of the autograft side, as 36.6% (26/71) of levels fused on the BCP<µm side but did not fuse on the autograft side. In contrast, 4.2% (3/71) of levels fused on the autograft side but not on the BCP<µm side. 39.4% (28/71) of levels had complete fusion of both sides, while 19.7%% (14/71) did not have fusion on either side. Statistical analysis through binomial modeling showed that the odds of fusion of BCP<µm was 2.54 times higher than that of autograft. Fourteen percent of patients experienced a procedure or possible device-related severe adverse event and there were four reoperations. Oswestry Disability Index (ODI) score decreased from a mean of 46.0 (±15.0) to a mean of 31.7 (±16.9), and 52.4% of patients improved with at least 15-point decrease.
Conclusion: This data, aiming to determine non-inferiority of standalone BCP<µm as compared to autograft for posterior spinal fusions, is promising. Ongoing studies to increase the power of the statistics with more patients is forthcoming.

O123

Constrained pedicle screws constructs in thoracolumbar fusion and their influence in revision surgery incidence

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Introduction: Despite the efforts to develop new systems and techniques to lower revision surgery rate in thoracolumbar vertebral fusion, it has increased along the last 20 years. 70% of the cases are due to mechanical failures, including implant failure, pseudoarthrosis and adjacent segment disease.
Aim: The objective of this study is to investigate the incidence of postoperative screw/rod mismatch after instrumented posterior fusion and to analyze the impact of mismatches on the need of revision surgery.
Materials and Methods: This retrospective observational clinical study includes all patients from the Spine-Unit of our hospital who underwent fusion surgery with pedicle screw/rod systems for predominantly degenerative pathologies between January 2013 and December 2018 and for whom clinically and radiologically complete preoperative, postoperative, and follow-up data were available. For the latter, this includes, at a minimum, a/p and lateral spine radiographs and information on revision surgery. Revision includes all subsequent procedures in which all or part of the original implant configuration is changed or removed. Radiographic parameters recorded are pedicle screw/rod mismatch (no/yes) and degree of pedicle screw/rod mismatch (angular deviation from a 90° alignment). Statistical analysis was performed using IBM SPSS Statistics, version 21.
Results: Out of 1183 cases screened, 406 met the above inclusion criteria. 3016 screws were implanted and measured. The most frequent diagnosis were degenerative disc disease and stenosis (55% of the total), followed by deformity, fracture and failed back syndrome (10% each). 77% of the patients had 3 levels or less fused. 42% of the patients had pedicle screw/rod mismatch, affecting 20% of the total number of pedicle screws implanted. Mean degree of mismatch was 8.7º. Revision incidence was 1.8%. However, the comparison between groups with versus without mismatch revealed statistically significant differences in the number or revision surgeries. The group of patients with no mismatch had a 0.9% revision rate whereas the group of patients with pedicle screw/rod mismatch had a 26.9% of revision surgeries (figure 1).
Conclusions: Pedicle screw/rod mismatch (any deviation from 90° formed by the axes between the rod and the screw head) is a relevant occurrence after fusion surgery that negatively affects clinical outcome in terms of revision rate. Uncontrollable correction maneuvers and fixations under constrain should be avoided as far as possible.

Figure 1:

Revision Procedure			
	Without Mismatch N=235	With mismatch N=171	P-value
No	99.1% (233)	73.1% (125)	<0.001
Yes	0.9% (2)	26.9% (46)	

Comparison of the two groups Without and With mismatches revealed statistically significant difference.

O124

What effect does T1 slope have on sagittal balance and the relationship with caudal end of three or more level posterior cervical fusions

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Introduction: Sagittal balance of the spine is achieved through the equilibrium created through the natural curvatures of the cervical, thoracic, lumbar vertebrate and pelvis. As the body ages, degenerative pathologies and muscular deconditioning can pull the body's center of mass forward, creating sagittal imbalance. Extending posterior cervical fusions into the upper thoracic spine for degenerative cervical pathologies has been thought to reduce rates of pseudoarthrosis and distal junctional kyphosis, leading to overall improved clinical outcomes. However, this extension is also associated with increased surgical time, blood loss and invasiveness. This study investigated the effect of T1 slope on post-operative Sagittal Vertical Axis (SVA) and whether extension of posterior cervical fusions into the upper thoracic spine (T1/ T2 caudal levels) provides improved sagittal balance in comparison to C7 caudal level.
Methods: A database of 327 patients from seven different centers who underwent a three or more level posterior cervical fusion was created. Only patients with two years follow up data were included. Two cohorts were created based on fusion caudal level, those whose fusion terminated at C7 and those whose fusions extended to T1 or T2. Basic demographic data was collected along with SVA and T1 slope radiographic measurements at pre-operative and incrementally up to two years post-operative intervals (1 month, 3 months, 6 months, 12 months, 24 months post-operative). The cohorts were then divided again into two subgroups, high T1 slope (>25°) and low T1 slope (≤25°) and subject to comparative analysis.
Results: were included in the C7 caudal cohort and 103 were included in the T1/T2 caudal cohort. The C7 cohort was 224 patients 55% female, with a mean age of 61±12 yrs. The T1/T2 cohort was 44% female with a mean age of 63.1±12.6 yrs. Mean BMI of the C7 cohort was 28.9±6.8, and 29.1±5.8 in the T1/T2 cohort. Mean SVA was significantly higher in patients with high T1 slopes (mean range 34.2-44.1mm) as compared to patients with Low T1 slopes (mean range 21-28.9mm) across all time intervals (pre-op to 24 months post-op). Additionally, the 25th percentile SVA of High T1 slopes were greater than the median SVA values of Low T1 slopes at all intervals. For both the high and low T1 slope cohorts, patients with a caudal T1/T2 had comparatively higher SVA values than their C7 counterparts at all intervals despite maintenance of cervical lordosis, however these differences were not statistically significant.
Conclusions: Increased sagittal imbalance was comparatively higher in patients with >25° T1 slope ranging across preoperative to 24 months postoperative radiographic measurements. Extension of the posterior cervical fusion to T1 or T2 did not improve sagittal balance in patients with high T1 slopes. In fact, extension of posterior cervical fusions across the junction lead to increased positive sagittal imbalance. The results of this study do not support routinely extending posterior cervical fusions into T1 or T2 to improve post-operative sagittal balance. Longer thoracic extension or other intra-operative measures must be sought in patients at high risk for sagittal decompensation.

O125

A randomized trial of cervical orthosis versus no orthosis following multi-level posterior cervical fusion

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Introduction: Temporary postoperative immobilization with cervical orthosis (CO) is commonly utilized following posterior cervical fusion (PCF). The biomechanical advantage of modern instrumentation to facilitate fusion means the additional stabilization from an external Cervical Orthosis is no longer required. Therefore, the primary indication for CO likely is a reduction in postoperative pain, although other potential advantages include decreased wound dehiscence and patient reassurance. Potential disadvantages may include patient discomfort, inconvenience, functional limitation, and cost to the health care system. Given the lack of evidence surrounding cervical collar use following PCF, our study aims to determine whether postoperative neck pain following multi-level PCF with CO is equivalent to multi-level PCF without orthosis.
Methods: We conducted a single-centre, prospective, randomized, non-blinded, equivalence trial. Between March 2020 and May 2022, patients requiring multi-level (2- or more level), open, posterior cervical fusion extending no further than the second thoracic vertebrae (C1-T2) were enrolled and randomly assigned by 1:1 allocation to postoperative cervical orthosis (Collar) for 6 weeks or no orthosis (No Collar). Randomization was stratified based on: 1. trauma vs degenerative indication; and 2. pre-operative opioid use. Exclusion criteria were traumatic spinal cord injury, infection, tumour, primary sagittal deformity, inability to provide consent or comprehend patient-rated outcome instruments, previous surgery involving the same level, dementia, substance abuse, and psychosis. The primary outcome measure was neck pain intensity during the first 4 weeks after surgery, using the numerical pain rating scale (0 to 10 with higher scores indicating more severe symptoms). The equivalence margin was set at δ=2 points. Secondary outcome measures included NDI, SF12, arm pain, range of motion (ROM), compliance, length of hospital admission, and comparison of procedural details and outcomes/complications postoperatively. A mixed longitudinal regression model for repeated measures was used to analyze the primary outcome, accounting for the correlation among the outcome score on the same patient at 2 days, 2 weeks, and 4 weeks. Treatment (collar vs no collar), time, treatment x time interaction and baseline scores were included as fixed variables.
Results: Sixty-two patients were enrolled in the study, 31 in the collar group and 31 in the no-collar group. At baseline, the Collar group had more neck pain than the No Collar group (5.3 vs 3.2, p=0.013). Otherwise, baseline characteristics and procedural details were similar between the groups. For the primary outcome, the neck pain intensity score was 4.6±0.3 for the Collar group vs. 4.9±0.3 for the No collar group. The 95% confidence interval (-1.4 to 0.2) was within the predetermined margin of equivalence. No differences were found between groups for NDI or SF12 at any of the time points. The collar group had reduced neck range of motion at 6 weeks, but there was no difference between groups after 12 weeks. No differences in postoperative complications or adverse events were observed.
Conclusion: Compared with patients treated with a CO, patients treated without orthosis maintain similar pain scores during the early postoperative period without increasing the risk of adverse events.

O126

Comparison of 3D printed custom navigation jigs with freehand pedicle screw insertion for posterior spinal fusion in scoliosis

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Background: Scoliosis is characterised by a curvature of the spine. Significant curvature of the spine is often treated with spinal fusion. There are many different approaches to spinal fusion, with freehand pedicle screw insertion being the most common. However, this has inherent inaccuracies and a greater danger of spinal cord injury due to mispositioning. In more recent years, a new navigation technique has arisen. This technique utilises 3D printing technology to create unique, custom made patient-specific screw jigs that fit onto each vertebra, allowing for accurate and precise pedicle screw insertion.
Material and Methods: The British Spine Registry and ICLIP were used to identify all scoliosis patients who underwent posterior spinal fusion from 16/01/2017-01/09/2022 at a South London tertiary medical centre and a London private hospital. 41 3DPCNJ patients were identified, and matched to 41 freehand patients by diagnosis and Lenke classification. Data was then collated regarding age, gender, diagnosis, duration of surgery, estimated blood loss, screw density, hospital length of stay (HLOS), SRS-22 scores, complication and return to surgery rate, and standing Cobb angles (pre- and post-operatively). P-values were calculated using an unpaired t-test and a Fisher's exact test.
Results: The average age was 15.22 (SD ± 2.69) N = 41, for the freehand group, and 15.93 (SD ± 2.51) N = 41, for the 3D printed custom navigation jigs (3DPCNJ) group. Both the freehand group and 3DPCNJ groups had a greater proportion of female patients, at 80% and 77% respectively. Screw density and per screw time for insertion was found to be significantly faster using 3DPCNJ (see Figure 1). There did not seem to be any differences in Cobb angles between the two groups (see Figure 2).
Conclusion: We show that 3D Printed Custom Navigation Jigs (3DPCNJ) for the insertion of Pedicle screws is safe and efficient. Whilst the operations took approximately the same time, there was a higher screw density in the 3DPCNJ group. This is reflected in a significantly faster time per screw insertion in cases assisted with 3DPCNJ. Furthermore this cohort takes into account our entire series including the learning curve early cases. Drilling pedicle tracks and tapping needs to be carefully done, and our techniques changed over time to mitigate blood loss and ensure haemostasis. One must work from cephalad to caudal which is the opposite direction of most who use freehand technique. Furthermore, facet or Ponte osteotomies must be done after screw insertion sequentially in small curves as screw density can prevent adequate osteotomies. In larger curves they can be conducted after all screws are inserted. There was no significant difference in SRS22 or Cobb angle correction rate. Sharing the load amongst more screws should help mitigate screw pull out. Further analysis will be conducted to look at kyphosis correction.

Intraoperative parameters	**Freehand (mean ± SD)**	**3DCPNJ (mean ± SD)**	**P-value**
Screw density (%)	38.43 (± 5.58), N=33	80.88 (± 17.56), N=41	P < 0.05*
Number of screws	15.70 (± 3.33), N=33	21.24 (± 5.37), N=41	P < 0 .05*
Duration of surgery (minutes)	294.64 (± 74.71), N=28	310.03 (± 76.94), N=29	P = 0.4471
Estimated blood loss (ml)	559.00 (± 274.60), N=30	628.32 (± 361.63), N=31	P = 0.4037
Time per screw insertion (minutes)	18.48 (± 4.48), N=23	14.74 (± 4.82), N=29	P < 0 .05*
Blood loss per screw (ml)	36.53 (± 18.23), N=24	29.52 (± 16.88), N=31	P = 0.1461
Postoperative outcomes	**Freehand**	**3DPCNJ**	**P-value**
Hospital length of stay (days)	7.64 (± 4.14), N=39	6.17 (± 2.53), N=18	P = 0.1708
SRS-22 pre-op	3.43 (± 0.51), N=27	3.45 (± 0.53), N=35	P = 0.8815
SRS-22 6 weeks post-op	3.75 (± 0.67), N=35	3.57 (± 0.49), N=24	P = 0.2654
SRS-22 6 months post-op	4.16 (± 0.59), N=18	4.12 (± 0.56), N=13	P = 0.8505
SRS-22 12 months post-op	4.4 (± 0.50), N=14	4.52 (± 0.30), N=4	P = 0.6579

Figure 7

	Preoperative			**Postoperative**		
Radiographic parameters	**Freehand**	**3DPCNJ**	**P-value**	**Freehand**	**3DPCNJ**	**P-value**
Standing Cobb	66.66 (± 14.84), N=41	62.05 (± 17.74), N=40	P = 0.2079	28.58 (± 10.55), N=40	27.24 (± 16.94), N=34	P = 0.6795

Figure 8

O127

Prospective, randomized, blinded clinical trial comparing PEEK and allograft spacers in patients undergoing lumbar fusion surgeries

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Introduction: Allograft and polyether-ether-ketone (PEEK) radiographic, biomechanical, histological properties have been extensively studied and both spacers have their advantages and shortcomings, but there are no comparative randomized spinal fusion clinical trials reported to date.
Aim: The study's primary objective was to prospectively investigate clinical and radiological outcomes in patients undergoing lumbar interbody fusions and randomized to receive either PEEK or structural bone allografts.
Patients and Methods: A prospective, randomized, blinded clinical trial was initiated at a single center. The patients were randomly assigned (1:1 ratio) to receive either femoral cortical allograft or PEEK interbody lordotic spacers. A total of 138 patients undergoing transforaminal lumbar interbody fusions (TLIF) were enrolled, and 121 patients finished the study. The primary clinical outcome parameters were scored from standardized patient-reported questionnaires. The severity of lower back and leg pain was evaluated using the 11-point Visual Analog Scale (VAS). The Oswestry Disability Questionnaire was used to evaluate chronic disability and activities of daily living. Health-related quality of life and functional outcomes were assessed using Health-related Quality of Life Questionnaire (SF-36 v2). Two scores within the scoring algorithm were analyzed: Physical Component (PCS) and Mental Component Summary (MCS). The primary radiological outcomes included restoration and maintenance of vertebral body height, lumbar sagittal and segmental alignment, and fusion status. All patients were followed for 2 years ± 2 months; radiographic and clinical outcomes were assessed at 3, 6, 12 and 24 months with an additional follow-up at 3 weeks for radiographic assessment.
Results: Although no differences were detected between the allograft and PEEK patient groups at any of the follow-up time points, there was a highly significant ($p<0.0001$) improvement in all clinical outcome measures. Overall, evidence of radiographic fusion was achieved in 118 (97.5%) patients at the 24 months follow-up. Three patients, all in the allograft group had pseudoarthrosis and underwent revision surgeries. Postoperative improvement of sagittal alignment, anterior (ABH,) or posterior body height (PBH) was achieved initially, it was mainly lost or reduced at the final follow-up and there were no statistically significant differences between the groups. At the end of the study, improvement and maintenance of lumbar lordosis were achieved in 43.3% and 49.2%
patients and segmental alignment in 38.3% and 36.1% for the allograft and PEEK patient groups, respectively. Similarly, ABH was improved and maintained in 28.3% and 36.1% patients and PBH in 28.3% and 44.3% for the allograft and PEEK groups, respectively.
Conclusions: Although, allograft-assisted surgeries may have reduced fusion rates, the study findings demonstrated that TLIF surgery with two different types of cages had a similar effect on radiological or clinical outcomes and there was a highly statistically significant improvement in all clinical outcome measures at end of the study regardless of the randomization group.

O128

Effect of interbody implant design on early clinical and radiographic outcomes in LLIF surgery

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Introduction: The design of spinal interbody fusion devices has evolved to include methods of creating novel porous structures in both polymers and metals. One goal of such designs is to create a more favorable environment for osseointegration to promote segmental stability and bony union. Surgeons performing lateral lumbar interbody fusion (LLIF), a minimally invasive, direct lateral retroperitoneal approach to the anterior spine, can choose from several interbody implant designs, including those with solid or porous structures made of polyetheretherketone (PEEK) or titanium alloy (Ti). In long term follow-up, LLIF patients have shown a high success rate of fusion, but there are few data on the influence of implant design on these outcomes from prospective, comparative clinical studies. The objective of this prospective, multicenter study is to compare the early clinical and radiographic outcomes of smooth PEEK, 3D-printed porous Ti, and porous PEEK interbody implants when used with cancellous allograft chips with bone marrow aspirate or cellular bone allograft in subjects who undergo LLIF surgery at one or two levels.
Methods: Clinical outcomes from 123 consecutive patients who underwent LLIF surgery (XLIF) using smooth PEEK (n=52), porous Ti (n=40), or porous PEEK interbody implants (n=31) for degenerative conditions of the spine were included in this report. Clinical outcomes were reported as change from baseline at 6 months postoperative for each patient-reported outcome (PRO): VAS (back pain, left leg pain, right leg pain, and worse leg pain) and ODI, within each treatment group. Radiographic outcomes were reported as proportion of subjects with apparent radiographic interbody fusion (defined as <3° flexion extension in range of motion objectively analyzed by medical metrics and evidence of continuous bony bridging at all levels on CT assessed by an independent third-party) at 6 months within each treatment group. Of the 123 patients included in this interim analysis, 79 (64%) patients were female, the mean age at surgery was 64 years, and the mean body mass index was 32.6 kg/m^2. The most common indication treated was degenerative spondylolisthesis (79%).
Results: From baseline to 6 months postoperative, mean back pain improved by 4.1, 5.2, and 3.6 in smooth PEEK, porous Ti, and porous PEEK groups, respectively. The mean worse leg pain also improved by 5.6, 4.9, and 4.1 in smooth PEEK, porous Ti, and porous PEEK groups, respectively. Mean ODI score also improved from baseline to 6 months postoperative by 21.0, 25.5, and 21.7 in smooth PEEK, porous Ti, and porous PEEK groups, respectively. At 6 months follow-up, the fusion rates for smooth PEEK (n=40), porous Ti (n=26), and porous PEEK (n=24) groups were 48%, 81%, and 54%, respectively.
Conclusions: The results of the interim analysis of this prospective, multicenter study show that XLIF surgery using either smooth PEEK, porous Ti, or porous PEEK interbody implants led to postoperative improvement in clinical outcomes, including back pain, leg pain, and disability. Mean radiographic and clinical outcomes improved in all groups, with apparent incrementally better outcomes in porous Ti compared to the other cohorts.

O129

Comparison of 3D-printed artificial vertebral body with titanium mesh cage to realign cervical spine: A preliminary study

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Introduction: Restoration of the physiological sagittal alignment is one of the main goals in treating cervical spondylotic myelopathy (CSM), which is related to the improvement of cervical function. Anterior cervical corpectomy and fusion (ACCF) has been wildly used in the clinical practice, and the titanium mesh cage (TMC) is currently the most common implant for reconstruction of in ACCF. However, many studies reported insufficiency of TMC in maintaining intervertebral height and restoring cervical curvature. The 3D-printed artificial vertebral body that was recently introduced has the characteristics of favorable mechanical and morphological properties, which is considered a favorable substitute for cervical reconstruction in ACCF. However, few studies have investigated the difference of clinical outcomes and cervical spinal realignment after surgery between TMC and 3D-printed artificial vertebral body.
Materials and Methods: Forty patients with CSM from January 2019 to January 2020 who underwent single-level ACCF in our hospital were randomized divided into two groups according to the use of TMC (TMC group, n=20) or 3D-printed artificial vertebral body (3D-printed group, n=20) with a follow-up time of 24 months. The radiographic parameters, including segmental angle (SA), C0-C2 Cobb angle (C0-2 CA), C2-C7 Cobb angle (C2-7 CA), C2-C7 sagittal vertical axis (C2-7 SVA), neck tilt (NT), T-1 slope (T1S), thoracic inlet angle (TIA), and intervertebral height were measured. The surgery data including operation time, blood loss, and length of postoperative stay were record, and the patient-reported outcomes of pre- and postoperative VAS (Visual Analogue Scale) score and NDI (Neck Disability Index) were compared between the two groups.
Results: Twenty-three males and 17 females were included in this study, with a mean age of 58.9 years, and no patient was lost to follow up. Baseline data of the two groups were balanced, with no statistical difference (P>0.05). No significant difference was observed regarding blood loss, length of postoperative stay, and postoperative VAS and NDI between the two groups. However, the operation time of 3D-printed group (102.3±9.3 minutes) was shorter than that of TMC group (124.3±8.9 minutes). The postoperative C2-C7 Cobb angle in 3D-printed group (21.6±5.7°) was significantly larger than that in TMC group (15.9±4.3°) (P<0.05), and the same went for SA (10.2±3.7° vs. 6.0±2.7°). There was a significant difference in postoperative C2-7 SVA between the 3D-printed group (16.1±3.1 mm) and TMC group (23.7±5.0 mm) (P<0.05). No significant difference was observed in C0-2 CA, NT, T1S, and TIA. The postoperative intervertebral height of the patients in the 3D-printed group (56.3±6.4 mm) were significantly higher than those in the TMC group (49.3±5.1 mm) (P<0.05). The rate of subsidence in the 3D-printed group (10%, 2/20) was lower than in the TMC group (30%, 6/20) (P<0.05).
Conclusions: 3D-printed artificial vertebral body is a good implant candidate for ACCF, which helps maintain intervertebral height and cervical physiological curvature.

O130

Comparative study of outcomes between allograft intervertebral disc transplantation and anterior cervical discectomy and fusion: a retrospective cohort study at least 5 years

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Introduction: Adjacent segment degeneration (ASD) after anterior cervical discectomy and fusion (ACDF) seriously affects the med- and long-term efficacy of the surgical treatment, resulting in recurrent axial symptoms or neurological dysfunction. In order to reduce ASD, our team has done some exploratory work on cervical intervertebral disc transplantation, which has proved its feasibility and safety. This study will evaluate the efficacy of allograft intervertebral disc transplantation (AIDT) and ACDF in the management of cervical degenerative disease.
Methods: All patients who received ACDF and AIDT in our hospital from 2000 to 2016 were collected and followed up for at least 5 years. The patient's basic information, surgery-related data, preoperative and postoperative imaging data at 1 week, 3 months, 1 year, 2-3 years, and 5-10 years after surgery were collected. Functional scores: Japanese Orthopedic Association score (JOA), Neck Disability Index (NDI), neck visual analog scale (N-VAS), arm visual analog scale (A-VAS), The Short Form Health Survey-36 (SF-36). Imaging data: All patients underwent digital radiographs in the lateral, hyperextension and flexion positions and magnetic resonance imaging (MRI) scans of the cervical spine. All imaging data of patients were reviewed. The cohort was divided into ACDF and AIDT groups, and the results were compared and analysed.
Results: Satisfactory clinical results were obtained in both groups, and there was no significantly difference in functional score between the two groups. The global range of motion (GROM) of the cervical spine in the two groups returned to the near normal level at 6 months postoperatively. The range of motion of adjacent segments (A-ROM) of the two groups also recovered to the near normal level at 6 months postoperatively, but the A-ROM in the ACDF group was significantly increased at 12 months after operation (P=0.02). There were significantly differences between the two groups at 12 months (P= 0.003), 24 months (P= 0.001) and 60 months (P=0.002) postoperatively. The T1 slope(T1S), C2-7 cervical lordosis(C2-7CL), and the C2-7 Sagittal Vertical Axis(C2-7SVA) had similar curves, and there was no statistical difference between both groups. The Ratio Value of the Grayscale (RVG) of both groups showed a decreasing trend, but the RVG decreased more significantly in ACDF group. And there was no statistical difference between two groups.
Conclusion: Allograft intervertebral disc transplantation is a safe and effective treatment for cervical degenerative disc disease, preserving the segmental mobility and had the advantage of decreasing adjacent segment degeneration.

O131

Finite element investigation on biomechanical response of novel porous cage based on bone quality analysis

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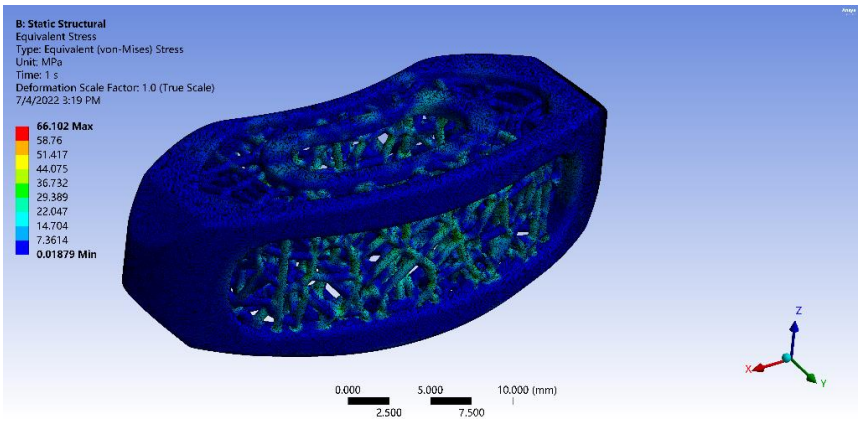
Introduction: Cage subsidence is a remarkable problem after interbody fusion surgery. Materials with lower elastic modulus like Polyether ether ketone (PEEK) have been applied on interbody cage manufacturing but its hydrophobic property become a fusion barrier. Porous metallic cage with better osteointegration and lower elastic modulus has been a trend, it may be modified further through patient-specific biomechanical customization.

Aim: This study is aimed to evaluate biomechanical performance between general porous titanium-alloy cage, biomechanically customized porous titanium-alloy cage, and PEEK cage through finite element analysis (FEA) on osteoporosis, osteopenia, and normal patient-specific spinal model.

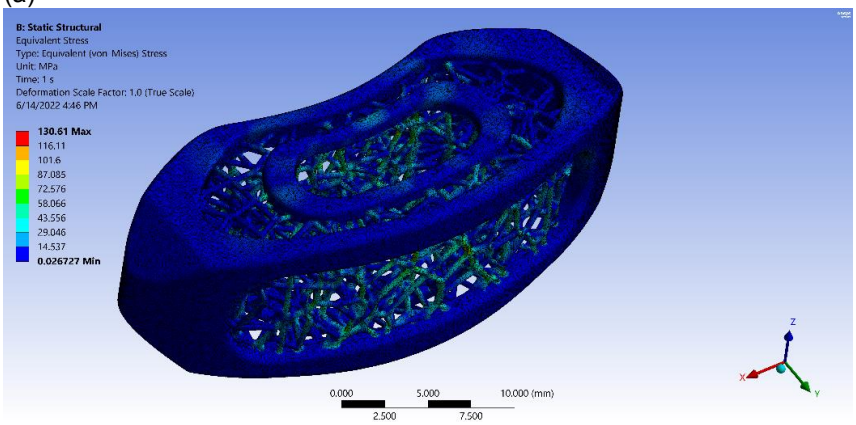
Methods: Porous cages were designed based on cancellous-mimic porous structure. L4-L5 Patient-specific spinal models are constructed through real patients' computed tomography data. Through measuring L4-L5 average endplate volumetric bone mineral density (EP-vBMD) of osteoporosis, osteopenia, and normal patients by AI bone quality analysis software called Bone's QCT, the aimed elastic modulus of cage for each case could be determined. The porosity-modulus relationship of porous cage was achieved through axial compression FEA. For each FEA model, porous titanium-alloy cage, biomechanically customized porous titanium-alloy cage, and PEEK cage are considered respectively. Material properties calculated from vBMD are used for cancellous and cortical bone in all FEA model. Compressive physiological loading and fixed L5 inferior surface are common boundary conditions for all simulations. Mechanical parameters like von mises stress and peak stress are collected for evaluation.

Results: A novel porous cage has been designed with different porosities from 60%~90% (examples: figure 1(a) 61.2%, figure 1(b) 80.76%) through changing its rod thickness. Simulated compressive elastic modulus were in range 2~10 GPa (figure 2).

Conclusions: FEA on novel porous cage with different porosities has demonstrated its ability for biomechanical customization as its compressive elastic modulus is similar to that of human cortical bone.



(a)



(b)

Figure 1 Simulated von mises stress contour of (a) cage with 61.2% porosity (b) cage with 80.76% porosity

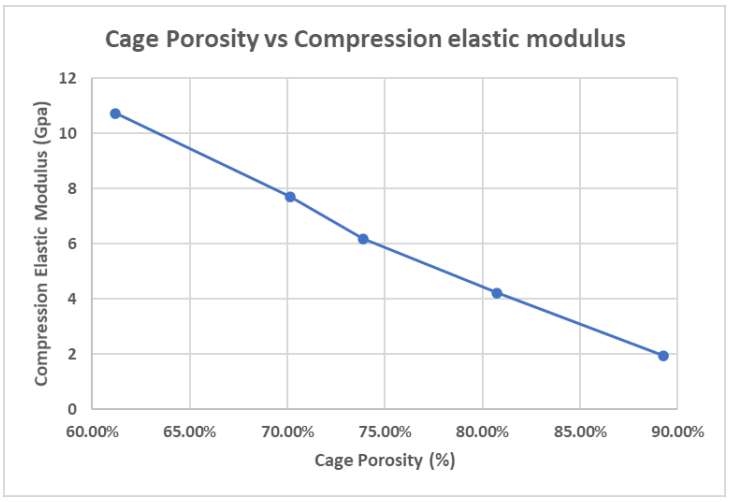


Figure 2 Cage porosity versus simulated compressive elastic modulus

O132

Targeted fully endoscopic visualized laminar trepanning approach under local anesthesia for resection of highly migrated lumbar disc herniation

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Purpose: To introduce a new fully endoscopic visualized laminar trepanning approach with a periendoscopic trephine under local anesthesia for resection of highly migrated lumbar disc herniation (LDH) and report the clinical outcomes of one year follow-up.
Methods: 21 patients with highly migrated LDH who underwent percutaneous endoscopic lumbar discectomy via the laminar trepanning approach from June 2019 to August 2020 were retrospectively reviewed. Patient-Reported Outcomes Measurement Information System (PROMIS) Short Forms-Pain Interference (PI) and Physical Function (PF) were selected as outcome measures. The operating duration and complication were documented.
Results: The average age of the 21 patients (15 males, 6 females) was 37.8±6.0 years (29-52 years). Disc migration originated from L4/5 in 19 patients, L5/S1 in 2 patients. The mean operative duration was 54.1±9.0 min (42-79 min). All patients were followed up to 12 months after the operation. PROMIS PI T-scores decreased significantly from preoperatively mean 68.6±2.4 to 54.4±1.9($P<0.001$) and 47.1±4.3($P<0.001$) at 6 weeks and 12 months, respectively. PROMIS PF T-scores improved significantly from preoperatively mean 26.7±4.7 to 44.3±4.2($P<0.001$) and 58.4±4.0($P<0.001$) at 6 weeks and 12 months, respectively. No complications and disc herniation recurrences occurred.
Conclusion: The targeted full endoscopic laminar trepanning under local anesthesia with a visualized periendoscopic trephine offers a safe, efficient and cost-effective option for the resection of highly migrated LDH.
Keywords: percutaneous endoscopic lumbar discectomy; targeted; visualized laminar trepanning; highly migrated lumbar disc herniation

O133

Effects of osteoporosis on biomechanics of various supplemental fixations for oblique lumbar interbody fusion (OLIF): A finite element analysis

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Background: OLIF is an important surgical modality for the treatment of degenerative lumbar spine disease. Various supplemental fixations were applied with OLIF, which can increase the stability of OLIF and reduce complications. However, it is not clear whether osteoporosis has an effect on supplemental fixation, therefore, the purpose of our study was to analyze the effect of osteoporosis on various supplemental fixation instruments for OLIF.
Methods: An L3-S1 finite element (FE) model was developed and validated, assigning different material properties to each component and establishing FE models of osteoporotic and normal bone lumbar spine. Development of OLIF surgical models with 5 various supplemental fixations (Standalone OLIF; OLIF with lateral plate fixation (OLIF+LPF); OLIF with translaminar facet joint fixation and unilateral pedicle and screw fixation (OLIF+TFJF+UPSF); OLIF with unilateral pedicle and screw fixation (OLIF+UPSF); OLIF with bilateral pedicle and screw fixation (OLIF+BPSF)), Under a follower load of 500N, the 7.5N·m torque was applied to all models to simulate different working conditions. Respectively, the range of motion (ROM) of normal bone and osteoporosis models, the maximum Mises stress of fixation instruments (MMSFI), as well as the average Mises stress of cancellous (AMSC) were calculated.
Results: Compared with normal mass bone OLIF model, no demonstrable change in each segment ROM was observed. The MMSFI was increased in all 5 osteoporotic OLIF models. In the OLIF+TFJF+UPSF model, the MMSFI increased sharply from 29.88 MPa to 59.00 MPa, from 59.11 MPa to 114.40 MPa, respectively, in both forward flexion and extension postures. The stress changes of the OLIF+UPSF, OLIF+BPSF, and OLIF+TFJF+UPSF models were similar, and the stresses all showed an upward trend. The AMSC decreased in the 5 osteoporotic OLIF models during flexion, extension, lateral bending, and axial rotation. The average stress change of cancellous bone was most obvious under the load of extension. The AMSC of the 5 OLIF models decreased by 14%, 23.44%, 21.97%, 40.56%, and 22.44%, respectively.
Conclusions: For patients with osteoporosis and normal bone, the stress distribution in cancellous bone and various supplemental fixations was relatively similar. However, under various supplemental fixations, the AMSC were all reduced and the MMSF were all increased in the osteoporotic model compared to the OLIF models of normal bone. Therefore, the biomechanical performance of the osteoporotic models may be inferior to that of the normal model when using the same fixation method, and may even increase the risk of fracture and internal fixation failure.
Keywords: Finite element analysis; Osteoporosis; Oblique lumbar interbody fusion; Different fixation instruments

O134

Unilateral biportal endoscopic lumbar interbody fusion assisted by intraoperative o-arm total navigation for lumbar degenerative disease: A retrospective study

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Background: Recently, unilateral biportal endoscopic lumbar interbody fusion (BE-LIF) has been successfully applied for degenerative diseases of the lumbar spine, with good clinical results reported. However, the drawbacks include radiation exposure, limited field of view, and steep learning curves.
Objective: This retrospective study aimed to compare the results between navigation and non-navigation groups and explore the benefits of BE-LIF assisted by intraoperative O-arm total navigation.
Methods: A total of 44 patients were retrospectively analyzed from August 2020 to June 2021. Perioperative data were collected, including operative time, estimated intraoperative blood loss, postoperative drainage, postoperative hospital stay, radiation dose, and duration of radiation exposure. In addition, clinical outcomes were evaluated using postoperative data, such as the Oswestry Disability Index （ODI）, visual analog scale（VAS）, modified MacNab criteria, Postoperative complications and fusion rate.
Results: The non-navigation and navigation groups included 23 and 21 patients, respectively. All the patients were followed up for at least 12 months. No significant differences were noted in the estimated intraoperative blood loss, postoperative drainage, postoperative hospital stay, fusion rate, or perioperative complications between the two groups. The radiation dose was significantly lower in the navigation group than in the non-navigation group. The average total operation time in the navigation group was lower than that in the non-navigation group ($P<0.01$). All clinical outcomes showed improvement at different time points postoperatively, with no significant difference noted between the two groups ($P>0.05$).
Conclusions: Compared with the non-navigation approach, O-arm total navigation assistive BE-LIF technology not only has similar clinical results, but also can provide accurate intraoperative guidance and help spinal surgeons achieve accurate decompression. Furthermore，it can reduce radiation exposure to surgeons and operation time ，which improve the efficiency and safety of surgery.

O135

Global realignment after posterior vertebral column resection in severe thoracolumbar post-tubercular kyphosis: Correlation with patient-reported outcomes

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Introduction: Spinal tuberculosis (TB) is a common form of extrapulmonary TB. According to previous studies, severe kyphotic deformity secondary to spinal TB occurs in 3–5% of patients treated conservatively, most of whom are afflicted with persistent back pain, gait disturbance, neurological deficits, and so forth. Spinal osteotomy can not only relieve the compression but also correct the local malalignment. After local realignment, reciprocal changes in unfused spinal segments will contribute to a new balanced spine, which is closely related to patients' quality of life. To our knowledge, few studies have investigated the spinopelvic realignment and its correlation with improved patient-reported outcomes (PROs) after corrective surgery in patients with PTK. In this study, we reviewed the clinical and radiographic data of patients with severe thoracolumbar post-tubercular kyphosis (PTK), and tried to figure out the underlying mechanism of global spinal realignment as well as its relation to PROs.
Materials and Methods: This was a multicenter retrospective study of patients who underwent posterior vertebral column resection (PVCR) for severe thoracolumbar PTK. Between September 2013 and June 2020, 82 eligible patients were reviewed. Patients' spinopelvic parameters, including focal scoliosis (FS), coronal balance (CB), sagittal vertical axis (SVA), focal kyphosis (FK), C2-7 lordosis (CL), thoracic kyphosis (TK), lumbar lordosis (LL), sacral slope (SS), pelvic tilt (PT), and pelvic incidence (PI), were recorded. The Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) score was assessed preoperatively and at final follow-up. The correlation between variations of spinopelvic parameters and improvement of PROs was evaluated.
Results: The CL decreased from 7.2 ± 7.3° to 3.3 ± 8.3° ($P<0.001$), as did FK (108.5 ± 16.4° to 38.7 ± 6.6°, $P<0.001$), FS (20.9 ± 2.2° to 5.1 ± 2.2°, $P<0.001$), and LL (75.5± 12.6° to 45.5 ± 7.9°, $P<0.001$). The TK improved from -5.6 ± 7.1° to 12.9 ± 8.2° ($P<0.001$). The PI-LL changed from -24.8 ± 13.4° to 4.8 ± 9.9° ($P<0.001$). The VAS decreased from preoperative 6.3 ± 1.3 to 1.9 ± 0.7 at final follow-up ($P < 0.001$). The ODI significantly decreased from preoperative 49.9 ± 12.3 to 12.8 ± 5.7 at final follow-up ($P < 0.001$). The improvement of VAS was found to be significantly correlated with the variations of CL (r= 0.478), FK (r= 0.651), TK (r= -0.457), LL (r= 0.531), and PI-LL (r= -0.549). The improvement of ODI was found to be significantly correlated with the variations of CL (r= 0.544), FK (r= 0.788), TK (r =-0.402), LL (r= 0.592), and PI-LL (r= -0.576). The multiple regression analysis revealed that FK was the only independent parameter correlated with the improvement of VAS and ODI
Conclusions: PVCR is a powerful means of treating severe PTK. Cervical, thoracic and lumbar spine were involved in realignment following local deformity correction. FK was found to be the most important parameter correlated with PROs, indicating that spine surgeons should pay more attention to reducing the residual local kyphosis.

O136

Cancellous and endplate bone mineral density of fusion level adjacent segments decreased after minimally invasive lateral fusion: A retrospective study of regional bone mineral density measurement using Phantomless-QCT

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Aim: To investigate the changes in the cancellous bone and endplate volumetric bone mineral density (vBMD) of fusion level adjacent segments in patients undergoing lateral lumbar interbody fusion (LLIF).
Methods: Patients with lumbar degenerative diseases who underwent LLIF surgery in our hospital from October 2018 to October 2021 were retrospectively analyzed, and the patients were screened according to the relevant inclusion and exclusive criteria. The cancellous and endplate vBMD of fusion level adjacent segments was measured by phantom-less quantitative computed tomography (PL-QCT) before operation and during postoperative follow-up. The preoperative and postoperative vBMD measurements were matched to analyze the cancellous and endplate vBMD changes of the fusion level adjacent segments. Cancellous and endplate vBMD were measured on adjacent segments above/ below the upper/lower instrumented vertebras (UIV+1 and LIV+1; UIV+ 1e and LIV+ 1e).
Results: Total 32 patients were included (27 females and 5 males). Patients' mean age was 60.1±7.1 years, and the average follow-up period was 7.2±4.8 months. The preoperative vBMD in UIV+1 group was higher than that in postoperative follow-up (131.9± 34.8 vs 115.8± 30.8, $P < 0.001$). The preoperative vBMD in LIV+1 group was higher than that in postoperative follow-up (134.8± 37.0 vs 117.2± 32.1, $P < 0.001$). The preoperative vBMD in UIV+1e group was higher than that in postoperative follow-up (312.9± 79.3 vs 287.7± 85.2, $P = 0.007$). The preoperative vBMD in LIV+1e group was higher than that in postoperative follow-up (314.7± 71.4 vs 296.1± 59.8, $P = 0.042$). In UIV+1 group, the change, and the change rate of cancellous bone vBMD were 16.1±17.7 and 11.4%±13.0%, respectively. In LIV+1 group, the change, and the change rate of cancellous bone vBMD were 12.2±12.1 and 17.3%±17.5%, respectively. The change and change rate of endplate vBMD in UIV+1e group were 11.4±18.3, -25.2%±49.2%, and 7.2±18.5, -18.6%±49.8% in LIV+1e group, respectively. There was no significant difference in preoperative, postoperative vBMD and vBMD change rate between UIV+1 and LIV+1 vertebral cancellous. There was no significant difference in preoperative vBMD and vBMD change rate between UIV+1 and LIV+1 endplate. However, there was a statistical difference in endplate vBMD at follow-up ($P = 0.035$). The change trend of cancellous bone vBMD in UIV+1 and LIV+1 was similar to that of endplate vBMD in patients underwent LLIF.
Conclusions: Both cancellous and cortical vBMD on adjacent segments to the fused level decreased after LLIF. There was no significant difference in cancellous and cortical vBMD loss between the superior and inferior adjacent segments.

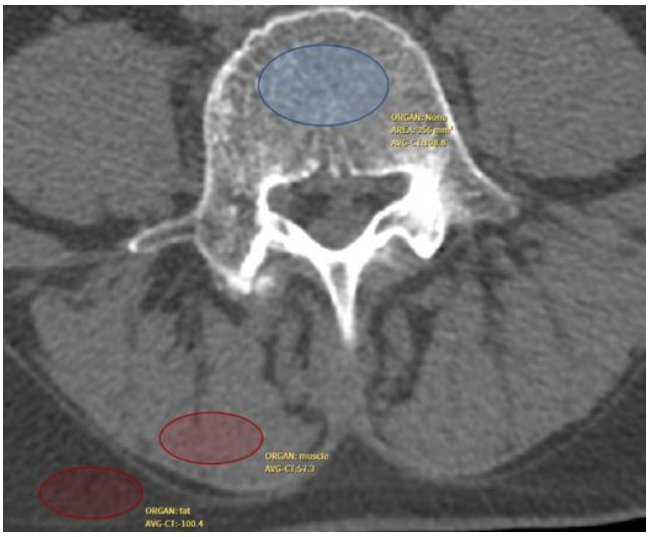

Figure 1 Spinal vBMD measurement based on subcutaneous fat and Paravertebral muscle

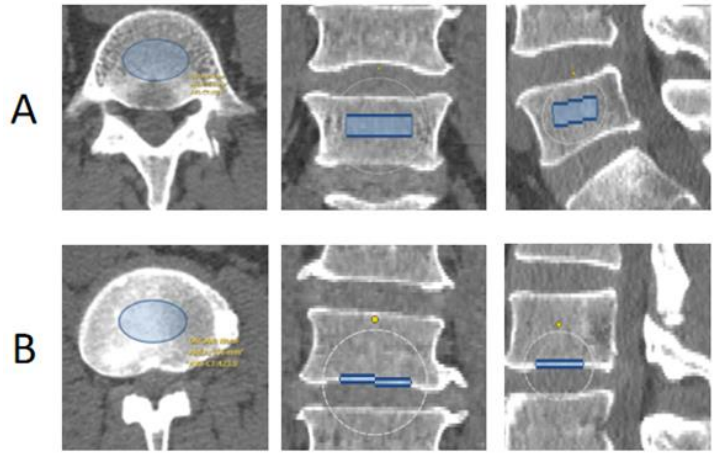

Figure 2 vBMD measurements on adjacent segments of interbody fusion, (A) Vertebral cancellous vBMD measurement on lower adjacent segment of interbody fusion (B) Vertebral endplate vBMD measurement on upper adjacent segment of interbody fusion

O137

Can the full-percutaneous endoscopic lumbar discectomy in day surgery mode achieve better outcomes following enhanced recovery after surgery protocol? A retrospective comparative study

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Background: Full-percutaneous endoscopic lumbar discectomy (F-PELD) is a popular operation for the treatment of lumbar disc herniation (LDH). Some studies have reported that F-PELD in day surgery mode produced favorable outcomes for LDH. At the same time, minimally invasive spinal surgery following enhanced recovery after surgery (ERAS) presents a rising trend in recent years, but few studies reported whether F-PELD will produce better outcomes in the day surgery (DS) mode combined with ERAS.
Objective: To analyze whether F-PELD in day surgery mode following ERAS can produce better clinical outcomes than in traditional surgery mode.
Methods: The patients who underwent F-PELD between January 2019 and October 2020 were retrospectively analyzed, and the patients who met the inclusive criteria were followed up. The patients were divided into day surgery (DS) group (n = 152) that combined with ERAS and traditional surgery (TS) group (n = 123) without ERAS. The length of hospital stays (LOS), visual analogue scale (VAS), and Oswestry Disability Index (ODI) of two groups were compared before surgery, immediately after surgery, one month after surgery, and one year after surgery.
Results: A total of 298 patients who underwent F-PELD were reviewed. 290 patients were included in the study and followed up, and 275 patients who had completed the follow-up were available for analysis. There were no statistically significant differences between the two groups in terms of age, gender, preoperative VAS, and ODI. There were significant statistical differences in the VAS and ODI immediately after surgery (VAS for back pain: DS group 1.4 ± 1.1, TS group 2.0 ± 1.2, $p < 0.001$; VAS for leg pain: DS group 0.8 ± 0.8, TS group 1.1 ± 1.1, $p = 0.010$; ODI: DS group 5.8 ± 4.3, TS group 7.6 ± 7.4, $p = 0.010$) and one month after surgery (VAS for back pain: DS group 0.8 ± 0.9, TS group 1.1 ± 1.0, $p = 0.035$; ODI: DS group 3.2 ± 3.5, TS group 4.5 ± 6.5, $p = 0.036$). At one year after surgery, the VAS (back pain: DS group 0.3 ± 0.6, TS group 0.3 ± 0.7, $p = 0.798$; leg pain: DS group 0.2 ± 0.4, TS group 0.1 ± 0.4, $p = 0.485$) and ODI (DS group 0.8 ± 1.2, TS group 0.7 ± 1.7, $p = 0.729$) were further improved, but no statistically significant difference was observed between two groups. LOS of DS group (1.38 ± 0.49 days) was significantly shorter than the TS group (5.83 ± 2.24 days, $p < 0.001$), and some postoperative complications occurred in the TS group, including throat discomfort (n = 5, 4.1%), discomfort after catheterization (n = 7, 5.7%), abdominal distention (n = 3, 2.4%), and nausea (n = 5, 4.1%). None of the above complications resulted in serious consequences.
Conclusion: The F-PELD in day surgery mode following ERAS produced a better shortterm clinical effect and reduced the LOS, which is worthy of promotion.
Keywords: percutaneous endoscopic lumbar discectomy, day surgery, enhanced recovery after surgery, lumbar disc herniation, endoscopy

O138

Osteotomized debridement versus curetted debridement in posterior approach in treating thoracolumbar tuberculosis: A comparative study

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Introduction: Spinal tuberculosis (TB) is the most common pattern of extrapulmonary TB, which usually occurs in thoracolumbar spine. Progressive destruction of the vertebral body can lead to many potentially serious consequences, including kyphotic deformity, neurologic deficit, and even paraplegia. For patients with indications such as spinal instability and progressive kyphosis, it is generally agreed that surgery is necessary. The posterior approach has gained popularity in recent years as it can provide satisfactory exposure for circumferential spinal cord decompression and allow posterior instrumentation to be extended for multiple levels above and below the focus. In the traditional one-stage posterior surgery, surgeons always perform debridement by curettes. However, it is hard to achieve complete focus clearance just by scraping, which will result in the survival of *Mycobacterium tuberculosis* and increased risk of recurrence. Therefore, we introduced posterior osteotomized debridement (OD) technique to achieve complete lesion removal. This study aimed to compare OD with traditional curetted debridement (CD) in treating active thoracolumbar TB.

Materials and Methods: From November 2013 to December 2018, 188 patients who were diagnosed with active thoracolumbar TB and underwent one-stage posterior surgery at our institution were retrospectively analyzed. 85 patients were treated with OD, reconstruction using titanium mesh cages (TMCs), and instrumentation (group OD), and 103 patients were treated with traditional CD, bone grafting, and instrumentation (group CD). All patients were examined clinically and radiologically at 4 weeks, 3 months, 6 months, 9 months, 1 year after surgery, and annually thereafter. The patient demographic data, laboratory results, imaging findings, and clinical efficiency, were compared between the two groups.

Results: The mean patient ages of group OD and group CD were 43.9 ± 11.8 years and 46.5 ± 13.0 years, respectively. The durations of follow-up were 39.7 ± 10.8 months in group OD and 41.6 ± 11.7 months in group CD. Group OD consumed less operation time and blood loss than group CD ($P < 0.05$ for both values). No significant difference in hospitalization time was found between the two groups ($P > 0.05$). The values of C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) in both groups returned to the normal range within one month postoperatively. All patients had significant improvement in Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) postoperatively. The mean fusion time in group OD was shorter than that in group CD ($P < 0.05$). There was no statistically significant difference in preoperative kyphotic angle between the two groups ($P > 0.05$), but group OD showed less correction loss than group CD at the final follow-up ($P < 0.05$). The rate of recurrence and surgery-related complications in group OD was lower than those in group CD.

Conclusions: Posterior OD, reconstruction with TMCs, and instrumentation is feasible and effective in treating active thoracolumbar TB. Compared with the traditional CD, OD can achieve radical lesion removal, more effective kyphosis correction, lower recurrence rate, and fewer complications.

O139

Radiological and clinical outcomes of OLIF in the correction of spinal sagittal imbalance. A systematic review of literature

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Introduction: The approach of oblique lateral interbody fusion (OLIF) surgery is established in front of the psoas muscle, using the retroperitoneal space between the psoas major muscle and the abdominal aorta, with less invasiveness of psoas and neural structures than lumbar lateral interbody fusion (LLIF), it does not require neurological monitoring. Since the OLIF approach is not blocked by the iliac crest, this procedure can apply to all lumbar segments, including the L 5 / S 1 segment. And compared with anterior lateral interbody fusion (ALIF) surgery, OLIF surgery with less vascular damage complication rate. Thereby, OLIF surgery has received more and more attention in clinical practice (Figure 1). Therefore, existing articles needed to be integrated and analyzed more comprehensively. Nevertheless, there was no relevant systematic review of OLIF in exploring spinal sagittal balance parameters and clinical prognosis. The purpose of this study is to collect relevant evidence from existing articles and evaluated radiological parameters and clinical outcomes and provide the scientific basis for clinical diagnosis and treatment by spinal surgeons.
Methods: The PRISMA flow chart was used to review the literature using PubMed, EMBASE, and the Cochrane Library, with a time until February 2022 (Figure 2). The ability of OLIF to correct sagittal imbalance was estimated by spinopelvic parameters, complication rates, and clinical outcomes at the last follow-up. The assessment of evidence-based medical evidence rating for each research included in this systematic review was assessed by the Oxford Centre for Evidence-Based Medicine (OCEBM) evidence rating assessment tool.
Results: Through our search strategy, 398 articles were screened and 16 articles were finally included with a total of 534 patients. All included studies provided at least level 4 evidence. The review showed that lumbar lordosis (LL), pelvic tilt (PT), sagittal vertical axis (SVA), PI-LL, L5/S1 segment lordosis (SL) had an average postoperative improvement of 25.9°,8.9°,77.5mm,18°,8.2°, ($p<0.05$) respectively. Sacral slope (SS) and pelvic incidence (PI) had an improvement of 10.1°and 1.4°($p>0.05$). Postoperative disc height (DH), cross-sectional area (CSA), and foraminal height (FH) increased by 85.2%, 34.4%, and 20.3% ($p<0.05$). Visual analogue scale (VAS) back, leg and Oswestry disability index (ODI) scores improved postoperatively by 80%, 71.9%, 56.8% ($p<0.05$). The overall complication rate was 28.7%, the top four of the complications are proximal junctional kyphosis [(PJK); (5.8%)], surgical infection (3.3%), proximal junctional fracture (3.1%), and cage subsidence (3.1%). In all the patients included, only a few cases of vascular injuries were reported and these reports of vascular injuries were published earlier. In the later articles, most of the literatures mentioned the protection of iliac vessels, and there were few complications of vascular injury in this research.
Conclusions: OLIF surgery achieves good radiographic and clinical outcomes in correcting sagittal balance and may be a reliable option for clinicians to correct the sagittal imbalance in patients. Although the vascular injury of L5-S1 segment is a possible problem of OLIF technology, good preoperative surgical planning and intraoperative vascular exploration can effectively reduce the injury.

Acknowledgements: spinopelvic parameters; clinical outcomes; oblique lateral interbody fusion; OLIF; sagittal imbalance

Figure 1

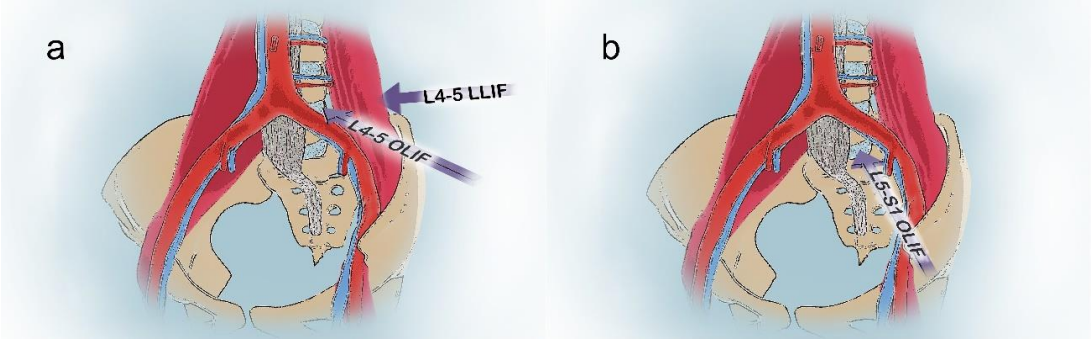
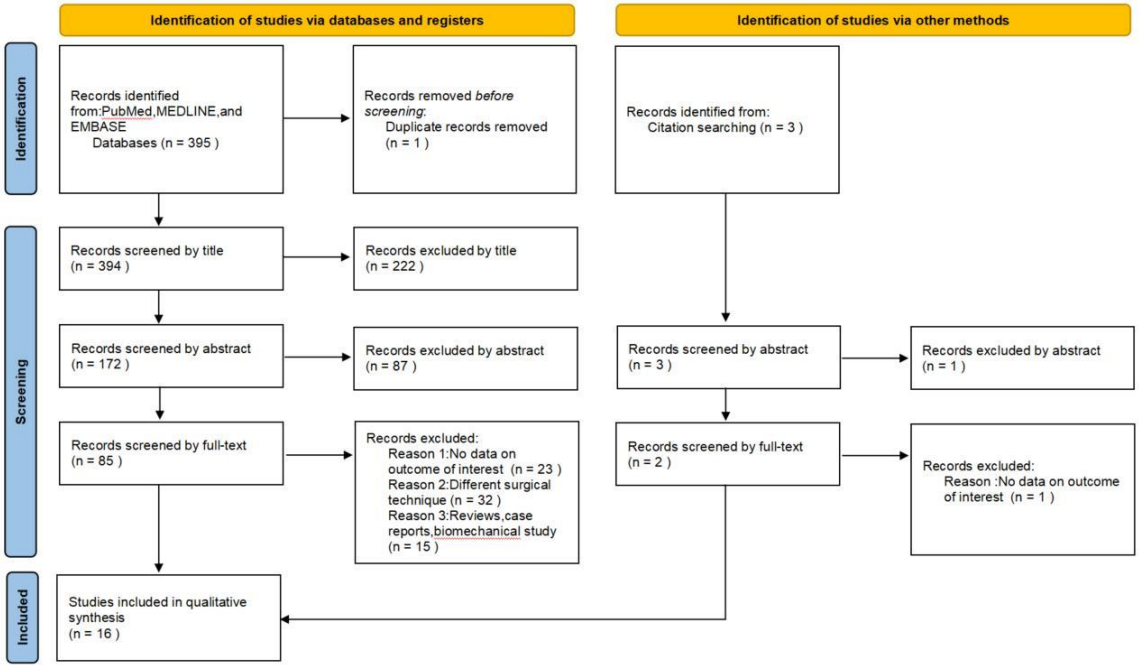


Figure 2



O140

A modified endoscopic transforaminal lumbar interbody fusion technique: Preliminary clinical results of 96 cases

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Background: As a newly emerging technique, endoscopic transforaminal lumbar interbody fusion (Endo-TLIF) has become an increasingly popular procedure of interest. The purpose of this study was to introduce a modified Endo-TLIF system and share our preliminary clinical experiences and outcomes in treating lumbar degenerative disease with this procedure.
Methods: Ninety-six patients (thirty-seven men and fifty-nine women; mean age 55.85±11.03 years) with lumbar degenerative diseases who underwent Endo-TLIF in our hospital were enrolled. The surgical time, volume of intraoperative blood loss, postoperative hospitalization time and postoperative drainage were documented. Clinical outcomes were evaluated by visual analog scale (VAS) scores, Oswestry Disability Index (ODI) scores, and modified MacNab criteria. Bone fusion was identified through computerized tomography (CT) scans or X-ray during the follow-up period.
Results: All patients were followed up for at least 12 months, and the average follow-uptime was 17.03±3.27 months. The mean operative time was 136.79±30.14 minutes, and the mean intraoperative blood loss was 53.06±28.89ml. The mean VAS scores of low back pain and leg pain were 5.05±1.37 and 6.25±1.03, respectively, before surgery, which improved to 2.27±0.66 and 2.22±0.55, respectively, after the operation($P<0.05$). The final VAS scores of low back pain and leg pain were 0.66±0.60 and 0.73±0.66, respectively ($P<0.05$). The preoperative ODI score (49.06±6.66) also improved significantly at the 3-month follow-up (13.00±7.37; $P<0.05$). The final ODI score was 8.03±6.13 ($P<0.05$). There were 10 cases of non-fusion (nine women and one man) at the 12-month follow-up, but no cases of non-union were identified by imaging at the final follow-up.
Conclusions: The present study demonstrated satisfactory clinical and radiologic results among patients who received Endo-TLIF treatment from our institution. This indicates that Endo-TLIF is efficient and safe for select patients.

O141

Minimally invasive posterior lumbar interbody fusion without operating microscope – How effective is it?

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Introduction: Posterior lumbar interbody fusion (PLIF) is one of the commonest surgeries performed in lumbar degenerative diseases. Open PLIF is very popular as it does not require specialised equipment like operating microscope. The disadvantage of open technique is the extensive muscle dissection, blood loss, increased postoperative pain, increased hospital stay, etc. We describe a surgical technique of minimally invasive PLIF (MIS -PLIF) which does not require operating microscope and can be deployed in less equipped centres.
Aim: To study the functional and radiological outcome following MIS – PLIF performed for lumbar degenerative conditions.
Materials and Methods: Eleven patients underwent MIS – PLIF in our centre between March 2019 and January 2021. Fusion levels were L4-5 (n=9), L3-4 (n=2). Standard surgical technique consisted of pedicle screw tracts creation by minimally invasive technique and guide wires left in place. Mini open midline incision was made for laminotomy and interbody fusion. Finally pedicle screws were inserted and rods connected. Duration of surgery, intraoperative blood loss, length of hospital stay were recorded. Functional outcome was scored using VAS, ODI, JOA and SF-12 scores preoperatively and at each follow up. Fusion on x-ray was scored by Bridwell criteria.
Results: All surgeries were single level fusions. Mean values of duration of surgery, intraoperative blood loss and length of hospital stay were 156 minutes (range: 100-240), 126 mL (range: 40-250) and 4.2 days (range: 3-6) respectively. Preoperative and postoperative VAS, ODI, JOA and SF-12 were as follows: VAS 7.2 vs 2.6 ($p<0.05$), ODI 66.65 vs 14.89 ($p <0.05$), JOA 6.4 vs 20.67 ($p<0.05$), SF-12 27.88 vs 64.17 ($p<0.05$). JOA improvement score (Hirabayashi index) was 68.73 (fair outcome). Ten patients has Bridwell grade I interbody fusion and one patient Bridwell grade II at final follow up.
Conclusion: MIS – PLIF technique gives excellent functional and radiological outcome in lumbar degenerative disorders. It provides the advantages of MIS fusion in less equipped centres without the need for an operating microscope. However, our study is limited by the small sample size and needs to be performed in a larger scale.

O142

Current physiotherapy assessment and treatment practices for low back pain in Nigeria: A national survey

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Introduction: The prevalence of low back pain (LBP) in Africa is high and Nigeria has been reported as having the highest prevalence rate. Despite advances in the physiotherapy management of LBP worldwide, studies have shown variation in the quality of physiotherapy management of LBP in Nigeria. The aim of this study was to evaluate, in detail, the current assessment and treatment practices used by physiotherapists in Nigeria for people with recent onset, recurrent, and chronic LBP.
Methods: This was a descriptive cross-sectional electronic national survey of registered physiotherapists who treat LBP in Nigeria. Sixty heads of physiotherapy units across all 36 states of Nigeria were notified about the study via email and WhatsApp messages and were asked to forward the information about the study to their physiotherapists who treat LBP. All consenting physiotherapists completed the survey anonymously via REDCap and all data were analysed descriptively.
Results: Of the 267 physiotherapists (mean age = 37.6 years, SD = 9.1) who completed the survey in full, 124 (46.4%) were males and 143 (53.6%) were females. Although most of the physiotherapists use traditional assessment methods, very few of them assess helpful/unhelpful movement patterns (10.1% = recent onset first-time, 10.9% = recurrent, 12.4% = chronic LBP), psychological distress (3.4% = recent onset first-time, 6.4% = recurrent, and 7.1% = chronic low back pain), and risk stratification/prognostic factors (2.2%, = recent onset first-time, 2.6% = recurrent, and 3.0% = chronic LBP). For treatment, the majority of the physiotherapists use back care education/ergonomic advice (80%), muscle techniques (96%), electrophysical modalities (98%), McKenzie therapy (59%), and aerobic exercises (63%), with some using pain education (28%), and graded activity (18-25%).
Stratified or individualised multimodal management programs such as cognitive functional therapy, StarT Back, or STOPS were rarely used (all < 1.5% of respondents). There was minimal differentiation of treatment methods between recent onset, recurrent, and chronic LBP. Most physiotherapists in Nigeria (245, 91.8%) do not use clinical practice guidelines (245, 91.8%), validated outcome measures (>87%), or a clinical reasoning framework (219, 82.0%). Over 99% of Nigerian physiotherapists expressed interest in learning evidence-based LBP assessment and treatment methods from international experts.
Conclusion: Few Nigerian physiotherapists are using guidelines, validated outcome measures, or contemporary assessment and treatment practices for LBP. However, they are very interested to learn these methods from international experts.

Ethical approval: La Trobe University Human Research Ethics Committee (HEC21324)

O143

Intraoperative anterior migration of expandable interbody fusion cage into peritoneum during MIS-TLIF

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Case: A seventy year aged obese female with BMI =40 with no other comorbidities and history of back pain for over one year with grade two L5-S1 lithesis was planned for L5-S1 MIS-TLIF (Minimally invasive transforaminal lumbar interbody fusion). During a routine MIS-TLIF cage insertion the Intraoperative, expandable peek cage got migrated anteriorly into the peritoneal space following the iatrogenic release of anterior longitudinal ligament during the expansion of the cage. As the patient was hemodynamically stable a decision was made to insert another cage from posterior under compression using the MIS screws. After finishing the MIS-TLIF patient was placed in supine position and anterior migrated cage was safely recovered using the retroperitorial anterior approach. Post operative period and subsequent follow up were uneventful.
Conclusion: Expandable TLIF cages while getting expanded are can lead to iatrogenic release of anterior longitudinal ligament. Surgeons must be aware of this rare complication which can result in anterior cage migration.

O144

Assessment of clinico-radiological outcome of empirical antimicrobial therapy in spinal infections with negative microbiological diagnosis

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Introduction: Spinal infections account for 2-7% of all musculoskeletal infections. Standard methods of detection of infections include tissue or pus culture, gram stain, AFB stain, KOH mount, TB-PCR, biopsy with histopathological examination. However 30-40% of spinal infections are not detected by the above tests.
Aim: To assess outcome of empirical antimicrobial therapy in spinal infections with negative microbiological diagnosis.
Materials and Methods: A retrospective study was conducted at our institute by following-up 209 patients with clinical evidence of spinal infection treated at our hospital between July 2014-August 2020 and having a follow-up of at least 1year. Routine radiographs, MRI, and microbiological tests including tissue or pus culture, gram stain, AFB stain, KOH mount, TB-PCR, biopsy with histopathological examination was done for all patients. Out of the 209 patients our study included 96(N=96) patients who had clinico-radiological evidence of infection but had negative microbiological reports. These 96 patients were divided into two groups, 76 of them had clinico-radiological features suggestive of Tuberculosis (Group A), while 20 of them had features suggestive of pyogenic infection (Group B). Empirical anti-tubercular drugs (ATT) were started in group A, and empirical antibiotics were started in group B. In addition to this, 20 patients in Group A needed a surgical debridement and stabilization procedure. Patients were followed up at 1 year and results were analysed in terms of clinical outcomes as per McNab's criteria, radiological outcomes, and complications of treatment.
Results: Clinically in Group A, 30(39.47%) patients had excellent results,35(46.05%) patients had good results, while the outcome was poor in 5(6.58%) patients.6 patients in this group was lost to follow-up. In Group B, 7(35%) patients had excellent results, while the remaining patients in the group 13(65%) had good results. Radiologically at 1 year follow-up, in Group A, the lesions were seen to be healed in 64(84.21%) cases, whereas it was not healed in 5(6.58%) patients,7 patients did not come for radiological follow-up. In group A, 23 patients had complications ranging from deranged liver function tests. graft subsidence to non-response to treatment needing switching over to IV antibiotics. While, in group B, 2 patients had complications of not responding to treatment and were switched over to anti-tubercular drugs.
Conclusion: Negative results for spinal condition are always a challenging condition. However based on clinico-radiological evidence for diagnosis and judicious use of antimicrobial drugs (ATTs and/or antibiotics) for treatment we could achieve overall good results in most patients.

O145

Black African scoliosis: Epidemiological, clinical, and therapeutic aspects about 78 cases observed over 12 years

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Introduction: The prevalence of scoliosis varies in the literature between 0.47 and 5.2%. However, there is a scarcity of data on the subject in the African literature.
Aim: The objective of our work is to seek to understand the characteristics of this condition in our environment to contribute to improving its management.
Patients and Methods: We carried out a descriptive cross-sectional study in 3 local hospitals over 12 years, from 2006 to 2017. The inclusion criteria were any patient of any age, whose file contains at least sociodemographic data. The exclusion criteria were an angle of curvature < 10° and incomplete files or patients who could not be contacted for progress control. Demographic, clinical, and therapeutic variables were collected and analyzed.
Results: We thus reviewed 78 patients. A female predominance and the preponderance of idiopathic scoliosis (53.8%) were noted. A high prevalence of scoliosis in one ethnic group (49%). History of prematurity was found in 44.6% of congenital scoliosis. The mean humpback was 2.1 cm. The patients presented neurological and respiratory signs in 20.96% and 9.68% of the cases respectively. The mean curvature was 45.4°. The seat of the curvatures was mainly thoraco-lumbar (38.7%) and thoracic (28%). The hemi-vertebrae were found in 50% of cases of structural scoliosis. The predominant extra-rachidial associated malformations were those of the limbs (28.8%). The treatment was orthopedic in 58.5% of cases and surgical in only 1.3% of cases. The evolution was considered favorable in 70% of cases.
Conclusion: Our series was mainly confronted with the rare African series, including that of Jenyo et al, which reported a prevalence of 1.21% in a population of Nigerian schoolchildren. This study allowed us to highlight a female predominance of scoliosis, to confirm a prevalence of idiopathic scoliosis and a high average curvature dependent on the diagnostic delay and early management. The orthopedic treatment as practiced in our context gives acceptable results. These results can be improved by early screening on a larger scale.

O146
Presentation and management of delayed uni and bifacet cervical dislocations

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Introduction: Cervical facet dislocations are a serious event following trauma, and frequently are associated with significant neurological deficits especially the bifacet variety. The management of patients presenting directly from the scene of the accident is well known. Much more controversial, however, is the management of patients presenting late. I would argue that they represent a distinct population of patients, very different in presentation, management and outcome from their counterparts who present acutely.
Methods: In this presentation, I review the aetiology, clinical presentation, management and outcomes of 14 patients presenting more than two months after their injuries, with cervical facet dislocation injuries.
Results: All patients were black males, ages ranging 19 -56 years. 6 had bifacet dislocations, and the rest had unifacet dislocations. The neurological status varied widely. One patient was ASIA A and had a concomitant severe head injury. 6 of the patients, all unifacet dislocations, were ASIA E. All patients received MRI scans and proceeded to open surgical reduction and internal fixation.
Conclusions: Cervical facet dislocations may present late where patients are received initially in peripheral units and either have severe head injuries with low levels of consciousness in which case the injuries are missed, or else have suffered lesser forms of trauma with no neurological fallout and are not subjected to thorough examination. The surgical management of these cases is demanding as bony and fibrous healing have set in already.

O147

Is anterior surgery necessary for TB spine? A series of 30 cases of tuberculosis of spine managed by all- posterior approach

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Introduction: Tuberculosis of the spine predominantly affects vertebral body and intervertebral disc. Surgical management traditionally involves anterior debridement with or without posterior surgery. Anterior approaches add to morbidity and risk of the surgery. We present a series of 30 cases of Tuberculosis of Spine – Thoracic, Lumbar and cervical managed successfully by all posterior approach.
Methods: 30 consecutive cases of microbiologically proven Tuberculosis of Spine treated during the period 2012 to 2020 were analysed retrospectively. Age range12 – 71 years. Cervical – 3, Thoracic 17, Lumbar 10. 13 cases presented with neurological deficits. All cases underwent posterior surgical management in the form of Pedicle screw / lateral mass screw fixation, transforaminal debridement and posterior decompression. Anterior approach for biopsy was done in cases of cervical spine. Anterior fixation or strut grafting was not done in any of our cases. Antitubercular antibiotics were given for 12- 18 months.
Results: 29 out of 30 patients had complete healing of Tuberculosis. One patient with drug resistant TB was lost to follow up. All other patients were followed up for minimum 24 months. There was no loss of fixation or significant increase in kyphotic angle. Out of 13 cases with neurodeficits, all 13 cases had neurological; recovery with 12 patients achieving ambulatory status.
Conclusions: All-posterior surgery is a safe and effective method for surgical treatment of tuberculosis of spine. All-posterior surgery can achieve the surgical goals like adequate debridement, obtaining tissue for biopsy, bone grafting, neural decompression and providing stabilisation while antitubercular chemotherapy achieves microbiological clearance. All-posterior surgery has the advantage of excellent surgical outcome while avoiding the morbidity of anterior surgery.
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O148

Use of Frailty score in predicting mortality and morbidity in elderly patients undergoing spine surgery for tubercular spondylodiscitis

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Introduction: Treatment of spinal tuberculosis in the elderly involves consideration of compromised physiology which often poses a clinical challenge to the surgeons to balance surgical safety versus deteriorating function. Frailty scoring has been reported as an effective tool to predict mortality and morbidity in cardio-vascular surgery and recently in hip fractures. Its use in spinal surgery is scarcely reported.
Aim: The aim of the study is to assess the use if frailty score in predicting Mortality and Morbidity in elderly patients undergoing spine surgery for spinal tuberculosis.
Materials and Methods: We included elderly patients operated for spinal tuberculosis. Demographic, clinical and radiological profile with operative details of instrumentation, blood loss, surgical duration and mortality were noted. Modified frailty score (MFS) (Table 1) was calculated for each patient. There were 26 patients (M/F=9/17) with a mean age of 73.2 years. The patients were divided into those with 30-day post-operative mortality (M) and those who survived (S). The Null hypothesis was that the MFS was comparable in both the groups.
Results: M group had 5 patients (19.2%) and S group consisted of 21 patients. There was no statistical difference between the groups with respect to mean age, sex, number of medical co-morbidities, ASA grade, Frankel grade C or worse, blood loss and operative time. The mean MFS in M group was 5 and in S group was 1.8 which was statistically significant. (P value< 0.001).
Conclusion: Higher MFS is associated with post-operative 30-day mortality in the elderly patients with spinal tuberculosis undergoing surgery. It can be used as a guide to predict 30 day post-operative mortality in these patients

O149

Results of mortality audit of elderly patients with tubercular spondylodiscitis undergoing spine surgery

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Introduction: Treatment of spinal tuberculosis in the elderly involves consideration of age and co-morbidities, and often leads to an extended conservative management. Surgical intervention in these patients becomes a complex decision. There are no studies on risk factors of mortality in surgically treated elderly with tuberculous spondylodiscitis.
Aim: The aim of the study is to do a mortality audit of patients with tubercular spondylodiscitis undergoing spine surgeries and identify the risk factors.
Materials and Methods: Two hundred and seventy-six patients with spondylodiscitis were operated between 2005 and 2015. 20 consecutive patients over 70 years of age with and proven tuberculosis who met the inclusion/exclusion criteria were included. Demographic, clinical and radiological data with operative details of instrumentation, blood loss, surgical duration, and mortality were noted. There were 20 patients (6 males, 14 females) with a mean age of 73.5 years. The patients were divided into those with mortality (M) and those who survived (non-mortality, NM). Various variables were statistically tested for immediate postoperative medical complications and mortality.
Results: There were four mortalities (20%). Age, sex, number of medical co-morbidities, American Society of Anaesthesiologists grade, Frankel grade C or worse, number of vertebrae involved, number of levels fused, blood loss and operative time did not have statistically significant impact on immediate postoperative mortality. Only preoperative immobility duration was statistically higher in the M group ($p=0.016$) than in the NM group.
Conclusion: Preoperative immobility is associated with immediate postoperative mortality in elderly patients with spinal tuberculosis undergoing surgery. The findings identify preoperative immobility as a risk factor for mortality, which could contribute to a more detailed prognostic discussion between surgeon and patient before surgery.

O150

Traction radiograph: A dark horse in assessing flexibility in adolescent idiopathic scoliosis patients undergoing non fusion anterior scoliosis correction surgery

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Introduction: Non fusion anterior scoliosis correction (NFASC) is a novel technique for correcting adolescent idiopathic scoliosis (AIS). Existing literature evaluating NFASC have raised concerns for overcorrection and undercorrection and thereby possibility of revision surgery. There is paucity of literature on determining flexibility of curves based on traction radiographs in patients undergoing NFASC. We hypothesize that traction radiographs guides in predicting post operative correction and also helps in determining force while applying intraoperative tensioning for curve correction. The current study aims to determine the relationship between pre operative traction radiograph and post operative correction following NFASC for AIS.

Methods: We evaluated 45 children with AIS who underwent NFASC with a minimum of one year of follow up. Pre operative AP and side bending films, supine traction and post-operative first erect and most recent radiographs were compared. A repeated ANOVA test was performed to measure the difference between Cobbs angle. P-value <0.05 was considered statistically different. Spearman correlation coefficient was used to ascertain the strength of association.

Results: The cohort included 43 female and 2 male patients with mean age of 14.9 years (Range 11-21 years). The cohort included 16 Lenke type 1, 5 type 3, 19 type 5, and 5 type 6. Mean pre op main thoracic (MT) and thoraco lumbar/lumbar (TL/L) cobbs were 52.1°±6.7° and 51.4°±8.9° respectively. Pre op cobbs for MT and TL/L on side bending radiographs were 32.1°±5.4°(37% flexibility) and 31.3°±6.5°(39 % flexibility) respectively. Pre op cobbs for MT and TL/L on traction radiographs were 23.1°±4.7°(56% flexibility) and 20.7°±5.3°(60 % flexibility) respectively. Post operative first erect standing radiographs showed correction to a mean of 17.3°±4.2°(67% correction) for MT curve and 13.4°±4.1°(74% correction) for TL/L curve ($p<0.001$). The most recent radiograph measured a mean of 16.9°±3.9° for MT and 14.2°±3.2° for TL/L curves (68% and 72 % correction) respectively. Spearman correlation coefficient showed significant positive correlation between traction radiographs and post op first erect radiograph for both MT and TL/L curves ($r= 0.5$, $p<0.001$).

Conclusions: Our study showed that pre operative traction radiographs helps in reasonably estimating post op correction for AIS patients undergoing NFASC. It also guides surgeon intraoperatively for appropriate tensioning for adequate correction. Thus, surgeons and families can expect post op curve correction similar or better than traction radiograph and hence traction radiograph can be a useful tool for appropriate patient selection for AIS patients undergoing NFASC.

O151

Clinical outcome of single-stage decompression and posterior stabilization in thoracolumbar spinal tuberculosis

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Objective: To assess the clinical outcome of single stage decompression and posterior stabilization in thoracolumbar spinal tuberculosis.
Methods: All patients aged between 18 and 70 years with clinically and radiologically proven symptomatic thoracolumbar spinal tuberculosis who failed with conservative treatment for 4 weeks or developed neurologic weakness between the treatments are included in this study. All patients were offered decompression and posterior stabilization with transpedicular screws and rods after explaining the above procedure. Clinical outcome was measured by modified Frankel grading; AIS (American Spinal Injury Association impairment score) grade impairment score; and pain assessment done with visual analog scale (VAS) pre- and postoperatively and at 3, 6, and 9 months of interval.
Results: The postoperative pain relief, neurologic improvement as per modified Frankel grade, AIS grade, and improvement in erythrocyte sedimentation rate and C-reactive protein were significant as compared with the preoperative status. The surgical interventions thus prove to have adequate relief to the patient and arresting the disease progression. The surgical outcome has very minimal intra- and postoperative complications.
Conclusion: Single-stage decompression and posterior stabilization in thoracolumbar spinal tuberculosis is safe, effective, and results in good clinical outcome. The advantages of surgery include thorough debridement, decompression, and achievement of spinal stabilization.

O152

Prospective outcome study of lumbar microdiscectomy based on MSU classification: Does MSU classification helps in better patient selection and decrease morbidity?

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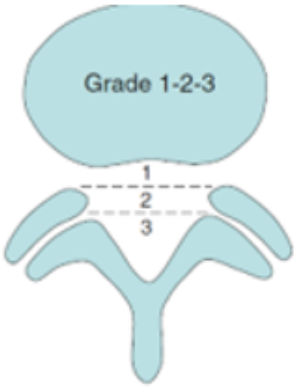
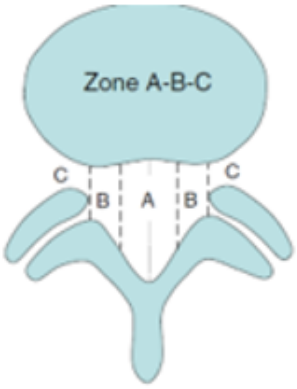
Objective: To test reliability of MSU classification of lumbar disc herniation in helping surgical selection and correlation with preoperative clinical presentation and postoperative clinical and functional outcome.
Materials and Methods: This is a prospective study of 202 consecutive patients who underwent microscopic discectomy for the treatment of single level, primary lumbar disc herniation from January 2020 to February 2022 with at least 6mon follow up. The Oswestry Disability Index was used to compare pre op and post op disability. Good or excellent outcomes represented minimal to no disability scores of 15% or less. Fair outcomes represented levels of minimal to moderate disability scored between 15 and 30%. Poor outcomes represented levels of moderate to severe disability scores of greater than 30%.
MSU classification: Antero-posterior extent of disc was described as 1, 2 or 3. Size 1 corresponds to disc herniation extending up to or less than 50 % of distance from posterior aspect of normal disc margin to intra- facet line. Size 2 as greater than 50% of that distance. And size 3 when it extends beyond interfacet line. When the disc herniation migrates caudal or cephalad the measurement is taken from posterior edge of vertebral cortex or end plate. Medio – lateral extent is further described as A, B or C. intra-facet line is divided into four equal compartments, zone a it is right and left central compartments, zone B is right and left lateral quadrants and zone C is the area lateral to medial margin of facet joints.





Results: 13 patients were excluded from final study because they could not be reachable and of the 189 patients 85% of the patients study were rated as good or excellent. 5 % (9) of the reported as fair. 10 %(12) of the patients as poor. 9(5%) patients underwent fusion surgery for recurrence. The most frequent types of herniation were type's 2-AB (69) and 2-B (45) and, 24 patients presented with impending cauda equina of which 18 were size 3. Motor deficit was commonly associated with type -2B, suggesting the combined importance of both size and location. 6 patients had small dural tear which did not alter the post-operative outcome.
Conclusion: The MSU classification is a simple and reliable method to objectively measure herniated lumbar disc. When used in correlation with appropriate clinical findings, the MSU classification can provide objective criteria for surgery that may lead to a higher percentage of good to excellent outcomes.

O153
Lumbar disc prolapse mimicker – Our experience

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Introduction: Lumbar root compression and radiculopathy are usually caused by disc herniations. Rarely, these symptoms may be presented due to unusual lesions such as an engorged epidural varix.
Aim: To describe our experience with cases of lumbar radiculopathy caused by an epidural varix – both were reported as disc prolapse on preoperative MRI.
Materials and Methods: Patient 1: A 45 year old lady presented with right sided L5 radiculopathy for 6 months which was not improving with conservative management. Her MRI revealed posterior annular tear at L4-5 with disc bulge abutting the right L5 root. She was taken up for L4-5 fenestration discectomy. Patient 2: A 58 year old male with 1 year history of left S1 radiculopathy not improving with non operative treatment. His MRI was reported as L5-S1 left sided disc prolapse with compression of left S1 root. He was planned for L5-S1 fenestration discectomy.
Results: Patient 1: Intraoperatively, on retraction of right L5 root, an engorged epidural varix was noted causing compression at the shoulder of the root. Electrocoagulation of the varix was performed and root was decompressed. No disc prolapse was found. Patient 2: Intraoperatively, thrombosed and thickened epidural varices were noted at the shoulder of left S1 root which was electrocoagulated and excised and root was decompressed. He had postop residual radicular pain which subsided with IV steroids for 5 days. Both patients are symptom free at last follow up (24 months and 8 months respectively).
Conclusion: Epidural varices are mimickers of lumbar disc herniation both clinically and radiologically. Intraoperative absence of loose disc fragments should alert the surgeon to explore for such unusual pathologies. Simple electrocoagulation of the varix produces symptom resolution.

O154
Screw-rod malalignment as cause of persistent pain after thoracolumbar fusion

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Introduction: Thoracolumbar vertebral fusion is a common technique used for the treatment of different spine injuries. Many instruments, approaches and assisting technologies have been developed to improve our results as spine surgeons. However, they have not improved as expected and some patients complain from pain and are unsatisfied despite radiological images look perfect. Biomechanical aspects are taking more and more importance along the last decades.
Aim: The objective of our study is to analyze the impact of malalignment in the complex rod/head of pedicle screw on clinical results, taking as the main parameter pain.
Materials and Methods: This is a retrospective observational clinical study. We included all patients from the Spine-Unit of our hospital who underwent fusion surgery with pedicle screw/rod systems during a 6 years period. In order to be included we requested to have clinical and radiological complete preoperative, postoperative, and follow-up data of the patient. Radiographic parameters recorded are pedicle screw/rod mismatch (no/yes) and degree of pedicle screw/rod mismatch (angular deviation from a 90° alignment). We recorded demographic variables, as well as clinical situation preoperatively and postoperatively and at follow up. Pain and ODI were the main parameters studied. Statistical analysis was performed using IBM SPSS Statistics, version 21.
Results: 406 met the inclusion criteria after screening 1183 cases. 3016 screws were implanted and measured. The most frequent diagnosis were degenerative disc disease and stenosis (55% of the total), followed by deformity, fracture and failed back syndrome (10% each). 77% of the patients had 3 levels or less fused. 42% of the patients had pedicle screw/rod mismatch, affecting 20% of the total number of pedicle screws implanted. Mean degree of mismatch was 8.7º. At final follow up, mean pain score measured with VAS was 2. When analyzed by groups, the group with mismatch had a VAS of 2.8. The group with no mismatch, had better clinical results in terms of pain with a VAS score of 1.4 (figure 1). These differences were statistically significant.
Conclusions: Mismatch between the rod and the head of the pedicle screw in thoracolumbar fusion has a direct impact on the main clinical result, which is pain. Those patients with mismatch in the alignment of the rod/screw construct are more painful than those where no mismatch is observed.

Figure 1:

Pain (VAS) at final FU)			
	Without Mismatch N=235	With mismatch N=171	P-value
Mean (SD)	1.4 (0.8)	2.8 (0.8)	<0.001

Comparison of the two groups Without and With mismatches revealed statistically significant difference.

O155

Non-surgical management of extruded disc herniations - Clinical and radiological results

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Introduction: Disc herniation is a prevalent spine disease. Luckily, most of them can be treated conservatively. However, disc extrusions are very symptomatic and in many cases, surgery is considered the main therapeutical option. Spontaneous herniated disc regression can occur. Understanding the clinical course as well as the magnetic resonance (MRI) characteristics may help the decision flow that surgeons should follow.

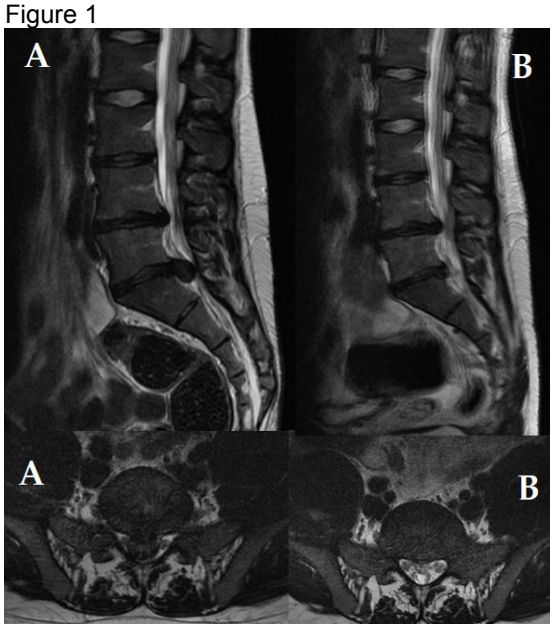
Aim: Our aim is to identify if big disc herniation regression is possible and to evaluate if the final clinical situation is acceptable.

Materials and Methods: We collected consecutive patients with herniated lumbar disc, as defined by American Spine Society by MRI, with spontaneous regression between 2017 and 2020. Demographic and clinical data, as well as clinical examination was collected. An MRI was performed along patient clinical assistance as per health care standards. A follow up MRI was performed at 12 months (+/- 3 months) after first MRI. Disc intensity on T2 sequence was recorded, as well as other MRI characteristics. A clinical interview on November 2021 was performed on every patient obtaining Oswestry scale (ODI), VAS and neurological examination.

Results: A total of 24 patients were included in the study. 83,3% were male. Mean age was 45.25 and mean body mass index 25,217. 33% manual labor workers, 33% on office job, 25% unemployed and 8,3% students. 83,3% showed L5-S1 hernia, with 8,3% sequestrated herniations and majority of cases occupying 25-50% of lumbar canal. Mean time for MRI control was 12,83 ± 2,73 months. 50% showed disc hipointensity on T2, while the other 50% showed isointensity on first MRI. All control MRI showed normointensity (Mcnemar p 0,031). 91,7% showed herniated disc size reduction of at least 50% (figure 1). Mean OS of 15,5 (min 2-max 60), and 75% had minimum disability. 2 patients required foraminal infiltration. 50% still regularly go to physical therapy. Study showed statistically significant differences on regard to radiculopathy (p 0,031) or drug intake (p 0,004), but no differences on pain Visual analogic scale nor motor or sensitive symptoms.

Conclusions: In patients with big disc herniations, conservative treatment is still a good alternative. Spontaneous disc herniation regression can be achieved, followed by a reduction in drug intake and improvement of radicular symptoms, allowing patient recovery with resulting minimum disability. No link was found between MRI intensity signal and clinical course.

Figure 1



A: L5-S1 disc extrusion invading more than 50% of lumbar canal. B: Images at 1 year follow-up showing the regression of the disc herniation.

O156

Brucellosis of the spine: A global public health problem - An analysis of 37 patients from a 'high risk' region

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Introduction: Brucellosis is a global public health issue and is one among the greatest socioeconomic problems in developing countries. The global incidence is estimated as 500,000 cases per year. Middle east has been identified as a 'high risk' region for Brucellosis by the Centers for Disease Control and prevention (CDC). Spondylitis is the most common presentation among osteoarticular Brucellosis.
Aims: We aim to report the clinical characteristics, diagnosis, management and outcome analysis of patients treated for Spinal Brucellosis. Our secondary aim was to evaluate the efficacy of IgG and IgM in the diagnosis of Brucellosis in our subset of patients.
Patients and Methods: A retrospective study of all patients who were treated for Brucellosis of the spine from 2010 to 2020 was conducted. Confirmed cases of Brucellosis of the spine (proven by blood culture or standard agglutination test > 1:160) as per the CDC (Centers for Disease Control and Prevention) guidelines and those who had completed treatment with adequate follow up were included.
Demographic profile of the patients, their presenting complaints, history of contact with Brucellosis, history of intake of raw/ unpasteurized milk (camel's milk), consumption of raw meat, history of contact with infected animals, family history, previous infection with brucellosis, and prior treatment with anti-brucellar medications (dosage and duration) was recorded. Pre-operative pain score (Visual Analog Scale) and the pre-operative neurological status of the patient (ASIA]Impairment Scale) were documented. Blood investigations which included haemoglobin, white blood cell count, blood culture, Standard agglutination test, IgG and IgM ELISA, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) were obtained. Plain radiographs and magnetic resonance imaging were performed prior to and after completion of treatment. Surgical indications were severe unrelenting pain secondary to significant mechanical instability and progressive neurological deficits. Treatment with triple drug regimen as per the WHO protocol as well as drug related complications were documented.
Patients were followed up every 2 months for the first 6 months, followed by quarterly visits in the first year and twice a year thereafter.
Outcome analyses included clinical, biochemical, and radiological parameters to assess the healing status.
Results: There were 37 patients enrolled with a mean age of 45 and an average follow up of 24 months. All of them presented with pain, 30% had neurological deficits. Surgical intervention was done in 24%(9/37patients). All the patients were treated with triple drug regimen for an average duration of 6 months. Those patients with relapse had a 14month period of triple drug regimen. The sensitivity and specificity of IgM was 50% and 85.71%. The sensitivity and specificity of IgG was 81.82% and 7.69%respectively.76% of them had good functional outcome, 82% of them had near normal neurological recovery and 97.3%(36 patients) were healed of the disease with relapse in one patient(2.7%).
Conclusions: Majority (76%) of the patients with Brucellosis of the spine were treated conservatively. Average duration of treatment of triple drug regimen was 6 months. The IgM has high specificity and IgG has low specificity in the diagnosis of Brucellosis.

O157

Morphometric analysis of lumbar pedicles in Saudi Arabian population: A computed tomography-based study on 1500 vertebrae. Are there inter-continental and regional variations?

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Introduction: Pedicle screw instrumentation is the most widely accepted method globally to achieve mechanical stability to the spine. Knowledge of pedicle parameters is a vital step in surgical planning and pedicle screw designing for spine surgeons. Morphology of the vertebrae has both genetic and ethnic variations. There is a lack of database on the anatomy of lumbar pedicles in Saudi Arabian population.
Aims: The primary objective was to create a database using exclusively computed tomography scan-based study on the morphometry of the lumbar vertebrae (L1-L5) of both genders in Saudi population. Secondly to analyze the intercontinental and regional variations of the pedicle parameters with available literature.
Patients and Methods: A retrospective study was done (after obtaining approval from IRB) on CT data of 300 patients who were treated at our tertiary center. Only adults from 18 to 60 years of age were included in the study. Exclusion criteria included patients with deformed vertebrae (secondary to trauma or osteoporosis), history of previous spine surgery (instrumented/uninstrumented) procedures, those with deformities (congenital or acquired), spondylolysis or spondylolisthesis.
Pedicle parameters like transverse pedicle diameter, chord length, length of the pedicle, height of the pedicle and pedicle axis angles were measured by two independent radiologists. The results were stratified based on the side of the vertebra and gender. Results were also analyzed with respect to other CT based morphometric studies from different continents and regions available in literature.
Results: Equal number of males and females were enrolled in the study. A total of 1500 pedicle parameters were measured. The inter observer bias recorded was not significant (p value of more than 0.05.) There was no statistical significance found between the sides of the vertebrae. Transverse pedicle diameter increased from L1 to L5 extending 5.76 to 13.62mm. The longest chord length was at L3 with an average of 50.92mm. Length of the pedicle decreased from L1 to L5 extending 16.01 to 9.93mm. Height of the pedicle showed a similar trend and decreased from 9.75 to 8.3mm (L1 to L5). Pedicle axis angle trajectory followed a gradual medial angulation pattern from L1 to L5(12.68^0 to 28.23^0).
There was statistical significance among the genders ($p < 0.001$) in relation to transverse pedicle diameter, chord length and height of the pedicle. Females had smaller transverse pedicle diameter, smaller chord length and shorter height when compared to males.
There was statistically significant difference in the pedicle parameters from all the published literature from from different continents and regions of the world.
Conclusion: Pedicle parameters are of paramount importance for proper selection and safe instrumentation of pedicle screws. There was no statistical difference in values between the left and right side of the pedicles. All the pedicle parameters were more in the males when compared to females. The transverse pedicle diameter, chord length and height of the pedicle showed statistically significant difference among the genders. Statistical significance was also observed in the pedicle parameters when compared among the Caucasians, western population, people living in the Asia pacific and Latin American regions.

O158

Ochronosis spine: Operative results of this very rare spinal manifestation

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Introduction: Alkaptonuria, a rare hereditary metabolic disease, is characterized by accumulation of homogentisic acid in tissues, pigmentation of cartlage in ears, sclera, valves, discs (ochronosis) and ossification of intervertebral discs.

Aim: To present and review two very rare cases of ochronosis spine with diagnosis of postoperative discitis and tandem stenosis along with their surgical outcome.

Materials and Methods: The diagnosis of ochronosis was made from distinguishing radiological features and confirmed by pathological and biopsy findings. First patient presented with severe backpain and bilateral lower limb radiculopathy since last 1 month after L5-S1 laminectomy and discectomy performed elsewhere 6 months ago Revision surgery in the form of debridement and instrumented interbody fusion was done.

Second patient had features of tandem stenosis due to ligamentum hypertrophy in lower thoracic and lower lumbar regions, wherein decompressive laminectomy was done at both levels using ultrasonic bone scalpel.

Results: We have reported for the first time, that an alkaptonuria patient showed spondylodiscitis following discectomy. Significant clinical improvement was noted in patient in immediate post operative period with Oswestry disability index improving from 34 to 6.

The second patient too had tremendous improvement in gait and radiculopathy.

Conclusion: Though rare, taking into account characteristic features of ochronosis spine like calcification of intervertebral discs, hardened auricular cartilage, black discolouration of urine on exposure to air, black disc material, ankylosed facet joints intraoperatively helps in pertinent diagnosis of the disease. Debridement, decompression, adhesiolysis around roots followed by the instrumented fusion of the lumbosacral spine was very effective in the treatment of postoperative spondylodisctis of ochronotic patient. Stenosis caused in such patients is often due to ossified ligamentum flavum which are more prone to dural injuries while decompression.

O159

Progressive dysphagia & dysphonia secondary to dish-related anterior cervical osteophytes: A case report

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Background: Dysphagia due to DISH (Diffuse Idiopathic Skeletal Hyperostosis) related anterior cervical osteophytes is not uncommon. However, this rarely leads to dysphonia and/or dysphagia along with life threatening airway obstruction requiring emergency tracheostomy.
Case Report: A 56-year-old male presented with progressive dysphagia and dysphonia secondary to DISH related anterior osteophytes at the C3-C4 and C4-C5 levels. The Barium Swallow, X-ray, MRI, and CT scans confirmed the presence of DISH. Utilizing an anterior cervical approach, a large beak-like osteophyte was successfully removed, while preserving the anterior annulus. After clinic-radiological improvement, the patient was discharged with a soft cervical collar, and NSAIDS (non-steroidal anti-inflammatories).
Conclusion: Large anterior osteophytes in Forestier Disease/DISH may cause dysphagia and dysphonia. Direct anterior resection of these lesions yields excellent results as long as other etiologies for such symptoms have been ruled out.
Key words: Dysphagia, Dysphonia, Anterior Cervical Osteophyte, DISH.

O160
Does posterior-alone approach suffices for C2 vertebral body lesions?

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Introduction: There is a lack of consensus regarding the optimal approach to the lesions that involve the C2 vertebral body. These lesions are usually approached anteriorly followed by a posterior stabilization of craniovertebral junction (CVJ). However, the anterior approach has certain limitations and surgical morbidities. A posterolateral corridor can serve as an alternative access to the C2 body lesions and in selected cases, this alone may suffice.
Aim: We describe our experience with C2 body lesions that were dealt primarily through posterior approach, and propose an algorithm in management of such cases.
Patients and Methods: Ten patients who harbored C2 body lesions were managed through a midline posterior approach along with posterior stabilization of CVJ in the same sitting. Their baseline and follow-up clinico-radiological data were reviewed.
Results: The following pathologies were encountered: aneurysmal bone cysts (2 cases), fibrous dysplasia (2), chordoma (2), Ewing sarcoma (1), metastases (1) and one case each of posttraumatic malunion and post inflammatory deformity. All the patients presented with progressive neck pain and 5 had spastic quadriparesis. There were no perioperative complications. All showed clinical improvement at the follow-up. An additional anterior approach was required only in two patients (chordoma-1 and aneurysmal bone cyst -1).
Conclusion: The intended goal of adequate debulking/ complete excision of lesion, neural decompression and stabilization of CVJ for C2 body lesions can be achieved through a single midline posterior approach in most cases. If necessary, an anterior approach may be added later depending upon the definitive histopathology. A tailored approach to the C2 body lesions obviates an additional anterior procedure and its access-related morbidities in majority of the patients.

O161
Cervical tethered cord – Not so rare entity

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Introduction: Tethering of the cervical spinal cord is a rare entity. The aim of this study is to analyze this author's experience with this rare entity and discuss the clinical, radiological, operative findings and outcome of patients with this condition.
Methods: All patients treated by this author from 2009- 2019 with tethering elements in the cervical spinal cord were included in this study. All patients underwent routine neurological evaluation, MRI of the whole spine, CT of the spine in selected cases and plain radiographs. The intraoperative findings and clinical presentations were noted. Postoperative complications were recorded. Postoperative MRI scans were done when deemed necessary. Follow up ranged from 6 months to 2 years.
Results: Number of patients: 12; age ranged from 1 month – 12 years. 10/12 patients were neurologically intact and were referred for medical consultation due to cutaneous markers. Of the two patients who presented with neurological deficits, one had mild quadriparesis and the other had paraplegia. The pathological entities causing tethering of the cervical spinal cord included: 7 cases of limited dorsal myeloschisis, 2 cases of terminal myelocystoceles and 3 cases of spinal dermal sinuses. One patient with with spinal dermal sinus had double lesion – one in the cervical region with intradural extramedullary dermoid cyst and another in the thoracic region with infected intramedullary dermoid cyst and the other patient with cervical spinal dermal sinus had an associated neurenteric cyst anterior to the cervical spinal cord. Both these patients presented with neurological deficits as mentioned above. All patients underwent surgical exploration and complete untethering of the cervical spinal cord which included excision of the limited dorsal myeloschisis,cervical spinal dermal sinuses, dermoid and neurenteric cysts. Patients with limited dorsal myeloschisis had excision of the stalk close to the spinal cord; the two patients with cervical myelocystoceles underwent repair of the same and patients with cervical spinal dermal sinus underwent excision of the dermal sinuses along with associated pathologies like dermoid and neurenteric cysts. One patient who presented with paraplegia due to infected intradmedullary dermoid became ambulant 6 months following surgery; the other patient improved but was lost for follow up after 6 months. All patients who were neurologically intact preoperatively maintained their intact neurological status postoperatively. Complications included: wound infections in 2 and mild CSF leak from the wound in 2 both of which subsided with conservative treatment.
Conclusions: Tethering of the spinal cord in the cervical region is rare. The most common causes cervical cord tethering include: limited dorsal myeloschisis, cervical myelocystoceles and cervical dermal sinuses. Early identification of the pathology and appropriate surgical intervention before the advent of severe neurological deficits leads to a good outcome.

O162

Comparative study between conservative and early kyphoplasty treatment for osteoporotic vertebral compression fractures (OVCF) in elderly patients

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Introduction: OVCF are prevalent in elderly population. Conservative therapy can lead to progressive incapacity. Vertebral augmentation is an effective and safe minimally invasive technique. We compare early, first 4 weeks, kyphoplasty treatment to non-surgical management. Pain reduction, analgesic intake and disability are studied.
Aim: The mean objective of this study is to analyse whether patients suffering of osteoporotic vertebral compression fractures are in need of less analgesia and show better functionality after early kyphoplasty as compared with the use of conservative therapy.
Materials and Methods: We conducted a prospective observational study in our hospital. We included patients over 75 years old with OVCF. They were divided into 2 groups: patients that followed kyphoplasty surgical treatment within 4 weeks after vertebral fracture compared to patients treated nonoperatively. We included 50 patients per group. Demographic data, VAS, analgesic intake, ODI, were recorded. Follow up was 1 year.
Results: 100 patients were included. Most of the patients in the study were women with a mean age of 80,5 years. All vertebral fractures were acute and had imaging evidence of persistent bone edema. Mean VAS score at initial diagnosis was 8,8 in the surgical group and 8,5 in the conservative group. Three months after kyphoplasty VAS score had decreased to 2,4 while in the conservative group was 4,4 and, one year later, surgical group VAS score was 1,3 and conservative group VAS score was 1,8. Oswestry disability Index (ODI) mean scores at initial diagnosis were 74% in the surgical group and 69,7% in the conservative group and after one year it was 15,4% and 31,6% respectively. The kyphoplasty group has a mean ASA score of 2,6, only 1 patient had to be hospitalised during 24 hours and cement leakage was detected in 4 patients without clinical repercussion.
Conclusions: Faster pain and disability reduction was achieved with kyphoplasty treatment. At 1-year-follow up, non-surgical management group, had greater disability comparted to kyphoplasty patients. Early performance improves mobilization and decreases the complications associated to conservative treatment; therefore, it should be considered as first election treatment in very elderly patients.

O163

Treatment of spinal metastasis in the 21st Century: A matched pair analysis

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Objective: Spinal metastases may present with different degrees of mechanical instability. The Spinal Instability Neoplastic Score (SINS) was developed to assess spinal neoplastic-related instability. Few have validated it clinically. This study aimed to compare the progression of a pathologic fracture due to spinal metastases between a conservative treated group and a group treated according to the SIN-Score.

Methods: A retrospective analysis of patients with a pathologic fracture due to a spinal metastasis between January 2018 and December 2020 was performed. We selected patients with a minimum follow- up of 12 months and analyzed them according to the SINS criteria. This patient have been divided in two groups, whether they have been a stabilization surgery due to spinal metastasis or not. For both groups were the primary endpoint the progression of vertebral body fracture following radiotherapy. The study design was a matched-pair analysis according to the SINS-Score, the sex, the age. the histology and the "Karnofsky Performance Index".

Results: In the conservative group 332 Patients were identified. Median age was 68 SD +/- 10,3. 38% were Female. Median follow- up was 26 months (range 12-29). 30, 283 and 19 Patients presented with low (0-6), moderate (7-12) and high (13-18) SINS, respectively. Fracture progression following radiotherapy was seen in 30%, 30% and 42% in cases with low, moderate, or high SINS (P = 0.522), respectively. (Forty-four percent of progression cases in the low group progressed to the moderate group without neurological deficits. Seventeen percent of the progression cases in the moderate group developed neurological deficits.)

In the interventional group 67 patients were identified. Median age was 68 SD +/- 14,17. 40% were female. Median follow up was 12,2 months (12-21). 4, 48 and 16 Patient presented with low (0-6), moderate (7-12) and high (13-18) SINS, respectively. Fracture progression following radiotherapy was not seen in any case. In forty case we performed 360° stabilization. In fourteen cases only a laminectomy was necessary by intraspinal tumor cuff and low / moderate SIN-Score. In other fourteen cases we only performed a dorsal stabilization without a corpectomy. In all cases we did not see any secondary alignment disorder or hints for an instability like loosening-hem.

The overall survival was, at the follow-up, 48% in the conservative group and 75% in the interventional group. Analyzing the quality of life, we choose the walking ability as a main feature. After one year, ninety-two percent in the interventional group are still able to walk, in contrast 86% in the conservative group.

Conclusion: SINS is an especially useful tool to assess stability of a pathologic fracture due to spinal metastases after radiotherapy for spinal metastases. Moderate or high SINS are associated with a remarkably high risk of fracture progression as well as risk for neurological deterioration. A treatment according to the SINS-Score show a satisfying result with conservation of the walking ability. Furthermore, there are hints, that a corpectomy is not always necessary due to the secondary strengthening of the vertebral body by radio oncology.

O164

Clinical outcome in patients >75 years undergoing spine surgery for lumbar degenerative spine disease: Impact of increasing age and modified frailty index on surgical morbidity

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Introduction: Surgical procedures for lumbar degenerative disc diseases (LDDD) are becoming more common in the elderly population, which is likely because of the advancements in surgical technique, improved anesthesia, patient expectations, and increasing longevity. There is a paucity of data on the effects of complication rates of aging and the presence of comorbidities in these population subgroups undergoing lumbar spine surgeries in the literature. The current study aims to find out the relation between age, American Society of Anesthesiologists score (ASA), 11 variable modified Frailty Index (mFI), and post-op complications among patients >75 years undergoing lumbar spine surgery for degenerative disc disease.

Methods: 50 consecutive patients >75 years age who underwent surgical procedures for LDDD at a tertiary care hospital between 2017 and 2019 were enrolled. A matched cohort of consecutive 50 patients was also included in the study and grouped as per their age i.e. 45-60, 61-75 years. The occurrence of per-operative complications, length of stay (LOS), and 30 days mortality were analyzed in comparison with the mFI, and ASA scores. mFI score of ≥ 0.27 was considered frail.

Results: The mean age of the study group was 80 years and the M: F ratio was 28:22. 14 out of 50 patients (28%) had complications and 2 (4%) patients died. The calculated 11 variable mFI on the study group showed a stepwise increment in post-op complications as mFI score increased from 0 to 0.36. A similar trend was observed in both the control group i.e.45-60 and 61-75. The LOS with mFI scores 0 was 2.5 ± 0.67 which increased to 8.33 ± 5.77 with mFI score 0.36 in the age group >75 years. The proportion of Clavien Dindo class IV complications (mortality, ICU admissions) was higher in mFI ≥0.27. Univariate logistic regression analysis showed that age and mFI are associated with any complications in the study group ($p<0.05$) and the association between ASA score and any complications were not significant.

Conclusions: Our study shows that 11 variable mFI owing to its brevity is a useful tool for predicting post-op morbidity and mortality in the geriatric population undergoing spine surgery. It was also found that increased ASA alone was not associated with increased complication rates.

O165

Managing cervical trauma in a resource constrained environment - What the first world should not forget

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Windhoek, Namibia is a high volume spinal trauma centre with limited resources yet has well placed and managed trauma protocols. The use of connes calipers is a strongly emphasized standard of care in cervical dislocations and is taught and maintained in National ATLS and EMS courses.
This talk focusses on indications and contra-indications to the use of connes calipers, application techniques and contra-indications. Practical tips on reduction and lessons learnt are presented and why it is relevant not only in Africa but should still be in the rest of the world.
Uni- and Bi-facet dislocations of the cervical spine are reduced in peripheral desolate areas saving lives. The experience in reduction has led to the creation of a traction table, a fully automated reduction machine capable of maintaining extreme angles and tensions during reduction of cervical dislocations. The results of the first 64 patients are presented which significantly reduced reduction times and 90% success rate.
Open reduction techniques from both anterior and posterior are presented.

O166
Educational potency of newly-developed high-fidelity spine model in spinal surgery

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Introduction: Surgical techniques in spinal surgery have become more diverse and complicated, but it gets more difficult for spine surgeons and trainees to obtain abundant training time and experience in the daily operative theater. As one of the effective training methods, high-fidelity radiograph-friendly 3D spinal bone model was newly developed.
Aim: To assess the educational potency of this bone model for the young spine surgeons.
Materials and Methods: A fictitious patient was created in electronic medical chart with imaging studies from one of our real patients with cervical kyphotic deformity and corresponding fictional medical history. Four young spine surgeons who have no operator experience for complex deformities were told to see this chart to make diagnosis and treatment plan in detail and to implement their plan after a month. 3D cervical spine model was created from the CT DICOM data of the original patient. The procedures by those surgeons were performed one by one with slight assist by a senior surgeon in the real operative theater with the actual equipment including surgical tools and imaging devices by their preoperative request. Their preparation and surgical time were recorded. The questionnaire which contained 5-point Likert scales and free comments were answered by the attendees.
Results: The participants spent 308 minutes on average for pre-procedural learning, 75 minutes on average for making surgical plan, and 127 minutes on average for their procedures. Three planned anteroposterior surgery, and one planned anteroposteroanterior (3 stage) surgery. Three used image intensifiers for lateral mass screws, and one used CT Navigation for all-pedicle-screw construct. Preoperatively kyphotic C2-7 angle of -47 degrees was corrected to -9 degrees on average (-3.3 to -20 degrees). All the attendees said they could devote themselves to the procedure, and positively appreciated this simulation as excellent training method. Likert scales were more than 4 points on average in all items indicating both the model and this experience were accepted quite positively by the attendees. The positive points were including; that the radiographic outcome can be compared to the others, that the model provides sufficient quality of the hand feeling and imaging (X-ray, CT Navigation) appearance. Written feedback and comment added on their operative report were also favorably appreciated. All of them desired to participate again if the similar session would be held.
Conclusion: The surgical simulation on our newly-developed bone model can bring satisfying training experience for young surgeons when combined with the realistic medical background and real operative environment. The fidelity and radiograph-friendly feature of the model were positively contributed to this experience. This simulation seems valuable especially for the young surgeons to experience challenging cases for their hands.

O167

Prospective cohort study with 2 years follow up of clinical results, fusion rate and muscle bulk for uniportal full endoscopic posterolateral transforaminal lumbar interbody fusion

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Purpose: 2 years postoperative evaluation of the cross sectional area of paraspinal muscle and clinical findings in patients who had interlaminar route uniportal full endoscopic posterolateral transforaminal lumbar interbody fusion(Endo-TLIF)
Overview of literature: There are limited short term follow up studies on efficacy, safety and physiological changes with 2 years follow up and there is no study on paraspinal muscle cross sectional area change on patients who had undergone uniportal Endo-TLIF
Methods: Evaluation of patients who underwent Endo-TLIF with minimum 24months follow up was performed. Clinical parameters of visual analog scale and Oswestry disability index were measured at preoperative, postoperative 1 week, 3 months postoperative and final follow up. Preoperative and one year postoperative Magnetic Resonance Imaging measurement of preoperative and postoperative Kjaer grade, right and left psoas muscle mass area, right and left paraspinal muscle mass area were performed.
Results: 35 levels of Endo-TLIF with minimum 24 months follow up were included. Complication rate was 6%, mean Bridwell's fusion grade was 1.37(1-2). There was statistically significant improvement at 1 week, 3months and 2 years in VAS (4.11 ± 1.23; 4.94 ± 1.30 and 5.46 ± 1.29) and in ODI (; 40.34 ± 10.06;(46.69 ± 9.14 and 49.63 ± 8.68) respectively, $p < 0.05$. Rate of successful operation with excellent and good MacNab's criteria at 2 years was 97%. There is a statistically significant increment of bilateral psoas muscle cross sectional area, right side (70.03± 149.1) mm2 and left side (67.59± 113.2) mm2,$p<0.05$.
Conclusion: Uniportal Endoscopic Posterolateral Lumbar Transforaminal Interbody Fusion achieved good fusion, improved clinical outcomes and favorable paraspinal musculature bulk in 2 years follow up study.

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O168

Differential diagnosis in tumoral lesions of the sacrum: Osteoblastoma case report - Treatment update

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Introduction: Tumoral lesions of the axial skeleton are a challenging pathology. They may be life threatening. In case that their treatment includes resection, it can lead to unstable situations for the skeleton. Differential diagnosis is important in order to apply the best treatment. Imaging and even anatomo-pathological analysis do not always show a specific diagnosis.
Aim: The aim of our study is to review the clinical-radiological characteristics of osteoblastoma and to know its forms of presentation, to distinguish between the main entities with which it poses a differential diagnosis and to know the options available for its treatment.
Materials and Methods: We present a 13-year-old boy patient who attended his Primary Care Centre complaining of two months of low back pain and difficulty in walking. He was consequently referred to the Paediatric Rheumatology Department. He told a story of non-radiating lumbar pain of inflammatory characteristics with partial response to treatment with non-steroidal anti-inflammatory drugs (NSAIDs). Then, physical examination revealed scoliosis, walking difficulties and alterations in the mobility of the left hip. Total spine X-rays were taken, showing lumbar scoliosis. Subsequently, imaging tests were carried out to extend the study. The Computed Tomography (CT) scan showed a lytic lesion in the apophyses of S1 and S2, as well as the pelvic Magnetic Resonance Imaging (MRI) revealed a space-occupying lesion located in the posterior sacral elements. Finally, with the aim of reaching a certain diagnosis, a CT-guided biopsy was performed, which result suggested a differential diagnosis between osteoid osteoma and osteoblastoma.
Results: Afterwards, the patient was referred to the Orthopedic Spine Department in order to assess surgical treatment of his pathology. It is then when wide resection were performed. There were no necessary to apply any adjuvant treatment. Also no instrumentation of the spine was required due to stability after resection. The immediate postoperative period was favourably and the patient was allowed to bear the full weight. At the beginning, he used two crutches as technical aids which he gradually abandoned a few days after surgery. Furthermore, pathological analysis of the intraoperatively resected tissue revealed a benign osteogenic tumour compatible with osteoblastoma. At last, six months later, the patient is autonomous, reports no pain and has no limitations in his daily life.
Conclusions: Osteoblastoma is a rare benign bone tumor mainly located in the spine. Its diagnosis requires not only imaging test but also an histopathological confirmation. Due to its low potential for malignancy and dissemination, the prognosis is generally good.

O169

Sacrifice of involved nerve root during surgical resection of foraminal and/or dumbbell spinal neurinomas

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Introduction: To achieve gross total resection (GTR) during surgical treatment of spinal benign nerve sheath tumors (NSTs), involved root resection is usually needed. In contrast to pure intradural NSTs, nerve sacrifice for intra-foraminal and/or dumbbell lesion is controversy regarding the risk for motor function. The authors hypothesize that the involved root is poorly functional in most cases since it is chronically compressed between the tumor and the bony contours inside the foramen with the potential of compensation by the adjacent roots. The aim of the study was then to confirm the safety of nerve root section and to evaluate the predictive factors of post-operative deficit.
Methods: All foraminal benign NSTs (WHO grade I Schwannomas and Neurofibromas) who underwent surgical resection from 2013 to 2021 at our institution were reviewed. The impact of preoperative clinical status, patients (age, sex) and tumors characteristics on long-term outcome were analyzed. Sensory and/or motor radicular deficit (RD) was considered for the all series while motor deficit (MD) was analyzed for the functional subgroup.
Results: A total of 26 patients were included with a mean follow-up (FU) of 22.4 months. Functional motor roots (C5-T1, L3-S1) were involved in 14 cases (53.8%). Presenting symptoms were axial pain (69%), radicular pain (42%) and RD (23%). In the functional roots subgroup, 35.7% (n=5/14) presented pre-operatively with MD which was moderate (MRC $\geq$3) in all cases. The involved nerve root was routinely sacrificed during surgery and the intracanal and foraminal part was successfully resected. GTR was obtained in 84.6% of cases and no recurrence was observed. Post-operative RD was observed in 8 patients (31%) in the total series including the worsening of a preoperative deficit in 3 cases. Among them, 5 persisted at last FU (19%). In the functional subgroup, new MD (including worsen of preop MD) occurred in 5 patients (35.7%), and persisted as moderate (MRC ≥3) in 2 patients (14.2%) at final FU. Among them immediate and persistent MD was an exacerbation of pre-existing deficit in 3/5 (60%) and a pure new deficit in 2/5 (40%), respectively. At final FU, the risk of permanent deficit was 20% for patients with pre-existing deficit and 10% for patients with no pre-operative deficit, $p>0.05$. Post-operative radicular and motor deficit had higher incidence of pre-operative radicular pain and deficit, older age, recent medical history and greater extraforaminal extensions, $p>0.05$. Even though, preoperative radicular pain was the only characteristic significantly associated with immediate ($p=0.03$) and permanent RD ($p=0.007$) in the entire cohort and immediate post-operative MD ($p=0.03$) in the functional subgroup at the univariate analysis.
Conclusions: Systematic nerve root amputation in foraminal NSTs didn't result into complete and definitive deficit and should be considered by surgeons to resect these tumors. Complete nerve root sacrifice permitted an oncologic surgery with a high rate of GTR and also a general improvement of the neurological status. Preoperative radicular pain was significantly predictive for post-operative deficit. Pre-operative deficit, extraforaminal extension and longer history seemed to be correlated with deficit although not significantly in our cohort. Their role should be further clarified.

O170

Transpedicular bone grafting with pedicle screw fixation - An effective treatment for pseudoarthrosis following osteoporotic thoracolumbar fractures: A retrospective study with 2 year follow up

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Introduction: Pseudoarthrosis following osteoporotic thoracolumbar vertebral compression fractures lead to significant functional disability, kyphosis and neurological deficit and often warrant surgical intervention. Advanced age and osteoporosis make the surgical treatment challenging. Transpedicular bone grafting of the pseudoarthrotic vertebra can help in direct healing of the defect. However there is paucity of literature on this technique in the treatment of this condition.
Aim: To evaluate the efficacy of Transpedicular bone grafting with posterior pedicle screw fixation in vertebral pseudoarthrosis following osteoporotic vertebral compression fractures.
Materials and Methods: A retrospective analysis of 21 patients (Age 61-83yrs) with symptomatic vertebral pseudoarthrosis following osteoporotic thoracolumbar compression fractures between years 2012 to 2020 in a single center were included in the study. 9 patients had clinical features of compressive myelopathy. All patients were surgically treated with posterior pedicle screw fixation and transpedicular bone grafting and Demineralised Bone Matrix insertion into the pseudoarthrotic vertebra. Bone graft was morcelized and inserted into the pseudoarthrotic cleft under fluoroscopic guidance through channels created in the bilateral pedicles of the pseudoarthrotic vertebra. All patients received treatment with daily subcutaneous injections of Teriparatide as per treatment protocol for Osteoporosis. Oswestry Disability index (ODI) and Pain Visual Analogue Scale(VAS) scores were assessed preoperatively and postoperatively at 3 months and two years.
Results: ODI score improved from preoperative mean 82 to 21 at three months postoperative and 24 at two years follow up. All 21 patients showed maintenance of kyphosis angle improvement at two years and no evidence of any implant loosening or new compression fractures. Myelopathy had improved in 8 out of 9 patients with 8 patients regaining ambulatory status.
Conclusion: Transpedicular bone grafting with posterior pedicle screw fixation is an effective treatment for pseudoarthrosis in osteoporotic fracture of thoracolumbar region. This method allows direct healing of the pseudoarthrosis and can restore function in these elderly patients.

O171

Longer wait times between referral and lumbar decompression surgery may contribute to poorer patient reported outcomes

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Introduction: Lumbar spinal stenosis is a degenerative condition characterised by narrowing of the spinal canal resulting in lower limb symptoms and is a frequent indication for lumbar spinal decompression surgery. Recent evidence suggests prolonged symptom duration and surgery wait time may lead to poorer post-operative outcomes. Here, we investigated the effect of surgery wait time on surgical and patient-reported outcomes following single-level lumbar decompression surgery performed by a single surgeon across four hospitals in Perth.
Methods: Demographic, perioperative and patient reported outcome measures (PROMs) were retrospectively assessed for participants who underwent lumbar decompression surgery with or without discectomy between June 2020 and October 2022. PROMs were collected pre-operatively and 12-months post-operatively and included the EQ-5D-5L to assess health related quality of life, visual analogue scale (VAS) to assess back and leg pain intensity and the Oswestry Disability Index (ODI) to assess back-pain related disability.
Results: This study included 113 participants with a median (interquartile range; IQR) age of 55.4 (27.8) years, a body mass index of 28.6 (7.2) and 39.8% female. The median wait time between referral and surgery was 58 days and ranged from 3 to 1,784 days. Improvements for all PROMs were clinically and statistically significant at 12-months post-operative ($p<0.0001$). The mean improvement was 15.2 and 0.27 points for the EQ-5D-5L Health VAS and Index, 3.2 and 4.1 points for the VAS for back and leg pain intensity, and 23.0 points for the ODI. Longer wait times associated with smaller improvements in EQ-5D-5L Health VAS (adjusted-$r^2=0.04$, $p=0.02$, estimate=-0.01) and Index (adjusted-$r^2=0.03$, $p=0.05$, estimate=-0.0001) scores, VAS for back pain (adjusted-$r^2=0.06$, $p=0.006$, estimate=-0.002) and leg pain (adjusted-$r^2=0.05$, $p=0.01$, estimate=-0.002) and ODI scores (adjusted-$r^2=0.06$, $p=0.004$, estimate=-0.014). Models predicting participant outcomes with wait time were not improved by including demographic and perioperative variables ($p>0.05$).
Discussion: We demonstrated an association between surgery wait times and patient-reported outcomes at 12 months after lumbar decompression surgery. We reported effect sizes of -0.0001 to -0.014 indicating that a participant with a surgery wait time of 550 days may expect to have a VAS score for back and leg pain of 1 point lower and an ODI score of 7 points lower than participants with a wait time of 50 days. Subsequently, the post-operative improvement from baseline in some participants facing longer waiting times may fail to achieve a minimum clinically important difference in outcome measures, thereby calling into question the utility of surgical treatment at some timepoints.
Conclusions: Prolonged waiting times produce poorer patient-reported outcomes and lessen the positive impact of lumbar decompression surgery. Increased surgical waiting times, most recently attributed to the impact of the COVID-19 pandemic will predictably negatively impact patient outcomes after lumbar decompression surgery. All countermeasures to limit waiting times to the recommended timeframes must be employed to minimise detriment to this patient population.

O172

The clinical and cost-effectiveness of lumbar fusion surgery compared to best conservative care for patients with persistent, severe low back pain: FusiOn veRsus bEst coNServatIve Care (the FORENSIC-AUS trial protocol)

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Introduction: The number of lumbar spine fusion surgeries is increasing in Australia, with rates 12 times higher in some areas compared to others. There is collective uncertainty whether fusion surgery is better than best conservative (non-surgical) care for patients with persistent, severe low back pain (LBP) who have degenerative lumbar spine disease. Six randomised controlled trials (RCTs), none in Australia, provide limited and inconclusive evidence. This new RCT has high relevance to Australia and other countries given volume of procedures and impacts of persistent LBP for patients (disability, pain), and society (costs, work loss).

Methods: The FORENSIC-AUS trial is a pragmatic, parallel, two-arm, multicentre RCT funded by NHMRC. Commencing in 2023, it will be conducted to the same protocol as the NIHR funded FORENSIC-UK trial. The sample comprises 270 patients (135 per arm), aged 18 to 65 years old, with persistent (6 months or more) and severe LBP (6 or more, on a pain NRS), with recent MRI evidence of lumbar degenerative spine disease, who have tried previous conservative treatment. They will also have been assessed as suitable for either one- or two- level lumbar fusion surgery or best conservative care (BCC). Patients with neurological signs/symptoms requiring decompression, those with spinal deformity, infection, tumours, spondylolisthesis (grade 3 or 4), spinal fracture, systematic inflammatory disease or previous fusion surgery will be excluded. Patients will be identified from public and private hospital and health services including private surgeon practices, screened for eligibility, invited to provide written informed consent and then randomised to lumbar fusion surgery or BCC. Any accepted standard fusion method/graft option is permitted to maximise external validity. BCC commences with a review by a senior spinal practitioner (usually a musculoskeletal physiotherapist), followed by a personalised treatment package based on a participant's goals, abilities and expectations, drawn from recommended non-surgical treatment options. Primary outcome is back-related disability, assessed using the Oswestry Disability Index at 24 months; secondary outcomes include pain intensity, quality of life, work, and healthcare use, over 24 months. An integrated Quintet Recruitment Intervention will investigate recruitment challenges, optimise recruitment and safeguard informed consent. Health economic analyses will determine cost-effectiveness. We plan to compare data across the two trials to compare results in the two healthcare systems, and pool data across the two trial to enable future subgroup analyses to determine characteristics of patients that benefit most from lumbar fusion or from BCC. We hope to secure future funding to facilitate participant follow-up to five years.

Results: This presentation will outline the FORENSIC-AUS trial protocol. Rationale for participant eligibility criteria, interventions, outcomes and other key elements of design will be discussed and trial innovations highlighted.
Conclusions: Together, the FORENSIC trials in the UK and Australia will provide world-leading evidence to reduce the collective uncertainty about lumbar fusion surgery for this patient population. The research team hope to promote active engagement of the spinal research and clinical community in this NIHR-NHMRC collaborative trial, to shape best evidence about the comparative effectiveness of spinal fusion surgery versus best conservative care.

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O173

10-year prediction of adjacent-level degeneration and disease after lumbar total disc replacement and fusion, a post hoc analysis of 7-year data from a prospective clinical trial

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Aim: To estimate the probability of adjacent-level degeneration (ALDeg) and adjacent-level disease (ALDis), and progression of ALDeg (ΔALDeg) beyond 7 years after TDR and to compare ΔALDeg between TDR and fusion using the final, 7-year follow-up data from the prospective activL IDE trial.

Methods: Patients with single-level, symptomatic lumbar disc degeneration who were unresponsive to at least 6 months of nonoperative care who received activL or ProDisc-L and had radiographs available were analyzed for the incidence for ALDeg, incidence of ALDis, and progression of ALDeg (ΔALDeg). Prediction of the probability of ALDeg, ALDis, and ΔALDeg with TDR to 10 years was conducted using logistic regression modelling. To predict the ΔALDeg with fusion, an unanchored MAIC was conducted to mitigate differences between the TDR and fusion patient cohorts and derive a five-year odds ratio (OR) that was applied. A sensitivity analysis using an unadjusted TDR cohort and five-year OR published by Zigler et al., 2018.

Results: The predicted probability of ALDeg after lumbar TDR was 18.8% by one year, 27.2% by five years, 35.0% by seven years, and 53.9% by 10 years. In contrast, the predicted probability of clinical ALDis was 4.2% by 10 years. These probabilities were similar to those observed in the activL trial during the seven-year follow-up. After matching and adjusting, TDR had significantly lower odds of ΔALDeg than fusion at five-years (OR 0.32;95% CI, 0.13-0.72). The probability of ΔALDeg was predicted to be lower with TDR than with fusion to 10 years (TDR vs. fusion: 1 year, 3.0% vs. 9.1%; 5 years, 11.3% vs. 29.6%; 7 years, 21.3% vs. 47.0%; 10 years, 41.4% vs. 70.0%) (Figure). Similar results were observed in sensitivity analysis (TDR vs. fusion: 1 year, 2.0% vs. 6.8%; 5 years, 10.4% vs. 29.3%; 7 years, 21.1% vs. 48.9%; 10 years, 43.2% vs. 73.1%).

Conclusions: Predicted probability of ALDeg and ALDis to 10 years is low with TDR. Progression of ALDeg is anticipated to be substantially lower with TDR than with fusion over 10 years.

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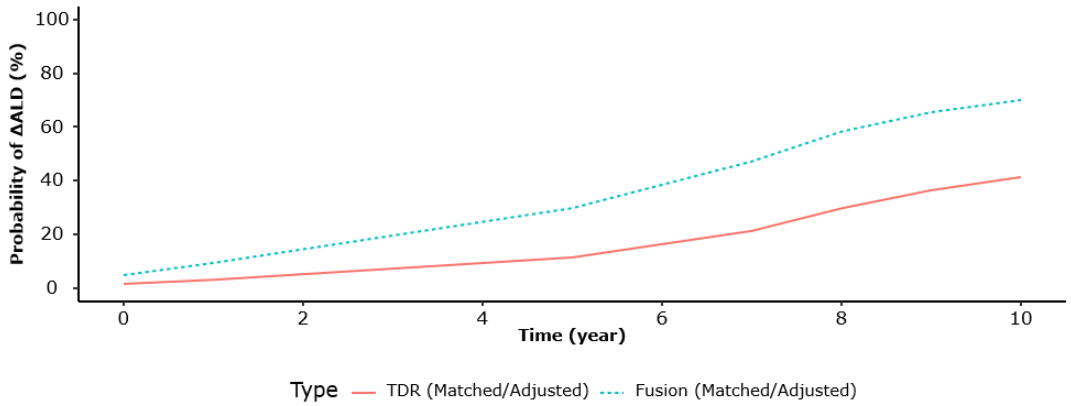
Figure: Prediction of ΔALDeg (% of patients) with TDR compared with spinal fusion through 10 years, primary analysis (matched and adjusted activL cohort)



	Time (years)	0	1	5	7	8	9	10
Probability of ΔALD (%)	Observed TDR	0	2.87	9.88	20.29	NA	NA	NA
	Predicted TDR*	1.45	2.98	11.34	21.27	29.71	36.49	41.4
	Predicted Fusion**	4.61	9.15	29.59	47.02	58.14	65.37	69.89

Note: The probabilities of ΔALDeg for TDR and the 5-year OR for ΔALDeg with TDR versus fusion were derived using the matched and adjusted activL cohort deriving from MAIC comparing activL to fusion cohort in Zigler et al. (2012). The probabilities of ΔALDeg for fusion were calculated using the derived probabilities of ΔALDeg for TDR and the 5-year OR for ΔALDeg with TDR versus fusion.

* Estimated using matched and adjusted activL cohort derived from MAIC

** Estimated using the matched & adjusted activL cohort derived from MAIC and the odds ratio results for ΔALD for TDR vs. fusion in Zigler et al. (2012)

Abbreviations: ALDeg = radiographic adjacent-level degeneration; ALDis = clinical/symptomatic adjacent-level disease; NA = not applicable; TDR = total disc replacement.

O174
Long-term outcomes following lumbar total disc replacement with M6-L

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Background: The motion preserving benefits of lumbar total disc replacement (LTDR) are well established. There is a paucity of long-term follow-up data on the M6-L prosthesis. The aim was to evaluate the clinical and radiographic outcomes of patients undergoing LTDR with M6-L and make comment about its effectiveness and durability.
Methods: A retrospective single center chart review was performed of all patients who underwent LTDR with M6-L between January 1, 2011, and January 1, 2021, either as standalone device or combined with a caudal anterior lumbar interbody fusion (ALIF) (hybrid procedure). Preoperative, postoperative, and final follow-up patient reported outcome measures (PROMs) (VAS back, VAS leg, ODI, and SF-12) and patient satisfaction were recorded prospectively. Device range of motion (ROM), adjacent segment degeneration/ disease and heterotopic ossification (HO) were obtained from flexion and extension lumbar radiographs at most recent follow-up.
Results: Sixty patients underwent LTDR with the M6-L device. Mean age was 41 [16–71] years and 38 (63%) were male. Sixteen (26.7%) underwent standalone LTDR, 42 (70.0%) a hybrid procedure, and 2 (3.3%) a 3-level procedure. Twenty-three (38.3%) patients were lost to follow-up. Thirty-seven (61.7%) were followed for a mean of 4.3 [1–10] years with 36/37 reviewed at a minimum of 2-years and 13/37 followed for over 5-years. Only one patient with osteopenia needed index level revision LTDR surgery for subsidence requiring supplemental posterior instrumentation. There were no osteolysis induced device related failures. Thirty patients obtained long-term follow-up radiographic data. Six patients had adjacent segment degeneration; none required surgery for adjacent segment disease (ASD). Three patients presented with clinically significant HO (2 with McAfee class III, 1 with class IV). The average M6-L ROM was 8.6 degrees. Mean preoperative baseline PROMs demonstrated statistically significant improvements postoperatively and were sustained at last follow-up ($P<0.05$).
Conclusions: Total disc replacement (TDR) with M6-L showed clinically significant improvement in PROMs that were sustained at long-term follow-up. There were no osteolysis induced device related failures. The device ROM was maintained and showed a downward trend over the 10-year study follow-up period. This paper demonstrated that the M6-L was an effective and durable arthroplasty device in this series.
Keywords: Complication; lumbar; outcome; total disc replacement (TDR)

O175

Lumbopelvic kinematic findings in patients having reactiv8 therapy for chronic low back pain

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Introduction: Chronic low back pain (CLBP) can cause a range of limitations in low back, pelvic and trunk movements depending on chronicity and cause. Recording quantitative lumbo-pelvic kinematics is now relatively easy due to the availability of commercial inertial measurement units and wireless movement analysis systems such as ViMove (dorsaVi, Melbourne). Since its development the ViMove system has been used to evaluate lumbar mobility in a wide range of studies in humans to assess normative data in patients with and without LBP. As part of our preoperative assessment program in a Clinical Care Pathway designed for patients being considered for restorative neurostimulation (ReActiv8, Mainstay Medical, Dublin, Ireland) lumbo-pelvic kinematics were recorded pre-operatively and serially after surgery. This study describes our preliminary findings for lumbo-pelvic range of movements and lordosis.

Methods: Study Type: Single centre Cohort study. Setting: Interdisciplinary, Independent Spinal Clinic in an Australian capital city. Cohort: Adult patients with CLBP implanted with restorative neurostimulator system (Reactiv8,). All patients were managed and assessed using a dedicated bespoke Clinical care Pathway that used the inclusion and exclusion criteria and assessment timelines from the ReActiv8 B Trial. Lumbopelvic kinematics were assessed using ViMove before and serially after surgery. Assessments were performed by an Exercise Physiologist experienced in recording lumbopelvic kinematics. For this study the parameters analysed were Standing Lumbar Lordosis, trunk flexion, trunk extension, side/lateral flexion (right and left) and standing pelvic tilt (anterior and posterior). Findings for each movement were compared to normative data available for all these parameters from ViMove databank.

Results: To date a total of 69 patients have been implanted with ReActiv8 neurostimulators. Detailed analysis of the first 34 patients having ViMove assessments (19 females, 15 males; median age 57 years: range 28-83 years) revealed the predominant abnormal finding was restriction of trunk extension (< 33 $\pm$ 8^{o}) in 30 patients (88%: 95% Confidence interval 77-98%). In amost all patients this restriction was due to limitation of lumbar extension whilst pelvic extension was normal. Trunk flexion was significantly reduced in 20 patients (59%: 95% CI 42-75%). Standing lumbar lordosis was significantly abnormal in 19 patients (56%: 95% CI 39-72%) with similar numbers of hyper- and hypolordosis. Lateral/side flexion was significantly limited (< 23 $\pm$ 5^{o}) bilaterally in 15 and unilaterally in 7 patients (65%: 95% CI 49 -81%). Standing Pelvic tilt was significantly abnormal in 17 patients (50%: 95% CI 33-66%). In 18 patients having serial ViMove measurements at between 3 and 6 months after implantation of ReActiv8 stimulators trunk extension had improved in 14, was unchanged in 3 (one of whom was normal at baseline) and was worse (5^{o}) in one. Median improvement was 8^{o} (range 4-22^{o}).

Conclusions: These preliminary results reveal a spectrum of lumbo-pelvic kinematic dysfunction in patients assessed prior to ReActiv8 therapy. The major feature is limitation of trunk extension predominantly due to significant impairment of the lumber extension component. Preliminary data from postoperative re-assessments shows that 78% of patients have improved trunk extension after 3-6 months of ReActiv8 therapy.

O176

Four-year durability of restorative neurostimulation effectiveness in patients with chronic low back pain and impaired neuromuscular control of lumbar spine stability

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Introduction: Mechanical chronic low back pain (CLBP) can be caused by impaired neuromuscular control of the lumbar spine stability. An implantable Restorative Neurostimulation system (ReActiv8® by Mainstay Medical) bilaterally stimulates the medial branches of the L2 dorsal rami for up to 30 minutes twice daily to override underlying inhibition of the multifidus muscles to facilitate motor control restoration. The ReActiv8-B randomized sham-controlled pivotal trial provided evidence of safety, effectiveness and durability of this therapy (clinicaltrials.gov/show/NCT02577354).[1,2] Few if any prospective neuromodulation trials have shared efficacy, safety and participant accountability outcomes beyond two years. Here we report the four-year results.
Methods: Eligible patients had activity limiting mechanical CLBP (VAS ≥6cm; Oswestry Disability Index (ODI) ≥21 points) despite medical management, which included at least pain medications and physical therapy. They had evidence of impaired multifidus motor control (positive prone instability test) and no indication for spine surgery.
Results: At baseline (N=204), participants were 47±9 years of age, had history of backpain for 14±11 years, had an average low back pain VAS of 7.3±0.7 cm, ODI of 39±10, EQ-5D of 0.585±0.174 points and had pain on 97±8% of days in the year prior to enrollment.
At 4 years (N=105 at time of submission*), average VAS improved by 5.0±2.3 cm, ODI by 23.8±14.4 points and EQ-5D by 0.247±0.206 ($P<0.0001$ for all outcome measures); 73% of participants had a ≥50% VAS improvement; 64% reported LBP-Resolution (VAS≤2.5 cm); 64% had a ≥20-point ODI improvement and 92% of participants were “definitely satisfied” with the treatment. Pain intensity and disability are interdependent symptoms and treatment success is determined by composite improvements in ODI and VAS: 80% had a substantial improvement of ≥50% in VAS and/or ≥20 points in ODI. Of participants using opioids at baseline, 76% had voluntarily discontinued or decreased consumption. The overall safety profile is favorable compared to other neurostimulation systems and no lead migrations were observed. Through the fourth follow-up year, 11/204 (5%) participants had requested device removal after resolution of pain and 26/204 (13%) citing inadequate pain relief.
Conclusions: Over a follow-up duration of 4 years, restorative neurostimulation has proved effective, durable, and safe. It provides specialists with a reversible treatment option targeting impaired neuromuscular control of lumbar spine stability in patients with refractory chronic low back pain and no indications for surgery.

*Follow-up visits still ongoing at time of submission.

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O177

Machine learning based image analysis tool for hybrid visualization of macroscopic-microscopic degenerative changes in intervertebral disc

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Introduction: Conventional magnetic resonance imaging (MRI) technology is used routinely to diagnose low back pain and associated disc degeneration pathologies and injuries. MRI investigation is based on signal intensity changes where the intervertebral disc is visualised as either "black or white" and lacks in inclusion of microscopic painful degenerative features and inflammation. Thus, disc degeneration when defined in terms of specific structural and microscopic changes as fissures, neo-innervations, and vascularisation then the relationship with pain is a clearer as a categorical treatment approach. However, where degeneration is defined in terms of only signal intensity as loss of water and proteoglycans or general radial bulging, then the relationship to pain is less clear**.** Thus, we aim to develop an interventional machine learning based tool by combining quantifiable microscopic histopathological painful changes along with MRI based Pfirmann grades of disc degeneration for hybrid assessment of macroscopic and microscopic features in painful disc degeneration.
Methods: Disc tissue was obtained from 100 patients (37-75 years) undergoing surgery for disc herniation (n=42), disc degeneration with spondylolisthesis (n=22), adolescent scoliosis (n=16). 'Control' non-degenerated pain free disc were from cadavers (n=20). Thin (5µm) sections were stained with H&E and toluidine blue for histological assessment of blood vessels, fissures, proteoglycan loss on an ordinal scale of (0-3).10 thick (30µm) frozen sections were immunostained for CD31 (endothelial cell marker), PGP 9.5 and Substance P (general and nociceptive nerve markers) and examined by confocal microscopy. Image analysis software was used to distinguish changes in the nucleus pulposus, inner and outer annulus fibrosus along with Pfirmann grades (1-5). Assimilation of scored and graded histological and MRI images, model selection, generalization parameters, and dimensions for supervised machine learning algorithm was set. Controlled parameters were based on the baseline values of the non-degenerated control cadaveric disc. Scored and ranked variables were tested with supervised and unsupervised kernel machine focusing on the interface between hardware and software operating system.
Results: The novel screening tool scored histopathological, MRI images, and distinguished between non-degenerated control, early, intermediate, advanced stages of disc degeneration pathologies based on significant identification of histological degenerative variables, CD-31 endothelial blood vessel markers, P.G.P 9.5 and Substance P positive nerve terminals in the tissue section and overlayed MRI images. Adjusting the magnification of images could reveal stages of inflammatory changes associated with pain and innervations.
Conclusion: The adopted technique suggests and shows that machine learning based microscopic and MRI changes can be coupled together to objectively identify signal intensity changes such as proteoglycan-depletion, microscopic disruptions, and painful tissue regions in patients with disc degeneration and pain.

O178

Molecular characterisation of human IVD degeneration for informed biomedical device development

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Introduction: Intervertebral disc (IVD) degeneration is one of the major contributing causes of low back pain, a health issue with significant socio-economic burden. Current regenerative approaches to IVD regeneration include cell therapies and tissue-engineered constructs using minimally invasive techniques to restore physiology. Biomaterial-based constructs with inherent bioactivity offer the possibility of sustained therapeutic effect for prolonged efficacy. These systems can be tuned to address aberrant molecular signalling in the IVD. Sialylation, a post-translational modification on proteins, has been identified in inflammatory and degenerative processes in IVD injury and ageing. This study describes detailed characterisation of sialylation in the human IVD to inform biomaterial design for IVD regeneration.
Methods: Healthy and degenerated human intervertebral disc samples were collected from local hospitals with ethical approval and informed consent. Label-free quantitative proteomic analysis was performed to characterise differentially regulated signalling pathways in degeneration. The *N*-glycan profile of the annulus fibrosus and nucleus pulposus was characterised by hydrophilic interaction – ultra-performance liquid chromatography-mass spectrometry (HILIC-UPLC-MS) in combination with exoglycosidase digestions. *In vitro* experiments assessed the efficacy and functional role of aberrant sialylation in human primary NP cells using 3Fax-peracetyl Neu5Ac, a sialylation inhibitor (Neu5Ac-inhib). Neu5Ac-inhib was loaded into the fabricated hyaluronic acid (HA) hydrogels and investigated in an *in vitro* model of IVD degeneration using human NP cells.
Results: Proteomic analysis revealed that acute-phase signalling, *N*-glycan synthesis, and extracellular matrix turnover were activated in degenerated tissues. *N*-glycan analysis revealed an increase in sialylation in degenerated AF and NP tissue. Cytokine-induced inflammation increased sialylation expression in human NP cells, and Neu5Ac-inhib effectively restored the sialylation expression to physiological levels. Inhibition restored normal cell migration, metabolic activity and reduced catabolic enzyme expression. The Neu5Ac-inhib was loaded in a HA hydrogel. Cross-linking resulted in hydrolytic stability and resistance to enzymatic degradation with no cytotoxic effect, optimised to effectively release Neu5Ac-inhib to inhibit hypersialylation in an *in vitro* model of IVD degeneration.
Conclusion: This study demonstrates the value of in-depth molecular characterisation of clinical samples for informed design of biomaterial-based therapies for tissue regeneration. The first *N*-glycome characterisation of the human IVD in degeneration has elucidated various roles of the glycome in disease progression. This study characterises the first glyco-functionalised system for IVD regeneration, optimised as a minimally invasive intervention for IVD degeneration.

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Untargeted metabolomics reveals the metabolic alterations and significance of fatty acid metabolism in intervertebral disc degeneration

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Introduction: Inflammation is a beneficial cellular response to fight against detrimental stimuli. However, if unchecked can lead to inflammaging and the progression of disc degeneration. Metabolic alterations with respect to inflammatory responses could be a perpetrator or play a role in the progression of disc degeneration. Fatty acids are known to influence many inflammatory responses, and altered fatty acid metabolism and a lipidomic profile are reported in several disease conditions, most recently in disc degenerative disorders. Hence to understand the fatty acid metabolite expression in disc degeneration phenotypes with respect to inflammatory responses, we performed global untargeted metabolomic analysis in healthy (Control normal discs n=21) and degenerative disc tissues (total n=40 (Modic n=20; non-modic n=20)) using uHPLC-MS/MS and GC-MS based approaches.
Methods: Untargeted metabolite profiling was carried out in 61 discs. The Control group consisted of 21 normal discs (ND) excised from 7 brain-dead voluntary organ donors; degenerated discs group consisted of 20 discs excised from 20 patients with Modic changes (MC) and 20 discs excised from 20 patients without Modic changes (NMC). The raw files obtained were further subjected to identification of metabolites using compound discoverer vs. 3.7. The resulting data were assessed by multivariate analyses such as principal component analysis (PCA), partial least squares regression (PLS), or PLS-discriminant analysis (PLS-DA), VIP score, enrichment ratio value, p-value, clustering analysis, and identification of biological pathways using MSEA pipeline from metaboanalyst.
Results: The uHPLC-MS-based metabolomics identified 131 (statistically significant) metabolites belonging to 23 pathways in IVD tissue. These metabolites are essential for the maintenance of cell homeostasis, energy metabolism, and host defense. Of these, 85 significant metabolites (65%) identified were involved in fatty acid metabolism pathways such as Biosynthesis of unsaturated fatty acids, Fatty acid degradation, Arachidonic acid metabolism, and Sphingolipid metabolism. Saturated fatty acids molecules such as Hexadecanoic acid, (S)-3-Hydroxyoctanoyl-CoA, (S)-Hydroxyhexanoyl-CoA and Lauroyl-CoA were upregulated in degenerated discs condition and, can lead to cellular lipotoxicity and cell death. Unsaturated fatty acid metabolites like Arachidonate are significantly upregulated in non-Modic, and sphingosine 1-phosphate is downregulated in Modic conditions. The arachidonate is catalyzed by several enzymes for metabolite formation that are pro-inflammatory in nature. The LOX-mediated pathway was prevalent in non-Modic condition, whereas CYP and COX-mediated pathway was significant in the Modic group. However, the control group had only basal expression of the metabolites involved in the arachidonic acid pathway.
Conclusion: The upregulation of arachidonate metabolism in degenerated discs in comparison to controls is indicative of increased inflammatory response and strengthens the role of inflammaging in disc degeneration. The preference of COX, LOX, and CYP pathways of arachidonate metabolism could provide insight into variation in inflammatory response between Modic and non-Modic phenotypes. Understanding fatty acid metabolism in corresponding disease plasma will provide more evidence of the disease progression and therapeutic options.

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Gender difference on high mTORC1 induced myopathy, IVD degeneration and kyphosis: TSC1mKO model study

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Introduction: The progression of degenerative thoracolumbar kyphosis is known to be associated with muscle weakness, IVD degeneration and vertebra wedging. Males have higher sarcopenia prevalence than female counterparts [1]. However, the relationship between gender and sarcopenia remains unclear as human cohort studies are confounded by various comorbidities. TSC1 muscle knockout (TSC1mKO) mice, an ideal animal model for sarcopenia, have muscle specific knockout of the TSC1 inhibitor, which leads to upregulation of mTORC1 causing sarcopenia and kyphosis in later stages of their life cycle.
Aims: To examine the effect gender has on paraspinal muscle myopathy, intervertebral disc degeneration and kyphosis in TSC1mKO mice.
Methods: Twenty-five female (Control 9M n=3, Control 12M n=9, TSC1mKO 9M n=5, TSC1mKO 12M n=8) and twenty-one male mice (Control 9M n=3, Control 12M n=10, TSC1mKO 9M n=3, TSC1mKO 12M n=5) were measured for thoracolumbar kyphosis, disc height, and trabecular bone architecture using high resolution microCT at endpoint 9, 12 months. Myopathic changes in the paraspinal muscle were examined via WGA/DAPI stain, and the extent of intervertebral disc degeneration was evaluated via FAST stain.
Results: Development of thoracolumbar kyphosis is more significant in 12-months-old male (103.16 ± 17.88) than female TSC1mKO mice (83.67 ± 17.18, p=0.026) (**Fig 1A**). The WGA/DAPI stained paraspinal muscle sections (**Fig 1B**) from female and male TSC1mKO mice show signs of myopathic alterations at 9 months, including the presence of central nuclei and triangular fibres. Myopathy worsens at 12 months and is reflected by male TSC1mKO having higher central nuclei (indicated by white arrow) and triangular fiber than female counterpart (35.17 ± 7.39% vs 18.90 ± 6.61%, p=0.006, 10.10 ± 7.43 vs 6.30 ± 4.85%, p=0.205).
Disc histological examination reveals 12-month-olds with reduction of disc height at L4/5 (TSC1mKO female 164 ± 27μm, TSC1mKO male 190 ± 88μm, Control female 230 ± 55μm, Control male 247 ± 59μm) (**Fig 1C**). Unlike normal aging mice, vertebral bone density of lumbar spine of 12-month-old TSC1mKO mice show significant increase in both females (TSC1mKO 27.97 ± 9.13 vs Control 10.28 ± 4.33) and males (TSC1mKO 28.49 ± 6.97 vs Control 15.74 ± 5.92). Fast staining disc score in 12-month-old male TSC1mKO mice is higher than female counterpart (L1/2, 5.8 ±1.6 vs 3.4 ±1.1, p=0.019, L4/5, 6.0 ±0.6 vs. 4.0 ±1.5, p=0.039) (**Fig 1D**).
Conclusions: This study demonstrates that paraspinal muscle myopathy is more severe in male than in female TSC1mKO mice. Male muscle is more susceptible to myopathy under high mTORC1 condition leading to the development of more severe thoracolumbar kyphosis and intervertebral disc degeneration than females.

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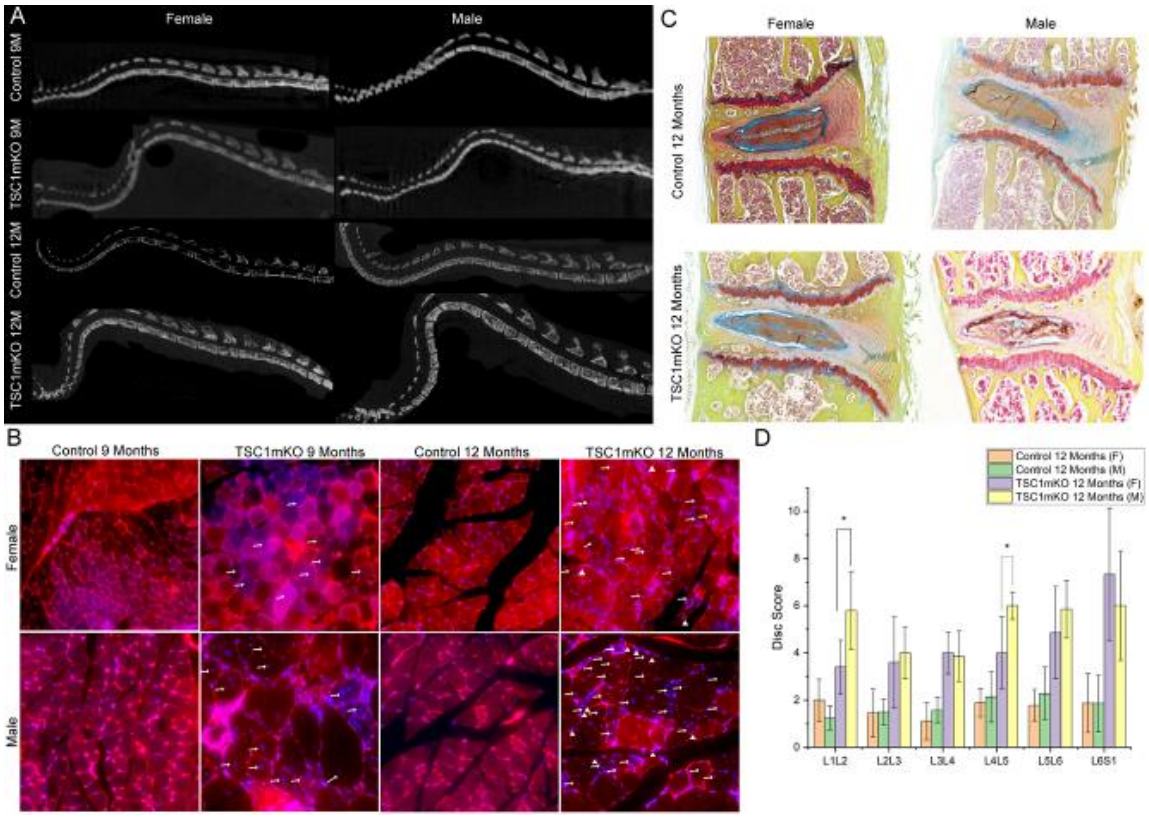
A
Female
Male
Control 6M
TSC1mKO 9M
Control 12M
TSC1mKO 12M
C
Female
Male
Control 12 Months
TSC1mKO 12 Months
B
Control 9 Months
TSC1mKO 9 Months
Control 12 Months
TSC1mKO 12 Months
Female
Male
D
Control 12 Months (F)
Control 12 Months (M)
TSC1mKO 12 Months (F)
TSC1mKO 12 Months (M)
Disc Score
0
2
4
6
8
10
L1L2
L2L3
L3L4
L4L5
L5L6
L6S1
*
*

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Development of treatment for intervertebral disc degeneration by the selective interference of the mTOR signaling pathway using the CRISPR–Cas9 system

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Introduction: Low back pain is a major global health issue, and intervertebral disc degeneration is recognized as one of its independent causes[1]. Autophagy is an important cell survival mechanism by self-digestion and recycling damaged components under stress, primarily nutrient deprivation[2]. The intracellular signaling pathway of the mammalian target of rapamycin (mTOR) negatively regulates autophagy as well as controls cell proliferation and protein synthesis[3]. We hypothesized that mTOR signaling and autophagy would be influential in the intervertebral disc, which is the largest avascular, low-nutrient organ in the body. Our objective was to elucidate roles of mTOR signaling in disc cells during degeneration by using the CRISPR–Cas9 system, a new gene modification method.

Methods: Gene silencing was performed using two gene modification methods, RNA interference (RNAi) and CRISPR–Cas9. (1) RNAi: Selective gene knockdown of the mTOR signaling pathway using small interfering RNA (siRNA)-mediated RNAi was applied to 12-week-old male Sprague–Dawley rat intervertebral disc nucleus pulposus (NP) cells (n = 6). Monolayer cells were cultured in 10% FBS-supplemented DMEM under 2% oxygen. To knockdown specific signals in mTOR signaling, siRNA against mTOR targeting mTOR complex 1 (mTORC1) and 2 (mTORC2), RAPTOR targeting mTORC1, or RICTOR targeting mTORC2 was reverse transfected through lipofection for 36 h. Cells after transfection were additionally cultured in 10% FBS-supplemented DMEM for 24 h. Western blotting for mTOR, RAPTOR, and RICTOR was performed to assess successful transfection with RNAi knockdown efficacy. Autophagic flux was also evaluated by Western blotting. Then, transfected cells were additionally cultured in serum-free DMEM with pro-inflammatory IL-1β at 10 ng/ml for 24 h. The incidence of apoptosis and senescence as well as the balance of matrix metabolism were examined by Western blotting. (2) CRISPR–Cas9: Selective gene knockout of the mTOR signaling pathway using the CRISPR–Cas9 system was applied to human disc NP cells, obtained from patients undertaking lumbar discectomy or interbody fusion surgery (n = 6). As in the RNAi experiment, we examined the knockout efficacy of mTOR signaling, levels of autophagy, apoptosis, senescence, and balance of matrix metabolism by Western blotting.

Results: Selective, specific suppression in protein expression of mTOR, RAPTOR, and RICTOR was successfully accomplished by both of RNAi knockdown and CRISPR–Cas9 knockout. However, the efficiency of transfection was 50.1–60.3% by RNAi and 69.2-79.2% by CRISPR–Cas9, respectively (p = 0.001, p = 0.00007, and p = 0.00003, respectively). In both treatments, mTOR-signaling suppression-mediated induction of autophagy and inhibition of apoptosis, senescence, and matrix catabolism were consistently observed, but the suppression of extracellular matrix degradation was the most prominent in the RAPTOR knockout group by CRISPR–Cas9.

Conclusions: Compared to transient gene functional suppression/knockdown by RNAi, CRISPR–Cas9 facilitates sustained gene functional elimination/knockout by genome editing, which can provide more reliable functional analysis of the mTOR signaling pathway in intervertebral disc nucleus pulposus cells. These results suggest that the selective interference of RAPTOR, resulting in mTORC1 inhibition, is a potent future molecular therapeutic strategy for degenerative disc disease.

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O182

Biological significance of fragmented SLRP`s, aggrecan and fibronectin in overloaded intervertebral disc

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Introduction: A feature of complexly loaded, degenerated intervertebral disc is increased expression of cytokines, chemokines, and matrix degrading enzymes that facilitates proteoglycan loss, allows cell clustering, hinders tissue repair, and enable phenomenon such as neo-innervations and vascularisation. We hypothesize, adverse loading also stimulates proteolytic fragmentation of aggrecan, fibronectin and small leucine rich proteoglycans (SLRP`s) such as biglycan, decorin, lumican, fibromodulin, and chondroadherin. Increased fragmentation disrupts the matrix by altering the spatial localisation, distribution and adhesion between these molecules and can influence the biomechanical and biochemical functions.
Patients and Methods: Ethical clearances for animal study were reviewed and approved by Institutional Animal Care & Ethics Committee (IAEC/SMIMS/2018/01) following the ARRIVE guidelines. 14 Sprague Dawley rats were loaded with external compression device calibrated to generate a force of 1.3 MPa. Control group comprised of 6 unloaded rats. Animals were euthanized at three different time points: 7, 15 days, and 30 days. After euthanasia loaded and unloaded disc tissue were collected from L1-L6 level, and subjected to protein extraction, immunohistochemistry, and histology. Protein extraction was done in 4M guanidium hydrochloride, precipitated in ethanol, and treated with keratanase and chondroitinase ABC. Protein extracts were analyzed with western blots by using antibodies to SLRP's (biglycan, decorin, lumican, fibromodulin, chondroadherin) aggrecan, and fibronectin (1:1000). 8um thin sections were stained with H&E, toluidine blue for histology and primary monoclonal antibodies to SLRP's, aggrecan and fibronectin (1:100) for immunohistochemical analysis.
Results: Low molecular weight fragments of SLRP's, aggrecan and fibronectin were greatest in 30 days loaded rat disc tissue. Biglycan, lumican, fibromodulin and decorin fragments were prominent at 36 KDa, while fibronectin, chondroadherin and aggrecan appeared between 35 to 22 KDa. Aggrecan core protein molecules were degraded at G1 globular and interglobular domain by matrix metalloproteases and aggrecanase in 7, 15 days loaded rat disc to generate a 36, 45 and 64 KDa fragments, but in 30 days loaded rat disc only aggrecanase activity was visible with aggrecan fragment at 64 KDa. Histology revealed severe proteoglycan loss in 15, 30-days loaded rat disc, with formation of large cell clusters, decline in primary antibody staining for all SLRP's, fibronectin, and aggrecan with loss in spatial localisation and alignment of matrix molecules in comparisons to controls. Unloaded control discs retained distinct uniform structural staining and showed absence of fragments.
Conclusions: Increased overloading allows accumulation of fragmented SLRP's, aggrecan and fibronectin molecules. These fragmented matrix molecules influence its own biosynthesis and activity by disrupting the normal adhesive structural linkages that exists between these matrix molecules, and overloading/adverse loading increases matrix fragmentation and contributes towards loss in spatial organization and distribution of these matrix molecules hence promotes matrix disorganization and can compromises the biomechanical functions of the disc.

O183

Safety and efficacy of a proposed dose of intrathecal morphine in single level lumbar spinal fusion surgery

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Introduction: Open **l**umbar fusion surgery requires safe and effective analgesia to facilitate early mobilization and discharge. NSAID's have a potential dose-dependent increase in non-union and should be avoided if possible. Opioids as first line treatment have perceived dangers, most of all respiratory depression. In a public service facility, early mobilization and discharge is of vital importance to accompany the large population burden. If peri-operative analgesia targets spinal cord μ-receptors directly, it will potentially offer segmental analgesia superior to conventional intravenous morphine and allow faster mobilization. Scrutiny of the existing literature allows for a proposed dose of intrathecal morphine of which safety can be confirmed.

Aim: To valuate the safety and efficacy of a 0.005mg/kg single intrathecal morphine dose (up to a maximum of 0.45mg) in first-time single level spinal surgery.

Materials and Methods: A prospective double-blind, randomized placebo controlled trial of 40 first time single level lumbar fusion patients were conducted. ICU data collected included clinical parameters (SpO_2, Respiratory Rate (RR), Opioid Induced Sedation Scale (OISS)), PCA volume usage, serial arterial blood gas analyses and opioid specific side effect observations. Pain assessment included numeric rating scale (NRS) lying still and while moving, A standardized mobility regime was utilized to monitor efficacy Functional scores measured the outcome up to 6 months. Alveolar gas formula ($P_AO_2=FiO_2(k) – PaCO_2/0.8$) evaluated causes of respiratory disfunction.

Results: PaO_2, $PaCO_2$, RR, SpO_2, and OISS confirmed safety of the 0.005mg/kg IT morphine as proposed. A significant reduction in $PaCO_2$ between 8-16 hours post-operatively supported by P_AO_2, RR, OISS and SpO_2 identifies the first 10 hours post-operatively as the highest risk for complications in IT and PCA morphine. The IT group had significant earlier mobilization and less pain (p=0.003). Post-extubation atelectasis was identified as an undiagnosed risk for respiratory complications in both groups. No significant difference in side-effects were noted between the groups nor overt sedation.

All incidents of PaO_2<8kPa were explained by either low FiO_2 or a decrease in functional residual capacity (FRC). Six week, 3-month and 6-month follow-up demonstrated significant improvement in all functional assessments.

Conclusion: IT morphine directly effects the spinal cord μ-receptors resulting in segmental analgesia allowing earlier mobilization compared to the more central acting analgesic effects of PCA morphine. The proposed dose is safe with minimal side-effects. The application will be particularly useful in obese patients where excess adipose tissue and uncertain volume of distribution can confound IV dose calculations. When using IT or PCA morphine, supplemental oxygen is suggested for the first 10 hours post-operatively and continuous monitoring of RR, SpO_2 and sedation should be done. SpO_2 warning of 92% will be sensitive to identify respiratory complications resulting from opioids and atelectasis.

O184

Comparative analysis of fusion rates between conventional open and minimally invasive scoliosis surgery for adolescent idiopathic scoliosis

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Introduction: For the application of minimally invasive scoliosi surgery (MISS) in surgery for adolescent idiopathic scoliosis (AIS), the midline soft-tissue collar is essentially preserved, and the main bed for fusion is provided only by the facets. Hence, it is important to study the fusion rates associated with the novel MISS techniques before they can be adopted on a large scale. The aim of this study was to investigate the preliminary clinical and radiological outcomes of MISS with facet fusion and compare them with those of conventional open scoliosis surgery (COSS) with posterior fusion for AIS using allografts and other graft substitutes.
Methods: A total of 86 patients were divided into 2 groups: Group A (COSS with allograft) and Group B (MISS with bone graft substitutes). Group B was further divided into 3 subgroups based on graft substitutes: B1) allograft, B2) demineralized bone matrix (DBM), B3) demineralized cancellous bone chips. Fusion was determined using conventional radiographs to visualize loss of correction >10°, presence of lysis around implants, breaks in fusion mass, and abnormal mobility of the fused segment. The SRS-22 questionnaire was used for clinical evaluation.
Results: The 2 groups were not significantly different in terms of age, gender, height, weight, body mass index, curve distribution, or fusion levels. The fusion rates were 83.3% and 97% in Group A and Group B with no statistical significance ($P = 0.070$). In group B, the fusion rates were 85%, 100%, and 100%, in subgroups B1, B2, B3 B with no statistical significance ($P = 0.221$). SRS-22 survey results were better among patients in Group B in terms of overall scores, satisfaction, and self-image (all $P < 0.001$). Subgroup comparisons in Group B yielded no statistically significant differences in terms of correction rate, fusion rate, and SRS-22 scores ($P > 0.05$).
Conclusions: MISS was associated with comparable facet fusion rates and clinical outcomes to those of COSS. In the MISS subgroups, however, the type of graft material had no effect on fusion rates or clinical outcomes. MISS technique in AIS correction showed comparable facet fusion rates with open surgery. It can become a valid and meaningful alternative to posterior open approach in routine practice.

O185

The incidence of complications in split tubular, endoscopic and robotic-assisted endoscopic TLIFs

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Introduction: With the advancements in the field of spinal surgery, fusion procedures have substantially increased and have led to the improvement of minimally invasive Transforaminal Lumbar Interbody Fusions (TLIFs) and its application in outpatient care centers. The aim of the current study was to compare the incidence of post-operative complications between tubular, endoscopic and Robot-assisted TLIF.
Methods: Patients who underwent single or multi-level TLIF between 2020 and 2022. Demographic and intra-operative variables (type of TLIF, levels, surgery time, blood loss, length of stay) were recorded. Data on post-operative complications was collected at 2 weeks, up to 3 months, 6 months and 1 year. ODI and CAT domains at different time points were collected. One way ANOVA with Bartlett's equal-variance test was used to compare demographics and intra-op variables among three approaches. Complication rates between three procedures were compared using Pearson chi-squared test.
Results: The current study included 137 patients undergoing TLIF. 57% were tubular, 28% were endoscopic, and 15% were Robot-assisted. The average age of the patients who underwent tubular was 50.73 ± 10.93 years, endoscopic 43.03 ± 10.33 years, and Robot-assisted was 46.68 ± 10.63 years. 67.15% of the patients were male, with 33.58% tubular, 20.44% endoscopic, and 13.14% Robot-assisted. 78.8% of the patients underwent single level TLIF (55.56 % tubular, 31.48% endoscopic, 12.96% Robot-assisted). 19.71% underwent 2 level TLIF (16.67% tubular, 14.81% endoscopic, 18.52% Robot-assisted). 1.46% of patients underwent 3 level TLIF (100% Robot-assisted). At 2 weeks post-operatively tubular TLIF had the lowest incidence of any complication (28.8%) compared to Endo TLIF (54.5%) or Robot-assisted (47.6%, p=0.032). The most common complication for tubular, endoscopic, and Robot-assisted TLIF was new neurological complication (radiculitis or numbness/tingling). All complications in Endo and Robot-assisted TLIFs were new neurological complications. In the tubular TLIF, 63% were new neurological complication, 21% wound and 10% (2 patients) other. Up to 3 months post-op the complication rates were not significantly different among groups 15% (tubular), 8.6% (Endo) and 5.5% (Robot-assisted, p=0.419). All were the new onset of radiculitis or numbness/tingling. Up to 6 months there were 2 complications in the tubular and three complications in the Endo group. Although Robot-assisted TLIFs had higher revision rates they were not significant (2.6% (tubular) vs. 2.6% (Endo) vs. 4.8% (Robot-assisted), p=0.862). There were no significant differences in ODI or CAT domains at different time points. When tubular TLIF was compared to all Endo approaches significant differences in complication rates at 2 weeks were observed (28.8% vs. 51.9%, p=0.010). ODI and CAT domains (pain interference, function and pain intensity) were similar across the groups.
Conclusions: The current study demonstrated that the tubular TLIF had lower complication rates than both Endo and Robot-assisted TLIF procedures at early time points. There were significantly less neurological complications in the tubular group compared to both Endo TLIF procedures. Robot-assisted cases had higher revision rates, however not significant. Patient reported outcomes were similar between the groups. Some of the limitations included learning curve, lack of randomization and use of BMP2.

O186

Risk factors for poor prognosis in patients with dural tear in surgical treatment of lumbar degenerative diseases: A multicenter database study

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Introduction: A dural tear (DT) that occurs during spine surgery for degenerative lumbar diseases is a relatively common complication. In symptoms that can be attributed to DT, frequent ones are positional headaches, nausea/vomiting and delayed wound-healing. Moreover, DT can lead to reoperation to treat spinocutaneous fistula. We aimed to investigate risk factors for poor prognosis in patients with DT including not only patient and surgical ones but also the extent of DT, repair techniques and postoperative management.
Methods: From 2012 to 2017, 12171 patients with degenerative lumbar diseases underwent primary lumbar spine surgery at 21 affiliate institutes of Osaka University. DT occurred in 429/12171 patients (3.5%, 206 men and 223 women). Revision surgeries were excluded. The average age was 68.8 years for men and 70.6 years for women. The surgical procedures consisted of laminectomy in 45%, posterior lumbar interbody fusion in 43%, discectomy in 10%, and others in 2%. DT was defined as the one which required additional procedures intraoperatively. We investigated 5 types of factors: patient factors (sex, age and BMI), surgical factors (surgical procedures, operative time, blood loss), the extent of DT (feasibility of suture and cauda equina herniation), repair techniques (suture, clipping, fibrin glue and polyglycolic acid sheet), and postoperative management (drainage duration). Postoperative outcomes were evaluated with regard to dural leak, headache, nausea/vomiting, delayed wound-healing, prolonged bed rest, postoperative lower limb paralysis (a reduction of 2 grade or more on manual muscle testing), and reoperation for dural leak.
Results: Dural leak, headache, nausea/vomiting, delayed wound-healing, prolonged bed rest, postoperative lower limb paralysis, and reoperation were observed in 118 patients (28%), 73 (17%), 65 (15%), 17 (4%), 171 (40%), 21 (5%) and 7 (2%, respectively. Significant risk factors for outcomes were as follows: long drainage duration for dural leak; women, young age, not using fibrin glue and long drainage duration for headache; women, young age, long preoperative time and long drainage duration for nausea/vomiting; laminectomy and long drainage duration for delayed wound-healing; blood loss and cauda equina herniation for postoperative lower limb paralysis; and causa equina herniation for reoperation.
Conclusions: This study showed that the long drainage duration was associated with poor prognosis in patients with DT. Moreover, women and younger patients were likely to suffer from headache and nausea/vomiting. In contrast, the use of fibrin glue reduced the incidence of headache. Severe DT with cauda equina herniation can lead to higher incidence of postoperative lower limb paralysis and reoperation.

O187

Lateral lumbar interbody fusion adjacent to pedicle subtraction osteotomy reduces mechanical complications requiring revision surgery

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Purpose: To compare the clinical and radiological results including postoperative mechanical complications between the patients who underwent pedicle subtraction osteotomy (PSO) with and without minimally invasive lateral lumbar interbody fusion (MI-LLIF) for the correction of adult spinal deformity (ASD).
Methods: A retrospective comparative study was conducted on consecutive patients undergone PSO with and without MI-LLIF adjacent to PSO for the correction of ASD. Clinical and radiological outcomes were compared between the two groups at regular time points. The primary outcomes included pain VAS, Oswestry disability Index (ODI) and standard spinopelvic parameters in whole spine standing radiographs. The secondary outcome was the incidence of mechanical complications requiring revision surgery.
Results: Sixty-eight patients (age at surgery 67.7 ± 6.2 years old, 5 males and 63 females) were enrolled. The mean follow-up period was 46 ±19 (range 24-108) months. Among them, 33 patients were group A (PSO with MI-LLIF) and 35 patients were group B (PSO without MI-LLIF). In comparison of baseline demographics, clinical and radiological outcomes, there were no significant differences between the two groups ($p>0.05$). However, in mechanical complications requiring revision surgery (rod or screw fracture, screw pullout), 5 (15.2%) in group A and 11 (31.4%) in group B showed statistically significant differences ($p=0.005$).
Conclusion: Supplementary MI-LLIF adjacent to PSO can reduce the reoperation due to mechanical complication.
Key words: lateral lumbar interbody fusion, pedicle subtraction osteotomy, adult spinal deformity, complications

O188

A whole spine MRI based ambispective cohort study of the prevalence and clinico-radiological association of lumbosacral transitional vertebra with degenerative disc disease

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Introduction: Lumbosacral transitional vertebra (LSTV) results in numerical alterations of the lumbar and the sacral segments, and prompt recognition of the LSTV is crucial. Literature concerning the true incidence of LSTV based on whole spine MRI and its association with low back pain, radicular symptoms, disc degeneration and facet morphology is lacking.
Methods: The study is an ambispective observational cohort study. The prevalence of LSTV was determined by studying the whole spine MRIs of 2011 poly-trauma patients. A prospective analysis of 2230 patients was done to determine the association of LSTV with low back pain, radicular symptoms, disc degeneration and/or facet tropism. Disc degeneration was measured at the level of three distal mobile segments by Pfirrmann's grading while the total end plate score (TEPS) was evaluated in the last mobile segment (C).
Results: The study included 1408 males and 603 females with a mean age of 48.5±8.2 years. Two hundred and thirty-three patients (140 males and 93 females) had LSTV demonstrating an overall prevalence of 11.6%. Forty-two patients had lumbarization of S1; while 191 had sacralization of L5. The prevalence of sacralization in female and male patients was 86/191 (45.2%) and 105/191 (55.0%) respectively; and the prevalence of lumbarization in female and male patients was 7/42 (16.6%) and 35/42 (83.3%) respectively. Castellvi's type 2A was the most common type (33.6%) of sacralisation while the O'Driscoll type 4 was the commonest sub-type (54.8%) of lumbarisation. LSTV was found in almost 15% of patients who presented with low back pain without radiculopathy while it was found in 17% of patients who presented with predominantly radicular symptoms. Sacralization accounted for more than 80% of the LSTV patients in both groups. LSTV patients demonstrated considerably advanced degeneration (Pfirmanns grade 3-5) at all three levels in comparison with non-LSTV patients (p= 0.001). The TEPS as well as the presence of facet tropism was significantly higher in the LSTV group as compared to the non-LSTV group.
Conclusion: LSTV is the most common developmental anomaly of the lumbo-sacral spine with an over-all prevalence of 11.4% of which sacralization constituted 82%. The most common type of sacralization was Castellvi's type 2A while the O'Driscoll type 4 ranked first in the lumbarization group. Patients with sacralization accounted for more than 80% of LSTV patients with either back pain or radiculopathy, which may be explained by the high incidence of disc degeneration of all 3 levels immediately proximal to a sacralised vertebra as well as a high incidence of end plate degeneration and facet tropism. A noteworthy finding was the increased incidence of facet tropism in lumbarization patients with predominantly radicular symptoms. The clinician should bear these in mind when counselling and managing patients, as this may influence the prognosis and outcome following treatment.

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O189

Clinical and radiological outcomes of minimally invasive transforaminal lumbar interbody fusion: A study of 345 patients

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Introduction: Minimal invasive Transforaminal Lumbar Interbody Fusion (MIS TLIF) is a standard treatment modality in lumbar diseases. We aim to analyze the clinical and radiological changes after surgical treatment with MIS TLIF for various lumbar pathologies.
Materials and Methods: We analysed 345 patients requiring fusion for various pathologies. All patients were operated using MIS TLIF by the same surgeon in a single institute. The clinical outcomes were measured using the visual analog scale (VAS) for pain and the Revised Oswestry Disability Index (ODI) for low-back pain/dysfunction. The radiological parameters including disc height restoration, fusion using Bridwell scoring system are recorded.
Results: 99% of patients were pain free and all showed improvement in pain scores. The mean VAS score improved from 8 pre-operatively to 1 and the mean ODI score improved from 33 pre-operatively to 7 at 2-year follow-up. SF-36 showed improvement in all 8 sub scales. Bridwell grade 1 fusion was achieved at the end of 6 months. Disc height restoration was a mean of 14.8±0.8. None of the cases were converted to open TLIF. Cage back out seen in 4 cases of which 2 were symptomatic and 2 were asymptomatic. Dural leak in 7 cases. No neurological deficit.
Conclusion: Minimally invasive TLIF is effective in the treatment of various pathologies needing fusion. The study demonstrates a statistically significant improvement in clinical outcomes and satisfactory radiological outcomes in terms of solid fusion.

O190

A pilot study on change in range of motion of adjacent segments following single level lumbar interbody fusion using disk angles

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Study Design: Clinical imaging study on spondylolisthesis patients who underwent single-level lumbar vertebral inter body fusion for L4L5.
Purpose: To assess the range of movement in the adjacent segments following single level L4 L5 fusion for degenerative spondylolisthesis as compared to their pre operative values. To determine the influence of change in intervertebral disk angle through flexion and extension on adjacent segment degeneration post-fusion surgeries.
Overview of Literature: Sagittal alignment is a strong indicator of adjacent segment degeneration. Intersegmental disk angle gives a better view of the restriction in the range of motions and hence adjacent segment degeneration.
Methods: A total of 100 sample radiographs were taken for measuring the flexion-extension and neutral angles of the lumbar spine *pre-* and *post-*operatively. The Cobb angle reading between the bottom plate of superior vertebra and top plate of inferior vertebra is taken as the measure for quantifying the lumbar range of motion. Differences in disk angles between pre-operative and post-operative data were found and statistically analysed.
Results: The combined range of motion (flexion+ extension) increased by 55% at the L3L4 the superior segment and decreased by 13 % at the L5S1, the inferior segment, postoperatively. The flexion increase was higher at the inferior segment and extension increase was higher at the superior segment, in terms of angle as well as the number of patients in the cohort study.
Conclusions: The disk angle is a better indicator of adjacent segment degeneration than lordosis based range of motion of the lumbar Spine. Predictions on adjacent segment degeneration can be done based on disk angle measurements.

O191

Alterations in biomechanics by finite element model analysis after lumbar spine fixation surgeries

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Introduction: Lumbar fixation/ fusion surgeries using pedicular screws and cages to decrease pain by decompression of stenotic segments and eliminating motion as well as restoration of segmental lordosis are more often performed then earlier. With these surgeries there is functional and morphological change in that region of spine altering its biomechanics. We studied this alteration in biomechanics by finite element model analysis to evaluate the alteration on lumbar spine movements, stress and strain in different aetiologies after fixation surgeries.

Objectives: To do finite element model analysis of lumbar spine and evaluate movements, stress and strains on lumbar spine after fixation surgeries during following situations

1)forward bending/side bending

2)sitting on floor

3)lifting weight of 5 kg

Methods: A total of 4 patients of 4 different aetiologies (fracture, lysthesis, infection and canal stenosis) of lumbar spine were screened and enrolled for the study. This was a biomechanical study where analysis applied to one aetiology at one region will provide information that can be extrapolated to similar aetiology patients and therefore one patient of each aetiology was taken as prototype. 3D CT scan of these patients were done preoperatively and postoperatively and at 4 months post operatively. We then in association with engineering faculty converted these CT findings into a mathematical Finite Element Model and using ANSYS software the analysis was done. This analysis was then compared to a reference standard normal healthy intact lumbar spine finite element model available in literature. The effect of pedicle screws and connecting rods on range of motion, stress and strain of lumbar spine were investigated.

Results: Finite Element analysis showed significant restriction of spine movements in all cases in both immediate post op and at 4 months post operatively. Stress and strain in fixed/fused segments during routine movements became normal but there is always increase in stress on adjacent segments, this phenomenon is also irrespective of aetiology. The stresses are more on proximal or distal adjacent segments of the fused portion of lumbar spine depending on different physiological conditions. Spine movements on clinical examination corelated with FEM findings.

Conclusion: After fixation surgeries instability and alignment of spine caused by disease or injury is corrected, but there is overall restriction of movements of lumbar spine compared to normal intact healthy spine. Thus, patients will have difficulty in few activities of daily living where extreme movements of lumbar spine is required. Adjacent segment degeneration and proximal junctional failure is also well understood by the increased stress seen in FE analysis.

O192

O-arm navigated versus free hand pedicle screw placement in lumbar spine: An RCT- advancement or a mirage of an edge over convention?

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Introduction: Navigation over the last two decades have been revolutionary in the field of spine surgery. Though O-arm–based navigation (ON) is considered a better choice than the conventional freehand (FH) technique for spine surgery, literature evidence showing the accuracy of ON compared with the FH technique is limited. The objective of the randomized control study is to compare free-hand (FH) and O-arm navigation guided (ON) pedicle screw placement in the lumbar spine.

Material and Methods: Adult patients undergoing single-level lumbar interbody fusion by an open, posterior approach were prospectively recruited and randomly assigned to free-hand (FH) or O-arm navigation guided (ON) pedicle screw placement. The outcome measures compared were: i) accuracy of pedicle screw placement – using Gertzbein-Robbins classification and angular deviation from the 'ideal' coaxial intrapedicular trajectory (in degrees), ii) surgical time taken exclusively for pedicle screw placement (minutes), iii) radiation exposure (seconds fluoroscopy), iv) incidence of cranial facet violation (%) and, v) clinical complications.

Results: Forty patients (80, in total) were randomly allocated to each group; a total of 160 pedicle screws were inserted by each of the two techniques. Although the accuracy of screw placement (ON: 97% v/s FH: 93%) and incidence of cranial facet violation (ON: 12% v/s FH: 22%) was better in ON group, this difference was not statistically significant. Placement of screws in FH group deviated significantly more (FH: 11.8° v/s ON: 3.6°) from the ideal coaxial intrapedicular trajectory. Both the surgical time for screw placement (ON: 28 ± 14.4 minutes v/s FH: 15.6 ± 7.5 minutes) and radiation exposure (ON: 54.2 seconds v/s FH: 32.2 seconds) were significantly more in the ON group.

Conclusion: In the hands of an experienced surgeon, O-arm navigation guided pedicle screw placement in the lumbar spine provides no added advantage over free-hand technique, while increasing the surgical time and the radiation exposure to the patient.

O193

Comparison of outcomes between robot-assisted minimally invasive transforaminal lumbar interbody fusion and open freehand lumbar interbody fusion

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Introduction: Freehand placement of pedicle screws by exposing the bony landmarks in a midline approach is the most common spinal fusion technique. Minimally invasive approaches have changed with Robotic- guidance, which facilitates performing such cases in a percutaneous paramedian approach. We compare one surgeon′s experience with both approaches. To analyze the perioperative and postoperative outcomes of patients who underwent Robotic guided Minimally Invasive transforaminal lumbar interbody fusion (Robotic MI-TLIF) and open freehand TLIF (O-TLIF) as a control.
Methods: We retrospectively reviewed patients who underwent Transforaminal Lumbar Interbody Fusion surgery between Oct 2019 - Oct 2020 with a minimum of average 2 years follow up. A total of 102 patients who underwent Robotic guided MI-TLIF during this time period were included in the study. A series of consecutive 102 patients who underwent open free hand TLIF during the same time period were used as a control group. *T* test and $\chi 2$ were used to analyze data. $P<0.05$ is considered as statistically significant.
Results: 204 patients,102 Robotic MI-TLIF vs 102 O-TLIF. No differences in age, gender-ratio or BMI were noted between the 2 cohorts. Of the 444 screws placed in the Robotic MI-TLIF 442 (99.5%) were accurate, while O-TLIF had 440 screws of which 414 (94.1%) were placed accurately ($p<0.0001$). Robotic MI-TLIF had blood loss of 63.5ml vs 98.4ml in Open-TLIF ($p< 0.001$). Average Hospital stay 1.6 vs 2.4 days Open-TLIF ($p<0.001$). Overall complication rate 0.98% vs 5.8% O-TLIF. Despite the robotic group being percutaneous and the control group open, the procedure time (134.7 vs 136.4 mins) and utilization of intraoperative fluoroscopy (8.6 vs 8.4 sec) were similar.
Conclusion: In comparing Robotic MI-TLIF vs Open TLIF, the Robotic Minimally Invasive procedure demonstrated increased screw accuracy, minimal blood loss, hospital stay and complications. VAS and ODI were similar in 2 years follow-up for both groups.

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O194
Is robot assisted TLIF better than traditional TLIF?

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Summary: Lumbar fusion surgery is the most widely accepted and performed surgery for various pathologies at the lumbar spine. Transforaminal lumbar inter body fusion (TLIF) is one of the most widely performed surgery across the globe for lumbar instability and also degenerative disc disease. Robot-assisted minimally invasive transforaminal lumbar interbody fusion (robot-assisted MIS-TLIF) has various advantageous over the standard open TLIF surgery in various modalities.
Hypothesis: It is established that Traditional Open TLIF is a "Gold Standard" procedure for variety of lumbar degenerative pathologies. In this study we hypothesize Robot-assisted minimally invasive transforaminal lumbar interbody fusion (robot-assisted MIS-TLIF) in a selected group of lumbar degenerative pathologies, which could increase accuracy of implant placement, low intra-op blood loss, less surgery time, lessen the hospital stay, dependence of post op pain medication and can be the future of implant placement in spinal surgery.
Study Design: Prospective
Introduction: Transforaminal lumbar interbody fusion (TLIF) is a widely accepted surgical technique for the management of numerous spinal conditions requiring spinal stabilization and fusion. Transforaminal lumbar interbody fusion (TLIF), a posterior spinal fusion approach, was initially described by Harms and Rollinger in 1982, and gained popularity after work by Harms and Jeszenszky in 1998. Compared with posterolateral and lateral approaches, Transforaminal may be advantageous, providing a wider area of intervertebral interbody graft bone contact surface, improved load-sharing, adequate access for complete decompression of the neural elements, restoration of neural foraminal height, and the ability to restore segmental lordosis at the involved level. Robot assisted TLIF surgery has more favorable outcomes than the open TLIF surgery in various modalities.
Methods: This is a prospective study including 95 patients who underwent Robot-assisted minimally invasive transforaminal lumbar interbody fusion (robot-assisted MIS-TLIF) and 95 patient who underwent traditional open TLIF surgery. All patients included in the study underwent single level Transforaminal lumbar interbody fusion. These patients were skeletally mature predominantly having single level pathology with single leg radicular symptoms and patients with grade I degenerative spondylolisthesis, failed conservative management for a period of 3 months. All the cases which fulfilled the inclusion criteria were segregated on basis of age and sex. Pre op regular standing X-RAYS ap and lateral views were taken, and Pre-op CT scan was done and the images were uploaded to the robot and planned the screws placement. Intra-op blood loss is noted, surgical time is noted, time for screw placement is noted, post op patient's requirement for analgesics is noted between the two groups.
Results: In our study we compared the efficacy and outcomes of 95 patients who underwent Robot-assisted minimally invasive transforaminal lumbar interbody fusion (robot-assisted MIS-TLIF)and 95 patient who underwent traditional open TLIF surgery. In Robot assisted MIS-TLIF The age group range was from a minimum of 28 years to a maximum of 80 years 57.6 =/- 2.55 years years. The mean age for the traditional open TLIF is around 57.5 +/- 2.67 years ranging from 30 to 82 years. Among the Robotic MIS-TLIF surgery group 40 were male patients and 55 were female patients, the other group has 45 male patients and 50 female patients. when compared with the average duration of surgery 105.6 for the Robot TLIF surgery and 166.4 for the traditional open TLIF surgery. average blood loss for the Robot MIS-TLIF surgery is 40ml whereas in the case of open TLIF is 130ml of blood loss.
Conclusion: In conclusion Robot-assisted minimally invasive transforaminal lumbar interbody fusion (robot-assisted MIS-TLIF) provides the patients safe spinal fusion surgery with accurate screw placements, less blood loss, early mobilization and reduce dependency on post op analgesics, reduced days of hospitalisation.
Take home message: Robotic spinal fixation is the future of spinal fixations and also for the complex deformity correction with almost precision.

O195

Novel mini-incision surgical fusion for single level lumbar degenerative spondylolisthesis: A pilot study comparing traditional PLIF

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Introduction: Degenerative spondylolisthesis is one the greatest burden and significant percent of the patient have symptoms ranging from back pain, neurogenic claudication and radiculopathy. Most of them end up requiring surgical intervention, instrumented lumbar interbody fusion. There are multiple fusion technique and the most popular are PLIF and TLIF. The recent advances, in surgical techniques and instrumentation it is possible to perform minimally invasive surgery, unilaterally decompressing bilateral roots while achieving fusion. Midline over the top decompression has been described in the year 1997 by Dr Spetzger, from Germany for the treatment of LCS and we have extrapolated the procedure, performed instrumented interbody fusion termed as mid-line over the top decompression and fusion (OTDF).
Aim: To compare the blood loss and functional outcome between the novel mini-incision technique, OTDF with conventional PLIF.
Materials and Methods: It's a prospective study undertaken in single tertiary hospital from 2021, with IRB approval. Patients with single level L4-5 lumbar degenerative spondylolisthesis who underwent instrumented lumbar interbody fusion are included in the study. Patients were segregated in 3 groups(N1,N2 and N3), each with 15 patients. N1 patients underwent OTDF, N2 underwent facet sacrificing PLIF and N3 underwent facet preserving PLIF. Blood loss and functional outcome were compared among these group.
Results: The demographics were similar across all the groups. The functional score were calculated with ODI, Pre-op average scores were N1,2,3 are 54.4, 57.2, 57.7 respectively and the postop ODI scores were N1,2,3 are 21.8,31.8, 29.6. Interop average interop blood loss N1,2,3 is 220, 370, 208 and the average drain blood loss are N1 210ml, N2 520ml and N3 500ml. None of the patients in N1 required blood transfusion, N2 and N3 had four patient requiring blood transfusion, the average difference between postop PCV for N1,2,3 was 5, 8.64, 7.96. Post op ambulation status across each group, N1 all patients ambulated same day, N2 and N3 had 3 and 2 patients who were ambulated on POD 2 due to back pain. One patient in N1 had postop radicular leg pain, postop CT showed inferior migration of screw, underwent screw removal. N2, 4 patients had leg pain which improved with neurotropic medication and one patient had inferiorly migrating screw which required screw removal. N3, 2 patients had radicular leg pain which improved on medication, one required steroid medication. Interop N3 2 patients had inferior pedicle breach, while performing laminectomy and instrumentation was extended cranially. N1 none had SSI, N2, 2 patients had wound soakage and settled, N3 1 patient had SSI. None of the patients in N1 required PCA or morphine, N2, 5 of them were on PCA and N3 2 were in PCA and 2 required morphine for pain management.
Conclusions: In our experience with short term follow-up, the mini-incision OTDF is better procedure, with low blood loss minimising the requirement of blood transfusion, reduced scarring, reduced requirement of morphine and early discharge from hospital.

O196

A modification in surgical technique –one of the ways to prevent Proximal junctional kyphosis in adolescent idiopathic scoliosis patients undergoing posterior instrumented correction: A poorly recognized modification

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Introduction: Proximal Junctional Kyphosis (PJK) is multifactorial in etiology. It is the development of kyphosis immediately above the spinal fusion construct. It is measured as the sagittal Cobb angle between the upper most instrumented vertebra (UIV) and the two levels above the UIV (UIV + 2) (Glattes et al), or UIV and (UIV+1) (valgeson et al), 10 degree greater than the preoperative measurement. Proximal junctional failure (PJF) is more severe than PJK and often goes for severe pain or neurological deficit and necessitates revision surgery. PJK is shown to correlate directly with pain and inversely with function. Progression of PJK, PJF lead to increased pain, neurological deficit, gait disturbances, sagittal imbalance and cosmetic problems. A Modification in the surgical procedure is done to retain the continuity of PLC and a deliberate effort is made to preserve the facet joint as far as possible at the proximal instrumented level. This is one of the ways to prevent PJK in AIS patients undergoing instrumented correction and posterior fusion. The study was done from 2007 to 2011 much before most of the published literature. It is published in international journal of scientific research (2019 January).

Materials and Methods: A prospective study was done from 2007 onwards with minimum 2 years follow up in 36 adolescent idiopathic scoliosis patients. The cobs angle ranged from 40-120 degrees. There was no strict specification on curve types. Pedicle screws and rods were used in all patients for the correction. PJK was measured in standing lateral whole spine xray film from the lower end plate of UIV to UIV +1. PJK was assessed preoperatively, postoperatively,at 6 months,1 year and 2 years

Results: Data where analyzed using SPSS 21.0. Continuous data where expressed as mean with standard deviation or as median. Paired continuous variables were analyzed using paired sample T test and P value less than 0.05 was considered statistically significant. Out of 36 patients who underwent the modification of the surgical technique by keeping the posterior ligamentous complex connections and spinous process of UIV, and UIV-1, with UIV +1, did not develop PJK. (More than 90% PJK developed in first 18 months after surgery.) In two years of follow up, all the four patients who did not undergo the modification developed PJK significantly. Two of the participants developed PJK up to 30 degrees. Modification in the technique is one of the ways to prevent PJK in AIS patients undergoing posterior correction and fusion.

Conclusion: The method described here is a biological way to retain the PLC continuity between the fused and non fused segments in long segment fusion in AIS patients compared to the use of mersiline tape around the spinous process of UIV and UIV+1 in order to create a functional posterior tension band (Ngoe Lam M Nguan, Christopher Y king, Robert A Hart, Curr Rev Musculoskeletal med (2016) 9:299-308) to prevent P JK. This modification in technique is one of the ways to retain a functional PLC in AIS patients with long segment posterior fusion.

O197

Comparison between relative efficacy of erector spinae plane block and caudal epidural block for early postoperative analgesia in lumbar spine fusion surgery

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Introduction: Postoperative pain management involves a standardized multimodal analgesic regimen with nonopioid agents or techniques to minimize the use of perioperative opioids to improve and expedite patients' recovery after surgery. Studies have shown that both caudal epidural block (CEB) and erector spinae plane block (ESPB) are effective in lowering pain and opioid consumption after lumbar surgery. However, there are no studies comparing the efficacy of these two blocks. So we aim to compare the relative efficacy of ultrasound-guided ESPB and CEB for postoperative analgesia after a single-level lumbar fusion surgery and compared it with conventional (opioid-based) multimodal postoperative analgesia.
Methods: This is a prospective, randomized controlled, double-blinded study involving 85 patients requiring a single-level lumbar fusion surgery. They were randomized into three groups- ESPB group (ESPB with multimodal analgesia), CEB group (CEB with multimodal analgesia), and control group (only multimodal analgesia). Demographic and surgical data (blood loss, duration of surgery, perioperative total opioid consumption, muscle relaxants used) were assessed. Patients in all three groups underwent the identical protocol for pre-emptive analgesia and induction of anesthesia. Patients in the ESPB group received the US-ESP block followed by multimodal analgesia, the CEB group received a caudal epidural block followed by multimodal analgesia while the control group received only multimodal analgesia.
Results: There were 27 patients in each group; the three groups were identical in demographic and surgical profiles. The total opioid consumption (TOC) in the 24 hours was significantly lower in both the block groups (ESPB, CEB) than in the control group (103.70 $\pm$ 13.34 vs. 105 $\pm$ 16.01 vs 142.59 $\pm$ 40.91mcg; $p<0.001$). The total muscle relaxant consumption during surgery was also significantly less in both the block groups (50.93 $\pm$ 1.98 vs 52.04 $\pm$3.47 vs 55.00 $\pm$ 5.29 mg; $p <0.001$). The intraoperative blood loss was significantly less in both the block group (327.78 $\pm$ 40.03 ml in ESPB group,380.74 $\pm$ 77.80 ml in CEB group) as compared to the control group (498.89 $\pm$ 71.22 ml) ($p < 0.001$). Compared to the block groups, the control group's pain scoring (NRS) was significantly higher in the initial 48 hours postoperatively when compared to the controls. Among the block groups, the immediate postoperative pain relief was better in CEB group than the ESPB group. However, the ESPB group had a longer duration of postoperative pain relief than the CEB group. The MOASS score at 1,2 and 4 hours was significantly less in the control group when compared to the block groups. The satisfaction score in the ESPB group (mean value of 9.70 $\pm$ 0.54) and CEB group (mean value of 9.52 $\pm$ 0.51) was significantly better when compared to controls (mean value of 8.30 $\pm$ 0.95) at the end of 72 hrs.
Conclusion: ESPB and CEB produce adequate postoperative analgesia after lumbar fusion surgery and may be utilized as auxiliary arms in multimodal analgesia. However, the postoperative analgesic effect duration was significantly longer in the ESPB group with relatively shorter surgical time and lesser blood loss than in the CEB group.

O198

The comparative prospective study of the functional outcome of robotic-assisted rehabilitation versus conventional rehabilitation in patients with spinal cord injury

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Introduction: Traumatic spinal cord injuries (SCI) are a major socio-economic burden and regaining the independent locomotive function is an obvious factor contributing to improved quality of life. However, conventional rehabilitation remains the mainstay in this part of the world.
Objective: We intend to compare the outcome between patients treated with robotic device-assisted rehabilitation and conventional rehabilitation and evaluate the efficacy of robotic gait training devices as a tool for rehabilitation in SCI individuals.
Patients and Methods: A Prospective study was conducted in our university-level teaching hospital between January 2019 to January 2021. Inclusion Criteria:1) All operated and non-operated patients with dorsolumbar spinal cord injury with ASIA A, B, C presenting to the OPD and Emergency Department.2) Patients between the age group of 12-60 years.3) Patients with traumatic disorders who have developed Neurological deficit ASIA A at the time of presentation. Patients fulfilling the inclusion criteria were enrolled in the study and divided into two groups; the first group was for conventional rehabilitation and the second group was for robotic rehabilitation. Pre-rehabilitation parameters were noted, viz.ASIA Score, WISCI II (Walking index in spinal cord injury), LEMS (Lower Extremity Motor Score), SCIM III (Spinal cord independence measure III), AO Spine PROST(Patient-reported outcome spine trauma), McGill QOL score, Step length, Max walking velocity, walking duration, VAS score for pain & Modified Ashworth scale for spasticity. The patients in both groups were allotted in an alternate manner, and both groups (conventional rehabilitation group and robotic rehabilitation group) were given respective rehabilitation training sessions six days/week for 12 weeks, with up to 45 minutes to 1 hour of training per session. Subjects were evaluated before and at 1, 2, 4, 6, 8, 10, and 12 weeks of training.
Results: A total of 30 patients were included in the study, with 15 in each group. The mean age was 30.9+/-7.9 in the robotic group and 34.6+/- 10.22 in the conventional group, with fall from a height being the predominant mechanism in both groups. The two groups were comparable in terms of distribution of age, gender, mechanism of injury, and initial neurological deficits as measured by ASIA grade. Patients in both groups had significantly better functional scores at the final follow-up compared to their pre-operative values. However, between-the-group analysis revealed that the robotic group performed significantly better in regard to the WISCI II score (p-value 0.001), LEMS score (p-value 0.04), AO-PROST score(p-value 0.001), McGill QoL score(p-value 0.04), and SCIM III score(p-value 0.003) at the final follow-up. However, improvement in sensory function did not differ between the groups. The robotic group also performed significantly better in terms of maximum walking velocity and step length.
Conclusion: Patients with traumatic spinal cord injuries should be offered the benefits of robotic rehabilitation over conventional methods whenever available, as the former portends both improved quality of life as well as motor recovery.

O199
Ossification of the ligamentum flavum: Unknown facets of the disease

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Background: Ossification of the ligamentum flavum is a common cause of myelopathy in Asians. The aim of this study is to report this author's experience with 41 cases of Ossification of ligamentum flaum (OLF) treated over 22 years period.
Methods: All patients with myelopathy due to OLF treated by this author were included. Neurological status was graded using Nurick's scale and modified JOA score. Whole spine MRI & CT of the spine at the affected levels to look for dural ossification were performed.The excised specimen was submitted for identification of calcium pyrophosphate dihydrate deposition disease (CPPD). Patients were also evaluated for the presence of fluorosis,DISH or other known causes of OLF. Complications were recorded and the postoperative status was assessed. Mean follow up was 14 months.
Results: Period of study: 1998 -2020. Lower thoracic region was the most commonly involved site, especially, T9- T12 followed by mid and upper thoracic levels. Three patients had cervical OLF. Associated cervical OPLL was found in 6 patients and one patient had spinal syringomyelia induced by OLF. The cause of OLF could be identified in 22 patients: 13 had CPPD, 3 had fluorosis; 4 had DISH, 1 had myositis ossificans progressiva and 1 had renal rickets. Dural ossification was found in 13 (32%) of patients. Thirty-nine patients underwent surgery. One patient each with renal rickets and myositis ossificans progressiva did not undergo surgery. Dural ossification was associated with increased risk of dural lacerations and CSF leaks. Postoperative deterioration was encountered in 3 patients.
Conclusions: OLF is an under recognized cause of thoracic myelopathy. The aetiology of this entity can be identified in the majority of the patients. Dural ossification is associated with increased postoperative morbidity.

O200

Degenerative lumbar spine decision making score (DLDMS): A clinically applicable predictive score in single level lumbar degenerative disc disease for formulating a surgical plan

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Introduction: Micro-lumbar discectomy and interbody spine fusion procedures are the work-horse surgical procedures in the management of symptomatic lumbar disc disease. Spine surgeon in their early years of practice can have surgical dilemma in choosing ideal surgical plan when dealing with a complex scenario. The treating surgeon has to balance the risk profile of fusion surgery with micro-lumbar discectomy as both the procedures can provide comparable functional outcome. A delicate balance is needed in preventing recurrent lumbar disc herniation (with micro lumbar discectomy) and mitigating instrumentation, fusion related complications (with interbody fusion).A clinical tool to aid in formulating an ideal surgical plan is needed to maximise surgical outcome of the patient.
Aim: We propose a decision-making predictive score taking into consideration all relevant independent risk factors to formulate an ideal surgical plan for patients with symptomatic single level lumbar disc disease.
Methods: Study was done with research grant approval from AO Spine. A clinical predictive score was formulated following a pilot study. The proposed clinical score comprises of eight parameters: age of the patient, primary or revision surgical procedure(following laminotomy/discectomy),disc height (based on lateral radiograph),instability on dynamic radiographs, morphology of disc protrusion (based on axial T2w MRI at the involved level),presence of Modic end plate changes, orientation of lumbar facets with or without facet tropism and presence of lumbo-sacral transitional vertebra. Each parameter will be awarded a score of 1 or 2 based on patients clinical and radiological profile. Patients scoring less than or equal to 5 to undergo Microlumbar discectomy and patients who score 6 or more to undergo Transforminal lumbar interbody fusion procedure. Two fellowship trained spine surgeons (with experience of 3 to 5 years after their fellowship)-one using the score(Group A),and other not using score(Group B-control) treated 40 patients with symptomatic single level lumbar degenerative disc disease in their respective group. All patients were analysed preoperatively and post-surgery at 12 months follow-up with Visual analog scale for back and leg pain, Oswestry Disability Index score, and SF-36 score. Evaluated parameters were analysed statistically and $p \leq 0.05$ was considered statistically significant. Success rate of individual surgeons who managed respective group and Difficulty index of surgeon who managed without using score was evaluated at 12 months follow-up.
Results: Mean age of patients was 44.5 years in group A and 47.4 years in group B. The predominant segmental level was L4/5 in both groups followed by L5/S1 and L3/4.Success rate of Group A-surgeon (50%) was higher than Group B-surgeon (32%).15% of Group B patients had poor surgical outcome at the latest follow-up. Statistically significant improvement in Group A patients were seen in all three evaluated parameters when compared to Group B patients at 12 months of follow-up (p values–VAS:0.004,ODI score:0.009,SF-36 score:0.018).Difficulty index of surgeon who didn't use the score was 15%.
Conclusion: The proposed predictive score comprising all risk factors can be used by spine surgeons when they are confronted with difficult scenario in decision-making of surgical management of patients with symptomatic single level degenerative lumbar disc disease. Accuracy, reliability and validity of the score needs to be evaluated in a larger scale.

O201

Simultaneous single stage decompression surgery for triple tandem spinal stenosis - Safety and outcome analysis

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Introduction: Portal of France in 1803 first described term spinal stenosis. Brain and Wilkinson in 1957, first described stenosis in both lumbar and cervical region. Dagi et al coined a term Tandem Spinal Stenosis for the same.[1,2,3,4]

Spinal stenosis is common degenerative condition but Triple (Cervical, Thoracic, Lumbar) Region spinal stenosis (TRSS) is rare. The prevalence may vary from 10% to 25.7% as per literature [5,6,7]. Management protocols differ as per the literature. Most of the articles support multi staged surgery for TRSS. We aim to propse Management protocols & functional outcome of our case series of TRSS using single staged spinal decompression surgery.

Material and Methods: It was Retrospective review of prospectively collected data of consecutive patients who underwent triple tandem decompression (Single staged triple region spinal decompression surgery) performed by same team of surgeons from Aug 2009 to Feb 2020. All pre/post operative clinical, post operative outcome data (Out/In patient department records) and surgical records (Operation Theatre records) were collected. Total seventeen patient's (12 male,5 female) data was collected. Patient's functional outcomes were analysed at six monthly intervals (minimum 4 months maximum10 years follow up). Visual Analog scale (VAS) and modified Oswestry disability index (mODI) were used to assess functional outcome.

On presentation, most of these patients had typical history of imbalance/ fine motor dysfunction/ bowel-bladder dysfunction, along with lower limb radiculopathy with neurogenic claudication with or without weakness. These symptoms were present in different combinations. High level of suspicion about concomitant compressive etiology at different spinal regions has to be present.

Inclusion criteria was patients presented with above mentioned symptoms confirmed on radiological studies.

Exclusion criteria was patients unfit for triple region decompression at same sitting due to medical reasons or patients having neurological cause determined by neurophysician, having major contribution in symptoms of patient. During pre op workup, one should get Neurology clearance from Neurophysician along with neurophysiological studies like EMG (Electromyography), NCV (Nerve conduction velocity), SSEP (Somato- Sensory Evoked Potentials) of all four limbs. These studies help in documentation and prognostication of the final outcome of surgery and to counsel patient about, what kind of neurological recovery one can expect, post surgery. All patients did Ophthalmology clearance in view of long hours expected surgical time in prone.

Surgical planning was done based on clinical symptoms, Roentgenograms (X Ray), Magnetic Resonance Imaging (MRI) and Computed Tomography (CT). All 17 patients underwent same stage triple region decompression surgery by same team of surgeons at five different hospitals. Training, surgical steps and pre – post surgical protocols were same for all hospitals. There were 12 male patients and 5 female patients ranging from 33 years to 79 years. Each patient's pre surgical VAS and mODI were recorded and same were re- documented post surgery at followup visits. All patients were asked to get their X Rays, MRIs done at 4 months and 12 months post surgery for radiological documentation. After that,MRI was repeated only if patient presented with new complaints. X rays were done once a year till 5 years. All patients underwent rigorous physiotherapy rehabilitation both during hospital stay and post discharge.

Results: 17 patients operated by same team of surgeons between August 2009 to Feb 2020 were studied. There were 12 male and 5 female patients. Commonest adverse event during surgery was dural tear and commonest complication post op was neurological deficit. Incidence of dural tear was 7/17 patient (41.17 %) & incidence of post op neurological deficit was 5/17 (29.41%). Out of these, 1 patient with upper limb, 3 patients with lower limb and 1 patient with both upper- lower limbs neurodeficits were noted. Out of 5, 2 had partial recovery whereas remaining 3 did not improve neurologically.

One male patient underwent revision dorsal decompression in view of deterioration of neurology in bilateral lower limbs secondary to restenosis at dorsal level 2 years after primary surgery.

Functional outcome was assessed using VAS and mODI. In our series followup ranges from 4 months minimum to 10 years maximum. Preop mean VAS neck score 7, arm score 5, back score 8, leg score 9

improved to postop mean VAS neck score 3, arm score 1, back score 2, leg score 2 respectively. Mean preop mODI of 79% improved to postop mODI of 30%.

Discussion: Triple regional spinal stenosis (TRSS) is rare condition. Treatment strategies are found to be variable in literature. There is condition called Tandem Ossification where we see thoracic ossified ligamentum flavum (OLF) with coexistent cervical ossified posterior longitudinal ligament (OPLL). Symptomatic cervical OPLL in such tandem ossifications reported to be 33.8% by Park et al[8]. The presence of hyperostotic lesions in lumbar spine in addition to cervical and thoracic ossifications were first described by Koizumi in 1962 [9]. Three regions stenosis were seen in rheumatological abnormalities such as idiopathic skeletal hyperostosis [9,10,11]

Important dilemma remains while ascertaining which region is more symptomatic in such patients. We gave more importance to clinical symptomatology along with matching radiological MRI findings while determining the same.

These patients presented with multiple symptoms in combinations. All presented with neurogenic claudication with radicular pain / paraesthesias in lower limb indicative of lumbar stenosis. Main confusion remains with cord level symptoms where one finds difficulty in ascertaining causative level, whether at dorsal or cervical region. In such scenarios, if patient has upper limb symptoms of radicular pain/ paraesthesias/ weakness exhibited by means of fine motor dysfunction of hand/ wasting of intrinsic muscles of hand, mostly patient has cervical cord compression. If these symptoms are absent but patient has imbalance along with bowel/ bladder dysfunction with or without weakness in lower limbs, one can attribute this to dorsal level cord compression.

Joseph Schaffer et al [12] proposed that symptoms of one region usually predominates and once first gets treated, subsequent regions get unmasked. Epstein et al opined severity of myelopathy and radiculopathy determine surgical plan. [13]

Few studies in literature focus on surgical management of tandem stenosis patients [13] with each studies having small number of cases with retrospective nature. Our study is unique in terms of offering single stage decompression for all three regions of stenosis with safe surgical outcome.

Conclusion: We suggest that single stage decompression surgery for proven case of triple regional spinal stenosis is an effective surgical way of treatment with reasonable good outcome in terms of functionality. One needs to rule non spine causes contributing in symptoms as they may have repercussions on final prognosis helping clinician in preop counselling.

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O202

An obstetric and gynaecological insight to measure the gender specific issues including menstrual disorders in patients with scoliosis: A genuine step towards empowering women's inclusive health

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Introduction: There is a glaring lack of literature regarding menstrual problems and disorders in scoliotic female patients. The impact of scoliosis on women's health, particularly pregnancy outcomes, labor dystocia, and the need for Cesarian deliveries is unknown. We aim to study the association of scoliosis with menstrual irregularities and adverse obstetric and reproductive outcomes along with the correlation of various maturity indicators with curve velocity

Material and Methods: Female subjects were recruited and their clinical-radiological assessment was done. Clinical assessment included a detailed menstrual, obstetrical, and reproductive history along with height, weight, and BMI. Radiological assessment includes radiographs of the whole spine along with pelvis, wrist, and hand, and USG pelvis. The radiological assessment included Cobb's angle, Risser's grade, the status of triradiate (TRC) cartilage, Sander's maturity score (SMS), Tanner-Whitehouse stage(TWS), and Thumb ossification(TOCI) index. For patients comprising the retrospective cohort, these data were retrieved from the patient's records. The prevalence and nature of menstrual irregularities and related disorders were assessed in the study population and were correlated with their USG findings. Curve velocity was correlated with various maturity parameters like Peak height velocity (PHV), age at menarche, Risser's grade, TRC closure status, SMS score, TWS score, and TOCI index in the perimenarchal period.

Results: Out of the total 182 subjects who were recruited, 52 have congenital scoliosis, 126 have idiopathic scoliosis, and the rest 4 have syndromic scoliosis. The mean age at menarche was 12.42 years. The mean duration of the cycle was 29.47 days. The mean duration of flow was 2.90 days. 75% of subjects had regular cycles and 77% of subjects had no inter-menstrual bleeding. Out of 4 non-nulligravida subjects with an average gestation of 38 weeks, 3 had delivery by C-section; 1 subject had an abortion in the 2nd trimester. 6.55% of subjects had a bulky ovary and PCOS morphology each. 1.63% of subjects had findings of s/o fibroid and endometriosis while the rest 1.63% had mild ascites. The mean Cobb's angle 1 year before menarche was 47.55 degrees, at menarche was 69.66 degrees, and 1 year after menarche was 70.57 degrees. The mean curve velocity before menarche was 15.57 degrees and after menarche was 10.38 degrees. The median Risser's grade 1 year before menarche was 1, at menarche was 3 and 1 year after menarche was 4. 87.10 % had closed TRC at 1 year before menarche while all the subjects have fused TRC at menarche and 1 year after menarche. The Median TWS score was H, I, and I in the 1 year pre-menarchal, menarchal, and 1-year post-menarchal period respectively.

Conclusion: Females with scoliosis have an early age at menarche with a more number of days of bleeding and more amount of flow and more incidence of inter-menstrual bleeding. Incidence of the Caesarian section is more in scoliotic females of reproductive age. On the USG pelvis, the prevalence of ovarian cyst findings is more and that of PCOS

O203

Disc below the fusion in adolescent idiopathic scoliosis -long term mri follow up with clinical correlation

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Introduction: Scoliosis surgery often involves fusing the mobile segments of the spinal column. Surgical fusion in a mobile region decreases the number of motion segments available which in turn can increase the lever arm at the preserved discs. This can potentially result in degenerative changes at these discs. MRI evaluation of these discs helps to assess the degree of degeneration. The clinical outcome of such patients is also of interest considering their young age at the time of surgery and the possibility of age-related disc degeneration happening over long term follow up. This study aims to assess the clinical and MRI outcomes in these patients.
Methods: The study was conducted in a single institution between June 2018 and July 2020 with a total of 24 patients who had undergone posterior spinal fusion for adolescent idiopathic scoliosis. Patients underwent T2-weighted MRI for assessment of degenerative changes at the disc just distal to the LIV. Pfirrmann grading was used for assessing the degree of disc degeneration and were graded as mild, moderate and severe Their clinical outcomes were evaluated using SRS 22r Questionnaire.
Results: There were 24 patients (19 Females and 5 Males) in this study with a mean follow up of 8.58 years (SD= 2.412). The average age at the time of follow-up up was 22.25 years (SD=4.099). The average preoperative curve magnitude was 57.33 +/- 16.28 degrees and maintained postoperative curve magnitude at follow-up of 24.45 +/- 12.3 degrees. 83.3% of the patients showed MRI evidence of disc degeneration in our study out of which 54.2% of those showed only mild degenerative changes at the disc level just distal to the LIV. 2 patients (8.3%) had severe changes. The SRS 22r questionnaire scores of our patients had an average score of 4.32. The correlation coefficient between overall SRS and Pfirrmann grade was r=0.057, showing that there is no statistically significant correlation between overall SRS and Pfirrmann grade on follow-up MRI (p value=0.79).
Conclusions: Majority of the patients undergoing spinal fusion surgery for adolescent idiopathic scoliosis develop degenerative changes at the disc distal to the LIV. However, most of them have good clinical outcomes in spite of these radiological changes.

O204
Instrumentation in children aged up to 5 years with spinal tuberculosis

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Introduction: Spinal Tuberculosis is still a common pathology encountered in developing countries. It is considered as medical disease which can be cured with antitubercular therapy (ATT). The risk of development and progression of deformity is higher in children due to several reasons. So, instrumentation may be required for stabilization and prevention of progression of deformity.
The instrumentation in children is challenging because of poor bone stock, narrow pedicles, cartilaginous vertebra and poor soft tissue mass. So, patients may come with implant backout, breakage and prominence.
Aim of Study: This study aims to study the outcome of instrumentation in children up to 5 years of age with spinal tuberculosis.
Materials/Methods: This is a retrospective study of all cases with spinal tuberculosis in children aged up to 5 years of age managed with ATT and instrumentation in Hospital and Rehabilitation Center for Disabled Children (HRDC) from December 2015 to February 2021. Medical records and X rays were reviewed. Level involved, deformity, neurological status, level of instrumentation, implants used and complications were recorded.
Results: Total of 8 children aged up to 5 years with spinal tuberculosis were managed with spinal instrumentation during the specified duration. The mean age was 4.25 years (ranged from 2-5 years). Four were boys and 4 were girls. Average follow up after surgery is 41.25 months (range 10-84 months). Dorsal spine was involved in 3 case, lumbar Spine in 2 cases and Dorso-lumbar spine in 3 cases. Posterior instrumentation only was done in 3 cases. Posterior instrumentation with anterior reconstruction with cage was done in 4 cases. Anterior reconstruction via anterior approach followed by short segment posterior instrumentation was done in 1 case. 4.5mm pedicle screws were used in 4 cases and 3.5mm lateral mass screws were used as pedicle screws in 4 cases. All cases were treated with ATT for 12 months duration. 6 cases had excellent deformity correction and no progression of deformity. One case developed proximal junctional kyphosis which was revised later. One case developed mild progression of kyphosis. 3 cases out of four in which pedicle screws were used developed hardware prominence.
Conclusion: Posterior instrumentation using pedicle screws in children aged up to 5 years is an effective armamentarium for prevention of deformity due to tubercular spondylitis. 3.5mm lateral mass can be used as pedicle screws to avoid implant prominence.

O205

Clinical & radiological outcome of minimally invasive decompression and interbody fusion in dorsal spondylodiscitis – 2 years follow up

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Aim: To evaluate the clinical and radiological outcome of a novel MIS interbody fusion through kambins or transforaminal approach in thoracic spine in spondylodiscitis
Introduction: Open Spinal fusions and decompression are a common treatment for dorsal spondylodiscitis with / without end plate defects and / or neurodeficit and back pain caused by pyogenic, tubercular and parasitic aetiology. Majority of this subset of patients are elderly and have many associated co-morbidities (DM, CKD, immunocompromised, myeloma, lymphoma etc). We introduce a novel MIS technique that allow thorough disc debridement and places an interbody graft or a cage similar to the MIS procedure as done in lumbar spine through a lumbar analogue kambin's triangle in dorsal spine and allow decompression through a tubular retractor system
Materials and Methods: This is a prospective observational study of 15 patients who had undergone this procedure. All the patients were assessed clinically &radiologically.Assessment of all patients were done using VAS score, ODI score and Radiological assessment was done using BRIDWELL score
Results: 15 patients underwent MIS interbody fusion and decompression for spondylodiscitis in dorsal spine with various associated medical comorbidities. There were significant improvement (p> 0.05)in ODI and VAS (Back) scores in the post operative periods. In addition there was significant improvements in ASIA scores of the patients who had neurodeficits. The Bridwell grading for spinal fusion shows grade 4 fusion in all the cases at the end of two years follow up.
Conclusions: MIS decompression and interbody fusion in dorsal spine is a novel and new technique with a very effective clinical and radiological outcome in this this subsets of patients.

O206

Functional outcome of the posterior only approach for decompression and fusion with or without interbody cage in thoracolumbar tuberculosis

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Aim: to evaluate the differences in functional and radiographic outcome in posterior only decompression, debridement and interbody fusion with and without titanium cage, in active thoracic and lumbar tuberculosis with non-ambulatory status at the time of surgery (Asia grade c and below).
Method: a total of 42 patients treated with posterior only approach for decompression, debridement and interbody bone grafting with and without cage operated between 2018 till July 2022 full filling the selection criteria were retrospectively evaluated. All surgeries were done at single institute with similar indication for surgery. Patients case records were evaluated for operation duration, blood loss, cobs angle before and after surgery, AS scores, neurological status (ASIA grading), ESR,CRP and neurological recovery in the follow up.
Results: Mean duration between first presentation to the surgery was 4.5 weeks (3 to 6 weeks), similar in both groups. Neurological grading was Asia grading maximum C and below with non-ambulatory status at the time of surgery. Average operation time was135 minutes in bone graft group, 150 mins in bonegraft with cage. Blood loss was 500 ml in bone graft group alone versus 750ml in bonegraft and cage group, Cobs' angle correction was18.5+-8.4 t0 9.1+- in bonegraft and 20+-10.5 t0 8+-6.5 in bonegraft and cage group. VAS changed from 4.5 to 0.8 in bonegraft group, from5 to 0.6 in bonegraft and cage group. ESR, CRP at 1 year follow up was normal in both groups.
Conclusion: the clinical and radiological improvement was not statistically significant in the two groups. However, the time duration of surgery and blood loss is significant I bgcage group. Final functional outcome, neurological recovery and ambulatory staus is independent on the bone graft with or without cage placement.

O207

Outcome of all posterior VCR in healed rigid tubercular kyphosis in 20 patients with of less than 10y age: A single surgeon 5 year follow up study

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Introduction: Even today tuberculosis spine is quite common in this part of the world. The Vertebral bodies in children are mostly cartilaginous & highly susceptible to rapid destruction. A severe kyphosis is not only has major cosmetic and psychological disturbance in a growing child, but also can result in secondary cardiorespiratory problems and late-onset spastic paraplegia due to cord compression.
Aim: To study the outcome of VCR, all by posterior approach in juvenile spines with severe kyphotic deformity with respect to level of instrumentation, immediate correction of kyphosis & also its long term maintenance & complications.
Patients & Methods: 20 children of less than 10 years age at presentation, unbalanced spine with or without spine at risk signs having documented progression of kyphosis with or without neural deficit who were treated by all posterior VCR with autologous morselized rib grafts & local bone chips were followed up to maximum of 5 years with radiographs and clinical images.
Results: All 20 cases showed excellent immediate correction. Intraoperative complications included screw pullouts, need for involvement of adjacent level in fusion, blood loss, transient Neuro monitor signal drops in 3 cases, however no Neuro deficits postoperatively in previous neurologically intact cases. Adjacent segment hypokyphosis in thoracic region & exaggerated cervical / lumbar lordosis present preoperatively improved significantly in the subsequent follow ups, achieving spinal balance. All cases showed good maintenance of achieved correction and excellent graft consolidation.
Discussion: TB spine primarily affects the cord area of the vertebral column. The principles of deformity correction by VCR in juvenile post tubercular kyphosis are essentially similar to that of in congenital scoliosis. Though the deformities appear to be similar, there are subtle differences between them which make PTK unique and challenging for the operating surgeon. Common form of congenital scoliosis due to hemivertebra, though, is usually a complex 3 plane deformity; the bone quality is adequate enough to withstand the huge stresses at the pedicle screw interface. Micro environment at the apex of deformity is clean, keeping the cord and its Dural coverings naive. Spinal cord is healthy. Whereas in PTK, though the deformity is a pure gravity assisted single plane deformity mostly due to biomechanical reasons, there is concomitant local osteoporosis due to chronic inflammation even in old healed cases. Intracanal Inflammation & granulomas lead to Dural scarring, adhesions, small vessel thrombosis, fibrosis and previous deficits make the spinal cord unduly sick (Sick Cord Syndrome). Osteoporotic juvenile PTK spine cannot sustain huge stresses across the pedicle-screw interface. Osteotomy is further complicated by Dural adhesions, leading to tears and vessel occlusions leading to deficits. Kyphosis Especially in younger age groups, it produces progressive restriction of pulmonary functions. Correction of such severe kyphosis is a technically demanding surgery with higher risk of dense neurologic injury.
Conclusions: Correction of an established deformity in a slender spine with severe deformity is both difficult and hazardous with a high rate of complications, even in experienced hands. All posterior approach with VCR & instrumentation for healed tubercular in young children is safe and effective procedure, depending upon surgeon's expertise.

O208

Percutaneous pedicle screw fixation in caries spine: Does early MIS fixation has advantage over conservative?

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Introduction: Tuberculous (TB) spine with spondylodiscitis has conventionally been treated with medical management and prolonged immobilization in bed. Surgical intervention is only indicated for progressive deformity or neurological deficit, preventing spinal cord compression and its complications. However, prolonged bed rest has its own set of complications and poor acceptability by the patient. We performed this study to investigate the role of fixation by percutaneous pedicle screw fixation (PPSF) in spondylodiscitis secondary to TB origin for pain relief and rapid early mobilization of the patient.
Material and Methods: Thirty-two cases of tuberculous spondylodiscitis were managed from March 2017 to 2019. Clinical assessment, radiological evaluation, and laboratory studies with over a year follow-up after PPSF without decompression. Visual analog scale (VAS score) and Oswestry disability indices (ODI scale, Hindi version) were used for outcome measure.
Results: Female-to-male ratio was 19:13. The average follow-up was 14 months ± 6 days and the duration for fusion was around 6 months. The mean duration of hospital stay was 4.006 ± 1.17 days. The average blood loss was 27.18 ml ± 17.71. The mean surgical time was 121.25 ± 14.59 min. ATT was continued for 12–18 months. Mean 48 days after surgery, and 1 year at follow-up, C-reactive protein, erythrocyte sedimentation rate, pain scores (VAS score), and ODI returned to their baseline. No failure of instrumentation or decline in neurovascular condition was reported after operative intervention.
Conclusion: Primary treatment of TB spine has been chemotherapy with limited indications for surgery. Severe pain in the presence of spondylodiscitis without neurological deficit or deformity projects as an unclear situation and a temporary surgical fixation gives stability to prevent uneventful neurological injury and promote early healing with faster rehabilitation in contrast to strict bed rest and external bracing.

O209

Demystifying occipitocervical tuberculosis: A journey of three decades from the era of minerva cast to minimal invasive procedures

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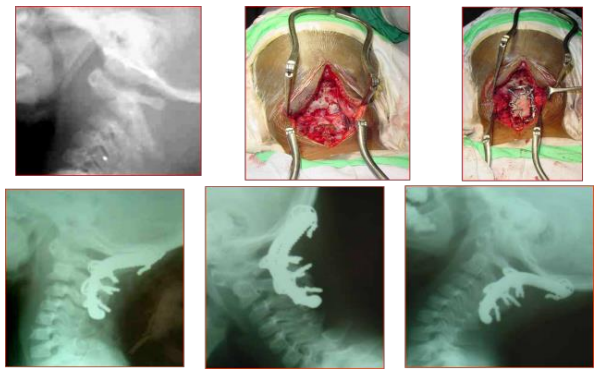
Introduction: Tuberculosis (TB) of Craniovertebral junction (CVJ) is an uncommon form of spinal TB, accounting for less than 1% of cases. The present article aims to describe unique anatomy and biomechanics involved in CVJ TB as well as evolution of management guidelines over last 3 decades. The authors have also attempted to design a protocol based management strategy for TB of the CVJ. This paper will assess the functional outcomes of patients treated using this protocol.
Methods: This retrospective study with a study duration of 30 years was conducted at a tertiary care centre in Mumbai. Approval from Institutional Ethics Committee was taken prior to commencement. 108 patients with tuberculosis of CVJ were evaluated. A treatment algorithm was developed for these patients based on the clinical and radiological classification. Patients were treated either conservatively or surgically using this algorithm. These patients were followed up for a minimum duration of 18 months and functional outcomes were assessed.
Results: We had a total of 64 males and 44 females with ages ranging from 4-60 years. All patients underwent a minimum follow-up of 18 months with a mean follow-up duration of 50.23±24.46 months (range, 18–153 months). 5 patients had lesions at multiple sites in the spine apart from CVJ. We had a total of 6 cases of MDR TB in our series. 60 patients were treated conservatively, 28 patients required occipito-cervical fusion (Figure 1 and 2), 18 patients needed trans-articular screws, 2 patient was treated with C1-C2 Harm's fixation. 6 patients had clinically appreciable tilt and 10 patients had axial settling in the conservatively treated group. However, there was no functional impairment. There was no neurological deterioration in any conservatively treated patient. In the surgically treated group of 48 patients not a single patient had neurological deterioration. Out of the 8 patients who were clinically grade 3, 7 patients were ambulatory at 18 months follow-up. 1 patient remained paraplegic. Fusion was achieved in all cases.
Conclusions: CVJ is a critical junctional area with a unique patho-anatomy which makes it inherently prone to instability. It has a lateral weight bearing column (Y-shaped beam), multi directional mobility and ligaments as the stabilizing structures. Infection probably begins in retropharyngeal space with secondary involvement of bone. Progression of the disease causes increasing ligamentous involvement, and the later stages involve increased bony destruction. Though the bacteria and the chemotherapy are the same, TB of the CVJ needs special attention because of the complex anatomy of the region and presence of vital structures in the vicinity. Improved understanding of biomechanics has resulted in better outcomes. Regardless of the technique utilized, sensitive chemotherapy and adhering to principles of biomechanics form the cornerstone of treatment.



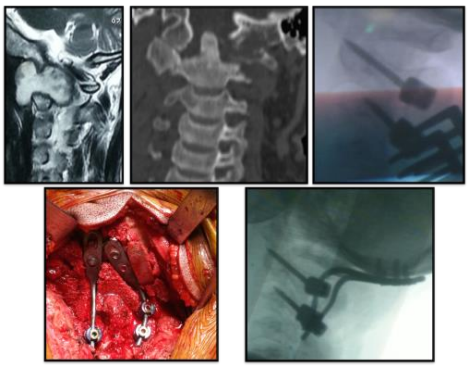


Figure 1: Occipito-cervical fixation using Hartshill
Figure 2: Occipito-cervical fixation with rod and plate construct: For severe C1 lateral mass destruction

O210

Concept of pedicle-vertebral angle (PVBA): A morphometric analysis of the angle between cervical pedicle and vertebral body in sub-axial cervical spine for safe insertion of pedicle screws

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Introduction: Cervical pedicle screw placement needs both appropriate entry point and angle of placement for maximum purchase for improved bio mechanical stability and reduced chances of complications.
Aim: To analyze the relation between cervical pedicle and vertebral body, and its importance as well as variations at different levels in sub axial cervical spine for the safe placement of Cervical pedicle screws.
Method: Patients undergoing cervical spine surgery in prone position underwent surgery with intra-operative 3D CT Scan. Planar probe was used to identify the virtual cervical pedicle trajectory on both sagittal and axial images for the sub axial cervical vertebral levels and screenshots taken. The Cervical Pedicle and Vertebral Body Angle (PVBA) was calculated on Surgimap software. PVBA was classified into three grades: grade 1 (0-20 degrees), grade 2 (21-40 degrees) and grade 3 (more than 40 degrees).
Results: 400 sub-axial cervical pedicles in 50 patients were analyzed. The mean age was 55.76 ± 13.6 years. There were 15 females and 35 males. The mean cervical angle (CK and CL) was 5.46 ± 16 degrees. Our analysis revealed that the angle significantly decreased at each level ($p<0.0001$). There were no significant associations between the cervical kyphosis/lordosis angles and pedicle angles at any level ($p>0.05$). Grade 3 pedicles were seen to be highest at C3 level.
Conclusion: PVBA assessment on pre-operative images aids in determining the angle of placement and entry point for safe placement. Due care needs to be taken during screw placement at C3 and C4 levels with higher angles.

O211
Clinicoradiological profile in spinal ligament ossification due to flurosis

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Introduction: Fluorosis is the most prevalent problem in India and around 65 million people are at a risk of dental fluorosis and skeletal fluorosis due to ossification of spinal ligaments. In spine, manifestations of fluorosis include Ossification of ligamentum flavum (OLF) and Ossification of posterior longitudinal ligament (OPLL) leading to spinal cord compression but as conditions like ankylosing spondylitis and DISH share similar features, a clear description of clinical and radiological features is not available in literature. This cross-sectional descriptive study aims to screen all degenerative disc disease patients for ossification spinal ligaments and describe the epidemiological, clinical and radiological features of spinal fluorosis.
Methods: Patients with degenerative disc disease (DDD) and underwent MRI were evaluated for thickening and ossification of spinal ligaments. Those who had thickening of spinal ligaments were further evaluated for spinal fluorosis. The diagnosis of spinal fluorosis was considered when patients were coming from fluorosis endemic areas, presence of dental fluorosis, ossification of interosseous membrane in forearm x-ray and absence of costochondral fusion in CT thorax. Clinical parameters analyzed include neurological status, mean ODI score, walking & working status, radiological parameters evaluated include number of levels of ossification, distribution of ossification, type of ligaments involved, number of levels of cord compression in CT and MRI. Descriptive statistics were used.
Results: Among 662 patients with degenerative disc disease, total of 49 cases were available during study period, 39 (79.59%) were males and 10 (20.41%) were females, with mean age of 53.87 (SD 11.73) years. 47 patients (96%) were from Deccan plateau region, which consists of many fluoride endemic districts while 2 patents gave history of residing in endemic areas earlier. Patient presented mainly with low back pain with radicular pain with deficits (paraparesis) in 66.6% patients followed by paraplegia observed 14.3% of cases and paraparesis in 18.3% cases. Mean ODI was 56.11 (SD 22.25). Among the spinal ossification, Ossification of ligamentum flavum was most common (44 patients -89.79%), among these except one all were confined to thoracic spine. Even in thoracic spine, involvement was common in lower thoracic levels (D10-11, D11-12) followed by upper thoracic levels (D2-3 and D3-4 levels). 36.7% of patients showed OLF of more than 4 levels. 16 (32.65%) had OPLL and except one all were in cervical spine.
Conclusion: Patients with OLF had more severe disability compared to degenerative disc disease without ossification. Multiple OLF at thoracic levels especially upper and lower thoracic levels are seen characteristically in most of the patients.

O212

The effect of arm positions used during radiography on frontal and sagittal spinal alignment parameters assessed by 3D ultrasound imaging in adolescents with idiopathic scoliosis

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Introduction: Clinicians detect progression of idiopathic scoliosis using radiographs approximately every 6 months during growth. During radiography, it is unclear which arm positions lead to frontal and sagittal measurements that are representative of the habitual posture and whether such positions could allow for the scoring of skeletal maturity. Spinal alignment can be quantified repeatedly in short intervals using non-invasive 3D ultrasound (3DUS) imaging to propose the most representative arm position for radiography. The aim of this study is to determine which arm positions used to acquire simultaneous frontal and lateral radiographs (some of which could allow hand-based skeletal maturity assessment) best represent habitual standing posture as measured using the angle of vertebral rotation (AVR), frontal, and sagittal curve angles.
Methods: Females with adolescent idiopathic scoliosis (AIS) treated non-operatively were recruited consecutively from our specialized Scoliosis Clinic. Their spines were scanned via 3DUS imaging in 10 arm positions: habitual standing, arms supported anteriorly at 60^{o} flexion, fingers to clavicle, chin, zygomatic, and eyebrows, arms abducted 90^{o}, hands on wall, on blocks, and hands unsupported. The last 4 positions listed would allow for the assessment of skeletal maturity. A trained evaluator digitized the center of the lamina using custom software to measure AVR differences (AVR twist), frontal, and sagittal curve angles. Repeated measures ANOVAs with Sidak post-hoc tests were used to compare positions.
Results: Twenty-seven females with AIS with a mean age, height, and weight of 14±2 years, 166±6 cm, and 53±9 kg, respectively, were included. There were no significant differences among the 10 arm positions for whole thoracic kyphosis, lordosis, or AVR twist measurements ($p>0.05$). There was a significant decrease in the maximum curve angle of any spinal region during hands unsupported (21±13^{o}) compared to habitual standing (26±14^{o}) ($p<0.05$). Additionally, there was a significant decrease in T4/T5-T11/T12 kyphosis during 90^{o} abduction (21±2^{o}) compared to the chin position (29±2^{o}) ($p<0.05$). Missing data was imputed using the means of the given positions. Four imputations were made between 2 positions.
Conclusions: The 10 arm positions evaluated do not have significant effects on lordosis or AVR measurements. Only the hands unsupported position showed a significant decrease in maximum coronal curve angle compared to habitual standing, showing that unsupported positions that raise the arms above the shoulders may not be comparable to habitual standing. Similarly, only 90^{o} abduction of the arms significantly decreased the T4/T5-T11/T12 kyphosis angle compared to the commonly used chin position. This could potentially exclude positions that expose the hands for skeletal maturity assessment. Research is currently underway to identify whether the same effects are shown when comparing single and double-curves in females with AIS.

Acknowledgements: The Scoliosis Research Society and Alberta Spine Foundation provided funding to this project.

Figure 1. Comparison of the mean maximum curve angle among 10 arm positions (*p<0.05 vs boxed position).

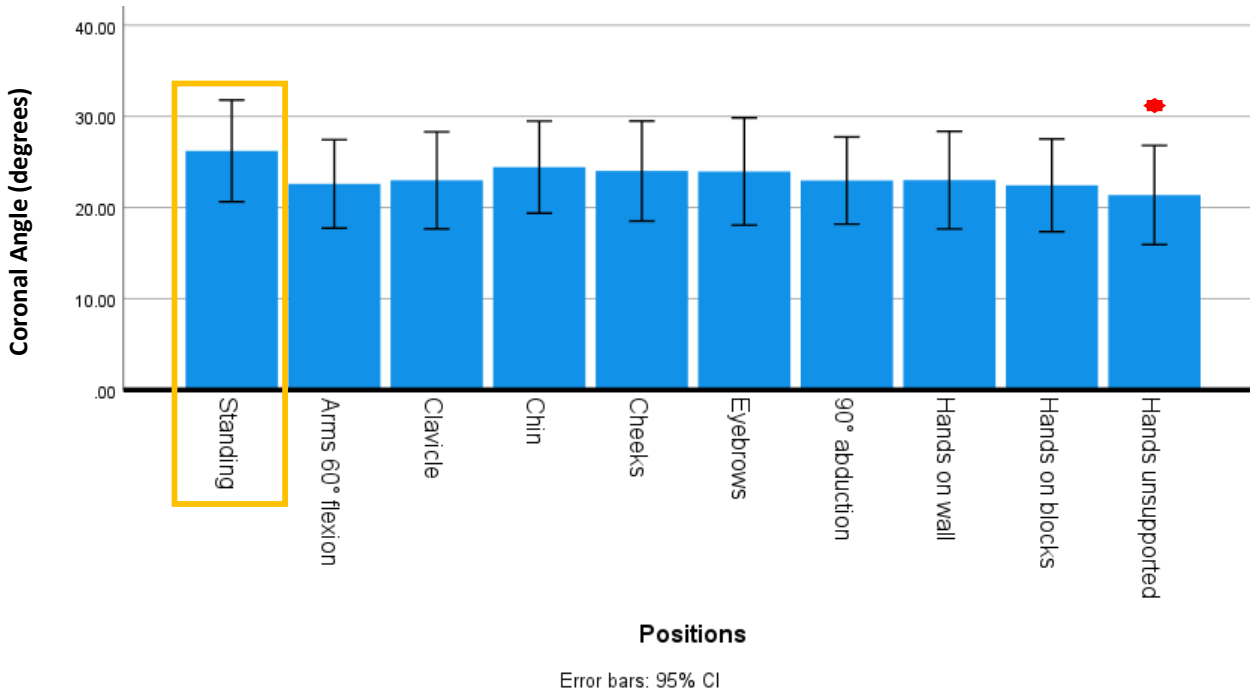
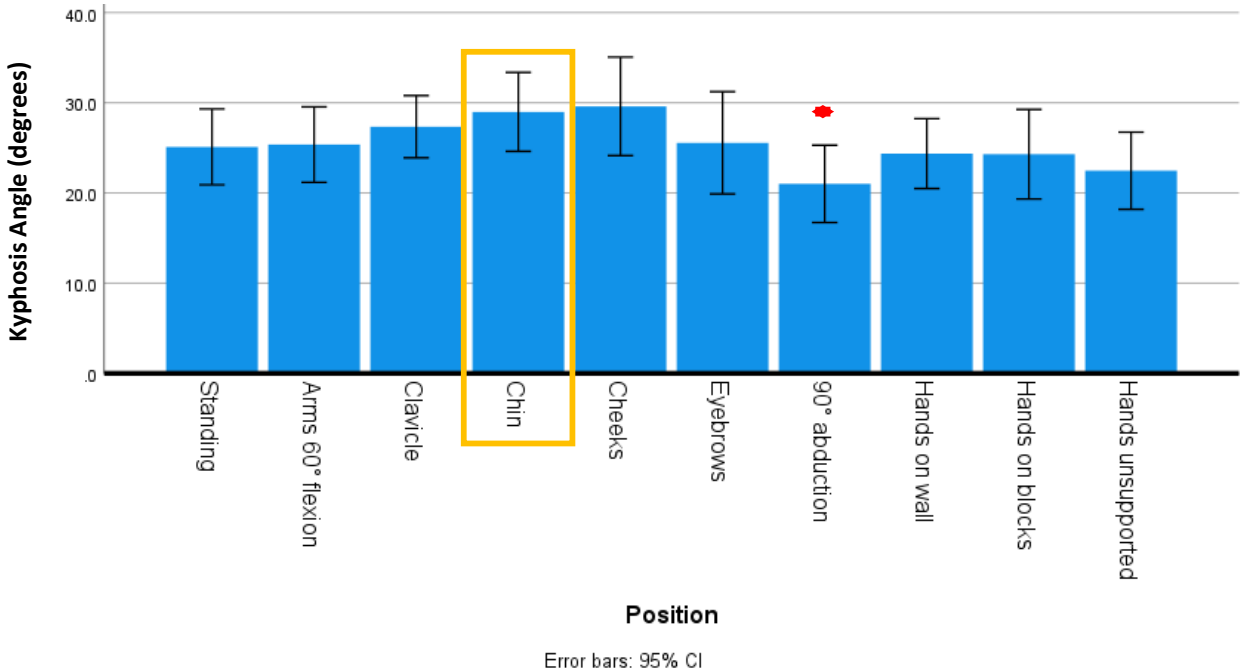


Figure 2. Comparison of the mean T4/T5-T11/T12 kyphosis angle among 10 arm positions (*p<0.05 vs boxed position)



O213

Validation of an artificial intelligence based method to automate cobb angle measurement on spinal radiographs of children with adolescent idiopathic scoliosis

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Introduction: Accurately measuring the Cobb angle on a posteroanterior (PA) radiograph is crucial for diagnosis and treatment decision of adolescent idiopathic scoliosis (AIS). However, manual Cobb angle measurement is time consuming and subject to human variation, particularly for inexperienced clinicians. Therefore, an automated method is sought to streamline clinical workflow and reduce measurement variation. Artificial intelligence (AI) has succeeded in segmenting features from medical images accurately. This study aimed to validate a novel AI-based algorithm that automatically measures the Cobb angle on PA radiographs by comparing with manual measurements and to evaluate its clinical feasibility in terms of measurement time.

Methods: Ethics approval was received. 330 spinal PA radiographs were extracted from the local scoliosis clinic. The inclusion criteria were: diagnosed with AIS, no prior surgery, not taken in-brace, and 55° > Cobb angle ≥10°. The 330 images were split into 130 images for AI model training, with data augmentation of random rotation, zooming, translation, and flipping to increase the number of images to >100,000, and 200 for validation. The spinal column and individual vertebral bodies (T1-L5) were segmented using convolutional neural networks, a type of AI model. The segmentation outputs were combined to form a fully automatic Cobb angle measurement algorithm. This method was validated by calculating the standard error of measurement (SEM), inter-method intraclass correlation coefficient ($ICC_{2,1}$), and percentage of errors within clinical acceptance (≤5°) between automatic-manual Cobb angle measurement pairs. A blinded rater with >20 years of experience performed the manual measurements. Results were further analyzed by curve region and severity (mild: <25°, moderate: 25°-45°, and severe: ≥45°). The $ICC_{2,1}$ values were not reported for curve severity groups because of the risk of attenuation when restricting the population variance.

Results: The AI method detected 346 of the 352 (98%) manually measured curves. The average Cobb angles of the 346 manual and automatic measurements were 24.7°±9.5° and 26.0°±10.5°, respectively. The SEM, $ICC_{2,1}$, and percentages within clinical acceptance for the different groups of analysis are tabulated in Fig. 1. All 6 missed curves were mild and ranged from 10°-21°. The clinical acceptance rates for curve severity and region groups ranged from 89%-100% and 90%-95%, respectively. The SEM for curve severity and region groups ranged from 0.97°-1.67° and 0.38°-0.99°, respectively. Fig. 2 shows image outputs from the automatic measurement algorithm allowing clinicians to quickly verify measurements. The average measurement time per image was 18±10s, which improves on the average 30s it takes an experienced rater to measure.

Conclusions: An AI-based algorithm was developed to measure the Cobb angle automatically on radiographs and yielded reliable measurements in quick time. Additionally, the algorithm outputs how the Cobb angle was measured, providing interpretability that can give clinicians confidence in the algorithm's measurements. Employing the method clinically could offer robust measurements to inform treatment decision in AIS and streamline clinical workflow.

Acknowledgements: This research was funded by the Stollery Children's Hospital Foundation through the Women and Children's Health Research Institute and the Natural Sciences and Engineering Research Council of Canada.

Grouping	# of curves manually measured	# of curves missed by proposed method	% within clinical acceptance (≤5°)	Standard error of measurement	Inter-method $ICC_{2,1}$
All	352	6	91% (316/346)	0.79°	0.92
Mild (<25°)	192	6	93% (173/186)	1.29°	--
Moderate (25°-45°)	148	0	89% (131/148)	1.67°	--
Severe (≥45°)	12	0	100% (12/12)	0.97°	--
Upper thoracic	37	1	95% (35/37)	0.49°	0.93
Main thoracic	150	2	90% (135/150)	0.99°	0.92
Thoracolumbar	44	1	95% (42/44)	0.38°	0.95
Lumbar	115	2	90% (104/115)	0.85°	0.88

Fig. 9 ***Automatic-manual Cobb angle paired measurement comparison results***

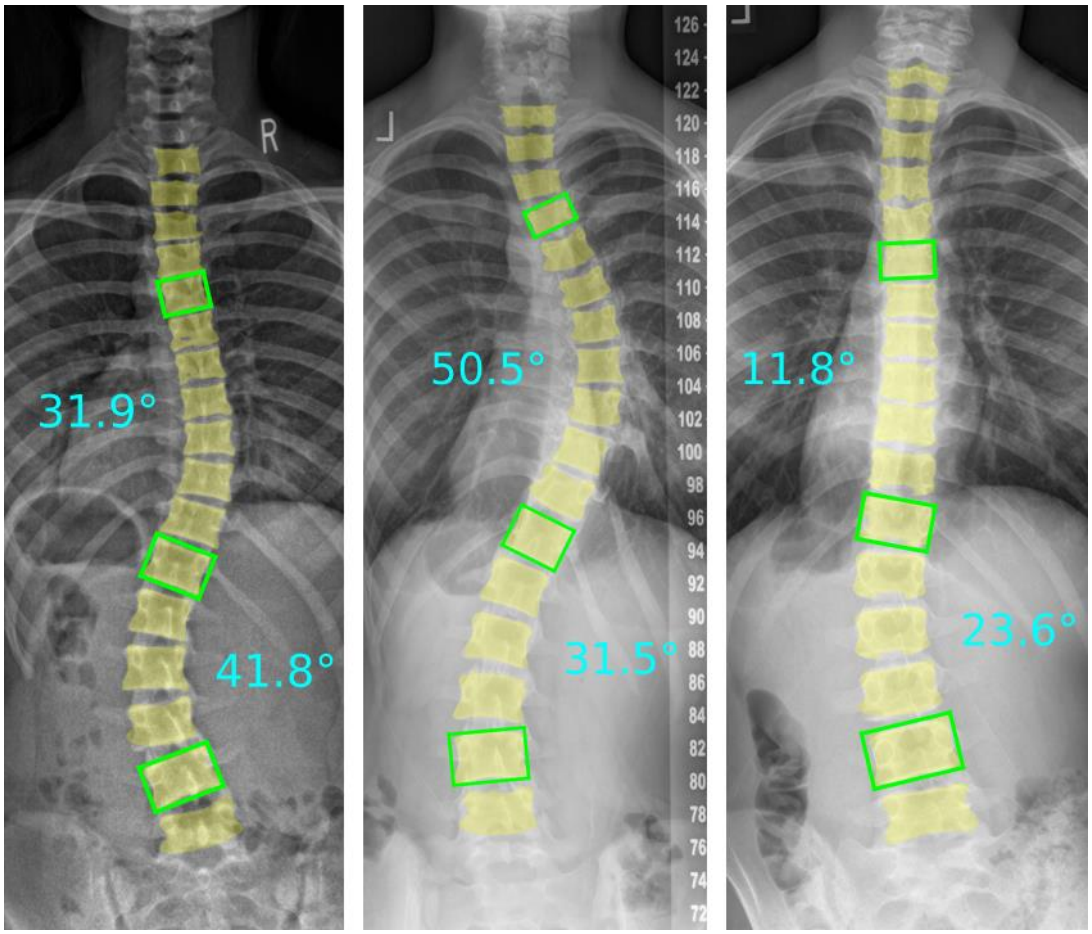

Fig. 10 ***Examples of automatic Cobb angle measurement outputs from the AI algorithm, with Cobb angles (cyan text) and relevant vertebrae (green boxes) labelled***

O214
Assessing the mental health landscape and need for counseling in the scoliosis community

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Introduction: The psychological impact of idiopathic scoliosis has been well established in the literature. Adolescents with scoliosis are at a greater risk for developing suicidal ideations, and while the diagnosis of scoliosis is concerning, bracing often compounds patients' stress levels. While it has not been studied in this population, counseling can be an effective coping strategy for adolescent patients with chronic illness. Therefore, the purpose of this study was to assess the current mental health landscape in the scoliosis community and to assess the need for counseling.
Methods: This study consisted of a cross-sectional survey. The survey included the SRS-22r, BSSQ-Brace, and questions about demographics, mental health, Scolios-us Mentor Program, and general scoliosis experience. The survey was distributed via email to Scolios-us Mentor Program participants and to scoliosis clinicians to provide to their patients. Responses about mental health, experiences with healthcare providers, and counseling were analyzed through a series of statistical testing for significant group differences and correlations.
Results: A total of 55 subjects were included in the final analysis, with a median age of 13 (IQR: 3) and diagnosis age of 10 (IQR: 4). Our results indicate that mental health is not being discussed as much as it is desired. A desire to discuss mental health was associated with lower function ($p=.005$), mental health ($p<.001$), SRS total scores ($p=.002$), and BSSQ-Brace scores ($p=.015$). If mental health was discussed by a scoliosis healthcare provider, subjects' management scores were higher ($p=.002$). If the physical therapist discussed mental health, subjects' self-image ($p=.020$) and SRS total scores ($p=.029$) were higher. If the orthotist discussed mental health, subjects' pain ($p=.014$) and BSSQ-Brace scores ($p=.011$) were lower. If the doctor, physician assistant, or nurse practitioner discussed mental health, subjects' management scores were higher ($p<.001$). Only 18.2% of subjects sought counseling, and most of these subjects found counseling to be very or extremely helpful. Half of subjects reported that they would prefer a combination of group therapy and individual therapy if they were to partake in therapy, followed by individual therapy (22.2%), group therapy (16.7%), and no preference (11.1%).
Conclusions: The mental health needs of scoliosis patients are not being met by the current healthcare system. Engaging in mental health discussions has the potential to increase outcomes, especially patients' satisfaction with their treatment. However, our results indicate that healthcare providers are not initiating conversations about mental health on a regular basis. As practitioners, the ability to acknowledge the desire to discuss mental health and refer patients to a clinical psychologist who is trained to meet those emotional and mental needs may improve our holistic approach to scoliosis care.

O215

Schroth – PSSE exercises can reduce the risk for progression during the peak of growth in curves below 25º: Prospective control study

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Introduction: The main treatment aim in mild scoliosis is to prevent progression and if possible, to avoid bracing. There is growing evidence that Physiotherapeutic Scoliosis Specific Exercises (PSSE) are superior to general or non-specific exercises. The objective of this study was to evaluate the efficacy of Schroth - PSSE, as an exclusive treatment, during the riskiest period of rapid growth.
Materials and Methods: Prospective Control study. 163 patients (148 girls – 15 boys, mean age 12.6 years, Risser sign 1.1, Thoracic (Th) Cobb angle 19.8º and Lumbar/Thoracolumbar (L/TL) Cobb angle 20.7º) performed Schroth - PSSE exercises in our clinic. They attended regular supervised sessions with a Physiotherapist and followed a home-program 5 times per week. Inclusion criteria were defined as Cobb angle > 15º, Risser 0-2 and Angle Trunk Rotation (ATR) > 5º, measured by scoliometer. The outcome parameters were the Cobb angle before and after the intervention (improvement or progression were defined as angle difference more than 5º) and the number of patients that finally needed a brace. Average follow up time was 20.1 months. Control group was consisted by 68 patients (63 girls – 5 boys, mean age 13.1 years, Risser sign 0-2, Cobb Th 18.6º, Cobb L/TL 18.9º). They were retrospectively analyzed and performed generic or no exercises.
Results and Discussion: For PSSE group, 13 patients (68.4%) remained stable, 3 (15.8%) improved and 3 (15.8%) worsened, while for Control group, 5 (22.7%) were stable and 17 (77.3%) worsened. 4 patients (21.1%) finally needed a brace for the PSSE group and 10 (45.5%) in Control group. The results seem to be significantly in favor of PSSE group, despite the fact that initial Cobb angle was higher than the Control group.
Conclusions and Significance: Schroth exercises (PSSE) reduced the risk of progression in Adolescent Idiopathic Scoliosis (AIS) patients, during the riskiest period of growth spurt. PSSE proved to be superior than general or no exercises. Our results are in accordance with the recently published literature, showing the effectiveness of PSSE, which should be the first step of scoliosis treatment, in order to avoid progression and bracing.

O216

Effectiveness of night-time brace or scoliosis-specific exercise for preventing progression of moderate-grade adolescent idiopathic scoliosis: Primary outcomes of a multicenter randomized controlled trial (CONTRAIS)

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Aim: Compare effectiveness of first-step interventions before considering full-time bracing for moderate-grade adolescent idiopathic scoliosis (AIS) according to CONTRAIS-trial primary outcomes.

Methods: Mulitcentre randomised controlled trial including patients with moderate-grade AIS (Cobbs angle 25-40°, apex Th7 or caudal, <1 year post-menarche, >1 year remaining growth). Treatments consisted of adequate self-mediated physical activity levels combined with either hypercorrective Boston brace night shift (NB), or scoliosis-specific exercise (SSE), or control (PA). Primary outcome was failure of treatment defined as progression of the Cobb angle >6 degrees, seen on two consecutive posteroanterior standing radiographs compared to the inclusion radiograph. Treatment success was defined as reaching skeletal maturity (<1.0 cm height growth over 6 months) without curve progression >6º. Pooled logistic regression and Kaplan-Meier survival analyses were performed according to Intention-to-treat and per-protocol principles weighted for treatment adherence and adjusted for baseline covariates (age, Risser, Cobb major curve and sex). Between group analyses were performed for surgery rate due to curve progression beyond the threshold of 50º of Cobb angle before reaching skelatal maturity despite transition to full-time bracing.

Results: 122/135 (90%) of patients remained in the study until endpoint. The average time in treatment for the NB, SSE and PA groups were 23.7 months (95% CI =19.8 to 27.6), 16.3 months (95% CI = 13.0 to 19.5), and 16.6 months (95% CI =13.4 to 19.7) respectively. In the intention-to-treat analysis, NB resulted in a higher success rate as compared to PA (74.4% vs 51.1%) and therefore a statistically significant lower hazard rate of treatment failure (HR=0.17; p=<0.001) which was similar in the per-protocol analysis (76.3% vs 32.4%; HR=0.04; p<0.001). The number needed to treat in order to prevent one case of curve progression with the NB was 4.3. There was no significant difference in the success rate or hazard rate of treatment failure for SSE compared to PA groups (57.8% vs 51.1%; HR=0.81; p=0.583), which was also similar in the per-protocol analysis (58.2% vs 37.1%; HR=0.63; p=0.408). Curve progression beyond the threshold of 50º Cobb angle before reaching skelatal maturity despite transition to full-time bracing required surgical intervention for 6 patients (13%) in the NB group, 8 patients (18%) in the SSE group and 11 patients (24%) in the PA group but there were no significant between-group differences (p=0.393).

Conclusions: NB demonstrated significantly higher success rate and therefore lower hazard rate of treatment failure compared to PA in the prevention of Cobb angle progress in moderate grade AIS. SSE did not show any significant clinical benefit when compared to PA.

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O217

Developing a new tool for scoliosis screening in a tertiary specialistic setting using artificial intelligence: A retrospective study on 10,813 patients

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Introduction: There is growing evidence supporting the efficacy of conservative treatment (e.g. exercises, soft and rigid bracing1) for Adolescent Idiopathic Scoliosis (AIS). As conservative treatment is more effective on skeletally immature spine, it is possible to obtain better results with early treatment 2. Thus, refined scoliosis screening can improve the care given to AIS patients. On the other hand, is important to consider that, while technological improvement has led in recent years to lower radiation dosage on x-ray examination, is not possible to nullify long-term cancer risk due to stochastic effect of radiation, even on low radiation dosage3. The aim of our study is to analyse if adding to the Angle of Trunk Rotation (ATR°) other fast and reliable clinical parameters can improve scoliosis screening.
Methods: We took into consideration 10,813 patients between 4 and 18 years old who underwent clinical and radiological evaluation for scoliosis in a tertiary clinic specialized in spinal deformities. After excluding patients who wore brace, had secondary scoliosis or did not have any hump, we analysed 7,378 cases. We considered ATR°, Hump (mm), visible asymmetry of waist, scapulae and shoulders, familiarity, sex, BMI, age, menarche (yes/no), localization of the curve. We implemented a Support Vector Machine (SVM) model to classify the Cobb angle according to different thresholds of 15, 20, 25, 30, and 40 degrees. We randomly split the dataset into 80%-20% for training and testing respectively. We used confusion matrices to evaluate the performances of the model for the different thresholds and we investigated the feature importance to understand which parameters contributed the most to model performances. Moreover, we compared the box plot of the variables between the correctly classified samples (True Positives) and the samples that should have been classified as positives, but were wrongly classified as negatives (False Negatives).
Results: The confusion matrices showed good performances in terms of accuracy using the different thresholds. In particular, the accuracies were 74%, 77%, 81%, 87%, and 93% for 15, 20-, 25-, 30- and 40-degrees thresholds respectively. As we expected increasing the threshold led to an increase in performance since a Cobb angle greater than 40 degrees is well reflected in the parameters collected and so it is easier to detect. For all the thresholds ATR°, Hump (mm), and visible asymmetry of waist were always in the top five most important variables for the prediction. The box plots showed that the samples that were wrongly classified as negatives had always statistically significant ($p<<0.01$) lower values of ATR° and Hump. This confirmed that these two parameters were very important for the correct classification of the Cobb angle.
Conclusions: Machine-learning based classification models have the potential to effectively improve the non-invasive screening for AIS thus reducing x ray exposure to healthy young individuals. Based on the positive results of the study, we might be able to develop, in a near future, a very flexible and easy-to-use tool, to enable physicians working in specialized setting to decide whether to prescribe radiographic imaging.

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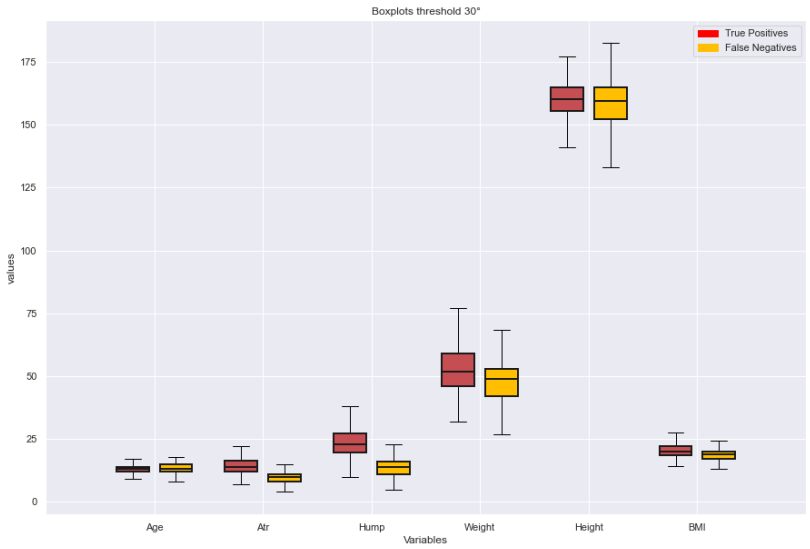

Figure 1: Comparison of the box-plot between True Positives (TP) and False Negatives (FN). It is clear that there is a significant difference in the distributions of the ATR and the Hump between the TP and FN. This confirmed that these two variables are important in the Cobb classification.

O218
Long-term outcome after brace treatment of Scheuermann's Kyphosis

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Introduction: In the literature, there are several papers on Scheuermann's kyphosis. It is a structural deformity of the spine that is classically characterized by anterior wedging of 5° or more of 3 adjacent thoracic vertebral bodies with kyphosis measuring greater than 45° between T5 and T12. Bracing treatment is able to obtain, during skeletal growth, remodelling of the deformed vertebras. The aim of this study was to confirm the effectiveness of conservative treatment in Scheuermann's kyphosis at a minimum follow-up of 10 years.
Methods: From a consecutive series of patients, included in a prospective database, we selected 158 patients with thoracic Scheuermann's kyphosis, treated using anti-gravity brace: 93 male, 65 female. The mean age at the beginning of the treatment was 14 years. Time bracing prescribed was max 20 hours daily, min 16 hours daily. Weaning was started when a full recovery of vertebral geometry was seen on a latero-lateral radiograph view or when growing was ended.
Radiographical measurements were performed on radiographs from a lateral projection, at the baseline (t1), at the end of the treatment (t2) and at 10 years of minimum follow-up (t3). To avoid the great variance in the range of curve angles in thoracic kyphosis that rely on the radiological position, x-rays were performed all observing the following position: standing with head straight, arms bent at 45° and hands placed on a support.
Were Analysed the anterior wedging angle (Alpha) of the apex vertebra and the degrees of the curve (Cobb methods).
Statistical Analysis was performed.
Results: The results from our study showed that of the 158 patients with a thoracic curve mean value of Cobb degrees was 57.6 ± 6.3 SD at baseline and 43.3 ± 7.8 SD at the end of treatment and at ten years of follow-up was 44.49 ± 7.4 SD (fig.2). The alpha angle was 14.43 ± 2.535 SD at baseline and 8.571 ± 3.589 SD at the end of treatment and at ten years of follow-up was 8.654 ± 3.57 SD.
The mean duration of treatment was 28.42 ± 12.07 months and the mean follow-up was 128.3 ± 11.07 months.
The difference between baseline and end of treatment, tested with One-Way Anova comparisons test, were significative ($p<0.0001$) for both Cobb and Alpha, instead the difference between end of treatment and follow up were not significative (p 0.3277).
Conclusions: The results confirm that conservative treatment in Scheuermann's Kyphosis, during skeletal growing, is effectiveness. The bracing treatment can obtain a remodelling of the deformed vertebrae. Furthermore, the correction is stable over time.

O219

A systematic review of machine learning models for predicting curve progression in teenagers with idiopathic scoliosis

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Introduction: Adolescent idiopathic scoliosis (AIS) is a common 3-dimensional structural spine change among adolescents that may compromise their physical and psychological well-being. The prediction of scoliosis progression remains challenging for doctors as they aim to tailor treatments based on patients' own progression risk. With the advancement of computational technologies, machine learning (ML) models have been developed to predict curve progression. However, no systematic reviews have summarized the predictor variables used and the accuracy of ML models in predicting curve progression in patients with AIS.
Aim: To systematically review literature regarding the development and validation of ML models using data collected at the first clinical visit to predict ensuing curve progression in patients with AIS.
Methods: Six scientific databases (CINAHL, Web of Science, MEDLINE, Scopus, PubMed and IEEE Xplore) were searched from inception to 21 September 2022. Reporting follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Two independent reviewers screened the titles, abstracts, and full-text articles to identify eligible articles based on predetermined selection criteria, and extracted relevant data. The Checklist for Critical Appraisal and Data Extraction for Systematic Reviews of Prediction Modelling Studies (CHARMS) was followed. The methodological quality of the included studies that developed ML models was conducted in accordance with the 6-domain IJMEDI checklist (problem understanding, data understanding, data, preparation, modelling, validation, and deployment).
Results: Of 2,111 identified unique publications, 57 articles were identified for full-text screening. Eighteen studies were included involving 3,884 patients with AIS and 40 ML models. Thirteen included studies developed 22 ML models to predict the risk of curve progression, 4 included studies developed 6 ML algorithms for predicting reaching curve severity thresholds of 25° for AIS with thoracic-thoracolumbar curves and lumbar curves (1 study), 40° (2 studies), 45 and 50°(1 study). Another 11 ML models in 3 included studies predicted the Cobb angle at a specific final clinical visit, while 1 included study predicted the curve shape and pattern variations. IJMEDI checklist revealed that a high percentage of the included studies had critical shortcomings in 4 aspects (61% in data understanding, 83% in data preparation, 95% in validation, and 95% in deployment). The identified ML models showed high accuracy, with the area under the receiver operating characteristic curve ranging from 0.70-0.85 in the category of curve progression prediction. However, most of the included studies were conducted in a single centre (16 studies), retrospective in nature (9 studies), and lacked internal and external validation (1 study included both internal and external validation, 11 studies were internally validated, and 6 studies had unclear reporting of validation).
Conclusion: While 40 ML models have been developed for AIS curve prediction, some deficiencies were noted in the development process and external validation of models. Importantly, no ML models have been evaluated or generalized to other clinical settings. Future studies should address these limitations and validate existing ML models in one or more clinics.

O220

The impact of pregnancy on women with adolescent idiopathic scoliosis: A scoping review

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Introduction: Adolescent idiopathic scoliosis (AIS) is the most common spinal deformity encountered in adolescents. Small deformities are equally encountered in boys and girls. However, larger curves are more prevalent in girls. AIS is associated with decreased quality of life, cosmetic deformity, visible disability, pain, and progressive functional limitation. For females with AIS, women's health issues are of particular concern in this population, especially pregnancy. As scoliosis management can range from simple observation to, in severe cases, surgery, it is essential to understand how this deformity may impact pregnancy outcomes.
Aim: This scoping review sought to summarise the best available evidence to determine how pregnancy may affect any spinal-related changes in women with AIS and how AIS may impact pregnancy and childbirth, differentiating patients who have been conservatively or surgically managed for AIS.
Methods: A scoping review design was selected to summarise the evidence describing pregnancy-related and scoliosis outcomes in childbearing patients diagnosed with AIS. The scoping review followed the PRISMA-ScR guidelines. A search was conducted using CINAHL, Scopus, Cochrane Database, MEDLINE, and EMBASE from inception to May 2022 to identify relevant articles in any language. Studies were included if they included pregnant women with a diagnosis of scoliosis of unknown aetiology (primiparous or multiparous). The results are summarized by outcomes, including pregnancy-related and scoliosis outcomes in patients conservatively managed for AIS and those surgically managed for AIS.
Results: Our comprehensive search strategy identified 6242 articles, of which 43 articles were considered eligible for this review. There were 20 cohort studies, 13 case-control studies, 4 case series, and 6 case report studies. Outcomes considered included: pain relating to pregnancy, pregnancy complications (e.g., pre-eclampsia), number of successful pregnancies and deliveries, epidural analgesia usage and success rates, types of delivery (vaginal or caesarean section), perinatal complications, back pain after delivery, and curve progression. Back pain appears to be more prevalent in this population during pregnancy and associated with the major curve and the decrease of lumbar lordosis. Although among patients with instrumented scoliosis correction, there have been reports of failed attempted spinal anaesthesia and minor complications related to epidural anaesthesia at a higher rate compared to non-instrumented patients and healthy controls, successful spinal analgesia can be achieved in patients with instrumented scoliosis correction. Overall, the caesarean section rate was similar in patients with AIS compared to controls without AIS, and to national averages. Minor curve progression often occurs during pregnancy in conservatively managed patients, whereas curves appear to remain stable in those with spinal instrumentation. The long-term outcomes and significance of these results remain unknown.
Conclusions: Higher quality prospective longitudinal research is needed to understand the relationship between pregnancy and AIS better. Further, the patient perspective, concerns and fears going through pregnancy with scoliosis have yet to be explored. Understanding the impact of pregnancy on women with AIS would have clinically relevant outcomes and could help provide pertinent answers to patients and healthcare workers.

O221

A systematic review comparing spinal alignment between standing positions in healthy adolescents or adolescents with idiopathic scoliosis

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Introduction: Adolescent Idiopathic Scoliosis (AIS) is assessed using repeated x-rays during growth. New stereo-radiography systems take frontal and lateral images simultaneously, requiring the arms to be elevated to see the vertebrae laterally. This affects sagittal angles. Imaging positions vary between centres. This study aimed to systematically review literature of the effect of arm positions used during radiography on spinal parameters in adolescents with AIS and healthy spines.
Methods: This review was registered in PROSPERO (CRD42022347494). Studies included assessed healthy participants ≥10 years old and with AIS between 10 and 18 years old with Cobb angles > 10° and compared arm positions in standing. Databases searched from inception to June, 2022 included CINAHL (EBSCO), EMBASE (OVID), MEDLINE (OVID), and WEB OF SCIENCE. The selection of population, imaging methods, measurements and positioning search terms was informed by a scoliosis expert, MSc student, and a librarian. Two reviewers screened titles and abstracts, then full-text articles and conflicts were resolved by a third reviewer. The effect of different arm positions on spinal alignment measurements were extracted. Quality was analyzed using the appraisal tool for Cross-Sectional Studies (AXIS). Meta-analysis was done if 2+ studies reported similar measurements and positions. Summary statements were formulated for other results.
Results: We screened 1332 abstracts and 33 full-texts and extracted data from 7 studies. The most common positions were habitual standing, fists on clavicle, and active (arms raised unsupported). Kyphosis, lordosis, and sagittal vertical axis (SVA) were most commonly measured. From meta-analysis, limited evidence from 3 low quality studies for a medium to large effect size of 0.78 [0.48,1.09] where kyphosis was smaller, and -1.23 [-1.55, -0.90] where lordosis was larger in the clavicle position compared to standing. Strong evidence from 2 high and 1 low quality studies shows a negligible effect size of 0.06 [-0.32, 0.21] where lordosis is larger in the clavicle position compared to active. Strong evidence from 2 high and 1 low quality study shows a negligible effect size of 0.03 [-0.38, 0.45] where kyphosis is larger in the clavicle position compared to active. Limited evidence from 2 moderate and 1 low quality study showed a posterior SVA shift by 31mm [24, 37] in the clavicle vs standing position. Moderate evidence from 1 high and 2 low quality studies showed SVA shifts posteriorly by -2mm [-3.4,-0.6] in active compared to standing. Qualitative review found limited evidence from 1 high or moderate quality study of no difference in curve angle or vertebral rotation between hands on wall and clavicle positions, and smaller T5/T12 kyphosis in the wall compared to the clavicle position. Further, a single study compared kyphosis, lordosis, or SVA for 8 pairs of other positions.
Conclusion: Evidence showed that elevated arm positions modify sagittal measurements compared to habitual standing. Some differences exist among elevated arm positions suggesting they may not be interchangeable. Most studies did not report on all relevant parameters. While clavicle is most used, it is unclear which position represents habitual standing. Research gaps and heterogeneity justify more research.

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O222

The validity of surface topography and plumbline measurement of sagittal balance & lumbar lordosis in adults

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Introduction: Sagittal balance and lumbar lordosis magnitude is associated increased with back pain and poor quality of life. Due to increased cancer risk and cost, repeated radiographic assessment is inappropriate for rehabilitation settings. We aimed to evaluate the construct validity of non-radiographic measures of sagittal balance and lumbar lordosis and explore the clinical thresholds for the classification of anterior sagittal balance determined non-radiographically.
Methods: We conducted a cross-sectional study, where sagittal vertical axis (SVA) and lumbar lordosis was measured with surface topography and plumbline non-radiographic methods and compared to EOS (radiographic gold-standard), in 63 adult participants (70% female, mean age 73 (SD 8.6) years). Intra-class correlation (ICC(2,k)), Bland Altman plots with 95% limits of agreement and Pearson's correlation were used to evaluate the validity of non-radiographic measures. Surface topographic and plumbline thresholds for classification into anterior sagittal balance were explored by generating receiver operating characteristic (ROC) curves based on SRS-Schwab classification of 40mm SVA.
Results: There was good agreement between radiographic sagittal balance and surface topography ICC(2,k) =0.780, and plumbline ICC(2,k) =0.816, measurements. The standard error of the estimate between radiographic and non-radiographic measures of sagittal balance was 33.2 mm for surface topography and 29.8 mm for plumbline measurement. Intra-rater reliability for plumbline measurement of sagittal balance (ICC(2,k)=0.972) and lumbar lordosis apex depth (ICC(2,k)=0.950) was excellent. The ROC curve determined thresholds of 21.5mm (sensitivity 73%, specificity 76%) for surface topography and 40mm (sensitivity 77%, specificity 84%) for plumbline measurement may be considered thresholds for anterior sagittal balance classification. There was fair correlation (r=0.45) and moderate agreement (ICC(2,k)=0.505) for lumbar lordosis magnitudes between radiographic and surface topography measurements. Correlation for lumbar lordosis magnitude between radiographic and a non-radiographic surrogate measurement, lumbar lordosis apex depth, was moderate (r=0.55) for surface topography and fair (r=0.47) for plumbline.
Conclusion: Plumbline and surface topography measurement have good validity and excellent reliability in adult populations for SVA, but further investigations are required to clarify the wide error margins. This suggests that non-radiographic methods of measuring sagittal balance have utility and repeatability in rehabilitation practice but should, at present, not replace radiographic imaging for diagnostic decisions regarding sagittal balance classification. Similarly, population and can be utilised for monitoring. However, the sub-optimal agreement with radiographic lumbar lordosis measurement suggests that non-radiographic measurement should not replace radiographic imaging for diagnostic purposes., the reliability of non-radiographic measurement of lumbar lordosis is excellent in rehabilitation settings for this.

O223

Correlation analysis of Cobb angle and linear spinous process angle in adolescent idiopathic scoliosis

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Introduction: The Cobb angle is significantly associated with curved spinous angle (SPA) which can be a good indicator to assess scoliosis in patients with adolescent idiopathic scoliosis (AIS), but there is no evidence definitely determining the relationship between Cobb angle and linear SPA. The study is to analyze the correlation of Cobb angle and linear spinous process angle (SPA) in adolescent idiopathic scoliosis (AIS) and discuss the possibility of assessing scoliosis by linear SPA.
Methods: Retrospective study. AIS patients treated and taken full spine anteroposterior x-ray in the 3rd affiliated hospital of Zhejiang Chinese Medical University in the past three years were analyzed correlation of Cobb angle and linear SPA which is the angle between the two lines drawn each by connecting the spinous process tip of the upper terminal vertebra with the spinous process tip of apical vertebra and connecting the spinous process tip of the lower terminal vertebra with the spinous process tip of apical vertebra on the x-ray film.
Results: A total of 113 AIS patients with age of 14.02±2.16 years were recruited, involving 26 males and 87 females; there were 71 cases with mild AIS and 42 cases with moderate AIS. Cobb angle in AIS patients is significantly inversely associated with SPA（r=0.564, P<0.001）, the linear regression equation is: Cobb angle=169.44-0.87×SPA; Cobb angles in patients with mild scoliosis are significantly and inversely associated with SPA（r=0.269, P=0.012）, the linear regression equation is: Cobb angle=46.83-0.18×SPA；Cobb angles in patients with moderate scoliosis are also clearly correlated with SPA（r=0.417, P=0.003）, the linear regression equation is: Cobb angle =113.89-0.52×SPA.
Conclusion: Linear SPA is significantly negatively correlated with Cobb angles, but the regression equation fits poorly, so it's not suitable for diagnosis of scoliosis; however, linear SPA is appropriate for self-controlled assessment of scoliotic therapy or for dynamic assessment of spinal flexibility.

O224

Evaluation of apical vertebrae rotation of subjects with adolescent idiopathic scoliosis using 3D ultrasonography

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Introduction: Axial vertebrae rotation (AVR) is a crucial parameter to evaluate the effectiveness of non-surgical treatments, such as brace and physiotherapeutic scoliosis specific exercise, for patients with adolescence idiopathic scoliosis (AIS). To monitor the effectiveness of these treatments, a tool which would provide reliable and repetitive AVR information of the scoliotic spine is essential. In current clinical practice, AVR is either evaluated indirectly by scoliometer in a forward bending posture or directly from the 3D reconstruction data obtained from bi-planar X-ray and computer tomography systems, which requires the usage of radiation and therefore not recommended for excessive application. Three-dimensional (3D) ultrasonography is radiation-free and is demonstrated to provide reliable coronal and sagittal assessments of scoliotic spine of patients with AIS, however, its validity and reliability on AVR assessment is yet to be investigated.

Aim: The aim of this study was to investigate the reliability of AVR obtained using 3D ultrasonography and evaluate the validity of the results by comparing with the AVR obtained from EOS bi-planar system.

Methods: 29 patients with AIS received EOS bi-planar radiographs and 3D ultrasonography scans in weight-bearing posture on the same day. 55 curves of average coronal Cobb angle 26.9 ± 11.3° were extracted from the patients and analyzed. Two raters with different experiences of AVR measurements using 3D ultrasonography performed AVR measurements on the 3D ultrasonography images using a dedicate software. Intra-rater, inter-rater and inter-method reliability were assessed using intra-class correlation coefficient (ICC). To further investigate the reliabilities, mean absolute difference (MAD) and standard error of measurement (SEM) also conducted. Furthermore, Bland Altman plot was employed to study the agreement and post-hoc linear regression were performed to investigate the possibility of bias between the AVR measurements of the two modalities.

Results: Pearson correlation coefficient of 0.901 was obtained between the AVR measurements obtained from EOS and 3D ultrasonography. No proportional bias was observed between the difference and mean of expected and radiographic Cobb angles ($p = 0.521$), with a mean error of 2.7°. Both ICCs for intra- and inter-rater reliabilities were no less than 0.95, with MAD and SEM no more than 2.2° and 1.1°, respectively.

Conclusions: 3D ultrasonography is demonstrated to generate reliable and valid AVR measurement in patients with AIS. In future, 3D ultrasonography could be used for screening and monitoring subjects with AIS and assessing the effectiveness of non-surgical treatments.

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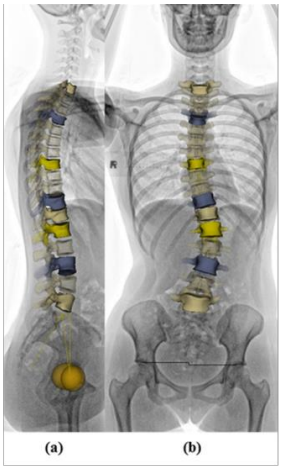

Figure 1. EOS full spine images of a patient with AIS in the (a) coronal

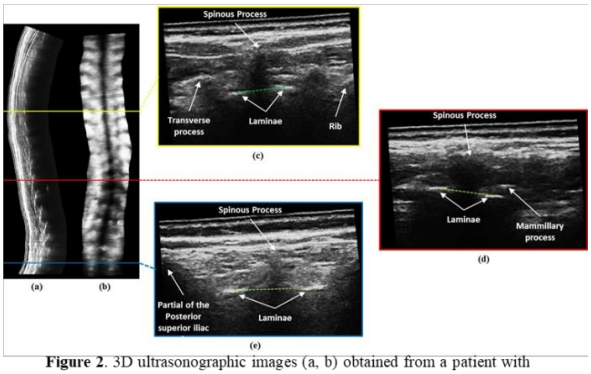

Figure 2. 3D ultrasonographic images (a, b) obtained from a patient with double curve AIS. AVR were assessed using the centre of laminae method on transverse images of (c) T8, (d) L1 and (e) S1.

O225

Correlation between the angle of trunk rotation (ATR) measured with a scoliometer and the Raimondi angle in patients with idiopathic scoliosis

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Introduction: Scoliosis is a three-dimensional condition with different impairments in each plane. In the axial plane, the scoliometer is widely used for screening and monitoring these patients, providing a clinical measurement of the angle of trunk rotation (ATR) during forward bending. The Raimondi angle is the corresponding radiographical measurement, providing the angle of vertebral rotation on standing X-ray. The main differences between these two measurements are the testing position and capturing internal or external changes.
Objectives: This study aimed to evaluate the correlation between the ATR and the Raimondi Angle in children and adolescents with idiopathic scoliosis.
Methods: This retrospective study was conducted using the database from a private clinic in Brazil including 102 patients sampled from 2021 to 2022 organized in alphabetical order and with clinical and radiological parameters available. The first forty-five participants of any gender, aged between 8 and 18 years old, were included. The exclusion criteria were lack of clinical or radiological information. Each participant was evaluated by means of a scoliometer for the ATR measurement and had the Raimondi angle measured on X-ray using the ISICO app during the first consultation. The Raimondi angle was obtained by inputting two measurements made with a ruler directly on the X-ray: the width of the apical vertebral body and the distance from the middle of pedicle to the edge of the vertebral body on the convex side. The Pearson's correlation was calculated between the ATR and Raimondi angles ($p<.05$). Correlation values were classified into: "insignificant" (<0.3); "low" (0.3 to <0.5); "moderate" (0.5 to <0.7), "high" (0.7 to <0.9) and "very high" (>0.9). With 45 subjects a correlation of 0.288 can be found significant at alpha 0.05.
Results: Fifty-seven patients were excluded for lack of information. The sample comprised 45 patients, of whom 37 were females. The mean age was 13.4±2.2 years, the height was 157.6±10.9 cm, the weight was 47±12 kg, and the BMI was 18.8±2.6 kg/m². The mean ATR was 9.4°±4.2°, the Raimondi angle was 16.8±8.3, and the Cobb angle was 34.1°±12.5°. The correlation between ATR and Raimondi angle was positive, low, and significant ($r= 0.465$; $p< 0.001$).
Conclusion: The findings of this study showed that there is a low correlation between the axial plane of scoliosis measured through the surface (ATR) in forward bending and internally in standing with the Raimondi angle. Based on our results, we suggest the use of both measurements for the evaluation and follow-up of patients with scoliosis, considering that the external and internal impairments on the same plane are not highly correlated. Both measurements provide relevant information and can be used for decision-making.

O226
Implementation and validation of automatic coronal Cobb's angle measurement with deep learning

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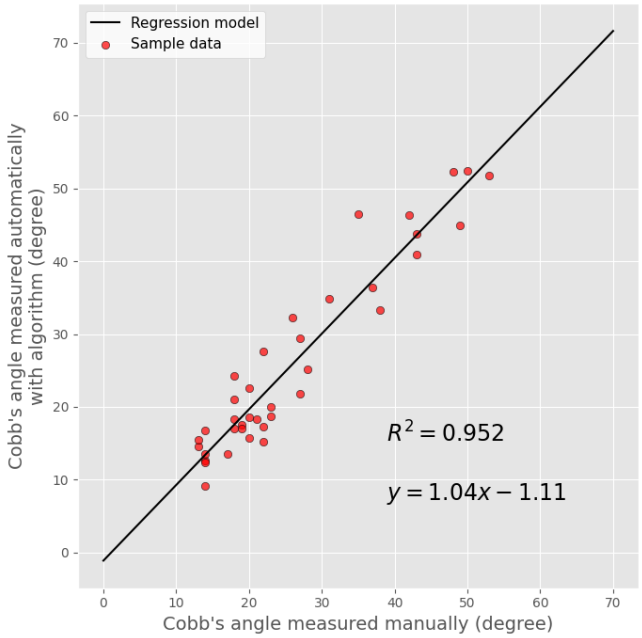
Introduction: Adolescent Idiopathic Scoliosis (AIS) is a 3D deformity of the spine that affects children. Cobb's angle measurement of spine radiographs is the gold standard for diagnosing AIS. However, it was found that high inter- and intra-operator variability (±9.6° and ±11.8° respectively) can be found during manual Cobb's angle measurement[1]. Furthermore, Cobb's angle measurement is a procedural task and can be automated, but yet typically done manually. Therefore, we proposed an automatic Coronal Cobb's angle measurement algorithm using readily available deep learning neural networks.
Methods: 39 patients with AIS (29F and 10M; Age: 15.8 ± 3.6 years) were recruited with varying severity of scoliosis (26.6° ± 11.3°). Patients were subject to scanning with the low-dose biplanar X-ray system, EOS, to acquire coronal full-body standing radiographs. Cobb's angles were manually measured, and landmarks corresponding to 4 corners of the vertebral bodies in coronal view were annotated by an expert. Another set of landmarks were acquired through prediction of a trained neural network on the same radiographs. An elimination-based Cobb's angle calculation algorithm was used to automatically calculate the Cobb's angle from the landmarks of the coronal radiograph.
Results: The manual Cobb's angle measurements and automatic Cobb's angle calculation showed a correlation of $R^2 = 0.952$ (Figure 2.). Manual annotations of vertebral body corner landmarks were taken as ground truth, and the model showed a Root Mean Square Error (RMSE) of 7.85 mm for landmark prediction.
Discussion: Results presented show that automatic Cobb's angle measurement of X-ray with a deep learning approach is feasible, with the added advantage of eliminating manual procedure associated with the method. Further studies with more subjects are needed to validate the reliability of the model with a larger dataset.

Reference:
[1]Loder R T, et al. "Variability in Cobb angle measurements in children with congenital scoliosis" *The Journal of Bone and Joint Surgery* 1995;77.5; 768-770.



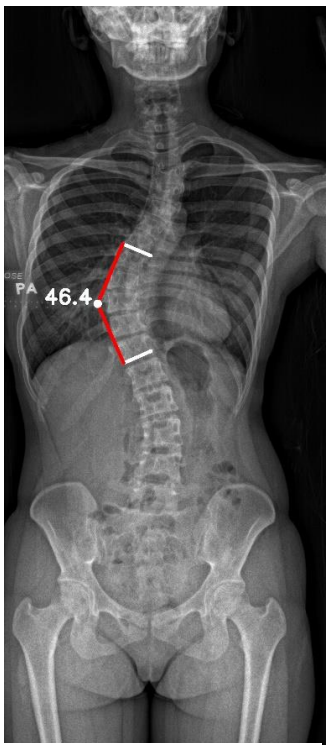


Figure 1 A typical example of automatic measurement of Cobb’s angle.

Figure 2 Correlation between automatic Cobb's angle measurement and manually measured Cobb's angle.

O227

Using vertebrae transverse features from 3d ultrasound to classify adolescent idiopathic scoliosis

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Introduction: Adolescent Idiopathic scoliosis (AIS) curve can be categorized into either structural or non-structural which depends on its skeletal morphology and flexibility. Using X-ray to characterize AIS curves remains the current clinical gold standard. Due to the concerns of the risks of excessive radiation exposure, in our previous works, 3D ultrasound imaging had proved the validity and reliability of the coronal measurement of spine with X-ray images; and 3D ultrasound had been demonstrated as a powerful alternative for classifying AIS curves using vertebrae spinous process. In addition, angle measurement using vertebrae transverse features had showed a closer correlation to X-ray Cobb, compared with that using vertebrae spinous process.
Aim: The aim of this study is to evaluate whether the newly proposed 3D ultrasound AIS curve classification method using vertebrae transverse features could outperformed the previous method using vertebrae spinous process to classify scoliotic curves, compared with X-ray results.
Patients and Methods: 33 AIS patients (16M and 17F; Age:13.2 ±1.5 years; Cobb: 14.7±3.9°) underwent both 3D ultrasound and X-ray scanning on the same day, where each had one standing X-ray with ultrasound images from three postures: erect, bending to left and right (**Fig.1**). For each case, an experienced clinician measured Cobbs as ground truth. Bending asymmetry index (BAI) was automatically calculated from the lateral bending profiles to characterize the location and magnitude of the structural curve. The new method involves the vertebrae transverse features (transverse process in thoracic and lumber lump in lumbar) for interpolating the spinal lines, was denoted as BAItp method (**Fig.2**).; while our previous published method using vertebrae spinous process as BAIsp method. Given that asymmetrical pattern was used to indicate the deviation between spine bilateral profiles, a larger BAItp / BAIsp generally implicated a worsen structural curve. With the BAItp / BAIsp results, the curve classification will be automatically translated with respect to Lenke Classification.
Results: It was shown that 73% of the subjects using BAIsp method (AUC=0.823, $p<0.001$) and 85% of the subjects using BAItp method (AUC=0.905, $p<0.001$) had correct curve classification against X-ray (**Fig.3**).
Conclusions: The study demonstrated the feasibility of using 3D ultrasound methods for AIS curve classification. Some discrepancies from ground truth could be explained by image registration error, motion artefacts or severe vertebrate rotation. Further studies will be conducted to evaluate the 3D ultrasound methods with a larger cohort and automate the entire procedures through deep learning approaches.

Acknowledgements: This study is partially supported by Research Impact Fund of Hong Kong Research Grant Council (R5017-18) and Health and Medical Research Fund of the Hong Kong (04152896).

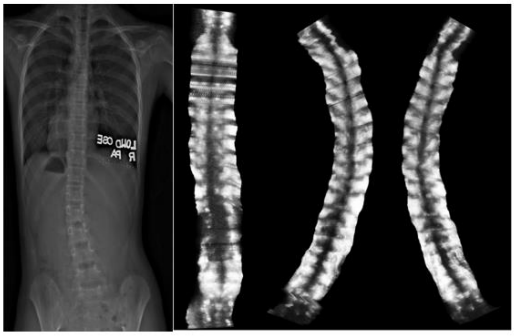

Fig.1 Examples of same-day X-ray (left) and 3D ultrasound images (right): from left to right, erect, bending to left and right, respectively.

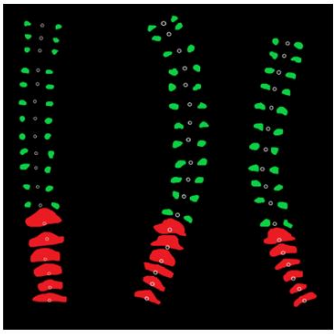

Fig.2 Examples of BAItp method interpolation from vertebrae transverse features.

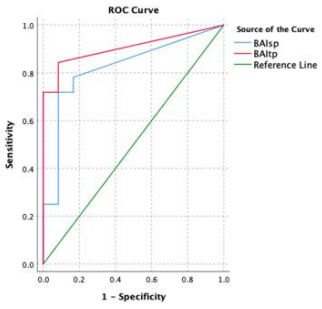

Fig.3 AUC analysis of BAItp and BAIsp methods.

O228

Intra- and Inter-evaluator reproducibility of Raimondi vertebral rotation angle measured by using the ISICO app in patients with AIS

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Introduction: The measurement of the vertebral axial rotation on X-ray provides relevant information and can be used for decision-making in some scoliosis-specific exercise (SSE) approaches. The reproducibility of this measurement is an important aspect for the decision-making process with implications for interpreting follow-up data.
Objective: To quantify the intra- and inter-evaluator reproducibility of the Raimondi vertebral rotation angle measured using ISICO app.
Methods: This retrospective study was conducted using the database from a private clinic in Brazil including 195 patients sampled from 2016 to 2022 in alphabetical order and available as digital X-rays. Patients with idiopathic scoliosis aged from 7 to 17 years old, with Risser 0 to 5 were included. The exclusion criteria were poor quality of the X-ray image and surgical treatment. For the measurement of the Raimondi angle, each X-ray was evaluated by four examiners using the ISICO's app. The Raimondi angle is obtained by inputting two measurements made with a ruler directly on the X-ray screen: the width of the vertebral body and the distance from the middle of pedicle to the edge of the vertebral body on the convex side. For the intra-evaluator reproducibility, two examiners measured each X-rays three times in two different occasions separated by 2 to 14 days. For interevaluator reproducibility, the examiners assessed all the radiographs once. Evaluators were blinded to each other and to their prior measurements. All examiners are certified to offer conservative treatment of scoliosis using the SEAS approach. Three are physiotherapists and one is a physiatrist. The examiners have 1 to 15 years of experience. The Intraclass correlation coefficient ($ICC_{3,1}$), standard error of measurement (SEM), and the minimal detectable change (MDC95%) were calculated ($p<.05$). The sample size required was 41 subjects (n=4 evaluators; $\alpha= 0.05$; $\beta= 0.20$; $H_0= 0.4$; $H_1= 0.6$). To prevent issues with sample loss we arbitrarily included 55 X-rays to measure.
Results: A total of 9 radiographs were excluded due to poor image quality. The sample comprised 46 to 52 for the intra-evaluator analysis depending on the number of images excluded by different examiners and 47 radiographs for the inter-evaluator analysis. The sample included 38 thoracic curves and 40 lumbar curves. For the intra-evaluator analysis of each rater, the $ICCs_{(3,1)}$ ranged from 0.95 to 0.99, with SEMs from 1° to 2° and MDC95s from 3° to 6° (table 1). For the inter-evaluator analysis, the $ICC_{(3,1)}$ was 0.75 for thoracic vertebral rotation and 0.73 for lumbar, both with SEM of 5° and MDC95 of 14°.
Conclusion: The Raimondi angle measured using the ISICO's app has adequate intra- and inter-evaluator reproducibility. The most precise measurement was obtained by using the same evaluator.

Table 1: Intra- and inter-evaluator reliability of Vertebral Rotation measurements of the thoracic and lumbar curves using the Raimondi method in the ISICO app.

		Sample	Vertebral rotation (Mean±SD)	$ICC_{(3,1)}$	95%CI	SEM	MDC
Intra-evaluator (# 1)	Thoracic	n= 46	10±16°	0.99	0.93 - 0.97	1°	3°
	Lumbar		15±9°	0.98	0.97 - 0.99	1°	3°
Intra-evaluator (# 2)	Thoracic	n= 52	15±9.6°	0.95	0.92 - 0.97	2°	6°
	Lumbar		16±10°	0.98	0.97 - 0.99	1°	4°
Inter-evaluator	Thoracic	n = 47	13±10.4°	0.75	0.63 - 0.85	5°	14°
	Lumbar		15±9.5°	0.73	0.61 - 0.84	5°	14°

O229

Changes in surface topography asymmetry are related to global ratings of change in adolescents with idiopathic scoliosis in the Schroth exercise trial for scoliosis

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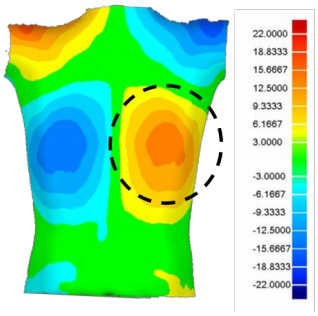
Introduction: Adolescent idiopathic scoliosis (AIS) is an abnormal three-dimensional curvature of the spine noted between the ages of 10 and 18 during rapid growth. Bracing and exercise can improve back appearance through postural correction. Surface topography (ST) objectively assesses torso appearance by evaluating external asymmetry. Yet, it is unclear how much change in ST measures is needed for patients to perceive as an improvement in their back condition. This study aimed to determine the association between perceived improvement in back status and changes in ST asymmetry measurements in patients treated for AIS and the ability of ST asymmetry measurements to detect patients perceiving improvements in response to treatment.
Methods: This is a secondary analysis from a randomized controlled trial comparing a standard care (n=60) and Schroth group (standard care + 6-months Schroth therapy, n=64). Standard care included observation or bracing. Participants were 10- to 16-year-old, with Cobb angle ranging from 10° to 45°, and no previous spine surgery. Full-torso ST scans were obtained at baseline and 6-months to quantify torso asymmetry changes. Deviations were measured between a reflection of the three-dimensional torso geometry and the original torso shape after aligning to minimize the distance using the best plane of sagittal symmetry A threshold of ±3mm was used to distinguish asymmetries due to scoliosis from normal deviations (fig.1). ST asymmetry measurements were root mean square (RMS) and maximum deviation (MaxDev) of the area with the largest asymmetries. The global rate of change (GRC) was self-reported at 6-months. Correlations between changes in ST measurements and the GRC were tested using a Pearson coefficient. GRC ratings defined two groups: improved (+2 little bit to +7 Very great deal better) and not improved (+1 to -7). Receiver-operating characteristic (ROC) curve helped determine the threshold for each parameter corresponding with the best balance between sensitivity and the false positive rate. The diagnostic accuracy for perceived improvement of meeting both the RMS and MaxDev threshold was also examined.
Results: Descriptives are in table 1. Fifty-eight of the 126 participants were lost to follow-up (n=17) or had missing data (n=41). GRC scores correlated with RMS (r=-0.27, p=0.03), and MaxDev (r=-0.25, p=0.04). For participants classified as improved with GRC ≥2, RMS and MaxDev decreased by 1.07mm (95%CI-2.0;-0.2) and 2.01mm (95%CI-3.6;-0.4), respectively. Likewise, for participants without improvements (GRC <1), RMS and MaxDev increased by 0.59mm (95%CI-0.5;1.7) and 0.53mm (95%CI-1.0;2.1), respectively. From the ROC analysis, a minimal decrease of -0.217mm for RMS and a maximal increase of 0.386mm for MaxDev showed the best compromise between sensitivity and false positive rate. Meeting both threshold for surface asymmetry improvements helped detecting perceived improvements (Table 1). Accuracy, sensitivity, and specificity of 62%, 56%, and 69% were obtained. In addition, a positive likelihood ratio of 1.8 and a negative likelihood ratio of 0.6 was obtained.
Conclusion: A significant relationship was observed between perceived improvement of patients undergoing treatment and changes in torso asymmetry measured by RMS and MaxDev. ST thresholds were proposed that potentially detect patients perceiving improvement with an accuracy of 62%.



$$MaxDev = Max(Deviations_i)$$

$$RMS = \sqrt{\frac{\sum(Deviations_i)^2}{n}}$$

$$i = 1, \cdots\cdots, n$$

Figure 11: Surface topography assessment showing areas of deviations. RMS and MaxDev was computed for the largest asymmetry patch area

Table 2: Baseline characteristics of participants and classification comparison of improvement based on the Global Rating of Change and the Surface Asymmetry threshold of improvement

Baseline Characteristics of Total Participants (n=68)	
Age (years)	13.2 (12.8; 13.5)[a]
Height (m)	1.6 (1.6; 1.6)[a]
Weight (kg)	45.5 (43.4; 47.6)[a]
Observation	10 (15%)[b]
Braced alone	23 (34%)[b]
Exercise alone	14 (21%)[b]
Braced + Exercise	21 (31%)[b]
Curve Type	3c (7;10%)[b] 4c (8;12%)[b] 3cp (24;35%)[b] 4cp (29;43%)[b]
RMS (mm)	12.2 (11.1; 13.3)[a]
MaxDev (mm)	17.5 (15.6; 19.4)[a]
Classification Results	
True positive (GRC ≥2, Both ST measures improved)	20 (29%)[b]
False positive (GRC<2, Both ST measures improved)	10 (15%)[b]
True negative (GRC <2, ≥1 ST measure(s) not improved)	22 (32%)[b]
False negative (GRC ≥2, ≥1 ST measure(s) not improved)	16 (24%)[b]
Accuracy	62%
Sensitivity	56%
Specificity	69%

[a] Mean (95% Confidence lower; upper limit)
[b] Count (percent of whole sample)

O230

A novel 3D spinal model reconstruction based on biplanar digitally reconstructed radiographs using deep learning

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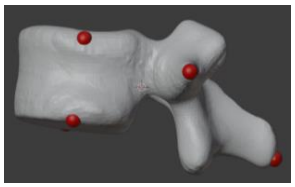
Introduction: Adolescent Idiopathic Scoliosis is a 3D deformity of the spine that affects children. 3D imaging methods of scoliosis using Computed Tomography (CT) is undesirable as it exposes patients to harmful radiation. Moreover, CT requires patients to be placed in supine position, consequently ruling out measurement of scoliosis under a weight-bearing position. Hence, 3D spinal reconstruction from low-dose standing radiographs have been research field of increasing interest. However, the current state-of-the-art method of low dose X-ray biplanar reconstruction is semi-automatic and takes about 20-30 minutes[1], rendering it undesirable in clinical routine settings.
Aim: The aim of this study is to develop an automatic biplanar reconstruction method of Digitally Reconstructed Radiographs (DRR) using Graph Convolutional Networks (GCN) and Convolutional Neural Networks (CNN) and validate the results with the corresponding ground truth CT data.
Methods: 104 CT scans were acquired from an online public CT dataset for vertebral deformation. The 3D mesh of CT scans were computed using the Medical Imaging Interaction Toolkit (MITK), and DRRs were generated using OpenGL written software. For each CT scan, vertebral meshes corresponding to vertebral level L1 – L5 were separated to make up a dataset size of 1768. Using statistical shape modelling, mean meshes for each vertebral level were computed from this dataset. Two neural networks predicting 3D position and vertebral 3D deformations from 2D images was used to align the mean meshes to DRRs.
Results: The mean Chamfer distances for the aligned mean meshes is 0.951mm, 1.52mm, 1.88mm, 2.5mm, and 1.77mm for L1, L2, L3, L4, and L5, respectively. For pose estimation, the Root Mean Square (RMS) error achieved was 7.41 mm.
Discussion: Results demonstrate and error of approximately 10% of the mean transverse diameter of vertebra bodies (~25 mm). More research must be done to investigate its performance on real-world X-rays, and to achieve more accurate results for vertebra reconstruction.

Reference:
[1]Somoskeöy S, Tunyogi-Csapó M, Bogyó C, et al. Accuracy and reliability of coronal and sagittal spinal curvature data based on patient-specific three-dimensional models created by the EOS 2D/3D imaging system. The Spine Journal 2012; 12(11); 1052-1059.

a)



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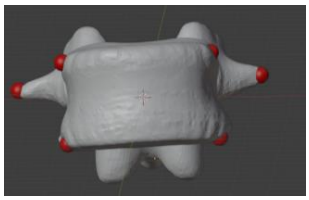

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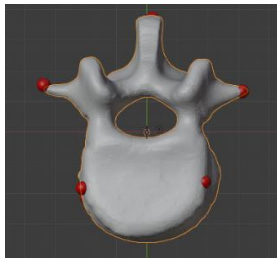

a) b)

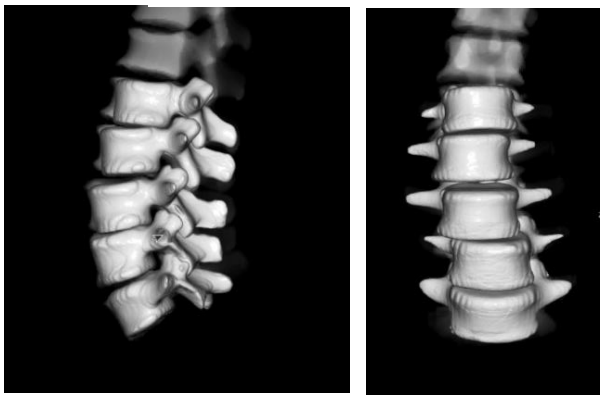

Figure 2 Alignment of mean meshes on DRR for L1-L5.
a) Sagittal view b) Coronal view

Figure 1 Points used for mean mesh alignment.
a) Sagittal view, b) Coronal view, c) Axial view

O231

A prospective external validation study to predict Cobb angle using deep learning algorithm with three-dimensional depth sensor considering the influence of garment in idiopathic scoliosis

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Introduction: Adolescent idiopathic scoliosis is most the common form of pediatric spinal deformity. Early detection of the deformity and timely intervention such as brace treatment will contribute to inhibit the progressive changes. A newly developed three-dimensional depth sensor imaging system with a convolutional neural network has been reported to predict Cobb angle.1 The purpose of the present study was to (1) evaluate the performance of the deep learning algorithm (DLA) in predicting Cobb angle using an independent external validation dataset, (2) to assess the predicting ability depending on the presence or absence of clothing in the prospective analysis.
Methods: We included 100 patients with suspected adolescent idiopathic scoliosis in this study. Patient 's back surfaces were shot under the following four shooting patterns: (1) Adam's forward bending without underwear; (2) Adam's forward bending with underwear; (3) Standing posture without underwear; (4) Standing posture with underwear. The correlation coefficient, Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) between the actual Cobb angles and predicted Cobb angles were calculated in each pattern.
Results: The correlation coefficient between the actual and predicted Cobb angles was 0.87(Fig.1), and the mean absolute error and root mean square error were 4.7˚ and 6.0˚, respectively in the Adam's forward bending without underwear (Table 1). There were no significant differences in the correlation coefficients between the group with and without underwear under the forward bending posture.
Conclusions: The performance of the DLA with 3D depth sensor was validated in predicting Cobb angle using an independent external validation dataset. Because the psychological burden of children and adolescents on naked body imaging is a unignorable problem, wearing underwear is valuable in clinics or physical examination at schools.

Reference:
[1]Kokabu T, Kanai S, Kawakami N, Uno K, Kotani T, Suzuki T, et al. An algorithm for using deep learning convolutional neural networks with three dimensional depth sensor imaging in scoliosis detection. *Spine J 2021*; 21:980-987.

Fig. 1

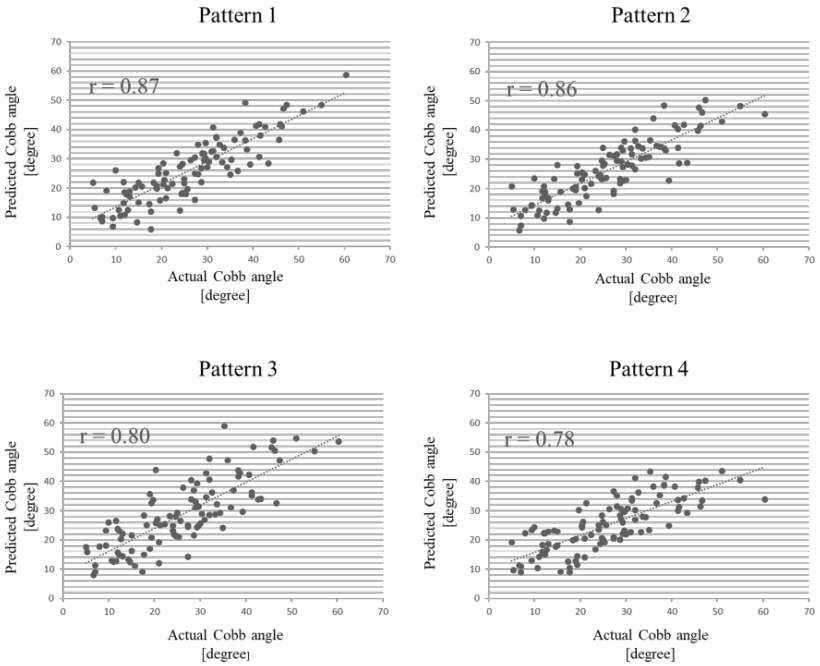

Table 1. The MAEs and RMSEs in each shooting pattern

	Pattern 1		Pattern 2		Pattern 3		Pattern 4	
	MAE (°)	RMSE (°)	MAE (°)	RMSE (°)	MAE (°)	RMSE (°)	MAE (°)	RMSE (°)
Mild group (0° to 19°)	5.1	7.4	4.9	6.3	6.4	8.6	6.1	7.5
Moderate group (20° to 39°)	4.4	6.0	4.2	5.4	6.7	7.8	4.7	5.8
Severe group (40°≤)	4.7	7.1	6.0	7.7	6.2	7.2	11.0	12.0
Total	4.7	6.0	4.8	6.1	6.3	8.0	6.1	7.6

MAE= Mean absolute error, RMSE= Root mean square error

O232

A novel inclinometer based on a palm-sized 3D ultrasound system for mapping axial trunk rotation

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Introduction: Adolescent idiopathic scoliosis (AIS) is the three-dimensional (3D) structural spine disorder that begins in early stage of puberty with no recognizable cause. Screening is important to early detect scoliosis for its treatment and management. The severity of trunk asymmetry can be indicated by measuring the axial trunk rotation (ATR) with an inclinometer in the Adam's forward bend test. There are studies of digitalized alternatives to the traditional inclinometer, Scoliometer. However, they either require manual value reading, only record single point rotation, simply use gyroscope, or are not being well integrated into a scoliosis assessment system. There is a need to develop a digitalized and systematic scoliosis screening system with an advanced spatial tracking. Although low-cost and radiation-free 3D ultrasound has been demonstrated to be reliable and eased the access to scoliosis diagnosis, it requires pre-scanning preparation such as cloth changing and gel applying. The extension of the ATR measurement for quick screening can fill the gap in scoliosis management of 3D ultrasound imaging. The objective of the study is to enhance the scoliosis diagnosis management with the 3D ATR scanning system based on a palm-sized 3D ultrasound system, by providing automatic ATR computation, additional 3D trajectory and visualization on continuous scans.
Methods: A digitalized inclinometer based on a palm-sized 3D ultrasound system, Scolioscan Air, was developed, namely Scolioscan Meter. A removeable cap with a notch at the middle and rollers on sides was applied to the 3D ultrasound probe for smooth scan on subjects' backs (***Figure 12***). To acquire the ATR values, subjects with AIS (n=20) were asked to perform forward bending in standing posture. The ATR values were computed using the spatial data from the 3D spatial sensor of the 3D ultrasound probe and visualized with the maximum ATR value derived automatically after a continuous scan along the spine (***Figure 13***). A paired t-test was used to examine if there is a significant mean difference between the ATR values acquired with Scoliometer and Scolioscan Meter. Significance level was set at 0.05.
Results: Mean±SD Cobb of the patients with AIS was 16.0°±5.2°. The paired t-test in the preliminary subject test showed that there is no significance mean difference between the ATR measurement using Scoliometer and Scolioscan Meter ($p=0.019$). There is an excellent correlation between them ($R^2 = 0.953$) with angle differences no more than 4.6 degrees.
Conclusions: The preliminary study showed the new inclinometer based on a palm-sized 3D ultrasound system can provide accurate and automatically computed ATR results. There may be error due to drifting or non-smooth movement as the scan is continuous. The system developed allows 3D ultrasound assessment right after Scolioscan Meter screening for suspected cases using the same machine and database, which speeds up the scoliosis screening and integrates its management.

Figure 12. ***System diagram of the Scolioscan Meter***

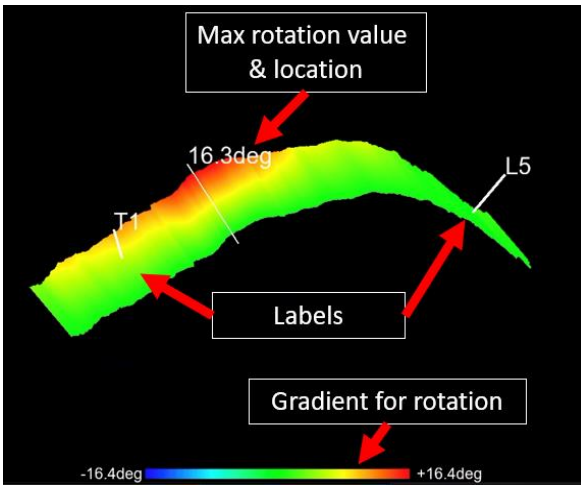

Figure 13. ***3D Visualization of the lateral curvature obtained from the Scolioscan Meter***

O233

Correlation of transverse rotation of the spine using surface topography and 3D reconstructive radiography in children with idiopathic scoliosis

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Introduction: 3D spine radiograph with reduced dose can be achieved using EOS imaging which captures simultaneous AP/Lateral views but requires an additional 15-40 minutes for reconstruction. Surface topography (ST) uses cameras to evaluate anatomic landmarks and back contour to reconstruct the 3D spine with the added benefit of faster processing and motion analysis. Previous studies have found moderate to strong correlation between ST and radiographs in the coronal plane though there is little research correlating the axial surface rotation (ASR) of ST and the axial vertebral rotation (AVR) of radiography in the transverse plane. The aims of this study were: 1) to characterize rotation patterns at all spinal levels with ASR and AVR; 2) to determine the correlation between the ASR, AVR, and Cobb Angle; 3) to create a risk assessment model for the progression of IS using a predictive model.
Methods: The IRB approved retrospective study was conducted on patients between the ages of 8-18 diagnosed with IS or spinal asymmetry who received both radiographs and ST measurements (DIERS formetric 4D, DIERS Biomedical Solutions, Germany) between the dates of 8/15/2018 and 3/1/2022 at Orthopedic Clinic. To quantify the correlation between ASR, AVR, and Cobb Angle, we computed the Pearson's correlation coefficient with its 95% confidence interval (R version 4.1.3). To account for the within-subject correlation, a linear mixed effect model was created to relate some demographic and ST variables. Using backward model selection, the best predictive model for the risk assessment of IS was selected.
Results: Fifty-two subjects met inclusion criteria. The mean age was 14.06 ± 1.71 and 39 (75%) were female. The average Cobb Angle was 24.09° ± 13.32° with AVR of -.086° ± 4.57° and the average Scoliotic Angle was 20.87° ± 11.54° with ASR of -2.33° ± 6.56°. In looking at patterns, AVR had maximal rotation at T8 while ASR had maximal rotation at T11. ASR and AVR were found to be similar by Bland Altman evaluation and mild/moderately correlated (r= 0.348, p =.006). (ASR-AVR) vs Cobb angle are found to be mildly correlated (r = 0.150, p=.001). The final predictive model is Cobb angle = 26.243 - 1.137(Age) - 7.689(Gender) - 3.590(T6) + 5.912(T7) - 2.684(T8) + 0.729(Scoliotic angle). R-squared of the predictive model is 0.869, which means 86.9% of the total variability in Cobb angle can be explained by the model.
Conclusions: This is a pioneering study looking at vertebral rotation using both ST and radiograph which shows that the ASR and AVR are significantly correlated in mild to moderate curvatures, though this relation deteriorates with more severe Cobb Angles. This study presents a novel predictive model for scoliosis progression which composites age, gender, and ASR, an analog of Cobb angle. ST estimates that maximal

vertebral rotation is at 1-3 spinal level lower than radiographs. The differences in ASR and AVR patterns may provide guidelines for padding placement with respect to de-rotation of the spinal deformity with bracing.

Acknowledgements: Thank Mr. Ford, BS, biomedical engineer for helping use Diers system at the Musculoskeletal Functional Assessment Center, Dept. of Orthopaedic Surgery.

O234
Sub-optimal reliability of the DRU risk classification

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Introduction: AIS treatment decisions depend on accurate inferences about remaining skeletal growth. The distal radius and ulna classification (DRU, radius stages 1-11, ulna stages 1-9) is reportedly a simple, reliable and accurate metric of skeletal maturity. Modeling suggests low (R9-11, U7-9), moderate (R8, U6) and high risk classifications (R1-7, U1-5) accurately predict risk of curve progression when combined with the Cobb angle. Reproducibility and clinical utility depend on the reliability of the risk classification across providers and patients.
Aim: 1. Evaluate the inter- and intra-rater reliability of the DRU risk categories suggested by Yamamoto et al. 2. Evaluate the change in reliability after a consensus session using a pre-test, post-test design.
Patients and Methods: 40 subjects (Risser 0-2) were selected from the BrAIST dataset. Three raters (resident, nurse practitioner, senior faculty) assigned radius and ulna stages and the films were randomly re-ordered and read a second time (pre-test). The team then convened to discuss disagreement between observers and agreed upon a simplification of the classification system. For example, an assigned defining characteristic for each stage, such as the distinction between R7 and R8 being the transition of the proximal lateral corner of the metaphysis from rounded to a single point. The team then developed consensus definitions for defining characteristics of each risk classification and repeated the readings (post-test). Inter- and intra-rater agreement were estimated using Krippendorff's alpha.
Results: Results are summarized in Table 1. Pre-Test: Rater 1 was highly consistent across the 2 reads, otherwise, the intra- and inter-rater coefficients were <0.65. Post-Test: Consensus did not result in uniform, meaningful improvements in intra- or inter-rater coefficients. In terms of individual patients, assuming all agreed on the Cobb angle, these 3 providers would give 34% two different prognoses using the radius risk classification and 52% using the ulna (1 would receive 3 different prognoses). The majority of disagreements were between the low and moderate risk categories for both the radius and ulna.
Conclusions: The DRU system has been recommended to guide AIS treatment. The lack of initial agreement here suggests the published definitions were either not clear or they were not applied in a consistent manner. Consensus on critical points distinguishing the risk categories led to some improvement in reliability. Although most coefficients could be interpreted as reflecting substantial agreement, many patients would receive different messages about their prognosis from these three raters. Further work should be done to estimate the reliability of the classification systems across a wider variety of providers and patients prior to its routine use in the clinic setting.

Table 1. Inter-rater agreement estimated by Krippendorff's alpha

	Radius Risk Classification				**Ulna Risk Classification**			
Intra-Rater	**Pre-Test**		**Post-Test**		**Pre-Test**		**Post-Test**	
R1	1.00		0.96		1.00		0.80	
R2	0.63		0.67		0.57		0.84	
R3	0.54		0.73		0.33		0.65	
	Pre-1	**Pre-2**	**Post-1**	**Post-2**	**Pre-1**	**Pre-2**	**Post-1**	**Post-2**
Inter-Rater	0.29	0.55	0.70	0.66	0.41	0.38	0.51	0.42

O235

Dural repair: Efficacy assessment of different techniques, a cadaveric study comparing the naked eyes and surgical loupes

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Introduction: Watertight dural repair is crucial to achieve successful dural tear sutures. Microscopic or surgical loupes are recommended to use to magnify and assist repairing the dura. However, many spine surgeons repair dural tears under the naked eye. The efficacy of repairing dural tears by the naked eye compared with microscopic or surgical loupes has never been studied.
Aims: This study aimed to compare the efficacy of dural repairing techniques using the naked eye or surgical loupes.
Methods: A cadaveric experimental study was conducted. Four fresh human cadaveric specimens were used to harvest the spinal cord. Dural tear and CSF leakage were simulated with a water pressure control system (Arthrex AR-6475 arthroscopic pump). We compared surgical repair using the naked eye and surgical loupes. Surgical closure was achieved using Prolene 6-0 and Durepair®. A total of 32 experimental dural tears were subdivided to four groups. The 4 groups were Prolene6-0 with the naked eye (n=8), Prolene 6-0 with surgical loupe (n = 8), Durepair® with the naked eye (n=8) and Durepair® with surgical loupe (n=8). The total time used for sutures and post suture CSF water leakage pressure were recorded and compared among the subgroups.
Results: Our results showed that surgical loupe assisted dural closure and sutures were significantly faster than the naked eye in both Prolene 6-0 (surgical loupe = 4.87±0.19 min, naked eye = 7.18±0.36 min, p <0.001) and Durepair® groups (surgical loupe = 9.84±0.21 min naked eye = 13.27±0.42 min, p <0.001). CSF Leakage pressure in the surgical loupe groups were higher than in the naked eye groups in both Prolene 6-0 (surgical loupe = 100.00±5.35 mmHg, naked eye = 96.88±7.99 mmHg, p = 0.373) and Durepair® (surgical loupe = 96.88±4.58 mmHg, naked eye = 95.63±4.17 mmHg, p = 0.577) but without significant difference. Prolene 6-0 was significantly faster to use for sutures than Durepair® in both sutures by the naked eye and surgical loupe assisted (p <0.001). Prolene 6-0 showed a higher leakage pressure than Durepair® in both the naked eye and surgical loupe assisted sutures but without significant difference (naked eye, p = 0.701, surgical loupe, p = 0.230).
Conclusions: Repairing a dural tear without using surgical loupes consumed more time and did not achieve similar maximum leak pressure compared with using surgical loupes. However, no statistically significant difference was observed in terms of CSF leakage pressure. Durepair® consumed more time than Prolene 6-0 while leakage pressure was similar. We recommended the use of surgical loupes when performing dural repair. Durepair® is suitable to repair larger dural defects that cannot be closed using a simple suture technique.

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O236

The electromyographic discrepancy of paravertebral muscles predicts an early curve progression of untreated adolescent idiopathic scoliosis

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Introduction: A higher electromyographic (EMG) activity is observed on the convexity of a scoliotic curve. This differs from non-scoliosis population and has been implicated as a causative factor in the progression of adolescent idiopathic scoliosis (AIS).
Aim: To explore the relationship between EMG discrepancy of paravertebral muscles and scoliosis progression of untreated AIS, how vertebral morphology and EMG discrepancy evolve during scoliosis progression, and to identify the difference of EMG activities between scoliosis and non-scoliosis participants in upright sitting and doing voluntary back-extension, respectively.
Patients and Methods: 534 adolescents were consecutively recruited. 267 girls with Cobb angles ≥ 10° (scoliosis cohort) and 267 girls with < 10° (non-scoliosis cohort) undertook EMG measurements at their first presentation. Radiographic and EMG reassessments were done at study initiation and the 7-month follow-up. Tele questionnaire was collected biweekly to record participants' sport intensity and to net the participants who encountered treatment during follow-up. An early scoliosis progression (progression cohort) was defined as an increase of Cobb angles ≥ 6° of the major curves at the 7-month whereas non-progression (non-progression cohort) was identified a change < 6°. The root mean square of the EMG (rms-EMG) signal of paravertebral muscles was collected with participants in upright sitting and doing voluntary back-extension in prone lying. A rms-EMG ratio (rms-EMG ratio = $\frac{rms-EMG\ of\ convexity}{rms-EMG\ of\ concavity}$) at the upper end vertebrae (UEV) / apical vertebral (AV) / lower end vertebrae (LEV) of the major curve, was calculated for statistical analysis and represented the EMG discrepancy of paravertebral muscles.
Results: A higher rms-EMG ratio at AV (sitting: 95% CI 0.49-0.57; p<0.01, back-extension: 95% CI 0.29-0.37; p<0.01) and LEV (sitting: 95% CI 0.21-0.27; p<0.01, back-extension: 95% CI 0.14-0.19; p<0.01) levels was noted in participants with scoliosis (n=267, age: 12.5±1.7 years, initial Cobb angle: 26.4±8.7°) compared to non-scoliosis controls (n=267, age: 12.5±1.6 years, initial Cobb angle: 6.7±1.1°) at baseline. Seventy-eight girls with AIS (28.8% of scoliosis cohort) showed scoliosis progression of the major curve (an increase of Cobb angle at the 6-month: 6.6±0.9°) at the 7-month. A significant higher rms-EMG ratio at the AV and LEV levels was noted in the progression cohort at either baseline (AV [sitting: p<0.01; back-extension: p<0.01], LEV [sitting: p<0.001; back-extension: p<0.01]) or 6-month (AV [sitting: p<0.01; back-extension: p<0.01], LEV [sitting: p<0.01; back-extension: p<0.01]). A rms-EMG ratio ≥1.7 at the AV level while doing voluntary back-extension was a risk factor for an early scoliosis progression at the 7-month.
Conclusion: In addition to skeletal immaturity, the rms-EMG ratio ≥1.7 at the AV level of paravertebral muscles, captured with voluntary back-extension in prone lying, was related with an early scoliosis progression after 7 months without treatment. The EMG discrepancy of paravertebral muscles at the AV and LEV was observed in the scoliosis population regardless of testing posture. A consistently higher EMG discrepancy, detected with back-extension at the AV level, was presented with radiographic changes in three dimensions of the major curve after 7 months without treatment.

O237

Analysis of the cement distribution pattern and other risk factors that affect the incidence of recompression fractures of vertebral bodies after vertebroplasty or kyphoplasty

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Introduction: With the increasing incidence of recompression fractures after vertebroplasty or kyphoplasty, this study analyzed the risk factors that affect the occurrence of recompression vertebral fractures, such as cement distribution, existence of avascular necrosis (Kummell's disease), type of procedures, bone mineral density, sex, and age.
Methods: Two hundred and thirty-eight patients who underwent vertebroplasty or kyphoplasty at the author's clinic from2005 to 2015 were enrolled in this study. The patients were divided into four groups according to the distribution of injected cement. The patients were classified as type 1 and type 2 when injected cement was contacted only to the upper or lower endplate of the body respectively. They were classified as type 3 when both the upper and lower endplates were contacted by injected cement. When neither the upper nor the lower endplate was contacted, the patients were called type 4. This study statistically evaluated the effects of the risk factors, including the cement distribution on the incidence of recompression vertebral fracture after vertebroplasty or kyphoplasty.
Results: There were 59 cases (24.8%) of recompression fracture after vertebroplasty or kyphoplasty, among the 238 cases. According to the analysis, the recompression of the vertebral body after vertebroplasty or kyphoplasty occurred more often when the compression fracture was accompanied by osteonecrosis at the body ($p<0.05$). The patients who had injected cement distributed at both upper and lower plate simultaneously (type 3) had a lower incidence of recompression fracture of the vertebral body after vertebroplasty or kyphoplasty($p=0.008$). In addition, the kyphoplasty group had a lower incidence of recompression after the procedure than vertebroplasty group ($p=0.02$).
Conclusions: Careful attention should be given to these patients with osteonecrosis at the compression fracture level through a preoperative evaluation. In addition, if the injected cement does not contact both the upper and lower endplates, careful observation is required during the follow-up period based on the high incidence of vertebral recompression fractures proven through this study. Further technical and biomechanical research and efforts will be needed to make the cement contact both endplates.

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O238

Core planar cell polarity genes VANGL1 and VANGL2 in predisposition to congenital scoliosis

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Introduction: Impaired somitogenesis leads to congenital vertebral malformations (CVMs), which clinically manifest as congenital scoliosis (CS). Wnt/ß-catenin signaling is central to somitogenesis, whereas the role of Wnt/planar cell polarity (Wnt/PCP) signaling in somitogenesis remains unclear. In vertebrates, PCP controls many fundamental cellular and developmental processes such as collective cell movement and convergent extension (CE), which coordinate the elongation and narrowing of the anterior-posterior (AP) body axis. Disruption of PCP signaling causes severe defects in humans and mice, the most common of which are neural tube defects that range from spina bifida in humans to craniorachischisis in mice. Vangl1 and Vangl2, the vertebrate homologs of *Drosophila* Vang, are two highly conserved four-pass transmembrane core proteins dedicated to PCP signaling that are required for a variety of embryonic developmental processes.

Aim: To analyze a multi-center and multi-ethnic cohort of CS patients and identify any deleterious *VANGL1* and *VANGL2* variants. To confirm variants' pathogenicity by *in vitro* and *in vivo* functional analyses in cultured cells, zebrafish, and genetically modified mouse models.

Patients and Methods: Patients with *VANGL1* or *VANGL2* variants were identified from multicenter and multiethnic CS cohorts from mainland China (708 cases), Hong Kong Special Administrative Region (SAR) of China (67 cases), Japan (1 case), and the United States (6 cases). Whole-exome sequencing was performed. Sanger sequencing was performed to confirm candidate variants. Immunoblotting and immunofluorescence was performed with staining of the endoplasmic reticulum and with quantification of the intramembrane/total signal. The *AB* zebrafish strain was used for microinjection. Zebrafish embryos were injected with *vangl2*-morpholino (MO) and raised until 2 days post-fertilization. *Vangl1* and *Vangl2* knock-in mouse strains were created and micro-CT analyses were performed.

Results: Nine *VANGL1* and eight *VANGL2* rare nonsynonymous missense variants were identified. The *VANGL1* p.E281G and *VANGL2* p.L226F were deemed likely to be gene-disrupting. Deletion of two core PCP components, Vangl1 and Vangl2, leads to defective somitogenesis and spinal malformation that mimics the conditions of human CVMs. By analyzing exome sequencing data from multi-center and multi-ethnic CS patients, we identified a number of rare variants of *VANGL1* and *VANGL2*. VANGL variants accumulated intracellularly with strong co-localization with the ER. Wildtype VANGL localized on the plasma membrane. We observed loss-of-function and dominant-negative effects among these variant alleles. CE movement defects and shortened AP body axis was observed in zebrafish (Figure 1). The failure of mutant *VANGL* mRNA to restore convergent extension defects in zebrafish models confirmed the variants' pathogenicity. Moreover, *Vangl1* knock-in (p.R258H) mice exhibited vertebral malformations in a *Vangl2* dose-dependent manner (Figure 2).

Conclusion: Our studies revealed new critical roles for PCP signaling in somitogenesis and predisposition to CVMs. Vangl1 and Vangl2 were highly expressed in developing somites, and *Vangl* mutant mice exhibited multiple spine and rib anomalies including hemivertebrae, which is the most common cause of

CS. We addressed the *in vivo* functional significance of the most deleterious variants in both zebrafish and mouse models. In a *Vangl2* dose-dependent manner, *Vangl1-R258H* knock-in mice developed caudal hemivertebrae or asymmetric vertebrae, mimicking the spinal anomalies in human patients.

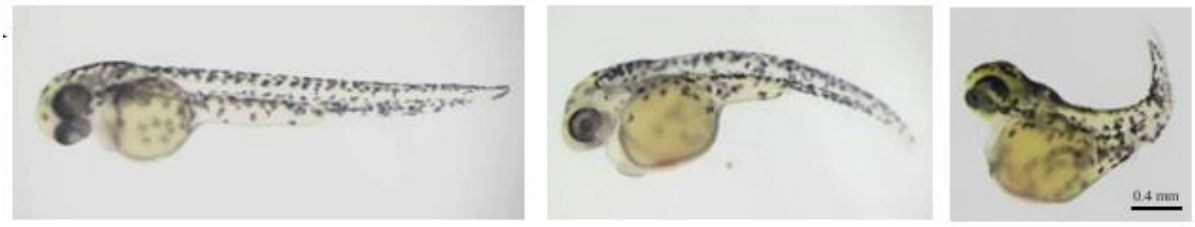

Figure 1: Comparing wildtype (left) with VANGL2 variant (middle). More severe phenotype with both VANGL2 and VANGL1 variant (right).

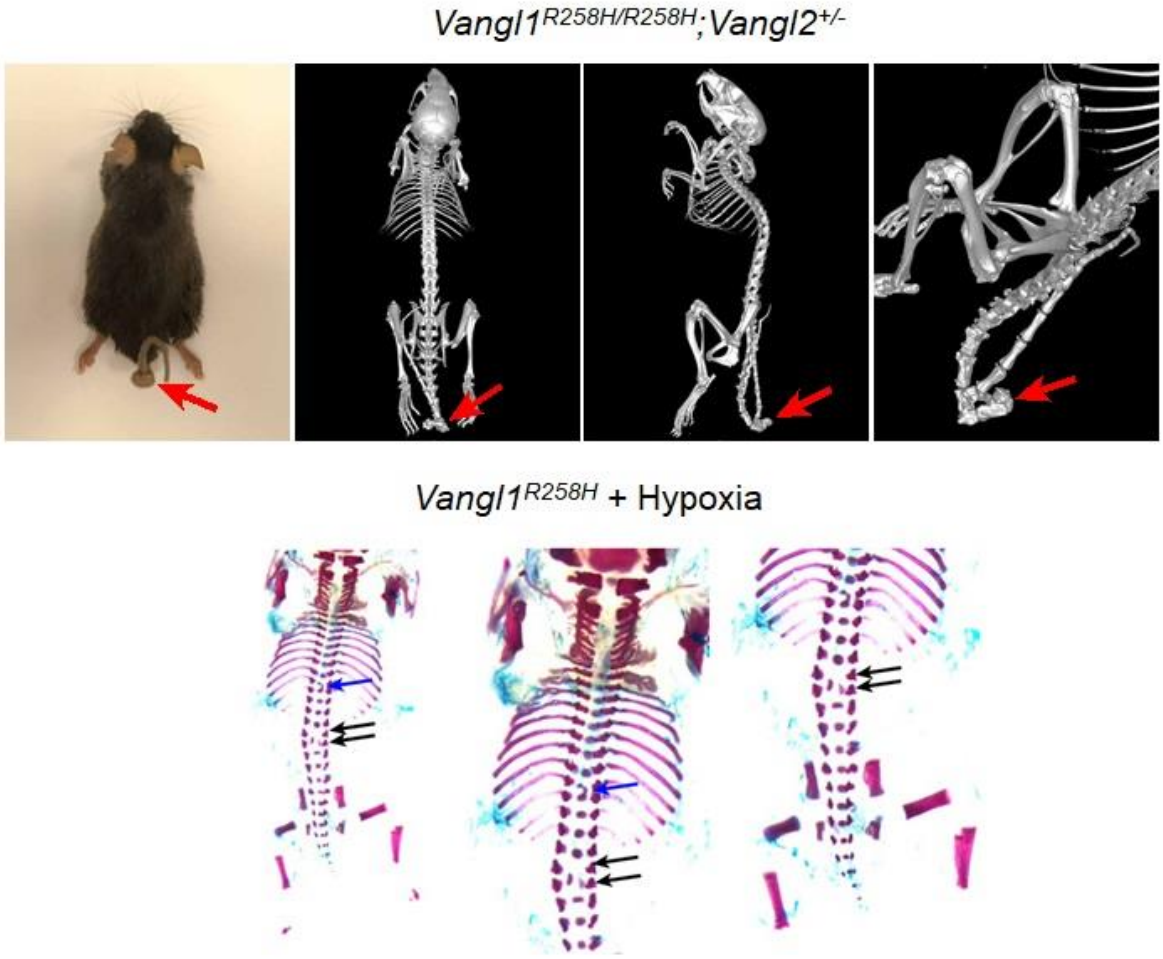

Figure 2: Knock-in mouse model with looptail, hemivertebrae, and asymmetrical vertebral malformations.

O239

Molecular interactions between intervertebral disc host proteins and putative pathogenic effector proteins in degenerate discs: A predictive insilico analysis

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Introduction: Sub-clinical infection has been hypothesized to play a role in etiopathogenesis disc disorders. Earlier reports have provided definite evidence of the prevalence of host-defense responses within the intervertebral disc, which serves as the proof-of-evidence for infection-mediated inflammatory mechanisms. In order to understand the rewiring of host metabolism, interactions between effector proteins (secretory proteins of the microbial consortia) and host proteins were studied.

Methods: Proteome data of 36 nucleus pulposus tissues were considered for the study under three groups: 11 healthy NP tissues from brain-dead voluntary organ donors (normal disc group (ND); Twenty five degenerated diseased group (DD)- 17 in modic and 8 in non-modic condition respectively. The proteome raw data were mapped with the bacterial and human proteome database to identify the host and bacterial proteins. Human proteins were manually curated based on literature evidence to identify the Pathogen Recognition Receptor (PRR) proteins. Similarly, bacterial proteins were screened for the presence of effector proteins by mapping with the bacterial T3 Secretory System library. Insilico-predictive analysis of molecular interactions between host proteins and putative pathogenic bacterial proteins was done to understand the host-pathogen regulatory mechanisms.

Results: Of 8746 identified human proteins, 23 were manually curated as PRRs (Pathogen Recognition Receptors). Following stringent statistical parameters (25% sample prevalence and ≥5 PSM), only six proteins such as C-type lectin domain family 3 member A (CLEC3A), C-type lectin domain family 11 member A (CLEC11A), C-type lectin domain family 2 member D (CLEC2D), Interferon- Inducible protein (AIM2), Fibronectin (FN1) and Vitronectin (VTN) were selected for the interaction study. To validate the host-pathogen interactions, molecular interaction analysis were performed between host PRRs and bacterial T3 secretory effector proteins. As a result, thermodynamically stable interaction prevails between the bacterial effector proteins with chosen five PRRs except for AIM2. While no bacterial T3 secretory effector proteins were detected in ND group, Forty-nine bacterial proteins [38: DD-Modic, 11: DD- Non-modic] were identified in DD group. Six effector proteins, such as ATP synthase subunit beta, Elongation factor Tu 1, Elongation factor Tu 2, Elongation factor G, Major outer membrane lipoprotein Lpp, and Outer membrane protein A, were selected after mapping against the T3 Secretory System Library.

Conclusion: Host PRR proteins such as CLEC3A, CLEC2D, CLEC11A, FN1, and VTN interacted with the bacterial secretory proteins such as 30S ribosomal protein S4 and UDP-glucose 6-dehydrogenase. Observed bacterial proteins indicate the bacterial presence in degenerate disc tissues, and observed PPR and its interactions indicate a possible host-microbiome interaction within NP tissues.

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O240

Long-term outcomes of vertebral body sliding osteotomy for the treatment of cervical myelopathy: A minimum of 5-year follow-up

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Introduction: Vertebral body sliding osteotomy (VBSO) is an anterior decompression and fusion technique involving the anterior vertebral body translation along with ossification of posterior longitudinal ligament or spondylotic lesion causing cord compression. VBSO has been reported to result in fewer complications, better lordosis restoration, and faster bone union than corpectomy. However, previous studies demonstrated the outcomes of VBSO with ≥2 years of follow-up, but its long-term outcome was not reported. Maintaining the advantages of VBSO in the early postoperative period during the long-term follow-up remained unclear. Therefore, this study aimed to 1) demonstrate the long-term outcomes of VBSO with a minimum of 5-year follow-up and 2) compare the results with other anterior reconstruction techniques including anterior cervical discectomy fusion (ACDF) and anterior cervical corpectomy fusion (ACCF).
Materials and Methods: A total of 128 patients, who underwent VBSO, ACDF, or ACCF for cervical myelopathy treatment and were followed up for >5-years, were retrospectively reviewed. Fusion, subsidence, C0–2 lordosis, C2–7 lordosis, segmental lordosis, C2–7 sagittal vertical axis (SVA), surgical complications, neck pain visual analog scale (VAS), neck disability index (NDI), and Japanese Orthopedic Association (JOA) score were assessed. Statistical comparisons between the VBSO, ACDF, and ACCF groups were made.
Results: The VBSO, ACDF, and ACCF groups included 38 (29.7%), 62 (48.4%), and 28 (21.8%) patients, respectively. No cases experienced dural tear, postoperative neurologic deterioration, infection, graft dislodgement and no patient required revision operation during the follow-up in the VBSO group. The VBSO revision rate (0/38, 0.0%) was significantly less than that of ACDF (8/62, 12.9%. $p = 0.023$) or ACCF (5/28, 17.9%, $p = 0.011$). VBSO demonstrated higher fusion rate at 6-month and 1-year follow-up, but the fusion rate at 5 years (97.4%) was not significantly different compared to ACDF (85.5%, $p = 0.054$) and ACCF (85.7%, $p = 0.077$). Segmental lordosis at the 5-year follow-up was significantly higher in the VBSO group (16.1 ± 7.6) than the ACDF ($p = 0.002$) or ACCF ($p < 0.001$) groups. Furthermore, C2–7 lordosis at the 5-year follow-up was significantly higher in the VBSO group compared to the ACCF group ($p = 0.017$). Neck pain VAS, NDI, JOA score, and JOA recovery rate did not show significant intergroup differences during the postoperative 5-year period.
Conclusion: No cases required revision operation in VBSO during a 5-year follow-up, which demonstrated significant results compared to ACDF or ACCF. VBSO reached stable construct earlier than other techniques, as demonstrated with a higher 6-month and 1-year fusion rate, which would have enhanced the long-term safety and decreased the need for reoperation. Furthermore, VBSO showed a greater capacity to restore lordosis than ACDF or ACCF since it preserves the vertebral body and includes multiple lordotic shape interbody spacer insertion, which was maintained during the long-term follow-up. Therefore, VBSO demonstrated advantages over ACDF or ACCF regarding revision rate and lordosis restoration in long-term follow-up and is considered a safe anterior reconstruction technique for cervical myelopathy treatment.

O241

Computer-assisted diagnosis with artificial neural networks for odontoid fracture detection

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Background: Artificial neural networks (ANNs) are computing systems inspired by the biological neural networks that constitute human brains. Computer-assisted diagnosis with ANNs from radiographic x-ray imaging was increasingly popular in the fields of medical image processing. Odontoid fracture is a common fracture of the axis and account for 10-15% of all cervical fractures. A literature review computer-assisted diagnosis with ANNs was not previously reported. This study proposes the ANNs for the detection of odontoid fracture by the Konstanz Information Miner (KNIME) analytics platform to offer a technique for computer-assisted diagnosis from radiographic x-ray imaging.
Methods: This study obtained four hundred thirty-two open-mouth (odontoid) radiographic views of cervical spine x-ray images for dataset repositories to develop an ANNs model base on a convolutional neural network (CNN) theory. All of the images contained diagnostic information, including normal radiographic images (n=216) and fracture images of the acute odontoid fracture (n=216). The model would classify whether the patient was odontoid fracture or not. Seventy percent of the images were training data sets used for model training, and thirty percent were used for testing. KNIME's graphic user interface-based programming enabled class label annotation, data preprocessing, model training, and performance evaluation.
Results: All radiographic x-ray imaging was reported under the graphic user interface program by KNIME. The ANNs model has performed 50 epochs of training. Performance model evaluation for detecting odontoid process fracture by the sensitivity (recall), specificity (predictive value) f-measure and prediction error were all 100%, 95.4% 97.77% and 2.3%, respectively. The model's accuracy was equal to 97% of the area under the receiver operating characteristic (ROC)curve for the diagnosis of odontoid process fractures.
Conclusion: ANNs models with KNIME analytics platform were successfully utilized for computer-assisted diagnosis of odontoid fractures using radiographic x-ray images. This approach can assist the radiologist in the screening or assist in the detection and diagnosis of acute fractures.
Keywords: Odontoid fracture, Computer-assisted diagnosis, Artificial neural networks, KNIME

O242

Establishing a relationship using CT between Facet Distraction and clinical outcomes after ACDF

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Introduction: Anterior cervical discectomy and fusion **(**ACDF), the gold standard treatment for radiculopathy and myelopathy, has the potential risk of inducing facet-mediated pain through over-distraction. However, the relationship between the clinical outcomes and facet distraction after ACDF remains unclear. Therefore, this study aimed to measure facet distraction using computed tomography (CT) and compare the results with clinical outcomes.
Methods: This was a retrospective cohort study. Patients (n=144) who underwent a single-level ACDF were included. Each patient underwent plain radiography of the lateral cervical spine preoperatively, immediately and 2years post-surgery. CT was performed preoperatively, and at 3days and 1year post-surgery. The inter-facet distance was measured at each time point, and changes in values from the preoperative distance were noted and used for study. Patient-reported outcome measures were obtained preoperatively and at 2year follow-up. Receiver operating characteristic (ROC) curves were generated to derive the critical facet distraction point.
Results: The neck pain VAS score (VASn) showed a tendency to decrease during the follow-up period, and VASn at 3weeks postoperatively (4.81 ± 2.11) was most severe. There was a significant positive correlation between facet distraction measured using CT 3days postoperatively and VASn 3 weeks postoperatively (Fig.1, Spearman's correlation coefficient: 0.703, P<.001). Facet distraction measured using radiography showed less correlation with VASn at all time points than CT. An ROC curve analysis showed that the cut-off value of Δ facet distraction was 1.8 mm for VASn ≥ 4 (AUC = 0.901, sensitivity = 87%, specificity = 81%) (Fig. 2). Based on the cut-off value of Δ facet distraction of 1.8 mm, the patients were divided into Group C (Control group; Δ facet distraction <1.8 mm, n = 69) and Group O (Over-distraction group; Δ facet distraction ≥1.8 mm, n = 75). Group O showed significant worse clinical outcomes than Group C, including neck and arm pain VAS scores at all time points until the final 2year follow-up (Table 1).
Conclusions: The change value of facet distraction measured using CT rather than plain radiography correlated better with neck pain, and over-distraction contributed to adverse long-term outcomes, including neck and arm pain after ACDF. Additionally, an over-distraction of ≥1.8 mm may cause radiculopathy of adjacent segments along with facet-mediated axial pain; therefore, cage height should be carefully determined to avoid over-distraction during ACDF.

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Table 1. Comparison of clinical outcomes between Groups O and C.

	Group C (Δ facet distraction <1.8 mm)	**Group O** (Δ facet distraction ≥1.8 mm)	***P*-value**
VASn 3w	2.41 ± 1.14	5.03 ± 2.01	<.001*
VASn 6w	1.29 ± 1.28	3.40 ± 2.01	<.001*
VASn 3m	2.49 ± 2.07	4.69 ± 2.42	<.001*
VASn 6m	1.84 ± 1.49	3.08 ± 1.54	<.001*
VASn 1y	1.00 ± 1.49	2.15 ± 1.59	<.001*
VASn 2y	0.62 ± 0.78	1.01 ± 0.85	.005*
VASa 3w	3.29 ± 1.93	4.23 ± 1.91	.002*
VASa 6w	2.78 ± 1.58	3.52 ± 1.83	.011*
VASa 3m	2.61 ± 1.80	4.11 ± 2.43	<.001*
VASa 6m	2.14 ± 2.11	2.96 ± 2.33	.036*
VASa 1y	1.61 ± 1.59	3.37 ± 2.10	<.001*
VASa 2y	0.91 ± 0.80	1.48 ± 0.87	<.001*

O, Over-distraction; C, control; w, weeks after surgery; m, months after surgery; y, year after surgery; VASn, visual analog scale score of neck pain; VASa, visual analog scale score of arm pain;
****P***<0.05, Mann–Whitney U test

Figure 1. Results of correlation between the neck pain visual analogue scale score and Δ facet distraction measured using CT and radiography after ACDF.

		VASn 3w	VASn 6w	VASn 3m	VASn 6m	VASn 1y	VASn 2y
ΔFacet Dis. 3d CT	Correlation coefficient	0.703	0.586	0.507	0.442	0.322	0.201
	P-value	<.001*	<.001*	<.001*	<.001*	<.001*	0.01*

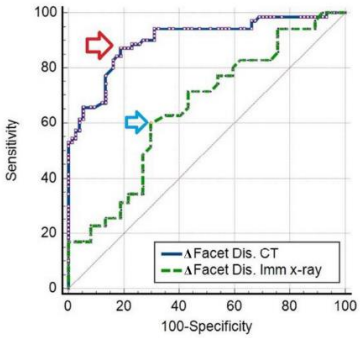
		VASn 3w	VASn 6w	VASn 3m	VASn 6m	VASn 1y	VASn 2y
ΔFacet Dis. Imm. x-ray	Correlation coefficient	0.275	0.307	0.237	0.141	0.172	0.195
	P-value	<.001*	<.001*	.003*	.110	.054	.029*

		VASn 3w	VASn 6w	VASn 3m	VASn 6m	VASn 1y	VASn 2y
ΔFacet Dis. 3m x-ray	Correlation coefficient	0.225	0.341	0.145	0.131	0.024	0.023
	P-value	.004*	<.001*	.112	.120	.464	.452

		VASn 3w	VASn 6w	VASn 3m	VASn 6m	VASn 1y	VASn 2y
ΔFacet Dis. 6m x-ray	Correlation coefficient	0.257	0.418	0.125	0.140	0.120	0.152
	P-value	.003*	<.001*	.191	.110	.137	.107

Dis., distraction; Imm, immediately after surgery; d, days after surgery; w, weeks after surgery; m, months after surgery; y, year after surgery; VASn, visual analog scale score of neck pain; CT, computed tomography; ACDF, anterior cervical discectomy and fusion.
** **P**<0.05, Spearman's correlation coefficient rank: green – high, purple – moderate, blue – low, and yellow – low*

Figure 2. *ROC curve analysis for the cut-off value of Δ facet distraction measured using plain radiography and CT after ACDF for a neck pain VAS score ≥ 4. The cut-off value (red arrow) for Δ facet* distraction measured using CT was 1.8 mm, AUC was 0.901, and the sensitivity and specificity were 87.14 and 81.08, respectively. Additionally, the cut-off value (blue arrow) for Δ facet distraction measured immediately after surgery using plain radiography was 2.56 mm, AUC was 0.654, and the sensitivity and specificity were 60.00 and 70.27, respectively.



Dis., distraction; ROC, receiver operating characteristic; AUC, area under curve; VAS, visual analog scale; Imm, immediately after surgery; CT, computed tomography.

O243
Conservative treatment of atlantoaxial rotatory fixation

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Introduction: Although atlantoaxial rotatory fixation (AARF) is typically treated conservatively, the optimal timing for inpatient treatment has not been established.
Aim: This retrospective study aims to investigate the course of AARF treatment.
Materials and Methods: We conducted a retrospectively review of patients with AARF who were treated at our hospital between April 2011 and March 2021. One patient with third-party actions at the point of injury was excluded because the timing of pain disappearance could not be determined. We collected data regarding age, gender, Fielding classification, treatment duration, treatment method, and outcomes.
Results: We included 136 patients [65 boys and 71 girls; average age: 5.6 (1–13 years)] with AARF. The courses of 109 patients (80.1%) were monitored to the point of cure, whereas 22 patients (16.2%) discontinued treatment and 5 (3.7%) were referred to other hospitals. The cause of onset was not attributed to any known cause in 51 (37.5%) patients, whereas the cause of onset was minor trauma in 32(23.5%) and during treatment for inflammatory diseases, such as colds, Kawasaki disease, mumps, or quinsy, in 53 (39.0%) patients. All patients had Fielding classifications of 1 and 2. The duration of the symptom started to consult our clinic was 0 days in 47 (34.6%); 1 day in 29 (21.3%), 2–7 days in 33 (24.3%), and 8–14 days in 15 (11.0%) patients. The longest duration of symptoms was 44 days after onset without any treatment. The median length of treatment was 9 days (interquartile range [IQR], 5–25 days). Fifty-nine (43.4%) patients were treated with collar fixation, 47 (34.6%) with only bed rest, 27 (19.9%) with Glisson's traction, 2 (1.5%) with bed rest upon hospitalization, and 1 (0.7%) patient needs remodeling therapy wearing with collar orthosis after Glisson's traction. Bed rest was indicated for all patients at the time of initial visit to the outpatient clinic. Those with symptoms continuing for 1–2 weeks after onset or with extreme pain were hospitalized. During the study period, no patient required reduction or surgical treatment with general anesthesia.
Conclusion: The use of Glisson's traction and remodeling therapy was successful in 100% of the patients treated. Approximately 80% of patients improved after only collar fixation or directed bed rest. Therefore, we could not confirm the appropriate time for conducting traction was appropriate. Moreover, the study did not include patients with Fielding classifications 3 and 4 Therefore, these cases will need further examination.

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O244

Curve flexibility assessment in adolescent idiopathic scoliosis (AIS) with major main thoracic curve: Comparison and correlation between physician-supervised supine side bending radiographs versus supine computed tomography (CT) scan

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Introduction: Previous studies reported good flexibility correlation between side bending radiographs (non-physician supervised) and supine radiographs. However, there were none that compared curve flexibility between physician-supervised supine side-bending (PSSB) radiographs and supine imaging. Supine Cobb angle measurements for adolescent idiopathic scoliosis (AIS) patients can be obtained from available preoperative supine CT scans.
Objective: To compare and correlate the Cobb angle and flexibility assessments between PSSB and supine CT scans.
Methods: AIS patients with major main thoracic curves who underwent posterior spinal fusion between 2012 and 2021 were reviewed. Patients who had preoperative anteroposterior standing radiographs, PSSB radiographs and supine CT scans were recruited. Data collected/calculated were demographic data, Cobb angles, curve flexibility, side bending correction index (SBCI) and supine correction index (SCI).
Results: A total of 203 patients with mean age 16.1 ± 4.5 years were included. The mean preoperative standing anteroposterior Cobb angle was 75.6 ± 21.8°. The mean Cobb angle was significantly smaller for PSSB (39.6 ± 22.9°) compared to supine CT (58.7 ± 20.2°) ($p<0.001$). The mean flexibility rate was significantly larger for PSSB (50.2 ± 18.2%) compared to supine CT scan (22.6 ± 10.8%) ($p<0.001$). The mean SBCI (1.4±1.0) was significantly lower compared to SCI (3.5±4.0) ($p<0.001$). Based on the Pearson correlation analysis, there were strong correlation for main thoracic Cobb angles between standing and PSSB ($r=0.867$, $p<0.001$); standing and supine CT ($r=0.899$, $p<0.001$); and PSSB and supine CT ($r=0.899$, $p<0.001$). There was moderate correlation for flexibility between PSSB and supine CT ($r=0.528$, $p<0.001$). However, there were no significant correlation between SBCI and SCI.
Conclusions: Supine CT scan generally correlated with PSSB radiographs and can be used for preoperative curve flexibility assessment in AIS patients.

O245

Reducing surgical site infections after spine surgery: The optimal amount of normal saline for intra-wound irrigation

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Introduction: Surgical site infection (SSI) following lumbar surgery can increase healthcare costs and ruin the success achieved through an operation. Irrigation of wounds with saline solution is widely accepted globally and safe for nearly all kinds of the surgical site. However, wound irrigation is still not addressed as a means of decreasing the incidence of SSI in elective surgery. The role and the optimal amount of intra-operative wound saline irrigation in preventing SSI in clean spinal surgery remain unclear. We aim to demonstrate that insufficient intraoperative irrigation may be a risk factor for postoperative SSI. Additionally, we investigated the optimal amount of normal saline for irrigation to prevent postoperative SSI.
Methods: Patients who had degenerative lumbar spine disease and had received open spinal fusion surgeries with at least 12 months follow-up were retrospectively included from January 2015 through April 2020. 193 patients were enrolled in the standard protocol group (irrigation with 2000 ml normal saline) compared with 251 patients in the enhanced protocol group (irrigation with > 6000 ml normal saline). Based on our protocolized Dept.al guidelines, all patients received the same preoperative preparation and standard surgical steps and postoperative care plan. Patients' demographic and surgical parameters were recorded. The main outcome measures included superficial wound infection, deep infection and overall infection. The fusion status was accessed based on the Bridwell grading system at the final follow-up. Self-reported and clinical outcome measures include visual analog scale and Oswestry Disability Index.
Results: The incidence of overall surgical site infection was 4.66% in the standard protocol group and 1.59% in the enhanced protocol group. The univariate analysis revealed a significant difference in DM, irrigation amount per h during surgery but not in age, BMI, smoking, operative duration, fusion level, and blood loss. We determined the optimal irrigation amount during surgery as 1400 ml per h based on the receiver operating characteristic (ROC) curve. This was statistically significant ($p = 0.033$) with an odds ratio of 9.284 (95% confidence interval 1.2–72.0). In the analysis of surgical factors, the infection group had a significantly lower irrigation amount during surgery.
Conclusions: We observed that diabetes and insufficient intraoperative irrigation were both risk factors for postoperative SSI following degenerative lumbar spine surgery. To reduce surgical site infection in lumbar spine surgery, intra-wound irrigation with more than 1400 ml/h of normal saline was recommended.

O246

Efficacy of vacuum-assisted closure in postoperative deep spinal infections. A retrospective analysis of 31 patients with spinal instrumentation

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Introduction: Surgical site infections (SSI) following spinal surgery are potential detrimental complications that increase hospitalization and expenses, cause significant morbidity and adversely affect the outcomes. Radical wound debridement, irrigation, and intravenous antibiotics are the conventional treatments for postoperative deep surgical site infection. Despite the best efforts, infections can persist. Our study aims to review the efficacy of the wound vacuum-assisted closure (VAC) system in treating deep surgical site infection after spine surgery with instrumentation and exposed dura.
Methods: We retrospectively reviewed 31 patients who underwent vacuum-assisted closure for postoperative spinal infections following spinal instrumentation between 2016-2020. The patient's demographic details and biochemical parameters were noted from the hospital information system, and imaging was analyzed by PACS. Other pertinent information included bacterial culture reports and antibiotic sensitivity patterns, duration of VAC application, number of cycles of VAC application before final wound closure, complications, and infection recurrence were noted.
Results: There were 17 females and 14 males in the study population. There were 21 lumbar spine surgeries and five thoracic and five thoracolumbar spine surgeries. Following wound debridement, VAC was applied to all patients. A mean of 2.5 cycles of VAC application, each lasting 5-9 days, was applied before wound closure. Twenty-seven had positive bacterial cultures, and the rest were culture-negative. Klebsiella and Pseudomonas were the most prevalent organisms. One patient died due to an unrelated cause, and one patient with chronic viral hepatitis had increased blood loss following VAC. All the patients had good healing of wounds with a minimum follow-up of 12 months with no recurrence of infections. All patients except one had retained the implants.
Conclusion: The VAC system is a valuable tool in managing postoperative deep spinal infections. It allows for the retention of the instrumentation and eradication of infection. It is safe, reliable, and easy to use.

O247

The infection control and spinal balance in patients receiving percutaneous endoscopic debridement and drainage (PEDD) for infectious discitis: A retrospective case analysis

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Introduction: Thoracolumbar discitis could usually be treated non-operatively with antibiotics. However, rapid diagnosis and treatment are still essential to achieve infection control while preserve spinal stability and neurological function. Except gold standard, CT-guided biopsy and culture, Percutaneous endoscopic decompression and drainage (PEDD) offered another unfolding technique for obtaining tissue while performing decompression for neurological symptoms. However, various diagnostic accuracy and absence of research on subsequent spinal instability remain a controversial issue.
Aim: To investigate the positive culture rate and impact on spinal instability in patients under through PEDD for deteriorated discitis after initial antibiotic treatment.
Methods: From 2015 to 2018, 60 patients received PEDD for their deterioration of hemodynamic or neurologic status secondary to infectious discitis. After culture sampling, debridement and drainage, the antibiotics were continued till resolution of symptoms or normalization of the Inflammatory biomarkers, ESR and CRP. Besides, VAS, ODI and modified Macnab's criteria were evaluated preoperatively, 1-week, 4-weeks, 6-months and 12-months postoperatively, representing the effectiveness of symptom relief. The positive culture rate was recorded as the diagnostic accuracy while the change of radiographic parameters was measured to evaluate the impact on the stability of the affected levels or global spine.
Results: 91% of cases achieved symptoms relief immediately postoperatively and 85% got infection controlled within 1-week postoperatively. There was 45% of cases found stably motion-preserved while 29% of cases got infected level fused at the last follow-up.
Discussion: The favorable outcomes guaranteed the effectiveness of PEDD. Despite the significant local kyphotic change over the infectious level since Post-op 6M, the SVA remained at a similar level representing the compensatory mechanism of global spine. However, there is still 14% received instrumented fusion over lesion levels within 1 year post PEDD. Thus, whether concomitant fusion or not still an issue of controversy and warrant further larger study to determinate.
Conclusions: Despite technique-demanding, the minimally invasive nature, effectiveness on infection control and symptom relief made PEDD an optimal strategy for certain patients could not sustain traditional open debridement for discitis. Although no significant instability found within postoperative 1 year, the gradual local kyphotic change may warrant further study to identify the need of concomitant fusion.

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O248

Is anterior-only approach a reliable surgical strategy in ankylosing spondylitis patients with cervical spine fractures

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Introduction: Current literature has established better outcomes following surgical management of cervical spine fractures in patients with ankylosing spondylitis. Literature favours combined anterior and posterior as well as posterior approaches over the anterior approach, however, it lacks an objective criteria to decide on the surgical approach. The study aims to determine the injury patterns in patients of AS with cervical spine injury, and identify, define, and analyze the determinants for stratifying surgical approach, evaluate the outcome and postulate a management strategy.
Methods: This is a retrospective study of patients with ankylosing spondylitis who underwent surgery for cervical spine injury having a minimum follow-up of 2 years. The patients' demographic profile, neurological status, neurological recovery, fracture pattern including translation and angulation, fracture classification, surgical duration, blood loss and postoperative complications were recorded and a comparative analysis of these factors between anterior, posterior and combined surgical approaches was performed.
Results: Forty-three males were included in the study with a mean age of 57 years. Forty-nine percent underwent anterior only, 16% posterior only, and 35% underwent combined anterior and posterior stabilization. Mean operative time was found to be significantly lower in anterior only (81.4 minutes, $p<0.05$), and posterior only (124 minutes, $p<0.05$) approaches as compared to combined antero-posterior approaches (266.6 minutes). The mean blood loss was significantly lower in the anterior only (87.5 ml, $p<0.05$) as compared to posterior only (714.7ml) and the combined antero-posterior- 912.7 ml) approaches. The mean translation and angulation in the patients who underwent anterior only, posterior only, and combined was 1.8mm and 4.8 degrees; 1.7mm and 5.7 degrees; and 3.7mm and 7.7 degrees respectively. There was a statistically significant difference in the translation in the patients who underwent anterior and posterior alone ($p<0.05$) compared to patients who underwent the combined approach.
Discussion: Our study provides insights into the management of cervical spine fractures in patients with ankylosing spondylitis. Our results, contrary to most literature, show that all the patients who underwent anterior approach had complete fracture healing and neurological recovery similar to patients who underwent posterior as well as combined approaches due to careful patient selection. Combined approach is the most preferred surgical technique, however, undisplaced fractures or fractures with a displacement ≤ 2 mm, are amenable to successful outcomes following anterior-only procedures in the absence of concomitant injuries. Posterior surgeries are reserved for patients with similar fracture charecteristics with injury in the cervico-thoracic region requiring instrumentation extending to the proximal thoracic spine as well as in patients having concomitant thoracic or thoracolumbar injuries requiring stabilization.

Acknowledgements: There are no disclosures or conflicts of interest.

O249

Atlas osteosynthesis screw placement using the intersection between lateral mass and inferomedial edge of the atlas posterior arch: Human cadaveric study

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Introduction: Atlas (C1) fracture is commonly treated conservatively. However, unstable Atlas fracture with or without associated ligamentous injuries may require surgical fixation. Osteosynthesis in displaced Atlas fracture is difficult to identify the proper entry point and trajectory to insert the lateral mass screw fixation. Aim is to compare the Atlas lateral mass screw placement using the intersection between the lateral mass and inferomedial edge of the posterior arch, as an isolated medial reference, between screw trajectory 0° and 15° angulation while performing Atlas osteosynthesis screw fixation.
Materials & Methods: Twenty-four Atlas in fresh human cadavers were prepared for inserting the 4.0-mm lateral mass screws. They were divided into 2 groups: Group 1; screws inserted at 3 mm lateral to the reference entry point with trajectory 0° angulation and Group 2; those inserted with trajectory 15° angulation. CT scan was performed before and after inserting Atlas lateral mass screws for evaluating atlas anatomy and screw breach grading.
Results: All parameters between Group 1 and Group 2 were found statistically different: bilateral intraosseous screw lengths (17.92±1.47 mm. vs. 20.71±2.4 mm.), bilateral screw length (29.92±1.72 mm. vs. 33.13±1.78 mm.), left screw medial angulation (x°) (0.67°±0.78° vs.14.17°±3.51°), right screw medial angulation (y°) (0.83°±1.03° vs.14.25°±2.53°) and bilateral screw medial angulation (0.75°±0.9° vs. 14.21°±2.99°). Only bilateral lateral mass screw superior angulation (z°) (22.21°±5.32° vs. 22.75°±7.94°) was not difference. Twenty-two screws (91.67%) using the 0°medial angulation and nineteen screws (79.17%) using the 15° medial angulation had no cortical violation (Grade 0). However, two screws (8.33%) with 0° medial angulation and five screws (20.83%) with 15° medial angulation had breach less than 2 mm (Grade 1) without screw pullout. There was no screw breach distance between 2-4 mm (Grade 2) or breach distance more than 4 mm. (Grade 3).
Conclusion: Using 3-mm lateral to an intersection between the lateral mass and inferomedial border of the Atlas posterior arch can be used to be an easily-identifiable constant entry point to insert the lateral mass screw with trajectory 0° and 15° medial angulation in Atlas fracture osteosynthesis.
Keywords: Atlas, C1 osteosynthesis screw; Lateral mass screw fixation; Inferomedial edge of posterior C1 arch

O250

The 'disc-endplate-bone-marrow complex' classification: A paradigm shift in our understanding of the modic vertebral endplate changes

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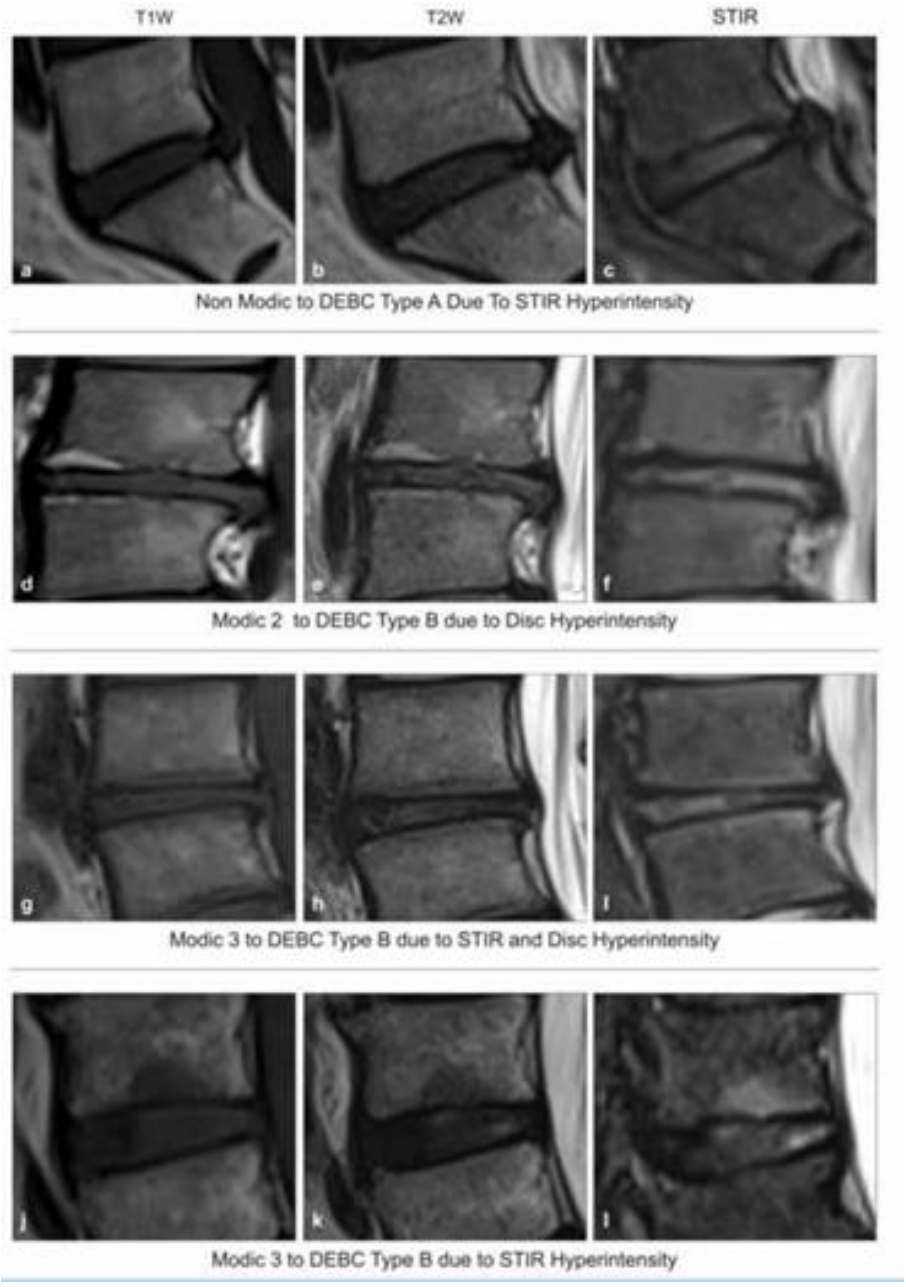
Introduction: With the current prominence and increased attention of the spine community on the end plate changes, it becomes important that we move forward and beyond the Modic change for accurate understanding. The disc, endplate (EP), and bone marrow region of the spine is a single anatomical and functional interdependent unit, but Modic classification(MC) is restricted to subchondral bone alone and also uses only T1 and T2 sequences, which have poor reliability to differentiate fat from edema.
Methods: This was a retrospectively analyzed prospectively collected clinico-radiological data performed with IRB approval to study the EP changes and correlate them to clinical outcomes. 445 consecutive patients who underwent whole spine MRI for the distant brain, cervical or thoracic spine injury formed the control group. 1085 consecutive patients presenting to the low back pain (LBP) clinic undergoing MRI formed the study group. All lumbar segments in the control and LBP groups were assessed for MC types. The same segments were also assessed with T1, T2, and STIR images. A concept of 'Disc-Endplate-Bone-Marrow" complex (DEBC) is proposed, and with the addition of STIR images - four activity stages were defined; Type-A: Acute inflammation; Type-B: Chronic Persistence; Type-C: Latent and Type-D: Inactive. A modifier H+ was added if there was a disc herniation. The classification was compared to MC and correlated to clinical outcomes.
Results: 3560 EPs of 445 controls and 8680 EPs in 1085 patients with low back pain (LBP) were assessed. 560 EPs of MC-II and 22 MC-III were found to have edema in STIR or hyperintensity in discs needing reclassification to the previously undescribed Type B of DEBC, which was found to be the most common (51.8%)(Figure 1). The incidence between control and LBP of H+ (12%vs28.8%) and its co-occurrence with DEBC (3.5%vs23.3%) was significant($p<0.0001$). The odds of the patient requiring surgery was 0.66 in pure herniations without DEBC, compared to 2.6 with only DEBC, and the highest of 5.2 in patients having both DEBC and H+. Deep infection was 0.47% in non-DEBC, compared to 2.4% in patients with DEBC ($p=0.002$), with maximum occurrence in Type B.
Conclusion: The DEBC classification is a paradigm shift in our understanding of the so-called Modic EP changes by considering the DEBC Complex as a whole. By the usage of STIR and the addition of disc intensity and EP erosions, 8.3% of patients in controls and 21.75% in the LBP group were reclassified to a previously undescribed 'chronic persistence' (Type B of DEBC) group, which had the highest incidence and influence for the need for surgery and infection. The addition of an H+ modifier was found to be critical as the co-existence of DEBC and H+ influenced treatment outcomes and the requirement for surgery and surgical infections. We believe that DEBC classification is an important advance in our understanding of the vertebral endplate changes over the classical MC and will have a significant role in both clinical practice and research in disc diseases.

Acknowledgements: The study was funded by Ganga Orthopedic Research and Education Foundation (GOREF). (GOREF-2022-20) and co-funded by Dept. of Biotechnology (BT/PR35631/MED/30/2186/2019)

Figure 1. Use of STIR and disc hyperintensity in reclassifying Modic changes to DEBC changes



O251

Anterior column realignment through open preposterior release-anterior-posterior fusion versus hybrid minimally invasive anterior-posterior fusion for dynamic sagittal imbalance of the spine

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Introduction: Recently, advanced sagittal correction of ASD has been introduced, such as pre-posterior release-anterior-posterior instrumentation (PAP) as a combined approach (anterior column realignment, ACR) and hybrid technique anterior-posterior surgery (AP) using minimal approach (lateral lumbar interbody fusion, LLIF) with open posterior instrumentation. ACR through PAP has conventionally invasive approaches, which have a limited utility for severe spectrum of sagittal plane deformity. However, PAP is an extensive surgery and is associated with a large amount of intraoperative blood loss and significant complication rates. To our knowledge, few comparative studies have been conducted between these two surgical procedures for adult spinal deformities.
Aim: The purpose of this study was to investigate the clinical and radiological outcomes after ACR through PAP and hybrid anterior-posterior surgery (AP) using minimally invasive LLIF.
Patients and Methods: Patients diagnosed with dynamic sagittal imbalance (DSI) between May 2012 and July 2019 were included in this study. The inclusion criteria were (1) age > 65 years at the index surgery, (2) DSI without major coronal imbalance, (3) patients who underwent ACR with proximal fusion level to T10 and distal to the sacropelvis using bilateral iliac screws, or minimally invasive lateral lumbar interbody fusion (LLIF) with insertion of three or more cages from L1-L5, and/or posterior lumbar interbody fusion (PLIF) or ALIF for L5-S1. Patients with (1) Incomplete data and radiographs, or (2) less than 2 years' postoperative follow-up were excluded. Clinical outcomes and radiological parameters were evaluated and compared between the groups.
Results: A total of 91 patients who underwent long fusions from T10 to the sacropelvis were enrolled and divided into two groups: AP and PAP. AP was performed in 26 and PAP in 65 patients. Preoperatively, VAS and ODI scores were similar between the two groups ($p>0.05$). However, the VAS for back pain was higher in the PAP group than that in the AP group at the final follow-up. The ODI score at the final was similar in both groups. The preoperative lumbar lordosis (LL) was 7.3°±22.8° in the AP and -10.4°±24.6° in the PAP group ($p=0.002$). The postoperative LL was 38.0°±9.1° in the AP and 52.5°±12.5° in the PAP group ($p<0.001$). The preoperative pelvic incidence (PI)-LL was 43.8°±24.2° in the AP and 67.5°±26.2° in the PAP group ($p<0.001$). Postoperatively, the PI-LL was 13.1°±11.3° in the AP and 4.6°±14.0° in the PAP group ($p=0.009$). PJFs developed in 5 patients (19.2%) in the AP group and 17 patients (26.2%) in the PAP group ($p>0.05$). However, rod fracture developed in 1 patient in the AP group and 16 patients in the PAP group, with statistical significance ($p=0.034$). Twelve patients (18.5%) underwent reoperation in the PAP group and four patients (15.4%) in the AP group.
Conclusion: Although PAP provides a more powerful correction for severe sagittal malalignment than AP procedures, PAP results in more mechanical complications requiring reoperations. Thus, this study does not suggest that one treatment is superior to the other.
Key words: adult spinal deformity, anterior column realignment, lateral lumbar interbody fusion, spinopelvic alignment, complications

O252

The criteria of severe dynamic sagittal imbalance in adult spinal deformity and its importance

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Introduction: There is no study about the evaluation for severity of dynamic sagittal imbalance (DSI) of adult spinal deformity patients.
Aim: To analyze characteristics of patients with "severe" DSI in adult spinal deformity and establish a criteria for them.
Materials and Methods: One hundred two ASD patients with sagittal imbalance and 4 cardinal signs of lumbar degenerative kyphosis (LDK) were retrospectively analyzed. All patients undergone spine surgery for deformity correction and were divided into 3 groups according to a diagnostic criteria. The criteria was based on Oswestry Disability Index (ODI) scores and dynamic feature ($\triangle Time_{walk}$**:** Time until C7SVA reaches 20cm or more after starting walking) of sagittal imbalance. The quality and quantity of paravertebral back muscles were analyzed and compared by using T2-weighted axial images in the Picture Archiving and Communication System (PACS) viewing software. We performed statistically time-dependent spinopelvic sagittal parameters analysis in the full standing lateral radiographs. The lumbar flexibility of patients was also analyzed based on dynamic (flexion and extension) lateral lumbar radiographs: rigid, less than 10°; not rigid, 10° or more.
Results: Under the diagnostic criteria, 102 patients could be classified into three groups: Mild ($\triangle Time_{walk}$ ≥ 3 min, 35 patients), Moderate (3 min > $\triangle Time_{walk}$ ≥ 30s, 38 patients) and Severe (30s > $\triangle Time_{walk}$, 29 patients). There was significantly higher signal intensity (533.4±237.5, P<0.001) and larger area of fat infiltration (35.2±5.4, P<0.001) in back muscles of severe group than in those of mild group (223.8±67.6/22.9±11.9) and moderate group (294.4±214.7/21.6±10.6). Also, the analysis of lumbar flexibility revealed significantly lower value in severe group than in mild and moderate group. Severe group had significantly larger lumbar kyphosis (LL, 26.1°±22.7°, P<0.05), higher pelvic incidence (PI, 60.4°±10.7°, P<0.05) and PI-LL (86.5°±26.6°, P<0.05) than mild group (5.2°±16.3°/52.9±13.2°/58.7°±18.8°) and moderate group (13.7°±28.6°/53.5±12.4°/66.6°±13.4°). PI-LL was statistically significant with AUC = 0.810 (95% CI, 0.666-0.954) when the baseline was set at 75.3°. Severe group showed more perioperative complications, less immediate postoperative correction of LL, and loss of sagittal balance achieved by immediate postoperative than other groups.
Conclusions: We suggest a criteria of severe dynamic sagittal imbalance in adult spinal deformity. First, C7SVA becomes greater than 20cm within 30 seconds after walking or standing. And second, Rigid lumbar curve less than 10° in dynamic lateral radiographs. And Third, PI-LL mismatch is more than 75.3°.

Keywords: adult spinal deformity, degenerative flat back, dynamic sagittal imbalance, diagnostic criteria, surgical strategy, severity

O253

Mechanical complications and global alignment and proportion score after limited long-segment fusion for de novo adult spinal deformity: Comparison of lateral lumbar interbody fusion and three-column osteotomies

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Introduction: Subtypes of de novo adult spinal deformity (ASD) in which lumbar kyphosis is the main deformity and there is no kyphoscoliosis of the thoracolumbar spine can be corrected by limited long-segment fusion. Many surgeons have avoided that stopping proximally in the upper lumbar spine would lead to a high percentage of proximal junctional kyphosis and/or failure because of the concentration of stress on these segments. The purpose of this study was to evaluate the global alignment and proportion (GAP) score and mechanical complications after limited long-segment fusion for this subtype of ASD and to compare lateral lumbar interbody fusion (LIF) and the 3-column osteotomies (3CO).
Methods: This was a single-center study of 50 patients (average age 66.5 year) who underwent limited long-segment fusion (average 4.8 levels) with and a minimum 2 years of follow-up for ASD. The exclusion criteria were T10–L2 kyphosis >20° and scoliotic deformity with an upper end vertebra above T12. LIF group included 38 patients, and 3CO group included 12 patients. GAP score was calculated using parameters from early postoperative radiograph. Proximal and distal junctional kyphosis and/or failure and implant-related complications were considered mechanical complications. GAP scores and mechanical complications were compared between the two groups.
Results: In LIF group, patients were grouped according to the GAP score: 4 (10.5%) as proportioned, 11 (28.9%) as moderately disproportioned, and 23 (60.5%) as severely disproportioned. After a mean 4.5 years of follow-up, 19 patients (50%) experienced mechanical complications and 10 (26.3%) underwent mechanical revision. In 3CO group, patients were grouped: 6 (50%) as proportioned, 4 (33.3%) as moderately disproportioned, and 2 (16.7%) as severely disproportioned. After a mean 7.1 years of follow-up, 2 patients (16.7%) experienced mechanical complications and 1 (8.3%) underwent mechanical revision. The area under curve for the GAP score predicting mechanical complications was 0.81. The differences were statistically significant in GAP scores (7.4 vs. 3.8, P= 0.0024) and mechanical complications (50% vs. 17%, P= 0.041) between the two groups (LIF vs. 3CO).
Conclusions: In terms of limited long-segment fusion preserving mobile intervertebral segments for subtypes of ASD, the GAP score can predict mechanical complications, the use of 3CO (posterior closing wedge osteotomy) to create lumbar lordosis can produce and maintain sufficient global alignment. LIF (open wedge correction) was reported a safe and effective approach in managing ASD, whereas limited long-segment fusion with LIF for ASD may affect the development of mechanical complications and still have limitations.

O254

Subcrestal iliac screw technique as an alternative for spinopelvic fixation technique: A cohort study of 73 patients with a modified low profile, free hand technique for insertion of subcrestal iliac screw

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Introduction: Spinopelvic fixation with iliac screws has been shown to provide biomechanical advantages of a more stable fixation and has seen increased usage in adult spinal deformity corrections. We have previously described a novel technique of sub-crestal iliac screw placement where the iliac screw is inserted at medial wall of the iliac crest, underneath the crest and above the SI joint. This modified entry point allowed for several advantages including a low profile screw head, free hand fluoroscopy free insertion and avoidance of SI joint violation. This study aims to report the clinical and radiological outcomes of our cohort of patients who underwent insertion of subcrestal iliac screws.
Methods: This was a retrospective cohort study, conducted at a single university hospital. All consecutive patients who had undergone iliac screw fixations with the sub-crestal iliac screw technique were included. Patient demographics, operative details, pre and post op clinical scores, and presence of any radiological or clinical complications pertaining to the iliac screws were recorded and analysed.
Results: A total of 73 patients underwent subcrestal iliac screw insertion, with a mean follow-up of 25.1 months ± 30.2 months with a minimum follow up time of 6 months. The mean age was 63 with 31.5 % males. 62 of the patients underwent iliac screw fixation as part of corrective surgery for degenerative scoliosis, while 7 underwent fixation for spinal metastasis, 4 for traumatic spinal fractures and 1 underwent the procedure for neuromuscular scoliosis correction.
Majority of procedures were performed open (64.4%). The most common diameter of subcrestal iliac screws used was 8.5 mm (32.4%), with the mean length of 83.3 mm.
Post-operatively, there was a statistically significant improvement in VAS back and VAS leg pain. Mean VAS back was 5.7 and VAS leg 4.46 with improvement to mean VAS back 1.13 ($p < 0.01$) and VAS leg 0.60 ($p < 0.01$). 86.3 % saw a 2 point decrease in VAS back and/or absence of back pain and 87.5% saw a 2 point decrease in VAS leg and/absence of leg pain. Implant related complications seen included iliac screw breakage (2.73%), rod breakage (6.84%), rod screw detachment (2.73%) and painful implant prominence (4.1%) of patients. Other notable complications included surgical site infections (2.73%), sacral fractures (2.73%) and gluteal pain (5.4%). A total of 3 patients required revision surgery (4.1%) 2 underwent revision for iliac screw and/or rod breakage with significant back pain and the last underwent revision for proximal construct complications.
Conclusion: The subcrestal iliac screw technique is safe and effective. With this technique, it avoids the use of side connectors, resulting in lower construct complexity and costs. Importantly, it reduces entry point related complications associated with traditional iliac screws but retains the advantages of the low-profile S2-alar-iliac screw.

O255

Curve overcorrection predicts coronal imbalance in selective thoracic fusion in adolescent idiopathic scoliosis

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Introduction: Surgical treatment of adolescent idiopathic scoliosis (AIS) aims to correct deformity, maintain a balanced spine while minimizing the number of fused segments without risking deformity progression in the unfused spine. Selective fusion in Lenke type 1 curves is generally recommended but is associated with a risk of distal or proximal decompensation as well as coronal imbalance. It is of interest to examine the frequency and cause of imbalance to optimize surgical results.
Aim: To access the rate of coronal imbalance and identify possible reversible predictors of imbalance.
Patients and Methods: AIS patients with Lenke type 1 curve with A, B and C lumbar modifiers underwent selective thoracic fusion over a 20-year period. Radiographic variables were measured at the preoperative, immediate and two-year postoperative stages. From the standing whole spine posteroanterior radiograph, the following variables were measured: tilt of lower instrumented vertebra (LIV) and upper instrumented vertebra (UIV), major curve Cobb angle and apical translation of the main thoracic and lumbar curve, C7-CSVL deviation, trunk shift, radiographic shoulder height, fusion mass shift, fusion mass angle and LIV disc angle. The curve fulcrum flexibility and fulcrum bending flexibility index (FBCI) were also studied. Coronal imbalance was defined as more than 2 cm of truncal shift or more than 2 cm list at two-year follow-up. The primary outcome was coronal imbalance at two-year follow-up. Data was reported as proportions (%), mean ± standard deviation or median with range, and data distribution was assessed by histograms.
Results: A total of 301 patients were included in the study. 79% were lumbar modifier A, 11% were type B and 10% type C. A postoperative FBCI of more than 125% (third quartile) resulted in an odds ratio of 2.1 (95% CI: 1.1-4.3) for coronal imbalance at two years (p = 0.031). At two-year follow-up, mean FCBI was 102±32% vs 112±30% (p=0.121). 189 patients (63%) showed coronal imbalance preoperatively. 78 patients were imbalanced at the postoperative stage. At the two-year follow-up, 17/78 (21.8%) remained imbalanced. This imbalanced group showed a lower preoperative flexibility (52±15% vs 65±15%) and a higher postoperative FBCI (133±32% vs 118±26%) (p=0.040) compared to the 61 patients that corrected the imbalance. We saw no significant changes in fusion mass or LIV tilt. RSH changed from 16 mm in both groups at the postoperative stage to 11±7 vs 7±6 mm in the balanced and imbalanced group at the two-year follow-up (p=0.002). Post-hoc, we analyzed type B and C curves to assess which immediate postoperative variables were associated with truncal imbalance. The median FBCI was 109% (46-189) in the balanced group and 133% (105-178) in the unbalanced group (p=0.034).
Conclusion: Coronal imbalance in type 1 AIS can be expected in 10% of cases. A decreased preoperative flexibility and an increase in FBCI is significantly associated with an increased rate of imbalance. Future studies may clarify whether correction strategy should aim to “under correct” less flexible curves or extend the fusion to address this issue.

O256

Directed versus non-directed standing postures in adolescent idiopathic scoliosis: Its impact on curve magnitude, alignment and clinical decision making

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Introduction: Proper positioning for radiographs is important to assess patients' usual functional posture in standing so that management strategies can be tailored to the standing alignment. To achieve better visibility of the sagittal alignment, it is recommended for example to have the patient standing upright with the arms slightly forward, elbows bent with fists on clavicles. Whether the natural posture of the patients affects coronal and sagittal radiological parameters remains unknown. Since patients acquire their relaxed posture during daily life rather than the directed position for spine radiographs, differences between non-directed posture and directed positioning may lead to Cobb angle and balance variations that warrant different treatment.

Aim: To investigate the difference in major curve Cobb angle and alignment between directed and non-directed positionings during whole body radiographs in adolescent idiopathic scoliosis (AIS) and to realize their clinical implication on treatment.

Patients and Methods: Patients with AIS presented for first consultation at the tertiary scoliosis clinic were recruited and were asked to stand in two positions for their low-dose head-to-toe radiographs: non-directed, passive position; and directed position by radiographer, confirming the chin, shoulder and pelvis positions (Figure 1). Radiological assessment included Cobb angle of major and minor curves, coronal balance (trunk shift, shoulder balance, pelvic obliquity, C7-CSVL deviation), sagittal balance and alignment, and spinopelvic parameters. Major curve Cobb angle difference >5º between directed and non-directed positioning was considered clinically impactful, patients with or without such difference were compared. Over- or under-representation of major curve 25º or 40º by non-directed positioning was examined for their relevance of clinical decision-making of bracing or surgery.

Results: A total of 198 patients (66.2% girls) were studied, with 22.2% experienced major Cobb angle difference between positioning. Non-directed positioning presented with smaller major Cobb angle than directed positioning (median difference: 6.0º, upper and lower quartile: -7.8, 5.8). A major curve ≥30º was susceptible to Cobb angle difference between positioning. Patients with Cobb angle difference had changes in shoulder balance ($p=0.007$), reduced SVA deviation ($p=0.011$), increased lumbar lordosis ($p=0.001$) and sacral slope ($p<0.001$) when assumed directed position (Figure 2). Non-directed positioning had 14.3% of major Cobb 25º under-represented and 9.9% over-representation, whereas 11.1% of >40º curves were under-represented.

Conclusion: Strict adherence to radiographic standardized protocol is mandatory for reproducing spine radiographs reliable for curve assessment, as non-directed position demonstrates smaller Cobb angles. Postural variation may lead to under-representation of the curve size relevant for bracing or surgical decision-making. Shoulder imbalance and pelvic obliquity relate to discrepancies in curve magnitude.

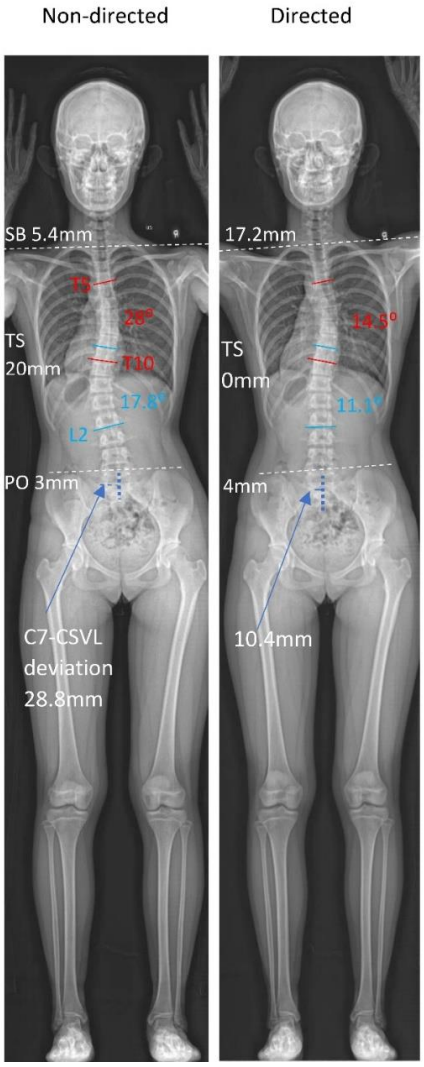

Figure 1: non-directed and directed positioning

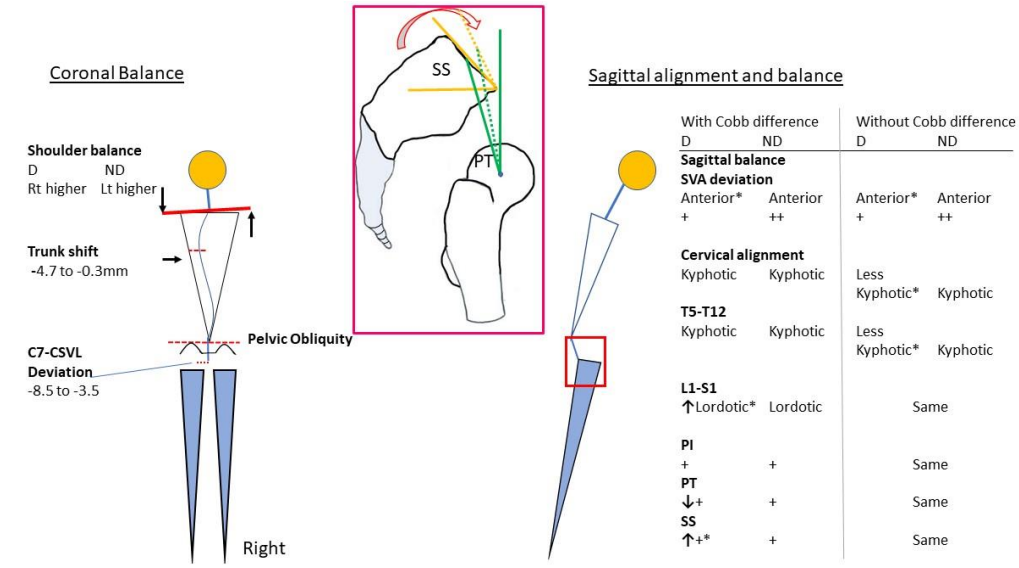

Figure 2: Coronal and sagittal alignment differences in non-directed and directed postures

O257
Fusion block tilt following corrective surgery in Lenke 5 adolescent idiopathic scoliosis (AIS)

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Introduction: We observed some Lenke 5 adolescent idiopathic scoliosis (AIS) patients developed fusion block tilt (FBT) following posterior spinal fusion (PSF) surgery. However, its occurrence and outcomes were not previously investigated.
Methods: We retrospectively reviewed 100 Lenke 5 AIS patients who had undergone PSF with minimum 2-year follow-up. FBT was defined as the angle between the longitudinal axis of the fusion block (line connecting the centroid of upper instrumented vertebra [UIV] and the centroid of lowest instrumented vertebra [LIV]) with the vertical axis (Figure 1). The calculated minimal detectable change of FBT was 1.131 degree. Therefore, we defined presence of FBT when the measured FBT was 2º or more. Demographic, SRS-22r scores and radiological parameters were collected and analyzed.
Results: At 2 month-postoperatively, FBT was found in 81.0% of patients. At final follow-up, patients who developed FBT had larger main thoracic (MT) Cobb angle (18.0 ± 8.5º vs. 13.1 ± 5.1º, p=0.018); larger MT apical vertical translation (MT-AVT) (13.7 ± 9.7 mm vs. 6.9 ± 4.8 mm, p=0.004); and larger disc wedge angle (DWA) (3.7 ± 3.4º vs. 1.8 ± 2.3º, p=0.021) when compared to those without FBT. 22% of patients with FBT developed unacceptable increase in main thoracic curve (UIMT) at final follow-up as compared to none among patients without FBT. 37.0% of patients with FBT developed FBT progression of 2º or more at final follow-up. However, there was no significant difference in radiological shoulder outcomes. There was no significant difference in preoperative and final follow-up SRS-22r scores between both groups.
Conclusions: AIS patients with Lenke 5 curves may develop FBT following PSF and some may progress over time. Patients who had FBT postoperatively were found to have larger MT curvature, larger MT-AVT and UIMT at final follow-up.

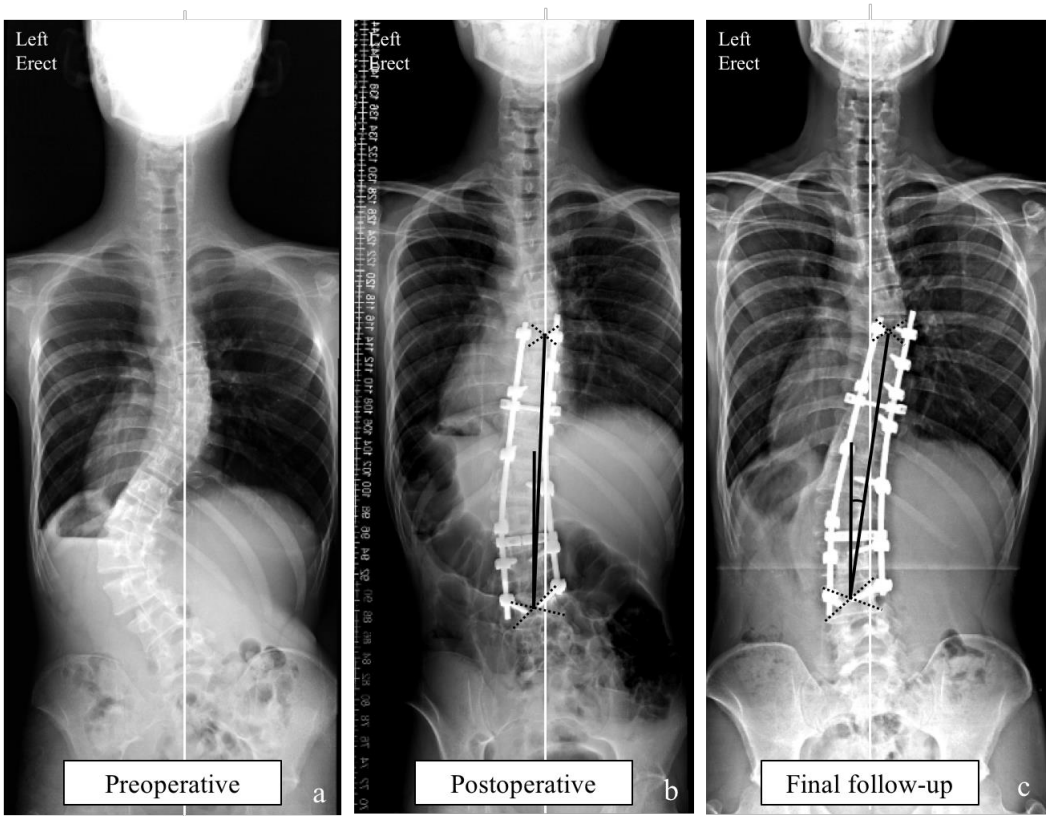

Figure 1

O258

Validation of the predictive formula for optimal upper instrumented vertebra (UIV) Tilt angle (based on pre-operative erect radiograph) in adolescent idiopathic scoliosis (AIS): A comparison with the calculated optimal UIV tilt angle derived from the supervised supine side bending films (SSBF)

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Introduction: The Optimal UIV Tilt Angle was described in 2016 and was calculated based on the SSBF. This parameter was found to have significant correlation with medial shoulder and neck balance after posterior spinal fusion (PSF) in AIS patients. Recently we have introduced a predictive formula for the Optimal UIV Tilt Angle based on pre-operative erect radiographs. The aim of this study was to validate the predictive formula and compare it with values obtained from the SSBF.
Methods: This was a retrospective study involving Lenke 1 and 2 patients. The Optimal UIV Tilt Angle derived from the predictive formula (0.396 x Pre-operative UIV Tilt Angle) – (0.349 x Pre-operative T1 tilt Angle) – 0.871 was P-Tilt Angle (P-TA). The calculated Optimal UIV Tilt Angle derived from the SSBF was C-Tilt Angle (C-TA). Correlation study was performed to compare these two values as well as to assess its accuracy for different UIV levels.
Results: A total of 134 patients were included, 18 (13.4%) males and 116 (86.6%) females. There were 102 (76.1%) Lenke 1 and 32 (23.9%) Lenke 2 patients, respectively. UIV were at T2 (41.8%), T3 (50.0%) and T4 (6.7%) in the majority of patients. The mean pre-operative Main Thoracic Cobb angle was 66.3 ± 16.6°, with flexibility rate of 56.8 ± 16.4%, correction rate of 64.7 ± 10.4% and side bending correction index of 1.2 ± 0.3. The correlation between P-TA and C-TA was 0.678 ($p<0.001$). For UIV at T2, T3 and T4, the P-TA was ≤3° compared with C-TA in 85.7%, 92.6% and 99.9% of patient, respectively. Conversely 10.8%, 4.5% and 0.0% of patients had P-TA ≥5° compared with C-TA at T2, T3 and T4, respectively.
Conclusions: There is significant correlation between P-TA and C-TA. Utilising the P-TA would reduce the need for additional side bending radiographs. However, the use of P-TA will need to be assessed in larger multicenter studies.

O259

A dedicated spine team approach optimised the efficiency of operating theatre utilisation while maintaining a standard patient care in adolescent idiopathic scoliosis surgery

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Introduction: Many protocols had been established to improve healthcare cost efficiency by optimising utilisation of operating theatre (OT). OT utilisation is one of the costliest constituents in the healthcare system. In view of high cost incurred in spine deformity surgeries, a dedicated spine team had been assembled to optimise OT utilisation while maintaining standard patient care.
Aim: To report on the efficiency of OT utilisation with a dedicated spine team approach for posterior spinal fusion surgeries (PSF) in adolescent idiopathic scoliosis (AIS) patients while demonstrating standardization of patient outcomes in terms of different stages of OT time and intraoperative blood loss.
Materials and Methods: This was a retrospective study of three AIS patients operated in a day, i.e., from 8AM to 8PM, by a dedicated spine team in a single academic institution between year 2021 and 2022. A dedicated spine team comprised of three senior spine consultants who operated using a dual attending surgeon strategy, an anaesthetic consultant, dedicated surgical scrub nurses, anaesthesiology nurses, radiographers, and neuromonitoring technicians assigned to all spine surgeries. All cases were performed according to the standardised protocols including patient preparation *(patient transport, positioning, and draping)*, anaesthesia protocol, image intensifier use, surgical techniques, and postoperative protocol. All team members were familiar with the standardized protocols. Primary outcomes measured were preoperative time *(time interval between patient's entry to OT and initiation of skin incision)*, operative time *(time interval between initiation of skin incision and completion of skin closure)*, postoperative time *(time interval between completion of skin closure and exit from OT)*, total OT time *(time interval between entry to OT and exit from OT)*, intraoperative blood loss, and blood transfusion requirement.
Results: 102 AIS cases were recruited where on average, 3 cases were operated per day from 8AM to 8PM (Figure 1). Mean age was 17.2±5.4 years with mean major Cobb angle of 63.3±15.5°. Mean preoperative, operative, postoperative, and total OT time for Case 1 were 37.4±4.9mins, 117.6±29.6mins, 14.4±6.1mins, and 169.4±31.3mins, respectively. OT timing for Case 2 were 36.9±5.4mins, 125.4±25.1mins, 13.7±3.7mins, and 174.6±25.8mins, respectively whereas Case 3 were 37.6±5.4mins, 125.8±29.4mins, 17.0±12.1mins, and 180.4±31.4mins, respectively. Case 1 to 3 had comparable OT timing for all stages (p>0.05). Intraoperative blood loss for Case 1 to 3 were 616.6±225.4mL, 649.4±275.6mL, and 648.6±260.1mL, respectively (p=0.832). None of the patients received blood transfusion (Table 1).
Conclusion: With a dedicated spine team approach, we can optimise the OT utilisation without compromising patient care by performing surgery on three AIS cases in a day. The OT timing and intraoperative blood loss for each stage were comparable between the first, second and last case operated on the day.

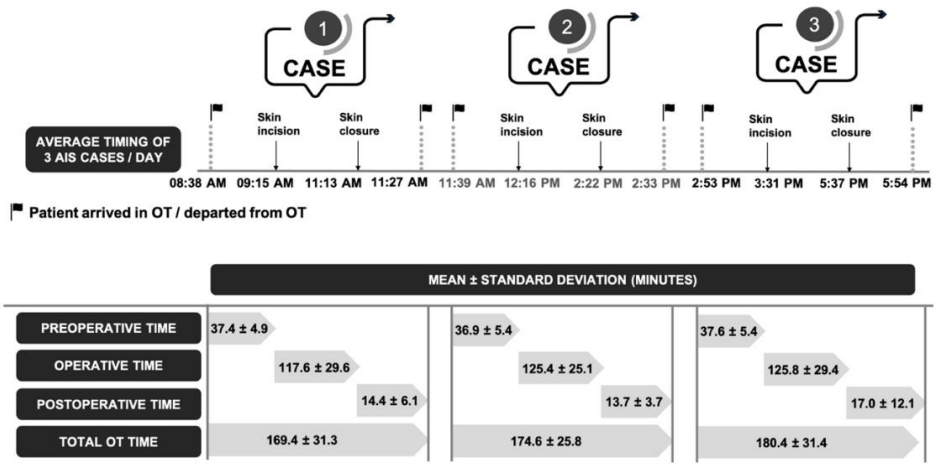

Figure 1. Illustration of average timing for 3 AIS cases performed by a dedicated spine team per day and the mean ± standard deviation for preoperative, operative, postoperative and total operating theatre (OT) time (p>0.05).

Table 1. Demographic, preoperative, and operative data for 102 AIS patients operated by a dedicated spine team approach.

	Case 1 N = 34	Case 2 N = 34	Case 3 N = 34	Total N = 102	*p* value
Age (years)	15.7 ± 4.1	17.5 ± 5.4	18.3 ± 6.2	17.2 ± 5.4	0.118
Gender					0.288
Female	33 (35.5%)	29 (31.2%)	31 (33.3%)	93 (91.2%)	
Male	1 (11.1%)	5 (55.6%)	3 (33.3%)	9 (8.8%)	
Height (cm)	157.6 ± 6.9	156.8 ± 6.6	156.2 ± 6.9	156.9 ± 6.8	0.691
Body weight (kg)	46.5 ± 9.2	48.8 ± 11.4	45.3 ± 10.5	46.9 ± 10.4	0.392
Body mass index (kg/m^2)	18.7 ± 3.2	19.7 ± 3.8	18.5 ± 3.5	19.0 ± 3.5	0.284
Lenke Classification					0.687
1	15 (32.6%)	14 (30.4%)	17 (37.0%)	46 (45.1%)	
2	4 (23.5%)	7 (41.2%)	6 (35.3%)	17 (16.7%)	
3	0 (0.0%)	1 (100.0%)	0 (0.0%)	1 (1.0%)	
4	0 (0.0%)	1 (33.3%)	2 (66.7%)	3 (2.9%)	
5	14 (46.7%)	9 (30.0%)	7 (23.3%)	30 (29.4%)	
6	1 (20.0%)	2 (40.0%)	2 (40.0%)	5 (4.9%)	
Risser					0.447
0	2 (40.0%)	1 (20.0%)	2 (40.0%)	5 (4.9%)	
1	3 (30.0%)	3 (30.0%)	4 (40.0%)	10 (9.8%)	
2	3 (25.0%)	6 (50.0%)	3 (25.0%)	12 (11.8%)	
3	5 (55.6%)	3 (33.3%)	1 (11.1%)	9 (8.8%)	
4	12 (44.4%)	8 (29.6%)	7 (25.9%)	27 (26.5%)	
5	9 (23.1%)	13 (33.3%)	17 (43.6%)	39 (38.2%)	
Preoperative major Cobb angle (°)	59.3 ± 9.4	65.4 ± 17.0	65.2 ± 18.2	63.3 ± 15.5	0.185
Preoperative Hb level (g/dL)	13.2 ± 0.9	13.3 ± 1.3	13.4 ± 1.3	13.3 ± 1.2	0.851
Intraoperative blood loss (mL)	616.6 ± 225.4	649.4 ± 275.6	648.6 ± 260.1	638.2 ± 252.5	0.832
Intraoperative ABG					
pH	7.37 ± 0.03	7.36 ± 0.03	7.36 ± 0.04	7.36 ± 0.03	0.617
PaO_2 (mmHg)	222.0 ± 40.3	219.2 ± 37.1	214.4 ± 30.3	218.6 ± 36.0	0.682
$PaCO_2$ (mmHg)	41.3 ± 2.1	41.5 ± 2.1	41.1 ± 2.3	41.3 ± 2.2	0.695
HCO_3^- (mmol/L)	23.1 ± 1.5	22.9 ± 1.5	22.6 ± 1.5	22.9 ± 1.5	0.373
Base excess	-1.6 ± 1.9	-1.9 ± 1.9	-2.3 ± 1.9	-1.9 ± 1.9	0.379
Lactate (mmol/L)	1.3 ± 0.6	1.6 ± 2.1	1.2 ± 0.4	1.4 ± 1.3	0.466
Postoperative Hb level (g/dL)	11.2 ± 0.9	11.2 ± 1.2	11.4 ± 1.1	11.3 ± 1.1	0.611
Blood transfusion					-
No	34 (33.3%)	34 (33.3%)	34 (33.3%)	102 (100.0%)	
Yes	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
OT time for each stage					
Preoperative time (mins)	37.4 ± 4.9	36.9 ± 5.4	37.6 ± 5.4	37.3 ± 5.2	0.856
Operative time (mins)	117.6 ± 29.6	125.4 ± 25.1	125.8 ± 29.4	123.0 ± 28.1	0.402
Postoperative time (mins)	14.4 ± 6.1	13.7 ± 3.7	17.0 ± 12.1	15.0 ± 8.2	0.213
Total OT time (mins)	169.4 ± 31.3	174.6 ± 25.8	180.4 ± 31.4	174.8 ± 29.7	0.308

Values expressed in number (percentage) or mean ± standard deviation.

ABG: arterial blood gas; Hb: haemoglobin; Pa: partial pressure in arterial blood; O_2: oxygen; CO_2: carbon dioxide, HCO_3^-: bicarbonate; OT: operating theatre

O260

Comparison of perioperative outcomes among adolescent idiopathic scoliosis (AIS) patients operated by a dedicated spine team approach: Were there any differences between the first, second and the last case?

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Introduction: Corrective scoliosis surgery has the potential risk of major and minor complications. Many recommendations in surgical management had been described with goals of improving the efficiency and outcomes of these patients. Interests in the concept of a dedicated team for surgical standardization had grown over the years. This is to improve the cost effectiveness of patient care while achieving desirable operative outcomes.
Aim: The purpose of this study was to compare the perioperative outcomes between the first, second and the last case of the day in AIS patients who underwent posterior spinal fusion (PSF) by a dedicated spine team approach.
Materials and Methods: Data of 123 AIS patients who underwent surgery utilising a dedicated spine team approach in a single centre between year 2021 and 2022 was retrospectively analyzed. Patients were classified in accordance with the sequence of surgery with Case 1 being the first case, Case 2 being the second case and Case 3 being the last case of the day. The dedicated team consists of three senior spine consultants who operated using a dual attending surgeon approach, dedicated anaesthetist, operative and anaesthetic nurses, radiographer as well as operation theatre assistant. Perioperative outcomes measured were operative time, intraoperative blood loss, blood transfusion requirement, haemoglobin level, number of screws used, length of hospital stay *(from completion of surgery to the day of discharge)*, and complication rate.
Results: The mean age of patients was 17.3±5.2 years. Mean major Cobb angle was 64.1±16.4°. There were no significant differences between Case 1 (N=41), Case 2 (N=41), and Case 3 (N=41) in terms of age, gender, body mass index (BMI), Lenke classification, Risser grading, and preoperative major Cobb angle (p>0.05). All perioperative outcomes between Case 1, Case 2, and Case 3 were comparable (p>0.05). The mean operative time, intraoperative blood loss, Hb drift, number of screws, and patient-controlled analgesia morphine usage were 127.8±32.9mins, 665.1±277.9mL, 2.0±0.8g/dL, 14.3±2.4 screws, and 15.9±11.2mg, respectively. Mean length of hospital stay was 3.0±0.2 days (Table 1). None of the patients required blood transfusion. The complication rate in this study was 2.4% with 3 complications. 1 patient with superficial surgical site infection requiring reoperation. 2 patients had superficial surgical site infection which resolved with antibiotics treatment.
Conclusion: Implementation of a dedicated spine team approach led to comparable perioperative outcomes between the first, second and the last case of the day among AIS patients operated in a consecutive case operation list. This could be due to improved efficiency while maintaining standardised patient care.

Table 1. Demographic and perioperative outcomes for 123 AIS patients operated by a dedicated spine team approach.

Demographic data	**Total N = 123**	**Case 1 N = 41**	**Case 2 N = 41**	**Case 3 N = 41**	***p* value**
Age (years)	17.3 ± 5.2	15.9 ± 4.0	17.3 ± 5.2	18.7 ± 6.1	0.050
Gender					0.144
Female	111 (90.2%)	40 (36.0%)	35 (31.5%)	36 (32.4%)	
Male	12 (9.8%)	1 (8.3%)	6 (50.0%)	5 (41.7%)	
Height (cm)	157.0 ± 6.9	156.9 ± 7.0	157.1 ± 6.3	157.2 ± 7.7	0.987
Body weight (kg)	47.0 ± 10.1	47.0 ± 9.1	48.1 ± 11.3	45.9 ± 10.0	0.611
Body mass index (kg/m^2)	19.0 ± 3.4	19.0 ± 3.1	19.4 ± 3.8	18.5 ± 3.2	0.465
Lenke Classification					0.265
1	56 (45.5%)	20 (35.7%)	19 (33.9%)	17 (30.4%)	
2	19 (15.4%)	4 (21.1%)	8 (42.1%)	7 (36.8%)	
3	1 (0.8%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	
4	3 (2.4%)	0 (0.0%)	1 (33.3%)	2 (66.7%)	
5	34 (27.6%)	16 (47.1%)	9 (26.5%)	9 (26.5%)	
6	10 (8.1%)	1 (10.0%)	3 (30.0%)	6 (60.0%)	
Risser					0.586
0	5 (4.1%)	2 (40.0%)	1 (20.0%)	2 (40.0%)	
1	11 (9.0%)	4 (36.4%)	3 (27.3%)	4 (36.4%)	
2	12 (9.8%)	3 (25.0%)	6 (50.0%)	3 (25.0%)	
3	10 (8.2%)	5 (50.0%)	3 (30.0%)	2 (20.0%)	
4	32 (26.2%)	13 (40.6%)	12 (37.5%)	7 (21.9%)	
5	52 (42.6%)	13 (25.0%)	16 (30.8%)	23 (44.2%)	
Preoperative major Cobb angle (°)	64.1 ± 16.4	59.5 ± 10.9	67.0 ± 17.5	65.8 ± 18.9	0.078
Perioperative outcomes					
Number of screws	14.3 ± 2.4	13.6 ± 2.6	14.6 ± 2.1	14.7 ± 2.4	0.074
Operative time (mins)	127.8 ± 32.9	119.2 ± 29.3	128.5 ± 27.9	135.8 ± 39.1	0.070
Intraoperative blood loss (mL)	665.1 ± 277.9	615.4 ± 218.9	680.1 ± 314.1	699.9 ± 291.4	0.358
Blood transfusion					-
No	123 (100.0%)	41 (33.3%)	41 (33.3%)	41 (33.3%)	
Yes	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Preoperative Hb level (g/dL)	13.4 ± 1.2	13.3 ± 0.9	13.4 ± 1.3	13.5 ± 1.3	0.707
Postoperative Hb level (g/dL)	11.4 ± 1.1	11.3 ± 0.9	11.3 ± 1.3	11.6 ± 1.2	0.471
Hb drift (g/dL)	2.0 ± 0.8	2.0 ± 0.6	2.1 ± 0.9	2.0 ± 0.8	0.852
PCA morphine usage (mg)	15.9 ± 11.2	17.9 ± 12.0	14.5 ± 9.0	15.2 ± 12.3	0.337
Length of hospital stay	3.0 ± 0.2	3.0 ± 0.2	3.0 ± 0.2	3.0 ± 0.2	0.518
Complication rate					0.772
Yes	3 (2.4%)	0 (0.0%)	2 (66.7%)	1 (33.3%)	
No	120 (97.6%)	41 (34.2%)	39 (32.5%)	40 (33.3%)	

Values expressed in number (percentage) or mean ± standard deviation.
Hb: haemoglobin; PCA: Patient-controlled analgesia; Length of hospital stay (from completion of surgery to the day of discharge)

O261

The alternation of junctional levels after decompression and alignment correction for cervical kyphotic deformity induced multilevel cervical myelopathy: A retrospective case analysis

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Introduction: Multilevel cervical myelopathy (MCM) caused by Cervical kyphotic deformity (CKD) had made an indication for cord decompression and alignment correction with long instrumented structure. However, the subsequential change over junctional level after the correction and fusion remains an unidentified issue. Therefore, the aim of this study is to evaluate the junctional alignment change as well as the functional outcome after long instrumented correction and decompression for the Cervical kyphotic deformity (CKD) induced Multilevel cervical myelopathy (MCM).
Method: From 2016 to 2019, 50 cases of CKD induced MCM were enrolled for decompression and correction. The sagittal alignment changes of junctional levels, including Occipital-cervical angle (C0-2 CA, Cobb Angle), C2-7 CA, C2-7 sagittal vertical axis (SVA), and T1 slope (T1S). While functional outcomes (mJOA score, VAS, NDI) were also evaluated preoperatively, 3-months, 6-months, 24-months, and 36-months postoperatively.
Result: The lordotic change and the improvements in functional outcomes were both considerable almost in every patient within 6-month postoperatively. However, the compensatory mechanism presented secondary to the chronic kyphotic deformity were found reversed as follow-up and turned significant since 12-month postoperatively. Besides, the reversed change on sagittal alignment, was positively related to the age, and the scale of lordotic corrected during the initial surgery. However, these changes were not significantly correlated to the functional outcomes at any time point of the follow-up.
Discussion: As horizontal gaze is the functional requirement of patient's daily life, decrease of T1S and hyper extension of Occipital-cervical junction occurred as compensation for the chronic cervical lordosis loss. If T1S decrease alone cannot achieve cervical sagittal balance, hyper-lordotic change in O-C2 segment may occur as secondary compensation. After alignment correction with instrumented fusion, patients tended to regain normalization of T1S, and the proportion of normalized T1S was related to the correction scale.
Conclusions: Reversed compensatory change after alignment correction occurred over junctional levels. The normalization of certain radiographic parameters, representing spinal balance could gradually achieve after the alignment correction. If neural and soft tissue allowed, the larger instrumented correction as needed would prefer to achieve more normalized cervical alignment without worry of deterioration of clinical outcome within 3 years follow-up.

O262

Comparison between the bone union rates using auto-iliac bone and bone morphogenetic protein without auto bone in a posterior atlantoaxial fusion procedure: Results from a minimum 1-year follow-up

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Introduction: Traditionally, auto-iliac bone has traditionally been the gold standard for bone grafting in spinal fusion but has been replaced recently by recombinant human bone morphogenetic protein-2 (rhBMP-2) in several operations. Atlantoaxial bone fusions are challenging due to the biomechanical stress that arises at this level. Therefore, some concerns have been raised regarding bone fusion using rhBMP-2 without auto bone in a posterior atlantoaxial fusion procedure. This study was conduct to 1) compare the bone union rates achieved with an auto-iliac bone graft and rhBMP-2 without auto bone 2) check to potential advantage and disadvantage of rhBMP-2 as bone graft material in posterior atlantoaxial fusion procedures.
Methods: The study included 103 patients who underwent a posterior atlantoaxial fusion due to a C1-2 pathology. As bone graft material, using an auto-iliac bone graft were assigned to the iliac bone graft group (group I, n=68), while cases involving rhBMP-2 without auto bone were assigned to a rhBMP-2 group (group B, n=35). We evaluated the bone unions in these cases using postoperative 1-year dynamic radiographs (flexion and extension position) and computed tomography(CT). To check atlantoaxial bone fusion, we analyzed pseudomotion in postoperative dynamic radiographs and bone bridge formation, facet joint fusion, and metal loosening in postoperative CT, respectively. Additionally, we analyzed and compared the demographic, operative, and clinical factors between the two groups of patients.
Results: No significant differences were evident between the bone union rates using 1-year dynamic radiographs in group I and B (66/68, 97.0%, vs 34/35, 97.1%, respectively; P=1.000). However, the bone union rates using 1-year CT in group I is higher than group B (59/68, 86.7% vs 18/35, 51.4%, repectively; P<0.001). Additionally, the operation time is longer in group I than group B (189.4±39.0 min vs 102.6±20.9 min, p<0.001). And, the hospital stay length also is longer in group I than group B (9.8±4.1 vs 7.7±4.8, p=0.048). A persistent pain at the graft site during at 1 year was reported in 20.6% (14/68) of patients in group I. Although clinical outcomes improved postoperatively in both group, no inter-group differences were observed.
Conclusions: There was no significant difference in the bone union rate on dynamic radiographs between two auto-iliac bone graft and rhBMP-2 without auto bone. Additionally, there was no difference in the clinical outcomes. Considering the advantages including decreased operative times, shorter hospital stay and donor site morbidity, rhBMP-2 has advantages as grafting choice for posterior atlantoaxial fusion procedure. But, this study also demonstrated that definite bone bridge formation and facet joint fusion on postoperative CT were lessly checked in the rhBMP-2 without auto bone group. Therefore, a long term follow-up is also required in posterior atalntoaxial bone fusion using rhBMP-2 without auto bone.

Table 3. The demographic and operative factors between two groups.

	Group I n=68	Group B n=35	P value
Age	57.1±17.6	60.0±14.6	0.512
Sex (%)			
Male	28 (41.2)	18 (51.4)	0.322
Female	40 (58.8)	17 (48.6)	
BMI	23.6±3.6	24.4±4.0	0.406
BMD (spine)	-1.7±1.3	-1.3±1.8	0.707
Smoking (%)	2 (13.7)	3 (19.3)	0.334
Operation time	189.4±39.0	102.6±20.9	**<0.001**
Hospital stays	9.8±4.1	7.7±4.8	**0.048**
Donor site pain	14 (20.6%)		
Fever > 37.5 (%)	19 (27.9)	9 (25.7)	0.810
CRP in postoperative 3 days	3.7±3.6	2.4±4.7	0.229

BMI, body mass index; BMD, bone mineral density; CRP, C-reactive protein

Table 2. The radiologic and clinical factors between two groups.

	Group I n=68	Group B n=35	P value
Bone union in dynamic radiographs (%)	66 (97.0)	34 (97.1)	1.000
Computed tomograph (%)			
Bone bridge	55 (80.8)	14 (40.0)	**< 0.001**
Facet joint fusion	12 (17.6)	5 (14.3)	0.663
Metal loosening	1 (1.4)	0 (0.0)	1.000
Bone union	59 (86.7)	18 (51.4)	**< 0.001**
Preoperative VAS-N	3.9±2.5	4.1±2.9	0.783
Postoperative VAS-N	1.9±1.7	2.2±1.5	0.590
Preoperative NDI	16.3±10.0	15.9±6.8	0.887
Postoperative NDI	9.7±7.6	11.2±10.3	0.776

VAS-N, Visual Analogue Scale for neck pain; NDI, neck disability index

O263

Predictive equations for cervical lordosis and T1 slope of young adult population without any neck symptoms - Analysis of 171 radiographs

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Introduction: Normative values of cervical sagittal (CS) parameters including physiological cervical lordosis (CL) and their relationship with the thoracic inlet (TI) parameters have been scarcely documented in literature for healthy Indian adults.
Aim: To analyse the CS and TI parameters in asymptomatic adults and form predictive equations for CL and T1 Slope (T1S).
Patients and Methods: We retrospectively analyzed cervical radiographs of 171 healthy adult volunteers and estimated normative value of CS and TI parameters. Thoracic inlet angle (TIA), neck tilt (NT) and T1S were the TI parameters and cervical parameters included C2-C7 CL (Cobb's method), cervical sagittal vertical axis (cSVA), C7 slope (C7S). T1S-CL was also calculated. Correlations were estimated and predictive equations were established using simple linear and stepwise multiple regression. Paired sample t test was used to see statistical difference between the estimated and measured values.
Results: The mean age of participants was 30±7.76 years. Mean TIA, T1S, NT, CL, cSVA, C7S, T1S-CL was 79.6±9.08°, 29.5±8.6°, 49.3±8.7°, 21.4±16.5°,18.8±12.4 mm, 25.7±7.9°, 8.7±13.8° respectively. We established following predictive equations- CL= 0.66 T1S+ 0.57 TIA - 0.68 SVA - 30.9 ($r=0.72$; $R^2=0.53$; $p<0.01$); CL=0.68 TIA - 30.4 ($r=0.41$, $R^2=0.34$; $p=0.04$) and T1S= 4.45 + 0.72 C7S ($r=0.77$; $R^2=0.62$; $p< 0.01$). There was no statistical difference between the predicted and the measured values of CL ($t=0.09$, $p=0.973$) or T1S ($t=0.14$; $p=0.84$).
Conclusion: This analysis of sagittal parameters in asymptomatic adult population provides valuable reference point for management of various cervical alignment disorders.

O264
The risk of injury to the internal carotid artery during C1 lateral mass screw fixation

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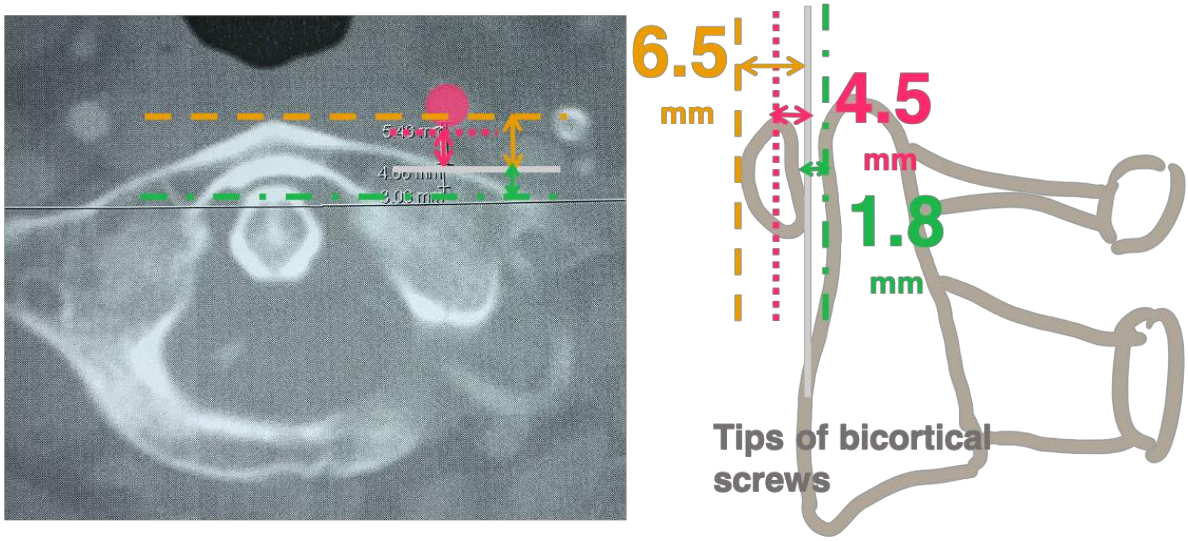
Introduction: C1 lateral mass screw fixation poses a risk of injury to the internal carotid artery (ICA) that locates anteriorly to the lateral mass. Few reports described injury of ICA caused by C1 screws. This study aimed to assess the anatomical relationship of ICA and C1 lateral mass and to evaluate the risk of injury to the ICA during C1 lateral mass screw fixation.
Materials and Methods: The author retrospectively analyzed 246 ICAs in 123patients who underwent computed tomography angiography of the cervical spine, 65 males and 58 females, with an average of 63.8 years old, to assess the position of the ICA in association with the C1 lateral mass. For patients with an ICA ventral to the lateral mass, the shortest distance between the ICA and the anterior cortex of lateral mass was measured to evaluate the risks of ICA injury. The sagittal distance from the anterior cortex of the lateral mass to the anterior arch apex and the odontoid process was also measured as the landmark for a tip of the bicortical screw.
Results: 57 out of 123 patients (46.3%, 42 unilaterally, 15 bilaterally) had the ICA in front of the C1 lateral mass, indicating the at-risk region. The remaining 65 patients had the ICA lateral to the C1 lateral mass. None had the ICA medial to the lateral mass. For those 57 patients in whom the ICA was in the at-risk region, the mean shortest distance between the ICA and the anterior surface of the C1 lateral mass was 4.5 mm (range 0.9–10.2 mm) (Figure). The mean sagittal distance from the anterior cortex of the lateral mass to the tips of the anterior tubercule and odontoid process were 6.5 and 1.8 mm, respectively (Figure). Those patients with ICA in the at-risk region significantly had higher ages and hypertension than those without at-risk ICA (Mann–Whitney U test, chi-square test, $p<0.05$).
Conclusions: A high percentage of patients demonstrate an ICA directly ventral to the C1 lateral mass, which poses a risk of ICA injury caused by an overpenetrated bicortical screw. Using lateral fluoroscopy helps visualize landmarks for the ideal position of the tips of bicortical screws. Our results showed that the majority of the anterior cortex of the lateral mass was behind the anterior tubercle of C1 and slightly anterior to the odontoid.



O265

Sarcopenia in paraspinal muscle as a risk factor of proximal junctional kyphosis and proximal junctional failure after adult spinal deformity surgery

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Introduction: A number of risk factors have been reported to be associated with proximal junctional kyphosis (PJK) and proximal junctional failure (PJF) after long-instrumented fusion for adult spinal deformity. Adult spinal deformities are often accompanied by back muscle atrophy.
Aim: The aim of this study was to identify the risk factors of PJK and PJF, including paraspinal muscle atrophy, and to compare the risk factors of the PJK and PJF.
Patients and Methods: Eighty-four consecutive patients who underwent a long-instrumented fusion for adult spinal deformities with a minimum follow-up of 2 years were included in the study. Patient, surgical, and radiographic factors were evaluated. Muscle volumes were measured using muscle/vertebra ratios of multifidus (MF), elector spinae (ES), and psoas (PS) muscles, and muscle functions were assessed using degree of fat infiltration at the L4-5 level.
Results: PJK occurred in 13 patients and PJF in 12. The combined PJK/PJF group consisted of 25 patients and the control group consisted of 59 patients without PJK or PJF. Mean durations to onset in PJK and PJF patients were 15.7 and 1.7 months, respectively. No surgical or radiographic risk factors of PJK or PJF were significant by multivariate analysis. Comparisons of paraspinal muscle atrophy between the control group and PJK, PJF, or combined PJK/PJF groups revealed MF, ES, and PS had smaller volumes in the PJK/PJF group than in the control group. ES atrophy and fat infiltration were more severe in the PJF group than in the PJK group.
Conclusion: This study shows that PJF developed much earlier than PJK after surgery. Paraspinal muscle atrophy and fat infiltration in the lower lumbar region were identified as significant risk factors of PJK and PJF, especially PJF. The possibility of PJK and PJF development should be considered when planning long-level fusion in patients with paraspinal muscle atrophy.

O266

Comparison of proximal and distal junctional failures after long fusion arthrodesis stopping at l5: Incidences and risk factors

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Introduction: Proper selection of fusion levels in adult spinal deformity (ASD) surgery is important not only to obtain the sagittal and coronal balance, but also to prevent progression of deformity and junctional problems. Junctional failures after long fusion stopping at L5 can present at both proximal and distal ends.
Aim: To investigate the incidence and risk factors of proximal and distal junctional failures after long lumbar instrumented fusion stopping at L5 for ASD.
Methods: Sixty-three patients who underwent long fusion surgery stopping at L5 and had a minimum follow-up of 2 years were reviewed retrospectively. Proximal and distal junctional failures (PJF and DJF) were defined as newly developed back pain and/or radiculopathy with corresponding radiographic failures. The incidence and risk factors of each junctional failures were analyzed using a log rank test and the Cox proportional hazards model.
Results: Twelve men and 51 women were included in our study. The mean age was 68.5±7.0 and the mean follow-up period was 84.5±45.3 months. PJF and DJF occurred in 17 (27%) and 16 patients (25.4%), respectively. PJF and DJF developed at a median of 32.1 months and 13.3 months, respectively, however the difference was insignificant. Three patients presented both PJF and DJF, and in all three patients DJF proceeded PJF. The risk factors for PJF included less BMI, higher preoperative LL, and higher postoperative SVA (HR=0.570, 1.055, 1.040, respectively). For DJF, higher preoperative SVA was an independent risk factor (HR=1.010). (Table 1)
Conclusions: In our ASD patients who underwent long fusion surgery stopping at L5, PJF and DJF occurred in 17 (27%) and 16 patients (25.4%), respectively. PJF and DJF developed at a median of 32.1 months and 13.3 months, respectively. Whereas less BMI, higher preoperative LL, and higher postoperative SVA were risk factors for PJF, higher preoperative SVA was an independent risk factor for DJF.

Table1. Risk factor analysis for junctional failures

	Univariate analysis	Multivariate analysis		
	P	HR	95% CI	P
PJF				
BMI (kg/m^2)	0.002	0.570	0.414-0.783	0.001
Preoperative LL (°)	0.121	1.055	1.011-1.102	0.013
Preoperative TK (°)	0.024			
Postoperative TK (°)	0.077			
Postoperative SVA (cm)	0.032	1.040	1.017-1.063	0.001
DJF				
Preoperative SS (°)	0.130			
Preoperative LL (°)	0.021			
Preoperative PI-LL (°)	0.030			
Preoperative SVA (cm)	0.026	1.010	1.001-1.019	0.026
Postoperative LL (°)	0.022			
Postoperative PI-LL (°)	0.106			

O267

Surgical strategy-oriented classification for the patients with severe dynamic sagittal imbalance

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Introduction: A concept, dynamic sagittal imbalance (DSI) was reported a dynamic feature in patients with degenerative flatback for the first time. There have been several studies on the diagnosis of DSI or its features. However, there have been no studies on surgical strategies for optimal outcomes in patients with severe DSI.
Aim: To analyze the characteristics of the patients with severe dynamic sagittal imbalance, develop a comprehensive classification, and raise optimal surgical strategy for each condition.
Materials and Methods: Prospectively, 193 patients with a mean age of 65.2 years (62-84 years) from 2017 to 2019 were tracked after surgical treatment for severe dynamic sagittal imbalance that was defined as C7SVA becomes greater than 20cm within 30 seconds after walking or standing in addition to rigid lumbar curve less than 10° in dynamic lateral radiographs and more than 75.3° of PI-LL in previous our study. The characteristic is mainly based on radiographic findings. It is classified according to three criteria: the location of the apex, depending on combined compression fracture and stiffness of apex segment. The receiver operating characteristic (ROC) curves were plotted to evaluate the cut-off value of compression rate (CR) of vertebral body. The patients were categorized into 1 of three groups according to the surgical strategy (anterior column realignment, ACR; posterior spinal fixation, PSF; pedicle subtraction osteotomy, PSO) implemented: ACR+ PSF, ACR+PSO+PSF, PSO+PSF. Time-dependent radiographic analysis with spinopelvic sagittal parameters from each group was assessed and compared with each other using ANOVA.
Results: The patients with severe dynamic sagittal imbalance can be mainly divided into 2 types according to the location of the apex: Type I (thoracolumbar; T12, L1, or L2), Type II (lumbar; L3, L4, or L5), and the following modifiers were identified as potentially influencing the choice of surgical strategy: A; CR ≤ 60% in thoracolumbar or ≤ 30% in lumbar and B; > 60% in thoracolumbar or > 30% in lumbar based on the cut-off value of CR of vertebral body (95% CI, P<0.001) and rigid or fused of apex segment (-, or +). Either Type I or Type II is further divided into four subtypes: Type IA-, Type IA+, Type IB-, Type IB+, Type IIA-, Type IIA+, Type IIB-, and Type IIB+. A surgical strategy was proposed to deal with each situation combining the different patterns and their modifiers by an expert's opinion consensus. At final follow-up, C7SVA (*P*=0.121), lumbar lordosis (LL) (*P*=0.665), and pelvic tilt (*P*=0.096), and PI-LL mismatch (*P*=0.701) were similar among three groups according to surgical strategy.
Conclusions: This surgical strategy-oriented classification can be used effectively to decide preoperative surgical planning for the patients with severe dynamic sagittal imbalance. Further research may be needed to validate the classification.

Acknowledgements: severe dynamic sagittal imbalance, characteristics, classification, surgical guideline

O268

Comparison of surgical outcomes between 3-column osteotomy and anterior-posterior fusion for osteoporotic vertebral fracture

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Background: Corrective surgery for osteoporotic vertebral fractures (OVF) is often difficult. While the elderly patient requires the least invasive technique possible, osteotomy (3CO) may also be necessary to achieve the desired correction angle. The purpose of this study was to compare the surgical outcomes of anterior-posterior fixation using X-core and 3CO.
Methods: We compared cases in which anterior-posterior fixation or 3CO was performed at our institution for OVF vertebral deformity. Since most of the cases in the lower lumbar region are fixed anterior-posterior, cases in the thoracolumbar transition region were selected. Anterior-posterior fixation was performed for those with mobility in the supine position, including the intervertebral discs above and below the fractured vertebra in dynamic imaging, and 3CO was performed for those with poor mobility. Anterior-posterior fixation was performed in 24 cases and 3CO in 26 cases.
Results: The mean age was 75.7 ± 6.6 years in the anterior-posterior fixation group and 73.2 ± 7.8 years in the 3CO group. Mean follow-up was 27.9 and 43.3 months, respectively. The mean operative time was 272 and 355 minutes, and the mean blood loss was 319 and 810 ml, both with statistically significant differences (t-test, $p<0.05$ for both). There were no differences between the two groups with respect to pain VAS or JOA scores. There was a statistically significant difference in local kyphosis between the anterior-posterior and 3CO groups, 32.1° and 50.3° preoperatively, but 20.6° and 23.7° at the last observation, with no difference between the two groups. Reoperation was more common in the anterior-posterior fixation group (17% in 4 cases and 8% in the 3CO group), although there was no significant difference. Correction loss was particularly high in the anterior-posterior group, especially in cases in which the local angle was corrected more than 6 degrees from that in the supine position at the time of dynamic imaging.
Conclusions: When vertebroplasty cannot be performed for OVF, anterior-posterior fixation including corpectomy or 3CO is necessary. Anterior-posterior fixation using an X-core was less invasive when local mobility was allowed, but if the target angle cannot be achieved in the supine position, 3CO should be considered because forcing the vertebrae to lift up from the anterior position may cause corrective loss.

O269

Difference of postoperative radiologic change on sacro-iliac joint by multi-factors in adolescent idiopathic scoliosis

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Introduction: Postoperative pain after mechanical correction and fusion in Adolescent Idiopathic Scoliosis (AIS) has always been a major concern for spine surgeons. It is hard to find reasonable causes for that kind of pain because AIS patients were so young and had low chance of other past histories. Generally, 15% of primary back pain or lower extremity pain is based on SI joint, so that we focused on change of SI joint after fusion operation.
Aim: to investigate the postoperative radiologic change of SI joint in AIS patients.
Methods: Patients who underwent mechanical correction and fusion operation at our hospital from 2005 to 2017 were selected as the study subjects. Patients with past history related to SI joint and delivery, or with inaccurate radiographs were excluded. We evaluated X-ray or CT scans for SI joint for all patients on preoperative, immediate postoperative, 6 month, 1year, 2year, and 5 year postoperative period. We measured fusion level, sagittal parameter of whole spine and parameter for evaluating scoliosis, for investigation of difference in radiologic change by them.
Results: Comparing two groups, more radiologic changes of SI joint was observed on patients who received fusion up to L3 and L4. Preoperative cobb's angle of major thoracic or thoraco-lumbar curve was not related to SI joint change, neither did postoperative cobb's angle and amount of corrected angle. But the amount of Cobb's angle change showed significant difference between SI joint change group and non-change group. Sagittal parameters (Lumbar lordosis, Thoracic kyphosis, Pelvic incidence etc.) were also unrelated to SI joint changes.
Conclusions: Posterior fusion up to L3 and L4 caused more radiologic degenerative changes of SI joint than fusion to upper than L3

Acknowledgements: Nothing to Disclose.

O270

Erector spinae atrophy/fatty infiltration is a risk factor for the development of adult spinal deformity - Results of a 6-year follow-up of a large cohort of residents

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Introduction: The purpose of this study was to identify predictors of adult spinal deformity (ASD) occurrence/progression in a longitudinal study.

Methods: This longitudinal cohort study was part of the Japanese Research on Osteoarthritis/ Osteoporosis Against Disability (ROAD) study. 796 participants in T-town, Wakayama Prefecture, were included in this study. 538 (158 males and 380 females, mean age 60.3 ± 12.2 years) were eligible for evaluation of standing lateral radiographs and baseline MRI of whole spine. They were followed up for 6 years. Lumbar spine (L1/2-5/S) disc degeneration (sum of Pfirrmann grade: 5-25), sum of thoracolumbar spine (T1-L5) morphological fracture grade (0-51) (Fx-index), cross-sectional area (CSA:mm^2) of PVM (multifidus, erector spinae) and psoas major and fatty infiltration ratio (FIR:%), were measured. The Progression (P) group was defined as those who met the following two conditions: 1) baseline PT > 20°, 2) C7 SVA > 50 mm progression and SVA > 50 mm. Results.

Results: The incidence of ASD was 23 (9.6%). Regarding MRI, sum of Pfirrmann grade (4.1±4.2, 2.3±3.5, p=0.0125), Fx-index (19.8±1.9, 18.0±2.6, p=0.0008), erector spinae CSA (11.8±3.2, 13.3±3.3, p=0.022), FIR (erector spinae: 12.0 8.0±8.0, 7.0±3.2, p<0.0001/ Multifidus: 16.2±4.6, 12.4±4.4, p<0.0001) were significantly difference among two groups, while no significant differences were observed in CSA and FIR in the psoas major muscle. Multiple logistic regression analysis (after adjustment for age, gender, and BMI) was used to determine the association between each parameter and ASD. There were significant differences in erector spinae cross-sectional area (+1mm, Odds ratio 0.78, 95%CI 0.63-0.95, p=0. 0129) and erector spinae FIR (+1%, 1.1, 1.02-1.20, p=0.0106) were predictors of the development of ASD.

Conclusions: Erector spinae muscle CSA/FIR is the most important factor that can cause ASD progression.

O271

The role of SPECT/CT in analysing the radiographic prevalence of asymptomatic degenerative spondylosis in a consecutive cohort of patients presenting with cancer

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Introduction: Degenerative spondylosis (DS) represents a challenging condition to diagnose and treat. The onset is often insidious but radiographic evidence does not necessarily equivocate to pain generators. The clinical picture could be further complicated by predisposing spine-related factors and underlying medical conditions accumulated over time. There are multiple modalities to investigate DS including X-ray, MRI and CT, but symptoms may not be equivocal to DS to support the clinical findings. The investigation of metastases commonly utilises SPECT/CT for identification of areas of increased osteoblastic activity to denote disease. It is also utilised as a second line investigation of potential pain generators in the spine. The aim of the study was to analyse the prevalence of asymptomatic DS in a consecutive hospital cohort of oncology patients who had SPECT/CT for investigation of metastases.

Methods: Oncology patients underwent SPECT/CT were analysed between 2015-2019.

Exclusion criteria: back pain, inflammatory disorders, metastases, trauma, infection. Radiology reports were examined for DS and anatomical distribution of tracer uptake.

Results: A total of 1182 patients had a Whole-Body SPECT CT used for the spinal analysis. After exclusions (age >80 [n=260], non-cancer [n=318], back pain [n=72]), 522 reports with cancer were utilised. Mean age was 65 (4-80). Age and distribution of DS are given in the table 1.

Conclusion: The prevalence of radiological asymptomatic DS is prevalent in large proportions of patients without back pain, and its incidence increases with age. Approximately 60% of 60 year old and 70% of 70 years old patients have asymptomatic DS in the lumbosacral region. We conclude that SPECT/CT will detect radiographic degenerative spondylosis in an asymptomatic hospital cohort and this prevalence increase with age. Therefore, this modality of imaging must be utilised with caution when investigating potential pain generators.

		Age Group					
		≤30 (n=0)	31-40 (n=11)	41-50 (n=39)	51-60 (n=87)	61-70 (n=178)	71-80 (n=207)
Location of DS (%)	Cervical			10%	29%	30%	33%
	Thoracic		27%	33%	61%	65%	64%
	Lumbo-sacral		9%	28%	62%	77%	76%
	Sacro-iliac joint		9%	10%	15%	16%	4%
	Whole spine			5%	20%	25%	27%
From 522 reports, 25% (5%) had adult spinal deformity: scoliosis (22, 88%), kyphosis (3, 12%)							

Table 1: Proportion of patients with DS by age.

O272

The relationship between compliance of physiotherapeutic scoliosis specific exercises and curve regression with mild to moderate adolescent idiopathic scoliosis

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Introduction: Studies demonstrated that the ability of physiotherapeutic scoliosis specific exercises (PSSE) to lead to curve regression. It is crucial as such to determine the required exercise compliance (EC) to lead to regression. In addition, the effects of PSSE in causing vertebral morphology changes is unclear.
Aim: To determine the requisite EC of physiotherapeutic scoliosis-specific exercise (PSSE) for achieving curve regression; to analyze whether the apical translation (AT), apical wedging (AW), and apical rotation (AR) of the major curve improve with regression effect.
Patients and Methods: Between 2019 and 2021, a total of 763 patients undertook a 6-month PSSE treatment. This resulted 426 compliable and 302 uncompliable patients remained available for analysis. For compliable patients, 213 with curve regression and 213 age- / sex-matched with curve stabilization/deterioration at the 6-month, were eligible for regression analysis to detect the relationship between EC and regression effect at the 6-month; receiver operating characteristic (ROC) curve analysis and Youden's index were applied to identify the threshold of EC leading to curve regression at the 6-month. The AT, AW, and AR of the major curve were compared before and after 6-month PSSE to investigate the radiographic parameters that improved with regression effect.
Results: EC was correlated with regression effect (odds ratio: 19.9, 95% confidence interval: 11.3–35.0, $p < 0.001$) and the cutoff threshold of EC was 4.4 h/week for 6 months to realize such an effect. AT was improved by 47.6% with curve regression, in which 152 cases remained curve regression and no case progressed into the operative threshold at the 1.5- to 2-year.
Conclusion: A 6-month PSSE protocol of 4.4 hours per week was potentially leading to curve regression in treating mild to moderate scoliosis. An improvement in AT of the major curve was observed with the regression effect.

O273

Randomized controlled trial comparing Immediate versus gradual brace weaning for adolescent idiopathic scoliosis

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Introduction: For adolescent idiopathic scoliosis (AIS), bracing is the most common intervention for controlling curve progression and brace-wear is discontinued once the patient has reached the end of skeletal growth. However, it is unclear whether slow weaning with reduced hours of brace-wear or immediate brace removal results in better outcomes.
Aim: To compare the degree of curve magnitude maintenance, truncal balance maintenance, and changes in health-related quality of life (HRQoL) between immediate and gradual brace weaning protocols via randomized controlled trial.
Patients and Methods: This prospective, open-labelled, randomized controlled trial included patients who underwent underarm bracing and fulfilled brace weaning criteria of Risser stage ≥4, >2 years post-menarche, and no bodily growth between 2 visits. Patients were randomly allocated into gradual weaning (brace-wear time shortened to night-wearing for 6 more months before complete weaning) and immediate brace removal. Assessment timepoints were post-weaning 6-months and 1-year. Patients were followed for at least 1-year post-weaning. Radiographic assessment included major and minor curve Cobb angles, truncal balance and sagittal balance. SRS-22r questionnaire and EQ-5D-5L were used for HRQoL assessment. Primary outcome was the change in Cobb angle from baseline to 6-months and 1-year follow-up. Secondary outcomes were the change in truncal balance, SRS-22r total score and EQ-5D utility score from baseline to follow-ups. Statistical analyses were performed according to intention-to-treat (ITT) and subordinately based on per-protocol (PP) principle. The PP analysis included all randomized patients in ITT who had no major protocol deviations. Primary analysis involved evaluating any differences in the Cobb angle change between baseline and follow-ups between the two protocols by independent sample *t*-tests.
Results: A total of 306 patients (82.4% girls) were consecutively recruited and randomized (Figure 1) into gradual weaning (n=151) and immediate weaning (n=155). Gradual weaning patients had 9.7±4.0 hours night-time brace-wear. There were no intergroup differences (p>0.05) of patient demographics at baseline, including weaning major Cobb angle (30.4º±8.3º versus 29.1º±8.6º in PP, 29.4º±8.3º versus 28.5º±8.7º in ITT). ITT and PP demonstrated similar intergroup comparison results. There were no differences of changes of major Cobb angle between gradual and immediate weaning at post-weaning 6-months, and 1-year (2.0º versus 2.6º, p=0.285). Changes of truncal shift, C7-CSVL and SVA deviation were of no difference between protocols (all at p>0.05). Both groups experienced similar HRQoL changes, except gradual weaning having greater increase of Function domain score of SRS-22r by 0.11 (p=0.036) at 1-year. No differences in curve progression was observed (Gradual:17.2% versus Immediate:18.1%, p=0.846). Similar curve regression rates occurred (Gradual: 46/151, Immediate: 33/155, p=0.067). Rebound at post-weaning 1-year was comparable (Gradual: 24/151, Immediate: 17/155, p=0.206) (Figure 2). Those with/without rebound or progression in gradual weaning had similar hours of nocturnal brace-wear (8.7±4.4 versus 9.9±3.9, p=0.153).
Conclusion: This randomized controlled trial indicates that gradual weaning and immediate weaning achieves similar brace outcomes in terms of curve magnitude maintenance and truncal balance, as well as patients' HRQoL for the follow-up period since brace weaning. Thus, gradual weaning appears to have no obvious benefits over immediate weaning.

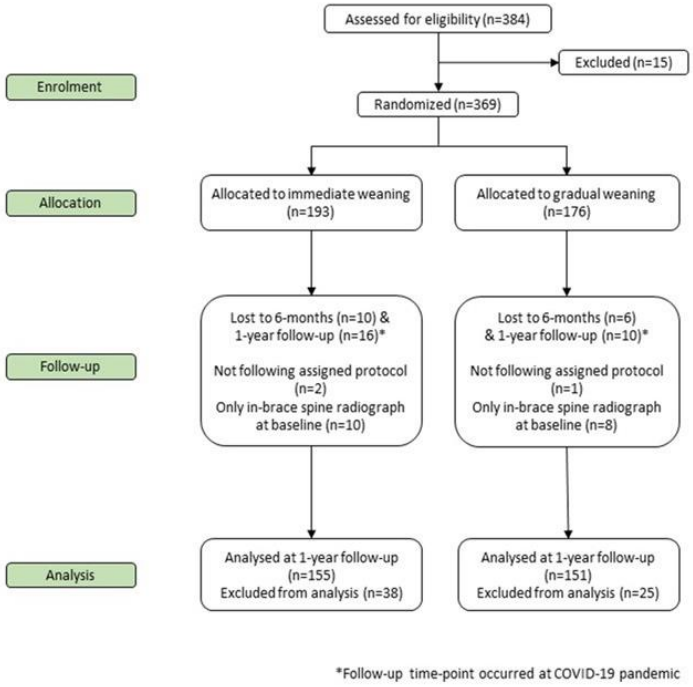

Figure 1: Patient recruitment flowchart

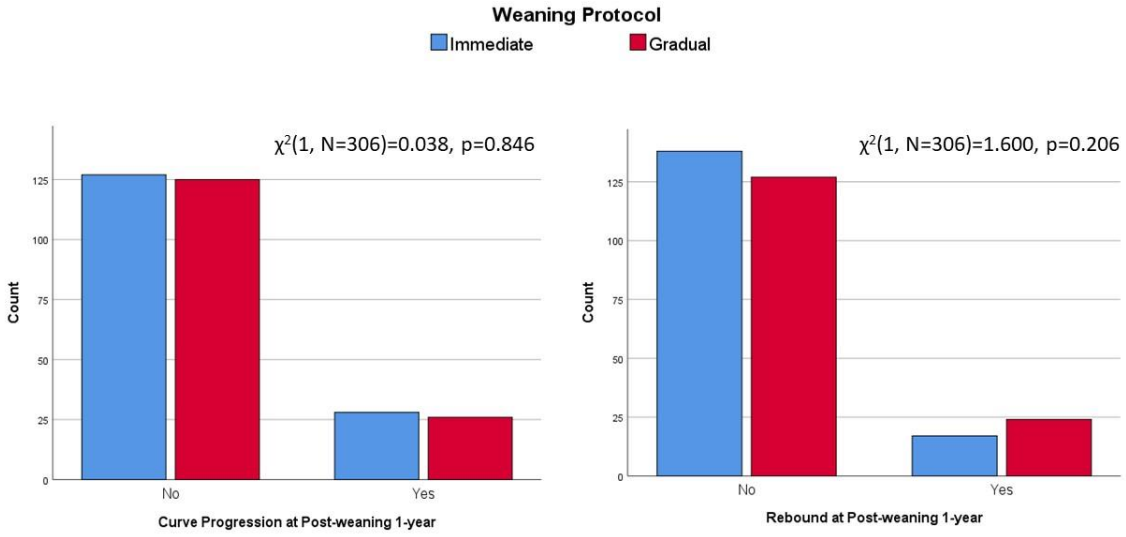

Figure 2: Outcomes at 1-year post-weaning

O274

A risk quantification reference table for progressed adolescent idiopathic scoliosis surgery: An exact case matched outcomes analysis

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Introduction: Surgical treatment delay in AIS due to family preferences is common. Multiple studies have demonstrated that patients with curve progression will result in more complex surgeries and increased complications. However, these studies were unable to quantify the exact amount of increase in risks and outcomes correlated to the curve progression and subsequent increased surgical complexity.
Aim: This study aims to quantify the increase in risks as the Cobb angle increases and provide a Quantifiable Risk Reference Table that can be utilized for counselling.
Patients and Methods: This was a retrospective Exact Matched case-control study, conducted at a single university hospital. AIS patients were divided into 3 groups: Group A: Cobb angle 50-60^0, Group 61-70^0 and Group C_{Final} ≥80^0. Each patient in Group C_{Final} who had curve progression were then traced-back-in-time (TBIT) to review the clinical data at earlier presentations at 50-60^0 (C_1), and 61-70^0 (C_2). Patient demographics, radiological, operative and outcomes data were compared between Group A vs C_1 and Group B vs Group C_2.
Results: A total of 614 AIS surgeries were reviewed. Utilizing the EM technique, a total of 302 AIS patients were recruited. There were 147, 111, 31 and 32 patients matched in Groups A, B, C_1 and C_2, respectively. $C_{2\ Final}$ patients had 34% curve pattern change, 23.2% higher incidence of requiring two surgeries and 17.3% increase in complications. There was a statistically significant increase of 2.4 spinal levels fused, 12% increase in implant density, 35% increase in operative time, 97% increase in intra-operative blood loss, 10% loss of scoliosis correction, 40% longer hospitalization stay, and 36% increase in costs for patients who had curve progression.
Conclusion: This study is the first to use a homogenously matched AIS cohort to provide a Quantifiable Risk Reference Table. The Risk Table provides essential knowledge for treating physicians when counselling AIS patients.

O275

Multicenter validation of using the distal radius and ulna (DRU) classification to predict scoliosis progression – APSS scoliosis focus group study

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Introduction: The peak height velocity (PHV) is a useful index to predict scoliosis progression in adolescent idiopathic scoliosis (AIS), but the timing of PHV varies from patient to patient. Risser staging has been often used to predict, but there are reports that it is insufficient for PHV prediction. Bone maturity assessment using hand and wrist X-rays such as the Distal Radius and Ulna (DRU) classification is growing in popularity and is used clinically in various countries. However, its cross-ethnicity and cross-cultural validity has never been evaluated.

Aim: The purpose of this study is to investigate the predictability of PHV and peak curve progression in patients with AIS from a multicenter study in the Asia Pacific countries.

Methods: AIS patients aged 10 to 18 years who were enrolled in a multicenter study at several Asian scoliosis referral centers and were subsequently available for follow-up for at least 6 months were prospectively reviewed. Baseline DRU grade and Cobb angle of the major scoliosis curve and changes in body height and cobb angle of major scoliosis curve over the following 6 months were investigated. The relationship between baseline DRU classification and changes in body height and Cobb angle of major scoliosis curve within 6 months was examined.

Results: The study collected data from 81 AIS patients (13 males and 68 females) from Asian countries (57 Japanese, 18 Malaysians, and 6 Taiwanese) with a mean age of 13.4 ± 1.8years. Baseline body height was 154.8 ± 8.4 cm and Cobb angle of major scoliosis curve was 24.2° ± 8.9°, whereas 6 months later they were 156.4 ± 7.8 cm and 23.7° ± 9.6°, respectively. The Jonckheere-Terpstra trend test indicated that, with an increasing Radius grade (R5/6/7/8/9/10/11), change in body height (5.5±0.9/3.8±2.4/2.2±1.4/1.5±1.2/0.6±0.7/0.8±1.3/-0.5, P<0.001) and Cobb angle (-1.0 ± 12.7/3.5 ± 2.3/1.6 ± 4.0/-1.3 ± 5.6/-2.1 ± 4.2/0.2 ± 2.7/-4.3, p=0.019) showed an increasing trend. Whereas for Ulna grade (U4/U5R5/6/7/8/9), there was a trend for change in body height (5.1 ± 1.5/2.9 ± 1.9/1.4 ± 1.4/1.2 ± 1.2/0.7±1.2/0. 7±1.0, P<0.001), but no statistically significant trend was found in the change of Cobb angle (1.3±6.2/3.1±7.8/1.7±4.1/-0.9±4.2/0.5±4.5/0.5±0.7, p=0.197).

Conclusion: The results of an Asian multicenter collaborative study validated the Radius grade of DRU classification as a practical bone maturity assessment with statistically significant trends in height and scoliosis curve changes. The DRU classification has the potential to detect patients with progressive scoliosis at an early stage. Especially in patients with R6 or less, scoliosis may progress in a short period of time, and more frequent and longer follow-up is necessary.

O276

The impact on spinal deformity progression among pediatric patients with SMA treated with Nusinersen

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Objective: The objective of this study was to evaluate the impact on spinal deformity progression among pediatric patients with SMA treated with nusinersen.
Background: The lifetime probability of spinal deformity progression reaching the surgical threshold in SMA is high. Although nusinersen treatment has been demonstrated to improve motor function, its impact on scoliosis progression is unknown.
Methods: A retrospective review of prospectively collected data from a territory-wide SMA cohort at our institution who received nusinersen treatment between 2018 and 2021 was performed. Longitudinal radiographic data on spinal deformity progression in the coronal and sagittal planes pre- and post-nusinersen treatment were reviewed. Serial changes in motor function were evaluated using the Children's Hospital of Philadelphia Infant Test of Neuromuscular Disorders (CHOP INTEND) and Hammersmith Infant Neurological Examination (HINE) for type 1 patients; and Hammersmith Motor Functional Scale Expanded (HMFSE), Revised Upper Limb Module (RULM), and 6-Minute Walk Test (6MWT) for type 2 and 3 patients. Their ambulatory status was recorded.
Results: 21 patients (Type 1=7, Type 2=7, Type 3=7) were included in the analysis. The median age at the time of nusinersen initiation was 6.2 years (range, 0.81-16.6 years), and the mean duration of follow-up was 23 months (range, 6-47 months). During the study period, motor function scores were stable or improved in 18 (86%) patients. In terms of ambulatory status after nusinersen administration, 57% of Type 1 patients became sitters from being non-sitters at baseline and 14% of Type 2 patients became supported walkers from independent sitters. Type 3 patients were also able to walk further in their 6MWT, improving from a baseline median distance of 50.1 meters to 73 meters at latest assessment. However, scoliosis continued to progress in all subtypes, with a mean rate of Cobb angle increase of 4.8, 13.8, and 3.9 degrees per year, respectively. A subanalysis of each subtype showed that the rate progression was most rapid during ages 5 and 10 years (16.5, 18.4, and 4.6 degrees per year for patients with type 1, 2, and 3 SMA respectively).
Conclusions: Although nusinersen improved motor function scores in pediatric patients with SMA, it did not prevent the development nor decrease the progression of scoliosis.

O277

Perception of spinal deformity among patients with adolescent idiopathic scoliosis

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Introduction: Adolescent idiopathic scoliosis (AIS) is the most common form of structural spinal deformity, affecting 1% to 4% of children globally. Patients with AIS are generally pain-free, however, some might be able to perceive their skeletal deformity, thus affecting their self-image. Major Cobb angle, coronal balance and truncal balance are radiological measurements used to evaluate AIS severity. The threshold of spinal deformity that alters patients' perception of their deformity is not known.
Aim: (1) To determine the correlation of the severity of scoliotic deformity using radiological measurements of major Cobb angle, coronal balance, truncal balance and curve type with an established validated SRS-22r instrument consisting of an overall score and five domains of self-image, pain, function, mental health and satisfaction. (2) To evaluate other demographic factors such as curve type, gender and age affecting patient perception of scoliotic deformity.
Materials and Methods: A retrospective analysis of prospectively collected SRS-22r data from 357 consecutive patients between February 2020 and May 2021 was conducted. Inclusion criteria were (1) 11 to 20 years old, (2) no leg length discrepancy, (3) underwent scoliosis screening at our tertiary institution. Each patient completed their SRS-22r questionnaire online prospectively. Standing erect radiographs of the patients were obtained using an EOS Imaging System. Radiological measurements were obtained by one researcher and confirmed by an Orthopaedic spine surgeon. The major Cobb angle was measured as the angle between the two end vertebrae of the largest curve. The coronal balance was measured as the horizontal distance between a plumb line drawn from the C7 vertebra and a vertical line bisecting the sacrum. The truncal balance was measured as the horizontal distance between a vertical line bisecting the thoracic cavity and a vertical line bisecting the sacrum. Patients were also categorised as having a single curve (one major curve with a minor compensatory curve) or a double curve (two curves with less than 5 degree difference in Cobb angles).
Results: Major Cobb angle and truncal balance had a significant but small negative correlation with SRS-22r. Coronal balance had no significant correlation with SRS-22r. Multiple regression showed that skeletal deformity (as measured by major Cobb angle and truncal balance) significantly affected self-image but not pain for patients with a major Cobb angle of 51-60° (R^2=0.265, p<.01), 61-70° (R^2=0.528, p<.01), and above 70° (R^2=0.277, p<.01). Skeletal deformity also significantly affected the self-image of patients with a single curve (R^2=0.117, p<.01), patients who are female (R^2=0.139, p<.01), and patients who are 14 years old and above (R^2=0.252, p<.01).
Conclusions: In our cohort, patients only started perceiving their scoliotic deformity when their major Cobb angle is above 50°. Patients who have a single curve were more likely to perceive their deformity than those with a double curve. Female patients and those who were 14 years old and above are more likely to perceive their deformity. Lastly, there was no clear relationship between pain and scoliosis.

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O278

Comparison of the assessment of sanders skeletal maturity using single low radiation dose EOS spine hand radiography and conventional hand radiography

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Introduction and Aims: Bracing is recognised as an effective treatment method in the prevention of curve progression for adolescent idiopathic scoliosis (AIS) in skeletally immature patients with moderate curves. Bone age is an important factor in determining initiation and conclusion of bracing with the Sanders skeletal maturity scale (SSMS) shown to be a reliable indicator of skeletal maturity with good correlation to peak growth velocity. Currently, this is based on a separate left hand PA radiograph, which requires additional radiation. In recent years, there is increasing popularity of the EOS slot-scanning system (EOS Imaging, Paris, France) for the assessment of AIS due to its significantly reduced radiation dose at the. With the goal of reducing radiation exposure and improving efficiency of clinic visits, this study aims to determine if a simultaneously performed low-dose EOS spine-hand radiograph would provide adequate image quality to allow for accurate assessment of skeletal maturity based on SSMS in AIS patients.
Methods: Radiographs from AIS patients aged 10-21 over a time period of 1 year who had consecutively underwent both a low-dose EOS spine-hand radiograph taken with the left hand positioned above the left shoulder and a conventional hand radiograph were selected. These radiographs were anonymized and collated into a viewing document. 12 trained spine surgeons then reviewed these radiographs and graded the skeletal maturity of the patient using SSMS based on both the EOS Spine-hand radiographs and the conventional PA hand radiograph imaging. Their responses were then analysed and used to determine agreement between the grading of the skeletal maturity across 2 imaging modalities using SSMS with conventional imaging as the gold standard reference point. Intra-class correlation coefficients were also used to determine the reliability of both the grading system and the imaging modalities.
Results: 240 Radiographs (80 conventional, 80 EOS, 80 inverted EOS images) were selected from 122 AIS patients who presented between July 2020 and July 2021. The absolute agreement in skeletal maturity grading between EOS imaging and conventional radiography was 61.2% using the SSMS method. 91.2% of responses fell within a single grade point difference with 21.3 % of responses reflecting a single point positive deviation grading and 9.2% of responses reflecting a single point negative deviation grading. Intra-class coefficients across the 12 respondents using the SSMS was 0.912 for conventional imaging and 0.850 for EOS imaging.
Discussion and Conclusions: Although the absolute agreement in skeletal maturity grading using SSMS between EOS imaging and conventional radiograph was less than expected at 61.2%, the fact that 91.2% of responses fell within a single point difference is encouraging. Furthermore, not only is the intra-class coefficient of 0.850 for EOS imaging using SSMS across 12 respondents is high but it is also similar to the reference standard of 0.912 for conventional imaging, indicating a high inter-rater reliability of the SSMS even with the EOS imaging. Overall, these results suggest that EOS imaging provides adequate image quality for the grading of skeletal maturity using SSMS and can be considered as a viable substitute to conventional imaging.

O279

Posterior instrumented spinal surgery outcomes in the elderly: A comparison of the 5-item and 11-item modified frailty indices

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Introduction: As the global population continues to age at an accelerating rate, this has been accompanied by an increase in the overall incidence of more complex spinal surgeries including posterior instrumentation and fusion in the elderly population. Hence, it is essential that an instantaneous easily accessible and validated pre-operative risk stratification tool is readily available to clinicians to rapidly assess this vulnerable but expanding geriatric cohort.
Aim: We sought to validate the most concise risk stratification system to date, the 5-item modified frailty index (mFI-5), and compare its effectiveness with the established 11-item modified frailty index (mFI-11).
Materials and Methods: A single centre retrospective review of posterior instrumented spine surgeries in patients aged 65 years and older between 2016-2018 during was conducted. The primary outcome was rate of post-operative major complications (Clavien-Dindo Classification ≥ 4). Secondary outcome measures included rate of all complications, 6-month mortality and surgical site infection. Multi-variate analysis was performed with defined frailty thresholds of mFI-5 ≥ 2 or mFI-11 ≥ 0.27. Adjusted receiver operating characteristic curves were generated and compared by DeLong's test. The indices were correlated with Spearman's rho.
Results: 272 cases were identified. The risk of major complications was independently associated with both the mFI-5 (OR 1.89, 95% CI 1.01-3.55, p=0.047) and mFI-11 (OR 3.73, 95% CI 1.90-7.30, p=0.000). Both the mFI-5 and mFI-11 were statistically significant predictors of risk of all complications (p=0.007 and p=0.003), surgical site infection (p=0.011 and p=0.003) and 6-month mortality (p=0.031 and p=0.000). Adjusted ROC curves (Table 1) determined statistically similar c-statistics for major complications (0.68 versus 0.68, p=0.64), all complications (0.66 versus 0.64, p=0.10), surgical site infection (0.75 versus 0.75, p=0.76) and 6-month mortality (0.83 versus 0.81, p=0.21). The two indices correlated well with a Spearman's rho of 0.944.
Conclusion: The mFI-5 and mFI-11 are equally effective predictors of postoperative morbidity and mortality in this population. Age itself should not be a decisive factor when risk stratifying preoperative elderly patients undergoing posterior instrumented fusion. The brevity of the mFI-5 is advantageous in facilitating its daily clinical use.

Table 1 – Comparison between the mFI-5 and mFI-11 indices by the Adjusted Receive Operating Characteristic (ROC) Curve

	mFI-5		mFI-11		P Value
	Adjusted ROC Area		95% CI		Adjusted ROC Area
				95% CI	
All Complications	0.66	0.58-0.75	0.64	0.55-0.72	0.10
Major Complication (Clavien ≥ 4)	0.68	0.62-0.74	0.68	0.61-0.74	0.64
Surgical Site Infection	0.75	0.66-0.84	0.75	0.66-0.84	0.76
Mortality Within 6 Months	0.83	0.76-0.91	0.81		

O280

The concept of recovery kinetics: An observational study of continuous post-operative monitoring in spine surgery

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Background: The spine surgeon's understanding of an individual patient's burden of disease and functional disability in daily life is shaped by patient-reported outcome measures (PROMs). Although PROMs are useful in understanding the patient's perception of their disease, the use of PROMs constitutes a "snapshot" approach of single timepoint data capture, omitting day-to-day fluctuations in functional status. We introduce the concept of kinetics when considering continuous and objective postoperative patient monitoring with wearable sensors.

Methods: A prospective single-centre series was performed using patients either undergoing lumbar decompression for lumbar spinal stenosis (LSS) (n=12), or posterior lumbar fusion for degenerative spondylolisthesis (n=12). The Oswestry Disability Index (PROM) was conducted preoperatively and 12-weeks postoperatively. During this timeframe, continuous measurements of step count and distance travelled were made using a wrist-based wearable accelerometer.

Results: Over the 12-week study period, mean daily step count for all participants improved from 4,700 to 7,700 steps per day (P=0.013), following an initial dip in total steps taken. The mean daily distance travelled improved from 3,300 to 5,300 meters per day (P=0.003). Decompression group recovered at a faster rate than the fusion group.

Conclusions: Although overall improvement was similar between the decompression and fusion groups, the recovery kinetics varied. The recovery kinetics approach of continuous postoperative monitoring provides additional insight to postoperative patient progress.

O281

What is the expected improvement in patient-reported outcome measures in the lumbar hybrid procedure for treating multilevel degenerative disc disease?

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Introduction: Chronic low back pain remains a significant burden on society. In those patients recalcitrant to non-operative treatment, debate continues over which surgical treatment is most effective and long-lasting. The anterior lumbar hybrid procedure has been shown to be effective in the treatment of multilevel lumbar degenerative disc disease through case series and comparative studies; however, reports of significant sample sizes are limited.
Aim: In 2017, the lead author published a case series involving 617 patients, with recalcitrant symptomatic multilevel lumbar degenerative disc disease, who underwent multilevel anterior hybrid reconstruction. As a follow on, the aim of this paper is to report the patient reported outcomes measures (PROMs) and satisfaction involving a larger cohort of 1335 patients and with longer follow up. This data will assist surgeons in informing patients about evidenced based outcomes and to determine whether their patients may benefit from this intervention.
Methods: Prospectively collected PROMs were analysed from a single surgeon's cohort of 1335 patients, with a minimum of two years follow-up, who underwent anterior lumbar hybrid reconstruction (multilevel reconstruction utilising a combination of total disc replacement and anterior lumbar interbody fusion) between 2005 and 2019 for symptomatic chronic multilevel lumbar degenerative disc disease. Data were collected preoperatively, three, six, and 12 months post-operatively, and annually thereafter. PROMs included patient satisfaction score, Visual Analog Scale Back (VAS back) and Leg (VAS leg), Oswestry Disability Index (ODI), and Roland-Morris Disability Questionnaire (RMDQ). Data were analysed and mean improvements were estimated for different representative patients.
Results: Improvement in pain and disability scores were clinically and statistically significant across all PROMs three months post-operatively (Figures 1 and 2). This improvement was sustained over the period up to their final follow-up. The improvement in scores exceeded literature reported thresholds for minimum clinically important difference (MCID) and substantial clinical benefit (SCB). Patient satisfaction was rated good/excellent in 90.7% of patients at six months follow-up. The estimated mean improvement at three months post-surgery for a patient from the mean baseline characteristics was 44.7 for VAS back, 26.6 for VAS leg, 25.5 for ODI, and 9.8 for RMDQ.
Conclusions: This study demonstrates that anterior lumbar hybrid reconstruction can benefit patients with a diagnosis of chronic symptomatic multilevel lumbar degenerative disc disease and that statistically significant improvement above MCIDs and SCBs can be expected in all PROMs over long-term follow-up. Importantly, the results show little decay over time. These results were reflected in the patient satisfaction scores.

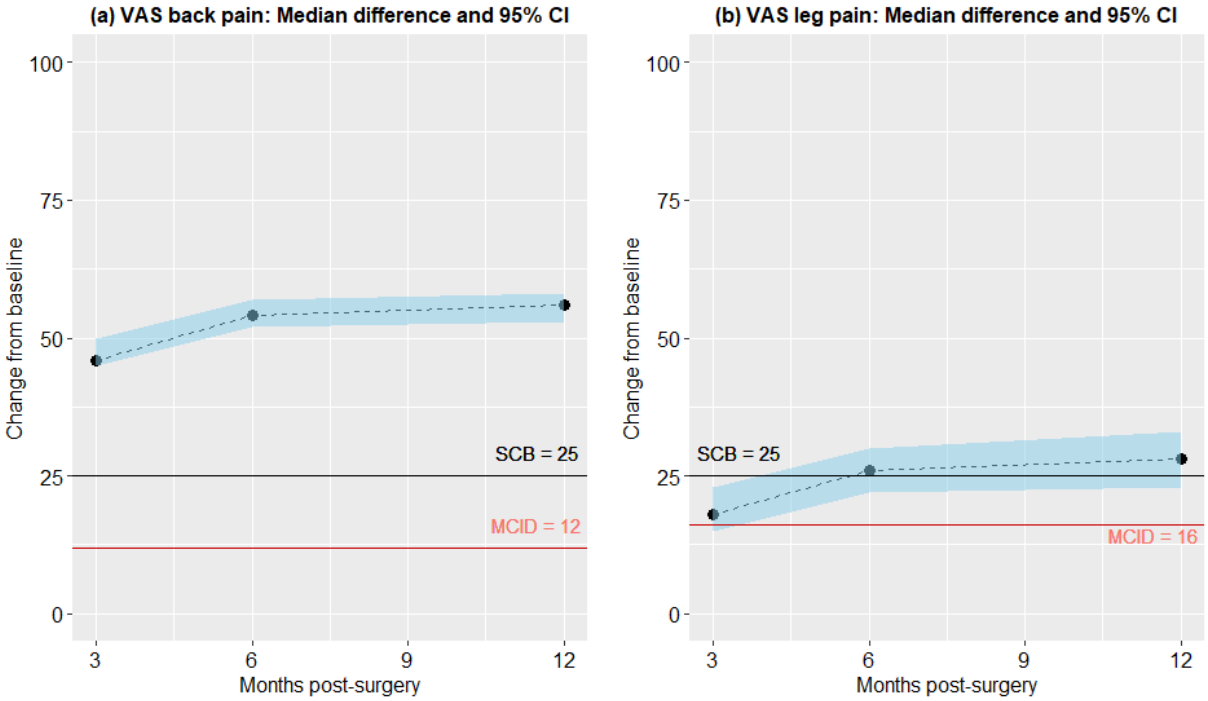

Figure 1. Median differences from baseline and 95%CI for VAS back and leg pain scores over 12 months after surgery. Minimum Clinically Important Difference (MCID); Substantial Clinical Benefit (SCB).

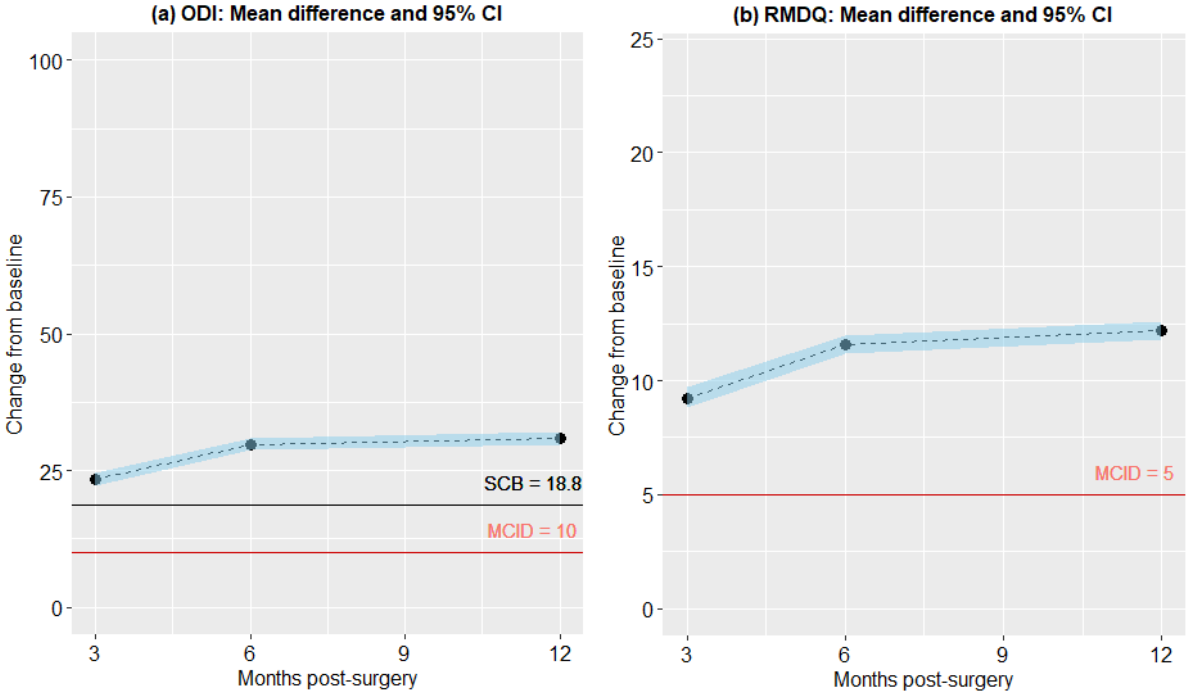

Figure 2. Mean differences from baseline and 95%CI for ODI and RMDQ disability scores over 12 months after surgery. Minimum Clinically Important Difference (MCID); Substantial Clinical Benefit (SCB).

O282

"Lateral-PLIF", modified PLIF technique for spinal arthrodesis: Concept, technique, results, complications, and outcomes

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Introduction and Aim: Posterior Lumbar interbody fusion surgery is an effective treatment option to treat degenerative conditions in the lumbar spine. There is still no consensus on the best operative technique, based on published inconsistent outcomes. We presented a variant of the PLIF technique, "lateral-PLIF", from a prospective consecutive series of patients. Illustrations are used to show the different steps.
This technique combines the benefits of both standard TLIF and PLIF and at the same time reduces their respective limitations, potential complications, and technical difficulties.
Patients and Methods: Patients underwent consecutively a single/double level Lateral-PLIF from January to December 2017 for the primary diagnosis of isthmic or degenerative spondylolisthesis, lumbar spinal stenosis, severe degenerative disc disease, and/or recurrent disc herniation. Patients were asked to complete prospectively pre- and postoperative questionnaires at 4 months, 1- and 2-years assessing pain (medication use) and ability to perform activities of daily living (ADLs) including lifting, walking, standing, sitting, work status, and social activities. Phone interviews provide treatment satisfaction rate at 4 years. Data related to the surgical procedure and post-operative complications were also collected. Radiological follow up findings (fusion and lumbar lordosis) were assessed at 1-year follow up visit.
Results: A total of 104 patients were consecutively included in the study. Patients were 57.8 ± 10.5 years old and presented with mechanical back pain (100, 96.1%), radicular pain (73, 70.2%), and motor weakness (23, 22.1%).
Estimated operative time was 155.8 ± 39.7 min for single level, 172.5 ± 47.1 min for double level. Average estimated blood loss for single level was 480 ± 405.9 ml, 700 ± 461.8 ml for double level.
We found high incidence of fusion rate (95%). A statistically significant improvement of function was noted (ODI decreased from 49.4 ± 12.5 [22-82] to 29.2 ± 17.1 [4-62], $p<0.001$, and Roland-Morris score from 14.9 ± 4.8 [3-24] to 8.4 ± 6.4 [0-19], $p<0.001$). Walking distance increased from 812m ± 543m, to 3443m ± 712m ($p<0.001$).
Complication included dural tear (6.7%), 5 (4.8%) cases of infections/wound dehiscence, 2 (1.9%) malposition of pedicle screws, 1 (0.9%) iatrogenic arterial injury during discectomy. Instrument failure were observed in 2 patients (1.9%). No iatrogenic neurological deficit and post-operative cauda equina syndrome were observed. No malposition or migration of the cages were noted. No LCR fistula and/or pseudo meningocele were seen. Diabetes, previous spine surgery, previous spinal fixation and total operative time were not associated with postoperative complications.
Conclusion: Our results suggest that Lateral-PLIF is a safe and efficient technique with extensive applicability to achieve lumbar fusion while restoring an appropriate disc height and a correct lordosis. Complications rates of dural tear and neurological deficit associated with the traditional PLIF technique were lower in our series compared to the rates usually reported in the literature. Although further comparative studies will be necessary to validate the final outcomes, surgeons might consider this technique before using a routine standard lumbar fusion approach.

O283

Does tether breakage predict progression to fusion? A pilot study of 15 AIS patients after VBT surgery

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Introduction: Vertebral Body Tethering (VBT) is a recent surgical procedure to correct adolescent idiopathic scoliosis (AIS) in skeletally immature patients. VBT is thought to modulate growth of the vertebral bodies by adjusting the asymmetric forces on the physis. A break in the tether would therefore lose the ability to modulate growth and the patient would experience progression in their scoliotic curve. The aim of this study is to analyse whether tether breakage is related to patients who progress to require a surgical fusion.
Methods: Preliminary study of AIS patients who have been treated with VBT. Data were prospectively collected to capture pre- and post-operative patient demographics, skeletal maturity, axial rotation, and coronal plane Cobb angle measurements. These data were collected at routine time points and final follow up was a minimum of 2-years. Suspected breakages were identified by a change in the screw angles of ≥5˚ between two radiographs imported into ImageJ.
Results: Fifteen patients have reached minimum follow-up and were included in this study. Fourteen of the fifteen patients have had a suspected tether breakage, and a total of twenty-nine suspected broken levels were identified. Average change in Major Cobb angle from the pre-operative Cobb to the final Cobb angle was -13.4˚ ±15.7˚ for the patients with a suspected break. The remaining patient with no breakage had a Cobb change of -29˚. Of the fourteen patients with suspected breakages, four progressed to require a surgical fusion. The mean Major Cobb change for these patients was 2˚ ± 4.7˚. The remaining ten patients had a mean Major Cobb angle change of -19.6˚ ± 14.2˚ and did not require further surgical intervention at 2-years post-operative. The patients who progressed to fusion were younger (11.2 years ± 0.4) than those who did not need fusion (12.4 years ± 1.6) with statistical significance (p=0.03). There were no other statistically significant differences between the two groups including Risser stage, Sander's score, or pre-operative Cobb angle.
Conclusions: The results demonstrate a very high rate of tether breakage, yet this does not directly relate with significant curve progression. Despite suspected breakages, VBT has successfully reduced the spinal curve and prevented progression in most patients. Further analysis with larger cohorts of AIS patients would be beneficial to analyse the relationship, as well as longer follow-up to monitor these patients until skeletal maturity is confirmed.

O284

Retrospective review of children and adolescents with neuromuscular scoliosis treated with BiPolar spinal fixation at the Sydney Children's Hospital, Randwick

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Introduction: Various deformities are common in neuromuscular conditions, including scoliosis and pelvic obliquity. Treatment has historically been posterior spinal fusion (PSF), often to the pelvis. The minimally invasive BiPolar spinal fixation technique is a promising alternative that allows for equivalent correction of neuromuscular scoliosis (NMS), with the option of progressive correction surgery. We report the results of this technique on a cohort of children and adolescents operated on consecutively at the Sydney Children's Hospital, Randwick.

Methods: This is a retrospective review of the medical records of children and adolescents with NMS operated on between April 2019 and July 2022 using minimally invasive BiPolar spinal fixation. Outcomes reported include demographics, perioperative haematological outcomes, operative time, length of stay (LOS), complications, radiographic outcomes and follow-up attendance.

Results: 32 cases were identified, 27 included in the study. The most common diagnosis for this cohort was cerebral palsy (GMFCS IV or V). Median (IQR) operative time was 210 (192 to 240) minutes and median (IQR) estimated intra-operative blood loss was 275 (200 to 400) mL, which decreased through the study (R^2=0.26, F(1, 24)=8.46, p=0.01). Mean (SD) fall in haemoglobin (Hb) pre- to post-operatively was 54 (17) g/L (t(26)=16.3, p<0.001); mean (SD) fall in haematocrit (HCT) was 0.16 (0.05) L/L (t(25)=15.8, p<0.001). Median (IQR) day of lowest post-operative Hb and HCT was day 1 (1 to 3). Median (IQR) post-operative LOS in hospital was 7.5 (7 to 11) days, and 3 (1 to 4) days in ICU. Median (IQR) LOS was significantly lower in 2021-22 compared with 2019-20 in hospital (Mann Whitney U=38, z=-2.08, p=0.04) and in ICU (Mann Whitney U=27.5, z=-2.64, p=0.01). 16 participants (59%) had at least one complication. The most frequent serious complication was pneumonia requiring ventilatory support in ICU (7 participants, 26%). There was one post-operative death. No participants experienced hardware failure or required a major revision operation. Mean (SD) correction in coronal Cobb angle was 46(14)% post-operatively, maintained at 41(18)% at latest follow-up, a statistically significant improvement (t(25)=10.9, p<0.001). Median (IQR) correction of spinopelvic angle (SPA) was 67(41-85)% post-operatively and 64(44-74)% at latest follow-up, a statistically significant improvement (Mann Whitney U=114, z=-4.33, p=<0.001). Mean (SD) weight gain over the study period was 4.5 (6.5) kg, which was statistically significant (t(16)=-2.84, p=0.01). The proportion of eligible patients attending follow-up at the milestones of 6, 12 and 24 months were 74%, 64% and 46%, respectively. Follow-up is currently at 2 years, with aim for follow-up to 5 years. Substantial attrition occurred because of travel restrictions and family reluctance to come to Sydney during the COVID-19 pandemic.

Conclusion: This minimally invasive BiPolar technique is an effective alternative to PSF in NMS, particularly in underweight and comorbid patients at high risk of complications with PSF. It provides adequate correction of deformities which is maintained over time without hardware failure or conversion to PSF. Further follow-up on this cohort is needed to assess maintenance of the correction and anticipated rod breakage rates. Further research will explore quality of life outcomes in patients undergoing this operation.

O285

5-year outcomes for single-level total disc replacement with a novel viscoelastic artificial cervical disc compared to Anterior Cervical Discectomy and Fusion (ACDF)

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Introduction: The M6-C Artificial Cervical Disc, with a compressible viscoelastic nuclear core and an annular structure, is substantially different from first generation articulating surface designs and has previously demonstrated favorable mid-term clinical outcomes.
Methods: A prospective, multicenter, controlled, IDE clinical trial is ongoing. 12 M6-C sites and 11 ACDF sites are participating in the study, with pre-op assessments followed by assessments at 6 weeks, 3 months, 6 months, 1 year, and annually out to 10 years post-op. 160 M6-C and 189 ACDF subjects were enrolled. Subjects presented with one-level symptomatic degenerative cervical radiculopathy and received either M6-C or ACDF at a single level. The M6-C and ACDF cohorts were propensity matched. Follow-up assessments are planned out to 10-years post-op.
Results: Neck Disability Index Scores are available for 106 M6-C and 93 ACDF subjects at 5 years. At 5 years post-op, M6-C subjects had a mean NDI score of 8.0 - significantly better than the mean of 18.0 observed in the ACDF group. M6-C subjects experienced a mean NDI improvement from baseline of 47.5 points at 5-years, compared to 33.4 for the ACDF cohort, significantly better for the M6-C group. At 5 years post-op, a statistically higher percentage of M6-C subjects experienced a 15-point improvement from baseline (98.1%) compared to the ACDF cohort (84.9%.)
Neck Pain and Shoulder/Arm Pain VAS Scores are available for analysis for 105 M6-C and 93 ACDF subjects at 5 years. At 5 years post-op, M6-C subjects had a mean Neck Pain VAS Score of 0.6, which was significantly better than the mean of 1.9 observed in the ACDF control group. M6-C subjects experienced a mean improvement from baseline of 6.5 points at 5-years post-op, compared to 5.1 for the ACDF cohort, significantly better for the M6-C group. Similarly significant results were observed in Shoulder/Arm Pain VAS Scores (worst side) at 5-years, with a mean of 0.5 for M6-C and 2.1 for ACDF, and a mean improvement from baseline of 6.8 for M6-C and 5.2 for ACDF.
Through 5 years post-op, 5 M6-C subjects experienced Supplemental Surgical Interventions (SSI) at the index level. These included 3 Removals, 1 Reoperation, and 1 Supplemental Fixation. Of the removals, 2 were performed due to persistent neck and arm pain (with 1 being replaced by a new M6-C,) and 1 was performed due to osteolysis associated with a confirmed infection. 11 ACDF subjects underwent SSIs through 5 years post-op.
Conclusions: The significant benefits in NDI and Neck Pain and Shoulder/Arm Pain VAS Scores associated with M6-C in earlier follow-up periods, compared to ACDF controls, appear to be maintained at 5-years post-op. SSI were lower in the M6-C group. When the M6-C was used at a single level, revisions for sterile osteolysis were not observed at 5-years post-op. The safety and performance of M6-C in this cohort will continue to be monitored out to 10-years post-op.

O286

First long-term follow-up results on wear-induced osteolysis following cervical total disc replacement using the M6-C™ Artificial Cervical Disc

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Introduction: The M6-C™ artificial cervical disc (Orthofix, Lewisville, Texas) is a routinely used cervical total disc replacement (CTDR) implant. In June 2020 Australian Therapeutic and Goods Administration published an implant hazard report because the Instructions for Use contained insufficient information regarding the potential consequences of peri-prosthetic osteolysis associated with the use of the M6-CTM. In a recent study, it was reported that after mid-term follow-up, 34% of patients implanted with the M6-C™ required revision surgery for wear-related osteolysis with an average of 5.5 years postop. However, their study did not report on the incidence and grade of osteolysis, as well as indication for revision surgery. Our study aims to investigate the prevalence, risk factors, and radiographic characteristics of long-term failure of the M6-C™ due to osteolysis.
Methods: We retrospectively analyzed the radiographic and clinical outcomes (EuroQuol-5D, Neck Disability Index, Visual analogue scale for neck and arm pain) of data collected during long-term follow-up of patients who underwent CTDR with the M6-CTM implant at a multi-center between 2011 and 2015. All patients were followed up with radiographic imaging (conventional X-ray, CT scan) of the cervical spine to detect osteolysis. Clinical outcome was determined by collecting patient-related questionnaires (EQ-5D-3L, NDI - Neck Disability Index, VAS - visual analog scale for neck and arm pain). Ethical approval was obtained from the local Institutional Review Board.
Results: In total 85 patients received CTDR with the M6-C™. So far, follow-up was completed in 45 patients (50 implants) with a mean age of 44.4 years (54% female). The mean follow-up time was 8.6 years (7.5-11 years). Thirty-one patients (74%) had single-level surgery. Prior to our follow up only 4 patients (10%) had revision surgery, but not due to osteolysis. Radiographic findings showed abnormal findings in 39/50 implants (78 %): osteolysis was found in 22/50 implants (44 %). Osteolysis which did not lead to implant failure was senn in 17/50 (34%). Implant failure due to osteolyis was seen in 5/50 implants (10%; all at C5/6; 5.4 – 9 years after index surgery). In addition, 17/50 patients (34 %) had various degrees of heterotopic ossification which led to a fused and immobile disc arthroplasty. The clinical outcome showed that the EQ-5D Health VAS is lower and both VAS for arm pain and NDI score is significantly higher in the group with failed implants.
Conclusions: In our cohort, we see a lower reoperation rate of the M6-C™ implant compared to the literature. However, osteolysis may be asymptomatic. Long-term radiographic follow-up results of the M6-C™ in this cohort are not favorable. Patients with this implant should undergo interval monitoring for major osteolysis or implant failure.

O287

Lower bone mineral density in DEXA-identified adolescents with idiopathic scoliosis at age 20

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Introduction: Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity of unknown origin, detected between the ages 10-18 years. It is typically diagnosed by a Cobb angle ≥10° measurement of the scoliotic curve on a standing radiograph.
Some studies have highlighted that the presence of eating disorder, lower bone mineral density (BMD) and lower body mass index (BMI) may be more common in people with AIS than those without. Altered hormone levels that regulate appetite and metabolism have been reported in participants with AIS. Previous findings suggest that altered nutrition and abnormal anthropometric features may be associated with the development of AIS.
Most studies examining factors related to AIS recruit participants through clinical settings (e.g. hospital or allied health centres), possibly biasing outcomes to participants who present to these clinics. Dual energy x-ray absorptiometry (DEXA) scans from an Australian cohort, the Raine Study, at age 20, present a contemporary opportunity to screen for participants with likely AIS in an unbiased community sample. This also enables comparison of biological, psychological and physical factors between people with AIS and those without.
Aim: The aims of this study were to: 1. Identify likely AIS in an Australian cohort using DEXA scans at age 20, 2. Compare the prevalence of nutritional-related variables, at ages 8, 10, 14, 17 and 20 between those with likely AIS and those without.
Methods: Likely AIS was determined with quantitative and qualitative criteria (modified Ferguson angle ≥10° and expert review of spinal curves on DEXA). Reported diagnosis of AIS by a healthcare practitioner was also noted. Continuous variables (serum leptin, serum adiponectin, serum vitamin D, BMI, BMD) were compared between those with and without likely AIS using t-test or Mann-Whitney U test. The categorical variables (reported diagnosis of eating disorder, eating disorder diagnosis based on a weight and eating disorder questionnaire) were compared using Fisher test. Multiple logistic regression and backwards selection were used to quantify the relationship between these variables and diagnosis of likely AIS.
Results: From 1238 participants with DEXA scans, 26 were identified with likely AIS (2.1%). There were 1139 with no indication of scoliosis. Diagnosis of AIS was reported despite little or no scoliosis curve (<3.8°) for 20 participants (1.6%), and diagnosis of AIS was not reported despite scoliosis curve ≥10° for 11 participants (0.9%).
Those with likely AIS had a lower BMD (median 1.0 vs 1.1 g/cm^2, p=0.03) at age 20 than those without. The risk of AIS odds ratio increased by 1.5 times for every 0.1 g/cm^2 decrease in BMD at age 20 (p=0.04, AUC=0.628).
Conclusion: There is potential for using a combination of quantitative measurement and qualitative criteria to evaluate DEXA images and identify likely AIS. Whilst a decrease in BMD was associated with an increased risk of AIS, nutritional factors contributing to lower BMD were not identified.

Acknowledgements: We would like to acknowledge the Raine Study participants and their families for their ongoing participation in the study and the Raine Study team for study co-ordination and data collection.

O288
Interplay of radiological parameters and functional outcomes following cervical laminoplasty

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Objective: In this study, we intend to evaluate the impact of clinico-radiological parameters on loss of cervical lordosis (LOCL) and functional outcomes following cervical laminoplasty.
Methods: Patients were evaluated for LOCL and its correlation with preoperative radiological parameters. The functional outcomes were studied using short form 36 (SF-36) questionnaire and neck disability index (NDI) which were in turn evaluated for correlation with preoperative radiological parameters and LOCL.
Results: A total of 110 patients who underwent laminoplasty for CSM (n=68) or OPLL (n=42) were included in the study. Preoperative cobb's angle (CA) (p=0.005), T1 slope (T1S) (p=0.001) and dynamic extension reserve (DER) (p <0.001) were found to be significant predictors of LOCL. At 1-year follow-up after surgery, we found that significant improvement in global SF-36 (p<0.001) and all its domains except Role Emotional (RE) and Mental Health (MH) did not show significant improvement after surgery. Though, there was apparently more improvement in those with no LOCL but it failed to reach statistical significance in each of the functional outcome scales i.e., improvement in NDI (p=0.341) and increase in SF-36 (p=0.927). For improvement in global SF-36, only symptom duration (p=0.029) was found to be significantly correlated.
Conclusions: In this study, we have found the radiological outcome, in terms of significant LOCL, to be dependent on preoperative CA, T1S and DER. However, neither the preoperative radiological parameters nor significant LOCL could predict functional outcomes.

O289
Dysphagia and dysphonia

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Introduction: Dysphagia and dysphonia are common complications after anterior cervical spine surgery (ACSS); However, there are few reliable clinical studies regarding prevalences, risk factors, measuring tools of dysphagia and dysphonia.
Aim: To introduce the risk factors of anterior cervical spine surgery on swallowing and vocal function and how to prevent dysphagia and dysphonia.
Methods: Medical records through the pubmed of 19 most reliable papers between 2012 and 2019 were retrospectively reviewed. We summarized and present the etiology, risk factors, measurement tools and how to avoid dysphagia and dysphonia including our own experiences.
Results: Risk factors are age(>60yrs), blood loss(> 300mL), female, larger less smooth plate, operative levels, increased op time, excessive esphageal retraction pressure, revision surgery, smoking and postoperative prevertebral soft tissue swelling. We present the sequential peri-intraoperative steps for reducing dysphagia and dysphonia.
Conclusions: ACSS is a safe surgical procedure but careful investigation and management are needed for reducing dysphagia and dysphonia. Also, team approach is inevitable to manage those problems.

O290

Direct trans-pedicular screw fixation for atypical hangman's fracture: A minimally invasive technique using the tubular retractor system

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Objective: The ideal treatment strategy of atypical hangman's fracture (AHF) is debatable. If surgical treatment is needed, direct trans-pedicular fixation technique is advantageous in that it stabilizes the fracture site and spares adjacent motion segments. The authors describe a simple, economical, and minimally invasive technique using the tubular retractor system (TRS) for surgical treatment of AHF.
Materials and Methods: Trans-pedicular screw fixation using the TRS was performed in seven patients with AHF. This technique was facilitated by using intraoperative fluoroscopy and a surgical microscope. Rigid cervical collar was used for 4 weeks, postoperatively. To evaluate postoperative radiological outcomes, cervical computed tomography (CT) was performed at postoperative 6 months. The clinical outcomes, including visual analog scale and neck motion, were evaluated.
Results: No intraoperative neuro-vascular injury or postoperative complications occurred. For all patients, dynamic radiographs and CT images demonstrated a stable construct. Clinical examination also showed satisfactory pain relief and restoration of the full range of motion in the neck.
Conclusion: Direct trans-pedicular screw fixation using the TRS for AHF appears to be safe and effective. This technique permits less skin incision and muscle dissection with good postoperative recovery. This report serves as a preliminary study and may be a surgical option for minimally invasive direct repair.
Keywords: atypical, direct, hangman's fracture, minimally invasive, trans-pedicular screw, tubular retractor

O291
Cervicothoracic junctional approach

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Introduction: Surgical approaches to the cervicothoracic junction often involve difficult dissection resulting from the close proximity of major vascular structures. The great vessels, the sternum, and the clavicle often limit accessibility during the procedure. The three most common indications for surgical intervention at the cervicothoracic junction are infections, neoplasms, and fractures. To adequately explore the anterior spine from C4 to T4 requires a midsternotomy with extended anterior cervical incision. This approach most adequately provides the extensive cranial-caudal exposure required in dealing with infections, neoplasms, and fractures at the cervicothoracic junction.
Methods: The posterior surgical approaches, as the laminectomy or the arthro-pediclectomy, fail to expose the anterior spinal elements. Thus, further surgical approaches have been proposed: postero-lateral, antero-lateral (thoracotomies) and purely anterior.
Results: Care must be taken when using anterior or antero-lateral approach so as not to injure the recurrent laryngeal nerve or the brachiocephalic vessels. When using the sternal splitting approach, it is important to keep in mind that it adds marked morbidity risk with the potential for a sternal wound infection. The transthoracic approach uses a proximal thoracotomy with removal of the third or fourth rib. Exposure to the first four thoracic ribs is adequate with this technique, but access to the lower cervical vertebrae can be difficult. Other complications associated with this approach are the added morbidity related to lung manipulation and the potential for Horner's syndrome resulting from damage to the sympathetic chain. In general, neurologic results depend largely on the patient's preoperative status and their underlying disease process. Postoperative complications, such as shoulder dysfunction, hardly ever occur, and swallowing dysfunction is usually short lived. A positive outcome is that some patients can achieve as much as a 20° correction of kyphosis.
Conclusion: The CTJ represents a unique region in the spine because of its biomechanical properties. It is also a difficult region to access anteriorly because of the vital structures ventral to the CTJ. The development of new surgical techniques and new instrumentation has allowed better access and fixation to the CTJ.

O292

Cervical sagittal parameters in degenerative cervical spondylolisthesis versus degenerative cervical kyphosis with myeloradiculopathy treated by anterior cervical discectony and fusion

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Introduction: The aim of study is to determine the preoperative and postoperative cervical sagittal parameters in patients with degenerative cervical spondylolisthesis and degenerative cervical kyphosis with myeloradiculopathy.
Materials & Methods: A retrospective medical records and radiographic study of 30 adult patients were reviewed. Fifteen patients with degenerative cervical spondylolisthesis and 15 patients with degenerative cervical kyphosis have been performed anterior cervical discectomy and fusion (ACDF) from 2010-2020. We measured the preoperative and postoperative cervical sagittal parameters: C0-2 angle, C1-2 angle, C2-7 angle, C2-7 sagittal vertical axis (SVA), T1 slope, neck tilt angle and thoracic inlet angle.
Results: Patients in degenerative cervical kyphosis group have C2-7 angle less than degenerative cervical spondylolisthesis group (-14.88±7.32 vs 9.60±13.60), leading to increase the mismatch between T1 slope and C2-7 angle in kyphotic group and hyperlordosis of C0-2 angle and C1-2 angle (31.13±7.68, 37.88±5.08) compare with spondylolisthesis group (13±10.20, 24.60±10.70). Whereas patients with degenerative cervical spondylolisthesis have C2-7 SVA (33.22±13.92) more than kyphosis group (13.70±13.60). After surgery, there is significant increase of the C2-7 angle in the kyphosis group compare before and after surgery (-14.88±7.32 VS 4.10±11.80). While the spondylolisthesis group has no significantly different parameters compare to before surgery. However, the postoperative cervical sagittal parameters of all patients are within the normal thresholds (T1-Slope minus C2-C7 lordosis<15° and C2-7 SVA<40 mm).
Conclusions: The study demonstrates the difference of sagittal parameters between degenerative cervical spondylolisthesis and kyphosis before and after surgery. ACDF not only provides neural decompressive procedure, but also corrects the regional cervical sagittal parameters.
Keywords: Cervical sagittal parameters, sagittal balance, cervical kyphosis deformity, cervical spondylolisthesis, degenerative cervical myelopathy, anterior cervical discectomy and fusion

O293

Analysis of risk factors associated with distal junctional failure after long level posterior cervical fusion and instrumentation

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Purpose: Recent advances in posterior cervical fusion and instrumentation techniques have made possible wider application in stabilization of various pathologies of the cervical spine. Distal junctional failure (DJF) remains the most prevalent risk associated with poor outcome. The aim of this study is to investigate and analyze the various factors affecting the occurrence of DJF after posterior cervical long level fusion and instrumentation.
Methods: We retrospectively reviewed cases of posterior cervical long level fusion surgery all performed by a single surgeon in two spine centers. The levels of fusion were anywhere from occiput to any levels of cervical or upper thoracic spine, with a minimum of 3 motion segments. The cases were grouped into postoperative non-DJF and DJF groups. All patients were observed with X-rays, bone mineral density (BMD) tests, and CT scans preoperatively and for a minimum of 12 months postoperatively. Demographic, perioperative and surgical data were compared and analyzed. Radiographic data from two groups, including C2 angle, T1 slope, cervical lordosis, cervical sagittal vertical axis (cSVA), and axial and sagittal Hounsfield units (HU) of lowermost instrumented vertebra (LIV) and the adjacent distal vertebra (LIV+1) were compared and analyzed.
Results: One hundred eighty-eight cases were included in this study, with 147 (81.2%) in non-DJF group and 34 (18.8%) in DJF group. Diagnoses included trauma, tumor, congenital anomaly, cerebral palsy, cervical spondylotic myelopathy (CSM), deformity, and ossification of longitudinal ligaments (OPLL). The percentages of CP, deformity, and CSM were significantly higher in the DJF group (26.5% vs 44.1%, 4.8% vs 26.5%, and 6.1% vs 17.7% respectively, all $p<0.05$). The number of levels fused were significantly higher in DJF group (5.05 ± 1.41 vs 6.15 ± 1.70, $p<0.0001$). Radiographically, parameters associated with DJF were postoperative C2 slope (15.20 ± 10.59 vs 18.91 ± 13.04, $p<0.037$), preoperative T1 slope (26.41 ± 9.89 vs 21.68 ± 8.92, $p<0.047$), and preoperative cervical lordosis (7.97 ± 11.81 vs 2.29 ± 13.98, $p<0.004$), as well as changes in cervical lordosis (1.86 ± 11.76 vs 7.23 ± 10.25, $p<0.015$) and T1 slope (-0.11 ± 8.75 vs 6.20 ± 8.15, $p<0.0002$). Axial HUs were significantly lower in the DJF group in both LIV (223.86 ± 103.13 vs 217.82 ± 91.24, $p<0.006$) and LIV+1 (192.2 ± 53.82 vs 170.2 ± 37.62, $p<0033$). Multivariate analysis revealed preoperative T1 slope and preoperative cervical lordosis, as well as pre-postoperative changes in those parameters to be independent risk factors, and thus a possible predictor of occurrence of DJF.
Conclusion: The occurrences of DJF were higher in CP, deformity and CSM cases, and cases with higher number of fused segments. Lower preoperative T1 slope and cervical lordosis, and excessive correction of those parameters were associated with DJF. Lower HU at LIV and LIV+1 were also associated with DJF.
FP-16

O294

Effectiveness of nasotracheal intubation in anterior cervical surgery including C3 lesions

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Introduction: Anterior approach cervical surgery is widely used for accessing C3 lesions. When operating with an anterior approach, the surgical field is obstructed by mandible. Neck extension is popular method to secure better surgical field but risk devastating neurological damage. To overcome this limited surgical field without neck extension, we adopted nasotracheal intubation and evaluated its efficiency.
Methods: We retrospectively analyzed 16 patients who underwent anterior cervical discectomy or corpectomy of C3 lesions via nasotracheal intubation. We enrolled an additional 29 patients who underwent anterior cervical discectomy or corpectomy of C3 lesions via orotracheal intubation as a control group. All patients had been diagnosed with cervical spondylotic myelopathy or ossification of the posterior longitudinal ligament. We measured the mandibular-cervical angle, which is the angle between the lower mandibular line and anterior vertebral line.
Results: The mandibular-cervical angle was increased by 7.3 with nasotracheal intubation compared to orotracheal intubation.
Conclusions: Nasotracheal intubation is an effective surgical option for securing the surgical field without neck extension in anterior cervical surgery including C3 lesions.

Reference:

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O295

C2 nerve root preservation/sacrifice in patients with atlantoaxial dislocation: Clinical outcomes and the feasibility of its preservation

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Introduction: Posterior C1-C2 fusion is a widely used fixation technique for atlantoaxial dislocation (AAD). The C2 ganglion is a restricting factor to an easy access of C1-C2 joints, and placement of C1 lateral mass screws. Both intentional C2 nerve root sectioning as well as its preservation have been described and are still debatable; the associated outcomes have been less studied.
Aim: We evaluated the clinical outcomes after C2 nerve root sectioning/preservation as well as the feasibility of its preservation in AAD patients.
Patients and Methods: This study involved both retrospective and prospective cohort of 253 patients who underwent posterior C1-C2 fusion for congenital AAD using C1 lateral mass screws. The decision to cut or preserve C2 nerve root was dependent on preoperative osseo-vascular radiology and intraoperative suitability of its preservation. Patients were followed-up at periodic intervals and questioned about C2 nerve-related dysfunction.
Results: Complex C1-C2 morphology with highly deformed joints was seen in 155 patients. The C2 nerve preservation rate was greatly influenced by the surgeons' learning curve. While the C2 nerve root was sectioned in 185 patients predominantly in the initial period, its preservation rate in later years raised upto 89.7%. Post-sectioning, the numbness, paresthesia and dysesthesia were present in 30.3%, 21.9% and 19.5% respectively. However, the symptoms did not disturb the daily activities of patients. Noticeably, 9 patients (5.1%) of these developed non-healing occipital ulcers requiring flap cover/ skin graft. After preservation, 23.6% patients developed new-onset C2 nerve root dysfunction albeit with no major disabling symptoms. The C2 nerve root preservation is feasible with robust inferior C1 lateral mass and normal sized ganglion. In patients with highly oblique joints/ spondyloptosis, incurved occiput, pseudofacets and anomalous vertebral artery, though the preservation initially seemed to be technically difficult, it could be achieved in about three-fourths, with gaining operative experience.
Conclusion: Although C2 nerve root dysfunction did not disable the quality of life in many patients, a subset after its sectioning, was prone for neuropathic ulcers. Given the existing controversy related to the C2 nerve root preservation/ sacrifice, we suggest its anatomical preservation, considering other aspects such as the etiology of instability, bony and vascular anatomy, and the surgeon's learning curve.

O296

How useful is C1-C2 fixation for patients with Chiari malformation without instability?

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Introduction: C1-C2 fixation without foramen magnum decompression (FMD) has been recently advocated for Chiari malformation (CM) without instability, and is controversial secondary to loss of C1-C2 movements. The claimed efficacy of this procedure over FMD, an established treatment modality for this condition has been less evaluated.
Aim: The objective was to assess the efficacy of C1-C2 fusion without FMD in Chiari patients without apparent atlantoaxial instability.
Patients and Methods: Forty such patients underwent C1-C2 distraction and fusion (without FMD). Pre-operative and follow-up clinico-radiological data were prospectively compared using Klekamp's neurologic scale, visual analog scale (VAS), pBC2 index for ventral brainstem compression and Vaquero index for syringomyelia.
Results: 28 patients (70%) improved in their neurological score and VAS while 8 remained in the same status, 3 deteriorated and 1 expired at follow-up. The clinical improvement was not associated with the severity of ventral cervicomedullary compression or presence of bony anomalies such as assimilated C1 arch, platybasia and basilar invagination despite the reduction in mean pBC2 index (7.9 vs 5.9). Syringomyelia reduced in 51.7%; Vaquero Index reduced at the follow-up (0.48) vs baseline of 0.38.
Conclusion: The efficacy of C1-C2 distraction-fusion for CM without instability is not superior when compared with the reported outcomes following standard FMD.

O297

The expression of mitofusin 1 and mitofusin 2 by oxidative stress in the cells from intervertebral disc

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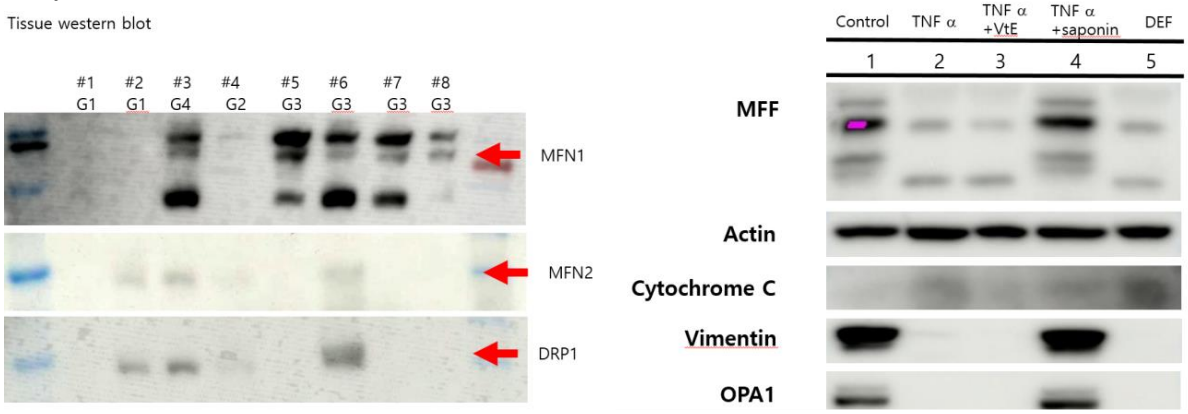
Introduction: Interverterbal disc (IVD) causes an imbalance between anabolism and catabolism by continuous physical force. Subsequently, extracellular matrix (ECM) homeostasis is disrupted, leading to IVD degeneration. Mitochondria are involved in energy production, maintaining intracellular calcium homeostasis, and regulating apoptosis. Physical forces change the membrane potential of intracellular mitochondria, thereby inducing cell proliferation and apoptosis. Dysfunctional mitochondria are unable to produce energy, leading to programmed cell death, such as apoptosis. Therefore, understanding and regulating mitochondrial dynamics and mitophagy functions can help slow down IVD degeneration. To understand the inflammatory response caused by oxidative stress during mitochondria fusion and to suppress apoptosis.

Methods:

• IVD tissue collection and cell separation
• Culture of IVD cells
• Determination of MFN1, MFN2, HIF1α, HIF1β, GLUT1, cytochrome C, COX Ⅳ, P62, LC3, PINK1, parkin, Bcl-2, Bax, Bak, nitric oxide, and β-actin expression levels
• Measurement of glycoprotein levels
• In invo mouse experiment

Results: The activity level of each mitochondria protein when treated with TNF-α and deferoxamine was examined. Through tissue western blot, the activity of MFN1, 2 and DRP 1 according to tissue grade was found. In addition, the levels of ubiquitinated proteins SQSTM1/P62, NDP52 and Optineurin could be found in each condition, and OPA1 and MFF involved in fusion and fission could be analyzed. Parkin and PINK1 involved in mitophage induction were analyzed, and other fibronetin, MMP13, IL6 and TIMP1,4 were also analyzed.



Conclusions: This study investigated the function of MFN1 in the mitochondria fusion reaction and confirmed the characteristics of MFN1 in the intervertebral disc degeneration process. Through this, it will be possible to change disc degeneration through the regulation of MFN function.

Acknowledgements: This work was supported by grants from the yonsei medical college research program.

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O298

Predictive 3D neural network for progressive collapse after osteoporotic vertebral compression fracture using magnetic resonance images

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Introduction: The vertebral collapse can be developed after osteoporotic vertebral compression fracture (OVCF) and the patients having the progressively collapsed vertebrae need to get aggressive treatment including surgery. Therefore, the prediction for the vertebral collapse after acute OVCF may be helpful in decision of the differentiated treatment for the patients with OVCF.

Aim: To investigate the convolutional neural network (CNN) model to predict the vertebral collapse after osteoporotic vertebral fracture using magnetic resonance image (MRI) of patients with acute OVF.

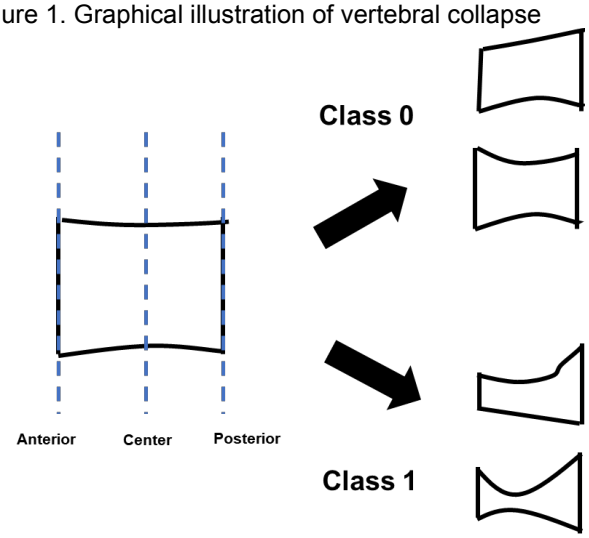
Patients and Methods: This retrospective study included 98 patients with acute OVCF. The sagittal T1 and T2WI of 82 patients were used for CNN training and internal validation. For test of the CNN, the sagittal MRIs of 16 patients in external dataset were used. We plotted the receiver operating characteristic (ROC) curve and calculated the area under the curve (AUC) to assess the performance of the CNN. And, we compared the accuracy, sensitivity, and specificity of prediction by different CNNs. To predict the vertebral collapse after acute OVF, we constructed CNN models depending on their structure: Inception V3, ResNet50, and DensNet The CNN models were trained and tested using internal and external dataset, respectively. The sagittal T1 and T2WI MRI of 98 patients were used in construction of the CNN.

Results: The accuracy and ACU of DensNet 3D model were higher than those of ResNet50 and Inception V3 model. In the final Inception3D model using sagittal T1 and T2WI MRI simultaneously, the accuracy and AUC were higher than those in the DensNet 3D model using T1 or T2WI MRI sequence alone (0.87 5 and 0.800 vs.0.625 and 0.667 vs. 0.750 and 0.667, respectively).

Conclusions: The DensNet CNN model trained multisequence MRI can predict the vertebral collapse after acute OVCF. In clinical field. The CNN model may be a useful tool in treatment strategy of patient with acute OVCF.

Figures:

Figure 1. Graphical illustration of vertebral collapse



Class 0 : anterior or central vertebral body height > 50% of the posterior height.
Class 1 (vertebral collapse): anterior or central vertebral body height < 50% of the posterior height.

Figure 2. Schematic illustration regarding preprocessing step

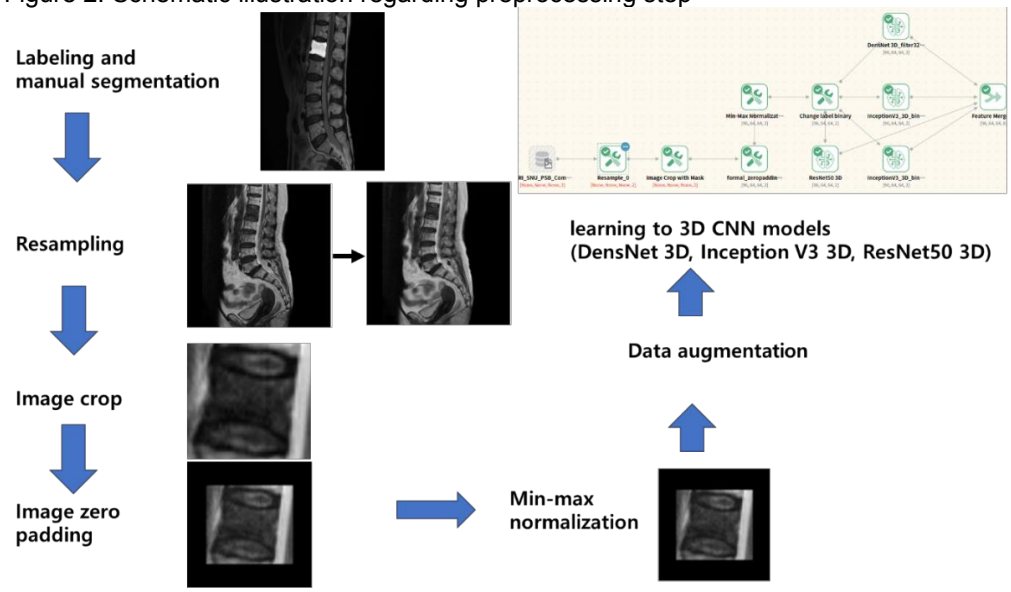
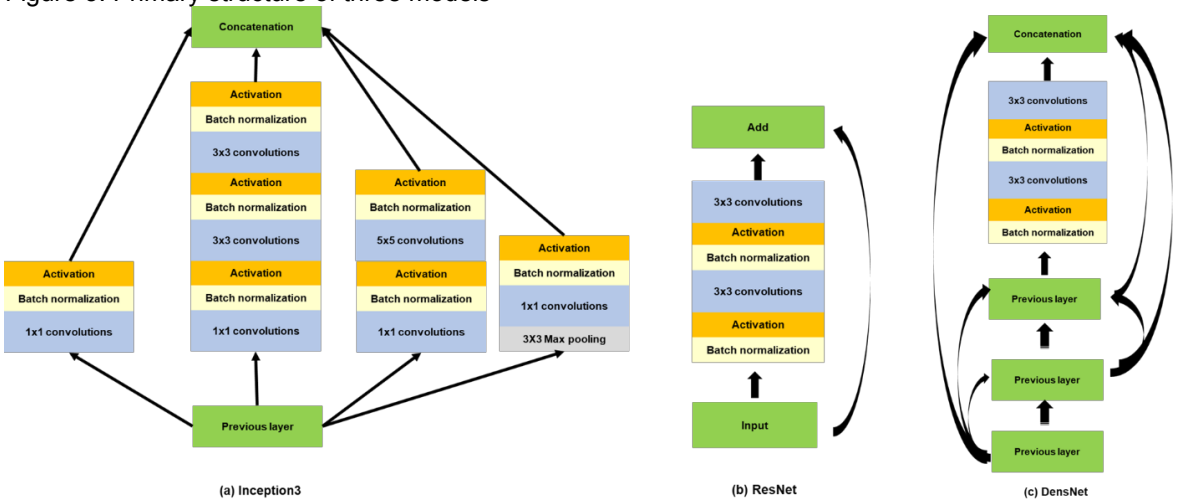


Figure 3. Primary structure of three models



(a), (b) and (c) are the most characteristic parts of the structure of the three models.

O299

Mesenchymal stem cell transplantation promotes functional recovery through mmp2/stat3 related astrogliosis after spinal cord injury

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Aim: Treatment with mesenchymal stem cells (MSC) has been highlighted in spinal cord injury (SCI). however, it was not fully revealed that the mechanism of MSC on SCI, especially acute astrogliosis. In this study, we determined whether acute transplantation of MSC improves the outcome of SCI through modulating astrogliosis.
Materials and Methods: Bone marrow derived rat MSCs were induced neural differentiation and transplanted after acute SCI rats. Matrix metalloproteinase (MMP) and neuro-inflammatory pathway were analyzed for acute astrogliosis at 1, 3 and 7 d after SCI in RT-PCR- and western blot analysis. Functional outcome was assessed serially at postoperative 1 d and weekly for 4 weeks. Histopathologic analysis was undertaken at 7 and 28 d following injury in immunohistochemistry.
Results: Transplantation of MSCs decreased IL-1α, CXCL-2, CXCL-10, TNF-α and TGF-β in a rat model of contusive SCI. Protein level of nuclear factor(NF)-κB p65 was slightly decreased while level of signal transducer and activator of transcription 3(STAT-3) was increased. At 7th days, area of lesion core, the number of astrocytes and microglial cells increased at MSC treatment group. In immunohistochemistry, MSC transplantation increased acute astrogliosis whereas attenuated scar formation with increased sparing white matter of spinal cord lesions. In RT-PCR analysis, mRNA levels of MMP2 was significantly increased in MSC transplanted rats. In BBB locomotor scale, the rats of MSC treated group exhibited improvement of functional recovery.
Conclusion: Transplantation of MSC reduces the inflammatory reaction and modulates astrogliosis via MMP2/STAT3 pathway leading to improve functional recovery after SCI in rats.

O300

Effectiveness of adipose tissue-derived stromal vascular fraction and bone morphogenic protein-2 in mini-pig spinal fusion model

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Stromal vascular fraction cells (SVF) contains mesenchymal stem cells called adipose tissue-derived stem cells, which are able to differentiate in bone, cartilage, and adipose tissue. SVFs are widely used in regenerative medicine due to their ability to differentiate into the cells of damaged tissues and organs. and it is expected that bone fusion technology can be upgraded by applying it with rhBMP-2.

In this study, we aimed to evaluate spine fusion rates with rhBMP-2 and SVF in mini-pig as lumbar spine oblique interbody fusion model as following: (1) the iliac crest bone graft group, (2) the carrier with rhBMP-2 group, and (3) the carrier with rhBMP-2 and SVF group (n=6x2level/each group).

At 8 and 16 weeks after surgery, mini-pigs were sacrificed to evaluate the new bone formation in micro CT imaging and histological analaysis. On micro-CT, group3 showed larger Bone volume fraction (BV/TV) and trabecular number. In HE staining, the group3 demonstrated highest new bone area at 16weeks. In Goldner's trichrome staining, the group3 showed highest mineralized area at 8 weeks. In von Kossa staining, the group3 showed Ca2+ area at 8 weeks. In mini-pig spine fusion model, the implantation of rhBMP-2 with SVF showed comparable osteoinductivity to autoiliac bone and increased new bone formation. These suggest the rhBMP-2 with SVF could be a novel feasible bone graft material.

O301

Deep learning model for classifying metastatic epidural spinal cord compression on MRI

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Introduction: Metastatic epidural spinal cord compression (MESCC) is a devastating complication of advanced cancer. A deep learning (DL) model for automated MESCC classification on MRI could aid earlier diagnosis and referral. The aim of this study was to train a DL model for the automated Bilsky classification of MESCC using axial T2W MRI. This could aid earlier diagnosis of MESCC and identify suitable candidates for radiotherapy versus emergent surgical decompression.
Materials and Methods: Patients with known MESCC diagnosed on MRI between September 2007 and September 2017 were eligible. MRI studies with instrumentation, suboptimal image quality, and non-thoracic regions were excluded. Axial T2-weighted images were utilized, and the data was obtained using a range of MRI platforms and parameters to prevent overfitting and train a more generalizable DL model. The internal dataset split was 82% and 18% for training/validation and test sets, respectively. External testing was also performed. Internal training/validation data were labelled using the Bilsky MESCC classification by a musculoskeletal radiologist (10 years of experience) and a neuroradiologist (5 years of experience). These labels were used to train a DL model utilizing a prototypical convolutional neural network. Internal and external test sets were labelled by the musculoskeletal radiologist as the reference standard. For assessment of DL model performance and inter-rater agreement, test sets were labelled independently by a neuroradiologist (5 years of experience), spine oncology surgeon (5 years of experience), and a radiation oncologist (11 years of experience). Inter-rater agreement (Gwet's kappa) and sensitivity/specificity were calculated.
Results: Overall, 215 MRI spine studies were analyzed [164 patients, mean age = 62 ± 12 (SD)] with 177 (82%) for training/validation and 38 (18%) for internal testing. On an internal test set, the DL model showed almost-perfect agreement (kappa = 0.92, $p < 0.001$) for dichotomous Bilsky MESCC classification (low grade versus high grade), similar to specialist readers, which included a radiation oncologist (kappa = 0.97, $p < 0.001$), a neuroradiologist (kappa = 0.96, $p < 0.001$), and a spine oncology surgeon (kappa = 0.98, $p < 0.001$). Similar performance was seen for external testing on a set of 32 MRI spines from a different institution with the DL model (kappa = 0.94, $p < 0.001$), radiation oncologist (kappa = 0.94, $p < 0.001$), neuroradiologist (kappa = 0.95, $p < 0.001$), and spine oncology surgeon (kappa = 0.94, $p < 0.001$) all showing almost perfect agreement (kappas = 0.94–0.95, $p < 0.001$) compared to the reference standard. The DL model showed high sensitivity/specificity of 97.6/93.6 on the internal test set and 89.9/98.1 on the external test set, respectively.
Conclusion: A DL model showed comparable agreement to a subspecialist radiologist and clinical specialists for the classification of malignant epidural spinal cord compression on MRI. The DL model could be used to triage MRI scans for urgent reporting, augment non-sub-specialized radiologists when they report out of hours, and improve the communication and referral pathways between specialties including oncology, radiation oncology, and surgery.

O302

Multi-modulation of immune-inflammatory response using bioactive molecule integrated PLGA composite for spinal fusion

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Introduction: Despite current developments in bone substitute technology for spinal fusion, there is significantly devoid of adequate materials for bone regeneration in clinical applications. Even though recombinant human bone morphogenetic protein-2 (rhBMP-2) is commercially available, it has known side effects of serious inflammatory response. There are needs for bone graft substitute that enhances osteogenesis without adverse effects. Here, we developed a bioactive molecule-laden PLGA composite with multi-modulation for bone fusion, and such bioresorbable composite scaffolds were considered for bone tissue engineering.

Methods: Among the main components, magnesium hydroxide (MH) is involved to reduce acute inflammation affecting disruption of new bone formation. Decellularized bone extracellular matrix (bECM) and demineralized bone matrix (DBM) composites were also employed for osteoconductive and osteoinductive activities, and especially, polydeoxyribonucleotide (PDRN, PN) derived from salmon trout, which is bioactive molecule, for angiogenesis offers an essential role for bone regeneration.

Results: Nano-emulsion method with Span 80 is used to fabricate bioactive PLGA-MH-bECM/DBM-PDRN (PME2/PN) composite to obtain highly effective and safe scaffold. The PME2/PN with this synergistic effect improved not only osteogenic and angiogenic gene expression for bone fusion, but also immunosuppression and polarization of macrophages that are important for bone tissue repair, using a rat model of posterolateral spinal fusion (PLF) and thus it demonstrated sufficient biocompatibility and bioactivity for spinal fusion.

Conclusions: A multi-modulation of immune-inflammatory response of the PME2/PN through bioactive agent incorporation was demonstrated. Both *in vitro* and *in vivo* evaluations, the PME2/PN performed great biocompatibility and anti-inflammatory effect. Therefore, our study furnished an advanced bone graft material with enhanced anti-inflammatory, angiogenic, osteogenic, and immune modulation activities in bone tissue engineering.

O303

Comparison of perioperative outcomes following conventional open surgery versus minimally invasive surgery for metastatic spinal tumors: A retrospective, propensity score-matched study

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Introduction: Surgical procedures have been proved to be efficient in alleviating pain and preventing neurological complications of patients with metastatic spinal cancers. There are two categories of surgical procedure for metastatic spinal cancers; conventional open surgery (COS) and minimally invasive surgery(MIS). The purpose of this study is to investigate relative advantages of MIS and COS respectively.
Materials and Methods: A retrospective, propensity score-matched study has been proceeded from April 2011 to December 2022 in the department of orthopedic surgery of Seoul St. Mary's Hospital. COS is defined as follows; corpectomy, wide open surgery (PSF, TES, PVCR), while MIS indicates percutaneous posterior instrumentation. For short-term analysis, data were collected until three month after spinal surgery. All the data were proceeded by the SPSS v.25. Among 146 patients who had gone through operation, (COS: 96 cases, MIS 50 cases), 15 patients for each group were finally selected by propensity score matching. Data were collected and analyzed in consideration of three phases; preoperative, intraoperative, postoperative. The preoperative data selected are tumor types, spinal instability neoplastic score (SINS), Revised Tokuhashi score, visual analogue scale (VAS) for back pain and radiating pain respectively, Eastern Cooperative Oncology Group (ECOG) score, Karnofsky score, Frankel grade. Intraoperative data include estimated blood loss, and number of instrumented segments. Postoperative data were collected include hospitalization period only in the department of orthopedic surgery, and scores (VAS, ECOG, Karnofsky, Frankel) followed up at 3 months after operation. Continuous dependent variables (estimated blood loss, hospitalization period) were described as mean standard deviation and categorical dependent variables (VAS, ECOG, Karnofsky, Frankel score) were analyzed using chi-squared tests.
Results: COS group had significantly more estimated blood loss (1053ml ± 913.1ml) and longer days of hospitalization (13.4days ± 5days) than MIS group (223.3ml ± 172ml) (8days ± 2.7days). Categorical indices (VAS, ECOG, Karnofsky, Frankel score) had improved after 3 month in both groups compared with preoperative status, and there was no significant statistical difference between the groups. Average improvement of the scores for COS group and MIS group were as follows; VAS (COS : 4.27 ± 1.67, MIS : 4.6 ± 1.76, p-value 0.214), VAS-radiating (COS : 4.73 ± 2.89, MIS : 3.93 ± 3.49, p-value 0.325), ECOG (COS : 0.27 ± 0.59, MIS : 0.53 ± 0.52, p-value 0.379), Karnofsky (COS : 6.7 ± 9.8, MIS : 9.3 ± 7.0, p-value 0.753), Frankel (COS : 0.67 ± 0.62, MIS : 0.53 ± 0.52, p-value 0.584).
Conclusions: There was no significant statistical difference between the groups in prognostic factors for pain, daily function, neurological status. In terms of estimated blood loss and days of hospitalization, MIS is more advantageous than COS. MIS can be strongly recommended in the future.

Key words: spine, Metastasis, Metastatic spine tumors, Metastatic spinal cord compression

O304
The feasibility of unilateral hemilaminectomy for the removal of intramedullary spinal cord tumors

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Introduction: The report about unilateral hemilaminectomy for IDEM tumors is prevail and its advantage was well-known. As the unilateral hemi-laminectomy provide narrow space and the surgeon's concern of the neural injury or incomplete removal, hemilaminectomy was not employed for the surgery of the intramedullary cord tumor. We adopted unilateral hemi-laminectomy not only for IDEM but also for intramedullary tumors to maintain its benefits of conserving spinoligamentous structure at the midline and contralateral muscular and bony structures. The author would like to describe its technique and feasibility.
Methods: A retrospective study and analysis were performed on 14 patients of intramedullary tumors who underwent unilateral hemi-laminectomy during June. 2008 ~ 2022. We used several technical tip for securing space for operation. We used 'lateral dural tacking' method to compensate narrow space induced by unilateral hemi-laminectomy. These skills also provide more room for intradural work due to ipsilateral shifting of dural sac. It allows the surgeon to avoid dural tear induced by unintended pulling. It also reduces the risk of unexpected epidural hematoma on ventral spinal canal.
Results: The pathologic reports of tumors were 5 Ependymomas, 4 hemangioblastomas, 3 metastasis, and 2 carvenous hemangiomas. As the clinical results, 11 improved, 3 unchanged and none aggravation in motor and sensory symptoms. The unilateral hemilaminectomy for intramedullary tumor was possible combining of lateral dural tacking method and microsurgical technique without difficulties. We can get benefits of reducing postoperative surgical site pain and postoperative instability. This benefits of conserving the spinoligamentous structure in midline looks greater in unilateral hemilaminectomy than bilateral laminoplastic laminotomy which may disrupt bilateral muscles and fascia that attached to the tip of spinous process.
Conclusions: The unilateral hemilaminectomy can be employed safely for the intramedullary tumors in selective cases. The benefits of unilateral hemi-laminectomy can be achieved not only for the surgery of IDEM tumors but also for intramedullary tumors.

O305

Peripheral nerve-derived stem cell spheroids induce functional recovery and repair after spinal cord injury

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Stem cell therapy is one of the most promising candidate treatments for spinal cord injury. Research has shown optimistic results for this therapy, but clinical limitations remain, including poor viability, engraftment, and differentiation. Here, we isolated novel peripheral nerve-derived stem cells (PNSCs) from adult peripheral nerves with similar characteristics to neural-crest stem cells. These PNSCs expressed neural-crest specific markers and showed multilineage differentiation potential into Schwann cells, neuroglia, neurons, and mesodermal cells. In addition, PNSCs showed therapeutic potential by releasing the neurotrophic factors, including glial cell-line-derived neurotrophic factor, insulin-like growth factor, nerve growth factor, and neurotrophin-3. PNSC abilities were also enhanced by their development into spheroids which secreted neurotrophic factors several times more than non-spheroid PNSCs and expressed several types of extra cellular matrix. These features suggest that the potential for these PNSC spheroids can overcome their limitations. In an animal spinal cord injury (SCI) model, these PNSC spheroids induced functional recovery and neuronal regeneration. These PNSC spheroids also reduced the neuropathic pain which accompanies SCI after remyelination. These PNSC spheroids may represent a new therapeutic approach for patients suffering from SCI. Clinical trial of these stem cell approach is on-going.

O306

The usefulness of trabecular CT attenuation measurement at L4 level to predict screw loosening after degenerative lumbar fusion surgery: Consider number of fused levels and postoperative sagittal balance

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Introduction: Although osteoporosis was not diagnosed in spinal dual X-ray absorptiometry pre-operatively, we encountered several cases of screw loosening within 1 year of lumbar fusion surgery. Purpose of this study is to evaluate the absolute value of L4 trabecular region-of-interest (t-ROI) computed tomography (CT) attenuation, which can predict pedicle screw loosening, and determine the changes in value according to number of fused levels and sagittal balance in patients undergoing lumbar fusion surgery
Methods: We enrolled 478 patients and analyzed factors related to screw loosening. We evaluated the association between L4 t-ROI CT attenuation and screw loosening and determined the best cutoff value of t L4 t-ROI CT attenuation for predicting screw loosening.
Results: The number of fused levels, postoperative C7-S1 sagittal vertical axis (SVA), and L4 t-ROI CT attenuation were independently correlated with screw loosening. According to number of fused level and postoperative C7-T1 SVA (≥36.9 mm or <36.9 mm), in patients with one-level fusion and C7-S1 SVA <36.9 mm, the optimal cutoff point of the L4 t-ROI CT attenuation predicting screw loosening was 106.5 Hounsfield unit (HU). L4 t-ROI attenuation did not change until two-level fusions. In patients with three-level fusions and C7-S1 SVA <36.9 mm, the optimal cutoff point of the L4 t-ROI CT attenuation predicting screw loosening was 159.0 HU. The optimal cutoff point of L4 t-ROI CT attenuation in patients with three-level fusions and C7-S1 SVA ≥36.9 mm was 191.0 HU.
Conclusion: L4 t-ROI CT attenuation value considering number of fused levels and sagittal balance is an accurate measurement method to predict screw loosening. Spine surgeons should be aware of the L4 t-ROI attenuation before surgery to improve the fusion rate and reduce instrument-related complications of lumbar spine surgery in osteoporotic patients.

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O307

Retrospective observation of combinatory effect with rh-BMP-2 and a systemic RANKL inhibitor for osteoporotic patients who undergo posterior lumbar interbody fusion

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Introduction: Spinal fusion is one of the most important goals of posterior lumbar interbody fusion surgery. In particular, when accompanied by osteoporosis, the risk of nonunion and subsidence are high, and various attempts have been try to overcome these. The success rate of spinal fusion was increased with the local application of rhBMP-2, but rhBMP-2-related complications also have been reported. Recombinant human BMP-2 (rhBMP-2) is a potent osteogenic agent but is also associated with osteoclast formation and bone absorption as well as bone formation. Denosumab is a human monoclonal antibody against the receptor activator of the nuclear factor-kappa B ligand (RANKL). It is a well-known RANKL inhibitor that blocks the differentiation and function of osteoblasts. We retrospectively explored the combinatory effect of local BMP-2 and systemic Denosumab in promoting bone fusion compared with BMP-2 alone. Aim of this study is to determine the combinatory effect of local recombinant human(rh)- BMP-2 in lumbar cage and systemic RANKL inhibitor for postoperative spinal fusion in osteoporotic patients who undergo posterior lumbar interbody fusion (PLIF)

Methods: This is a retrospective observational study, which included 223 consecutive patients with spinal stenosis who underwent PLIF between 2017 and 2019 in severance hospital. Baseline and postoperative follow up (at last, more than 1 year) clinical outcomes were assessed and radiographic assessment included lumbar flexion-extension range of motion, and subsidence. Patients' postoperative subsidence was defined at the last lumbar CT image. Additionally, BMP-2 related complications such as postoperative fluid cyst formation, fever was examined. Statistical analyses were performed to identify patient and dose of BMP-2 associated with subsidence, motion of fused vertebra.

Results: A total (N = 162) patients were included in final analysis. BMD showed statistically significant differences whether subsidence occurs (N = 151) or not (N = 11) ($p = 0.046$). In pearson correlation analysis, it was observed that the motion of fused vertebra after PLIF was higher as the patients' BMD was lower. When applied the RANKL inhibitor for osteoporotic patients, fusion status were better and tendency of low incidence of postop cyst formation was observed.

Conclusions: The difference in clinical factors among groups divided with the fusion status, subsidence, postoperative cyst formation were observed after surgery according to the dose of rhBMP-2 and application of RANKL inhibitor that occurred during the observation period after PLIF in patients with lumbar stenosis. Combinatory application of the rh-BMP2 and RANKL inhibitor can enhance bone fusion after PLIF for the osteoporotic patients with less complication than single usage of rh-BMP2.

O308

Comparison of inflammatory markers changes in patients who used postoperative prophylactic antibiotics within 24 hours after spine surgery and five days after spine surgery

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Objective: C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and white blood cell (WBC) counts are inflammatory markers used to evaluate postoperative infections. Although these markers are non-specific, understanding the normal kinetics after surgery may be helpful in the early detection of postoperative infection. In line with the recent trend of reducing the duration of antibiotic use, this study investigated the inflammatory markers of patients who received antibiotics within 24 hours after surgery according to the Health Insurance Review & Assessment Service's guidelines, and compared them with those of patients who had received antibiotics for five days, which was proven to be non-infection.
Materials and Methods: The study consisted of 74 patients divided into two groups. All patients underwent posterior lumbar interbody fusion (PLIF) at a single institution between 2019 and 2020. Group A included 37 patients who received antibiotics within 24 hours after the PLIF procedure, and group B consisted of 37 patients who had used antibiotics for five days. A 1:1 nearest-neighbor propensity-matched analysis was used. Clinical variables relevant to the study included age, sex, medical history, body mass index (BMI), estimated blood loss, and operation time. Laboratory data included CRP, ESR, and CRP, all measured preoperatively and postoperatively on days 1, 3, 5, and 7.
Results: The dynamics of CRP tended to decrease after reaching a peak on postoperative day 3. There was a similar trend in both groups A and B, and the average CRP level in group B was slightly higher than that in group A; however, the difference was not statistically significant. Multiple linear regression analysis revealed that operation time, number of fused levels, and estimation of blood loss were significant predictors of greater CRP peak value ($r^2 = 0.473$, $P < 0.001$) in patients. No trend (a tendency to decrease from a peak value) could be determined for ESR and WBC count within postoperative day 7.
Conclusion: Although there were slight differences in the numerical values and kinetics, sequential changes in inflammatory markers according to the duration of antibiotic administration showed similar patterns. Knowledge of CRP kinetics allows the assessment of the degree of difference between clinical and expected values.

Key Words: Inflammatory, Marker, Spine, Surgery,

O309

Perioperative results and complications after posterior lumbar interbody fusion (PLIF) for spinal stenosis in geriatric patients over than 80 years old

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Objective: As increasing the size of the geriatric population, the number of elderly patients, who need the surgery for painful degenerative spinal stenosis has been increasing. The geriatric population may be relatively high complications, because of age and age-associated medical conditions. However, there is a lack of studies addressing the perioperative complications and outcomes in elderly patients with posterior lumbar inter body fusion with screw augmentation (PLIF).
Materials and Methods: We retrospectively reviewed the medical records and radiographic studies of geriatric patients who had spine surgery of PLIF due to spinal stenosis for 5 years. We divided into 2 groups (A; 65-79 years old, B; over than 80 years) according to the age. Surgical level of each groups, hospital day and postoperative day, co-morbidities, complications including postoperative delirium, clinical outcomes were analyzed. Operative reports, hospital and outpatient clinic charts, and radiographic studies were reviewed.
Results: Group A was composed of 52 patients, their mean age was 68.4 and female dominant (n=33), and their mean surgically fused level was 1.79 level. Group B was 31 patients, their mean age was 82.1 and female dominant (n=19), and their mean surgically fused level was 1.28 level. Comparing between two groups, complications, postoperative hospital stay were slightly increase in Group B and co-morbidity was statistically high in Group B, however clinical outcomes were similar between two groups
Conclusion: Increasing age might be an important risk factor for complications in patients undergoing PLIF, However, we would like to recommend that if the situation of spine of extreme geriatric patients need PLIF, it should be in the surgeon's consideration after careful selection and clinical judgement.

Key Words: Lumbar spine, Posterior lumbar interbody fusion (PLIF), Complication, Geriatrics

O310

Difference in the Cobbs angle between standing and supine position as a prognostic factor after vertebral augmentation in osteoporotic vertebral compression fractures

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Objective: We retrospectively analyzed patients with osteoporotic vertebral compression fracture (OVCF) undergoing vertebral augmentation to compare the Cobbs angle changes in the supine and standing positions and the clinical outcomes.
Methods: We retrospectively extracted the data of OVCF patients who underwent vertebral augmentation. Back pain was assessed using a visual analog scale (VAS). Supine and standing radiographs were assessed before treatment to determine the Cobbs angle and compression ratio. Receiver operating characteristic curve analysis was performed to determine the optimal cutoff to predict favorable outcomes after vertebral augmentation.
Results: A total of 249 patients were included. We observed a statistically significant increase in the VAS score change with increasing Cobbs angle and compression ratio ($P<0.001$), and multivariate logistic regression analysis showed that a difference in the Cobbs angle (OR, 1.27) and compression ratio (OR, 1.12) were the independent risk factors for predicting short-term favorable outcomes after vertebral augmentation. In addition, we found that the difference in the Cobbs angle (OR 1.05) was the only factor for predicting mid-term favorable outcomes after vertebral augmentation. The optimal cutoff value of the difference in the Cobbs angle for predicting mid-term favorable outcomes was 35.526.
Conclusion: We found that the mid-term clinical outcome after vertebral augmentation was better when there was a difference of approximately 35% or more in the Cobbs angle between the standing and supine positions. Surgeons should pay attention to the difference in the Cobbs angle depending on the posture when deciding to perform vertebral augmentation in patients with OVCFs.

Keywords: osteoporotic vertebral compression fracture; vertebral augmentation; Cobbs angle; compression ratio

O311

Thoracolumbar slope is related with HRQOL and aggravation of sagittal imbalance in patients with adult spinal deformity: Prospective observational cohort study

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Objective: The purpose of the present study was to evaluate the natural course of primary degenerative sagittal imbalance (PDSI), its aggravating factors, and health-related quality of life (HRQOL) associated with various SAPs in patients with PDSI who have not undergone surgery.
Materials and Methods: 103 participants volunteered to participate. The spinal alignment parameters (SAPs), including T1 pelvic angle (T1PA), thoracolumbar tilt (TLT) and slope (TLS), were measured on whole-spine standing radiographs. The back and lumbar muscle volumes were measured. To determine HRQOL at baseline and at 2-year follow-up, face-to-face questionnaires were administered, which included visual analogue scale (VAS) of the back and leg, Physical Component Summary (PCS)/Mental Component Summary (MCS) of Short Form-36 (SF-36), Oswestry Disability Index (ODI), and Mini-Mental State Exam (MMSE).
Results: Overall HRQOL measures had improved after 2-years of follow-up compared to baseline. PDSI aggravation was observed in 18 participants (26.1%). TLS, sagittal vertical axis (SVA), and T1PA were strongly correlated with each other. TLS, SVA, and T1PA were correlated with ODI score. Among them, TLS was most highly correlated with ODI score. TLS greater than -3.5^{o} was a predicting factor for PDSI aggravation ($p = 0.034$; confidence interval: 1.173–63.61, odds ratio 8.636).
Conclusion: The present study implied that PDSI does not necessarily worsen with aging. TLS is an appropriate parameter for assessing the clinical situation in patients with PDSI. Furthermore, a TLS greater than -3.5^{o} predicts PDSI aggravation; thus, TLS may be a useful parameter for predicting prognosis in PDSI.

O312
The efficacy and safety of E.BMP 2 for lumbar interbody fusion

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Introduction: The use of rhBMP-2 in spinal fusion was published on its effectiveness and stability in many papers. However, studies so far have mostly focused on posterolateral fusion (PLF) and anterior lumbar interbody fusion (ALIF), and few on posterior lumbar interbody fusion (PLIF).
Aim: This study aims to determine how effective and safe the delivery of E.BMP2 with hydroxyapatite (HA) and a β-tricalcium phosphate complex carrier is for PLIF.
Study Design: A retrospective study.
Patient Sample: Patients who underwent 1~3 Levels of PLIF for degenerative lumbar diseases (DDD) between 2015 and 2020 with a follow-up period of ≥1 year were enrolled. A total of 254 patients (357 Levels) were included in the analysis. The analysis evaluated each segment level. 160 patients (221 Levels; 1 level (107), 2 levels (45), 3 levels (8)) received local bone autograft with E.BMP-2 groups (max. 0.5mg/Level), and 94 patients (136 Levels; 1 level (56), 2 levels (34), 3 levels (4)) underwent only Local bone graft (control group).
Outcomes Measures: The primary outcome of this study was the comparison of the fusion rate of the X-Ray and CT of the two groups. The secondary outcome of this study was the Clinical Outcomes (VAS, ODI, PCS, MCS) on patients and complications (osteolysis, Subsidence, Screw loosening) on CT scans.
Methods: The fusion was evaluated through X-Ray and CT. On the X-Ray, solid fusion was defined when the difference between extension and flexion was less than 5 degrees. On the CT scan, solid fusion was defined when the upper and lower vertebral bodies were connected by trabecular bone. Clinical evaluation was performed using the VAS for back pain, ODI for disability, and PCS and MCS of 36 Item form Health Survey for functional effect and quality of life. All assessments were conducted in both groups of patients preoperatively and 12 months postoperatively by the independent pain-specialized nurse. In addition, complications such as osteolysis, cage subsidence, and screw loosening were investigated using radiographic CT scan imaging.
Results: Fusion rate by X-rays evaluation was achieved in 92.31% (204/221) in the E.BMP2 group and 82.35% (112/136) in the control group (p=0.0041). Fusion rate by CT evaluation were 206/221(93.21%) and 120/136(88.24%) respectively in E.BMP2 and control group(p=0.1048). The difference between the two groups was statistically significant on the X-ray evaluation. The clinical results were excellent in both groups, and both groups showed statistically significant improvement. Postoperative complications were osteolysis was 14 out of 221 levels (6.33%) in the E.BMP2 group and 13 out of 136 (9.56%) in the control group (p=0.2632), Subsidence occurred in 18 patients (8.14%) in the E.BMP2 group and 9 patients (6.62%) in the control group. Those results were not showed statistical significance between both groups. In the case of screw loosening, the incidence rate of that was high in the control group, and it was at a statistically significant level.
Conclusions: In PLIF, E.BMP2 may be a good alternative to local autograft in terms of a better fusion rate and fewer side effects. The limitation of this study was the small sample size, and future studies are mandatory to prove.

Keywords: Degenerative, Interbody, Fusion, Lumbar, Spondylolisthesis, E.BMP2

O313

Trauma apportionment score of simple osteoporotic vertebral compression fracture with extrinsic factors

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Objective: Osteoporotic vertebral compression fractures are very common fragility fractures of the spine in elderly people. However, the demonstration of causality and apportionment of trauma in patients with osteoporosis after simple compression fracture is not an easy process. There is a lot of debate between insurance companies and patients in terms of compensation, especially in traffic accident cases. Therefore, the purpose of this study is to present a traumatic apportionment score table that can estimate and evaluate the rate of extrinsic factor involvement in osteoporotic compression fractures.
Materials and Methods: We enrolled patients with simple osteoporotic compression fractures from January to December 2019. There were 86 cases of simple osteoporotic fractures without metastatic findings. The level of trauma was classified and factors such as age and gender were investigated. In addition, the onset of symptoms, the presence of existing underlying diseases, in particular, the presence or absence of diseases related to osteoporosis, and T-scores of bone mineral density (BMD) exams were investigated. The underlying factors were previous osteoporotic compression fracture history, diabetes mellitus, chronic liver disease, chronic kidney disease, thyroid disease, parkinson disease, heart failure, and cancer history.
Results: The mean age was 78.4 ± 7.7 years, and there were 64 females, significantly more than males. There were 41 cases of unknown trauma, 39 cases of low-level trauma, and 6 cases of high-level trauma. The most common underlying disease was cancer (27 cases), and unknown trauma accounted for 16 cases. The mean T-score in BMD was -3.5±1.1. Based on five factors, a trauma apportionment score table for extrinsic factor involvement was prepared. As for the rate of apportionment of extrinsic factors calculated using the proposed table, 35±13% was apportioned to trauma in unknown cause cases, 43±10% in low-level trauma cases, and 65±8.3% in high-level trauma cases.
Conclusion: It is expected that the trauma apportionment score table will be helpful a tool in estimating extrinsic factor apportionment rate in simple osteoporotic vertebral compression fracture patients.

O314

Comparison of postoperative outcomes between conventional and prone single position direct lateral interbody fusion (DLIF): A single center experience

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Introduction: Direct lateral interbody fusion (DLIF) is a representative surgical method of minimal invasive fusion surgery, which minimizes bleeding intraoperatively. However, it has the disadvantage of prolonged preparation due to the process of placing the patient in lateral position at first and flipping to the prone position.
To overcome this obstacle, DLIF without changing patients' position had been devised. In particular, it has been reported that "the prone single-position DLIF" yields equivalent radiologic and clinical outcomes compared to the conventional method significantly lowering postoperative complications, operation time, and duration of hospitalization. However, it is difficult to say that it has sufficient evidence because a few institutions have conducted studies on a limited number of patients for a limited period of time.
Methods: Therefore, we analyzed the data of 17 the prone single position DLIF cases from October 2019 to October 2022 and designed this study to compare the results with the data of conventional DLIF conducted during the same period. The 17 patients of conventional DLIF group were selected considering similar demographic characteristics to the patients who underwent the prone single position surgery. And the operation time, intraoperative bleeding, length of hospitalization, and postoperative complications were analyzed as the clinical outcomes. Because all patients had additional posterior fusion and/or decompressive laminectomy with posterior lateral fusion using pedicle screw fixation, operation time was calculated by summing time spent on DLIF and posterior surgery. And we also tried to analyze the radiologic outcomes by evaluating the amount of change in lumbar lordosis, segmental lordosis, disc space height, and the fusion rate at the index level postoperatively.
Results: After statistical analysis of the patients' characteristics, the conventional surgery group showed statistically higher value in operation time (308.53 min ± 69.48 vs 208.06 min ± 74.60, p=0.001), blood loss (647.06 cc ± 512.19 vs 317.65 cc ± 198.39, p=0.025), and numbers of operated levels (1.88 ± 0.70 vs 1.47 ± 0.51, p=0.05). There was no statistically significant difference of radiologic outcomes such as the amount of change in segmental and lumbar lordosis, the fusion rate and subsidence rate between two groups except for the statistically higher amount of change in disc height in conventional surgery patients group. (5.93 mm ± 2.52 vs 2.62mm ± 3.33, p =0.004). There were 4 postoperative complications in conventional DLIF group while 2 in prone single position DLIF, totaling 6 cases. Complications such as pulmonary edema, transient left leg weakness and hypoesthesia were observed, but there was no significant difference.
Conclusions: According to the results, we suggest that the prone single position DLIF might be better for the patient's prognosis in that the amount of intraoperative bleeding and duration of operation could be reduced significantly. However, no difference in the postoperative radiological outcome and the occurrence rate of complication was found in our study. In order to prove the practicality of the prone single position DLIF, a long term prospective study should be conducted with a large number of samples in the future.

O315
The next generation spine surgery robot and the future

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Introduction: Recent innovation of spine surgery has shown new equipment in the operation room to enhance surgeon's task and successful operation. This topic will present current, global status of development of spine surgery robot, technical demands for spine specialized robot, initial works for developing and design new spine robot system. the 2nd generation of Spine anatomical registration, graphic user interface for spine surgery based on the artificial intelligence will be introduced.
Methods: In the 1st generation of spine surgery robot, Spine surgery robot is under developing by the collaboration of Yonsei University Health System and Curexo Company in Korea, we planned screw paths and performed screw insertion under robot guidance. Using C-arm and CT images, we proved accuracy by comparing the 3D distance of the placed screw head/tip from the planned screw head/tip and 3D angular offset. The analysis of early clinical experience 113 patients (448 screws) was done, the accuracy and clinical outcome will be presented. The development strategy of 2nd generation robot was introduced.
Results: Clinical study using 1st generation of spine surgery robot, the success rate of GRS A or B was 97.6%. the 3D distance accuracy of pedicle screw insertion showed excellent results without neurological complication; entry offset (2.66±1.36mm), target offset (2.40±1.38mm), depth offset (1.86±2.15mm), angular offset (2.33±1.57 degree). The new feature of 2nd generation robot; preoperative planning using 2D CT by 2D-3D image registration, autoplanning system by AI and cloud-based image analysis and autoplannning platform, and automation in the future.
Conclusion: The Korean 1st spine surgery robot showed good accuracy for the execution of an intended planned trajectory and screw path and can use existing C-arm in early clinical application. The 2nd generation Spine surgery robot in Korea will be introduced in near future and it has the potential to improve patient safety, operator comfort, reducing radiation hazards and procedure efficiency in the field of spinal surgery. The surgery data analysis, neural network could be valuable features in the future.

Key Words: Spine, Robot, development, AI, autoplanning

O316

Practical experience of the 1st generation Korean spine surgery robot: Learning curve and screw bias analysis

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Introduction: Robotic spine surgery techniques provide reduced pedicle screw malposition and radiation exposure during surgery. This technology is one of the most rapidly expanding areas in spine surgery, with increases in both the number of systems available worldwide and the number of publications on the subject in USA. However, the distribution of spine robots is very limited in Korea. Our institution started robot guide surgery from October 2021. In this study, we aimed to report the radiological results and initial experience of robotic spine surgery.

Materials and Methods: The CUVIS System (Curexoⓡ, Korea) was used to plan and execute pedicle screw placement in percutaneous consecutive cases performed in the period of October 2021 to March 2022. The database was reviewed to assess the outcomes included time per screw, breached screws, and other complications. Screw placement was assessed in patients with postoperative CT studies. The speed of screw placement and fluoroscopy time were collected at the time of surgery by personnel affiliated with the robot's manufacturer. Complication and imaging data were reviewed retrospectively.

Results: A total of 235 pedicle screws were inserted in 54 patients with robot guidance. The overall mean robot procedure duration was 94 minutes for initial 18 cases, 83 minutes for next 18 cases and 70 minutes for last 18 cases. The average time for robot procedure time per screw was 31 min/screw, for initial 18 cases, 20 min/screw for next 18 cases and 17 min/screw for last 18 cases. The cause of time delay was skiving of point due to wrong dilator position or too short drill head. This limitation can be overcome by using the navigation-guide ball-tip probe. A successful pedicle screw during surgery was possible in 97.31%, but 12 pedicle screw was replaced with a C-arm guide because of intra-operative error was identified during tapping procedure. The main risk factors for C-arm guide conversion by intra-operative bias were S1 pedicle screw and high BMD. Postoperative imaging revealed that 187 screws were perfect, screw malposition of 2mm was observed for 30 screws, and screw malposition >2mm was observed for 6 screws. But, there were no cases of screw malposition that required reposition. There were no complications from hardware placement issues.

Conclusion: Robot-guided spine surgery certainly requires a learning curve, especially in terms of time and skiving. However, this learning curve can be overcome in a short period of time. In addition, it has the advantage of being completely free from radiation exposure and providing high accuracy. However, it is still necessary to find a way to overcome the time-consuming part of O-arm registration and intra-operative planning.

O317

Water dynamics in unilateral biportal endoscopic spine surgery and its related factors: An in vivo proportional regression and proficiency-matched study

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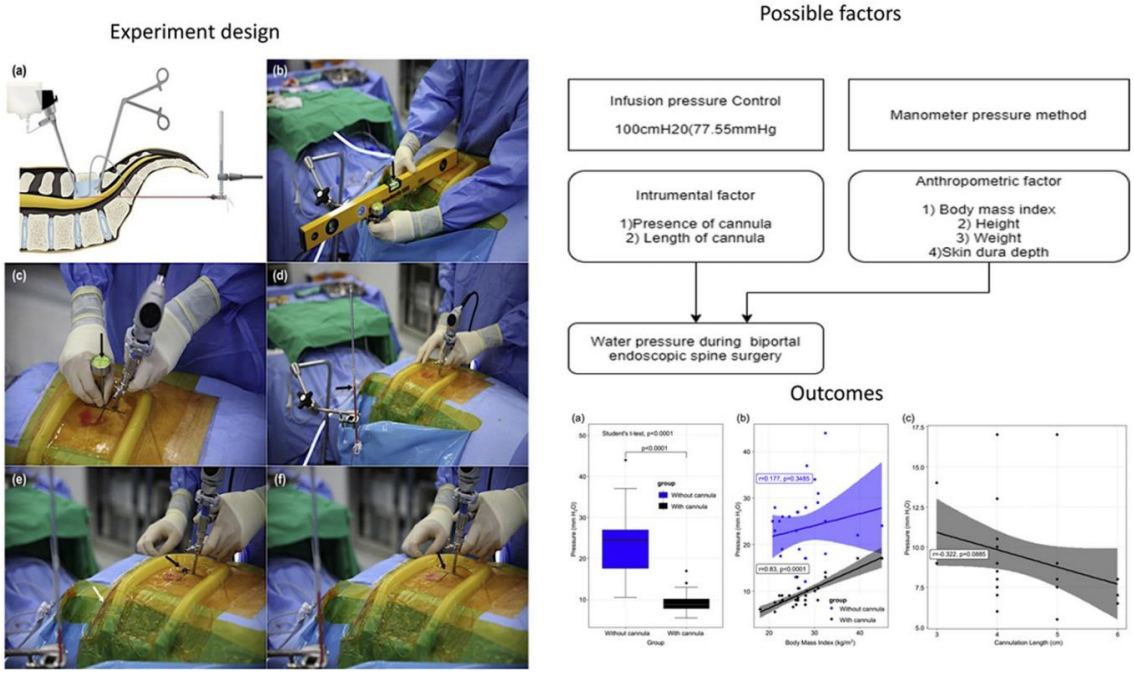
Background: Stable water dynamics during endoscopic spine surgery improves the surgeon's comfort and patient's outcomes. We aimed to measure the water dynamics during spinal surgery and identify the factors that facilitate stable water dynamics.
Methods: This open-label, prospective, proficiency-matched, in vivo study included patients with single-level degenerative spinal disease. After assessing their heights and balancing the matched instrument, we measured the irrigation fluid pressure in various situations. We performed multiple regression analysis based on odds ratio (OR), confidence interval (CI), and relationships (proficiency-matched) with possible instrumental and physical characteristics. The instrumental factors were the presence and length of a rigid cannulation, and the physical characteristics were body mass index (body mass index [BMI]), skin-to-dura depth, height (interaction with BMI), and body weight (interaction with BMI).
Results: Of the 36 patients, 29 were included. The mean pressure of the operation cavity was 16.66 ± 9.12 cm H_2O (12.25 ± 6.71 mm Hg). Water pressure with the rigid cannulation (9.41 ± 2.94 cm H_2O [6.92 ± 2.16 mm Hg]) was significantly lower than that without cannulation (23.43 ± 7.57 cm H_2O [17.26 ± 5.57 mm Hg], $P < 0.01$). Water pressure correlated with cannular length (OR = −1.08, CI = −1.79, −0.37, $P < 0.01$) and BMI (OR = 0.56, CI = 0.12, 0.99, $P < 0.01$). BMI showed a proportional relationship (r = 0.84, $P < 0.01$).
Conclusions: During biportal endoscopy, we suggest maintaining water pressure between 4.41 cm H_2O (2.41 mm Hg) and 31.00 cm H_2O (22.83 mm Hg). Compared to physical characteristics, placement of the cannula and appropriate cannula length are important factors that affect water dynamics.



O318

Biportal endoscopic translaminar approach for the lateral recess stenosis and contralateral extraforaminal disc herniation

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Objective: Biportal interlaminar approach for unilateral laminotomy and bilateral decompression (ULBD) has long been considered the first treatment option for symptomatic lumbar degenerative disease such as central canal stenosis or foraminal disc extrusions and stenosis. Interlaminar approaches. It is satisfactory for central canal stenosis, However limited to the contra lateral side lesion with foraminal/extraforaminal stenosis or herniated disc. If we used 'translaminar' approaches, It is not difficult to perform full decompression from the central canal to the contralateral extra foraminal area. The purpose of our study is to introduce our technique of translaminar approach for the lesions with contra-lateral recess stenosis and extraforaminal stenosis at the same time.
Techniques: The "trans-laminar" approach targets lamina more directly than the "inter-laminar" approach, which used generally in central canal decompression. It is the same principle as the full endoscopic PSLD's keyhole laminotomy for discectomy and the thoracic decompression technique by UBE. Since the translaminar approaches make the portal more proximally than interlaminar approaches, the initial point of the laminotomy would be more proximal than formar decompression. When approaching the epidural space after sufficient bone work, the working portal becomes parallel to the exiting root-disc level compared to the interlaminar approach. This allows access to bony spurs, hard disks, and even to the extraforaminal area around the exiting root. Thus, you can achieved the contra-lateral side foraminotomy more easily.
Results: We successfully performed "translaminar approach" for the patient who got central stenosis, traversing root compression due to contra lateral recess stenosis and even extraforaminal stenosis. There were no complications related with surgery. VAS and ODI were significantly improved after surgeries.
Conclusion: This procedure may be a safe and efficacious treatment option for contralateral lesions or multiple-sites stenosis. Thus, this new-designed endoscopic based technique could be a feasible alternative to staged decompression surgeries for multiple site stenosis. although more cases and long-term follow up studies are needed to obtain accurate clinical results.

O319

Psoas weakness following oblique lateral interbody fusion surgery: A prospective observational study with an isokinetic dynamometer

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Background Context: Although the approach corridor of oblique lateral interbody fusion (OLIF) protects intrapsoas nerves with minimum compression, transient weakness remains the most often reported postoperative complication.
Purpose: To evaluate how the hip flexor strength changed following OLIF using a dynamometer.
Study Design/Setting: A prospective observational study.
Patient Sample: Forty-six patients who underwent single or multi-level OLIF for lumbar spondylolisthesis.
Outcome Measures: Isokinetic dynamometer values (peak torque, total work, average power), Visual analogue scale (VAS) scores for leg pain, hypoesthesia, subjective weakness of left hip flexor, Oswestry disability index (ODI), body mass index, bone mineral density, radiologic findings of psoas muscle (cross sectional area (CSA), Hounsfield unit (HU), fat portion grade), and psoas retraction time.
Methods: The isokinetic muscle strength of the hip flexor was measured five times (preoperative, postoperative 2days, 1week, 1month, and 3months) for both legs. The peak torque was defined as the postoperative left hip flexor strength, and was compared to the preoperative baseline value. The left and right hip flexor strength were also compared at each time point. For logistic regression analysis, when the peak torque was below the median value, it was defined as lower peak torque.
Results: Up to one week after surgery, left hip flexor strength was significantly decreased (paired differences of peak torque was 22.6%, $P < 0.001$). In the results of multivariate logistic regression analysis, diabetes (OR = 8.43, P = 0.020) and psoas HU (OR = 0.916, P = 0.034) were associated with lower peak torque one week after surgery. From one month after surgery, postoperative psoas weakness was not significant. In the questionnaire survey, subjective left hip flexion weakness was reported in 8.5% (4/47) of patients 1 week after surgery, and only 2.1% (1/47) remained after 3 months of operation. The frequency of left anterior thigh pain and hypoesthesia decreased from 85.1% (40/47) to 2.1% (1/47) from 1 week to 3 months after surgery. Compared with immediately after surgery, the mean VAS score for left anterior thigh or groin pain was significantly decreased at 1 month after surgery (PO2D: 4.04±1.84, PO1M: 1.67±1.10, $P < 0.001$).
Conclusions: Psoas strength after OLIF surgery declined significantly up to 1 week after surgery as a result of dynamometer measurement. Patients with diabetes or lower psoas muscle HU showed delayed recovery from postoperative psoas weakness. However, the weakness was insignificant from 1 month after surgery. At 3 months after surgery, the other psoas-related problems (left anterior thigh pain and hypoesthesia) were also disappeared.

Keywords: Complication, Dynamometer, Hounsfield Unit, Oblique lateral interbody fusion, Psoas muscle, Transient weakness

O320

Safety and efficacy of intraoperative Doppler sonography-assisted cervical pedicle screw fixation: A retrospective comparison with conventional pedicle screw implantation

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Objective: To introduce a new Doppler sonography-assisted pedicle screw fixation technique that enables vertebral artery (VA) monitoring during surgery and compare the accuracies of Doppler sonography-assisted cervical pedicle screw fixation and the conventional technique.
Methods: This retrospective study was performed on 164 consecutive patients that underwent pedicle-based screw fixation from C2 to C6 between January 2013 and August 2020. Surgery was performed without intraoperative Doppler sonography in 84 cases (the Control group) or with intraoperative Doppler sonography in 80 cases (the Doppler group). Proper positioning of pedicle screws was graded, and the incidences of VA injury and screw breach in the Control and Doppler groups were compared.
Results: Three hundred and ninety-nine screws were placed in the 164 patients (Doppler, 186 screws; Control, 213 screws). The percentages of well-positioned screws in the two groups were significantly different (Doppler, 97.8%; Control, 85.0%). There were two cases of VA injury in the Control group, an incidence of 2.4%, but no case in the Doppler group.
Conclusion: Doppler sonography can be used intraoperatively to help guide the trajectory of the cervical pedicle screw insertion. It can detect the VA inside the screw trajectory and may reduce the risk of VA injury during cervical pedicle screw fixation.

Table 1. Characteristics of patients

Characteristics	Total	Doppler Group	Control Group	P value
No of patients	164	80	84	
Age(years±SD)	60.9±15.1	60.1±16.3	61.8±13.9	0.46
Sex (M/F)	67 (40.9%) /97 (59.1%)	37 (46.3%) / 43 (53.8%)	30 (35.7%) / 54 (64.3%)	0.17
No of Screws	350	137	213	
Etiologies (%)				0.03
Anomaly	33 (20.1)	22 (27.5)	11 (13.1)	
Degenerative	58 (35.4)	31 (38.8)	27 (32.1)	
RA	40 (24.4)	15 (18.8)	25 (29.8)	
Trauma	29 (17.7)	9 (11.3)	20 (23.8)	
Tumor	2 (1.2)	2 (2.5)	0 (0)	
infection	2 (1.2)	1 (1.3)	1 (1.2)	

Table 2. Screw position according to the Modified Gerzbein and Robbins Classification

Screw Position	Total (n=399)	Doppler (n=186)	Control (n=213)	P value
1	302 (75.7%)	158 (84.9%)	144 (67.6%)	
2	61 (15.3%)	24 (12.9%)	37 (17.4%)	
1+2	363 (91.0%)	182 (97.8%)	181 (85.0%)	<0.01
3	28 (7.0%)	3 (1.6%)	25 (11.7%)	
4	5 (1.3%)	0 (0%)	5 (2.3%)	
5	3 (0.8%)	1 (0.5%)	2 (0.9%)	
3+4+5	36 (9.0%)	4 (2.2%)	32 (15.0%)	<0.01

O321

Improvement in spino-pelvic alignment in patients operated for high grade lumbar Spondylolisthesis with MIS TLIF

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Introduction: High grade spondylolisthesis management has dramatically evolved over the years, with a change from traditional anterior approaches to minimally invasive oblique and posterior only procedures assisted by pedicle screw instrumentation Systems. Restitution of sagittal balance is important after lumbar fusion, because it improves fusion rate and may reduce the rate of adjacent segment disease. The objective of the study is to analyze the clinical and spino-pelvic alignment changes after surgical treatment of high grade spondylolisthesis with MIS TLIF

Methods: We analyzed 52 patients affected with high grade spondylolisthesis classified using Myerding classification over the period of 3 years. All patients were operated using MIS TLIF by the same surgeon. The clinical outcomes were measured using the visual analog scale (VAS) for pain and the Revised Oswestry Disability Index (ODI) for low-back pain/dysfunction. Spino-pelvic parameters Pelvic incidence (PI), Sacral slope (SS), Pelvic tilt (PT), disc height ratio DHR, segmental lumbar lordosis and maximal Lumbar lordosis (LL) were assessed to measure the radiological outcomes. Post operatively X-rays were done at 3 months and 6 months and 2 years. The CT scan was done 6 months after surgery. A 2 year follow up was done.

A prospective follow up of 2 years was done to assess the clinical and radiological changes after the intervention.

Results: Age at surgery averaged 54.7 (±8.6) years. 99% of patients were pain free and all showed an improvement in pain scores. The mean VAS score improved from 8 pre-operatively to 0 and the mean ODI score improved from 35 pre-operatively to 5 at 2-year follow-up. SF-36 showed significant improvement in physical and mental components.

Radiological parameters improved following surgery with significant improvement in notes for SS, LL and DSA.

Thirty three percent of the patients exhibited anterior imbalance preoperatively, with high pelvic tilt (18.4° ± 6.7°). 36 (70%) had a large pelvic tilt (>20°), due to retroversion of the pelvis as an adaptive response to the loss of lordosis. Three dural tears (5%) were reported intraoperatively. Disc height and lumbar lordosis at fusion level significantly increased postoperatively ($p < 0.05$ and $p < 0.001$). Pelvic tilt was significantly reduced ($p < 0.01$) postoperatively, whereas the global sagittal balance was not significantly modified ($p = 0.07$). Bridwell grade 1 fusion was achieved at the end of 6 months. None of the cases were converted to open TLIF. No neurological worsening noted. No major perioperative complications were noted.

Conclusion: MIS transforaminal interbody fusion is an effective way of treating high grade spondylolisthesis with a consistent improvement in pain scores and statistically significant improvement in DHA, PT, LL and SS with early surgical recovery, lesser morbidity and early functional rehabilitation.

O322

Synergistic effect of RG-7112 & o-vanillin combination treatment for intervertebral disc degeneration

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Introduction: Low back pain is a global health problem that is directly related to intervertebral disc (IVD) degeneration. There is growing recognition that senescent cells accumulate during tissue degeneration, where they contribute directly to disorders like heart disease, cancer, and osteoarthritis. We have previously demonstrated that senolytic drugs (RG-7112 & o-Vanillin) target and remove senescent cells from the IVDs both *in vitro* and *in vivo* improving tissue homeostasis and providing symptomatic pain relief. One drawback of using a single senolytic agent is the failure to target multiple senescent anti-apoptotic pathways in the same cell type, or different cell populations within a target tissue. Concurrently targeting multiple and indirectly related anti-apoptotic pathways may result in increased selectivity for senescent cells in the absence of toxicity for normal proliferating or quiescent cells. An obstacle of the senolytic agents currently under investigation is their failure to target the same cell type in different species, or different cell types within a species. It is therefore imperative to test novel agents for effectiveness against senescent cell burden, and for potential deleterious side effects, in pre-clinical models with clinically relevant cells. The ability to prevent or even slightly delay the onset of low back pain would have a tremendous socio-economic impact. The **overall objective** of this project is to determine if the combination of two senolytic drugs, o-Vanillin and RG-7112, can selectively remove senescent cells, reduce inflammatory mediators, and relieve pain in degenerating human IVDs cells and in middle-aged SPARC null mice with back pain *in vivo* better than the drugs alone.

Methods:

Human IVD cells: Cells were treated with the 4 different combinations of o-Vanillin and RG-7112 for 4 days. Sections were then immunohistochemically stained with antibodies to p16, ki-67, caspase3 and inflammatory cytokines to measure the level of senescence, level of proliferation, level of apoptosis and inflammation respectively.

SPARC-null Mice: SPARC-null mice and age-matched wild-type C57BL6 female and male animals were used in this study. The drugs were administered by oral gavage once a week. Grip strength (axial discomfort), acetone-evoked behaviour and mechanical sensitivity to von Frey filaments (radicular pain) were assessed on non-treatment days. IVDs from the lumbar spine and spinal cord were collected and analyzed, for the senescence-associated secretory phenotype factors, senescence, and neural markers.

Results: The combination of o-Vanillin and RG-7112 significantly reduces the number of senescence cells when compared to the senolytic drugs alone in degenerate human IVD cell pellets. During pain behaviour analysis using a combination of the drugs, cold allodynia, radicular pain and axial discomfort were significantly reduced in the SPARC-null model.

Significance: Combining senolytic compounds further reduce pain behaviours, and pain mediators and improve tissue homeostasis in cells from symptomatic patients and in a clinically relevant mouse model of lower back pain and IVD degeneration. If proven true, these therapies could revolutionize the treatment of back pain for millions of patients worldwide and be one step closer to offering a preventative treatment for individuals at risk of lower back pain or avoiding/prolonging the need for invasive surgery.

O323

Electromyogram diagnosed chronic lumbar radiculopathy is highly associated with L4-S1 regional multifidus atrophy on magnetic resonance imaging

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Introduction: Lumbar multifidus atrophy (LMA) is recognised as having clinically significant implications[1]. Pathology producing lumbar radiculopathy (LR) is known to be associated with LMA with one of the mechanisms presumed to be denervation affecting the medial branches of segmental posterior rami but there are a paucity of large studies formally evaluating the relationship between LR electrodiagnostics and LMA[2].
Methods: A cohort of consecutive patients with chronic low back related symptoms were seen by a spinal surgeon and referred for further radiological and electrodiagnostic assessment by independent observers. Specifically, patients with electromyogram performed by a neurology clinic (blinded to imaging findings) that diagnosed chronic LR were included for analysis. LR was defined as >20% polyphasic motor units change sampling the affected myotome (L5 or S1) on quantitative needle EMG with excluded patients being those with concurrent peripheral neuropathy, myelopathy, myopathy or >2 month delay between acquisition of EMG and MRI. Radiological LMA assessments on from 3T magnet MRI by a radiology clinic (blinded to EMG findings) were analysed for an association to LR findings. MRI evidence of LMA was measured by dual observers on 3D proton density weighted gradient echo sequence images (Axial slices) at L5 vertebral body and graded according to the Kader grade and percentage fat atrophy according to the Dixon dual echo method[3] using silhouette based digital subtraction measured with (>15%) changes or Kader≥1 designated as atrophy. Significance of association was assessed using Chi-Squared test.
Results: 100 eligible patients with L5 and/or S1 LR on EMG (107 with 7 excluded) were analysed (69% male, Mean age 53 range 22-83) with 86% and 68% having symptoms for more than 6 and 12 months respectively. Kader grading was: 2% grade 0, 68% grade 1, 19% grade 2 and 11% grade 3, respectively. 98% of patients with EMG proven LR had LM atrophy (χ^2=<0.05). The 2 patients that had LR but did not meet radiological LMA criteria had borderline changes (~10% atrophy with Kader 0) and symptoms less than 6 months.
Conclusions: This diagnostic study reveals EMG proven chronic LR is highly associated with the presence of MRI based LMA. Based upon these results, the finding of LMA represents a biomarker for the presence of chronic LR.

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O324

Investigating disease burden, management approaches, and clinical course prediction of low back pain using machine learning based on data from 6,426 patients in Hong Kong

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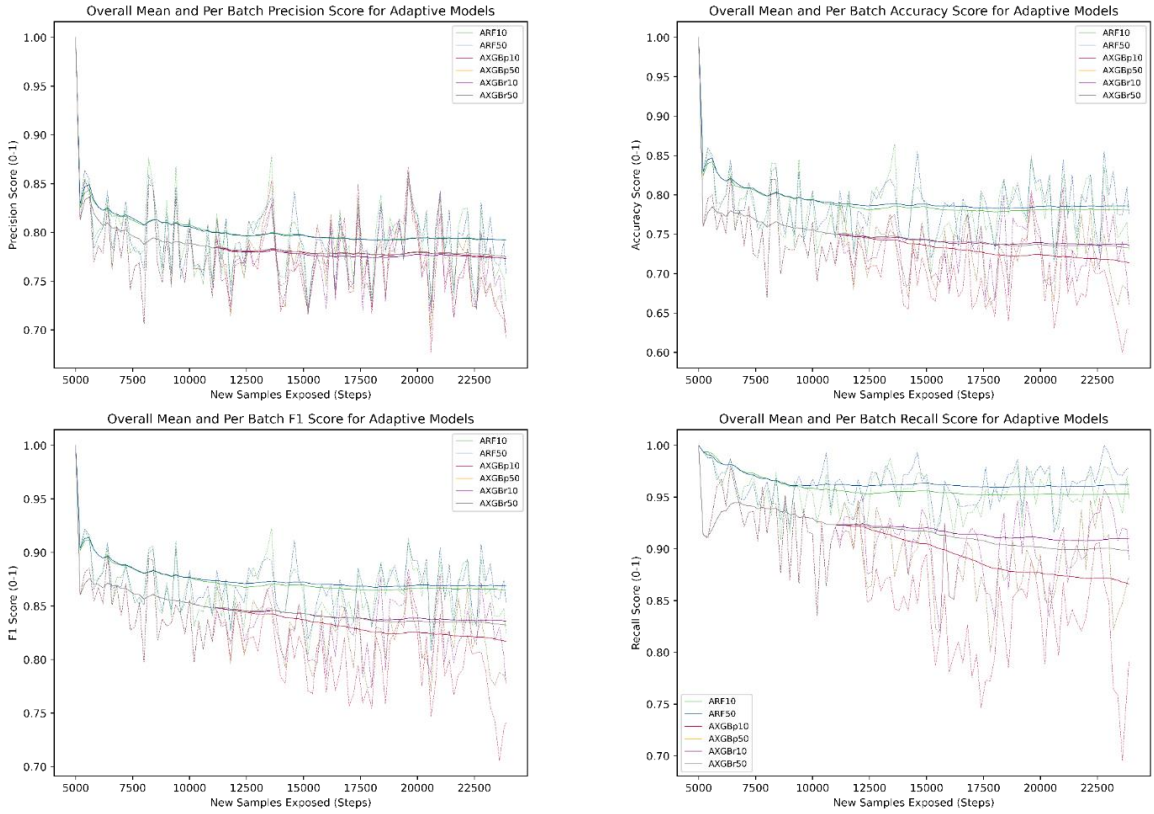
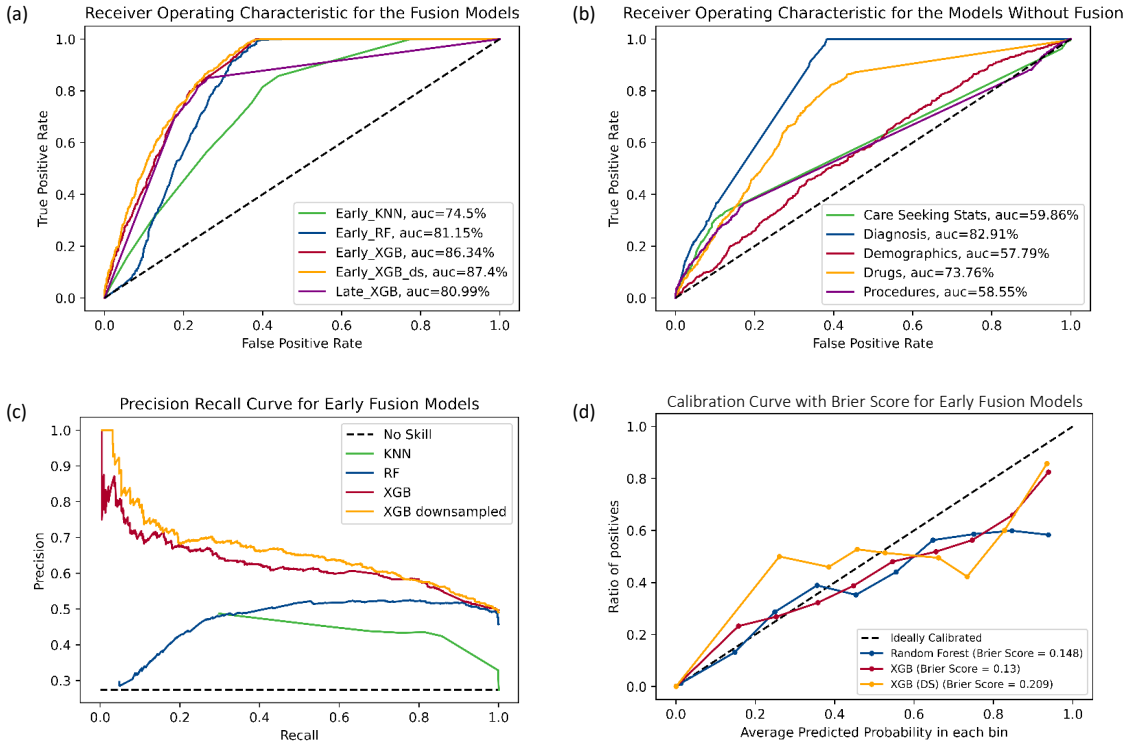
Purpose: Low back pain (LBP) is the major cause of years lived with disability worldwide with largely unclear etiology. Many developed recurrent or chronic LBP, which cast a heavy burden on health systems. We hence aimed to: (1) evaluate the disease burden and management plan of LBP at general practitioner and specialist care level; and (2) develop novel screening algorithm for detecting patients at-risk of developing chronic LBP (cLBP) for early interventions.
Methods: Medical records for patients from 2011 to 2020 were extracted from a cluster of hospitals in Hong Kong. We analysed the incidence and prevalence trends of LBP cases, patterns of analgesic prescription, operations and physiotherapy referrals, and developed machine learning models to predict the onset of cLBP for patients completing the first year of treatment. Models were trained and validated on patient record before and after 2017, respectively. We furthered test a set of adaptive models for the same task and adopted a test-then-train validation method on incoming data arranged in chronological order.
Findings: Our search identified 6,426 patients from 2011-2020. The age-adjusted prevalence for LBP among patients from Central and Western and Southern district rose from 14.4% to 25.2% in the past decade ($p = 0.0002$), with 80% having non-specific diagnoses. On average, tramadol and surgeries were introduced at 1.51 years (SD = 2.20 years) and 2.11 years (SD=2.33) after the initial diagnosis. Physiotherapy referrals in the first year were associated with fewer future emergency room visits ($p=0.0043$) and general outpatient clinic visits ($p=0.0116$). Adaptive random forest model (Figure 1) out-performed non-adaptive XGBoost model (Figure 2) in identifying patients with cLBP at the first year post-diagnosis (sensitivity 95.3% v 82.0%, positive predictive value 79.2% v 62.3%).
Interpretation: Given the increasing burden of LBP in Hong Kong, opioids are commonly prescribed as the first-line treatment but demands for potent alternatives and operations will rise with high prevalence of recurrent and chronic cases. Early physiotherapy referrals are associated with favourable recovery and less emergency room visits. Our machine learning models effectively identify LBP patients at high risk of persistence for further evaluations or focused care. Adaptive models, which can adjust for dynamic data trends, were shown to be effective in delivering robust prediction despite changes in epidemiology.

Figure 1: Performance Metrics for Adaptive Models on Dynamically Predicting Incidence of Chronic LBP Cases Among LBP Patients



Abbreviations: ARF10 – Adaptive Random Forest with 10 estimators, ARF50 – Adaptive Random Forest with 50 estimators, AXGBp10 – Adaptive XGBoost Model with 10 estimators, push update method, AXGBp50 – Adaptive XGBoost Model with 50 estimators, push update method, AXGBr10 – Adaptive XGBoost Model with 10 estimators, replacement update method, AXGBr50 – Adaptive XGBoost Model with 50 estimators, replacement update method

Figure 2: Performance Metrics for Various Models on Predicting Incidence of Chronic LBP Cases Among Newly Diagnosed LBP Patients



O325

Underweight and overweight are both risk factors for vertebral fracture: A nationwide population-based study

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Introduction: With the progress of the aging society, the incidence of vertebral fractures is increasing. Vertebral fractures are associated with various morbidities and can increase the mortality, thus it is important to prevent them. Although there have been studies on body mass index (BMI) as one of the risk factors for vertebral fracture, the relevance is still controversial.
Aim: We explored the effect of BMI on the development of vertebral fracture.
Patients and Methods: The subjects of this study were 561,779 randomly selected adults (≥ 40 years old) who underwent a national health examination in 2009 and had no previous fractures. All insured Koreans aged 40 years and older, and all workers aged 20 years and older, must undergo regular NHIS checkups every 1–2 years without cost. These data provide information concerning anthropometric measurements, smoking and alcohol consumption status, and medical history through self-reported questionnaires and laboratory finding. We classified all patient groups as <18.5 (underweight), <23 (healthy), <25 (risk-to-overweight), <30 (overweight), and 30≤ (obese) according to BMI. We investigated the incidence of vertebral fractures from 1 year after the date of examination. The hazard ratio (HR) and 95% confidence interval (CI) of vertebral fracture according to the group were calculated using Cox regression analysis.
Results: During the mean follow-up period of 8.3 years, vertebral fractures occurred in 1.3% of the total population. Adjusted (for sex, age, smoking, drinking, low income, regular exercise, diabetes, hypertension, dyslipidemia, and chronic kidney disease) HRs with 95% CI of underweight, risk-to-overweight, overweight, and obese groups compared to healthy group were 1.213 (1.037-1.419), 0.982 (0.925-1.042), 1.053 (0.994-1.117), and 1.081 (0.929-1.259), respectively (P =0.0201).
Conclusions: At an 8.3-year follow-up, underweight increased the risk of vertebral fractures by 1.2 times. Overweight and obese increased the risk of vertebral fractures by 1.1 times each. People who are underweight or overweight need to pay more attention to the prevention of vertebral fractures.

O326

Immunohistochemical analysis of SOD2 expression and oxidative stress markers in human intervertebral discs

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Introduction: Oxidative stress is one of the causes of intervertebral disc (IVD) degeneration, and it has been reported that the generation of excessive reactive oxygen species may accelerate IVD degeneration through cellular senescence and apoptosis. Recently, single-cell RNA sequencing analysis suggested that superoxide dismutase 2 (SOD2), an antioxidant enzyme in mitochondria that metabolizes superoxide into oxygen and hydrogen peroxide, may be one of the predictive biomarkers of IVD degeneration. Previous reports also showed that SOD2-positive cells decrease with age in the nucleus pulposus (NP) of mouse lumbar IVD, and SOD activity decreases with age in rat lumbar IVD. The purpose of this study was to investigate the relationship of SOD2 expression and oxidative stress markers to IVD degeneration and aging of human NP tissue.
Methods: Human IVD tissue samples were collected from 18 patients (9 males, 9 females; age ranging from 16 to 78 years) undergoing lumbar surgery. NP tissues were isolated and immediately cryopreserved. Immunohistochemical staining for SOD2 and advanced glycation end products (AGEs) as oxidative stress markers were performed on fresh frozen sections. Next the percentage of positive cells and percentage of positive area were calculated respectively. Intracellular and mitochondrial superoxide levels were evaluated by dihydroethidium (DHE) and MitoSOX fluorescence staining, and mean fluorescence intensity (MFI) was quantified. IVD degenerative levels were classified by preoperative MRI according to Pfirrmann grading system (mild degeneration; Grade 2, moderate degeneration; Grade 3, severe degeneration Grade 4), and the association between IVD degeneration, age, percentage of positive cells and area, and MFI were analyzed. Multiple sets of data were confirmed normally distributed via Shapiro–Wilk test and analyzed via one-way ANOVA, followed by Tukey's post hoc test. The correlation between two values was analyzed using Spearman's rank correlation coefficient.
Results: There were 4 patients with Grade II (mean±SD age 24.5±5.2 years), 6 patients with Grade III (32.3±12.1 years), and 8 patients with Grade IV (63.1±13.0 years). SOD2-positive cells were 29.3±3.8% in Grade II, 54.6±5.6% in Grade III, and 69.8±11% in Grade IV ($P < 0.001$). AGEs-positive area was 3.1±3.1% in Grade II, 10.6±5.0% in Grade III, and 33.0±4.7% in Grade IV ($P < 0.001$). MFI of DHE was 1.6-fold higher in grade III ($P = 0.002$) and 2.2-fold higher in grade IV ($P < 0.001$) compared to grade II. MFI of MitoSOX was 1.6-fold higher in grade III ($P = 0.004$) and 2.1-fold higher in grade IV ($P < 0.001$) compared to grade II. SOD2-positive cell rates were positively correlated with patient's age and AGEs-positive area ($r=0.72$, $r=0.74$; $P<0.01$).
Discussion: The expression of SOD2, as well as oxidative stress markers, was enhanced with the progression of IVD degeneration and aging. This result is contrary to previous reports in rodents, suggesting that the rodent NP, which is composed mainly of notochordal cells, and the human NP, which is composed mainly of chondrocyte-like cells, may have different responses to oxidative stress. Further research in these different roles of SOD2 and oxidative stress in IVD degeneration is a promising target for potential therapies.

O327

Investigation of accuracy in 3D images of lumbosacral nerve roots developed by artificial intelligence technology

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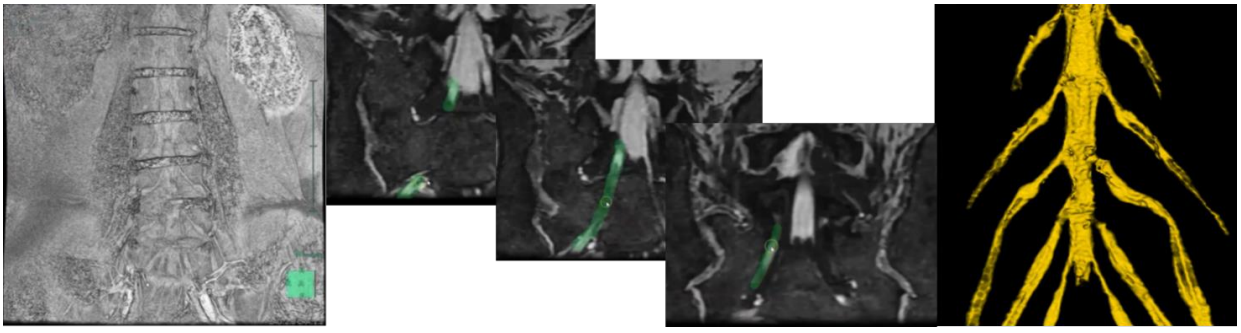
Introduction: Lumbosacral nerve root anomalies are relatively rare, but can be a risk factor for iatrogenic nerve injury intraoperatively. Two-dimensional (2D) magnetic resonance image (MRI) images are often used for preoperative diagnostic imaging, which are difficult to differentiate nerve root. Although evaluation with 3D images is beneficial, the method of creating such images is very complicated, time-consuming, and labor-intensive. Therefore, we have developed a software program that automatically generates 3D images from MRI lumbosacral nerve volume data using artificial intelligence (Figure). In this study, we conducted an epidemiological study on the presence and morphology of lumbosacral nerve root anomalies using this software, and evaluated the accuracy and clinical usefulness of this modality.
Materials and Methods: We evaluated the incidence and morphology of nerve root anomalies on 3D images of 1,500 patients (642 males, 858 females, mean age: 60.5 years) who underwent MRI exam at our hospitals from Apr. 2016 to Sep. 2022. We also evaluated the accuracy of the 3D images by comparing with those manually generated using conventional methods.
Results: The incidence of nerve root anomalies was 53 (3.5%) out of 1,500 cases, a total of 58 nerve roots. Regarding level localization, 35 nerve roots (60.3%) were located at L5-S1 level, 19 nerve roots (32.8%) were located at S1-S2 level. As to morphology, 23 nerve roots (39.7%) were classified as Neidre-MacNab Type 1A and 24 nerve roots (41.4%) as Type 1B, 1 nerve root (1.7%) was Type 2B, and 10 (17.2%) were Type 3. There were 7 cases that did not match the conventional method, all of which were anomalies. There were no differences between two groups in the visualization of normally running cases.
Discussion: The frequency of lumbosacral nerve root anomalies has been reported to vary from 0.5% to 30% based on anatomy and imaging evaluation, and conjoined nerve roots are considered to be the most common type. In this study, the incidence of nerve root anomalies was 3.5%, and more than 80% were conjoined nerve root, which were not significantly different from previous studies. Localization was also similar to previous reports. In addition, there were almost no differences in the imaging results comparing conventional methods, demonstrating the validity and accuracy of this method. In spine surgery, including spinal endoscopic surgery, nerve root anomalies are a risk factor for iatrogenic nerve root injury, so preoperative image evaluation is very important. The images obtained by this method facilitate the 3D understanding of the nerve runways, and the simplicity of the image preparation makes it highly useful in clinical practice.
Conclusion: The 3D images automatically generated by this method using AI technology have simplicity and accuracy. This imaging modality is highly useful and convenient in clinical practice where safety is required.



O328

Nonoperative management of three-column ankylosed spine fractures: Is it possible?

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Introduction: Three-column fractures in the ankylosed spine are inherently unstable, but few studies have assessed clinical and functional outcomes between operative and non-operative treatment. The purpose of this study was to further investigate the outcomes of operative versus non-operative treatment following 3-column fractures of the ankylosed spine.

Methods: A retrospective review of patients with ASD including ankylosing spondylitis (AS) or diffuse idiopathic skeletal hyperostosis (DISH) who sustained trauma resulting in an unstable 3-column spinal fracture from 1999-2020 was performed. Self-reported measures including neck disability index and Oswestry disability index were obtained. Physiologic outcomes measures including XR, CT and MRI imaging were evaluated for assessment of fusion status, fracture displacement, and worsening sagittal balance. Functional outcome measures obtained included ambulatory status (use of assistive device) and neurologic status based on most recent physical exam. Patient demographics, Charleston comorbidity indices and injury specific data were collected. Radiographic inputs included identification of the ankylosed segment, initial fracture displacement, identification of epidural hematoma or cord compression. Clinical outcomes included neurologic deficit and mortality. Radiographic outcomes included fusion status and progressive deformity. Each clinical and radiographic input was analyzed to determine if there was a correlation with treatment modality chosen. Outcomes were compared based on treatment modality chosen (operative versus non-operative). A subgroup analysis was performed between AS and DISH patients to determine if there was any association with fracture characteristics or radiographic outcomes.

Results: A cohort of 138 ASD patients with 153 fractures was identified; 56% with ankylosing spondylitis, 29% with diffuse idiopathic skeletal hyperostosis, and 16% with both diagnoses. The majority of injuries occurred in the thoracic spine (50%) following a ground level fall (67%). One-hundred sixteen (76%) fractures were treated operatively, while 37 (24%) were treated non-operatively. When comparing treatment groups, the non-operative group was found to be older with a higher Charleston comorbidity index ($p<0.0001$). There was no significant difference between groups in terms of injury severity score ($p=0.26$). Significantly more AS cases were treated surgically compared to DISH cases (81% vs. 59%, $p=0.01$). Displaced fractures were more likely to be treated surgically ($p=0.04$) and those that were displaced and treated non-operatively had a trend towards increased risk of progressive deformity (RR=2.67, 95% CI 1.09-6.52, $p=0.07$). There was no significant difference in rate of failed fusion, or rate of neurologic sequelae between treatment groups but there was a higher 90-day mortality and decreased survival rate in patients treated non-operatively compared to operatively. Seventeen percent of patients undergoing surgery had wound complications, but there was no difference in rate of blood clots or respiratory complications between treatment groups.

Conclusions: This study highlights that non-operative treatment of non-displaced three-column fractures of the ankylosed spine can allow for successful clinical and radiographic outcomes, although patients treated non-operatively had higher mortality rates independent of injury severity score. Therefore, the risks and benefits of surgery should be weighed against goals of long term clinical and functional outcomes as well as the likelihood of successful fusion based on fracture characteristics.

Table 1: Patient demographics (n=153 fractures).

	Overall	**Operative**	**Non-operative**	**p-value**
Male Gender	126 (82%)	98 (84%)	28 (76%)	0.22
Mean Age at Presentation (years)	75±12	72±11	83±9	**<0.0001**
Mean BMI (kg/m^2)	33±7	34±7	31±8	**0.04**
Tobacco Use	64 (42%)	48 (42%)	16 (43%)	1.00
Diabetes	68 (44%)	50 (43%)	18 (49%)	0.57
Charleston Comorbidity Index	5±3	5±2	7±3	**<0.0001**

Table 2: Injury Specific Data (n=153 fractures).

	Overall	**Operative (n=116, 76%)**	**Non-operative (n=37, 24%)**	**p-value**
Ankylosing Disease				
AS	85 (56%)	69 (81%)	16 (19%)	**0.009**
DISH	44 (29%)	26 (59%)	18 (41%)	
AS+DISH	24 (16%)	21 (88%)	3 (13%)	
Injury Level				
Thoracic	76 (50%)	56 (74%)	20 (26%)	0.80
Cervical	36 (24%)	29 (81%)	7 (19%)	
Thoracolumbar	28 (18%)	22 (79%)	6 (21%)	
Lumbar	12 (8%)	8 (67%)	4 (33%)	
Cervicothoracic	1 (1%)	1 (100%)	0 (0%)	
Mechanism of Injury				
Ground level fall	101 (67%)	71 (61%)	30 (86%)	**0.02**
Motor vehicle collision/High energy	30 (20%)	27 (23%)	3 (9%)	
Fall from height	20 (13%)	18 (16%)	2 (6%)	
Injury Severity Score	14±8	15±1	13±1	0.26
Displaced Fracture	71 (50%)	58 (82%)	13 (18%)	**0.04**
Treatment Team				
Orthopedics	72 (47%)	57 (49%)	15 (41%)	0.45
Neurosurgery	81 (53%)	59 (51%)	22 (59%)	

Table 3: Survival and functional outcomes.

	Overall	Operative	Non-operative	p-value
90-day mortality rate	15% (95% CI=10%-22%)	11% (95% CI=7%-19%)	30% (95% CI=17%-46%)	**0.0008**
1-year survival	75% (95% CI = 67%-81%)	80% (95% CI = 72%-87%)	57% (95% CI = 40%-73%)	**0.0008**
Neurologic sequelae	21 (15%)	16 (14%)	5 (17%)	0.77
Nonunion/Revision	11 (11%)	9 (10%)	2 (13%)	0.66
Worsening PI-LL Mismatch	20 (47%)	16 (80%)	4 (20%)	0.64

Table 4: Complications.

	Overall	Operative	Non-operative	p-value	§Relative Risk
DVT/PE	9 (6%)	6 (4%)	3 (2%)	0.45	1.57 (0.41-5.96)
Wound Complication	20 (13%)	20 (17%)	0 (0%)	**0.004**	N/A
Pneumonia/ARF	33 (22%)	22 (19%)	11 (30%)	0.17	1.58 (0.84-2.92)

§Relative risk of non-operative to operative treatment.

Table 5: Subgroup analysis AS vs. DISH*

	Overall	AS (n=85, 66%)	DISH (n=44, 34%)	p-value
Demographics				
Male Gender	106 (82%)	73 (86%)	33 (75%)	0.15
Mean Age at Presentation (years)	74±12	72±12	77±11	**0.02**
Charleston Comorbidity Index	5±3	5±0.3	6±0.4	**0.005**
Treatment				
Operative	95 (74%)	69 (81%)	26 (59%)	**0.01**
Non-operative	34 (26%)	16 (19%)	18 (41%)	
Multilevel Fracture on Presentation	20 (16%)	16 (19%)	4 (9%)	0.13
Displaced	60 (50%)	40 (51%)	20 (49%)	0.85
Fused	11 (13%)	10 (17%)	1 (4%)	0.16
Worsening PI-LL Mismatch	17 (44%)	13 (46%)	4 (36%)	0.72
Neurologic Sequelae	18 (15%)	12 (67%)	6 (33%)	1.00

*patients with features of both AS and DISH were removed from subgroup analysis

Table 6: Pelvic parameters at the time of fracture in relation to fracture characteristics, treatment, and outcomes.

	PI	**p-value**	**PT**	**p-value**	**SS**	**p-value**	**LL**	**p-value**	**PI-LL Mismatch**	**p-value**
Injury Level										
Thoracic	53°±16°	0.36	22°±11°	0.53	30°±12°	0.66	49°±12°	0.86	7°±13°	**0.01**
Cervical	44°±16°		13°±5°		31°±21°		50°±21°		6°±5°	
Thoracolumbar	60°±15°		24°±13°		35°±10°		45°±20°		21°±19°	
Lumbar	48°±13°		17°±13°		31°±5°		46°±15°		12°±14°	
Fracture Levels										
Single	56°±14°	0.12	23°±12°	0.77	33°±11°	**0.01**	49°±14°	**0.0002**	12°±15°	0.17
Multilevel	49°±14°		24°±12°		25°±8°		32°±9°		19°±8°	
Fracture Displacement										
Nondisplaced	52°±13°	0.11	22°±11°	0.50	30°±11°	0.17	46°±15°	0.42	12°±11°	0.59
Displaced	57°±15°		24°±12°		34°±11°		48°±16°		14°±18°	
Treatment										
Operative	55°±15°	0.80	24°±12°	0.22	31°±11°	0.27	46°±15°	0.33	15°±16°	0.15
Nonoperative	54°±12°		20°±10°		34°±8°		50°±15°		9°±11°	
Fusion Status										
Fused	45°±10°	0.26	15°±5°	0.18	30°±9°	0.88	41°±22°	0.24	10°±10°	0.95
Nonunion/Revision	53°±16°		22°±13°		31°±13°		50°±12°		10°±14°	
Worsening PI-LL Mismatch										
Yes	54°±16°	0.54	24°±11°	0.46	29°±13°	0.89	43°±18°	0.99	12°±10°	0.18
No	56°±15°		27°±14°		29°±8°		43°±14°		18°±16°	

PI: Pelvic Incidence. PT: Pelvic Tilt. SS: Sacral Slope. LL: Lumbar Lordosis.

O329

Impact of social determinants of health on preoperative opioid utilization in patients with lumbar degeneration

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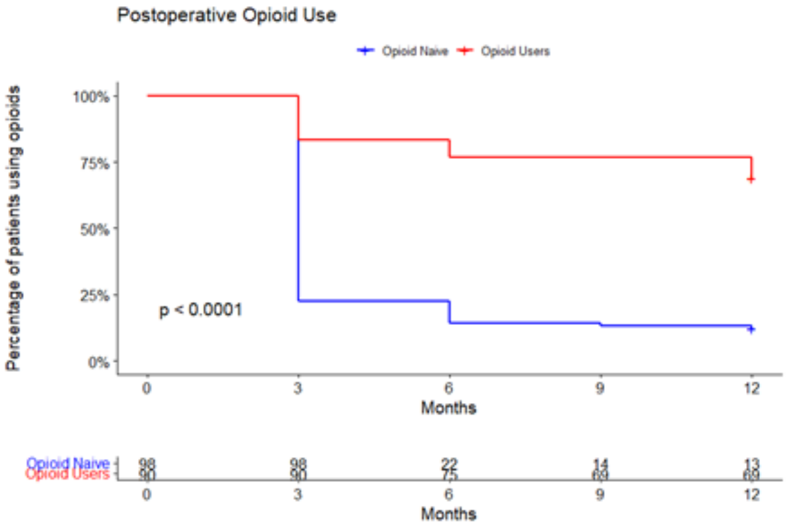
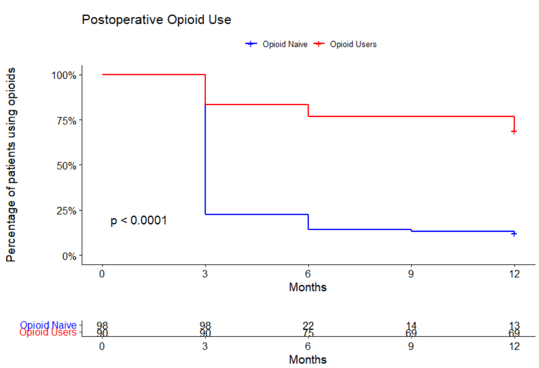
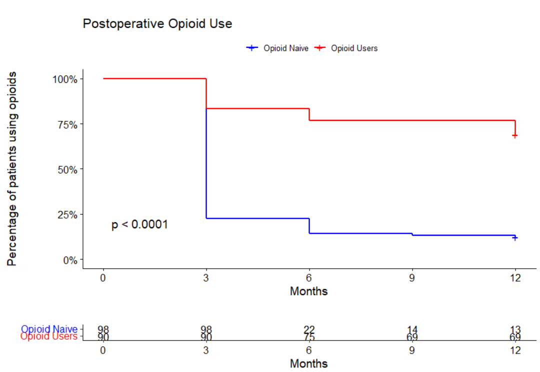
Introduction: Socioeconomic and environmental factors, referred to as social determinants of health (SDOH), have been demonstrated to significantly impact health outcomes in spine patients. With new initiatives aimed at decreasing opioid utilization, it is imperative to understand what factors, including SDOH, impact the likelihood of preoperative opioid use in spine patients.
Methods: This retrospective non-matched case-control study included a consecutive series of patients from a single institution undergoing elective spine surgery for lumbar degenerative pathology in 2019. Patients were included if they had ≥ 3 months of preoperative data and ≥ 12 months of postoperative data. Patients were categorized according to the presence or absence of prescribed preoperative opioid use. Preoperative opioid users (OU) were compared with opioid naïve (ON) patients regarding ten social determinants of health factors available in the electronic medical record: age, gender, race, preferred language, ethnicity, work status, community median income, religious belief, insurance status, and marital status. The two groups were also compared based on four health-related behaviors (HRB): tobacco use, alcohol use, drug use, and physical activity level. Community median income was determined using 2019 American Community Survey data with low-income limit set at $82,200 for the San Francisco area. Physical activity level was measured using metabolic equivalence of task (METS) which was recorded by an anesthesiologist during preoperative intake. Multivariate logistic regression was used to determine associations between SDOH and preoperative opioid use.
Results: Of 188 patient records reviewed, 98 were opioid naïve and 90 used opioids before surgery. All preoperative opioid users had ≥ 3 months of continuous opioid use. The OU cohort were found to have significantly more prior spine surgeries [mean: 1.07 ± 1.36 vs. 0.44 ± 0.84 $p<0.001$] and comorbidities including diabetes [20.0% vs. 8.16%, $p=0.021$], hypertension [57.8% vs 42.9%, $p=0.041$], anxiety and depression [47.8% vs. 30.6%, $p=0.016$] compared to the ON cohort. Multivariate analysis of SDOH and HRB factors demonstrated that unemployment (odds ratio (OR): 5.14 (95% confidence interval (CI): 1.95, 14.4) $p=0.001$), lower levels of physical activity (OR: 3.376 (95% CI: 1.52, 9.33), $p=0.005$), and being below low-income limit (OR: 3.85 (95% CI: 1.27, 11.7), $p=0.001$) were independent risk factors for preoperative opioid use. Age range between 40-59 was nearly a statistically significant risk factor (OR: 3.247 (95% CI: 0.91, 12.79), $p=0.077$). Postoperatively at one year follow-up, OU were more likely to continue to use opioids compared to ON [72.2% vs. 15.3% $p<0.001$] (Figure 1).
Conclusions: In adults treated with surgery for lumbar degenerative pathology, unemployment, low physical activity level, and low community median income were associated with preoperative opioid prescription. Preoperative opiate use is a strong predictor of post-operative opiate utilization at every follow-up timepoint up to 1 year after surgery. Recognition of the impact of SDOH and HRB factors on preoperative opiate prescription, and on post-operative opiate use is useful to guide policy to reduce opiate dependence in lumbar spine surgery.

Figure 1: Comparison of Postoperative Opioid Use Between Opioid Naïve and Opioid Users.







O330

Handheld smartphone-based spinal navigation versus CT-based image-guided navigation in the placement of thoracolumbar pedicle screws

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Introduction: Computer-assisted navigation technologies are improving outcomes in the field of spine surgery. However, these systems are not widely available or utilized globally. This is likely due to their high cost, lack of operational flexibility, radiation generation, and increased surgical time. Therefore, a handheld smartphone-based navigation system (SBNS) has been developed that has the potential to provide accurate navigational guidance that mitigates these limitations. This system's program leverages the smartphone's computing power and sensitive built-in gyroscope to navigate pedicle screw trajectory based on standard diagnostic MRI / CT images and perioperative lateral X-rays. We evaluated the accuracy and reliability of this system in a clinical setting.

Methods: A clinical study on the accuracy of pedicle screw placement through an open approach was performed to assess the accuracy of the SBNS and to compare it to CT-navigation (Medtronic O-arm / StealthStation). The design of the study device allowed the SBNS to be attached to the CT-navigation probe enabling a head-to-head comparison. Once attached, the SBNS was used to plan and communicate the proper trajectory of the pedicle screw. The CT-navigation system could not generate telemetry during this process as the SBNS blocked its sensors. The SBNS was then rotated, allowing the CT-navigation to provide its trajectory. This information was compared to the telemetry provided by the SBNS. If the telemetry matched, the SBNS was used to continue. If they did not match, the CT-navigation superseded, placement was done with CT-nav, and the SBNS was assigned a failure. The surgeon had the option to override CT-navigation based on their clinical judgment. The outcomes were a head-to-head comparison of the systems as assessed by the operating surgeon intraoperatively and accuracy of screw placement as determined by an independent radiologist based on post-placement CT scan. Placement was scored according to the Gertzbein-Robbins scale. Scores of "A" and "B" were considered a success, and scores of "C" or worse a misplacement. A diagnostic accuracy test was performed with sensitivity and specificity analysis.

Results: 92 screws were placed in 20 patients. A 98.9% successful placement rate was achieved with both systems (CT-navigation and SBNS both had one error). A sensitivity analysis showed 98.8% accuracy (best-worst case scenario 98.9%-94.5%). The specificity between CT-navigation and SBNS best-worst case scenario showed a 1.08% false-positive result in both scenarios. The radiologic assessment demonstrates a high probability of equivalence (> 0.99) to the historic CT-based navigation performance standard of 95.8% accuracy[1], and a high probability (> 0.99) of >5% superiority to the historic fluoroscopic assisted placement performance standard of 91.5% accuracy[1].

Conclusions: In this initial study, the smartphone-based navigation system demonstrated the ability to provide accurate navigational guidance in the placement of pedicle screws, while reducing radiation exposure to the patient and staff and offering the ability to be operationally and economically efficient. A prospective randomized study comparing the systems is now warranted.

Reference:

[1]Perdomo-Pantoja, et al, World Neurosurg. (2019) 126:664-678.

O331

Proposed objective scoring algorithm for walking performance, based on relevant gait metrics: The Simplified Mobility Score (SMoS™) — Observational study

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Background: Walking is a fundamental part of living, and its importance is not limited by age or medical status. Reduced walking speed (WS), or gait velocity, is a sign of advancing age, various disease states, cognitive impairment, mental illness and early mortality. Activity levels, as defined in the literature as “daily step count” (DSC), is also a relevant measure of health status. A deterioration in our walking metrics, such as reduced WS and DSC, is associated with poor health outcomes. These objective measures are of such importance, that walking speed has been dubbed “the 6th vital sign”. We report a new objective measure that scores walking using the relevant metrics of walking speed and daily step count, into an easy-to-understand score from 0 (nil mobility) to 100 (excellent mobility), termed the Simplified Mobility Score (SMoS™). We have provided equal weighting to walking speed and daily step count, using a simple algorithm to score each metric out of 50.
Methods: Gait data was collected from 182 patients presenting to a tertiary hospital spinal unit with complaints of pain and reduced mobility. Walking speed was measured from a timed walk along an unobstructed pathway. Daily step count information was obtained from patients who had enabled step count tracking on their devices. The SMoS of the sample group were compared to expected population values calculated from the literature using 2-tailed Z tests.
Results: There were significantly reduced SMoS in patients who presented to the spinal unit than those expected at each age group for both genders, except for the 50–59 age bracket where no statistically significant reduction was observed. Even lower scores were present in those that went on to have surgical management. There was a significant correlation of SMoS scores with subjective disability scores such as the Oswestry Disability Index (ODI) and Visual Analogue Scale (VAS) in this cohort.
Conclusions: The SMoS is a simple and effective scoring tool which is demonstrably altered in spinal patients across age and gender brackets and correlates well with subjective disability scores. The SMoS has the potential to be used as a screening tool in primary and specialised care settings.

O332

SpineTrak: The first randomized control trial using the Apple Watch to objectively track spine surgical patients

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Introduction: Early mobilization after surgery is associated with reduced complications, decreased length of hospitalization, and greater psychological well-being. Current methods for evaluating spine surgery outcomes are limited and rely on patient-reported outcome measures (PROMs), which are subjective and may be influenced by psychiatric comorbidities and chronic pain. Wearable activity monitors, including the Apple Watch (AW), allow for real-time tracking of objective activity, including steps, distance traveled, flights climbed, etc. The goals of our study are (1) To determine the feasibility of wearing the AW before/after surgery; (2) To determine whether objective metrics correlate with PROMs before/after surgery; (3) To evaluate whether surgery improves AW objective measures; (4) To investigate whether patients are more satisfied with their care and have a better understanding of their recovery using the AW; and (5) To determine a novel composite metric combining objective and subjective measures to better predict post-operative spine surgery recovery.
Methods: Eligibility was restricted to adult patients undergoing elective spine surgery at Stanford University Hospital across 5 spine surgeons. Using 1:1 randomization, we formed an intervention and a control group with a target enrollment of 100 patients each. All patients complete PROMs and a study-specific questionnaire pre-operatively and at 6 weeks, 3 months, 6 months, and 1 year post-operatively. Intervention patients also receive an AW 2-6 weeks pre-operatively and wear it daily for 1 year after surgery. To collect health data from their AWs, intervention patients download a study-specific app, SpineTracker. Visual reports of PROMs (Figure 1a) and AW activity data (Figure 1b) are provided to intervention patients and surgeons at each follow-up visit.
Results: To date, we have enrolled 177 patients (n=90 intervention; n=87 control). On average, intervention patients (n=76) have worn the AW for 84.8%±18.8% of the days since enrollment for 14.1±3.0 hours per day. At their 6-week follow-up, 67% of patients said it was extremely or very helpful to see their Apple Watch activity data. 76% were extremely or very satisfied with the use of the Apple Watch in their spine care. Spine surgeons stated the Apple Watch data helped them understand how their patient was doing in 96% of follow-ups. Preliminary analyses reveal different recovery profiles for patients and have been able to predict the requirement for revision surgery in some patients (Figure 2).
Conclusions: To the best of our knowledge, SpineTrak is the first randomized control trial to assess the feasibility of using a commercially available activity monitor in spine patients before and after spine surgery. Preliminary results indicate patients are highly compliant with wearing the Apple Watch. Both patients and surgeons have been satisfied with the use of the Apple Watch in their spine care. Preliminary analyses show poor correlation between Apple Watch measures and PROMs, demonstrating the need for a metric that combines objective and subjective measures of spine surgery recovery.

Acknowledgements: This study is funded partially by a research grant from Stryker.

Figure 1: Progress report demonstrating a) PROM survey results and b) objective Apple Watch data for SpineTrak study patient before and after C3-5 anterior cervical discectomy and fusion.

1a)

Patient:
MRN:
Surgery: C3-5 anterior cervical discectomy and fusion

Surgeon:
Surgery Date:

SpineTrak: Quality of Life Surveys	Before Surgery	After Surgery: 6 weeks	After Surgery: 3 months	After Surgery: ~6 months	After Surgery: ~1 year
SF-36					
Physical Function	55	65 (↑)	80 (↑)	95 (↑)	95 (↔)
Role Limitations, Physical Health	0	0 (↔)	50 (↑)	75 (↑)	100 (↑)
Role Limitations, Emotional Problems	100	100 (↔)	100 (↔)	100 (↔)	100 (↔)
Energy/Fatigue	20	65 (↓)	70 (↑)	70 (↔)	75 (↑)
Emotional Well-being	76	92 (↑)	92 (↔)	92 (↔)	92 (↔)
Social Functioning	50	63 (↑)	88 (↑)	75 (↓)	100 (↑)
Pain	45	78 (↑)	68 (↓)	68 (↔)	90 (↑)
General Health	60	85 (↑)	70 (↓)	60 (↓)	75 (↑)
EQ-5D					
Mobility	75	100 (↑)	100 (↔)	100 (↔)	100 (↔)
Self-care	100	100 (↑)	100 (↔)	100 (↔)	100 (↔)
Usual Activities	75	75 (↑)	100 (↑)	100 (↔)	100 (↔)
Pain/Discomfort	50	75 (↑)	75 (↔)	75 (↔)	75 (↔)
Anxiety/Depression	75	100 (↔)	100 (↔)	100 (↔)	100 (↔)
Back or Neck Disability Index					
NDI	58	66 (↑)	78 (↑)	92 (↑)	92 (↔)
PROMIS					
Physical Function	63	63 (↓)	81 (↑)	100 (↑)	100 (↔)
Anxiety	81	100 (↑)	100 (↔)	88 (↓)	100 (↑)
Depression	100	100 (↑)	100 (↔)	100 (↔)	100 (↔)
Fatigue	31	69 (↓)	75 (↑)	56 (↓)	81 (↑)
Sleep Disturbance	38	75 (↑)	75 (↔)	63 (↓)	75 (↑)
Ability to Participate in Social Roles & Activities	50	50 (↑)	56 (↑)	81 (↑)	81 (↔)
Pain Interference	25	75 (↑)	88 (↑)	94 (↑)	100 (↑)

• All scores are converted to **scale 0 (worst imaginable health)** to **100 (best imaginable health)**
• Colors: **red (maximum disability)**, **light red (severe disability)**, **yellow (moderate disability)**, **light green (some disability)**, **dark green (minimal disability)**

1b)

Patient:
MRN:
Surgery: C3-5 anterior cervical discectomy and fusion

Surgeon:
Surgery Date:

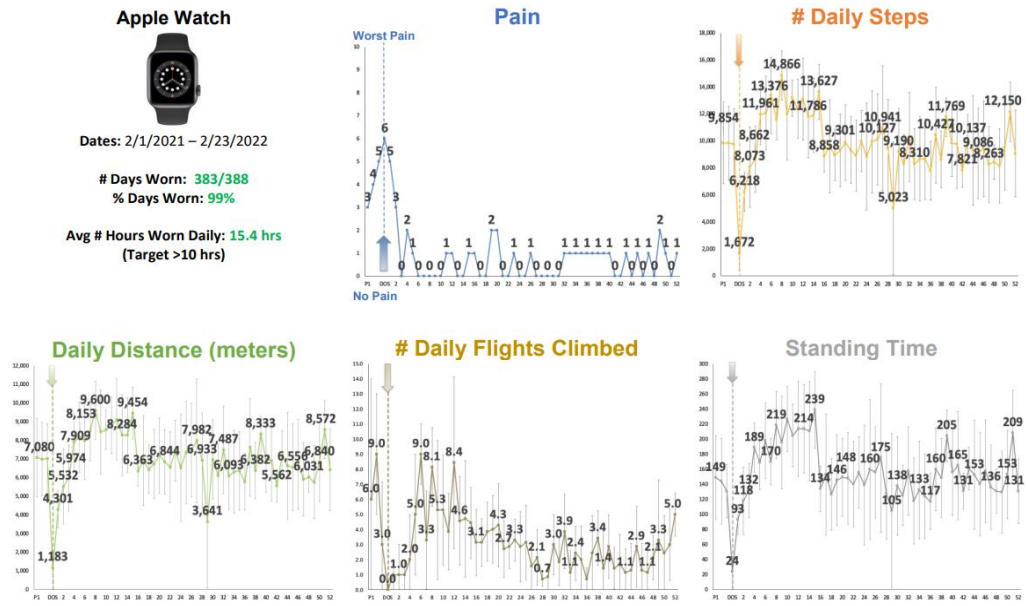
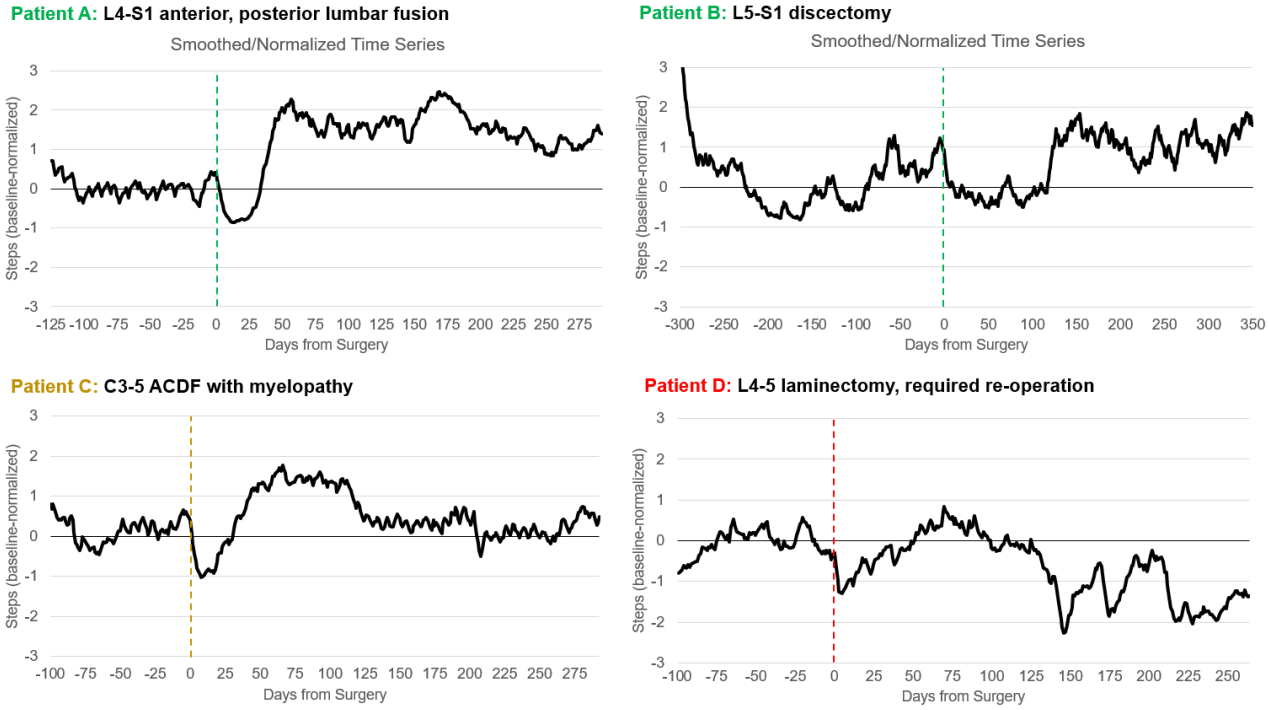


Figure 2: Recovery profiles for daily steps, normalized to baseline pre-operative data, of patients with good recovery (Patients A & B) and poor recovery (Patients C & D).



O333

SpineQ: Unsupervised learning-based pipeline for fully automated quantitative analysis of lumbar MRI with preliminary validation

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Introduction: Low back pain (LBP) is a common health problem, with a lifetime incidence of 80%. It is believed that LBP results from pathological changes that occur with lumbar degenerative diseases (LDD). Currently, the clinical diagnosis and treatment planning of LDD is usually done manually which is inefficient and relies heavily on the surgeon's experience and subjective judgment, which is prone to inter-/intra-operator variance and can lead the inconsistent treatment results. Automated quantitative analysis can have great significance to improve the efficiency and consistency of diagnosis and treatment planning. However, the existing learning-based measurement requires expensive manual annotation for model training, and new labels may be needed to finetune the model for the data collected from different institutions.
Aims: We aim to develop SpineQ, which is an unsupervised learning-based pipeline for the automated and consistent quantitative analysis of lumbar MRI without relying on any manual annotation.
Methods: A retrospective LDD dataset was collected from the southern Chinese population and contained sagittal and axial MRI scans from 2473 subjects, where 1978 were used for pipeline development (age: 18-40 30.7%, 40-50 38.1%, >50 31.2%; gender: 39.3% male; BMI: <18.5 7.4%, 18.5-25.0 68.5%, >25.0 24.1%), and 495 were used for validation (age: 18-40 29.9%, 40-50 39.2%, >50 30.9%; gender: 38.9% male; BMI: <18.5 8.1%, 18.5-25.0 66.7%, >25.0 25.2%), SpineQ adopted our previously published Spine-GFlow, which is a robust unsupervised multi-tissue segmentation framework, as backbone. Spine-GFlow accurately identifies different anatomical structures from lumbar MRI without relying on any manual annotation. Based on the segmentation result, anteroposterior (AP) vertebral body (VB) diameter, midline VB width, mid-AP canal diameter, canal width, mid-AP dural sac (DS) diameter, pedicle width, lamina angle, and facet joint angle from axial view; as well as mid-AP VB diameter and midline VB height from sagittal view (Figure 1), were measured using the symmetrical boundary searching and rule-based distance retrieve algorithm. The automated measurement accuracy was validated by comparison with the manual measurement results annotated by a spine specialist.
Results: Validations on the retrospectively collected dataset showed that the deep learning pipeline achieved satisfactory performances on the measurement of mid-AP VB diameter (mean absolute error (MAE) 3.919mm/4.779pix), midline VB width (MAE 3.469mm/4.230pix), mid-AP canal diameter (MAE 2.239mm/2.730pix), canal width (MAE 2.632mm/3.210), mid-AP DS diameter (MAE 3.272mm/3.990pix), pedicle width (MAE 2.452mm/2.990pix), lamina angle (MAE 5.324 degree), and facet joint angle (MAE 4.911 degree) from axial view; as well as mid-AP VB diameter (MAE 2.386mm/2.909pix) and midline VB height (MAE 2.468mm/3.010pix) from sagittal view.
Conclusions: SpineQ for fully automated quantitative analysis of lumbar MRI has been developed and tested. The fast and consistent parameter measurement can assist clinicians and researchers in scientific research, large scale clinical studies, efficient and consistent treatment planning. A prospective study needs to be performed for further validation.

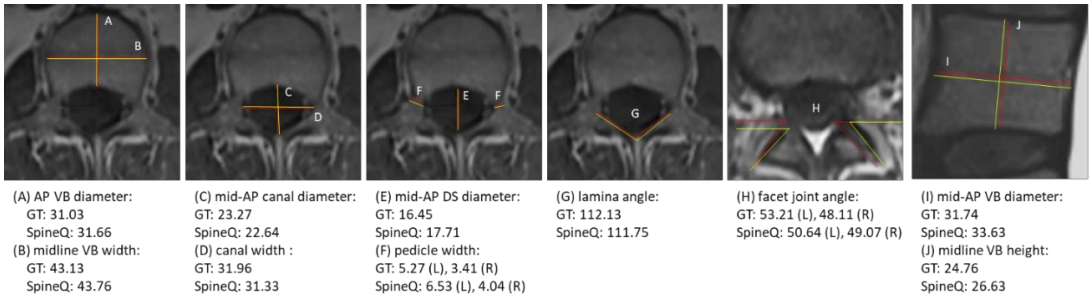

Figure 1. Illustration of ground truth (GT) parameters (red) and SpineQ measurement results (yellow).

O334

Targeted multifidus muscle activation reduces fibrosis of multifidus muscle following intervertebral disc injury

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Introduction: Low back pain and injury are associated with structural remodelling of the multifidus muscle including increased connective tissue (i.e., fibrosis). Experimental intervertebral disc (IVD) degeneration in animal studies induces fibrotic changes that include increased fibrogenic gene expression (Collagen I and III) and increased cross-sectional area of connective tissue across the multifidus muscle, as well as increased thickness of the epimysial layer of connective tissue that around the muscle. These changes would impact the capacity of muscle to generate torque and regulate loading of the spine. Whole body aerobic exercise has been shown to *partially* attenuate these fibrotic changes but does not completely restore multifidus health. More targeted exercise of the multifidus muscle might induce more complete resolution of fibrosis. This study aimed to investigate whether neurostimulation of the multifidus muscle could reduce fibrosis of the multifidus muscle in a model of IVD degeneration in sheep.
Methods: IVD degeneration was surgically induced in 18 merino sheep via a partial thickness unilateral annulus fibrosus lesion to the right side of the L1/2 and L3/4 IVDs. All 18 sheep received an implantable neurostimulation device, that provides stimulation of the L2 medial branch of the dorsal ramus (ReActiv8, Mainstay Medical). Three months after surgery, the animals were divided into two separate groups, Non-Activated and Activated. The Activated animals received two 30-minute neurostimulation sessions per day for 3 months. The Non-Activated group received no stimulation. Six months after surgery, the multifidus muscle was harvested adjacent to the spinous process adjacent to L2 and L4 and. The muscle tissue underwent Van Gieson's and Sirius Red staining, to examine tissue fibrosis. Expression of fibrotic genes was assessed using quantitative PCR.
Results: Targeted activation of the multifidus muscle reduced levels of fibrosis in the Activated group, compared to the Non-Activated group in the multifidus at L4 (which includes fascicles activated by the L2 nerve root stimulation). Analysis of major connective tissue (Van Gieson's stain) and connective tissue surrounding individual muscle fascicles (Sirius red) both demonstrated less connective tissue cross sectional area in the across all regions of the multifidus muscle at L4 in the Activated group. Levels of Collagen III expression in the Activated Group were lower in the L4 muscle. No differences were detected to the cross-sectional area of muscle or adipose tissue, or Collagen I expression at L4 between groups. The multifidus muscle adjacent to the L2 spinous process was not activated by neurostimulation of the L2 nerve root. No measures of the multifidus muscle at L2 differed between the Non-Activated and Activated groups.
Conclusions: These data reveal that targeted activation of the multifidus muscle reduces histological and genetic signs of muscle fibrosis induced by IVD degeneration.

Acknowledgements: This study was supported by a research grant from Mainstay Medical Limited. PH is supported by a fellowship from the National Health and Medical Research Council of Australia (NHMRC). BG is the research director for Mainstay Medical and PH has been appointed as a consultant to Mainstay Medical.

O335

Texture analysis of ultrasound images to evaluate multifidus muscle composition: A comparison between healthy subjects and patients with low back pain

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Introduction: Understanding how low back pain (LBP) affects back muscle composition is important because muscle performance and function are determined in part by muscle structure. Ultrasonography is extensively used as the first line of imaging for the evaluation of muscle composition because is safe, accessible, and provides real-time imaging. Most previous studies using ultrasound only consider muscle size. Analysis of muscle structure has largely been restricted to analysis of fat and muscle in MRI. Some studies have implementing ultrasound for analyses of structure, but with problems related to high inter-operator variability, dependence on echo-intensity and interpretation of structural features. New image processing approaches can overcome these limitations and provide measures of connective tissue content (which is challenging with MRI). Texture analysis characterises the spatial variation of pixel intensities within ultrasound images. These complex image processing features can provide surrogates of muscle composition and tissue characteristics. This study aimed to explore whether texture features of the multifidus muscle differ between individuals with and without LBP.
Methods: Transverse ultrasound images from the right multifidus muscle at the fifth lumbar vertebrae were used. Texture features[1] (local binary patterns and histograms of oriented gradients) from the thoracolumbar fascia (i.e., region-of-interest with connective tissue texture) were used to train a support vector machine that was used to classify each pixel within the image area covered by the multifidus muscle (segmented by an evaluator with experience). The support vector machine model was trained with 1014 region-of-interests from 20 healthy participants. Images from twelve healthy participants and twelve with acute LBP (within 2 weeks of onset of pain) were used to calculate the percentage of pixels within the multifidus image presenting connective tissue-like texture. Values were compared between groups (t-test, significance < 0.05).
Results: The support vector machine resulted in an accuracy of 75.6(0.6)% for the local binary patterns and 85.3(3.6)% for the histograms of oriented gradients. Both texture measures suggest a lower number of pixels with connective tissue texture in the LBP group than the healthy group (Figs 1 and 2).
Conclusions: This study shows for the first time the potential utility of texture features extracted from ultrasound images to characterise muscle composition in the multifidus muscle. Both textures utilised here detected differences in muscle composition between healthy and acute LBP participants. As both textures are different in nature[1], we are confident that the findings are not circumstantial to the texture used. Less connective tissue in the multifidus muscle in acute LBP could have several interpretations including a greater proportion of other tissue such as fat, differences in connective tissue prior to LBP, and so on. Further work is required to consider these possibilities. Our findings open the door for the use of more complex multiclass/multitexture classifiers for detailed quantification of fat and connective tissue infiltrations within the multifidus muscle. Future studies could explore the usefulness of other types of textures, combination of parameters (e.g., region region-of-interest size) and learning models (e.g., deep learning) to improve the accuracy of the classification models.

Reference:

[1]Paris M., Mourtzakis M. Muscle Composition Analysis of Ultrasound Images: A Narrative Review of Texture Analysis. *Ultrasound in Medicine and Biology* (2021); 47; 880-895.

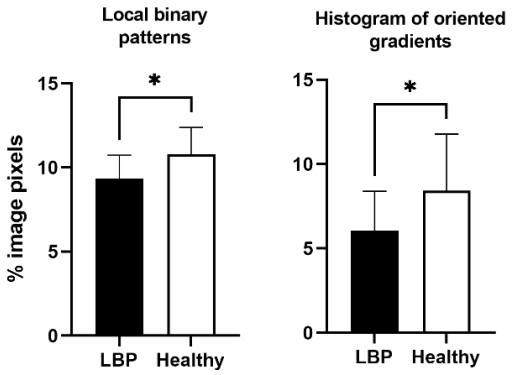

Figure 1: Percentage of pixels within the multifidus muscle image presenting connective tissue-like texture (t-test, significance < 0.05), comparison between groups (low back pain [LBP] and healthy controls).

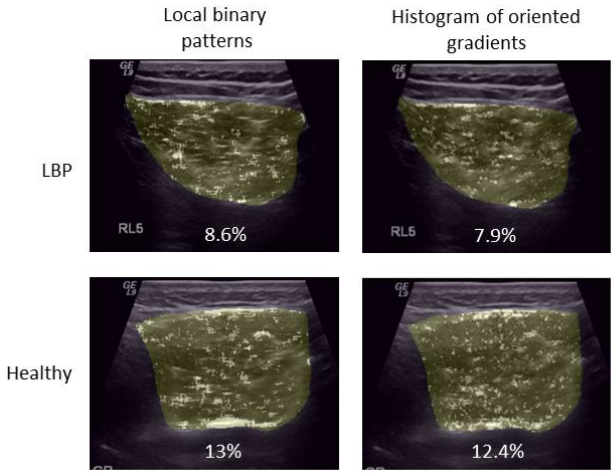

Figure 2: Representative images of participants from each study group (healthy and low back pain (LBP)). Left panels show outcome from local binary patterns and right panels show outcome from histogram of oriented gradients method. Segmented multifidus muscle is highlighted and white pixels within the segmented muscle represent pixels with texture classified as connective tissue using the relevant method. Numbers represent the percentage of connective tissue-like pixels in relation to the total segmented area.

O336

The pelvic tilt response to ASD realignment surgery depends on preoperative compensatory ability of the thoracic spine

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Introduction: Some adult spinal deformity (ASD) patients do not seem to improve their pelvic tilt (PT) following realignment surgery. However, the driving forces behind this lack of PT response are not well investigated. We hypothesized that the preoperative compensatory ability of the thoracic spine and its coordination with the pelvis-hip complex is associated with PT response. The purpose of this study is to investigate the perioperative compensatory coordination between the thoracic spine and pelvis-hip complex regarding PT response. In particular, we focused on its relationship to the occurrence of proximal junctional kyphosis (PJK) after surgery.
Methods: The authors retrospectively extracted data for patients with ASD who underwent a minimum 5-level fusion to the pelvis with mobile segments preserved in the thoracic spine (i.e., upper instrumented vertebra between T8 and L1). PJK was defined as ≥ 10° progression of the proximal junctional angle or reoperation due to progressive kyphosis during a 1-year follow-up. The sagittal parameters were analyzed on whole-spine standing radiographs: SVA, PI-LL, TK, and the T1-L1 pelvic angle (TLPA). The TLPA is the angle formed by lines extending from the center of T1 and L1 to the femoral head axis. The greater standing-TLPA value can account for the low compensatory ability of the thoracic spine against the lumbopelvic pathology (i.e., increasing kyphosis and truncal forward inclination of the thoracic spine). Patients with preoperative standing-TLPA > 23° are at risk of PJK. To evaluate the pelvis-hip complex function, PT and proximal femoral angle (PFA) were also measured. The PFA change (difference before and after surgery) was calculated to quantify whether a hip extension would improve after surgery.
Results: A total of 50 patients with ASD were enrolled (84% female; mean age 74.4 years). PJK occurred in 19 (38%) patients. Preoperatively, the PJK group showed significantly greater standing-TLPA (30.0° vs. 14.9°) value compared with the non-PJK group, although there was no significant difference in age, sex, SVA, and PI-LL between the two groups. Two weeks after surgery, SVA (56.5 mm vs. 48.1 mm) and PI-LL (14.5° vs. 11.7°) were comparable between the two groups, but the PJK group showed significantly greater postoperative standing-TLPA (18.2° vs. 9.0°) and PFA (198.2° vs. 191.8°) values with residual pelvic retroversion (PT > 20°, 89.5% vs. 32.3%). There was a negative correlation between the preoperative standing-TLPA and the perioperative change in PFA (r = -0.50, 95% CI: -0.78 to -0.055). At a final follow-up, TK was significantly greater in the PJK group (50.7° vs. 31.4°).
Conclusions: PT response was closely associated with the preoperative compensatory ability of the thoracic spine. Approximately 90% of patients with PJK were PT non-responder. Our results underscore that we should plan ASD surgery considering not only PI-LL mismatch but also the preoperative compensatory ability of the thoracic spine because poor thoracic compensation before surgery is linked with residual hip extension and pelvic retroversion after realignment surgery.

O337

Do spinal degeneration and lumbar multifidus muscle quality affect clinical outcomes in patients with low back pain?

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Introduction: Most imaging-based investigations into the relationships of the lumbar multifidus muscles (LMM) to spinal pathology and low back-related clinical findings such as low back pain (LBP), leg pain or disability have focused on cross-sectional analyses. Few non-surgical, longitudinal studies investigating these relations have been published, with none assessing the potential mediating role of the LMM between degenerative pathology and 12-month clinical outcomes.
Aim: This prospective cohort study estimated the longitudinal effects of aggregate degenerative lumbar MRI findings and multifidus muscle quality, separately and combined, on 12-month pain and disability outcomes.
Patients and Methods: Patients from a public outpatient spinal clinic presenting with a primary complaint of low back and/or leg symptoms were included. Aggregated spinal degeneration was based on the presence and/or severity of eight common degenerative findings on MRI, and LMM quality was based on the percentage of MRI-measured lean? muscle cross-sectional area. Outcome measures at baseline and 12-month follow-up were: LBP and leg pain intensity (0-10 numeric rating scales); LBP-related disability (Roland Morris Disability Questionnaire (RMDQ)). Mixed effects generalized linear models, adjusted for baseline age, sex, body mass index, and pain duration, were used to separately estimate the effect of LMM quality and aggregated spinal pathology for the three outcomes. A separate mediation model estimated the direct effect of spinal pathology on leg pain and the indirect effects of spinal pathology and LMM quality on leg pain. Results were reported as unstandardized beta coefficients with 95% confidence intervals.
Results: Data from 569 patients [235 males; mean (SD) age: 45.1 (9.7) years] were included. Multivariable analysis revealed a reduction of -0.65 [-0.14; -1.16] on the RMDQ at 12-month follow-up for each 10% increase in LMM quality and a leg pain rating increase of 0.99 [0.14; 1.84] at 12-month follow up in the presence of four or more degenerative pathologies at baseline. The level of LBP at 12 months was not affected by LMM quality or the number of degenerative changes at baseline. A small but non-significant mediating role for LMM quality was found between degenerative spinal pathology and 12-month leg pain intensity.
Conclusions: In this study, we demonstrated that a greater number of lumbar degenerative MRI findings contribute to increased leg pain intensity at 12 months. While a greater proportion of higher-quality LMM appears to contribute to small reductions in disability ratings at 12 months, LMM quality did not appear to mediate the effect of pathology on leg pain intensity. Multifidus muscle quality, lumbar spine degeneration and LBP-related outcomes seem to have complex relationships, which may include different pathways.

O338

Does degenerative scoliosis result from loss of mechanical integrity of the annulus fibrosus in degenerated intervertebral discs?

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Introduction: Intervertebral disc degeneration (degen) is an age-related progressive structural failure of the disc. During this degenerative process, some patients develop malalignment of the spine in the form of degenerative scoliosis (dScoli). These painful conditions significantly decrease the patient's quality of life and in many cases surgical intervention is required. Why malalignment occurs in some cases and not others is poorly understood.
There is no known structural difference between deformity and non-deformity IVDs. We hypothesize that a reduction in shear stiffness of the AF leads to the development of dScoli. The aim of the present study was to measure elastic and viscoelastic shear properties and compare structural differences between normal, degenerative, and dScoli patient samples of the annulus fibrosus (AF).
Methods: Samples were collected from patients undergoing anterior degen or dScoli surgeries, limited to L4-5 and L5-S1 discs (University of Calgary Ethics ID REB18-1308). Normal samples were collected from cadaveric donations. 30 patients were recruited, with standing X-rays to confirm deformity diagnosis and modified Pfirrmann grade from T2-weighted MRI images (Table 1). Mechanical testing of $5mm^3$ AF tissue cubes was performed in shear loading. Two identical cubes were prepared from each disc. One cube was tested in radial shear, and the other in a circumferential direction, mimicking shear deformation observed in dScoli. Four strain intervals of 2.5% with 20-minutes of relaxation were applied, totalling 10% strain. Shear modulus was calculated using a line of best fit between each of the most relaxed points of the four strain intervals. Following 10% strain loading, a similar four-interval test, but to 40%, was also performed due to significant laxity in some samples. Shear modulus was calculated using MATLAB and statistics were performed using R (one-way ANOVA and post-hoc T-test). An 18-sample subset was stained with hematoxylin and eosin and were histologically scored with the ORS Spine classification system for human AF.
Results: In the radial direction, there were no significant differences between groups (ANOVA, $p=0.38$) (Figure 1). In the circumferential direction, there were significant differences between groups (ANOVA, $p<0.05$), with a large difference between the degen and dScoli samples (post-hoc t-test $p=0.07$). Similar trends were present at 40% strain (post-hoc t-test $p=0.06$). Despite differences in mechanics, there was no significant difference in Pfirrmann or histological scores in degen and dScoli samples.
Conclusions: These results suggest that the AF in dScoli patients is less stiff in shear than degen AF. Ongoing expansion of our database will strengthen the current preliminary conclusions. A lack of relationship between histological appearance and mechanical function will be further explored alongside potential interplay between age, sex and deformity. Decreased shear modulus in AF may be the etiology of dScoli and is an important target for further characterization.

Figure 1

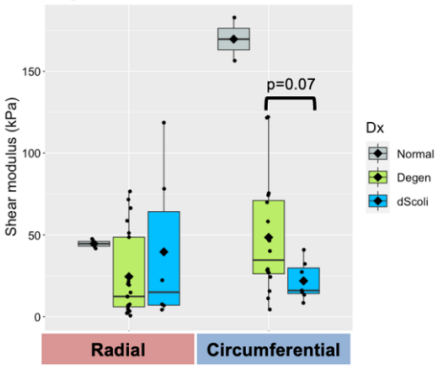

Figure 2

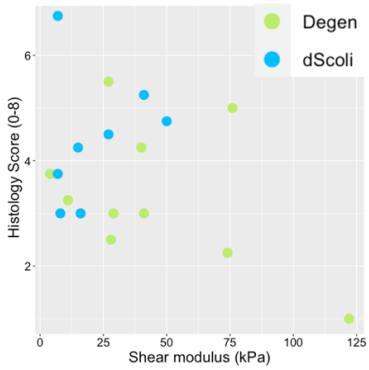

Table 1

	Normal	Degenerated	dScoli
Participants	2	22	8
Age	35 ± 4	44±9	66±7
Sex (Female/Male)	(0/2)	(12/10)	(4/4)
Pfirrmann grade	1	6.6±1.6	4.7±2

Table 2

Shear modulus (kPa)	Normal	degen	dScoli
		Degenerated	dScoli
Radial	44±4	24±25	43±52
Circumferential	169±18	48±36	18±9

O339

Touched vertebral as an ideal the lowest instrumented vertebra in thoracic curves of adolescent idiopathic scoliosis: A suggestion of modified Suk classification

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Introduction: There were no consensus for determination of distal fusion level in adolescent idiopathic scoliosis (AIS). Recently, the touched vertebra (TV) was recommended as a universal reference point for lowest instrumented vertebra (LIV) selection. The Suk classification was introduced for the treatment of AIS using pedicle screw instrumentation (PSI), but there remain limitations in inter-observer agreement between surgeons. This study is aimed to evaluate the distal fusion level via the TV method compared to determining the LIV via the Suk classification in thoracic curves of AIS.
Methods: A total of 129 thoracic AIS patients determined by Suk classification were analyzed based on whether the LIV matched the TV. The radiological parameters and distal fusion level-related complications were measured preoperatively, postoperatively, at 5-year follow-up.
Results: Of the LIVs determined by Suk classification, 48.1% (62/129) matched the TV. The loss of distal motion segment were significantly higher in caudad TV group ($P < 0.001$). Regarding complications, distal junctional kyphosis (4.8% vs. 7.5%), unsatisfactory results (21.0% vs. 25.3%), and coronal decompensation (3.3% vs. 13.4%) were less common in the matched TV group than the unmatched TV group. Among these three complications, only coronal decompensation showed a statistically significant difference among the three groups ($P = 0.038$). The 5-year follow-up CSVL–LIV difference showed a significant moderate correlation with change in disc angulation ($R = 0.447$, $P = 0.020$) and 5-year follow-up LIV tilt angle ($R = 0.493$, $P = 0.005$).
Conclusions: Selecting the TV as LIV in the thoracic curve of AIS has benefits for minimizing the loss of mobile segment and reducing the complications (especially coronal decompensation). In Suk classification, the TV is also an ideal landmark for determining the distal fusion level for AIS patients with thoracic curves. Therefore, we suggested that modified Suk classification.

O340

o-Vanillin modulates cell phenotype and extracellular vesicles of human mesenchymal stem cells and intervertebral disc cells

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Introduction: Intervertebral disc (IVD) degeneration is a major etiology of LBP[3]. Human mesenchymal stem cell (hMSC) and extracellular vesicle (EV) therapy is a promising treatment for discogenic LBP. Our objective is to explore ortho-Vanillin (o-Vanillin, a natural anti-inflammatory and senolytic compound) use in enhancing hMSC differentiation toward disc-like cells and improving the phenotype of disc cells (DCs) from IVDs of surgical patients with LBP.
Methods: Degenerate disc tissue from consenting patients undergoing spinal surgery for LBP was collected according to the procedures approved by McGill University ethical review board (IRB#s A04-M53-08B and Tissue Biobank 2019-4896). Proteoglycan synthesis, inflammatory mediators, and senescent cells were evaluated in pellet cocultures and conditioned media (CM). EV transfer between monolayer hMSCs and DCs was observed using fluorescence microscopy. EV release in CM was detected by nano-flow cytometry. Quantitative PCR was conducted to examine hMSC differentiation and DC phenotype in pellets following CM transfer. All experiments were performed in the presence and absence of o-Vanillin.
Results: The proteoglycan synthesis was significantly higher in cocultures (DCs:hMSCs 1:1) compared to each cell type alone, which was further significantly increased by o-Vanillin treatment. IL-6 and IL-8 concentrations significantly decreased in the o-Vanillin-treated cultures. The number of $p16^{INK4a}$ positive senescent cells was significantly decreased when hMSCs and DCs were 1:1 combined and was further decreased by o-Vanillin treatment in the pellet cocultures. o-Vanillin significantly increased EV release and/or uptake in hMSCs and DCs. The total vesicles generated by hMSCs were significantly more than that generated by DCs both with and without o-Vanillin treatment. There was a significant increase in total EVs from both hMSCs and DCs when treated with o-Vanillin. The expression of IVD markers, such as *FOXF1, PAX1, TIE2, SOX9,* and *ACAN*, significantly increased in hMSCs exposed to DC CM. The expression of *FOXF1*, *TIE2*, *SOX9*, *HIF-1α*, and *ACAN* was further significantly increased by o-Vanillin in hMSCs adding to the effect of DC CM. In DCs exposed to hMSC CM, the expression of *FOXF1, SOX9,* and *HIF-1α* significantly increased. In addition, the expression of *FOXF1*, *TIE2, SOX9*, and *HIF-1α* was further increased following o-Vanillin treatment in DCs adding to the effect of hMSC CM.
Discussion: There is a crosstalk between hMSCs and DCs resulting in an improved IVD cell phenotype, hMSCs promoted proteoglycan synthesis while reducing senescent cells, all further enhanced by o-Vanillin. Further, o-Vanillin increased vesicle release and/or uptake and suppressed inflammatory cytokine production. Therefore, the combination of hMSCs and anti-inflammatory/senolytic compounds may improve the outcome of cell supplementation and EV therapy for LBP.
Significance: Our data indicate that senolytic and anti-inflammatory properties of o-Vanillin have the potential to improve stem cell-based therapies. Enriched and purified EVs or secretome generated *ex-vivo* in a controlled environment, may overcome some of the shortcomings of cell-based therapies. The advantages of lower immunogenicity, longer shelf life and storage time, simpler and more feasible transportation, and lower tumorigenesis risk make cell-free therapy a promising treatment in IVD repair.

O341

Single-cell RNA-seq analysis identifies late-stage nucleus pulposus cell and reveals Serglycin is an essential biomarker of intervertebral disc degeneration

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Introduction: Intervertebral disc degeneration (IVDD) is a natural progression of the aging process that the main driver of most spinal degenerative diseases, which leads to tremendous social and economic burden. However, the mechanisms underlying IVDD and potential therapeutic target have not yet been fully elucidated.
Methods: In this study, we performed Single-cell RNA-sequence analysis to identify cell subset. $SRGN^{-/-}$ and IVDD model mice was constructed. Then, SRGN was detected by Western blotting (WB), immunohistochemical staining (IHC), immunohistochemical fluorescence staining (IF) in human nucleus pulposus tissues and mice IVDs.
Results: Single-cell RNA-sequence analysis was used to identify cell subsets and their gene signatures in healthy human and degenerative nucleus pulposus (NP) to determine their differentiation relationships and characterise the diversity within specific cell types. Furtherly, pseudotime sequencing analysis showed the late-stage nucleus pulposus cells (NPCs) at the pseudospace trajectory end and the late-stage NPCs was mainly distributed in degenerative NP tissues, and confirmed that SRGN was significantly elevated in the late-stage NPCs. Interestingly, Immunohistochemical and immunofluorescent staining results also confirmed that SRGN expression was significantly up-regulated in degenerative NP tissues. Then, by establishment of the $SRGN^{-/-}$ mice, our results showed that inhibition of SRGN significantly alleviates the IVDD. Subsequently, we identified that SRGN upregulates the expression of inflammatory cytokines (IL-1β, TNF-α and CCL3) and accelerated the macrophage infiltration through activating the NF-κB signaling pathway in vivo and vitro. Finally, screened by the molecular docking analysis, we applied Daphnetin (DAP), an anti-inflammatory drug and potential SRGN-combiner in IVDD mice models. Administrated with DAP obviously downregulated the inflammatory cytokines expression and decreased macrophage infiltration, alleviating the IVDD.
Conclusions: The identification of late-stage NPCs cells provided new insights into cell-based NP tissue, and SRGN was an essential biomarker of late-stage NPCs, the SRGN elevated late-stage NPCs promote local inflammatory response demonstrated a novel mechanism of IVDD, which contributes to the development of a novel diagnostic and therapeutic strategy.

Keywords: Intervertebral disc degeneration; Serglycin; Daphnetin; inflammatory response

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O342

IL-6-enriched extracellular vesicles from IL-1β-primed mesenchymal stem cells modulate annulus fibrosus cell metabolism

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Introduction: Extracellular vesicles (EVs) secreted by mesenchymal stem cells (MSCs) cultured under basal conditions were shown to reduce cell apoptosis and inflammation in intervertebral disc (IVD) degeneration models and to promote extracellular matrix synthesis and proliferation of IVD cells [1]. Priming with interleukin (IL)-1β improved the pro-anabolic effect of the MSC secretome on the IVD [2]. Taking this into consideration, we investigated the proteomic content of secretome and EVs from IL-1β-primed versus non-primed MSCs. Moreover, the potential of EVs from IL-1β-primed MSCs to modulate the gene expression pattern of annulus fibrosus cells (AFCs) was compared to the respective entire secretome.
Methods: Human MSC were cultured with or without 1 ng/mL IL-1β for 48h (n=4). EV were purified from the entire secretome by ultracentrifugation. EV morphology, particle diameter and polydispersity were assessed by transmission electron microscopy and dynamic light scattering. Western blotting of CD81 and calnexin was performed. Secretome and EVs produced by non-primed (Control-Sec and Control-EV, respectively) or IL-1β-primed MSCs (IL-1β-Sec and IL-1β-EV, respectively) were investigated by proteomics. Human AFCs isolated from IVD biopsies of disc degeneration patients were cultured with IL-1β for 48h (n=4-8). Subgroups were treated with i) Control-Sec, ii) IL-1β-Sec, iii) Control-EV, and iv) IL-1β-EV. Unstimulated AFCs were used as control. MSCs and AFCs were analysed for the gene expression of matrix metalloproteinase *MMP1*, MMP inhibitor *TIMP1* and collagen type I (*COL1A1*). Statistics: one-way ANOVA (significance, $p<0.05$).
Results: IL-1β-primed MSCs presented upregulated *MMP1* and downregulated *COL1A1* ($p<0.05$). Both Control- and IL-1β-EVs displayed typical size distribution (diameter of 105±53 nm, PdI of 0.30), expressed the positive EV marker (CD81) and did not express the negative EV marker (calnexin). several proteins were differentially regulated when comparing the proteome content of secretome (Fig. 1A) or EVs (Fig. 1B) produced by MSCs under IL-1β versus control conditions; however, we identified only 6 proteins that were common to IL-1β-Sec and IL-1β-EV groups (Fig. 1C). Gene ontology analysis revealed that IL-6 was associated with the regulation of body fluid levels and the extracellular matrix. IL-1β stimulation of AFCs upregulated *MMP1* and *TIMP1* ($p<0.05$), whereas expression of *COL1A1* was downregulated with respect to the control ($p<0.0001$; Fig. 2). Interestingly, we determined that similar to IL-1β-Sec, IL-1β-EVs upregulated *TIMP1* ($p<0.0001$) and *COL1A1* expression, possibly through modulation of IL-6 signaling.
Conclusions: IL-6 acts as both a pro-inflammatory cytokine and an anti-inflammatory myokine and has been proposed as a serum biomarker of IVD degeneration [3]. Overall, we hypothesize that EV enrichment with IL-6 may play a role in the modulation of IVD matrix metabolism, in line with the data from the AF cell culture investigations. Regarding treatment with EVs versus entire secretome, the results demonstrate a potent anti-inflammatory effect of the whole secretome and EV on human AFC. However, IL-1β-EV may have a stronger effect on AF matrix metabolism, representing a promising therapeutic approach.

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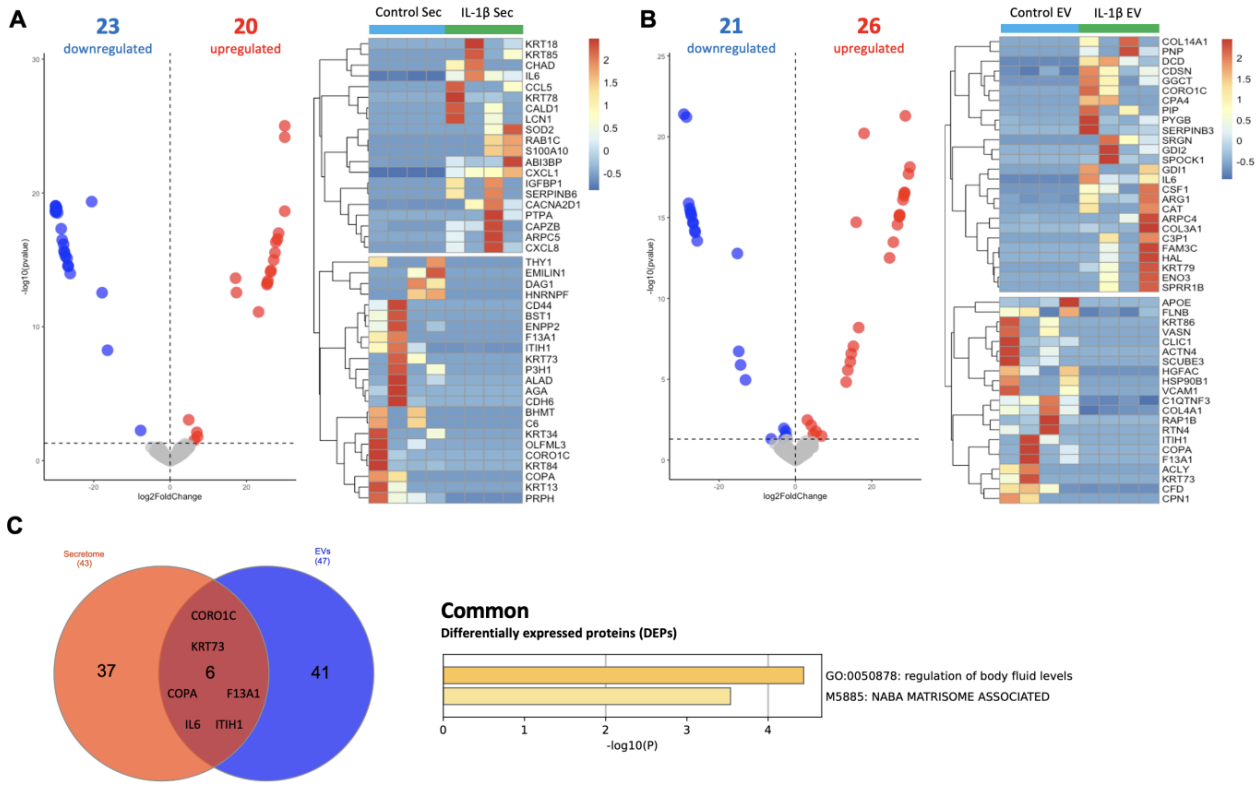

Fig. 1. Proteomic analysis of the secretome and EV produced by non-primed (Control-Sec and Control-EV, respectively) or IL-1β-primed MSC (IL-1β-Sec and IL-1β-EV, respectively). Volcano plot and heatmap of the differentially expressed proteins (DEPs), in which red represents upregulated DEPs and blue represents downregulated DEPs in **A)** IL-1β-Sec *versus* Control-Sec and B) IL-1β-EV *versus* Control-EV. C) Unique and common DEPs between IL-1β-EV and IL-1β-Sec. n=4, p<0.05.

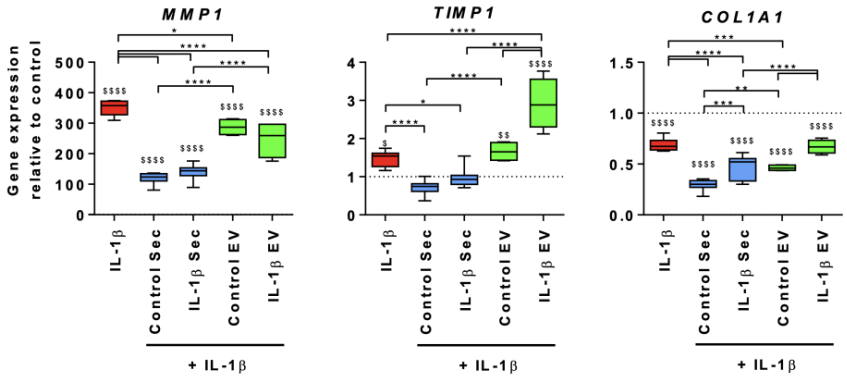

Fig. 2. Relative mRNA expression of *MMP1*, *TIMP1* and *COL1A1* for IL-1β stimulated annulus fibrosus cells and subsequently treated with secretome (Sec) or EV from control or IL-1β-primed MSCs. Results were normalized to *GAPDH* and non-stimulated control cells. n=4–8; $, comparison to control; *, comparison between treated groups and IL-1β stimulation alone, one-way ANOVA.

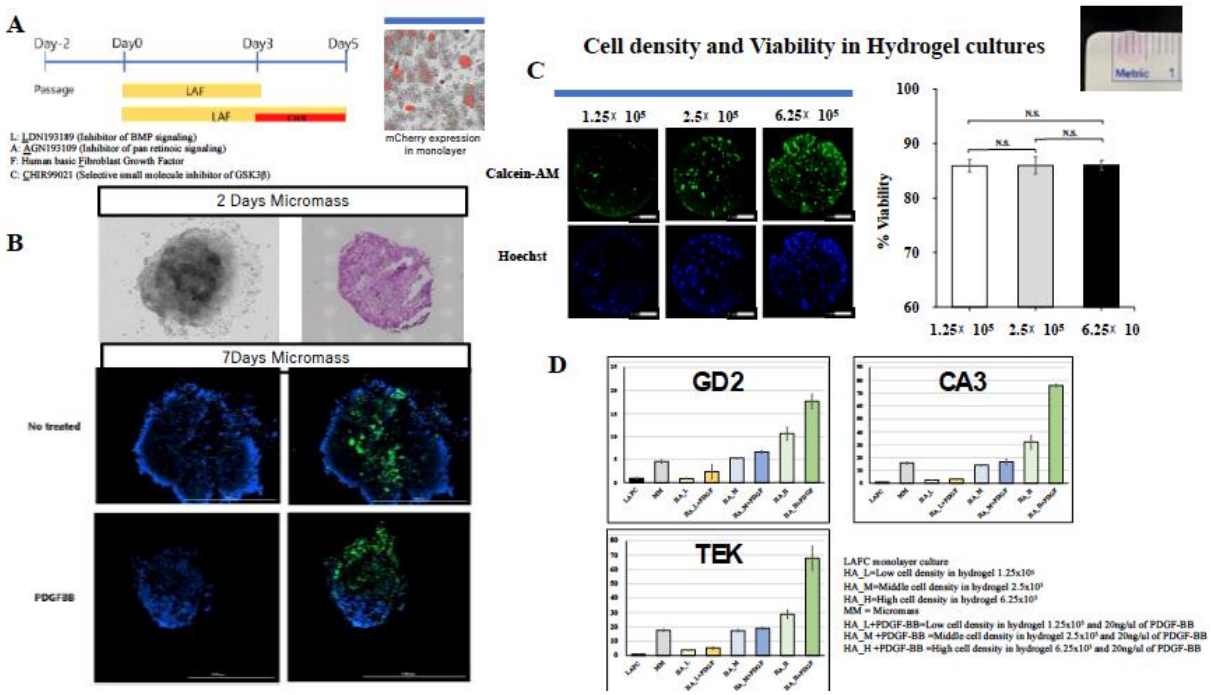

Figure 1: Maturation of Notochordal Cells Derived From Human Induced Pluripotent Stem Cells **A)** CRISPR-Cas9 based targeted genome editing approach to insert mCherry fluorescent reporter into 3'UTR of Noto gene in human skin fibroblast induced pluripotent stem cell (hiPSC) cell lines (HDFa-YK27). For notochordal like-cell differentiation cells were treated with the LAFC cocktail of factors (LDN-193189, AGN193109, and bFGF2 protein) for a period of 3 days followed by addition of a small molecule CHIR99021 (a known inhibitor of GSK3β) for the following 2 days. **B)** Micromass cultures after 2 and 7 days. **C)** Cell viability was maintained after 14 days of culture. **D)** PDGF-BB treatment enhanced NP-like cell differentiation as evidenced by increased in mRNA expression of the NP markers CA3, TEK and B4GALNT.

O344

Roles and mechanisms of curculigoside in alleviating nucleus pulposus cell apoptosis by upregulating BMAL1 expression via the JAK/STAT3 pathway

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Background: Intervertebral disc degeneration (IVDD) is the main cause of low back pain. Inflammatory factors and the circadian switch gene Basic Helix-Loop-Helix ARNT Like 1 (BMAL1) play key roles in IVDD pathogenesis. Curculigoside is a potential anti-inflammatory compound. The present study aimed to investigate the role of curculigoside in regulating BMAL1 expression during the inflammatory response and the mechanism of action in IVDD.
Methods: Dysregulated genes were identified by RNA sequencing analysis. Western blotting (WB), immunohistochemical staining (IHC), immunohistochemical fluorescence staining (IF) and real-time fluorescent quantitative PCR (RT–qPCR) were used to detect BMAL1 expression in 24 human intervertebral disc specimens (male: female =13:11), BMAL1-knockout mice and IVDD model mice. The regulatory effects of curculigoside and BMAL1 on nucleus pulposus (NP) cells were examined by siRNA, flow cytometry, IF and WB. The therapeutic effect on mice was evaluated by intraperitoneal injection of curculigoside.
Results: BMAL1 expression was negatively correlated with the degree of IVDD. BMAL1 expression was significantly lower in tumor necrosis factor (TNF)-α-induced degenerative NP cells. After siRNA-mediated BMAL1 knockdown, apoptosis in degenerative NP cells was significantly higher than that in the control group, while the overexpression lentivirus had the opposite effect. BMAL1 is regulated by the JAK-STAT3 pathway, and curculigoside upregulated BMAL1 by inhibiting STAT3 phosphorylation, inhibiting apoptosis, improving extracellular matrix components, and alleviating IVDD.
Conclusion: Curculigoside can inhibit apoptosis and improve the extracellular matrix by upregulating BMAL1 expression, which is low in IVDD. This study provides a therapeutic strategy to alleviate apoptosis associated with inflammation-induced IVDD.

Keywords: Intervertebral disc degeneration; BMAL1; Curculigoside; Apoptosis

Acknowledgments: Thanks to the Experimental Animal Center of the First Affiliated Hospital of Sun Yat-sen University for providing the animal feeding and experimental platform, and thanks to some of the instruments provided by the Public Experimental platform of Precision Medicine of the First Affiliated Hospital of Sun Yat-sen University.
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O345

Inhibition of the phosphatase pleckstrin homology domain leucine-rich repeat protein phosphatase (PHLPP) to promote NP cell regeneration

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Introduction: Back pain is often correlated with intervertebral disc (IVD) degeneration (IDD). Hallmarks of IDD are breakdown of the extracellular matrix and increased apoptosis. We previously showed that *Phlpp1* deficiency delayed IDD in mice by promoting matrix synthesis and inhibiting apoptosis. The small-molecule PHLPP inhibitors NSC117079 and NSC45586 inhibit PHLPP in several cell types, but their efficiency varies between tissues. The aim of this study was to test the efficacy of each inhibitor to promote a healthy NP cell phenotype in mice, and identifying downstream targets of PHLPP in degenerated human NP cells.
Methods: Mouse experiments were performed with IACUC approval. Five-month old C57BL/6J mice (n=10/group) were euthanized and coccygeal IVDs were dissected for organ cultures. IVDs were cultured under serum deprivation to simulate IDD and either kept untreated or treated with NSC117079 or NSC45586 for three days. After culture, IVDs were analyzed by PCR (PHLPP expression), histochemistry (H&E), immunohistochemistry (Keratin19) and apoptosis (TUNEL). Human degenerated nucleus pulposus (NP) cells were extracted following IRB approval (n=5). Cells were cultured under serum deprivation followed by Inhibitor treatment to assess AKT and ERK phosphorylation, FOXO1, Keratin19, Aggrecan, and MMP13 expression (Western blot), cell viability (MTT), and gene expression for Keratin-19 (PCR). Data were analyzed using Kruskal-Wallis-Testing (GraphpadPrism 8) with a statistical significance of $p<0.05$.
Results: After culture under serum deprivation, inhibitor treatment significantly decreased NP cell apoptosis compared to untreated IVDs (Figure 1A). In untreated IVDs, NP cells appeared small and condensed while the notochordal cell phenotype was maintained after inhibitor treatment. Only treatment with NSC45586 prevented shrinkage of the notochordal band (Figure 1B). Similarly, Keratin-19, a marker for a healthy NP phenotype, was only increased after NSC45586 treatment (Figure 1C). In degenerated human NP cells, NSC45586 treatment promoted cell viability (Figure 2A), increased *Keratin19* and *Aggrecan* expression while decreasing *MMP13* expression (Figure 2B). Immunoblotting demonstrated slightly increased AKT phosphorylation and increased FOXO1 deposition while ERK phosphorylation was downregulated when treated with NSC45586 (Figure 2C). Inhibiting FOXO1 activity reversed the beneficial effects of NSC45586 treatment on *Keratin19* expression, but blocking AKT or activating ERK showed no effects (Figure 2D). The Inhibitor NSC117079 did not show significant alterations in any of the measured parameters (Figure 2B-D).
Conclusions: Together, these data suggest NSC45586 as potent PHLPP Inhibitor against IDD in mouse IVD organ culture and human NP cells. FOXO deficiency has previously been shown to disrupt IVD homeostasis and notochordal cell differentiation, confirming the indispensable function of FOXO1 in the IVD. PHLPP is known to regulate AKT and ERK pathways, which regulate cell survival, not the cell phenotype. This might explain why AKT and ERK phosphorylation were increased/decreased after NSC45586 treatment without effects on *Keratin19* expression after AKT inhibition or ERK activation. Taken together, our findings suggest that NSC45586, but not NSC117079, may act as a therapeutic target to inhibit PHLPP1 and induce FOXO1-dependent Keratin19 expression in IVD degeneration.

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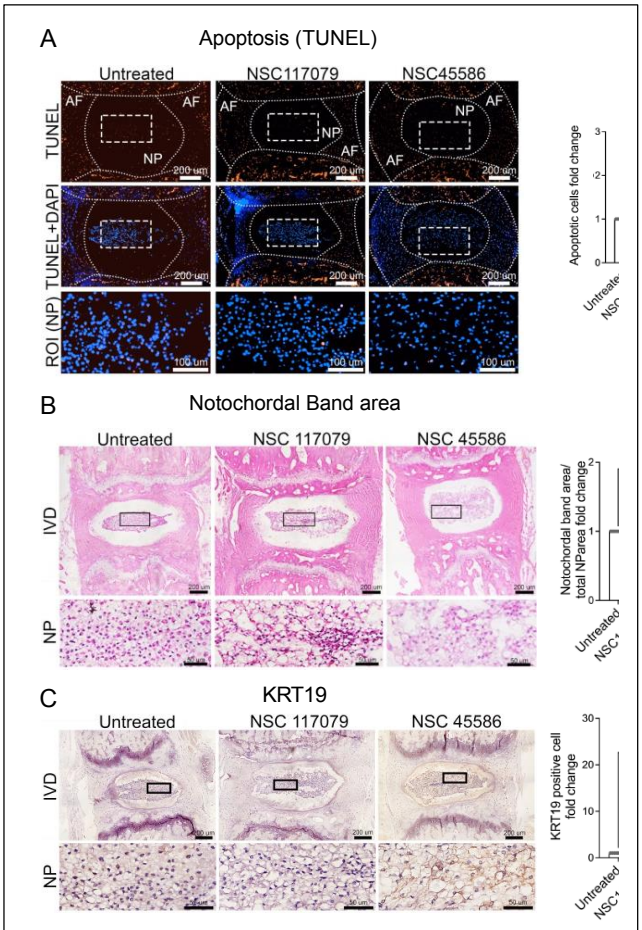

Figure 1: The Small Molecule PHLPP inhibitor NSC45586 promoted a healthy NP phenotype under serum deprivation. **A)** Both Inhibitors promoted cell survival under serum deprivation Blue = nuclei, Red = apoptotic cells **B)** The notochordal cell band area

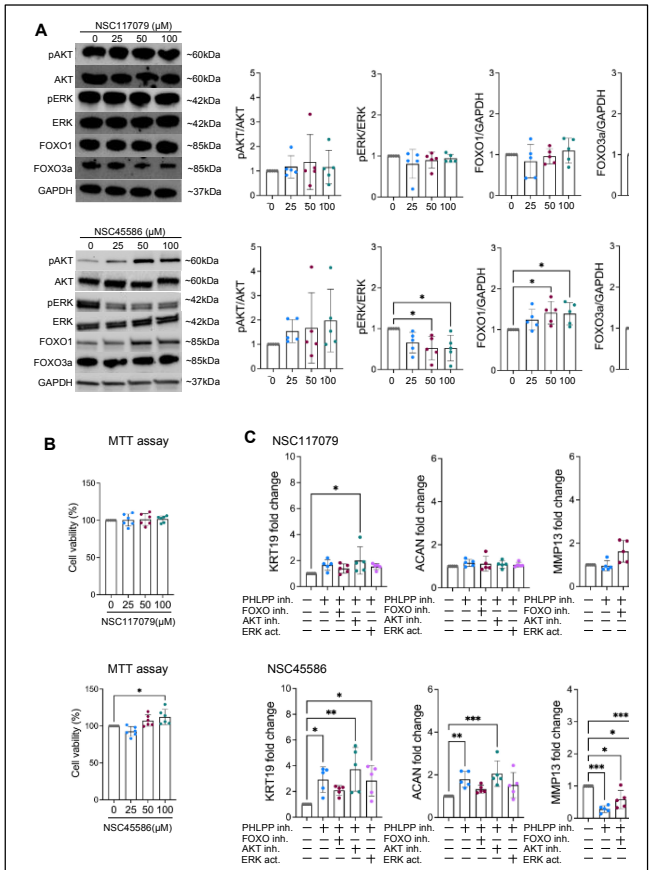

Figure 2: The Small Molecule PHLPP inhibitror NSC45586 promoted a healthy NP cell phenotype in degenerated human NP cells. **A)** Immunoblotting of AKT & ERK phosphorylation and Expression of the transcription factors FOXO1 and FOXO3a. **B)** Cell viability was maintained after inhibitor treatment **C)** PHLPP inhibition with NSC45586 promoted gene expression of Keratin19 (KRT19) and Aggrecan

O346

Transient Receptor Potential Vanilloid 4 (TRPV4) knockdown decreases extracellular matrix synthesis via autophagy suppression in rat intervertebral disc

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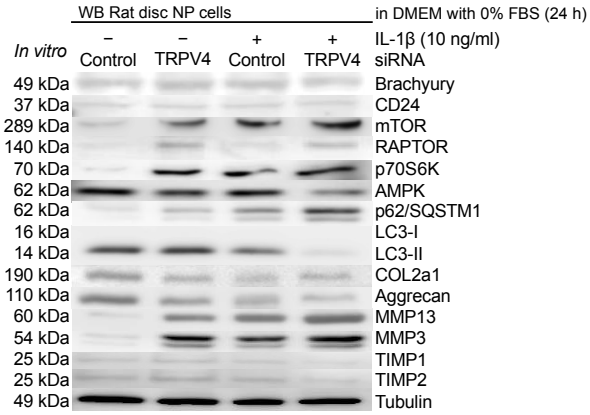
Introduction: Transient Receptor Potential Vanilloid 4 (TRPV4) has been identified as a Ca^{2+}-permeable channel and reported to be activated under a physiological mechanical stimulation in disc nucleus pulposus (NP) cells *in vitro.* Autophagy via Ca^{2+}-dependent AMPK/mTOR pathway is activated under hyperosmotic stress in notochordal cells. We hypothesized that TRPV4 is involved in the maintenance of intradiscal autophagy and matrix metabolism. Our objective was to elucidate the role of TRPV4 in rat intervertebral disc autophagy and extracellular matrix metabolism through loss-of-function study with the RNA interference (RNAi) technique.
Methods: *In-vitro* study: (1) Disc NP cells harvested from 12-week-old male Sprague-Dawley (SD) rats were used. Small interfering RNA (siRNA) was applied to knockdown TRPV4 by the reverse transfection method. Cells after transfection were cultured in DMEM with or without 10% FBS for 24 h to simulate nutrient deprivation. Expression of AMPK, mTOR, LC3-II, and a substrate p62/SQSTM1 as well as TRPV4 was measured by Western blotting (WB). (2) Next, cells after the transfection were cultured in serum-free DMEM with 10-ng/ml interleukin-1 beta (IL-1β) for 24 h. Autophagy markers and extracellular matrix molecules (COL2a1 and Aggrecan), catabolic matrix metalloproteinases (MMPs) and tissue inhibitor of metalloproteinases (TIMPs) were assessed by WB. (3) Apoptosis and senescence levels were determined by real-time RT–PCR for *PARP*, *Caspase-9*, *p21/CIP1*, *p16/INK4A*, and *p53* expression.
In-vivo study: Thirty-six 12-week-old male SD rats were used, and TRPV4 and control siRNAs were injected into respective coccygeal (C) discs. (4) To confirm *in-vivo* transfection, WB for TRPV4 was conducted in rat disc NP-tissue protein extracts 2 and 28 d after injection. (5) A rat tail model of disc degeneration induced by temporary static compression was designed. While non-specific siRNA was injected into C8/9 (loaded control) and C11/12 (unloaded control), TRPV4 siRNA was injected into C9/10 (loaded experimental) and C12/13 (unloaded experimental). Then, axial force at 1.3 MPa was applied for 24 h and subsequently released. Radiographic degeneration was assessed at 0 and 28 d after compression.
Results: *In-vitro* study: (1) TRPV4 expression significantly decreased by TRPV4 RNAi. The AMPK and LC3-II decreased and mTOR and p62/SQSTM1 increased, indicating autophagy suppression via AMPK/mTOR pathway. (2) Pro-inflammatory IL-1β stimulation with TRPV4 RNAi decreased COL2a1, Aggrecan, and TIMPs and increased MMPs, indicating suppression of extracellular matrix metabolism (Figure). (3) In real-time RT–PCR, IL-1β stimulation with TRPV4 RNAi displayed increased expression in *Caspase-9*, *p21/CIP1*, *p16/INK4A*, and *p53* and decreased expression in *PARP* ($P < 0.05$).
In-vivo study: (4) WB displayed sustained decreases in TRPV4 protein expression 2 and 28 d after injection. (5) In the loaded/TRPV4 siRNA-injected discs, radiographic disc height significantly decreased compared to the other conditions 28 d after compression ($P < 0.05$).
Conclusions: *In vitro,* TRPV4 knockdown suppressed autophagy with AMPK inhibition and also suppressed extracellular matrix metabolism and raised apoptosis and senescence levels under pro-inflammatory IL-1β stimulation. *In vivo*, intradiscal injection of TRPV4 siRNA was effective as long as 28 d, resulting in radiographic disc degeneration. The TRPV4 could be a therapeutic target for intervertebral disc diseases via modulating autophagy.

Figure. Pro-inflammatory IL-1β stimulation with TRPV4 RNAi



O347

Glial activation in sensory and motor regions of the cortex is related to sensorimotor function in individuals with low back pain maintained by nociplastic mechanisms

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Introduction: Chronic pain involves communication between neural and immune systems. Recent data suggest localization of glial (brain immune cells) activation to the sensorimotor regions of the brain cortex (S1/M1) in chronic low back pain (LBP). As glia performs diverse functions that impact neural function, activation might contribute to sensorimotor changes, particularly in LBP maintained by increased nervous system sensitivity (i.e., nociplastic pain). This study aimed to: (i) compare evidence of glial activation in S1/M1 between individuals with and without LBP (and between nociceptive and nociplastic LBP phenotypes), and (ii) evaluate relationships between glial activation and sensorimotor function.
Method: Simultaneous PET-fMRI measured glial activation in functionally defined S1/M1 in pain-free individuals (n=8) and individuals with chronic LBP (n=9; nociceptive: n=4, nociplastic: n=5). Regions of S1/M1 related to the back were identified using fMRI during motor tasks and thermal stimuli. Sensorimotor measures included single and paired-pulse transcranial magnetic stimulation (TMS) and quantitative sensory testing (QST). Sleep, depression, disability, and pain questionnaires were administered.
Results: Glial activation was significantly greater in the lower back cortical representation of S1/M1 for individuals with LBP group who presented with clinical features consistent with primary nociplastic pain than both nociceptive LBP and painfree groups. The nociplastic LBP group had lower corticospinal excitability (measured with recruitment curve). Glial activation in S1/M1 was weakly negatively correlated with intra-cortical facilitation (r=-0.41), positively correlated with greater sensitivity to hot (r=0.52) and cold (r=0.55) pain thresholds, and positively correlated with poor sleep, depression, functional disability and BMI.
Conclusion: This study provides evidence for neuroinflammation in S1/M1 of the brain that is greater in individuals with clinical features that suggest predominant nociplastic pain mechanisms. Glial activation was associated with sensorimotor and clinical features. Although this cannot be interpreted as causal, the data provide foundation to speculate on possible mechanisms to be interrogated in future studies. Neuroinflammation in back regions of S1/M1 in individuals with nociplastic LBP could plausibly explain some characteristic features of this LBP phenotype.

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O348

Intervertebral disc divided into three regions according to the origin and polarity of macrophages

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Introduction: Macrophages have been recognized as cells responsible for phagocytosis. In recent years, however, they have been reported as central cells in the immune response that control the flow of disease, with a variety of functions depending on polarity, origin, and organ. Involvement of macrophages in intervertebral disc (IVD) degeneration has been reported in many studies. However, its origin, phenotype and distribution during the denaturation process is not clear. Knowledge of the detailed distribution of macrophages in the disc degeneration process is important for understanding the pathomechanisms and establishing novel therapeutic targets. Therefore, this study was designed to determine the distribution of bone marrow-derived macrophages (BMDMs)/ tissue-resident macrophages, macrophage phenotype and cytokine expression in the process of intervertebral disc (IVD) degeneration.
Methods: To distinguish BMDMs, GFP-labeled bone marrow chimeric rats (n=12) were generated. The degenerative process of the intervertebral disc was reproduced in a rat caudal disc puncture model (n=49). Iba-1 was used as the macrophage marker, and Iba-1(+)GFP(+) was defined BMDMs and Iba-1(+)GFP(-) as tissue-resident macrophages. Similarly, Iba-1 and iNOS double-positive cells were defined as M1 macrophages, and Iba-1 and Arginase double-positive cells were defined as M2 macrophages. The IVD sites were divided as follows: the endplate(EP); inside area of annulus fibrosus and nucleus pulposus(iAF/NP); outside area of annulus fibrosus(oAF), measurements were taken in each area. Immunoblot analysis was used to evaluate differences in cytokines (M1-induced: TNF-a, IL-1b, IL-6, M2-induced: TGF-b, IL-4, and IL-10) depending on the distribution of BMDMs.
Results: BMDMs appeared early in oAF and gradually in EP, in contrast. On the other hand in iAF/NP, BMDMs were absent, and tissue-resident macrophages increased gradually. Macrophage polarity was M2 dominant in each area, and especially dominant in EP. Expression of IL-1b decreased gradually at endplate, and that of IL-4 increased early after disc puncture at inside of the annulus fibrosus.
Conclusions: During the disc degeneration process, BMDMs were observed mainly in EP and oAF, with few in iAF/NP. The BMDMs that accumulated in the oAF early after puncture are thought to be phagocytic cells that recognized the disc cells as foreign. In contrast, BMDMs also increased in the EP over time, especially at this site, which was M2-strongly dominant. In the EP, tissue is classified as "bone" tissue in IVD. In bone, BMDMs are recognized as precursors of osteoblasts, and their M2 polarity inhibits osteoclast differentiation. Therefore, their M2 polarity may be involved in bone metabolism in the EP. In iAF/NP, nucleus pulposus cells had altered morphology and simultaneously enhanced expression of the macrophage marker Iba-1. IL-4 is considered a cytokine associated with M2 polarity, and its expression also enhances tissue-resident macrophage expression. Nucleus pulposus cells are capable of self-cleaning of the IVD. Therefore, this is considered to be the tissue-resident macrophage in IVD. In the present study, the intervertebral discs were divided into three major groups according to the origin and phenotype of macrophages. This result will further our understanding of intervertebral disc pathology.

O349

Prognostic value of conventional MRI and diffusion tensor imaging in surgically treated degenerative cervical myelopathy patients

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Study Design: Prospective observational cohort study
Introduction: Degenerative cervical myelopathy (DCM) is a common cause of acquired spinal cord impairment, and surgical decompression remains an important treatment option. There is no valid and standardised method to incorporate quantitative radiological findings into the assessment of the patient's condition and prognosis. We aimed to analyse the usefulness of MRI [compression ratio (CR), transverse area (TA), signal intensity ratio (SIR)] and DTI indices [fractional anisotropy (FA), Apparent diffusion coefficient (ADC), Relative anisotropy (RA), Volume ratio (VR)] in predicting the prognosis in DCM patients, managed surgically and to study changes in the MRI and DTI indices following surgery, and if there is any correlation with clinical outcome to these parameters.
Methods: 66 patients of DCM managed surgically were enrolled. Pre op assessment included clinical (mJOA score, Nurick grade, NDI and VAS scores) and radiological (MRI and DTI scans) parameters. Clinical parameters were recorded at 1 month and at final follow up scans were repeated and clinical parameters noted. Patients were divided into group A (poor outcome) and group B (good outcome) based on clinical recovery (mJOA recovery rate).
Results: 66 patients were available for final follow up at 4months. Group A had 36 patients and group B had 30. All the clinical parameters improved more in group B compared to group A, inter group statistical significance was noted in mJOA score and Nurick grade at final follow up (p value <.0001). MRI parameters of CR, TA and SIR improved post operatively compared to pre-operative values in both groups, with intra group statistical significance noted only in group A. Baseline FA values (0.61± 0.198) were more and ADC (1760.47 ± 623.71) was less as expected in group B compared to A (FA -0.55 ± 0.16, ADC - 1833.32 ± 504), but not significant. The area under the receiver–operator characteristic curve was calculated for all the radiological parameters showed change in TA values was significant (p value 0.0317) with a cut off value of > -0.06 cm^2. Area under ROC (AUC) was highest in Change in TA (0.669) followed by Change in CR (0.653) and Change in FA (0.602). The least AUC was seen in pre-operative VR (0.51) followed by SIR (0.52).
Conclusion: Patients in group B showed improvement in all clinical parameters (mJOA, Nurick, NDI and VAS) following surgery compared to group A. Out of all the radiological parameters only change in TA had significant ROC curve values. Though DTI parameters of pre-operative mean FA and mean ADC in group B was higher and lower than group A, it was not statistically significant. We conclude that both MRI and DTI help in diagnosis, but we could not find any significant role to help in prognostication except for change in TA values.

O350

Anterior cervical hybrid fixation for severe multi-level ossified posterior longitudinal ligament (OPLL)

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Introduction: Cervical myelopathy is the commonest cause of spinal cord dysfunction, can be due to cervical degeneration or OPLL. There is a controversy regarding appropriate surgical protocol for multi-level myelopathy. Multi-level anterior corpectomies are associated with high incidence of implant related complications. This study aims to evaluate the outcomes of Anterior Hybrid Fixations (single or 2 level corpectomies with ACDF) with respect to implant related problems, neurological outcome and fusion.
Objectives: This study aims to evaluate the mid-term and long-term outcomes of Anterior Hybrid cervical fixation (ACHF) for Multilevel OPLL causing Cervical Myelopathy.
Material and Methods: This is a single centre, single surgeon, Prospective study done between January 2012 and January 2022 (10 years). 66 patients (mean age 55.76 ± 11.93) diagnosed with Multi-level OPLL with significant symptoms were operated with Anterior Cervical Hybrid Fixation (ACHF) and were followed for up to 2-5 years (maximum 10 years). The patients were assessed clinically (VAS score), neurologically (Nurick's score), functionally (mJOA scoring system) and radiologically (Central Sagittal Alignment - CSA, C7 sagittal Vertical Axis - CSVA, T1 slope, Fusion Segmental angle - FSA, Fusion Segmental Height - FSH).
Results: Significant improvement was noted in the mean VAS score (4.91 ± 1.37 to1.11 ± 0.4), Nurick grading (3.27 ± 1.16 to 2.18 ± 0.96) and mean mJOA (11.7 ± 3.78 to 14.58 ± 3.13). Mean Radiological correction achieved post-op is 5.03 ± 2.69 degrees; CSA (9.27 ± 8.96 to 14.68 ± 8.61), C-SVA (23.53 ± 11.46 to 28.47 ± 11.50), FSA (2.47 ± 5.36 to 5.42 ± 6.55) and FSH (68.76 ± 6.23 to 73.57 ± 6.87). Fusion was noted in all the patients in minimum of 6 months follow-up. No significant change in the radiological parameters noted at final follow-up.
Discussion: Anterior surgery removes the pathology that causes the myelopathy with better chance of neurological recovery. Only disadvantage being longer duration of surgery and high incidence of implant related complications in multi-level corpectomy. By doing hybrid fixation, incidence of implant related complications are almost nil, with better neurological recovery.
Conclusion: ACHF is a good surgical option for multi-level OPLL requiring surgery, as they have better construct stability, fusion rate and neurological recovery with lesser implant failure, cage subsidence, dural tears, C5 nerve palsy and recurrence of symptoms. There was significant improvement in neurology and none of our patients required revision.

O351
Midterm results of cervical suspension bridge laminoplasty for degenerative cervical myelopathy

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Introduction: This is a retrospective study to evaluate the mid-term outcomes (minimum 3 years follow-up) of a novel technique of performing un-instrumented open-door suspension bridge laminoplasty (SBCL) in degenerative cervical myelopathy.
Materials and Methods: Retrospective data were collected from 92 patients who underwent un-instrumented ODCL for compressive cervical myelopathy at a single institution from January 2010 to May 2019. The preoperative and postoperative modified Japanese Orthopaedic Association score (mJOA) and Modified Nurick grading were documented. Cervical lordotic angle (C2–C7) and range of motion (ROM) were obtained from the preoperative and postoperative radiographs at minimum 3 years follow-up.
Results: The average age was 61.2 ± 7.8 years. The average time of presentation was 6.8 ± 3 months. In this study, majority had segmental OPLL; remaining were continuous & mixed OPLL and multiple-level spondylotic myelopathy. C3–C6 was the most commonly operated level (69.56%). The mean operating time was 109 ± 31 min with a mean blood loss of 152.7 ± 75 ml. There was a significant improvement in the mJOA scores (8.4 ± 1.1–13.3 ± 0.9, P<0.0001) and Modified Nurick grading (4.2 ± 0.8–2.1 ± 0.5, P < 0.0001) at 36-month follow-up. Preoperative C2–C7 angle had an average decrease of 6.1^0 at 36-month follow-up (19.5 ± 7.2–13.4 ± 8.8, P < 0.0001). There was a mean reduction of 5.5^0 ± 3.78° noted in the C2–C7 ROM between the preoperative and final follow-up.
Conclusion: Un-instrumented SBCL is an easily reproducible and economical alternative to the standard instrumented cervical laminoplasty with equivalent mid-term outcomes.

O352

Does the use of SONOPET ultrasonic aspirator decrease the complication rate of laminectomy in cervical myelopathy patients?

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Introduction: Cervical laminectomy for cervical myelopathy has been performed traditionally with osteotomes and rongeurs and more recently with High-speed burr (HSB). However, these methods can cause devastating soft tissue injury by direct contact and are difficult to use in areas with an already compressed cord. We evaluated the use of an SONOPET ultrasonic aspirator (SUA), for the patients operated for cervical myelopathy and compared the outcomes to those operated with HSB.
Methods: A retrospective analysis was done and patients operated for cervical laminectomy between January 2017 and October 2020 were included. They were divided into two groups based on the device used for laminectomy i.e, HSB and SONOPET. We compared the demographic, clinical and functional outcomes for patients for one year post operatively. We used the modified Japanese Orthopaedic Association (mJOA) and Visual Analogue score (VAS) for both arm pain and neck pain and Nurick Grading,
Results: 177 patients were included of which 101 were operated with an HSB and 76 by SONOPET.
Demographic and baseline parameters were comparable. However, the duration of surgery ($p<0.001$) and the rates of total complications ($p=0.041$) were significantly higher in the HSB group. Of note, accidental durotomies were significantly lower in the SONOPET group ($p=0.024$). Other variables like blood loss, hospital stay and incision length were similar. Functional outcomes were comparable among the two groups.
Conclusion: SONOPET ultrasonic aspirator has a higher safety margin and helps in achieving a shorter duration of surgery. Specially, the rates of accidental durotomies are significantly less with the use of SONOPET.

Keywords: SONOPET; Ultrasonic scalpel; cervical myelopathy; High speed burr; Dural tear

O353

CT based morphometric study of the sub axial cervical spine pedicles in a sample of Indian population, to assess the safety and feasibility of cervical pedicle screw in the sub axial spine.

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Introduction: CT Based Morphometric Study of the Sub axial Cervical Spine Pedicles in a sample of Indian Population, to assess the safety and feasibility of cervical pedicle screw in the Sub axial spine.
Material and Methods: The computerized tomography scans of 500 subaxial cervical spine vertebrae were analyzed from 100 patients presenting to the JPNATC, AIIMS, New Delhi and undergoing cervical spine computerized tomographic (CT) scan for unrelated cause as part of ATLS protocol. Pedicle width (PW), Pedicle Axis Length (PAL), Pedicle Transverse Angulation (PTA) and Lateral Pedicle Distance (LPD) were calculated on Axial CT scans and Pedicle Height (PH), Pedicle Length (PL), Superior Pedicle Distance (SPD) and Pedicle Sagittal Angulation (PSA) were calculated on Sagittal CT scans.
Results The overall Mean Pedicle width ranged from 4.3 at C3 to 5.7mm at C7. Mean Pedicle Height ranged from 5.5 at C3 to 6.1 mm at C7. Mean Pedicle Transverse Angulation ranged from 44.5^{o} at C3 to 37.1^{o} at C7. Pedicle Sagittal Angulation ranged from 16.65^{o} at C3 to 3.29^{o} at C7. Mean Lateral Pedicle Distance ranged from 1.6 at C3 to 3.4mm at C6. Mean Superior Pedicle Distance ranged from 3.5 at C3 to 1.15mm at C7. Mean Pedicle Axis Length ranged from 29.6 at C3 to 33.04mm at C7. Mean Pedicle Length ranged from 5.2 at C3 to 5.78mm at C7.
Conclusion: Our CT based study revealed that cervical pedicle screw placement is possible in majority of Indian population except at C3 in females. A thorough understanding of pedicle anatomy with proper CT based preoperative planning can mitigate the risk associated with pedicle screw placement in Subaxial cervical spine.

O354

Can quantitative analysis of motion of after cervical total disc replacement be accurately done on flexion extension radiographs?

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Introduction: The advantages which cervical total disc replacement offer over ACDF are preservation of disc motion, reduced biomechanical stresses on the adjacent disc, and prevention of bone graft site complications. Motion analysis of TDR can be done with qualitative and quantitative measures. For most accurate measurements analysis on computed tomography scan has been recommended by some authors. However, obtaining a CT scan on follow-up is rarely practiced in these cases.
In this study we try to look at some methods of qualitative analysis of motion at the index level after TDR on radiographs.
Methods: 45 patients operated for total disc replacement at Stavya Spine Hospital between April 2010 to April 2020 were followed up in 2022. Immediate Postoperative and Follow-up flexion extension radiographs of these patients were analyzed using SurgimapTM software for segmental and global parameters.
Segmental measurement of motion was done by measuring the change (delta) of the index vertebral angle method (IVA) and the disc height method (DH). The opinions of 3 senior spine surgeons were also taken to check for motion on radiographs. Cross analysis was done in between these to find out the most accurate method for motion analysis.
Conclusions: Quantitative analysis of TDR is still an area of investigation. Both the index vertebral angle and Disc height method can be used for a quick analysis of motion on flexion extension x-rays, however there may be some difficulties in measurement due to endplate irregularities, errors of rotation in capturing radiographs, etc.
Acknowledgements: This was a self-funded study.

O355

The effect of corticosteroids in postoperative dysphagia in anterior cervical spine surgery: A randomised trial

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Introduction: Anterior cervical decompression and fusion is a commonly performed surgery for treating cervical myelopathy or radiculopathy, especially of degenerative aetiology. Though a relatively safe procedure, it has been associated with multiple complications, dysphagia being one of the commonest. Multiple causes are attributed for this, with prevertebral soft-tissue swelling (PSTS) having a strong association. Use of peri-operative intravenous corticosteroids has shown to reduce dysphagia by reducing PSTS. We conducted a prospective, randomized, double-blinded, controlled study of the effects of steroids on post operative dysphagia on the basis of both clinical and radiologic assessments.
Methods: A total of 58 patients were enrolled and randomly assigned to receive intravenous saline or dexamethasone. 28 of them were given 3 doses of intra-venous dexamethasone, first dose of 0.3 mg/kg preoperatively followed by 2 doses of 0.15 mg/kg at 8 and 16 hours postoperatively. The other group of 30 patients received saline as placebo. Clinical outcome was measured using EAT-10 and Bazaz outcome measure scales. C-spine lateral view was done to assess the swelling index based on degree of pre- and postoperative PSTS at the level of surgery.
Results: Baseline demographics were not significantly different between the 2 groups. The degree of dysphagia according to the EAT-10 score was lower in drug group on POD 1, 2 days (p value 0.005,0.057) and 1 week (p value 0.912) but became comparable on 1 and 4 months. Similar outcome was seen in bazaz scale, but was not statistically significant. Swelling index was comparable up to 1 month post op, but at final follow up was significantly lower in drug group (p value 0.003). No difference in complication rate, functional outcome was noted between the two groups.
Conclusion: Perioperative use of Dexamethasone in anterior cervical surgeries improved immediate post operative dysphagia which become insignificant by 1 month. The clinical outcome was not reflected by radiological parameter of swelling index. There were no significant complications associated with steroid usage. Use of ideal dose of steroid is a cheap and effective method to reduce immediate post operative dysphagia without significant complication.

O356

Is foramen magnum decompression really needed after C1-C2 posterior fixation for congenital atlantoaxial dislocation/ basilar invagination with Chiari malformation?

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Introduction: Atlantoaxial dislocation (AAD)/ basilar invagination (BI) may have co-existent Chiari and syrinx with small posterior fossa volume. The treatment widely practised in such condition is stabilization of craniovertebral junction (CVJ) along with foramen magnum decompression (FMD). The distraction of dens and realignment of C1-C2 per se is likely to open up the ventral foramen magnum questioning the role of additional FMD.
Aim: The objective is to analyse the outcome after C1-C2 posterior reduction & fixation without FMD in patients with congenital AAD and Chiari.
Patients and Methods: This is a retrospective analysis of 38 patients of BI/AAD with Chiari in whom C1-C2 posterior reduction and fusion was performed without FMD. The baseline clinico-demographic and radiological data was evaluated and compared at their latest follow-up. A mathematical formula to estimate the reduction in posterior fossa volume secondary to encroachment by dens in AAD/BI is also described.
Results: AAD was irreducible in 65.8% of patients. Syringomyelia was present in 73.7% of patients. Most patients (91.9%) improved in their clinico-radiological status after fixation alone. None required FMD at a later stage. In 3 (8.1%) patients, there was radiological resolution of syrinx without appreciable clinical improvement. Five patients in whom the dura was opened inadvertently had transient postoperative neurological worsening.
Conclusion: Posterior C1-C2 distraction and fusion alone appears to suffice in the management of AAD/BI with Chiari. Distraction of dens reverses dural tenting restoring the posterior fossa volume apart from relieving ventral brainstem compression. Additional FMD is not necessary. In fact, dural opening may be counterproductive.

O357

Starting endoscopic spine surgery practice in a tier 2 city of India: An initial experience and learning curve

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Introduction: Endoscopic spine surgery has been an elusive field in the spinal surgery space in India that has recently gained more momentum due to advancements in technology and awareness about minimally invasive spine surgery. However, there is a scarcity of formal training opportunities in the Endoscopic Spine Surgery space in India with a relatively fewer number of surgeons adopting this technique. This study was done to evaluate the viability and initial outcomes of a young surgeon entering endoscopic spinal surgery practice in a Tier 2 city in India.
Methods: A prospective analysis of the initial outcomes of the first 40 patients (53 levels) who underwent transforaminal endoscopic lumbar spine surgery at multiple hospitals in tier-2 cities in India done by a single spine surgeon working as a freelancing surgeon was done. All the patients with a minimum follow-up of 6 months were included. Various demographic, radiological, and clinical parameters were studied especially focusing on overall operative time, time for the preparation of the operation theatre, preoperative as well as post-operative VAS scores at regular intervals, and SLR angles. Patients were divided into 2 groups of 20 patients each in chronological order and various parameters were compared among these two groups. All surgeries were done under local anesthesia with sedation.
Results: There were 19 male and 21 female patients. The average age was 45.8 years. The average BMI was 29.0 (range 22 to 44). 11 patients were operated on for multiple levels while 29 patients underwent single-level decompression. L4-L4 was the most commonly operated level. 9 patients had stenosis without instability while 31 patients had prolapsed intervertebral disc alone. The average SLR was 28.85 degrees. The surgeries were performed at 11 different hospitals over a period of 11 months. The average OT preparation time was 47.5 minutes, while the average operative time per level per side was 68.1 minutes. In the initial 20 cases, the average preparation time was 56 minutes which was reduced to 39 minutes in the next 20 cases($p<0.01$). Similarly, operative time per level per side in the first 20 cases was 79 minutes which was reduced to 60 minutes in the next 20 cases ($p<0.01$). The average preoperative VAS score of the entire study group was 8.25 which significantly reduced to 1.78 on postop day 1 ($p<0.01$) and was 2.0 at 1-month post-surgery and 1.95 and 1.87 at 3-month and 6-months post-surgery respectively. None of the patients required blood transfusion and there were no incidences of infections.
Conclusions: Transforaminal Endoscopic spine surgery is a rewarding surgery with favorable outcomes with minimal complications and good patient satisfaction. This technique can turn out to be a viable option for young spine surgeons in India who are working as freelancing surgeons during their initial years of practice.

O358
Uniportal dual mode dry- saline endoscopy for lumbar disc herniation

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Introduction: Posterior dry-medium endoscopic lumbar discectomy techniques have been successfully used for treatment of lumbar disc prolapse. A drawback observed in these techniques was repeated blood staining of scope tip while working close to surgical target. To address this drawback we innovated and modified design of previous Arthrospine system and made it compatible for used in air and saline medium for treatment of lumbar, cervical and thoracic disc prolapse. In this paper Operative technique is described and results of Lumbar discectomy are discussed.
Methods: For study purpose 80 Patients underwent Endoscopic discectomy by Arthrospine "Duo" system for lumbar disc prolapse. The procedure is done by a muscle dilatation approach using 5mmand 10mm dilators. Arthrospine "duo" tube is passed over 10mm dilator. Arthrospine working insert is adjusted over tube in press fit manner. Endoscopic discectomy is then carried out with help of 30 degree arthroscope and conventional microdiscectomy instruments in air or saline medium.
Results: As per modified Macnab criteria 80%(n=64) patients had excellent, 12.5% (n=10) good, 6.25%(n=5) fair and 1.25 patient (n=1) had poor result. Leg pain VAS numerical scale improved from scale of 7.87+/-0.68 to 1.3=/-0.67 at 2 years followup. The complications observed were dural tears and transient paraesthesias in 4 patients (5%) each, nerve root injury in 1 patient (1.25%) and superficial wound infection in 5 patients (6.25%).
Conclusion: Uniportal Arthrospine "Duo" system can be used in both air and saline medium and is excellent minimal invasive option for lumbar discectomy.

O359

Interlaminar endoscopic discectomy versus microdiscectomy for L5-S1 lumbar disc herniation: A propensity matched study

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Introduction: Lumbar disc herniations (LDH) is a common disorder of the spine. Patients not responding to conservative measures are treated by surgery. Microdiscectomy is considered the gold standard procedure for LDH. With changing trends, minimally invasive techniques like endoscopic discectomy are now popular and have gained acceptance. Studies have compared microdiscectomy with endoscopic discectomy for LDH with variable outcomes. Interlaminar endoscopic lumbar discectomy (IELD) is preferred at the L5-S1 level due to the direct approach and ease of access facilitated by wide interlaminar space. There is paucity in the literature comparing clinical outcomes between microdiscectomy and interlaminar endoscopic discectomy for LDH at the L5-S1 level. The primary aim of our study is a propensity-matched comparison of back pain, sciatic pain, and functional outcome between microdiscectomy and interlaminar endoscopic discectomy for L5-S1 disc herniation.
Methods: This is a Propensity Matched study of 100 patients who had undergone surgery for symptomatic LDH at L5-S1 level. 50 patients treated by microdiscectomy and 50 patients treated by IELD were compared with follow-up of 18 months. Baseline data were retrieved from the electronic medical records system. 1:1 propensity matching was performed between two groups on baseline covariates and a propensity score was computed. Patient-reported outcome measures were obtained from EMR during follow-up outpatient visits. Primary outcome measures were back pain and sciatic pain. Back pain and sciatic pain were assessed by the Visual Analogue Scale for back pain (VAS-B) and sciatic pain (VAS-L) respectively. Functional outcome was assessed using Oswestry Disability Index (ODI) Score, McNab Score, and 12-item Short Form Survey (SF-12) score. Data was obtained at baseline (pre-op) and at 0, 1, 3, and 18-month post-operative periods. Duration of hospital stay (in days) and duration of the procedure (in minutes) were noted.
Results: Mean preoperative VAS-B and VAS-L were similar in both groups. Mean VAS-B was significantly ($p<0.001$) lower in the IELD group at the immediate postoperative period and 1-month follow-up when compared with the microdiscectomy group. Mean VAS-B continued to be lower in the IELD group compared to the microdiscectomy group at 18 months, although not significant. There was no significant difference between IELD and microdiscectomy groups with regard to improvement in sciatic pain (VAS-L). ODI score was significantly ($p<0.001$) lower in the IELD group at immediate post-op and 3 months post-operative period but comparable to the microdiscectomy group at 18 months. This indicated a better early functional recovery in the IELD group compared to microdiscectomy. There was a significant difference ($p=0.004$) in the hospitalization period between the two groups with early discharge noted in the IELD group. Duration of the IELD procedure was significantly ($p<0.001$) shorter compared to Microdiscectomy.
Conclusion: Both IELD and Microdiscectomy had a favorable clinical outcome for symptomatic L5-S1 LDH. Endoscopic Discectomy has the advantage of lower back pain, better functional recovery in the early postoperative period and shorter hospital stay compared to Microscopic Discectomy. However, at long-term follow-up, pain and functional outcomes are comparable in both groups.

O360

"Difficult Cases"- Analysis of factors for ease of surgery in interlaminar endoscopic lumbar discectomy

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Introduction: Interlaminar endoscopic lumbar discectomy (IELD) has evolved as a solution to overcome the difficulties of endoscopic transforaminal approach at lower lumbar levels. But the advent of IELD has expanded the indications of endoscopic surgery from discectomy at L5-S1 mainly and few L4-5 levels to unilateral laminotomy with bilateral decompression for the management of spinal stenosis. Not all patients are suitable candidates for IELD because of the anatomical variations and degree of pathologies. The average duration of surgery according to previous studies is about 69.6 min.
Objective: To analyse factors responsible for technical difficulties while performing percutaneous endoscopic interlaminar surgery.
Material and Methods: A prospective study of 45 cases who underwent Interlaminar endoscopic discectomy (ILED) from January 2021 to June 2022 at our institute by a single surgeon. Surgeries were divided as fast (duration <69.6min) and slow (>69.6 min). Factors responsible for prolonged duration assessed radiologically, intra operatively. Duration of symptoms, Visual analog score (VAS) for pain, Oswestry Disability Index (ODI), disc level, operative time, intraoperative blood loss, complications, and follow-up data at 1 and 6 months postoperatively.
Results: 37 surgeries were done at L5-S1, 8 were done at L4-L5. 20 surgeries were fast, 25 were slow. Average duration of surgery was 66.31 min. Bone drilling (Lamina, Facet) done in 17 patients. Among various factors for prolonged duration Facet hypertrophy seen in 4, severe canal stenosis in 3, Osteophyte in 1, migrated disc in 3, narrow inter laminar window in 1 patient.
Conclusion: Though the factors which may appear difficult in the initial cases may be mastered along the learning curve, Facet hypertrophy, Calcified discs, Migrated disc, long standing symptoms and other factors were found to influence the outcome of the patients undergoing IELD.

O361

Role of unilateral biportal endoscopy in treatment of cervical radiculopathy, technical note and early results

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Background: Cervical radiculopathy is fairly common in Spine practice with incidence of 107.3 per 100,000 in men and 63.5 per 100,000 women. Majority of these patients respond to conservative management, but others need surgical intervention. There are various surgical approaches to treat cervical radiculopathy. ACDF is the most preferred treatment for cervical radiculopathy caused by foraminal narrowing with/without para-central disc herniation. The procedure has approach related risks and also involves removal of almost entire normal anterior part of the disc to reach the posterior pathological fragment. Additionally we need to stabilise the segment by doing an inter-body fusion, compromising one motion segment and subjecting the individual to possible implant related complications. The authors have tried and explored the posterior lamino-foraminotomy and discectomy approach via UBE (Unilateral Biportal Endoscopic) approach to reach the pathology directly and avoid fusing the motion segment. Being percutaneous the approach involves blunt separation of muscle causing least collateral damage to surrounding musculature. Also this approach is done under continuous irrigation giving clearer vision and lesser bleeding, resulting in faster recovery.
Methods: A total of 17 cases of unilateral upper limb radiculopathy were operated with UBE (Unilateral Biportal Endoscopic) approach with posterior cervical lamino-foraminotomy with discectomy in prone position under general anesthesia. Visual analogue scores and modified Macnab criteria were used for assessment of pain pre and post-operatively with minimum of 8 months to maximum 2.5 years of follow up.
Results: At the final follow up the mean VAS for upper limb pain improved from 8.4+/- 2.2 to 0.9+/-0.5 indicating significant reduction in pain. Modified Macnab score showed Excellent result in 76% (13 out of 17), Good in 17% (3 out of 17), and Fair in 7% (1 of 17 patients). Complications included 2 patient having mild hyposthesia and one patient having persistent tingling in upper limb.
Conclusion: With UBE technique posterior cervical lamino-foraminotomy with discectomy can be performed safely and effectively. There is minimal soft tissue dissection with preservation of motion segment thus preventing fusion. Additionally there is cosmetic wound healing with faster recovery and early return to work.

O362

Mini-open transforaminal lumbar interbody fusion: 2 years outcome study

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Introduction: Minimally invasive lumbar interbody has become standard of care to treat lumbar degenerative conditions. Traditionally, percutaneous screws are placed under fluoroscopic or navigation guidance as part of the minimally invasive fusion procedure. However, these techniques involve significant radiation to operating surgeon and/ or to the patient. We utilize anatomical landmarks of the vertebrae to insert pedicle screws using an expandable retractor system with minimum fluoroscopic requirement.
Aim: To analyze clinical and functional outcome of Mini-Open Transforaminal Lumbar Interbody Fusion (MO-TLIF) at minimum two years.
Materials and Methods: 137 patients (88 males) with a mean age of 49 (18-78) years underwent single level MO-TLIF for lumbar degenerative conditions. Patients were suffering from back-pain and/ or radicular symptoms. Intra-operative surgical data, including radiation exposure for the entire surgery, was collected. Patients were followed post-operatively for a minimum of two years. Patients Reported Outcome Measures (PROM) were recorded at follow up visits. Radiographs were taken at 6 weeks, 3 months, 12 months and 24 months from surgery. Any complication during surgery or in post-operative period was recorded.
Results: Mean surgical time was 103±13(90-135) minutes. Total blood loss was 80±30 (50-150) ml. Average post-operative length of stay in hospital was 1.3 (1-3) days. There were no mal-positioned screws requiring revision surgery. Oswestry Disability Index improved from preoperative 45 to post-operative 15. Complications were asymptomatic non-union (2 patients), intra-operative dural tear (1 patient) and superficial surgical site infection (2 patients).
Conclusions: MO-TLIF is a minimally invasive lumbar fusion technique with comparable outcome scores to other lumbar interbody fusion techniques. It has all the advantages of a minimally invasive technique without increased radiation risk.

O363

Clinical outcomes following navigation assisted minimally invasive sacroiliac joint fusion through lateral approach

Study design: Retrospective study design.

Purpose: In this study author aimed to describe a technique of sacroiliac joint fusion through lateral approach using navigation and to document clinical results using visual analog scale (VAS) scores.

Methods: Patients diagnosed with SIJ dysfunction were treated using triangular titanium implants between August 2018 and March 2021 with help of navigation system. In this study of 36 patients, 51 joins were fused. Patients fusion was documented on computed tomography and X-rays done at routine intervals during the follow-up, and clinical outcome was documented with help of visual analog scale (VAS) scores.

Results: The mean preoperative VAS score was 7.2 ±1.1, and the mean 12-month postoperative VAS score was 1.6 ±1.46. This difference was statistically significant ($p < 0.05$) and demonstrated a substantial clinical improvement in pain. Mean operative time was 34±9 minutes and blood loss was 22±35ml. There was one case of complication which required removal of one implant. All 36 patients had successful fusion evidenced on CT.

Conclusion: We conclude that SIJ fixation using triangular titanium implants is a safe and effective procedure for the fixation of the SIJ. Further investigation is warranted to determine the best surgical treatment for SIJ pain.

O364

A minimum 2-year MRI evaluation of postoperative spinal canal and foramen expansion in OLIF patients

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Introduction: Minimally Invasive Oblique Lumbar Interbody Fusion (MIS OLIF) is a novel technique that utilizes a retroperitoneal approach to achieve indirect decompression of neural elements by ligamentotaxis. MIS OLIF also leads to expansion of the spinal canal by ligamentotaxis of the buckled ligamentum flavum. With time, there is hypotrophy of the ligamentum flavum. Thus, the spine canal cross-sectional area increases. The purpose of our study was to determine the spinal canal expansion by MIS OLIF.
Materials and Methods: Patients who underwent OLIF from 2016-2020, with a minimum 2-year follow-up were included in the study. Patients who underwent the procedure for spinal infections and trauma were excluded. Spinal canal cross-sectional area (SCA), spinal canal AP width (SCW) and cross-sectional area of foramen (CSAF) on right and left sides were measured on pre-operative, immediate post-operative, and final follow-up MRI scans. Clinical outcome was done using Macnab's grading.
Results: 19 patients with 30 OLIF segments were included in the study. Mean age was 60.8 years. Mean follow-up was 37.9 months (24 months-72 months). 94.8% patients had excellent, and 5.2% patients had good clinical outcome. There was an average 48.6% increase in SCA immediate post-op and 135.7% increase on final MRI scans. A subset analysis was done based on degree of stenosis graded by Schizas classification. 15 segments with grade (A+B) stenosis showed an increase in SCA of 75.6%. 15 segments with grade (C+D) stenosis showed 195.6% increase in SCA. Fusion was seen in all segments. No patients required direct decompression.
Conclusion: Indirect decompression by MIS OLIF is adequate in decompressing the spinal canal with favorable radiological and clinical outcomes which continue to improve over time, thus avoiding the need for direct decompression. With time, the SCA increases significantly along with hypotrophy of ligamentum flavum.

Key words: OLIF, lateral techniques, minimally invasive surgery

O365

Development, pilot, pathway implementation and evaluation of an advanced practice physiotherapy triage pathway in adolescent idiopathic scoliosis

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Background: Scoliosis is described as a lateral spinal curvature exceeding ten degrees on radiograph with vertebral rotation. Approximately 80% of scoliosis presentations are adolescent idiopathic scoliosis (AIS). Of this 80%, 10% require conservative management and approximately 0.1-0.3 % require surgical deformity correction. Treatment outcome is dependent on combinations of factors such as curve magnitude, skeletal growth, curve progression risk factors and service user choice. Current management for AIS in the UK occurs in Surgeon or Paediatrician-led clinics. The musculoskeletal assessment and triage of AIS appears well-suited to an advanced physiotherapist practitioner (APP) skill set. The aim of this service evaluation was to scope, develop, implement and evaluate the initial pilot and subsequent full implementation of an APP-led AIS triage pathway in a tertiary scoliosis and deformity centre and to make comparisons of local conservative management with the current International recommended AIS conservative management guidelines.

Method and Results: Three phases were outlined for this project: scoping, implementation, and evaluation. A clinical competency package was developed for training and development of APPs. Clinic inclusion criteria for AIS and a patient assessment form was developed. Pilot implementation of the new care model resulted in an APP-led assessment and triage clinic of patients presenting with AIS. All patients assessed in the pilot phase were discussed with a spinal surgeon. Once the clinic was implemented, regular multi-disciplinary meetings were held fortnightly. Consultant and APP agreement (% of total), waiting times, surgical management, and patient satisfaction were reviewed. From these results an independent AIS advanced practice pathway was implemented and comparisons of local treatment outcomes with current international guidelines of conservative AIS management were included.

Results: Initial scoping included observation of Spinal Consultant deformity and scoliosis clinics over X months. Competency packages were developed for APPs, including: X ray interpretation and Cobb angle measurement, consultant clinic shadowing, consultant teaching and patient case based discussions. In the initial pilot pathway implementation, 49 patients were seen over the four-month period and 53 further new patients were seen during the implementation phase over a three-month period (total n=102). 33% (n=34) of new patients seen were diagnosed with AIS. Of these, 26% (n=9) were directly listed for surgery, and 18% (n=6) fulfilled recommended bracing criteria and were referred. 53% (n=18) were referred for physiotherapy. Consultant / APP percentage agreement was high for Cobb angle measurement (82%), management plans (90%), and further diagnostic requests (94%). There were no adverse events. Patient satisfaction levels were high with all respondents very satisfied or satisfied (n=20, (5% of all patients seen). Waiting times were reduced from ten weeks to two weeks in the initial pathway implementation.

Conclusion: APP-led AIS clinics can provide similar levels of management and assessment as Spinal Consultants with high levels of satisfaction. Of those seen in clinics, only a small percentage required surgery, justifying the use of an APP in first line triage, Bracing and physiotherapy referrals were in line with conservative pathway international guidelines.

O366

Using a convolutional neural network with a Huber loss output regression layer to predict the maximum cobb angle of adolescent idiopathic scoliosis from surface topography torso scans

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Introduction: AIS is a prevalent type of scoliosis, affecting 80% of structural scoliosis patients1. X-ray exposure during scoliosis management increases the risk of cancer later in life. Thus, our group has developed a markerless surface topography (ST) technique to quantify AIS and reduce the risk of x-ray radiation2. To get spine information from trunk ST, our group utilizes state-of-the-art artificial intelligence (AI) techniques on the ST scans, specifically, convolutional neural networks (CNNs). The objective of this study is to use CNN to predict the maximum Cobb angle in patients with AIS using asymmetry measured from ST scans.
Methods: 521 ST scans on AIS patients (age 10-18 years) who had not undergone surgical treatment available and used for the model. Cobb angle was measured from an x-ray for these patients, and the max Cobb angle was used with its corresponding ST. Moreover, The model was designed with three blocks of convolution, and max pooling layers, with each convolutional layer followed by a ReLU activation. Two data augmentation layers were added before the convolutional block to increase the data size. A 30% spatial weight dropout was used to avoid overfitting. An output regression layer was utilized to predict the value of the maximum Cobb angle for each patient. A Huber Loss function was used as a loss function as it is less sensitive to data outliers compared to the squared error loss. The collected data were processed into deviation maps between the original and reflected torso[2] highlighting areas of asymmetry, and then converted to a two-channel pseudo image as an input to the CNN. Using K-Folds cross-validation, the dataset was split into ten folds, and then each of these was used as a validation set. Each image was randomly varied at each epoch by random rotation from 0.2 rad and horizontally and vertically inverted within each fold. The best-performing model was selected as the final model.
Results: In predicting the Cobb angle, the range of the mean absolute errors (MAEs) of the Cobb angle was 6.77 to 9.89 degrees. Fig. 1 shows the change in MAE across epochs of the best-performing CNN (MAE = 6.77 degrees).
Conclusions: An ST-based CNN with a cross-validation approach shows promising results in predicting AIS max Cobb angle. Implementation of this approach may allow clinicians to reduce the reliance on x-rays for scoliosis monitoring.

Acknowledgments: This work was partly supported by the Canadian Institutes of Health Research (CIHR) and the Women and Children's Health Research Institute (WCHRI).

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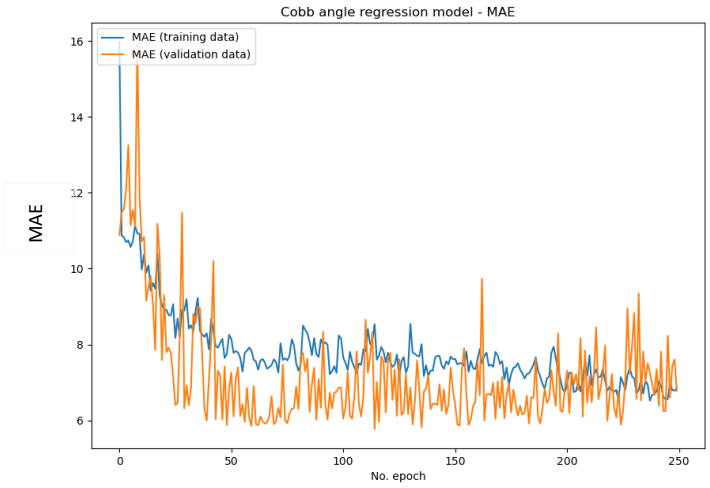
Figure 1: Progress of training and validation MAE over 250 epochs.



O367

Monitoring of spine curvature changes of patients with adolescent idiopathic scoliosis (AIS) using three-dimensional ultrasound

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Introduction: To detect curve progression of adolescent idiopathic scoliosis (AIS), X-ray examination using the Cobb method is the gold standard in clinical practice with a 5-degree increment being the cut-off threshold. Radiation-free 3D ultrasound imaging has been validated for the assessment of AIS by locating specific bony features[1]. However, there is a paucity of study reported about the feasibility of using 3D ultrasound in monitoring spine curvature changes, which can help to reduce by a large portion of radiographs during follow-up examination if this method works.
Aim: The aim of this study is to investigate whether 3D ultrasound imaging can provide comparable results to radiographic Cobb angle in assessing spine curvature changes in AIS patients.
Materials and Methods: 136 AIS subjects (94F and 42M; Age: 14.1 ± 1.89 years) with different scoliosis severity (24.3 ± 14.4 degrees) were included. Each subject underwent bi-planar X-ray and 3D ultrasound (Scolioscan, Telefield Medical Imaging Ltd, Hong Kong) scanning on the same date for each clinical visit. Subjects underwent second assessment with time interval of 4-24 months. Manual measurement of scoliotic curvature was conducted by drawing lines along the transverse processes and laminae on the coronal ultrasound images, whereas Cobb measurement was conducted on X-ray images[2]. Cobb angle changes and ultrasound angle changes of more than 5 degrees represents scoliosis progression detected by X-ray and ultrasound, respectively. The sensitivity and specificity of using ultrasound angle measurement for detecting scoliosis progression were studied with the corresponding radiographic Cobb angles as a reference.
Results: Among the 136 subjects, 21 of them showed scoliosis progression in X-ray assessment while 19 of them showed scoliosis progression in ultrasound assessment. Table 1 and Figure 1 show the progressive and non-progressive cases. The sensitivity and specificity of using 3D ultrasound for detecting scoliosis progression were 0.93 and 0.90, respectively. For the two false negative case, the potential causes could be inconsistent postures between two radiographs taken and subject movement during ultrasound assessment, as noted from X-ray images.

Table 1. Results for the spine curve changes detected by 3DUS

	Progressive cases detected by X-ray	Non-progressive cases detected by X-ray
Test Positive by 3DUS	19 (True Positive)	8 (False Positive)
Test Negative by 3DUS	2 (False Negative)	107 (True Negative)

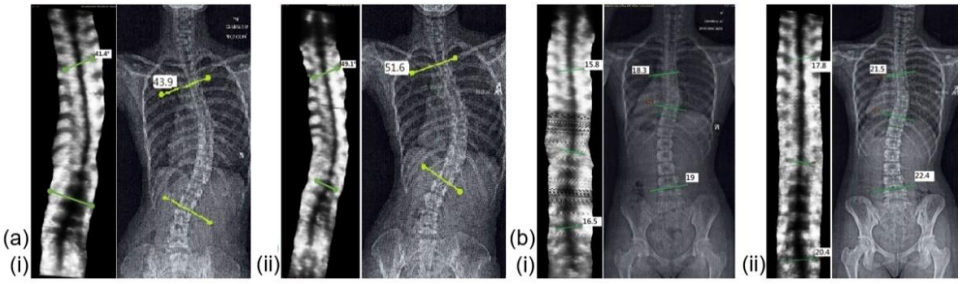

Figure 1. Ultrasound coronal image and radiographs with (a) a typical progressive case at (i) first visit and (ii) follow-up visit; and (b) a typical non-progressive case at (i) first visit and (ii) follow-up visit

Conclusion: 3D ultrasound imaging is sufficiently comparable to radiographs in monitoring spine curvature changes in AIS patients, demonstrating that its potential for reducing exposure to radiation during follow-up examination. Further studies with larger number of subjects are worthwhile to demonstrate its clinical values.

Acknowledgements: This study is partially supported by Research Impact Fund of Hong Kong RGC (R5017-18).

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O368

The apex vertebrae of the scoliotic curves. Study of their frequency in 11758 cases

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Background and Aim: This descriptive study differs from the usual classification of scoliotic curves according to the segment of the spinal column affected by the misalignment (thoracic, thoracolumbar, and lumbar) but aims to identify the vertebrae that most frequently represent the apex in the scoliotic curves.
Methods: The following inclusion criteria were defined from a database of 8061 subjects classified as scoliotic patients:
- Curves with apexes from T4 to L4 of at least 10 Cobb degrees.
- Males and females
- Age 9-18
- Without previous treatments (brace or specific exercises)

Considering 8061 scoliosis subjects with 4470 single curves, 3485 with double curves (6970 curves), and 106 with triple curves (318 curves), the apical vertebrae of a total of 11758 curves were identified.
Results: The most frequent apical vertebrae in the case of single curves are concentrated in a segment of three adjacent vertebrae (T12 23% - L1 15.5% and L2 14.5%).
In the case of double curves, the most frequent apical vertebrae are concentrated in two pairs of vertebrae. D8 18% and T9 18% for a total of 36% and L1 14% and L2 19% for a total of 25%.
In cases of triple curves, the apexes are concentrated in three groups of vertebrae. In the upper part of the spine, D4 21% - D5 5.6% - D6 6.2% for a total of 33%.
In the middle part of the thoracic portion D8 6.8% - D9 13.1% - D10 8.1% for a total of 28%
In the lumbar portion of the spine L1 6.5% - L2 14.4% - L3 8.7% for a total of 30%.
Conclusion: In the case of single curves, in 63% of them, the apex is concentrated in the portion of the spine defined as the thoracolumbar portion and which geometrically corresponds to the middle segment of the spine. Even if the number of thoracic vertebrae is more than doubled in respect to the lumbar vertebrae, the height of the lumbar vertebrae is considerably greater than the thoracic vertebrae and this suggests that the biomechanics underlying the deviations do not consider the number of vertebral segments but their total height.
In the case of double curves, the apexes of the curves are mainly located in the upper and lower portion of the portion defined as the thoracolumbar spine and which corresponds to a sort of curve inversion point.
In the case of triple curves, the situation is comparable to cases of scoliosis with double curves. The most frequent apex vertebrae are the same, both in the case of scoliosis with double and triple curves. The curves of the upper portion of the spine seem to be an event that is added to the more typical lower misalignments.

O369

Deep learning and 3D surface modelling facilitating radiation free spine alignments measurements with preliminary clinical validation

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Introduction: Adolescent idiopathic scoliosis (AIS) is the most common type of spinal disorder affecting children. Clinical screening and diagnosis require physical and radiographic examinations, which are either subjective or increase radiation exposures. Recent ultrasound technology examining scoliosis is radiation free but stationary. MSKalign is our in-house developed device, which takes a light-based depth image of a nude back (RGBD) as input and synthesizes a radiograph-comparable image (RCI) for spine alignments analysis. We aim to clinically validate the accuracy of MSKalign measured alignments using the alignments measured on radiographs as gold standard.
Methods: To validate MSKalign (Fig. 1), we prospectively recruited AIS patients From January 2021 to April 2021. For each patient, a nude back RGBD image and a whole-spine standing posteroanterior radiograph (EOS® Imaging, Paris, France) were acquired. To validate the reliability of our system in RCI synthesis, firstly, six anatomical landmarks (C7, the tip of coccyx (TOC), posterior inferior iliac spines (PIISs) and inferior scapular angles) were automatically detected on the RGBD images, using our previously published AlignPro methods (https://www.aimed.hku.hk/alignprocare). These landmarks combined with the RGBD image, were inputted into PatchGAN for RCI synthesis.
Results: The prospective cohort with 300 AIS patients (74% female, age range 10-18) contained different deformity severities (28% normal-mild, 61% moderate and 10.9% severe). The detection of the 7th cervical vertebra (C7) and TOC landmarks achieved the best performance (mean±SD) compared with the other landmarks in terms of MED and MMD (C7: MED=1.0±0.5, MMD=1.2±0.6; TOC: MED=1.0±0.5, MMD: 1.3±0.6). The detection of left and right PIISs achieved an inferior performance (Left PIIS: MED=1.6±1.2, MMD=2.0±1.3; Right PIIS: MED=1.7±1.2, MMD=2.1±1.2). For the detection of left and right inferior scapular angles, the average values of both the MED and MMD achieved less than 4 pixels (Left inferior scapular angle: MED=3.0±2.1, MMD=3.6±2.4; Right inferior scapular angle: MED=2.9±2.3, MMD=3.5±2.4). The synthesized RCI contained sufficient anatomical information that could quantify disease severities and curve types through visual assessments.
Conclusions: Our portable system and device have the potential to facilitate fast and accurate AIS analysis without radiation. The clinical significance includes, 1) AIS patients can obtain spine alignment results with no radiation; 2) the analytical process is automated and fast, facilitating fast screening and clinical managements.

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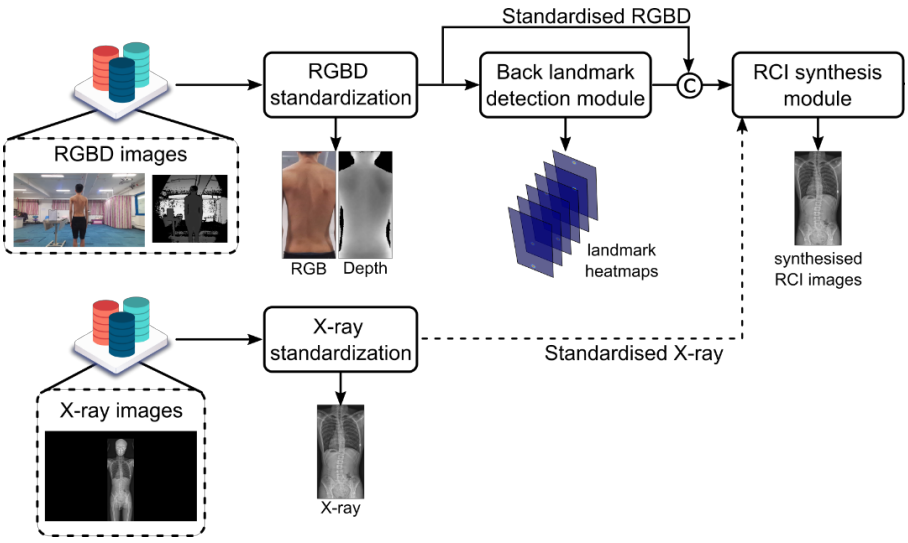
Fig. 1: MSKalign technology pipeline.



O370

Evaluation of thoracic flexibility in the sagittal plane with the thoracic stiffness test: Intra and inter-operator reliability

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Introduction: The sagittal measurement of the thoracic spine mobility is fundamental data for the choice of a conservative treatment to be set for a patient with pathologies affecting this portion of the spine. There are no objective and easy-to-perform clinical tests available. The study aims to evaluate the intra- and inter-operator reliability of the Thoracic Stiffness test, a variant of the Shober test [1] used for the lumbar spine.
Methods: The TST test is performed with the subject in an upright position. Two landmarks are identified on the subject's back at the spinous processes C7 and T12. The distance in cm between the two points is measured.
The subject performs a spinal forced forward and backward bending. The distances between the two landmarks are measured again in the two limit positions. The delta between these measurements and the one taken in the neutral position was calculated. The intra-operator validation was performed by taking the measures described and repeated after 2 hours. It was not possible to repeat the measurements after a longer time because some subjects practised a treatment with exercises that could change the measurements. The inter operator validation was performed with the second assessor who took the blinded measurements immediately after the first. These measurements were performed blinded by two operators on 50 subjects. Data analysis was performed by calculating the interclass correlation and using the Pearson test. The Bland and Altman plots were created.
Results: The C7-T11 measurements in the neutral position were 30.7 ± 3.3 cm on average. Flexion Max 35.4 ± 4.0, Ext. Max 29.0 ± 3.2. The average difference between the Neutral Position and the Maximum Flexion is 4.62 cm. The average difference between the Neutral Position and Maximum Extension was 1.8 cm. The inter operator validation was performed with the second assessor who took the blinded measurements immediately after the first. The average difference between the measurements taken by the two operators was:
Neutral position = 0 Maximum Flex 0.24 cm Maximum extension 0.03 cm. The regression r indices indicate a very strong correlation for all three measures. Neutral position 0.98852. Maximum deflection 0.99218. Maximum extension 0.97452928.
Conclusion: The differences in the blinded measures taken by the two evaluators and the regression indices r show a very strong correlation. The Plots of Bland and Altman also graphically show the same result. The Thoracic Stiffness Test is reliable and allows one to obtain very important information. For patients with sagittal postural dysfunctions, objective data describing the mobility of the thoracic spine in a sagittal plan underlines the need to dedicate an adequate effort to the recovery of flexibility. The same test also allows us to evaluate the variations of the mobility that the conservative program has reached.

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O371

Surface topographic measurements of trunk asymmetry distinguishes adolescent idiopathic scoliosis stratified by severity and controls

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Introduction: Adolescent idiopathic scoliosis (AIS) is a 3 dimensional deformity of the spine that results in visible asymmetries that can be measured using surface topographic (ST) scans (e.g., back surface rotation, shoulder asymmetry, rib prominence, trunk shift, and waist crease asymmetry). This study aims to investigate if the ST measurements are able to distinguish between controls and mild, moderate and severe AIS patients.

Methods: Our spinal alignment registry has 160 AIS patients and 49 controls at present. All subjects received whole body ST scans standing with their arms at ~30° of abduction. AIS subjects also received standard of care biplanar imaging, and Cobb angle was measured. An automated analysis pipeline computed several ST measurements (Figure 1). Analysis of Variance (ANOVA) identified differences across controls, mild (10° < Cobb ≤ 25°), moderate (25° < Cobb ≤ 45°), and severe (45° < Cobb) AIS patients. Post hoc paired t-tests with Bonferroni correction ($p<0.00833$) determined which groups were different.

Results: AIS patient cobb angles averaged 40.4° (range: 10°-93°; StDev: 19.4°). Means and standard deviations for each group for each ST parameter, and ANOVA p value, are reported in Table 1. ANOVA demonstrated significant differences across groups for all measures. Post hoc tests on Table 2 showed that 3 or more ST parameters were different for every pairwise comparison except controls vs. mild AIS.

Conclusions: This study establishes the normative ST values for controls and AIS patients stratified across severity. The ST measures studied demonstrated significant differences across groups (ANOVA, $P<0.001$). Further, ST parameters were different for every pairwise comparison except controls vs. mild AIS. This normative data may be used for comparison with other ST outcomes and as a metric for severity of AIS. Our data suggest that ST may be an effective method for scoliosis screening and monitoring progression of scoliosis.

Acknowledgements: Funding support for this project was provided by the Leon Root Chair in Pediatric Orthopaedic Surgery at the Hospital for Special Surgery (HSS), the Hospital for Special Surgery Lerner's Children's Pavilion Research Fund, the Foundation Yves Cotrel Basic Science Research Grand, the Neumann Family Fund Foundation, and the Professor Rahamimoff Travel Grant for Young Scientists of the US-Israel Binational Science Foundation. Physical space was provided by the HSS Dept. of Radiology, and construction costs were supported by HSS.

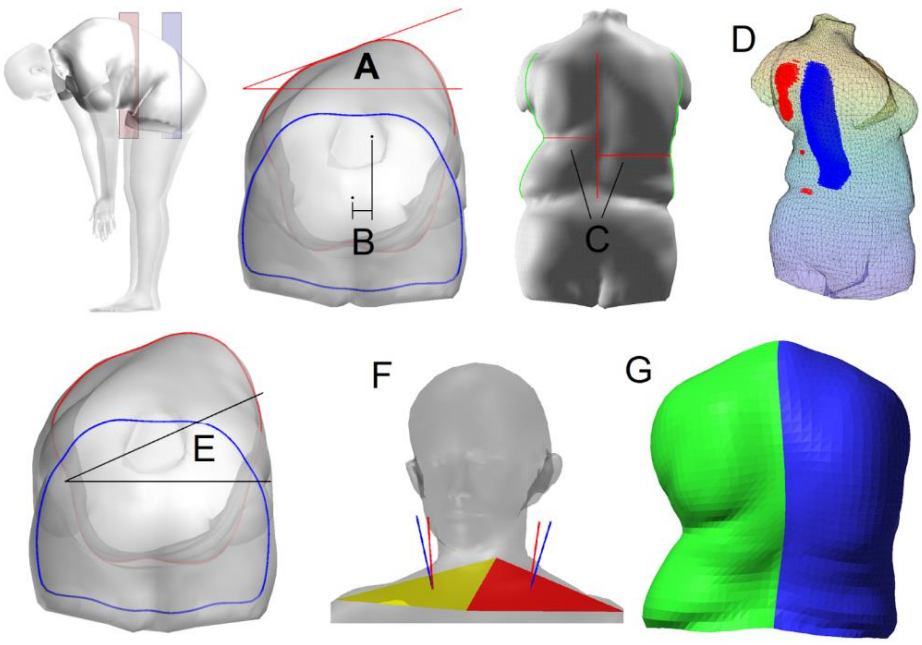

Figure 1: Surface topography measurements. A. Back Surface Rotation B. Trunk Lateral Shift C. Waist Crease Lateral Asymmetry D. Rib Prominence E. Max Trunk Rotation F. Shoulder Normal Asymmetry G. Back Area Asymmetry

Table 1: Mean values and standard deviations of surface topographic measurements in controls, mild, moderate and severe AIS subjects and ANOVA p value.

Measure	Control, N = 49	Mild AIS, N = 46, Cobb: 16.3° (10.0°-24.5°)	Moderate AIS, N = 37, Cobb: 36.0° (25.5°-45.0°)	Severe AIS, N = 73, Cobb: 58.2° (45.4°-92.6°)	ANOVA
BSR max (°)	4.18 (1.59)	5.24 (1.79)	7.54 (2.89)	9.75 (3.60)	<0.001
Back Area Asymmetry	1.47 (1.36)	2.45 (1.78)	2.78 (2.01)	6.51 (3.76)	<0.001
Trunk Lateral Shift (mm)	9.00 (4.35)	11.87 (6.75)	15.64 (7.67)	17.81 (7.41)	<0.001
Max Trunk Rotation (°)	5.82 (3.10)	6.65 (4.19)	8.84 (3.79)	14.50 (5.83)	<0.001
Rib Prominence (L)	0.11 (0.07)	0.11 (0.09)	0.17 (0.08)	0.26 (0.11)	<0.001
Shoulder Normal Asymmetry (°)	5.10 (3.23)	5.04 (3.84)	6.61 (4.89)	10.01 (6.41)	<0.001
Waist Crease Asymmetry (cm)	0.74 (0.62)	1.07 (0.79)	1.81 (1.20)	2.55 (1.56)	<0.001

N:number of subjects

Table 2: Post hoc multiple comparison test with Bonferroni correction. * Indicates $p<0.00833$ and statistical significance.

Measure	C vs. Mi	C vs, Mo	C vs. S	Mi vs. Mo	Mi vs. S	Mo vs. S
BSR max (°)		*	*	*	*	*
Back Area Asymmetry			*		*	*
Trunk Lateral Shift (mm)		*	*		*	
Max Trunk Rotation (°)		*	*		*	*
Rib Prominence (L)			*	*	*	*
Shoulder Normal Asymmetry (°)			*		*	*
Waist Crease Lateral Asymmetry (cm)		*	*	*	*	*

C: Control; Mi: Mild AIS; Mo: Moderate AIS; S: Severe AIS; BSR: Back Surface Rotation

O372

Surface topographic measurements of trunk asymmetry distinguishes adolescent idiopathic scoliosis in different regions (thoracic, thoracolumbar, and lumbar) and controls

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Introduction: Adolescent idiopathic scoliosis (AIS) is a 3 dimensional deformity of the spine, with an apex that may occur in the thoracic, thoracolumbar or lumbar region. The appearance of these curve regions may vary depending on the surface deformities of each patient. This study investigates whether control patients can be differentiated from those with thoracic, thoracolumbar or lumbar AIS using surface topographic measurements.

Methods: We recruited 209 subjects (160 AIS patients and 49 controls) to participate in this study. Surface topographic scans were taken using a 30 camera whole body scanner with subjects in the A pose with their arms abducted to about 30 degrees. Cobb angle was measured on standard of care biplanar radiographs for AIS patients. We computed several surface topographic measurements with an automated analysis pipeline (Figure 1). ANOVA was used to determine differences between controls, thoracic (apex T2 to T11), thoracolumbar (apex T12 and L1), and lumbar (apex L2 to L4) AIS patients. We differentiated groups using post hoc multiple comparison tests with Bonferroni correction.

Results: AIS patient cobb angles averaged 40.4° (10°-93°; Standard deviation: 19.4°). Means, standard deviations, and ANOVA test results are reported for each surface topographic scan in Table 1. One-way ANOVA demonstrated significant differences between groups for each ST measurement. Post hoc tests indicating differences between curve locations are reported in Table 2. The most significant differences were noted between thoracic and thoracolumbar, and thoracic and lumbar regions.

Conclusions: Back surface rotation, trunk lateral shift, and waist crease asymmetry are able to distinguish all AIS curve regions from controls, suggesting that these ST measures are sensitive to all curve locations. Back area asymmetry, rib prominence, and shoulder normal asymmetry are different in thoracic versus all other curve locations, suggesting that these ST measures are most sensitive to thoracic curves.

Acknowledgements: Funding support for this project was provided by the Leon Root Chair in Pediatric Orthopaedic Surgery at the Hospital for Special Surgery (HSS), the Hospital for Special Surgery Lerner's Children's Pavilion Research Fund, the Foundation Yves Cotrel Basic Science Research Grand, the Neumann Family Fund Foundation, and the Professor Rahamimoff Travel Grant for Young Scientists of the US-Israel Binational Science Foundation. Physical space was provided by the HSS Dept. of Radiology, and construction costs were supported by HSS.

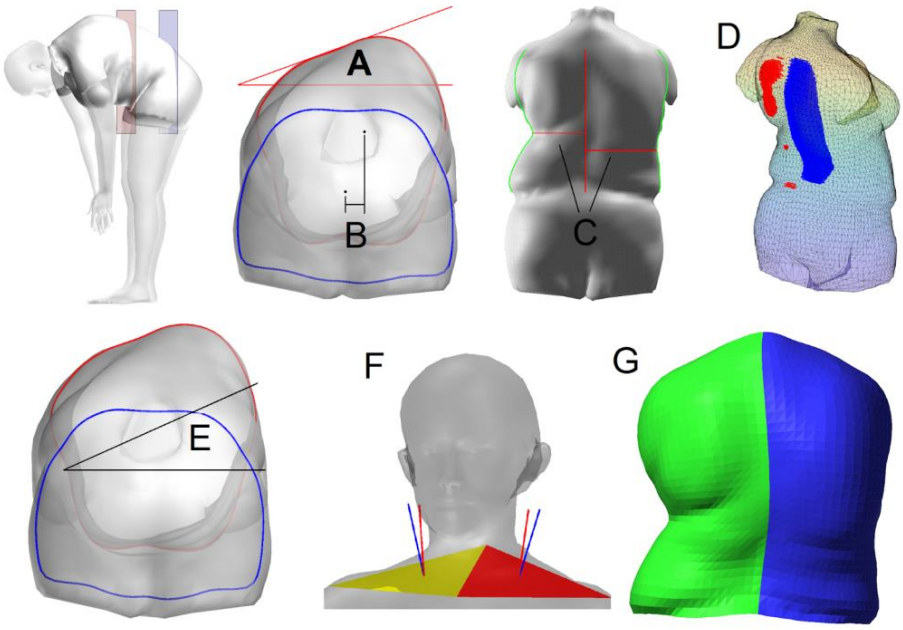

Figure 1: Surface topography measurements. A. Back Surface Rotation B. Trunk Lateral Shift C. Waist Crease Lateral Asymmetry D. Rib Prominence E. Max Trunk Rotation F. Shoulder Normal Asymmetry G. Back Area Asymmetry

Table 1: Mean values and standard deviations of surface topographic measurements in controls, thoracic, thoracolumbar, and lumbar regions, and ANOVA p value.

Measure	Control N = 49	Thoracic AIS, N = 96, Cobb: 46.5° (10.3°-92.6°)	Thoracolumbar AIS, N = 36, Cobb: 32.4° (10.0°-69.5°)	Lumbar AIS, N = 24, Cobb: 27.7° (10.0°-55.3°)	ANOVA
BSR max (°)	4.18 (1.59)	7.98 (3.57)	8.24 (3.92)	7.02 (2.88)	<0.001
Back Area Asymmetry	1.47 (1.36)	5.59 (3.68)	2.25 (2.21)	3.04 (2.08)	<0.001
Trunk Lateral Shift (mm)	9.00 (4.35)	14.70 (6.91)	16.58 (8.25)	17.35 (9.37)	<0.001
Max Trunk Rotation (°)	5.82 (3.10)	12.19 (6.11)	12.19 (6.11)	6.9 (4.20)	<0.001
Rib Prominence (L)	0.11 (0.07)	0.22 (0.12)	0.14 (0.09)	0.13 (0.09)	<0.001
Shoulder Normal Asymmetry (°)	5.10 (3.23)	9.38 (6.33)	4.56 (3.05)	5.94 (4.29)	<0.001
Waist Crease Asymmetry (cm)	0.74 (0.62)	1.88 (1.44)	2.25 (1.50)	1.68 (1.23)	<0.001

Table 2: Post hoc multiple comparison test with Bonferroni correction. * Indicates $p<0.00833$ and statistical significance.

Measure	C vs. T	C vs. TL	C vs. L	T vs. TL	T vs. L	TL vs. L
BSR max (°)	*	*	*			
Back Area Asymmetry	*			*	*	
Trunk Lateral Shift (mm)	*	*	*			
Max Trunk Rotation (°)	*	*			*	
Rib Prominence (L)	*			*	*	
Shoulder Normal Asymmetry (°)	*			*	*	
Waist Crease Lateral Asymmetry (cm)	*	*	*			

C: Control; T: Thoracic Region; TL: Thoracolumbar; L: Lumbar Region

O373

Medication for osteoporotic vertebral fracture: Can imminent fracture risk be reduced?

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Introduction: Osteoporotic vertebral body fracture (VFx) risk is markedly elevated within the next 12 months following the initial VFx. However, little information is available regarding the efficacy of osteoporosis medications on “imminent risk” of VFx following the fresh VFx. In this study, we performed longitudinal analysis on bone mass in vertebrae adjacent to the fractured vertebra by quantitative computed tomography (QCT) measurement to compare the therapeutic efficacy of teriparatide (TPD) or alendronate (ALN) on imminent risk of VFx.
Methods: A non-blind randomized controlled trial. Total of 23 Japanese female treatment-naïve primary osteoporosis patients who injured a single-level thoracolumbar osteoporotic VFx were enrolled. Either TPD (20 μg/day) or ALN (35 mg/week) was commenced within 2 weeks after VFx. QCT analysis was performed on cranial and caudal vertebral bodies adjacent to the fractured vertebra before treatment and 6 months after the treatment.
Results: Percent changes in volumetric bone mineral density of trabeculae bone over a 6-month period following the initial fracture in cranial vertebral body adjacent to fractured vertebra were 13.0 ± 5.4 % and -3.2 ± 6.0 % for the TPD and the ALN groups respectively and those in caudal vertebral body were 6.9 ± 5.4 % and –9.2 ± 6.3 % for the TPD and the ALN groups respectively. DXA study showed that percent changes in BMD of L2-4 lumbar spine over a 6-month period were 6.1% and 2.2 % in average for the TPD and ALN groups respectively.
Conclusions: TPD therapy may reduce risk of imminent VFx after fresh VFx but ALN therapy may not. The reason for the bone loss in adjacent vertebrae despite ALN therapy may be due to significant bone loss caused by immobilization of the fracture site, low physical activity, and impaired load transmission through the failed disc/endplates during the post-fracture period.

O374
Characteristics of a spinal sagittal malalignment in patients with osteoporosis

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Introduction: Patients with osteoporosis often report intermittent low back pain (LBP). Several factors, including high bone turnover, vertebral fractures, and low muscle mass, are reported risk factors associated with both LBP and osteoporosis. Especially, we focused on spinal sagittal malalignment in patients with osteoporosis. In this symposium, we would like to introduce two clinical research projects about spinal sagittal malalignment.

The prevalence and characteristics of a spinal sagittal malalignment in patients with osteoporosis

Aim: To elucidate the prevalence and characteristics of spinal sagittal malalignments in patients with osteoporosis.

Materials and Methods: 259 patients with osteoporosis were included in this study. SVA, PT, and PI-LL were measured in addition to the number of vertebral fractures. According to the SRS-Schwab classification, SVA>40 mm, PT>20 degrees, or PI-LL>10 degrees defined a spinal sagittal malalignment. The prevalence of a spinal sagittal malalignment was evaluated by the number of vertebral fractures. In patients without vertebral fractures, we assessed five functional scores of the JOABPEQ for LBP scores and compared between malalignment and normal alignment group.

Results: 205 out of 260 (78.8%) patients had a spinal sagittal malalignment. The prevalence of a spinal sagittal malalignment in patients with 0, 1, or ≥1 vertebral fractures was 71.5%, 86.0%, and 86.3%, respectively. All 5 JOABPEQ functional scores in the spinal sagittal malalignment group were significantly lower than those in the normal alignment group ($p<0.05$).

Conclusion: In the current study, the majority of patients with osteoporosis had a spinal sagittal malalignment, and even in patients without vertebral fractures, more than 70% patients have spinal sagittal malalignment. Additionally, patients with osteoporosis and a spinal sagittal malalignment had LBP. These findings suggest that a spinal sagittal malalignment is one potential risk factor for LBP in patients with osteoporosis.

The risk factors of spinal sagittal malalignment in patients with spinal diseases

Aim: To better understand the patho-mechanism and natural course of spinal alignment, the effect of factors such as muscle mass and strength on spinal sagittal malalignment were determined in a multicenter cross-sectional study.

Methods: After excluding metal implant recipients, 1823 of 2551 patients (mean age: 69.2±13.8 years; men 768, women 1055) were enrolled. Age, sex, past medical history (Charlson comorbidity index), body mass index (BMI), grip strength (GS), and trunk muscle mass (TM) were reviewed. Spinal sagittal malalignment was determined by the SRS-Schwab classification. Multiple comparison analysis among four groups (Normal, Mild, Moderate, Severe) and multinomial logistic regression analysis were performed.

Results: On multiple comparison analysis, with progressing spinal malalignment, age in both sexes tended to be higher, further, TM in women and GS in both sexes tended to be low. On multinomial logistic regression analysis, age and BMI were positively associated with spinal sagittal malalignment in Mild, Moderate, and Severe groups. TM in Moderate and Severe groups and GS in the Moderate group were negatively associated with spinal sagittal malalignment.

Conclusion: Aging, obesity, low TM, and low GS are potential risk factors for spinal sagittal malalignment. Thus, early intervention for muscles, such as exercise therapy, is needed.

O375
Surgical strategy for osteoporotic vertebral fracture based on multicenter cohort study

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Introduction: In the majority of osteoporotic vertebral fractures (OVFs), the associated pain gradually subsides as bony union and stability progress with conservative treatment. However, some patients present with intractable back pain for prolonged periods of time, while others suffer from severe back pain or neurological deficits that develop within a few months after the fracture. However, the surgical strategy remains controversial. Therefore, the purpose of this study is to investigate the effective treatment strategy for osteoporotic vertebral fractures based on our previous papers.
Methods: We have conducted 3 cohort studies previously. The first study was performed between 2005-2007 to investigate the risk factors for poor outcome of conservative therapy. Second one between 2012-2015 was to reveal the time course of MRI. Third one between 2015-2018 was to reveal the efficacy and limitation of BKP.
Results: Posterior wall injury, high intensity (similar to cerebrospinal fluid) or diffuse low intensity areas on T2-weighted magnetic resonance imaging were associated with delayed union and residual intractable back pain. BKP for the patients with these risk factors were effective. A decrease in ADLs occurred in 5.6% of patients in the BKP group and 26.7% of patients in the conservative treatment group ($P<0.001$). However, angular motion ≥14°, endplate deficit, and split type fracture was the highest risk factor for revision surgery.
Conclusions: ADLs, quality of life, and vertebral deformity showed greater improvement with BKP intervention for fresh OVF with poor prognostic factors than with conservative treatment at 6 months after injury. However, a split type fracture, angular motion ≥14° and large endplate deficit (>3 mm) are risk factors for revision surgery after BKP. Treatment strategies for patients with these risk factors should be carefully evaluated, considering the inherent difficulties in performing revision surgery after BKP.

O376

Analysis of treatment effect with teriparatide on device-related vertebral osteopenia after lumbar spinal interbody fusion using Hounsfield unit values

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Introduction: No effective method for preventing device-related osteopenia in the vertebrae has been reported. The aim of the present study was to investigate the effect of teriparatide on device-related vertebral osteopenia after single lumbar spinal interbody fusion and compare osteopenia in fused and non-fused spinal segments using Hounsfield unit (HU) values.
Methods: The present study was a retrospective cohort study. We reviewed 68 consecutive patients (28 men and 40 women) who underwent single-segment (L4–5) transforaminal lumbar interbody fusion (TLIF) with cage and pedicle screw fixation. The patients were divided into two groups according to whether they were treated with teriparatide (teriparatide and non-medication groups). The primary outcome measure was HU values measured on CT images from each L1 to S1 vertebral body12-month postoperatively. Secondary outcome measures were femoral neck bone mineral density (BMD), T-score, osseous union, and clinical outcomes using the Japanese Orthopedic Association (JOA) scoring system 12-month postoperatively.
Results: There were significant decreases in HU values of lumbar vertebral bodies at all levels and BMD and T-score values obtained using dual-energy X-ray absorptiometry (DEXA) of the femur between preoperative and postoperative 12-month CT in the non-medication group ($P<0.05$). On the other hand, there were no significant differences between preoperative and postoperative 12-month HU values of each lumbar vertebral body and BMD values of the femur in the teriparatide group. Osseous fusion scores in the teriparatide group were significantly better than those in the non-medication group. There were no significant differences in postoperative Japanese Orthopedic Association scores between the two groups.
Conclusions: Administration of teriparatide during the perioperative period may prevent bone loss associated with spinal fusion surgery.

O377
Screw fixation techniques and augmentation methods in osteoporotic spine

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Introduction: Osteoporosis is a common disease in elderly population and is a major public health problem worldwide. It is not uncommon for spine surgeons to perform spinal instrumented fusion surgeries for osteoporotic patients. However, in patients with severe osteoporosis, instrumented fusion may result in screw loosening, implant failure or nonunion because of poor bone quality and decreased pedicle screw stability, and increased graft subsidence risk. In addition, revision surgeries to correct previously failed instrumentation are progressively more common in patients with osteoporosis. Therefore, techniques to enhance the fixation of pedicle screws are required in the spinal surgeries for osteoporotic patients.
Methods: We reviewed the current surgical strategies for screw fixation and augmentation in osteoporotic spine and discussed their indication and effectiveness. Usefulness of pre-/post-operative drug administration for osteoporosis to enhance pedicle screw stability and spinal fusion was also reviewed.
Results: In surgeries for osteoporotic spine, the number of pedicle screw placements and the number of fusion levels should be considered to obtain sufficient spinal stability and rigid internal fixation. It is also important to evaluate preoperatively not only bone quality but also fusion/ankylosis of the spine in adjacent levels, global alignment as well as patient's daily activity.
Various optional instruments, such as spinal hook, sublaminar wiring/band and S2AI screw are available for augmentation of the pedicle screw fixation. Modified screw trajectories, such as cortical bone trajectory (CBT) screws, penetrating endplate screws and hooking screws can be beneficial for increasing the screw stability. Other materials, including polymethylmethacrylate (PMMA), calcium phosphate cement, hydroxyapatite stick to be inserted in prepared pedicle holes can be used to enhance the screw fixation. Many clinical investigations and biomechanical tests support the effectiveness of these augmentation methods although the clinical evidence is spare so far.
Several previous studies revealed that teriparatide administration to improve bone quality can reduce pedicle screw loosening and increase fusion rate following spinal surgeries.
Conclusions: Various techniques to enhance pedicle screw fixation can be used in spinal surgeries for patients with osteoporosis. More rigid screw fixation with effective augmentation may reduce risks of screw loosening and implant failure, and provide better postoperative clinical outcomes. Pre-/post-operative drug administration to improve osteoporosis can enhance pedicle screw stability and spinal fusion after surgery. Further translational studies should be performed to provide firm evidence for optimal surgical treatment of osteoporotic spine.

O378

Association between clinical symptoms and distribution of OPLL based on prospective nationwide study

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Introduction: Ossification of posterior longitudinal ligament (OPLL) often results in the onset and deterioration of myelopathy. However, it still remains controversial how ossification predisposition influences clinical symptoms including pain, restriction of daily activities and quality of life in patients with OPLL.
Methods: Data were prospectively collected from 16 institutions across Japan. 239 patients with cervical OPLL were enrolled. Primary outcomes were patient-reported outcomes, including visual analog scale (VAS) pain scores and other questionnaires. Whole-spine computed tomography images were obtained as radiological outcomes, and associations were studied between clinical symptoms and radiologic findings, including distribution of OPLL, the sum of the levels where OPLL was present (OP-index), and canal narrowing ratio (CNR) grade. Cervical OP-index was Grade 1 in 113 patients, Grade 2 in 90, and Grade 3 in 36.
Results: There were no significant correlations between radiologic outcomes and VAS pain scores. Cervical OP-index was linked with lower extremity function, social dysfunction, and locomotive function. CNR grade was not correlated with clinical symptoms, but Grade 4 was associated with lower extremity dysfunction.
Conclusions: Thickness and extension of ossified lesions may be associated with lower extremity dysfunction in cervical OPLL.

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O379
Long-term outcome of surgery for OPLL

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Posterior decompression surgery is usually indicated in patients with cervical myelopathy due to ossification of the posterior longitudinal ligament (OPLL), as OPLL frequently brings multi-level spinal cord compression. We have reported more than 20 years follow-up after en bloc laminoplasty for the patients with OPLL. The overall surgical outcome was satisfactory in most of the cases, however, we encountered several patients who developed postoperative neurological deterioration during follow-up period. One of the causes of neurological deterioration in the long-term follow-up was newly developed spinal cord compression by the progression of OPLL. Five % of the patients required an additional second surgery due to OPLL progression. Mixed and continuous type of OPLL have a risk of OPLL progression. In our research, several biomarkers, such as hypersensitive CRP and periostin, were related to the progression of OPLL. Thus, inflammation as well as bony activity might cause the progression. Recent papers reported the possibility to reduce OPLL progression by fusion surgery instead of laminoplasty. Postoperative radiculopathy, including C5 palsy is another issue. It has been reported that 5% of the patients have postoperative radiculopathy. We have a patient with severe arm pain after en bloc laminoplasty. She had severe neuropathic pain for more than 20 years. In my presentation, I will talk about long term outcome of posterior decompression for OPLL based on our experience and also raise some issues after surgery.

O380
Anterior versus posterior approach for ossification of posterior longitudinal ligament

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The most desirable surgical approach for degenerative cervical myelopathy has been long debated. AO Spine CSM North America and International studies revealed that both anterior and posterior decompression showed similar postoperative outcomes and rates of complications.[1] However, the studied cohort included only limited numbers of ligamentous ossification patients. Several previous comparative studies have reported conflicting results and no consensus has been established with regard to which approach is preferred for decompression of ossification of posterior longitudinal ligament (OPLL). While surgical approach must be determined on case-by-case basis, there are a few scenarios in which one specific approach should be considered over the other. In addition to the radiologic determinants in cervical spondylotic myelopathy, OPLL features that need specific attention include 1) OPLL type (segmental vs. continuous), 2) OPLL size and its occupying ratio, and 3) cervical alignment. The single most useful method that incorporates these factors for the assessment is modified K-line.[2] Anatomical challenges associated with anterior approach including dural ossification should be also well recognized pre-operatively.

	Anterior approach	Posterior approach
Options	Anterior corpectomy and fusion Vertebral body sliding osteotomy	Laminectomy and fusion Laminoplasty
Pros	Direct removal of OPLL	Multilevel decompression
	Lordosing effect	
Cons	Anatomical challenges	Contraindicated for severe anterior compression (hill-shaped, occupying ratio > 60%, K-line negative)
	Dural tear related to ossification	C5 palsy
	Adjacent segment degeneration	Surgical site infection
	Visible scar in the front	Axial neck pain
	Dysphagia/Dysphonia	
	Pseudarthrosis	

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O381
Current interpretation and usage of MEPs

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Introduction: The surgery for the Ossification of the posterior longitudinal ligament (OPLL) is high risk spine surgery. Because OPLL surgeries have high occurrence rate of neurological deficit after surgery so far. To avoid this complication, we should use transcranial motor-evoked potentials (MEPs). In my presentation, I would like to show the data regarding MEPs for OPLL surgery.
Methods: We reviewed the previous published data from nationwide multicenter cases in which MEPs monitoring was used in OPLL (cervical and/or thoracic). The items for review were 1) the occurrence rate of neurological deficit, 2) the validity of alarm point (more than equal 70%), 3) the alert timing which we should care, 4) the factors which related to poor baseline waveform derivation in MEPs.
Results: The occurrence rate of postoperative motor deficits was 2.4% (cervical) and 11.9% (thoracic). The sensitivity was 100%, specificity was 86.9%. Highest alert timing was corpectomy in cervical OPLL and decompression in thoracic OPLL. Poor baseline wave form derivation was thoracic lesions, preoperative motor deficit of MMT < 3, surgery for OPLL.
Conclusions: Based on our results, we could show the background of the reason why we need to use it. We strongly recommend using MEPs for OPLL surgeries. We believe usage of MEPs must be safety for patients with OPLL as well as spine surgeon.

Acknowledgements: We thanks to all of spinal cord monitoring working group members of the Japanese society for spine surgery and related research.

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O382
Study of sacral lateral tilt in the idiopathic scoliosis patients with Lenke type 5 curve

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Introduction: Studies on sacral lateral tilt in idiopathic scoliosis are few and still unclear. Some reports suggested a relationship between the lumbar curve in the patients with adolescent idiopathic scoliosis (AIS) and the sacral lateral tilt, but the details were unknown. In this study, we reported our observations of sacral lateral tilt before and after anterior spinal fusion (ASF) for Lenke type 5 curve.
Methods: The subjects were 67 AIS patients (mean age 16 years, 7 males and 65 females) who underwent ASF for Lenke type 5 curve between 2007 and 2018 and were observable for at least 2 years, with a mean observation period of 60.8 months (24-134). The radiographic parameters including thoracolumbar/lumbar curve Cobb angle (L), L4 tilt, sacral tilt (ST): the angle formed by a line touching the lowest point of the right and left sacral wing and the horizontal line, femoral head reference angle (FHRA): the angle formed by a line touching the most cephalad aspect of both femoral heads and the horizontal line, sacral obliquity angle (SOA): ST minus FHRA, were measured at preoperative and final follow-up from the standing posteroanterior X-ray radiograph. The t test was used to compare preoperative and final follow-up parameters. In addition, the ratio of the lower end vertebra (LIV) = L4 were compared between the two groups divided by median value of ST (chi-square test). The correlation between radiographical parameters and SRS-22 scores at final follow-up were also investigated. The level of significance was set at $p = 0.05$.
Results: The value of parameters (preoperative / final follow-up,p) were, L: 45.0±9.3/12.8±9.0,$p<0.001$; L4 tilt: 22.5±5.2/1.4±6.1, $p<0.001$; ST: 6.7±3.2/4.2±2.8, $p<0.001$; FHRA: 0.86±1.4/0.24±1.3, $p<0.001$; SOA: 5.7±2.9/3.9±2.6, $p<0.001$. The value of all parameters were significantly decreased at final follow-up. The median value of ST was 6˚, then the patients were divided into < 6˚ group (n = 30) and ≥ 6˚ group (n = 37). The ratio of the LIV = L4 were significantly higher in ≥ 6˚ group (69%) than that in < 6˚ group (40%), $p = 0.0062$.
No correlation was obtained between each radiographical parameter and SRS-22 scores, however, in case of subanalysis with patients who has been followed for more than 5 years (n = 34), functional domain significantly correlated with ST and SOA, correlation coefficient was -0.47 ($p = 0.02$) and -0.42 ($p = 0.03$) respectively.
Discussion: Current study demonstrated that the mean value of ST which indicate lateral tilting angle of upper part of sacrum including S1 endplate was 6.7˚, the mean value of SOA which shows anatomical lateral tilting of sacrum in the pelvis excluding the effect of tilting caused by the difference of femoral head position was 5.7˚, and ST and SOA decreased through the ASF. High value of ST would be a cause of lower position of LEV (i.e. LEV = L4) in lumbar curve. Moreover, lateral tilting of sacrum could be a pathology which cause functional disability in postoperative AIS patients.

O383

Non Fusion Anterior Scoliosis Correction (NFASC) for double sided Adolescent Idiopathic Scoliosis (AIS) curves in Skeletally Mature children: Clinico-Radiological outcomes with 2 years follow up

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Introduction: Nonfusion anterior scoliosis correction (NFASC) offers a dynamic fusionless correction option for children with adolescent idiopathic scoliosis (AIS). Existing clinical studies have evaluated the role of anterior vertebral body tethering in double-sided AIS curves in skeletally immature children done as a single staged procedure and raised concerns over respiratory complications, blood loss, and increased usage of post-op opioid consumption and length of stay (LOS). We hypothesize that the application of novel NFASC in skeletally mature children (Risser ≥4 and Sanders ≥7) with double-sided AIS curves done through a staged procedure reduces respiratory complications, cord breakage, post-op opioid consumption, and reduced LOS.

Methods: A prospective analysis of 10 skeletally mature AIS patients with double curves who underwent NFASC with a minimum of 2 years follow-up was included in the study. Pertinent clinical and radiographic data collected include skeletal maturity, curve type, Cobb angle, sagittal parameters, and patient-reported outcome measure SRS-22 questionnaire.

Results: 9 females and 1 male were included in the cohort and their mean age was 15.2±1.52 years (Range:13-21 years). The mean Sanders score was 7.3±0.4 and the mean Risser score was 4.1±0.3. There were 5 patients in each Lenke 3 and Lenke 6. Cranial and caudal instrumentation levels were T5 and L4. The mean blood loss was 102.3 ±10.4 ml, and the mean operative time was 169.0 ±14.2 mins. The average LOS was 4.5±1.01 days. Mean pre-op main thoracic (MT) and thoracolumbar/lumbar (TL/L) cobbs were 54°±6° and 53.5°±10.9° which got corrected to 18°±3.4° (66% correction) and 15.3°±2.4° (70% correction) respectively. At two years follow up, the MT and TL/L curves were stabilized at 17.4°±2.6° and 16.5°±1.5° respectively. No neurologic, cardiopulmonary-related, and or implant-related complications were recorded. Mean SRS-22 score pre-op and post-op were 3.5 ± 0.3 and 4.5 ± 0.1, respectively ($p<0.01$).

Conclusions: Double-sided NFASC provided 67% correction for MT (54° to 17.4) and 68 % correction for TL/L curve (53.5° to 17.4°) at 2 years follow up with no major complications. Staging procedure and post op pain management with epidural reduces opioid consumption and improve pain scores and reduces LOS.

O384

Effect of enhanced recovery pathway (ERP) resulting in reduced length of stay (LOS) and opioid consumption after non-fusion anterior scoliosis correction (NFASC) surgery for adolescent idiopathic scoliosis (AIS): A single centre experience

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Introduction: There have been several reports on enhanced recovery pathway (ERP) in patients undergoing posterior spinal fusion (PSF) for Adolescent Idiopathic Scoliosis (AIS) resulting in early recovery and mobilization, decreased usage of opioids, early discharge and overall improved patient satisfaction. However, there is paucity of literature emphasizing its role in AIS patients undergoing non fusion anterior scoliosis correction surgery (NFASC). NFASC for AIS is a major surgical procedure and may be associated with significant postoperative pain and increased opioid consumption. ERP is a multidisciplinary approach aimed to expedite rapid recovery, reduced LOS, and minimizes morbidity associated with NFASC surgery.
Methods: Retrospective analysis of 35 AIS patients who underwent NFASC with Lenke 1 and Lenke 5 curves with a minimum of 1 year of follow up was done. Patient demographics, surgical details, postoperative analgesia, mobilization, length of stay (LOS), patient satisfaction survey score with respect to information and care, and 90 days complications were collected.
Results: The cohort included 34 female and 1 male. The mean age at the time of surgery was 15.2 years (11-18 years). Mean Sanders score was 6.8±0.6 and mean Risser score was 4.2±0.5. There were 16 Lenke 1 and 19 Lenke 5 in the study. Mean pre operative major thoracic and thoracolumbar/lumbar Cobb's angle were 52˚±7.6˚ and 51˚±4.5˚ respectively. All underwent tethering with upper instrumented vertebra being D5 and lower instrumented vertebra being L4. Average blood loss during surgery was 102 ±6.4 ml and average surgical time was 168 ± 10.2 mins. The average time to commencing solid food was 6.5±1.5 hrs. The average time to mobilization following surgery was 15.5± 4.3 hrs. The average duration to stopping of epidural was 42.5±3.5 hrs. The average dose of opioid consumption intraoperatively was 600.5±100.5 mcg of fentanyl intravenous (IV) and 12.5±4.5 mg morphine IV Post operatively opioids were administered via an epidural catheter at a dose of 2 mg of morphine every 24 hours up to 2 days and an infusion of 2mcg/ hour of fentanyl along with 0.12-0.15% ropivacaine. The average duration to transition to oral analgesia was 55.5±8.5 hours. 20 patients had urinary catheter and the average time to removal of catheter was 17.5±1.4 hours. 25 patients had chest tube and the average time to removal of chest tube was 25.5±3.2 hours. The average length of hospital stay was 3.1±0.5 days. No patient had postoperative ileus or requirement of blood transfusion or any other complications. No correlation was found between LOS and initial cobb angle.
The average patient satisfaction score for both information and care were 8.9 ± 0.5 and 9.1 ± 0.4 respectively.
Conclusion: Our study shows promising results on application of ERP in AIS patients undergoing NFASC with reduced LOS and indirectly the cost, reduced post operative opioid use, early mobilization, enhance patient recovery, and overall improve patient satisfaction score.

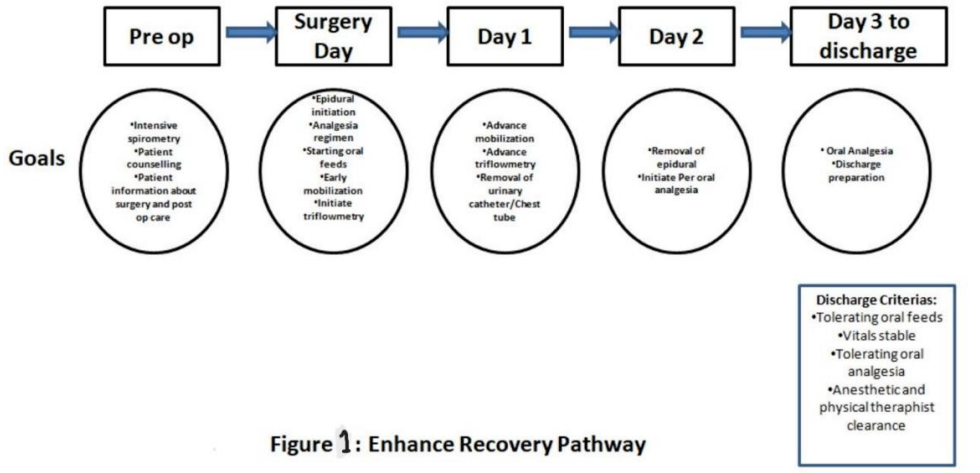

Figure 1: Enhance Recovery Pathway

O385

Selection of the appropriate parameter to measure sacral tilt in Lenke type 5C adolescent idiopathic scoliosis

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Introduction: Adolescent idiopathic scoliosis (AIS) Lenke type 5C has mainly thoracolumbar/lumbar (TL/L) curve. It has been reported that pelvic obliquity (PO) was a risk factor of the postoperative coronal decompensation in corrective surgery, PO is of importance when planning surgical treatment. Iliac obliquity (IO), the parameter of iliac tilt, is often used as a pelvic parameter in past reports. Nevertheless, IO does not reflect the possible presence of sacroiliac joint compensatory motion and iliac and sacral asymmetry. Meanwhile, sacral tilt directly affects coronal balance in scoliosis and is influenced by the shape of the sacroiliac joints and the sacrum. We suppose sacral obliquity (SO), which expresses sacral tilt, is an appropriate pelvic parameter in AIS. However, the method of measuring PO has not been established yet.
Aim: The primary aim was to establish an appropriate pelvic parameter measurement method and the additional aim was to investigate the magnitude of pelvic parameters on the coronal balance in patients with AIS Lenke type 5C.
Patients and Methods: Thirteen patients underwent corrective surgery from August 2014 to July 2021 in our hospital were included in this study. Their demographic and radiological data was collected preoperatively. Cobb angle, L5 tilt, C7PL-CSVL, and lower limb discrepancy (LLD) were measured on the standing whole spine X-ray PA view. Sacral obliquity (SO), the slope of the upper endplate of S1, and iliac obliquity (IO), the tilt of the line connecting the iliac crests, were measured on the standing/supine X-ray and computer tomography (SO/IO-standing, SO/IO-supine, SO/IO-CT, respectively). S1 angle and S2 angle were the angle of upper and lower endplates of S1/S2 measured on CT.
Results: The mean age was 18.5 ± 4.0 years, and all of them were females. Cobb angle was 45.7°± 6.4°, L5 Tilt was 13.4°± 3.5°. S1 angle was 5.5°± 3.4°, S2 angle was 0.9°± 2.3°. S1 angle was significantly greater than S2 angle ($p < 0.001$). Cobb angle and C7PL-CSVL had no correlation with any pelvic parameters. SO was greater than IO for all measurement methods. SO-standing was highly correlated with SO-CT ($rs = 0.825$, $p = 0.001$). L5 tilt had high correlations with SO-standing ($rs = 0.789$, $p = 0.001$), SO-supine ($rs = 0.799$, $p = 0.001$), and SO-CT ($rs = 0.876$, $p = 0.001$); meanwhile, L5 tilt was correlated poorly with IO-standing and IO-supine, and moderately with IO-CT ($rs = 0.427$, $p = 0.145$). S1 angle was also correlated well with SO-CT ($rs = 0.876$, $p < 0.001$), and L5 tilt ($rs = 0.600$, $p = 0.030$).
Conclusion: The mean S1 angle was 5.5°, indicating that S1 is an asymmetric vertebra in this series. S1 angle had good correlations with SO-CT and L5 tilt, so that S1 asymmetry is considered one of the main causes of pelvic tilt. SO correlates better with L5 tilt than IO. These findings suggest that SO is more appropriate for pelvic parameter than IO. The weakness with measuring SO is its low visibility on standing X-P, but measurement on CT may be useful.

O386

Automated measurement of spinal alignment for scoliosis using deep learning

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Introduction: Spinal alignment is an important factor to evaluate scoliosis. However, manual measurement is complicated and time-consuming. There is another problem of inter-rater measurement error. There are few studies that measured multiple radiographic parameters in scoliosis using deep learning.
Aim: To automate the measurement of spinal parameters in scoliosis patients using deep learning.
Patients and Methods: We included 1197 whole-spine images (696 frontal and 501 lateral) from 434 patients with scoliosis. Congenital scoliosis was excluded from this study. Two spine surgeons labeled 4 vertices of the vertebrae from C7 to S1 that were defined as the ground truth. Several parameters (main thoracic curve (MT), coronal balance, T1 tilt, thoracic kyphosis (TK), lumber lordosis (LL), sacral slope (SS), pelvic incidence (PI)) were calculated based on the landmarks. We divided the dataset into training and test data by the 5-fold cross-validation method for the AI model. Errors between the ground truth and the AI measurement were calculated.
Results: Based on the ground truth, main thoracic curve (MT) was 29°± 21° (mean±SD), coronal balance was -14 ± 34 pixels, and T1 tilt was 1.0°± 7.8°. As for sagittal parameters, thoracic kyphosis (TK) was 31° ± 14°, lumbar lordosis (LL) was -49° ± 12°, and sacral slope (SS) was 36° ± 7.5°. The mean absolute error (MAE) between the ground truth and AI was 3.2°± 3.5° for MT, 2.9 ± 2.4 pixels for coronal balance,1.9°± 1.6° for T1 tilt. As for sagittal parameters, the MAE was 4.4° ± 3.5° for TK, 5.3° ± 4.5° for LL, and 4.3° ± 3.8° for SS. The correlation coefficient between the ground truth and AI was 0.99 for MT and 0.89 for TK.
Conclusion: The measurement error of the AI was within the range usable in actual clinical practice. The measurement of the lateral aspect is somewhat difficult and needs to be improved.

O387

Intrathecal administration of recombinant human hepatocyte growth factor for acute traumatic cervical spinal cord injury: Double-blinded, placebo-controlled and randomized phase I/II study

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Introduction: Hepatocyte growth factor (HGF) was first identified as a potent mitogen for mature hepatocytes and has gained attention as a strong neurotrophic factor in the central nervous system. We reported the therapeutic efficacy of intrathecal infusion of pharmaceutical recombinant human HGF (KP-100) for acute spinal cord injury (SCI) in animal models including non-human primate. The purpose of this study was to evaluate the safety and efficacy of intrathecal KP-100 administration for traumatic SCI patients in the acute phase.

Materials and Methods: This study was a multicenter, double-blinded, randomized, placebo-controlled, parallel-group phase I/II clinical trial and was performed from June 2014 to May 2018 at 3 high-volume SCI centers in Japan. Patients meeting the following criteria were registered: 1) cervical SCI with modified Frankel grade of A/B1/B2 at 72 hours after injury (B1: light touch preservation only at sacral segments, B2: light touch preservation at wider area, B3: pinprick preservation at sacral segments), 2) 18-75 years old. The randomization was imbalanced at 2:1, predominantly in the KP-100 group. The study drug (0.6mg of KP-100) was for the first time administered intrathecally through lumbar puncture procedures within 6 hours after registration at 72 hours after injury (Day 0) and was repeated once a week for a total of 5 times. The observation period was until 24 weeks after the primary administration (Day 168). Adverse events were evaluated during the follow-up period. Efficacy was evaluated in change from baseline in American Spinal Injury Association (ASIA) motor and sensory scores.

Results: 1) 45 subjects were divided into the two groups (28 in KP-100; 17 in placebo). The subjects did not show any serious adverse events caused by KP-100. 2) Two patients were excluded in the KP-100 group because of respiratory dysfunction after first drug administration and neurological functional analysis was performed for 43 patients (26 in KP-100; 17 in placebo). KP-100 contributed to motor improvement at several time points and the changes from baseline in the ASIA motor score were different between the KP-100 and placebo groups at Days 140 (12.6 ± 2.4 vs. 4.8 ± 3.0, P=0.050) and 168 (12.4 ± 2.4 vs. 5.3 ± 3.0, P=0.079). 3) Whereas slightly better motor improvement was observed in upper extremities in the KP-100 group compared to the placebo group without statistical significance (final scores 4.9 ± 0.9 vs 4.3 ± 1.2), significant recovery occurred in the lower extremity at Days 140 (7.5 ± 1.8 vs. 1.1 ± 2.2, P=0.031) and 168 (7.3 ± 1.9 vs. 1.3 ± 2.3, P=0.049). 4) In the subset of subjects with Frankel grade A, the proportions of subjects who gained at least 1 point on their lower-extremity motor scores were 33.3% (5/15) and 6.3% (1/16) in the KP-100 and placebo groups, respectively (P=0.083).

Conclusions: Intrathecal KP-100 is a potential therapeutic strategy for traumatic SCI at acute phase. Phase III trial (Non-randomized, single arm) has been conducted since June 2020 recruiting patients with ASIA impairment scale grade A at 72 hours after injury.

O388

iPSC-derived neural precursor cells: Potential for cell transplantation therapy in spinal cord injury

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Spinal cord injury (SCI) is a devastating event that causes permanent neurologic impairments. Cell transplantation therapy using neural precursor cells (NPCs) is a promising intervention aiming to replace damaged neural tissue and restore certain functions. Because the protocol to produce human induced pluripotent stem cells (iPSCs) was first established, we have attempted to apply this technology for regenerative therapy in SCI. Our group reported beneficial effects of iPSC-derived NPC transplantation and addressed safety issues on tumorigenicity after grafting. These findings are now tested at the clinical trial stage, the protocol of which has already been approved by the Ministry of Health, Labour and Welfare in Japan.

Current transplantation therapies treat patients at the subacute phase after injury, highlighting the need for effective treatments for chronic SCI. We have developed optimal rehabilitation protocols for animal models of chronic SCI and found that continuous treadmill training results in elevated neurotrophic and synaptic-related factors and functional recovery. Furthermore, combining rehabilitation with cell transplantation promoted neuronal differentiation and more effective recovery. Since the percentage of patients with chronic spinal cord injury is higher than that of subacute spinal cord injury, further research will be conducted to improve the probability of an effective treatment method.

O389
Augmented and mixed reality in spine surgery: Utility and limitations

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Introduction: Recent advances in navigation assisted spine surgery have certainly penetrated minimally invasive spine surgery field and now is moving towards merging of lates technologies like augmented and mixed reality. Augmented reality technology allows for a minimally invasive approach to many surgical procedures offering image-guided navigation to the surgeon in real time, in mixed reality, real and 3D rendered spine images are intertwined allowing for interaction with and manipulation of both the real and virtual environment. However due to its infancy, it is still uncertain if it will benefit patients and surgeons.
Methods: We have conducted a prospective controlled study aims to assess the effect of AR on adolescent idiopathic scoliosis surgical deformity correction outcomes and surgeons' fatigue.
Results: AIS patients scheduled for surgical deformity correction were prospectively recruited and assigned to standard or AR-supported surgery, using lightweight smart glasses. Their demographic and clinical features were recorded. Pre- and post-surgery spinal features were tracked via radiographic images. Moreover, surgery time and blood loss were recorded and compared. Finally, participating surgeons were asked to fill in questionnaires (e.g., VAS-fatigue) to compare the impact of AR on the surgeons' well-being.
Discussion: Our study highlighted enhanced outcomes for spinal deformity correction of Cobb angle, thoracic kyphosis, and vertebral rotation change in favor of AR-supported surgery. Moreover, AR resulted in a trend of reduced surgery time. Finally, fatigue scores showed consistently a significant reduction in fatigue and discomfort for the surgeons after AR-supported surgery, including eye strain, head fatigue, and concentration.

O390

A deep learning algorithm to identify cervical ossification of posterior longitudinal ligaments on radiography

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Introduction: A deep learning algorithm capable of detecting cervical ossification of the posterior longitudinal ligament (OPLL) on radiography has the potential to facilitate the provision of adequate and timely therapy. Further, it may improve patient safety and decrease radiation exposure by minimizing the need for computer tomography (CT). Hence, the purpose of present study was to validate the diagnostic yield of our deep learning algorithm created for detecting cervical OPLL on radiography, and to compare its diagnostic accuracy with that of experienced Japanese spine physicians.

Methods: A total of 486 patients (243 patients with OPLL and 243 age and sex matched controls) were enrolled in the study. The presence/absence of OPLL was confirmed via CT. The deep learning algorithm, which diagnosed the presence/absence of OPLL on cervical radiography and highlighted areas of ossification in positive cases, was constructed using a convolution neural network model. The accuracy and the area under curve (AUC) of the receiver operating characteristic curve were calculated. Subsequently, using 50 randomly selected samples, numbers of correct diagnoses were compared between the algorithm and the consensus of four spine physicians.

Results: The diagnostic accuracy of our deep learning algorithm was 0.88; and the AUC determined was 0.94 (95% confidence intervals: 0.92–0.97, $p<0.001$). In addition, our deep learning algorithm had significantly more correct diagnoses than did the spine physician consensus (47/50 versus 39/50, respectively; $p = 0.041$, Fisher's exact test).

Conclusions: The accuracy of our deep learning algorithm in the diagnosis of cervical OPLL on radiography was significantly higher than that of the experienced spinal physician consensus. The algorithm could improve physician's OPLL diagnostic accuracy by using different diagnostic criteria than physicians and may help both physicians and patients by facilitating the provision of adequate therapy with minimal radiation exposure.

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O391

Machine learning web application for predicting functional outcomes in patients with traumatic spinal cord injury following inpatient rehabilitation

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Introduction: Accurately predicting functional outcomes in patients with spinal cord injury (SCI) helps clinicians set realistic functional recovery goals and improve the home environment after discharge.

Aim: The present study aimed to develop and validate machine learning (ML) models to predict functional outcomes in patients with SCI and deploy the models within a web application.

Patients and Methods: The study included data from the Japan Association of Rehabilitation Database. Patients with SCI who were admitted to an SCI center or were transferred to a participating postacute rehabilitation hospital after receiving acute treatment were enrolled in this database. The primary outcome was functional ambulation at discharge from the rehabilitation hospital. The secondary outcome was the total motor Functional Independence Measure (FIM) score at discharge. We used binary classification models to predict whether functional ambulation was achieved, as well as regression models to predict total motor FIM scores at discharge. In the training dataset (70% random sample), using demographic characteristics and neurological and functional status as predictors, we built prediction performance matrices of multiple ML models and selected the best one for each outcome. We validated each model's predictive performance in the test dataset (the remaining 30%).

Results: Among the 4181 patients, 3867 were included in the prediction model for the total motor FIM score. The mean (SD) age was 50.6 (18.8) years, and 3245 (83.9%) patients were male. There were 3161 patients included in the prediction model for functional ambulation. The CatBoost Classifier and regressor models showed the best performances in the training dataset. On the test dataset, the CatBoost Classifier had an area under the receiver operating characteristic curve of 0.8485 and an accuracy of 0.7713 for predicting functional ambulation. Likewise, the CatBoost Regressor performed well, with an R^2 of 0.7844, a mean absolute error of 9.6529, and a root mean square error of 13.5561 for predicting the total motor FIM score. The final models were deployed in a web application to provide functional predictions. The application can be found at http://www.ortho.m.chiba-u.jp/general/4560.

Conclusion: Our prediction models developed using ML successfully predicted functional outcomes in patients with SCI and were deployed in an open-access web application.

O392

Comparison of the Cobb angle measurement between manual and digital methods among five military hospitals

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Introduction: The Cobb angle measurement of the spine is an important parameter for assessing patients with scoliosis in terms of diagnosis, treatment planning, follow-up for severity and disease progression. This angle can be obtained from a plain X-ray film in an upright posteroanterior view or can be measured from digital images. A 5° curve progression is considered clinically significant.
Methods: Using plain X- ray films of patients diagnosed with scoliosis, a comparative study of the Cobb angle measurement was conducted. A total of 120 images were recorded in a compact disc in the Digital Imaging and Communications in Medicine (DICOM) system and was used to install in computer systems of 5 military hospitals (Hospitals A, B, C, D, and E), and then was interpreted using each hospital digital PACS. The mean difference of 5° is considered clinically significant. The validity of measurements was analyzed using paired t- test for the mean equivalence. The reliability of one time measurement was also performed using Intraclass Correlation Coefficient (ICC).
Results: Both one time and an average of three times of digital measurements among Hospitals A, B, C, D and E revealed significant differences when compared with the manual measurement ($p < 0.01$). However, no clinical significance of both one time and the averaged three measurements were observed when the mean difference was less than 5°. In the combined process group (Hospitals C, D and E), a significant difference of the manual and digital measurements was observed ($p<0.01$). However, no clinical significance using both one time and averaged three time measurements was found when the mean difference was less than 5°. The data of one time digital measurements were reliable (ICC= 0.9).
Conclusions: The use of digital Cobb angle measurement is a convenient practice. A significant difference using manual and digital methods was found using both one and combined processes; however, no clinical significance was observed. One time digital measurement revealed validity as those found in three time averaged measurements.

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O393

Which spinopelvic and hip morphological parameter are risk factors for hip joint osteoarthritis in postoperative adult spinal deformity patients?

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Introduction: Few papers reported that hip joint osteoarthritis (hip-OA) would progress after spinal fusion surgery for adult spinal deformity (ASD). The purpose of this study is to investigate which spinopelvic and hip parameters are significant risk factor for hip-OA progression in postoperative ASD patients.

Methods: 100 patients (65.8 yo) who underwent surgery for ASD and 196 hip joints excluding 4 joints with previous THA were included. Radiographical measurement at preoperative and postoperative included spinal, pelvic and hip joint parameters (Acetabular roof obliquity: ARO、Central edge angle: CE). Hip-OA was evaluated by Kellgren and Lawrence system at postop 1 month, postop 2 and 5-year. Unpaired t-test, chi-square test, logistic regression analysis were used for statistical analysis ($p < 0.05$).

Results: The mean number of fixation segments was 7.2, including 68 sacroiliac joint fixation by iliac screw. Spinal parameters (postop 1 month / change between preop and postop 1 month) were TK: 27.5±12.2˚/10.7±11.3˚, LL: 41.1±12˚/34.9±19.6˚, PT: 23.1±9.4˚/-11.6±9.2˚, SS: 27.5±7.8˚/11.3±8.8˚、PI: 50.6±10.8˚/-0.44±4.8˚, scoliosis Cobb: 13.4±10.1˚/-15.3±12.5˚, SVA: 26.5±35.2mm/-81.3±67.7mm、coronal balance: 17.1±12.8mm. Hip parameters (postop 1 month) were ARO: 7.8±5.4˚、CE: 30.3±7.1˚. Hip-OA progressions were observed in 15 cases and 23 joints. The hip joints were divided into two groups depending on a progression of hip-OA (group-P) and no progression (group-N). Comparison of spinal and hip parameters between the two group indicated that sacroiliac joint fixation (group-P 91%, group-N 74%, $p = 0.045$), ARO (group-P 12.4˚, group-N 7.1˚, $p < 0.001$), CE (group-P 25.4˚, group-N 31˚, $p < 0.001$), change in PT (group-P -15˚, group-N -11˚, $p < 0.025$) and change in PI (group-P -5.4˚, group-N 0.2˚, $p < 0.001$) were parameters with significant difference. Logistic regression analysis using the above mentioned 6 parameters as independent variables revealed age (OR = 1.1, 95%CI = 1.01-1.2, $p = 0.019$), ARO (OR = 1.18, 95%CI = 1.01~1.37, $p = 0.035$), change in PI (OR = 1.25, 95%CI = 1.09~1.44, $p < 0.001$) as the factors significantly associated with progression of hip-OA.

Conclusions: This is the first study which demonstrated that AOR and decrease in PI after ASD surgery are risk factors for Hip-OA progressions. The decrease in PI after spinal fusion surgery using iliac screw has been reported by some studies. Sacroiliac joint would have varying degree of mobility among the patients, and the larger mobility would result in the lager decrease in PI after the fusion surgery using iliac screw. It is speculated that mechanical stress against hip joint had increased by the fixation of sacroiliac joint with large mobility which might buffer hip joint against mechanical stress before surgery.

O394

3D patient-matched template guides let to benefit of increased mean screw diameter and length, improving accuracy of cortical bone trajectory screws: A 5-years international experience

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Introduction: In the last years, in all field of spine surgery, many strategies were described to improve mechanical properties while preserving reduced invasiveness. Cortical bone trajectory has been initially proposed for positioning of bicortical screws in order to increase the screw's purchase with a minimal invasive approach.

Aim: The aim of this study was to analyse whether significant differences exist between free-hand 3D planning screw placement and 3D printed template guided Cortical Bone Trajectoriy (CBT) screw positioning in terms of accuracy, screw dimension and potential complications.

Patients and Methods: Data were extracted from a prospectively collected database. Adult patients fixed with CBT screws for lumbar degenerative pathologies were considered for this analysis. A group of patients in which screws were placed by using 3D planning free-hand technique (PG) were compared to a second group of patients that underwent screw positioning by using customized 3D printed template guides (TG). Screw dimension, accuracy, clinical and radiological outcomes and complications were collected and assessed in all cases.

Results: A total number of 1004 screws and 251 patients was evaluated for this study. The PG included 158 patients (632 screws) while the TG evaluated 93 patients (372 screws). The TG group involved screws of larger size from L3 to S1. Differences between the two groups concerning Raley classification, average entry point distance from the target, standard deviations, cone inclusion of the actual trajectory and screw size for each level reached statistical significance ($p \leq 0.05$) in favour of TG group. In particular TG group showed an inferior surgical time and X-ray dose. Clinical outcomes were satisfactory in both groups at the last follow-up (mean 26.2 months)

Conclusions: The use of 3D patient-matched template guides was able to safely maximize diameter and length of cortical bone trajectory screws, with sizes comparable to traditional convergent pedicle screw, getting improved accuracy of the screw placement. Following previous evidence about CBT biomechanical properties, these advantages allow to increase fixation strength over traditional convergent pedicle screw trajectories with all benefit of a minimally invasive approach.

O395

5-year radiological outcomes post interlaminar device insertion for symptomatic lumbar spinal stenosis

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Introduction: Lumbar spinal stenosis (LSS) is a common spine condition encountered during clinical practice, with likely increasing prevalence due to ageing populations. The current gold standard for symptomatic LSS is open decompression and fusion. However, that option poses its own unique set of drawbacks such as increased soft tissue morbidity and adjacent segment degeneration. This has led to the development of adjunct use of the interlaminar device (ILD) as an increasingly popular alternative which is less invasive and provides dynamic stabilisation thus reducing surgical morbidity compared to the open decompression and fusion. There are varying designs available for interlaminar and interspinous devices, all aiming to serve a common goal of limiting extension at the affected index lumbar segment and allowing for increased foraminal height and reduced disc pressure. This in return may translate into a longer symptom free interval with reduced recurrence or need for further procedures. There is a paucity in the current literature about the radiological parameters that are affected or maintained with the use of an ILD and the implications of those observations. Current literature is also limited to short term studies.
Aim: To compare and monitor several radiological indices as a surrogate marker to determine the effectiveness of the ILD insertion up to 5-years postoperatively.
Patients and Methods: A retrospective review of prospectively collected data under a single surgeon cohort study, consisting of 116 patients who underwent spinal decompression with and without an ILD insertion between 2007 - 2015 was performed. Patients who met the study criteria were offered the choice of an ILD insertion. Those who accepted an ILD insertion were placed in the D+ILD group (n=61) and underwent an additional step involving the insertion of an ILD (Coflex or Stenofix) at the involved level through the same surgical incision; while those opting for decompression alone, were placed in the DA group (n=55). All patients in both groups received the same postoperative care. Radiological indices consisting of anterior and posterior disc height, foraminal height at the level of decompression, segmental lordosis and sagittal angle were assessed both preoperatively and up to 5-years postoperatively.
Results: The D+ILD group achieved and maintained significant radiological correction at all time points for posterior disc height, foraminal height, sagittal height and L4 to S1 lordosis measured while the DA group did not attain this; implying good lateral recess restoration and neuroforaminal decompression. This in return is translated into better clinical outcome scores in the postoperative period and improvement in radiological parameters. The findings are consistent with current literature supporting the adjunct use of an ILD for reducing intradiscal pressure and stability in extension.
Conclusion: The use of an interlaminar device in conjunction with spinal decompression in patients with symptomatic LSS has been shown to offer a sustained correction in radiological parameters.

O596

Comparison of posterior and anteroposterior spinal fusion for 7 points of Load Sharing Classification - thoracolumbar vertebral fracture

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Introduction: TL AOSIS and Load Sharing Classification (LSC) have recently been used to classify and treat thoracolumbar vertebral fractures. It is said that anterior reconstruction of the vertebral body results in superior clinical outcomes for patients with an LSC score of 7 or more. However, minimally invasive posterior fusion has tended to be selected over more invasive anterior fusion due to the development of equipment and techniques. On the other hand, there is still a need for a consensus on the surgical method and extent of fixation for thoracolumbar fractures. Therefore, we compared the postoperative outcomes of patients with an LSC score of 7 in whom anterior reconstruction could not be performed due to multiple injuries.
Materials and Methods: During the survey period from April 2019 to March 2020, 29 cases with LSC 7 points (average age 54.1 years, 17 males, 12 females, affected vertebraI body Th5-L5, TL AOSIS A2-B2) were classified into a posterior fusion group (A group; 21 cases) and an anteroposterior fusion group (B group; 8 cases), and a comparative study was conducted. We examined the age, sex, operation time, blood loss, correction rate of fracture vertebral body kyphosis angle(ΔVK) and local kyphosis angle(ΔLK) before and after surgery. VK correction loss and LK correction loss at three months after surgery. One year after surgery, the NRS and ODI score was also performed for clinicaI evaluation. Statistical analysis was performed using a t-test or Mann-Whitney U-test, with a significance level of 0.05.
Results: There were no significant differences between the two groups in age, sex, ΔVK, ΔLK, VK correction loss, and LK correction loss three months after surgery, NRS, and ODI scores. Although there was no statistically significant difference between the two groups in operation time (group A; 79.0±36.5 minutes, group B; 141±94.0 minutes, P=0.14), bleeding was significantly less in group A. (Group A; 58.5±35.6 ml, Group B; 268±342 ml, P=0.01).
Conclusion: With an LSC score of 7 or higher, vertebral body collapse may be severe, and bone fragments may protrude into the spinal canal. Therefore, reconstruction of the damaged vertebral body is usually considered. In this study, the reduction was relatively maintained even when surgery was performed with posterior fusion alone in patients with LSC of 7 points. There was no significant difference between postoperative correction loss and clinical outcomes compared with anteroposterior fusion. On the other hand, posterior fusion alone resulted in significantly less blood loss than anteroposterior fusion. From this study, we suggested that even in cases where anterior reconstruction is recommended with an LSC score of 7, as in this case, there is little intraoperative invasiveness, and satisfactory treatment results can be obtained with posterior alone in the short term.

O397

Pull-out resistance of facet versus laminar C2 screws: An experimental comparative biomechanical investigation

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Background: Trans-pedicular or trans-isthmic screws for C2 instrumentation represent the gold standard; however, the anatomy is not always compatible (hypoplastic pedicles, procidentia of the vertebral artery). Alternatives have been proposed, using laminar screws or, recently, bicortical facet screws.
Research Question: To date, no biomechanical studies have compared facet *versus* laminar screws of C2. We propose a morphometric analysis and a pull-out strengths comparison of both techniques.
Study Design: *In vitro* randomized comparative biomechanical study.
Methods: Thirty-two human cadaveric C2 vertebrae beneficiated from a CT-scan imaging and a Dual X-Ray Absorptiometry before receiving both techniques, randomized according to side and sequence. Screws positioning was verified using 2D X-rays. Sixty-four mechanical tests were performed using pure tensile loading along the axis of the screws until pull-out. The mean pull-out strengths were compared using paired tests, multivariate and survival analysis (Kaplan-Meier curves).
Results: The morphometric data were consistent with previous studies. Regarding the 64 tests, the mean pull-out strength of laminar screws (707 ± 467 N) was significantly higher than that of facet screws (390 ± 230 N) ($p = 0.0004$). Bone mineral density was moderately positively correlated with pull-out strength ($r = 0.42$ for facet screws and $r = 0.3$ for laminar screws). Both techniques were mechanically equivalent when an intra-laminar cortical grip was not achievable for laminar screws. The mean pull-out strength for LS with laminar cortical grip (1071 ± 395 N) was significantly higher than that of LS without (423 ± 291 N) ($p < 0.0001$).
Discussion: Our results strongly suggest that bicortical facet screws of C2 offer less mechanical resistance (almost half lower) than laminar screws, except if the intra-laminar grip is not achievable. Alternative loading biomechanical scenarios may be investigated to further confirm these results.

O398
Paraspinal muscle morphology in patients with proximal cervical spondylotic amyotrophy

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Background: Proximal cervical spondylotic amyotrophy affects muscles in the upper extremities. In cases that lack improvement with conservative treatment, surgery is recommended; however, the preoperative factors associated with poor outcomes remain unclear. We hypothesized that assessing fatty degeneration of the cervical spinal muscles and examining its relationship with functional impairment would help predict postoperative improvement in neurological function. Accordingly, this study aimed to evaluate atrophy and fatty degeneration of cervical spinal muscles in proximal cervical spondylotic amyotrophy.
Methods: This study included 18 patients who underwent proximal cervical spondylotic amyotrophy surgery. We performed selective laminoplasty and foraminotomy. Preoperative paraspinal muscle cross-sectional area and fatty degeneration were quantified and correlated with neurological function.
Results: Neurologic improvement based on manual muscle testing occurred in 12 of 18 patients, allowing us to compare preoperative and postoperative statuses over 12 months. On the affected side, at the C4/5 level, fatty degeneration was more significant in the trapezius, whereas, at the C5/6 level, fatty degeneration was more significant in the splenius capitis and trapezius. The fatty degeneration of the C4/5 and C5/6 trapezius significantly correlated with preoperative muscle strength and postoperative muscle strength improvement.
Conclusions: The degree of fat infiltration of the muscle correlated with pre- and postoperative muscle strength at the lesion level. This study suggested a relationship between cervical muscle morphology and clinical manifestations of proximal cervical spondylotic amyotrophy. The marked increase in trapezius fatty infiltration at the C4/5 and C5/6 levels may be a valuable indicator for predicting postoperative poor muscle strength improvement.

O399

Cartilage endplate disruption on MRI-T1WI as a novel risk factor for postoperative recurrence of lumbar disc herniation

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Introduction: Symptomatic recurrence after lumbar disc herniation (LDH) is an unfavorable complication that often requires reoperation. Although various risk factors have been reported, preoperative predictive factors remain unknown. In this study, we investigated the association between disruption of the cartilage endplate on MRI-T1-weighted images (T1WI) and the postoperative recurrence of LDH.
Methods: A total of 54 patients who underwent open/microendoscopic lumbar discectomy for a single-level LDH from 2018 to 2022 were retrospectively reviewed. Patients were divided into two groups according to the occurrence of symptomatic recurrence. On preoperative MRI-T1WI sagittal images, the disc was divided into two areas, anterior and posterior, and the cartilage endplate disruption was evaluated. Patient background (age, sex, BMI, smoking, and diabetes mellitus), level of LDH, spinopelvic sagittal parameters (PI, PT, SS, and LL), and disc degeneration (Pfirmann classification) were investigated and compared between the two groups. A logistic regression analysis and a receiver operating characteristic curve analysis were performed.
Results: The symptomatic recurrence occurred in 9 (17%) patients with a reoperation rate of 78% (7/9 patients). There were no significant differences in patient background, level of LDH, spinopelvic parameters, and degree of disc degeneration between the two groups. The symptomatic recurrence group had a significantly higher rate of disruption of the cartilage endplate in the posterior area compared with the no-recurrence group (78% vs. 31%, P = 0.02). Adjusting for patient background using multivariate analysis, disruption of cartilage endplates in the posterior area on preoperative MRI-T1WI was an independent risk factor of symptomatic recurrence (odds ratio, 7.5; 95% confidential interval, 1.2- 46.3; P = 0.029). Furthermore, disruption of cartilage endplates in the posterior area on preoperative MRI-T1WI had a predictive accuracy of symptomatic recurrence with sensitivity of 69% and specificity of 78%.
Conclusions: Disruption in the cartilage endplate on preoperative MRI-T1WI was closely associated with symptomatic recurrence after LDH surgery. These results suggest that this novel MRI parameter is practical and useful as a novel predictor of symptomatic recurrence because MRI-T1WI sagittal image is a standard imaging protocol requiring no special MRI sequence.

O400

The effectiveness of chemonucleolysis with condoliase for treatment of recurrent lumbar disc herniation

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Introduction: Recurrent lumbar disc herniation (occurred postoperatively after a herniaectomy) is reported to occur in 23.1% of patients two years after lumbar disc herniation surgery. Surgery for this herniation is much more difficult than the initial surgery due to dural adhesion and scar tissue growth, and lumbar interbody fusion may be necessary depending on the degree of additional bone resection. There are few reports on the clinical results of chemonucleolysis with condoliase for recurrent lumbar disc herniation. If chemonucleolysis with condoliase is useful for recurrent herniation, it may be a less invasive treatment option compared to surgery. The purpose of this study is to investigate the effects of chemonucleolysis with condoliase for treatment of recurrent lumbar disc herniation.
Methods: One hundred and forty-nine patients (141 patients with primary herniation and 8 patients with recurrent herniation) who underwent chemonucleolysis with condoliase for lumbar disc herniation between April 2020 and May 2022, and were evaluated pre-injection, 1 month after the injection and 3 months after the injection. The evaluation items were age, gender, level, and degree of pain (back pain and lower limb pain). The degree of pain was evaluated using the Numerical Rating Scale (NRS). The Holm test was used to statistically test for changes in lower limb pain. The *Mann–Whitney* U test was used to statistically test the difference of lower limb pain between primary and recurrent herniation at pre-injection, 1 month after injection, and 3 months after injection.
Results: The mean age was 44.4 ±16.6. The injection levels are as follows (primary/ recurrent); 3/ 0 (L1/2), 9/ 1 (L2/3), 10/ 2(L3/4), 67/ 1 (L4/5), 52/ 4 (L5/S). The NRS (lower limb pain) of patient with primary herniation was 7.0 (5.0-8.0) pre-injection, 2.0 (1.0-4.0) at 1 month after injection ($p<0.01$), and 0.0 (0.0-3.0) at 3 months after injection ($p<0.01$), showing significant improvement. The NRS (back pain) of patient with primary herniation was 5.0 (4.0-7.0) pre-injection, 3.0 (0.5-4.8) at 1 month after injection ($p<0.01$), and 1.0 (0.0-3.0) at 3 months after injection ($p<0.01$), showing significant improvement. In the case of recurrent herniation, the pre-injection values of 7.0 (6.5-8.0) improved significantly to 3.0 (1.0-3.5) ($p=0.042$) at 1 month post-injection and 0.5 (0.0-1.3) ($p=0.043$) at 3 months post-injection. No statistical improvement of recurrent herniation NRS (back pain) was not observed, 6.0 (3.0-7.3) at pre-injection, 2.5 (1.8-5.8) ($p=0.27$) at 1 month post-injection, and 0.8 (0.0-2.8) ($p=0.27$) at 3 months post-injection. There was no significant difference in NRS (back pain and lower limb pain) between primary herniation and recurrent herniation at pre-injection, 1 month after injection, and 3 months after injection.
Conclusions: Chemonucleolysis with condoliase is a potential treatment option for recurrent herniation.

O401

Outcome of lumbar intradiscal condoliase injection therapy in our hospital

Objective: To evaluate the outcome of lumbar intradiscal condoliase injection therapy (ICT) in patients with lumbar disc herniation (LDH).

Subjects and Methods: Thirty-nine patients who had undergone ICT at our department and were followable for at least 3 months were included in the study. The mean age was 52.9 years, the male-to-female ratio was 24:15, and the high incidence was L3/4: 5, L4/5: 23, and L5/S: 11. The Pfirrmann classification was III: 6, IV: 31, and V: 1. The following evaluation items were assessed: operative time and complications, resorption rate and time required for resorption, number of cases requiring surgery and time required for surgery, and symptoms that improved. The mean follow-up period was 48.8 weeks.

Results: The mean operative time was 9.4 minutes, and one patient had a drop in blood pressure immediately after injection as a complication. MRI showed LDH reduction in 21 patients (53.8%), with posterior: 12/24 (50.0%), lateral: 4/7 (57.1%), cephalad: 1/1 (100%), caudal: 3/4 (75.0%), slip: 1/3 (33.3%). Nine patients (56.3%) had worsening back pain and lower limb pain at the time of ICT and were resorbed. The average time required for resorption was 25.5 weeks. Surgery was required in 5 cases (12.8%), including 4 cases of posterior prolapse and 1 case of lateral hernia. The mean time to surgery was 11.3 weeks after ICT.

Discussion: In the literature, the absorption rate on MRI is 70~80%, which is low in this study. The high age of the patients in our department and the high number of IV patients in the Pfirrman classification may have contributed to the poor results. However, surgery was avoided in 87.2% of patients, and patient satisfaction was not low. Furthermore, ICT was effective even in patients with lateral or caudally migrated LDH, regardless of the morphology, and ICT was considered to be the ultimate minimally invasive treatment in patients without paralysis. The presence or absence of lower back pain at the time of injection did not seem to affect the efficacy of ICT.

Conclusion: The symptomatic improvement rate was 66.7%, and 53.8% on imaging. Surgery was avoided in 87.2% of cases. Regardless of the morphology, even lateral and caudally migrated LDHs were effective.

O402

Effective modulation of inflammation to promote intervertebral disc regeneration using a 3D hybrid protein nanoscaffold

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Chronic inflammation is commonly seen in intervertebral disc (IVD) degeneration and also considered a major cause of the back pain, but currently there is no widely-adaptable approach for robustly inhibiting adverse inflammatory signals in IVD degeneration. Inflammation-induced tissue fibrosis, extracellular matrix (ECM) degradation, and dysregulated immunometabolism have also further compounded the treatment of severe IVD degeneration. Our aim is to address these challenges by adapting a nanomaterial-templated protein assembly (NTPA) strategy. Specifically, proteins were first densely decorated onto a biodegradable 2D nanomaterial (MnO2 nanosheets), then the protein-decorated nanomaterial were assembled with cationic polymer (e.g., chitosan) into 3D nanoscaffolds via an electrostatically driven interfacial assembly technique. As a proof-of-concept, gelatin (denatured collagen proteins) that does not self-assemble at physiological conditions was successfully used to form 3D nanoscaffolds with tunable porosities without requiring covalent modifications on the proteins. Additionally, 3D PHP nanoscaffolds become self-therapeutic with the incorporation of MnO2 nanosheets and cationic polymers, which are known to catalyze the scavenging of ROS and bind NAs, respectively. Using 3D PHP nanoscaffolds, we also demonstrate the first sustainable delivery of bromo external domain inhibitor (BETi), a highly potent epigenetic inhibitor of inflammation, for IVDD treatment. Implantation of BETi-loaded self-therapeutic 3D PHP nanoscaffolds into a nucleotomy IDD rat model effectively suppressed chronic inflammation, restored healthy ECM and disc cell components, enhanced tissue regeneration, and successfully reduced IVDD-associated pain. We thus establish a robust anti-inflammatory strategy for treating IVDD and a variety of other chronic inflammation-associated devastating diseases and conditions.

Keywords: 2D Nanomaterials; Nanoscaffolds; Self-assembly; Intervertebral disc injuries; Inflammatory diseases

O403

Adiponectin receptor agonist AdipoRon prevents the progression of intervertebral disc degeneration in a rat tail puncture model

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Introduction: Adiponectin, a hormone secreted by adipocytes, is known to have anti-inflammatory and insulin resistance. Intervertebral disc (IVD) degeneration is one of the major causes of low back pain and is always accompanied by inflammation. Previous reports have shown that AdipoRon, an orally active adiponectin receptor agonist, decreased pro-inflammatory and catabolic factors in human nucleus pulposus (NP) cells in vitro[1]. This study aims to investigate the therapeutic value and the molecular mechanism of AdipoRon on IVD degeneration through an in vivo study using rat tail puncture models.
Methods: An established rat tail annular puncture model for IVD degeneration was used[2]. A continuous disc histological degeneration scale and levels of catabolic and pro-inflammatory factors of extracellular matrix (ECM) in the rat tails (Co8-12, random order) were compared among four experimental groups. Group C was the control group. Groups P and P+A were comprised of rats whose tail discs were punctured using a 20G needle to the center of the NP. Following the initial puncture, either PBS (2 μL per disc, group P) or AdipoRon (2μM, 2 μL per disc, group P+A) was randomly injected into the center of the IVD. Group A was comprised of rats with 2-μL of AdipoRon injection using a 33-gauge needle at the disc center through a 5-mm longitudinal skin incision to evaluate the effects of AdipoRon without the puncture. Catabolic and pro-inflammatory factors of ECM and AMPK pathway factors were assessed using immunofluorescence. Both results were obtained 14 and 28 days after the puncture.
Results: A significant increase in TNF-α-positive cells was observed in groups P and P+A compared to group C 14 days after the puncture (P; $p<0.001$, P+A; $p<0.001$), whereas no significant difference was observed in group A compared to group C. Moreover, significant increases in IL-6-positive cells, ADAMTS-4-positive cells, and MMP-13-positive cells were also observed in groups P and P+A, whereas no significant difference was observed in group A. In contrast, 28 days after the puncture, the increase of these factors in group P+A was significantly suppressed compared to that in group P (TNF-α; $p<0.001$, IL-6; $p<0.001$, ADAMTS-4; $p=0.007$, MMP-13; $p=0.004$). In control, an abundance of p-p65-positive cells was observed at both time points. However, 14 days after the puncture, there was a significant increase in the number of p-p65-positive cells in groups P and P+A (P; $p<0.001$, P+A; $p<0.001$), although no significant difference was observed in group A compared to group C. Twenty-eight days after the puncture, the increase in group P+A compared to that in group P was significantly suppressed ($p<0.001$). On the other hand, an abundance of p-AMPK-positive cells was observed at both time points in groups C and P. However, 14 and 28 days after the puncture, there was a significant increase in p-AMPK-positive cells in groups A and P+A (A; $p<0.001$, P+A; $p<0.001$), although no significant difference was observed in group P compared to group C.
Conclusions: Our results have demonstrated that AdipoRon administration in the rat tail puncture model could prevent the progression of IVD degeneration with suppressed production of catabolic and pro-inflammatory factors of ECM by phosphorylation of the AMPK pathway. Therefore, the protective effect of AdipoRon administered on disc NP cells may inhibit IVD degeneration.

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O404
Study of the effect of adipose tissue dysfunction in IVDD

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Introduction: Intervertebral disc degeneration (IVDD) is a common cause of low back pain (LBP) and may cause herniated or slipped discs. Obesity (OB) and type 2 diabetes (T2D) are among the most prevalent metabolic diseases worldwide. The incidence of LBP and IVDD is higher in obese and diabetic individuals, which suggests causative and epidemiological correlations between OB, T2D, and IVDD. Several studies have demonstrated the existence of biomechanical and biochemical stimuli that may boost IVDD development in individuals affected by OB and T2D. While some mechanisms have been described, including excessive biomechanical stress, adipokine-mediated inflammation, vertebral microstructure alterations, and toxicity of AGEs in disc tissues, it remains difficult to state whether IVDD could develop indifferently of these disorders or if its pathogenic background may be accentuated by OB and T2D.
Aim: To investigate the role of OB and T2D related secretome signaling on nucleus pulposus (NP) cells degeneration, and describing how adipose tissue dysfunction can contribute to the pro-inflammatory and catabolic state of NP cells in intervertebral disc degeneration. Our objective is to further understand the role of OB and T2D conditions on enhancing IVDD.
Patients and Methods: Human disc and adipose tissues were collected from 20 patients undergoing spine surgery. All patients provided their informed consent for the collection and use of surgical waste for research purposes. Cells and tissues were cultured in an indirect co-culture system that allows the study of NP cells-adipose tissue secretome interactions. Adipose tissue supernatants were collected after 10 days culture. Then the tissues were split, harvested for 12 hours, and treated either with 100ng/mL LPS or kept as control condition. After 24 hours of treatment, tissues were washed and the supernatants were collected after 24 hours of additional culture. Human primary degenerative NP cells were isolated from disc tissue and used for the experiments at passage 2. They were treated with the adipose tissue supernatants from normal weight and obese patients for 24 hours, and mRNA expression levels of pro-inflammatory mediators, adipokines, and phenotypic markers were determined by RT-qPCR. Additionally, LPS induced adipose tissue supernatant was employed and their effect was similarly analyzed.
Results: We demonstrated that adipose tissue secretome from obese patients is able to increase TNFα, IL-6, Leptin, Lipocalin-2 and decrease Tie2 and Aggrecan expression in human primary NP cells. However, none of these alterations was induced by the adipose tissue from the healthy patients. We also observed that the LPS pre-treatment of both healthy and obese adipose tissues enhanced the secretome detrimental effect on the NP cells.
Conclusion: Our results indicate that the dysfunctional state of the adipose tissue, either from obese patients or induced by LPS-treatment, can trigger a pro-inflammatory and catabolic state in degenerative NP cells, which supports the hypothesis that OB and T2DM may worsen the progression of IVDD pathophysiology.

O405

Matrix production enhancing effect of laminin in cultured human nucleus pulposus progenitor cells

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Introduction: Previous reports have shown nucleus pulposus (NP) cells that express angiopoietin-1 receptor (Tie2) form a susceptible progenitor cell population that presents colony-forming ability and an excellent extracellular matrix (ECM) production capacity1. However, Tie2 expressing NP cells rapidly decrease with aging and disc degeneration1, thus the potential mass culture of NP cells able to maintain Tie2 expression is an auspicious target for the development of regenerative therapies for intervertebral disc degeneration2,3. Laminin is a known ECM component that can support stem/progenitor cell features2. In this study, we examined the potential of laminin-coating for maintaining Tie2+ NP progenitor cells in vitro.
Methods: Human surgical tissue was obtained following approval by the Tokai University institutional ethics review board(17R173) and informed consent from patients. Cells were isolated from human NP tissue (n=5, mean age: 19.1±3.0 years) obtained from patients who had undergone lumbar disc herniation surgery and cultured for 6 days (20% FBS, 37°C, O2 5%, CO2 21%, 3x104 cells/6mL). Cells were expanded on two types of dishes; i.e., non-coated [N group] and laminin-coated (MAX iMatrix-511, 0.5µlLmL) [L group]. Expanded cells were compared on cell proliferation rates, phosphorylation of Erk and Akt through Western blotting, and cell surface marker (Tie2, GD2, and CD24) expression as well as intracellular ECM products (type 2 collagen (Col2) and proteoglycans (PG)) evaluated by flow cytometry. Finally, after 14 days of culture, the NP cells were harvested and seeded in methylcellulose medium to assess their ability to form spherical colonies. Statistical analysis was performed through student t-test, where a $p<0.05$ was considered statistically significant, values are given as mean ± standard deviation. Results. The cell proliferation rate (18.6 ± 16.2% in the N group and 50.8 ± 33.6% in the L group, $p < 0.05$) was significantly higher in L group. (Figure 1) This was confirmed by Western blotting, which also showed stronger ERK and AKT activation in the L group. The Tie2 expression rate was maintained at 7.1±3.5% in the N group and enhanced to 18.5±7.4% in the L group ($p<0.05$). GD2 and CD24 were similarly expressed in both groups. ECM production, assessed through flow cytometry, showed more Col2 positive cells in group L (group N: 13.2±7.8%, group L: 25.7±8.9%, $p<0.05$) but no clear differences in PG rates was observed (group N: 99.34±0.57%, group L: 99.48±0.26%). The spherical colony-forming ability (40.7±8.8 /1000 cells in the N group and 70.53 ±18.0 /1000 cells in the L group, $p<0.05$) was also significantly higher in the L group.
Conclusions: The augmented spherical colony-forming ability and proliferation characteristics in the L group confirm the ability of laminin to enhance or maintain the stem/progenitor cell phenotype in culture. Moreover, the increased rate of Col2 positive cells, underlines the potential of laminin coating for producing more regenerative cell populations. Ongoing research is examining the potential of laminin to support in mass production of regenerative NP cells as a cell therapeutics for intervertebral disc repair.

Acknowledgments: Special thanks to Mr. Araki (Tokai University, Japan) for their technical support of the western blot analysis.
Conflict of interest: This study was funded by TUNZ Pharma Co., Ltd. SH is a paid employee of TUNZ Pharma Co.

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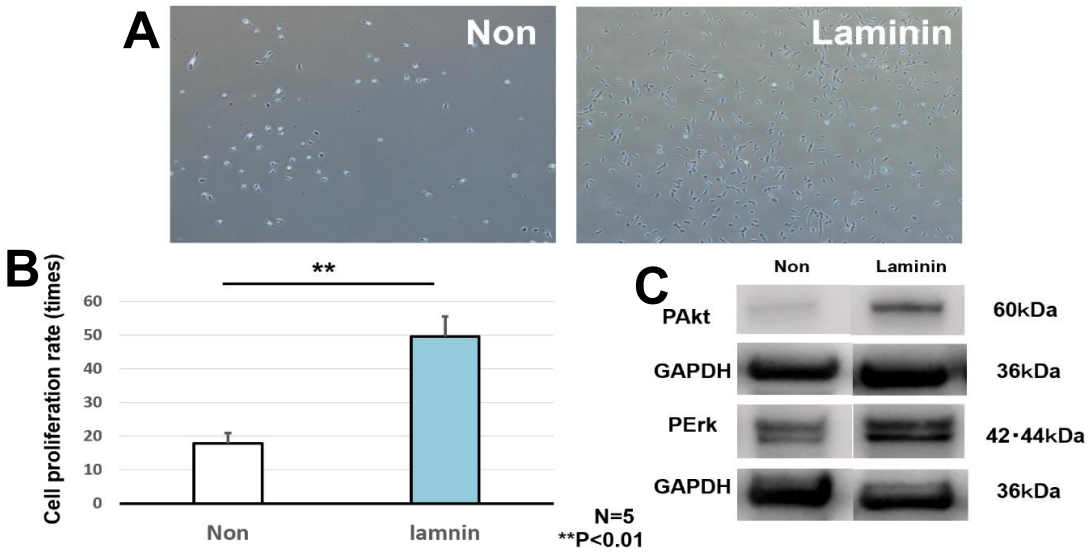
Figure 1A）Laminin coating promotes NP cell attachment and proliferationB）Cell Proliferation rate. C）Expression of phosphorylated Erk and Akt by Western blotting.



O406

Combination of ultra-purified stem cells with an alginate sodium reduces discogenic pain

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Introduction: Low back pain (LBP) is a major health problem in developed countries. Intervertebral disc (IVD) degeneration is a major cause of LBP. However, treatments directly approaching the etiology of disc degeneration and discogenic pain have not yet been established. We previously showed that ultra-purified alginate (UPAL) gel implantation into rat IVDs promotes tissue repair and reduces discogenic pain.1 We also obtained good manufacturing practice compliant, clonogenic bone marrow-derived mesenchymal stem cells (known as rapidly expanding clones; RECs) and demonstrated that implantation of UPAL gel and REC into the injured IVDs promoted tissue repair compared to gel alone.2 We hypothesized that mixed administration of REC and UPAL would reduce LBP associated with IVD degeneration. The aim of this study is to evaluate inflammatory cytokines, tissue degeneration, and pain-related behaviors in a rat caudal IVD degeneration model by injecting a mixture of REC and UPAL without gelation.
Methods: Rats (12 weeks old, 260–300 g) were operated on under general anesthesia. Co4/5 and Co5/6 IVDs were punctured using an 18G needle. Rats were randomly assigned to the following four groups (n=3 rats; n=6 IVDs, in each group): Sham group (skin incision only), Punch group (NP punching only), UPAL group (injection of UPAL solution after NP punching), and REC+UPAL group (injection of mixed solution of REC and UPAL after NP punching). In UPAL group, UPAL (400-600 mPa/s, Mochida Pharmaceutical Co., Ltd., Tokyo, Japan) solution of 4 μL per IVD was injected into the IVD from a different route than the punch using a micro syringe with a 26G needle (Hamilton, Reno, NV, USA) immediately after NP punch. In REC+UPAL group, UPAL solution was mixed with REC to achieve a mesenchymal stem cell concentration of 1×10^6 /ml. Immediately after the NP punch, the mixture of REC and UPAL (4 μL per IVD) was injected using a micro syringe with a 26G needle. Histological evaluation and immunohistochemical staining were performed on postoperative days 1-28, and percentages of TNF-α, IL-6, and TrkA positive cells was calculated. Hargreaves test, von-Frey test, and Tail flick test were performed as pain-related behavioral analysis.
Results: Histological IVD degeneration scores of REC+UPAL and UPAL groups on postoperative day28 were significantly lower than Punch group and not significantly different from Sham group (Figure1). Immunohistochemical analysis showed that percentages of positive cells for TNF-α, IL-6 and TrkA were significantly lower in REC+UPAL group than in Punch and UPAL groups (Figure2). Pain-related behavioral analysis showed that REC+UPAL and UPAL groups had significantly longer latencies for the Hargreaves and von Frey tests and significantly shorter latencies for the Tail flick test (days1 to 28) compared to Punch group.
Conclusions: Injection of REC and UPAL into the IVDs reduces discogenic pain by suppressing the expression of inflammatory cytokines and nerve growth factor receptors. This noninvasive treatment strategy for IVD disorders, which can be performed with a single injection, is expected to be applied to the treatment of chronic LBP caused by IVD disorders and to regenerative therapies that can inhibit degenerative degeneration of the IVDs.

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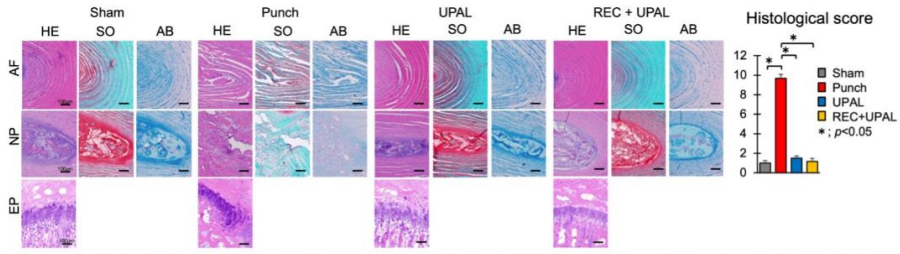

Figure 1. Histological evaluation. Hematoxylin and eosin (H&E), Safranin O and Alcian blue staining were performed. Data are given as means ±SD.

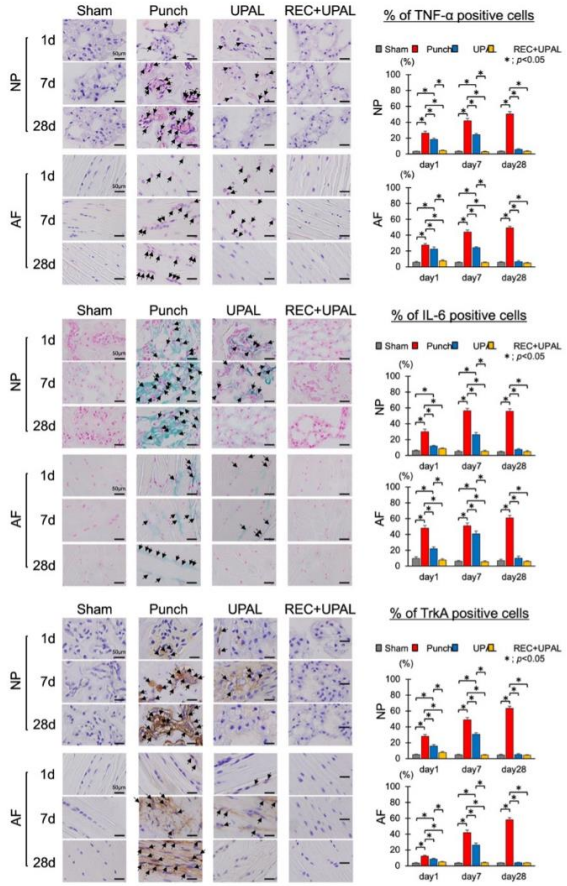

Figure 2. Immunohistochemical evaluation of TNF-α, IL-6 and TrkA. Data are given as means ±SD.

O407
Bioactive glass bone for posterolateral lumbar fusion in rats: A pilot study

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Spinal fusion is a common procedure and autograft is still considered as gold standard for bone grafting. However, autograft may be insufficient in volume or contraindicated and associated with inherent morbidity. Various bone substitutes have been developed to supplement or assist autograft, including bioactive glass. Few experimental studies have assessed its efficacy for spinal fusion in association with autograft, moreover on rats.
The study concerned 8 male Sprague-Dawley rats. In part 1 of the study, 4 rats underwent a posterolateral lumbar spine fusion surgery, with autologous iliac crest alone on the left side and mixed with bioactive glass on the right side. The factors for failure were addressed in part 2. To get adequate graft while reducing morbidity, autograft was replaced by allograft in part 2 of the study, fresh (n=2) or frozen (n=2). The spines were harvested at 8 weeks post-operatively and analyzed by micro-CT and histomorphometry to assess the fusion process.
In part 1, rats struggled to regain preoperative weight and 2 died; the 2 who survied presented no fusion. In part 2, the rats who received fresh allograft died prematurely and the rats who received frozen allograft presented bone bridges. The micro-CT found higher bone mass and lower bone density on the bioactive glass side, and histomorphometry found evidence of bone remodeling on the bioactive glass side in 1 rat.
Although we cannot conclude on an advantage of bioactive glass for spinal fusion due to the size of the sample, the preliminary results are encouraging.

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Key words: Arthrodesis; spine; bioceramics; rodent; animal model; spine fusion.

Abreviations:
- BMC: Bone Mineral Content
- BMD: Bone Mineral Density
- BS/BV: Bone Surface per Bone Volume
- BV: Bone Volume
- BV/TV: Bone Volume per Tissue Volume
- ConnD: Connectivity Density
- DA: Degree of Anisotropy
- DMSO: Dimethylsulfoxide
- FD: Fractal Dimension
- HA: hydroxyapatite
- Micro-CT: Micro-computed tomography
- ROI: Region of interest
- RPMI: Roswell Park Memorial Institute medium
- SMI: Structure Model Index
- Tb.N: Trabecular Number
- TBPf: Trabecular Bone Pattern factor
- Tb.Sp: Trabecular Separation
- Tb.Th: Trabecular Thickness
- Tb.Th.SD: Standard Deviation of Trabecular Thickness
- TMD: Tissue Mineral Density

Author contribution statement:
T BROUSSOLLE: Elaboration of the design, execution of the ex-vivo manipulations and writing of the manuscript.
JP ROUX: Elaboration of the design and execution of the ex-vivo manipulations.
A PASARET: Elaboration of the design and execution of the in-vivo manipulations.
C VOGT: Elaboration of the design and execution of the in-vivo manipulations.
R CHAPURLAT: Elaboration of the design and reviewing of the manuscript.
C BARREY: Elaboration of the design and reviewing of the manuscript.

O408

Bioactive glass (S53P54) and polyethylene-glycol and glicerol water soluble synthetic adhesive as an effective fusion promoter in anterior lumbar interbody fusion surgery

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Introduction: Spinal fusion remains the mainstay of treatment for many different spine conditions and fusion may be achieved in several different ways, though not all methods are inherently equally effective and reliable. In principle, the larger the contact area, the shorter the distance between bony elements, and the presence of living bone (osteogenic, osteoconductive and osteoinductive properties) all increase the chances of successful fusion. In certain cases, the gap being fused may be quite wide and it may be difficult to obtain a sufficient quantity of live autologous bone graft. Anterior lumbar interbody fusion cages (ALIF, OLIF, LLIF, mesh and expandable cages) necessarily increase the distance between end plates, making it difficult to bridge the gap with new bone. In such cases we rely on synthetic materials which can provide sufficient graft volume, while reducing donor site morbidity. According to our knowledge there have been no studies analyzing the fusion capacity of isolated bioactive glass and polyethylene-glycol and glycerol water soluble synthetic adhesives in anterior lumbar approaches. We present a retrospective analysis of cases having undergone single or multilevel anterior lumbar interbody fusion procedures using interbody cages filled with bioactive glass.
Methods: We analyzed the radiological results of patients having undergone anterior lumbar interbody fusion procedures using lumbar interbody cages filled with bioactive glass without additional autologous bone. Follow-up was performed by standard clinical evaluation, radiographs at regular intervals, as well as by CT scan at 6 and 12 months to analyze fusion success/failure through the cage.
Results: Patients having undergone anterior, oblique, or lateral lumbar interbody fusions through cages displayed successful bony fusion from endplate to endplate through the cage device at 6 to 12 months follow-up.
Conclusions: Bioactive glass is an effective fusion promoter with a high rate of successful fusion when used alone in an anterior lumbar interbody fusion cage.

O409
A novel treatment strategy for nonunion targeting senescence cells

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Introduction: Nonunion is one of the major complications after spinal fusion surgery. Nonunion has a significant negative impact on patient quality of life and healthcare costs. Recent advance in spinal instrumentation increased fusion rate, but it cannot attain 100% fusion rate. Recently, the association of senescent cells and senescence-associated secretory phenotype (SASP) with a variety of bone diseases are attracting attention. We hypothesized that accumulation of senescent cells is also involved in the pathology of nonunion and investigated the involvement using a rat model of femoral nonunion.
Methods: Existence of senescent cells at femoral nonunion sites were investigated by fluorescent immunostaining of p16 and MMP-3 and qPCR of p16, p21 and inflammatory cytokines at every week until 5 weeks after surgery. Then the effects of mTOR pathway inhibition which is a predominant senescence on the healing of nonunion was investigated by comparing BMP-2 and agent X (bone forming agent with effects of mTOR pathway inhibition.
Results: At nonunion sites, the accumulation of senescent cells was observed mainly in the callus around the fracture ends. In the BMP-2 treated group, accumulation of senescent cells was observed in the newly regenerated bone area, but the group treated with agent X the number of senescent cells in the new bone was significantly decreased.
Discussion: This is a first report that senescent cells involve in the pathology of nonunion (Figure1). The strategy targeting senescent cells can be an attractive option for the treatment of spinal nonunion.

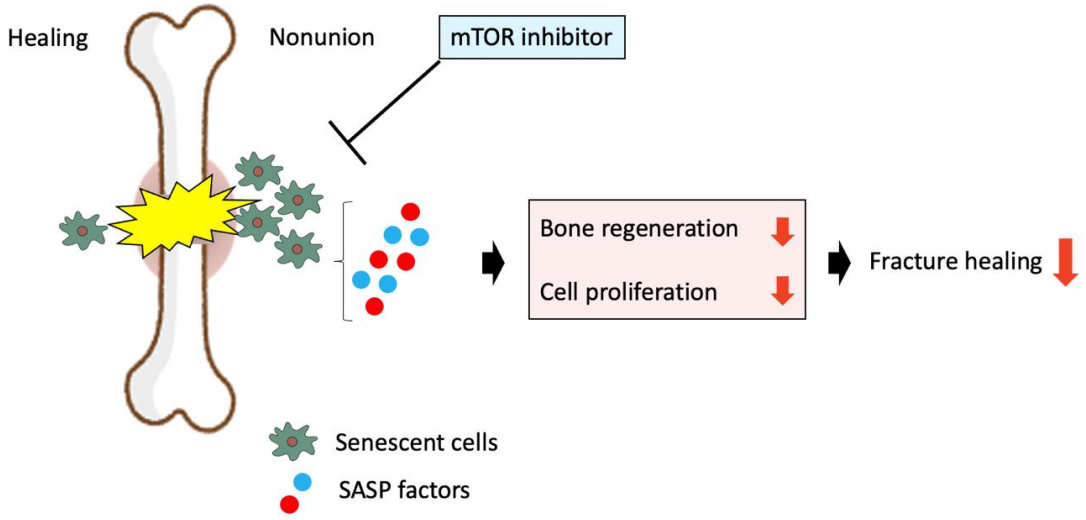

Figure1 Accumulation of senescent cells at femoral nonunion sites

O410

Preclinical study of human bone marrow-derived mesenchymal stem cells using a three-dimensional manufacturing setting for enhancing spinal fusion

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Introduction: Spinal fusion surgery is a surgical technique that connects one or more vertebrae at the same time to prevent movement between the vertebrae. Although synthetic bone substitutes or osteogenesis-inducing recombinant proteins were introduced to promote bone union, the rate of revision surgery is still high due to pseudarthrosis. To promote successful fusion after surgery, stem cells with or without biomaterials were introduced; however, conventional 2D-culture environments have resulted in a considerable loss of the innate therapeutic properties of stem cells. Therefore, we conducted a preclinical study applying 3D-spheroids of human bone marrow-derived mesenchymal stem cells (MSCs) to a mouse spinal fusion model.
Methods: The size and distribution of MSC-Spheroids made were measured, and the viability of live and dead cells was confirmed. Then, DNA Quantification Assay, Flow Cytometry Analysis, Proteome Analysis, and Bioinformatic Analysis were performed. A Spinal Fusion Model was made using an 8-week-old female C57BL/6 mouse weighing 22 g, and a gelatin sponge scaffold was used to implanted spheroids. Manual Assessment of Spinal Fusion, Biomechanical Testing, and Micro-computed Tomography were performed to see the in vivo effect. Histology was analyzed by Hematoxylin-Eosin, Masson's Trichrome Staining, Immunohistochemistry, and Immuno-fluorescence.
Results: In our animal study, the mass-produced and quality-controlled MSC spheroids, either undifferentiated or osteogenically differentiated were well-integrated into decorticated bone of the lumbar spine, and efficiently improved angiogenesis, bone regeneration, and mechanical stability with statistical significance compared to 2D cultured MSCs. the 3D-cultured groups displayed significantly higher levels of expression of some proteins related to both angiogenesis and osteogenesis (than the 2D-ctrl group), such as transmembrane glycoprotein NMB (GPNMB, also known as osteoactivin) that promotes osteoblast differentiation as well as endothelial cell migration and proliferation, thus supporting bone regeneration and ITGAV known to play a role in the regulation of angiogenesis and osteogenesis through introducing the pathways of FGFs and IGFs. Histological analyses of HE and MT staining demonstrated that the amount and area density of new bone formations were significantly increased in both 3D-undiff and 3D-osteo groups compared with decortication only and 2D-ctrl groups, while no significant difference was found in 3D-undiff and 3D-osteo groups. In the results of the average immunoreactivity of osteocalcin and osteopontin, 3D-undiff and 3D-osteo groups demonstrated significantly higher expression levels of both osteocalcin and osteopontin compared with decortication only and 2D-ctrl groups, while 3D-undiff and 3D-osteo groups were not significantly different. Significantly higher expression of CD31 was observed in 3D-undiff and 3D-osteo groups than in decortication only and 2D-ctrl groups, which suggested that exceedingly activated angiogenesis occurs in the implanted sites of the 3D-undiff and 3D-osteo groups.
Conclusion: While increasing research evidence promises more powerful therapeutic implementation of 3D-cultured MSC spheroids than MSCs conventionally cultured on a monolayer, there have been few cases of successful translation into the clinic. We believe that our study makes a meaningful contribution to the clinical application of MSC spheroids in spinal fusion surgery as a new bone tissue substitute and further inspiration for the versatile use of MSC spheroids in the biohealth industry.

Acknowledgements: This research was supported by the Korea Centers for Disease Control and Prevention (2018ER610300) and the National Research Foundation of Korea (2020R1A2C4001870 and 2020R1F1A1072695)

O411
Stem cell-exosome efficacy for osteoclast activity regulation

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Purpose: Osteoporosis is one of the most common skeletal disorders caused by the imbalance between bone formation and resorption, resulting in quantitative loss of bone tissue. Since stem cell-derived extracellular vesicles (EVs) are growing attention as novel cell-free therapeutics, the therapeutic effects of EVs from mesenchymal stem cells (MSC) on osteoporosis pathogenesis are necessary. However, the experimental researches with EV on osteoclast activity have been rarely documented. In this study, the authors aimed to investigate the inhibitory effects of EV from human subcutaneous fat-derived MSC on RANKL-induced osteoclast differentiation.
Methods: In this study, we isolated exosomes from human subcutaneous fat-derived MSCs using the tangential flow filtration method. The isolated exosomes were analyzed for size, concentration, shape, and major surface markers using nanoparticle tracking analysis, transmission electron microscopy, and flow cytometry. Osteoclastogenesis was determined by TRAP staining, F-actin ring formation, and bone resorption assay. NF-κB and MAPKs activation was analyzed by transfection assay and Western blot, respectively. Real-time PCR was performed to examine the expression of osteoclastogenesis-related genes. Histological changes, increases in TRAP-positive cells, and cathepsin K expression were examined as well.
Results: EV from subcutaneous fat-MSC (MSC-EV) inhibited the RANKL-induced differentiation of bone marrow-derived macrophages (BMDMs) into osteoclasts in a dose-dependent manner. F-actin ring formation and bone resorption were also reduced by EV application of RANKL-treated BMDMs. In addition, MSC-EV decreased the RANKL-induced activation of the TRAF6/NF-jB/MAPKs axis at the early stage and the expression of osteoclastogenesis-related genes in BMDMs treated with RANKL. PRMT1 and ADMA levels, new biomarkers for osteoclastogenesis, were decreased by MSC-EV treatment. Thus, the anti-osteoclastogenic effect of MSC-EV was mediated by a cascade of inhibition of RANKL-induced TRAF6, JNK, PRMT1, and NF-κB signaling.
Conclusion: These findings suggest that MSC-EV inhibited RANKL-induced osteoclast differentiation by the downregulation of molecular mechanisms and exerted anti-osteoporotic effects.

O412

The iPS cell-derived platelet preparation reduces bone morphogenetic proteins requirements and suppresses adverse events in bone formation promoting

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Background: Bone morphogenetic proteins 2 have excellent bone-forming ability in a dose-dependent manner, but adverse events such as tumorigenesis and infection have been reported due to overuse. In this way, overuse of single cytokines should be avoided and improved usage is needed. In recent years, a method for producing a large amount of artificial platelets characterized by being deficient in human leukocyte antigen (HLA) and suppressing the autoimmune response, has been established by iPS cell technology. we have confirmed that the iPS cell-derived platelet preparation includes many kinds of cytokines and have an effect of promoting early and rigid bone union.

Purpose: To investigate whether the use of iPS cell-derived platelet preparations affects the efficacy and safety of bone formation-promoting therapy with BMP2.

Subjects and Methods: The bone fusion promoting effect using animals as a safety study, 8-week-old SD rats were used (n = 40), and a lumbar posterior lateral fusion model was created and transplanted an artificial bone between the transverse processes. It was divided into the following two groups according to (1) BMP2 alone group, (2) BMP2+iPS cell-derived platelet group. In both groups, BMP2 usage was used at varying concentrations (0, 0.5, 5, 15(μg)). The bone fusion was evaluated 2, 4 weeks after surgery. In addition, a histological evaluation (bone formation amount, characteristics of trabecula involved in bone strength). We investigated the appearance of adverse events such as tumorigenesis, hyperinflammation, and infection.

Results: In BMP2 alone group, there was no significant difference at 2 weeks, and at 4 weeks, the amount of new bone formation and the union rate was significantly higher in both groups with a BMP2 of 5or15μg. In BMP2+iPS cell-derived platelet group, there was a significant difference in the high-dose group with BMP2 of 5μg or more at 2 week, and at 4 weeks, even in the group with low BMP2 dose, the amount of new bone formation and bone union rate were significantly higher than those in BMP2 alone group.($p < 0.05$). Regarding adverse events, in BMP2 alone group, a high dose of 15μg caused some adverse events in all cases (100%), but in iPS cell-derived platelet group, the occurrence was suppressed (50%).

Discussion: In this study, BMP use showed volume-dependent bone formation in both groups. However, in the BMP2 alone group, adverse events such as hyperinflammation and infection occurred significantly more with high dose use. In contrast, in the iPS cell-derived platelet group, good early bone formation was observed even in the BMP low-dose group, and there were few adverse events. The use of a single cytokine is not physiological from the viewpoint of good quality angiogenesis and scaffold formation. Like autologous blood-derived PRP, the iPS cell-derived platelet preparation contains multiple cytokines and is considered to be indispensable for high-quality new bone formation.

Conclusion: It was suggested that the iPS cell-derived platelet preparation may reduce the amount of BMP used and the appearance of adverse events in promoting bone formation.

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The role of microglia macrophages activation and TLR4 NF-kB MAPK pathway in distraction spinal cord injury-induced inflammation

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Background: Distraction spinal cord injuries (DSCIs) often occur as the neurological complication of distraction forces following the implantation of internal fixation devices during scoliosis correction surgery. However, the underlying mechanism behind these injuries remains unclear.
Purpose: The present study aimed to explore the activation of microglia and macrophages, as well as changes in TLR4-mediated NF-κB and MAPK pathway activity after DSCIs in Bama miniature pigs.
Methods: Prior to surgical intervention, the pigs were randomly divided into three groups: the sham group, the complete distraction spinal cord injury (CDSCI) group, and the incomplete distraction spinal cord injury (IDSCI) group. After surgery, the Tarlov scale and individual limb motor scale (ILMS) were used to evaluate changes in the pigs' behavior. All pigs were euthanized 7 days after surgery, and histopathological examinations of the spinal cord tissues were performed. Immunohistochemistry was used to detect Caspase-3 expression in the anterior horn of spinal gray matter tissues. Immunofluorescence staining was utilized to assess the M1/M2 phenotype changes in microglia/macrophages and NF-κB P65 expression in central DSCI lesions, while western blotting was performed to determine the expression of TLR4/NF-κB/MAPK pathway-related proteins.
Results: The results of the present study showed that the Tarlov and ILMS scores decreased significantly in the two DSCI groups compared with the sham group. Hematoxylin and eosin (HE) and Nissl staining revealed that the tissue structure and nerve fiber tracts in the distracted spinal cord tissues were destroyed. Both DSCI groups showed the number of surviving neurons decreased and the Caspase-3 expression increased. The results of the immunofluorescence staining indicated that the CD16 and CD206 expression in the microglia/macrophages increased. Between the two DSCI groups, the CDSCI group showed increased CD16 and decreased CD206 expression levels. The intensity of the fluorescence of NF-κB P65 was found to be significantly enhanced in pigs with DSCIs. Moreover, western blot results revealed that the expression of TLR4, p-IκBα, NF-κB P65, p-JNK, p-ERK, and p-P38 proteins increased in spinal cord tissues following DSCI.
Conclusion: The present study was based on a porcine DSCI model that closely mimicked clinical DSCIs while clarifying DSCI-associated neuroinflammation mechanisms, in turn providing evidence for identifying potential anti-inflammatory targets.

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Multimodal therapy strategy based on a bioactive hydrogel for repair of spinal cord injury

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Introduction: Traumatic spinal cord injury results in permanent and serious neurological impairment, but there is no effective treatment yet. Tissue engineering approaches offer great potential for the treatment of SCI, but spinal cord complexity poses great challenges. In this study, the composite scaffold consists of a hyaluronic acid-based hydrogel, decellularized brain matrix (DBM), and bioactive compounds such as polydeoxyribonucleotide (PDRN), tumor necrosis factor-α/interferon-γ primed mesenchymal stem cell-derived extracellular vesicles (TI-EVs), and human embryonic stem cell-derived neural progenitor cells (NPC). The composite scaffold showed significant effects on regenerative prosses including angiogenesis, anti-inflammation, anti-apoptosis, and neural differentiation. In addition, the composite scaffold (DBM/PDRN/TI-EV/NPC@Gel) induced an effective spinal cord regeneration in a rat spinal cord transection model. Therefore, this multimodal approach using an integrated bioactive scaffold coupled with biochemical cues from PDRN and TI-EVs could be used as an advanced tissue engineering platform for spinal cord regeneration.
Methods: To characterize the hyaluronic acid hydrogel containing DBM, PDRN, and TI-EV, rheological analysis was conducted with the verification of each material. Western blot, Immunofluorescence, and HUVEC (Human umbli) formation assays were performed in vitro to analyze the survival rate of DBM/PDRN/TI-EV@Gel in NPC and to investigate angiogenesis, anti-inflammation, anti-apoptotic effect, and neurodifferentiation. Animals were grouped according to the type of injected hydrogel as follows: sham, n=6; SCI, n=22; SCI + DBM@Gel, n=15; SCI + DBM/PDRN@Gel, n=17; SCI + DBM/PDRN/TI-EV@Gel, n=14; SCI + DBM/PDRN/TI-EV/NPC@Gel, n=12.
Animals were assessed for motor function by BBB scoring at 1, 4, 7, 10, 14, 21, and 28days post-injury, sacrificed on day 28. The spinal cord samples were evaluated for inflammation and apoptosis, neuronal generation, and remyelination through histological examinations such as H&E and Luxol fast blue staining, and immunofluorescence.
Results: To explore the effects of DBM/PDRN/TI-EV/NPC@Gel in vivo, we injected the bioactive HA-based hydrogel containing DBM, PDRN, TI-EVs, and NPCs into a rat model with a completely amputated spinal cord. We expected to observe spinal cord regeneration by enhancing neural differentiation with increased M2 macrophage infiltration and angiogenesis and decreased M1 macrophage-associated inflammation (Figure 1A). To elucidate the neural regeneration efficacy of the DBM/PDRN/TI-EV/NPC@Gel in vivo, behavioral analysis, immunofluorescence, histology, and qRT-PCR experiments were performed 28 d after hydrogel administration (Figure 1B). After SCI transection, treatments (DBM/PDRN@Gel, DBM/PDRN/TI-EV @Gel, and DBM/PDRN/TI-EV/NPC@Gel) were injected and the Basso, Brestti, and Bresnahan (BBB) locomotor rating scale was used to rate movement at 1, 4, 7, 10, 14, 21, and 28 d post-injury. All groups gradually recovered over time after SCI. In particular, the degree of recovery in the BM/PDRN/TI-EV/NPC@Gel group increased rapidly. When comparing the SCI (9.523), DBM/PDRN/TI-EV@Gel (10.393) group and the DBM/PDRN/TI-EV/NPC@Gel (14.5, $p < 0.01$) group on day 28, DBM/PDRN/TI-EV/NPC@Gel showed excellent recovery speed and degree of motor function (Figure 1C). In our experiment, rats showed the greatest degree of motor function recovery in the DBM/PDRN/TI-EV/NPC@Gel group. A detailed evaluation of the BBB scoring according to the movement of the hind limbs showed near-normal movement in the rats of the DBM/PDRN/TI-EV/NPC@Gel group at 28 d post-implantation (Video S1, Supporting information).
We regarded DBM/PDRN/TI-EV/NPC@Gel as the only treatment that led to recovery and investigated its effect on pro-inflammation response and apoptosis to evaluate nerve regeneration. The SCI group showed the highest expression of CD68, an activation marker for microglia and macrophages that play a role in the inflammatory response (Figure 1D); ionized calcium-binding adapter molecule 1 (Iba-1), a microglia/macrophage-specific calcium-binding protein marker (Figure 1E); and high mobility group box-1 (HMGB1), a marker of M1 macrophage differentiation and ischemia-reperfusion-induced tissue damage (Figure 1F).
Relationships for CD68, Iba-1, and HMGB1 between the SCI group and other groups were significant ($p < 0.0001$) in each group, suggesting a lack of pro-inflammatory response when the substance was implanted.

In particular, CD68 (0.064%), Iba-1 (0.107%), and HMGB1 (0.370%) representing M1 macrophages of DBM/PDRN/TI -EV/NPC@Gel group were not observed in the relative ratio for region of interest (Figure 1G-I). In addition, IL-1β was most strongly expressed in the SCI group. IL-1β mRNA expression was 1.91-fold lower ($p < 0.05$) in the DBM/PDRN/TI-EV/NPC@Gel group than in the SCI group (Figure 1J). We also tested the expression levels of the apoptotic cytokines p53, Bak, and caspase-3 mRNA to identify intraneuronal apoptosis, which could be elicited in association with the pro-inflammatory response. Activation of the complex apoptotic response mechanisms results in impaired motor function. In the DBM/PDRN/TI-EV/NPC@Gel group, the mRNA expression of p53 and Bak was lower than that in the SCI group, but the difference was not significant (Figure 1K, L). However, compared to the control, significant mRNA expression of caspase-3, a cytokine and key mediator of apoptosis in the cysteinyl aspartate-specific protease family, was found in the DBM/PDRN/TI-EV/NPC@Gel group (Figure 1M). The DBM/PDRN/TI-EV/NPC@Gel also reduced inflammatory apoptosis, the primary injury caused by BSCB disruption after SCI.

Luxol fast blue (LFB) staining was performed to compare and analyze the region of the area ratio of white matter which represents aggregates of oligodendrocyte progenitor and mature cells. Under magnified conditions (50 μm), DBM/PDRN/TI-EV/NPC@Gel showed an arrangement of cells similar to that observed in the sham tissue, with intact morphology (Figure 2A). Quantitative analysis of white matter relative to total area showed significant results in the DBM/PDRN/TI-EV/NPC@Gel (47.740%, $p < 0.05$) and the DBM/PDRN/TI-EV@Gel (46.139%, $p < 0.05$) when compared with the SCI (37.285%) group (Figure 2B). The gene expression of oligodendrocyte transcription factor 2 (Olig2), which plays a role in reprogramming ependymal cells to generate oligodendrocytes after SCI, showed significant result mRNA expression: DBM/PDRN/TI-EV/NPC@Gel group was 2.16-fold higher ($p < 0.05$) than SCI group (Figure 2C). This suggested that oligodendrocyte generation may have been promoted in the DBM/PDRN/TI-EV/NPC@Gel group. A2B5 (an oligodendrocyte progenitor cell marker) exhibited only slight expression in the DBM/PDRN/TI-EV/NPC@Gel group. The quantitative analysis showed no significant difference between all groups, a cell structure like that of the sham group was stably seen (Figure 2D, E). In contrast, NG2 (an oligodendrocyte precursor cell marker) showed very distinct positive expression, with statistically significant results between the DBM/PDRN/TI-EV/NPC@Gel group (10.480%, $p < 0.0001$) and the SCI group (1.976%, $p < 0.0001$) (Figure 2F, G).

Conclusions: In summary, our HA-based hydrogels containing DBM, PDRN, TI-EV and NPC with optimal conditions for effective neurogenesis as an injectable formulation can be promising biocompatible candidates for treatment of spinal cord injury. In vivo transplanted DBM/PDRN/TI-EV/NPC@Gel improved motor function after SCI and reduced M1 macrophage-associated inflammation at the lesion site of spinal cord injury. This hydrogel increased angiogenesis and M2 macrophage transition and nerve differentiation and exhibited anti-apoptotic effects through down-regulation of pro-inflammatory cytokines and up-regulation of anti-inflammatory cytokines. In addition, the destruction of BSCB was minimized to maintain tight junctions, and it was possible to effectively promote axonal regrowth and myelination. The findings of this study suggest that DBM/PDRN/TI-EV/NPC@Gel is a candidate for minimally invasive therapy with excellent neuroregeneration after spinal cord injury.

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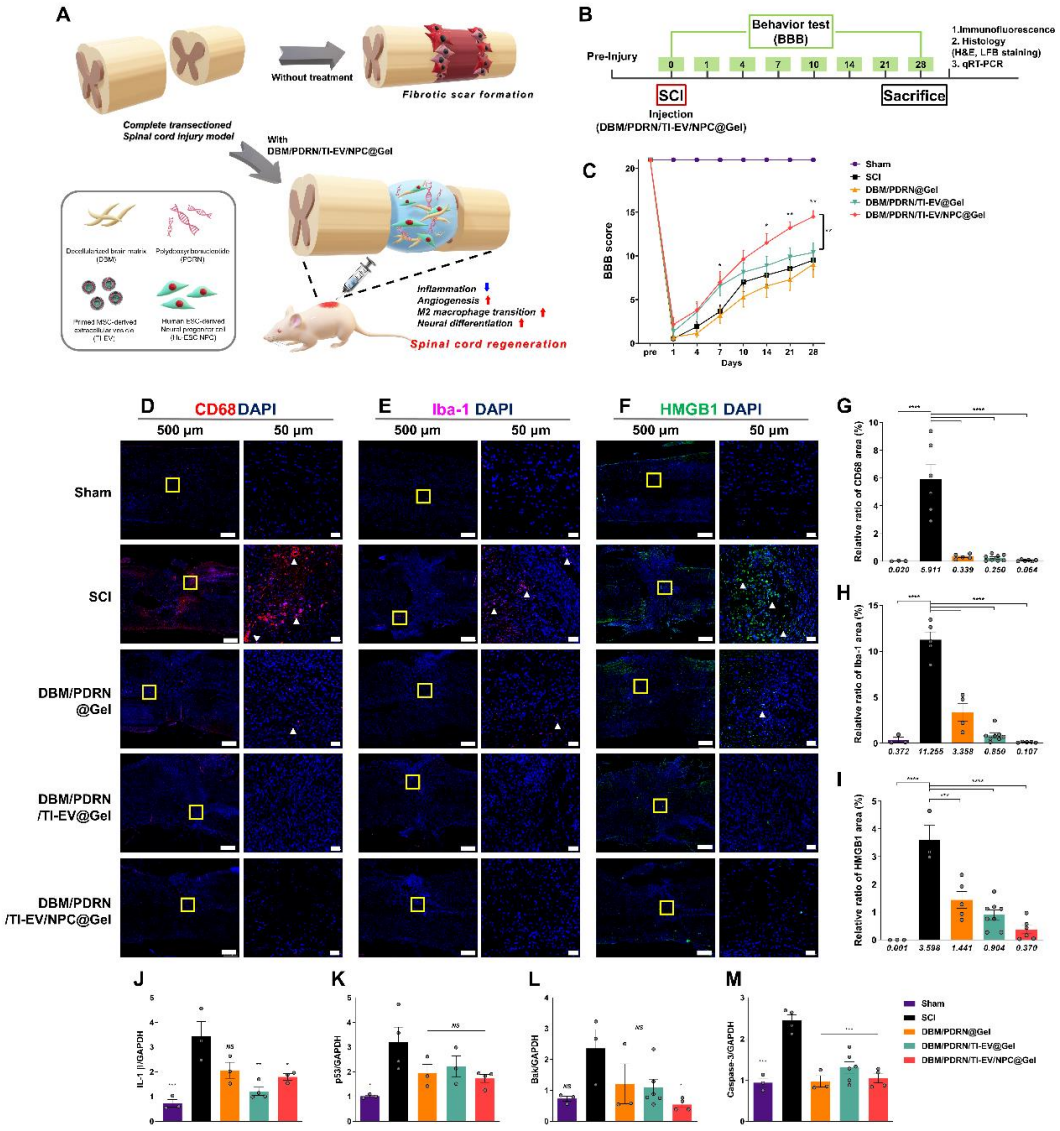

Figure1. In vivo administration of DBM/PDRN/TI-EV/NPC@Gel induces motor function recovery by preventing pro-inflammation and apoptosis. A) Schematic illustration of the multimodal therapy strategy using the functional hydrogel. B) Schematic illustration of the in vivo experiment plan. C) BBB locomotor rating scale graph at 28 d. Representative immunofluorescence images of longitudinal spinal cord sections were obtained 28 d after injection from animals with only spinal cord injury, DBM/PDRN@Gel, DBM/PDRN/TI-EV@Gel, and DBM/PDRN/TI-EV/NPC@Gel treatment; pro-inflammatory marker D) cluster of differentiation 68 (CD68), steady stage microglia and pan-macrophage marker E) ionized calcium-binding adapter molecule 1 (Iba-1), and ischemic pro-inflammatory M1 marker F) high mobility group box 1 (HMGB1). Immunofluorescence (IF) quantification results of each group: G) CD68, H) Iba-1, I) HMGB1. RT-PCR results, relative to GAPDH expression, for genes encoding the pro-inflammatory cytokine J) interleukin 1 beta (IL-1β) and the apoptosis-related proteins K) p53, L) Bak, and M) caspase-3. RT-PCR data are presented as mean ± SEM of triplicate experiments (n=3 or more). The yellow box in the 500 μm immunofluorescence image represents a 50 μm area. The scale bar is indicated by a white bar in the lower right corner. White arrowheads indicate the marker positive reaction. One-way ANOVA was followed by the Tukey test. Error bars represent the SEM (n=3). BBB scoring data were analyzed using two-way ANOVA followed by the Bonferroni test. **** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$; NS, not significant.

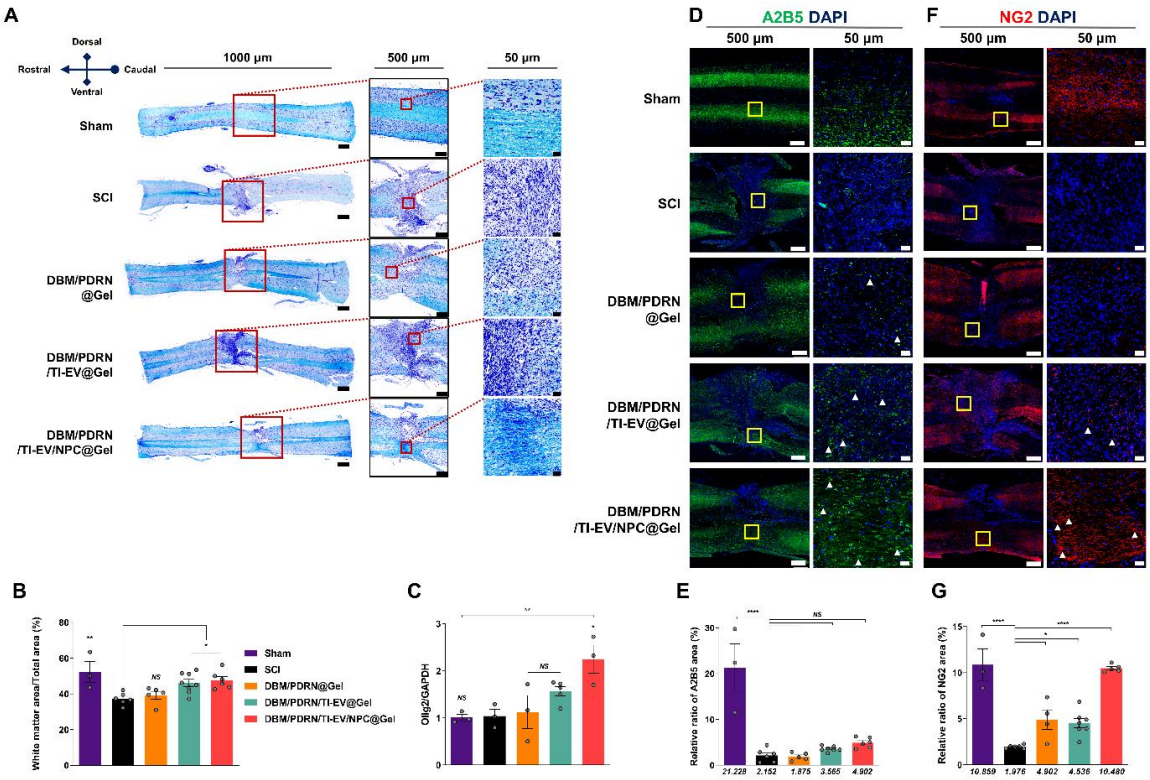

Figure2. DBM/PDRN/TI-EV/NPC@Gel enhanced remyelination with motor functional recovery effects. A) Representative images of LFB staining 28 d after DBM/PDRN/TI-EV/NPC@Gel injection post-SCI. B) Quantitative analysis shows the percent area of white matter among total area. C) RT-PCR results for the target gene oligodendrocyte transcription factor (olig2) are shown relative to GAPDH expression, a housekeeping control gene for quantitative analysis. Representative immunofluorescence images of longitudinal spinal cord sections were obtained 28 d after injection from animals with only injury, DBM/PDRN@Gel, DBM/PDRN/TI-EV@Gel, and DBM/PDRN/TI-EV/NPC@Gel groups. Representative immunofluorescence images for the oligodendrocyte progenitor and neuroendocrine cell marker D) A2B5 and the oligodendrocyte precursor cell surface marker F) neuron-glial antigen 2 (NG2). Immunofluorescence quantification results for E) A2B5 and G) NG2. The red boxes in the 1000 μm LFB staining images represent 500 μm areas; the boxes in the 500 μm images represent 50 μm areas. The yellow box in the 500 μm immunofluorescence image represents a 50 μm area. The scale bar is indicated by a white bar in the lower right corner. The white arrowheads indicate a positive reaction for the marker. One-way ANOVA was followed by the Tukey test. Error bars represent the SEM (n=3). **** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$; NS = no significant.

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Determining the instantaneous center of rotation of the cervical spine via computer-assisted radiographic analysis

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Introduction: In vivo cervical spine motion combines rotation and translation, resulting in mobile or instantaneous center of rotation (ICR). The ICR is defined as the intersection point of perpendicular bisecting lines from two or more corresponding points between sagittal radiographs during flexion-extension. We present computed motion analysis for semiautomatic two-dimensional cervical ICR acquisition, validated using a dual orthogonal fluoroscopy imaging system (DOFIS) and radiostereometric analysis. Segmental ICR locations were analyzed using a standardized cervical coordinate system.
Methods: We reviewed the flexion-extension lateral cervical radiographs of 51 radiographically unremarkable individuals (age, 31.7±4.4 years; male:female ratio, 35:16), and landmarked each corner of the vertebral body using a custom program written in MATLAB. The program automatically registered the inferior adjacent vertebral body and calculated the optimized ICR locations of the upper vertebrae, with minimum overall distances to the perpendicular bisecting lines connecting multiple corresponding points. The ICR locations were standardized as a percentage of the height and depth of each vertebral body. The ICRs of each subject were fitted to a two-dimensional Gaussian distribution model using an expectation-maximization algorithm. Five sawbone cervical spines were used for validation; four metal beads were placed on each vertebra, and the ICR locations were calculated and compared with those previously validated using a DOFIS.
Results: The overall accuracy of computer-assisted ICR determination was approximately 2 mm; thus, landmarks and ICRs could be determined via digital analysis. The ICRs of each cervical segment demonstrated level-dependent distribution. During cervical flexion-extension, the ICRs were in the inferior adjacent vertebral bodies; thus, the ICRs were located relatively posterior (C3: 61.49%±18.72%, C4: 57.25%±17.03%, C5: 43.09%±15.85%, C6: 31.78%±15.11%), and superior (C3: -108.73%±30.47%, C4: -82.81%±36.48%, C5: -50.84%±25.10%, C6: -40.44%±24.81%) to the vertebral width and height, respectively.
Conclusions: The present computer-assisted system efficiently calculated the ICR; thus, probabilistic distribution may help to distinguish abnormal motion. The ICRs of the cervical spine were in the inferior adjacent vertebral body with level-dependent distribution, shifting from anterior-inferior to posterior-superior for C3–6.

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Design and biomechanical analysis of stand-alone lumbar cage implant for posterior interbody fusion

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Introduction: Spine surgery for interbody fusion using intervertebral cage implants has become a prescribed method in the treatment of disc degenerative disease and spondylolisthesis. Cage implant provides stability for functional spinal unit and augments fusion. However, this is almost always augmented with pedicle screws and rods which is an additional procedure resulting in increased blood loss, operative time, cost and hospitalization. Hence, stand-alone cage devices are being used in cervical spine, but the designs and their effectiveness are still investigational in the lumbar spine. This study aims at designing an intervertebral cage with a selflocking mechanism.
Methods: The design includes a titanium body with two screws and a slider arrangement, to provide locking of the implant body with the spinal bones. The dimensions of the implant were chosen to best suit the lumbar L4/5 Intervertebral disc. The final element analysis was performed on the modeled implant that is placed between the modeled L4 and L5 vertebrae, to analyze load and stress distribution within the implant during flexion, extension, lateral bending and axial rotation.
Results: The biomechanical analysis displays a higher stiffness in lateral bending. In flexion, higher load is taken by the titanium body and in extension, the screws and the slider take the maximum stress. Results indicate that the proposed design with the locking mechanism with stand load, provide fixation and stability.
Conclusion: The developed models exhibited satisfactory mechanical behavior and hence could be subjected to biomechanical testing with modeled vertebrae in the subsequent work. Based on the study outcome, further analysis and modifications for improvements could be planned. Therefore, these implant designs show more prospects for further biomechanical tests to analyze their effect on the spinal bones and the surrounding ligament muscles.

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Comparison in the accuracy of thoraco-lumbo-sacral orthosis designed by a conventional contact casting technique with a plaster bandage versus by a new non-contact 3D digital scanning technique

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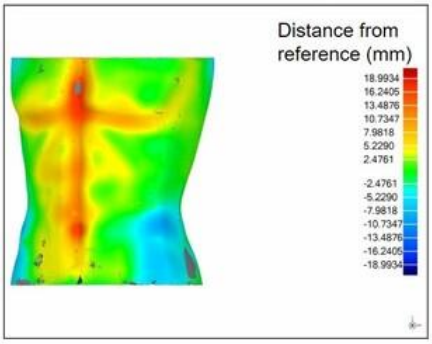
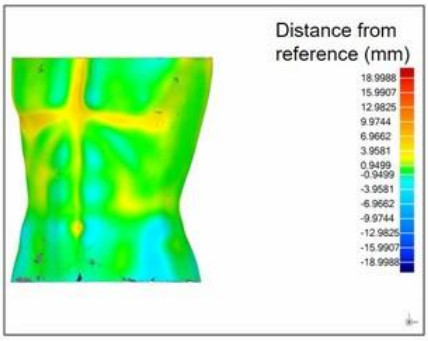
Introduction: The plaster bandage technique is a common conventional method for spinal orthosis molding. However, this technique requires body contact and close distance to patients. To reduce potential risks of unexpected sexual harassment, personal space violation, environmental pollution by plastic waste, and COVID-19 pandemic, the development of non-contact spinal orthosis-molding techniques is highly demanded. Thus, to clarify the usefulness of a recently developed 3D digital scanning technology, we investigated the difference in the adaptability of thoraco–lumbo–sacral orthosis designed by a conventional contact casting technique with a plaster bandage versus by a new non-contact 3D digital scanning technique.
Methods: We purchased commercially available Japanese mannequins individually simulating an adult man, adult woman, obese adult woman, and child (height 113 cm) (total 4 models), molded and actually made thoraco–lumbo–sacral orthoses based on the plaster bandage technique and on the 3D digital scanning technique (total 8 groups), and compared the fitting adaptability. (1) Corseted mannequins were scanned with a high-precision scanner, the data of which were superimposed to analyze the accuracy of the body shape reproduction. (2) Corseted mannequins were further scanned with computed tomography (CT), in which the gap between the mannequin's body and orthosis was evaluated by using ImageJ (https://imagej.nih.gov/ij/). The area of the gap was measured and summed up on respectively four consecutive axial CT slices at four different segments (bust, underbust, torso, and waist) for each model (total 16 slices). Then, the percentage of the gap area relative to the mannequin's body area on each axial slice was calculated. Two-way ANOVA with Tukey post-hoc test was used.
Results: (1) The reproducibility of the mannequin's shape was higher for the orthosis using the 3D digital scanner (Fig. 1). The difference in the shape reproducibility was distinct particularly in the areas with uneven, curvy surfaces, e.g. the mid-back, protruding ilium, and around the bust. (2) In CT comparison between techniques (Fig. 2), the mean gap in models for an adult man, woman, plus-sized woman, and kid was 12.0%, 17.2%, 9.5%, and 12.0% in the plaster bandage-based orthosis but 8.4% ($p = 0.0004$), 10.9% ($p < 0.00001$), 5.4% ($p = 0.00003$), and 7.8% ($p = 0.00001$) in the 3D digital scanner-based orthosis, consistently indicating the decreased gap area by the 3D digital scanning technique. Between models, adult woman had the biggest gap by both techniques with significance to all other models by the plaster bandage (all $p < 0.00001$) but only to obese woman ($p < 0.00001$) and kid models ($p = 0.004$) by the 3D scanning.
Discussion: In addition to known advantages of using the non-contact 3D digital scanner including a reduced working time and skill bias in orthotists, capability of molding in the supine position, and no need for patient contact, this pilot study presents an improved accuracy of the thoraco–lumbo–sacral orthosis adaptability. As the next step, we will further collect the data on the 3D digital scanning technology from comparative studies of healthy volunteers.

Fig. 1 Findings of high-precision scanner analysis.
(An adult male model)

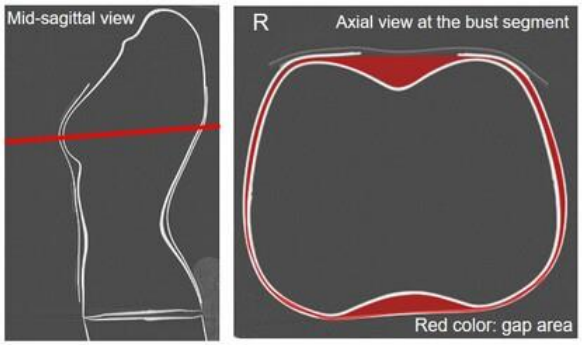


Plaster bandage

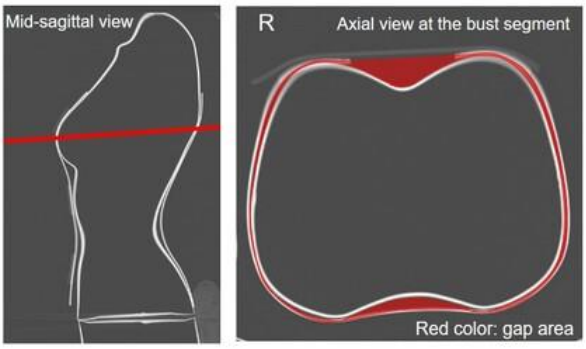


3D digital scanner

Fig. 2 Findings of axial CT analysis at the bust segment.
(An adult female model)



Plaster bandage



3D digital scanner

O418

Ligamentum flavum hypertrophy significantly contributes to the severity of neurogenic intermittent claudication in patients with lumbar spinal canal stenosis

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Introduction: Ligamentum flavum hypertrophy (LFH) is a known contributor to lumbar spinal canal stenosis (LSCS). However, the clinical significance and quantitative role of LFH compared to other components, such as disc bulging and facet hypertrophy, have not yet been examined. We investigated the correlation between the quantitative radiological factors, clinical symptoms, and outcomes in patients with LSCS.
Methods: In total, 163 patients diagnosed with single-level (L4–L5) stenosis were included. The patients were divided into two groups according to claudication severity: >100 m for mild (n = 92) and <100 m for severe (n = 71). The visual analog scale (VAS) was used to quantify back and leg pain, and the Oswestry Disability Index (ODI) and Short form-36 (SF-36) physical component summary (PCS) scores, and Macnab criteria were evaluated as clinical factors 6 months after treatment. We measured the baseline canal cross-sectional area, ligamentum flavum (LF) area, disc herniation area, dural sac area, fat area, and LF thickness using MRI. A comparative analysis was performed to evaluate the association between radiologic and clinical factors. Additionally, further comparative analyses between the types of surgeries were performed.
Results: Among various radiologic factors, the baseline LF thickness (odds ratio [OR] 1.73; 95% confidence interval [CI] 1.25–2.41) was the only major contributing factor to the severity of claudication in the multivariate logistic regression analysis. The types of surgery (decompression alone *vs.* fusion) did not significantly differ in terms of their clinical outcomes, including back and leg VAS, ODI, SF-36 PCS, and satisfaction with the MacNab classification.
Conclusion: LF thickness is a major factor contributing to claudication severity.

O419

Smart glasses can reduce radiation exposure and improve the accuracy of percutaneous pedicle screw insertion

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Introduction: In the field of spine surgery, increased radiation exposure for surgeons as well as patients is a major concern as minimally invasive spine stabilization surgeries become more common. Smart glasses have a wearable display that allows operators to obtain various information during surgery without taking their eyes off of the surgical field. This study aimed to elucidate that projecting fluoroscopic images onto the smart-glass display during percutaneous pedicle screw (PPS) insertion can reduce radiation exposure and improve the accuracy of PPS insertion.
Methods: First, Operator A wearing smart glasses inserted a total of 10 PPSs into 5 vertebrae of L1-5 bilaterally in one lumbar model bone under fluoroscopic guidance. Then, a total of 10 PPSs were inserted in another lumbar model bone without wearing smart glasses. Operator B also performed the same procedure. The X-ray irradiation was manipulated by the operators themselves using a footswitch of the image intensifier. The time required to insert each bilateral PPS into one vertebra (insertion time), fluoroscopic time, and radiation exposure dose were measured. In addition, CT images were taken after PPS insertion to assess the presence or degree of screw deviation. The insertion time, fluoroscopic time, radiation exposure dose, and insertion accuracy were compared between two groups: one group using smart glasses (SG group) and the other group using a conventional fluoroscopy monitor without smart glasses (N-SG group). Interoperator comparisons were also performed with and without smart glasses, respectively.
Results: For Operator A, PPS insertion time per vertebra was 530±144 seconds in the SG group and 559±152 seconds in the N-SG group (p=0.76), fluoroscopic time was 106±42 seconds and 145±47 seconds, respectively (p=0.21), radiation exposure dose was 1.38±0.54 mGy and 1.70±0.64 mGy, respectively (p=0.48), and insertion accuracy was 70% (2 screws with lateral cortical perforation; LCP and 1 screw with medial cortical perforation; MCP) and 70% (3 screws with MCP), respectively (p=1.0). For Operator B, insertion time was 534±211 seconds in the SG group and 615±120 seconds in the N-SG group (p=0.76), fluoroscopic time was 124±69 seconds and 137±40 seconds, respectively (p=0.73), radiation exposure dose was 1.54±0.93 mGy and 1.57±0.54 mGy, respectively (p=0.95), and insertion accuracy was 100% and 70% (2 screws with endplate perforation; EPP and 1 screw with MCP and EPP), respectively (p=0.21). Interoperator comparisons with smart glasses show that there was no significant difference between the two operators (insertion time; p=0.97, fluoroscopic time; 0.63, radiation exposure dose; p=0.75, and screw accuracy; p=0.21). Interoperator comparisons without smart glasses also show that there was no significant difference between the two operators (insertion time; p=0.54, fluoroscopic time; p=0.79, radiation exposure dose; p=0.73, and screw accuracy; p=1.0).
Conclusions: The use of smart glasses showed a tendency for both surgeons to shorten insertion time and to reduce radiation exposure. For Operator B, insertion accuracy improved. We continue further researches to demonstrate the efficacy of smart glasses for clinical application.

O420
Augmented reality navigation technology for spinal cord tumor resection

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Introduction: With the development of information and communication technology, the advanced techniques such as augmented reality (AR) or virtual reality (VR) technologies have been applied in the medical field. AR is a novel technology of overlaying the virtual information in the real world and recently available in the clinical setting. Thanks to the development of the operating microscope, microscope-based AR technology (AR microscope) was used in cranial neurosurgery in 1990s. Implementation of AR microscope support in spine surgery have been reported since 2018. Purpose of this study is to clarify the utility of AR microscope for spinal cord tumor surgery.
Methods: We evaluated 13 patients including 6 male and 7 female who were diagnosed with spinal cord tumor and underwent tumor resection in our hospital. We created three-dimensional (3D) fusion images from preoperative magnetic resonance images (MRIs) and computed tomography (CT) scans using BrainLAB Curve navigation platform (BrainLAB AG, Munich Germany) and Smartbrush software (BrainLAB AG). After intraoperative surface registration, 3D fusion images were overlayed as AR navigation images in the surgical microscope (KINEVO 900, Carl Zeiss, Oberkochen, Germany). We evaluated the accuracy of registration and the navigation mismatch between tumors and AR navigation images.
Results: Their average age was 62.9 years old (33 to 79 years old). Types of tumor were 2 cervical dumbbell tumors, 4 thoracic intradural spinal cord tumors (2: intramedullary, 2: extramedullary), 1 thoracic extradural metastatic spine tumor, and 6 spinal cord tumors of lumbosacral lesion. Gross total resection was conducted except 2 cases of scheduled two-staged surgery and metastatic spine tumor resection. Their Modified McCormick scales revealed no remarkable changes between before and after tumor resection (I: 7->8, II: 3->1, III: 2->4, IV: 1->0). Intraoperative surface registrations were very accurate (less than 1 mm) except 1 case of thoracic intradural extramedullary tumor which had difference between preoperative and intraoperative spinal alignments. One case of mobile cauda equina tumor had the navigation mismatch between intradural tumor and AR navigation image.
Conclusions: AR microscope can visualize the anatomical structures such as muscle, nerve, bone, vessel, and tumor reconstructed by preoperative MRIs or CT images on the surgical field through the heads-up-display. Therefore, we could safely resect the complicated spinal cord tumors. This technology helped us to understand the anatomical landmark even during revision surgery which was in the surrounding scar tissue. AR microscope is now available for these complicated cases. In the future, the application of AR technology in spine surgery is expected to expand, and it must be used appropriately.

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O421

Establishment of an intraoperative assisted endoscopic common iliac vein segmentation model and object detection model for intraoperative support of OLIF51 (Oblique Lateral Lumbar Interbody Fusion 51)

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Introduction: OLIF51 (Oblique lateral interbody fusion for L5-S1), a minimally invasive anterior lumbosacral fusion technique, exposes the anterior L5/S intervertebral disc with a small field of operative view and allows anterior fusion equal to or better than conventional fusion techniques. The small field of view can involve possible massive bleeding by injuring great vessels such as common iliac vein, that can be avoided by total anatomical recognition. To achieve that, we aimed to develop a real-time detection model of the common iliac vein using two methods of machine learning: semantic segmentation and object detection using images extracted from intraoperative endoscopic movies.
Methods: Object-detecting engines of DeepLabv3+ and YOLOv5 were used for semantic segmentation and object detection. 391 images extracted from 3 cases and 614 images from 4 cases of the common iliac vein were trained using these engines, and the common indices were the probability of detecting the target of detection, Precision, and the probability of not detecting objects outside the detection target, Recall. Dice, a segmentation index, was used for DeepLabv3+, and mAP, using Precision and Recall, was used for YOLOv5. The models (which classify whether the tissue in the image is vein or not) were evaluated using test images.
Results: When the model was evaluated using test images, DeepLabv3+ recorded 0.933, 0.993, and 0.823 for Precision, Recall, and Dice, respectively. On the other hand, YOLOv5 recorded 0.925, 0.922, and 0.948 for Precision, Recall, and mAP, indicating that YOLOv5 was superior in terms of accuracy. Inference speeds of 159.4 ms and 9.7 ms were recorded for DeepLabv3+ and YOLOv5, respectively, indicating the superiority of YOLOv5. These results suggest that YOLOv5 achieves sufficient detection accuracy and vein detection speed compared with the DeepLabv3+, and may be suitable for real-time use in intraoperative endoscopy.
Conclusions: We developed and evaluated a semantic segmentation model and an object detection model to detect the common iliac vein. The inference speed of YOLOv5 was faster, suggesting the suitability of YOLOv5 for real-time use during the operation.

O422

The accuracy comparison of automatic pedicle screw and cortical screw trajectory planning using domain-transform manifold learning

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Introduction: The use of robots and artificial intelligence in the medical field is gradually spreading. In the field of spinal surgery, the use of robots for pedicle screw fixation with navigation systems has been reported. Various attempts have been made to improve the algorithm performance and to precisely control the robot, along with efforts to minimize work errors in human spinal tissues. Our robotic spine surgery study group reported representative results of optimizing the pedicle screw insertion path by matching the C arm image with the CT image taken before surgery. However, it also takes time for the surgeon to plan the pedicle screw path before surgery. This study explores the reduction of screw planning time and the optimal setting of the screw path using artificial intelligence.
Methods: Our study group trained a domain-transform manifold learning algorithm based on spine ap/lat x-rays and spine CTs from a total of 200 patients retrospectively collected as a paired dataset scanned before and after surgery. Pedicle screws or Cortical screws were placed from L2 to S1 for posterior lumbar interbody fusion. After generating virtual screws into each vertebra, errors between the planned insertion path and the inserted screw were quantified using the Gertzbein-Robbins system (GRS) and offset calculation.
Results: A total (N = 200) patients were included in the final analysis. After the training algorithm, including 70 patients with pedicle screws inserted and 70 patients with cortical screws inserted, test the accuracy using the left of each 30 patients of the pedicle screw and cortical screw. Almost all (93.33% [28/30]) were classified as GRS A or B, while one (3.33%) was GRS C. in pedicle screw, and 86.67% [26/30] were classified as GRS A or B, while three were GRS C. One was GRS D. The mean and standard deviations of entry, tip, and angular offset were similar between the pedicle screw and cortical screw.
Conclusions: This study reported that when setting the path for pedicle screws using a robot, it is possible to do it faster and more accurately through an algorithm using domain-transform manifold learning algorithm. The Neurospine surgeon confirmed clinical accuracy in both the pedicle screw and cortical screw, which was virtually generated. Interestingly, the algorithm also reflected laminectomy, and it will be possible to quantify and analyze spinal decompression in the future.

O423

Magnetic resonance image segmentation of the compressed spinal cord in patients with degenerative cervical myelopathy using convolutional neural networks

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Introduction: Spinal cord segmentation is the first step in atlas-based spinal cord image analysis, but segmentation of compressed spinal cords from patients with degenerative cervical myelopathy (DCM) is challenging.
Aim: The purpose of the present study is to segment the spinal cord from T2-weighted axial magnetic resonance images of DCM patients using convolutional neural network (CNN). Furthermore, we assessed the correlation between the cross-sectional area (CSA) segmented by this network and the neurological symptoms of the patients.
Patients and Methods: The CNN architecture was built using U-Net and DeepLabv3+ and PyTorch. The CNN was trained on 2762 axial slices from 174 patients, and an additional 517 axial slices from 33 patients were held out for validation and 777 axial slices from 46 patients for testing. The performance of the CNN was evaluated on a test dataset with Dice coefficients as the outcome measure. The ratio of CSA at the maximum compression level to CSA at the C2 level, as segmented by the CNN, was calculated. The correlation between the spinal cord CSA ratio and the Japanese Orthopaedic Association (JOA) score in DCM patients from the test dataset was investigated using Spearman's rank correlation coefficient.
Results: The best Dice coefficient was achieved when U-Net was used as the architecture and EfficientNet-b7 as the model for transfer learning. Spearman's r_s between the spinal cord CSA ratio and the JOA score of DCM patients was 0.38 (P = 0.007), showing a weak correlation.
Conclusion: Using deep learning with magnetic resonance images of deformed spinal cords as training data, we were able to segment compressed spinal cords of DCM patients with a high concordance with expert manual segmentation. In addition, the spinal cord CSA ratio was weakly, but significantly, correlated with neurological symptoms. Our study demonstrated the first steps needed to implement automated atlas-based analysis of DCM patients.

O424
3D printing in spinal surgery: Current and future

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Introductions: The Fourth Industrial Revolution is the current and developing environment in which disruptive technologies and trends such as the Internet of Things (IoT), robotics, virtual reality (VR), Three-dimensional (3D) printing and artificial intelligence (AI) are changing the way modern people live and work. Three-dimensional (3D) printing technique, also known as **'**Additive manufacturing technique**'**, is a process of making 3D-printed objects from 3D digital or other electronic data source. It was first used in industry for printing new products, and then introduced into medicine. Nowadays, it is popularized in many aspects of spine surgery.
Materials and Methods: In spinal Surgery, application of 3D printing can be categorized three areas, first area is anatomical models for training or pre-operative surgical planning, second is customized implants tailor-made to the surgeon's needs. Last is patient-specific surgical instruments such as pedicle screw drill-guides or jigs.
Frequently, intraoperative C-arm X-ray monitor or O-arm monitor or computed tomography (CT) with computer-assisted guide system was used previously. However, the system is expensive, with considerable radiation exposure, is complex to operate, and requires intraoperative bone registration. So the patient-specific navigational template to improve the accuracy of screw placement and decrease the screw misplacement complications in spine surgery. However, the 3D-printed model and patient-specific navigational template is time consuming, and their preparation may require 2 h to 2 days, depending on the volume of models and the machine used. The centralization by platform can be solution.
Conclusions: The 3D printing techniques are applied in areas of research, education, surgical planning, design navigational template, and 3D-printed implant of spine surgery. The initial results of 3D-printed implant are promising, but this technology is still evolving.

O425

The current evidence for 3D printing vs PEEK cage in lumbar interbody fusion

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Lumbar interbody fusion has been popularized as a standard surgical treatment for unstable degenerative lumbar diseases.
Recently, the most popular cages are 3D printed titanium (3DP) and polyetheretherketone (PEEK) cages with distinct biomechanical properties. 3DP and PEEK cages have been evaluated in the cervical and lumbar spine, with conflicting bony fusion and subsidence results. Using Preferred Reporting Items for Systematic reviews and Meta-analyses (PRISMA) guidelines, this study's authors investigated the literature evaluating 3DP and PEEK cages to assess subsidence and fusion rates in the lumbar spine.
The clinical and radiological outcomes of 3DP and PEEK cages for lumbar interbody fusion were explored in several studies, but the findings were largely inconsistent regarding fusion and subsidence rates. Hence, this study presents a systematic review and meta-analysis to evaluate the clinical outcomes of interbody cages in lumbar interbody fusion, including PLIF, TLIF, ALIF, and LLIF.
The 3DP and PEEK cages used for lumbar interbody fusion are associated with similar subsidence rates, but 3DP cages have a higher fusion rate than PEEK interbody cages. Randomized controlled trials are needed to assess better the effect of cage materials and potential factors that could influence the outcomes of interbody lumbar fusion.

O426
Polymer based bone regeneration research

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Introduction: Tissue engineering is a study for tissue regeneration using cells, cytokines, and scaffold. Among them, scaffold plays an important role as a cell support. These scaffolds have pores that can nourish or discharge waste from cells, which can be distinguished into large macrophores and small microphores.
Methods: Polymer is one of the materials that are in the spotlight as various biomaterials due to its excellent processability and biocompatibility. Several of these polymer materials are biogradable materials that can be absorbed in the body when inserted into the human body. When various methods are applied using such a character, aggregation may be induced during bioabsorption. Among them, the representative material is PCL, and it has the advantage of being easy to process due to its low melting point. In this study, it was investigated whether the degree of promoting aggregate regeneration can be adjusted by adjusting various fore sizes using such PCL scaffolds. In addition, a structure mixed with hydroxyapatite was produced to improve the degree of bone regeneration. However, this PCL scaffold has a disadvantage of low mechanical stress, making it difficult to apply it in fields requiring large rigidity. To overcome this, we studied the increase in rigidity through the production of Kagome structure using 3D printing. This structure showed a large increase in rigidity, and it was possible to manufacture a Kagome structure in this phore form and thus a PCL polymer for bone regeneration that ensured rigidity through alkali precipitation for HA exposure.
Conclusions: Polymer based scaffold can improve osteogenic potential and mechanical properties by using of many techniques and have a positive possibility to improve their capacity.

O427
Discoscopic findings in the high-intensity zone of lumbar intervertebral discs

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Introduction: High-intensity zone (HIZ) of lumbar intervertebral discs is a high-intensity signal located in the posterior annulus fibrosus in T2-weighted magnetic resonance images. HIZ has been reported to be an effective indicator for annular disruption and discogenic pain. However, because HIZ was often observed in also asymptomatic patients, the significance of the HIZ remains to be established. Recently, as improvement of full-endoscopic spine surgery, we can get detailed intradiscal findings. We often observed intradiscal bleeding and/or inflammation matching the HIZ under full-endoscopic surgery. We hypothesize that HIZ denotes bleeding and/or inflammation in intervertebral discs. The purpose of this study was to investigate the characteristics of discoscopic findings of HIZ.
Methods: We retrospectively reviewed 208 patients who underwent full-endoscopic lumbar surgery under local anesthesia between January 2021 and August 2022. Patients where the endoscope was not inserted inside the disc, previous surgery at the same/adjacent level, Modic change and spinal infection were excluded. We considered the characteristics of discoscopic findings of HIZ as bleeding and/or inflammation in intervertebral discs, and named it “red annulus fibrosus (RAF)”. We compared the occurrence of RAF between in patient with HIZ and without HIZ. Moreover, we evaluated signal intensity of HIZ and defined the true HIZ (tHIZ) as at least 50% brighter than adjacent cerebrospinal fluid. We also compared the occurrence of tHIZ between HIZ with RAF and without RAF. Statistical analysis was performed using Chi-square test. The threshold for significance was set at $p < 0.05$.
Results: Fifty-nine patients were enrolled in this study (45 male; 14 female patients; mean age, 46.8 [12–77] years). Thirty of 59 patients had HIZ of lumbar intervertebral disc (50.8%). RAFs were detected in 33 of 59 patients (55.9%). The occurrence of RAF in patients with HIZ was significantly higher than in without HIZ (21/30, 70.0% vs 12/29, 41.4%: p=0.03). The tHIZ were detected in 18 of 30 patients with HIZ (60.0%). The occurrence of tHIZ in HIZ with RAF was significantly higher than in HIZ without RAF (15/21, 71.4% vs 3/9, 33.3%: p=0.02).
Conclusions: The past histologic study of HIZ lesion showed the ingrowth of the vascularized granulation tissue. In this study, we confirmed the same findings endoscopically. We concluded from this study that HIZ was likely to denote RAF. However, some patients with HIZ were not observed RAF. It was important to differentiate HIZ with RAF from HIZ without RAF. Signal intensity of HIZ (the true HIZ) could be the good predictor of the occurrence of RAF with preoperative MRI.

O428

Temporal MRI analysis of degenerated discs following platelet-rich plasma releasate injection for discogenic low back pain patients

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Introduction: Intervertebral disc (IVD) degeneration has been implicated as one of the important causes of low back pain (LBP). Clinically, subchondral vertebral lesions and/or annular fissures were found on MRI along with the progression of IVD degeneration; these changes are known as modic changes1 and high-intensity zone (HIZ)2, which are associated with the occurrence of LBP. Platelet-rich plasma (PRP) is an autologous blood concentrate containing a vast majority of bioactive proteins. Recently, PRP has been increasingly used for the treatment of discogenic LBP. It has been reported that intradiscal injection of the releasate isolated from PRP (PRPr) significantly improved the LBP intensity similar to that of glucocorticoid injections at eight weeks post-injection3. The purpose of this study was to evaluate time-dependent changes in disc degeneration, including modic changes and HIZ, after the intradiscal injection of PRPr in the previous randomized clinical trial.
Methods: This study is a retrospective review of the previous randomized, double-blind, active-controlled clinical trial. Patients aged > 18 years who had LBP for more than three months with one or more lumbar discs (L3/L4 to L5/S1) with evidence of degeneration, as indicated by magnetic resonance imaging (MRI), and at least one symptomatic disc, confirmed using standardized provocative discography, were considered for inclusion. Sixteen patients (mean age: 32.2 ± 8.3 years old, 11 men, five women) with discogenic LBP were randomly assigned to receive an intradiscal injection of either autologous PRPr or corticosteroid (CS) (betamethasone sodium phosphate). Fifteen patients in both groups who wished to have PRPr treatment received an optional injection of PRPr eight weeks later. MRI examination was performed at baseline, 6- and 12- months post-injection. MRI grading of disc degeneration was evaluated by modified Pfirrmann grading system. Modic changes and HIZ in the target discs were assessed on the MRI (T2-weighted image). The dimension of HIZ on the mid-sagittal MRI was quantified. The correlation between the HIZ dimension and the extent of LBP (VAS) was statistically evaluated.
Results: 1. MRI grading score of disc degeneration at baseline (4.6±0.8) showed no significant differences during the observation period. 2. Modic changes were found in four patients (40% of the total, five discs). Three discs were type II, and two discs were type III. The occurrence rate of modic changes was not changed during the observation period. 3. HIZ was identified in 11 patients (68.6% of total, 13 discs) at baseline. The mean dimension of HIZ of total subjects (10.21±5.3 [mm2]) at baseline was decreased at six months (8.5±4.6) and 12-month (6.0±4.7) ($P<0.01$); however, no significant differences were found between the two groups. There was no significant correlation between the HIZ dimension and VAS in LBP.
Conclusions: MRI disc degeneration score was not changed by intradiscal injection of PRPr for the patients with discogenic LBP. On the other hand, the dimension of HIZ showed a time-dependent decrease; this suggests that local injection of PRPr may induce tissue repair within the degenerated discs.

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O429

Efficacy of PRP administration for intervertebral disc in low back pain patients with Modic type 1 change: Two cases report

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Introduction: Although Modic type 1 is known to be strongly associated with LBP, a treatment for Modic type 1 has not yet been established. Meanwhile, platelet-rich plasma (PRP) has been widely used in the clinical setting for tissue regeneration and repair. Recently, especially in the field of orthopedics, PRP has demonstrated regenerative ability to repair injured tissues, including tendons, ligaments, and cartilage. However, to the best of our knowledge, there is no clinical trial of PRP injection for the intervertebral disc of LBP patients with Modic type 1.
Aim: we aimed to verify the safety and efficacy of PRP injection in LBP patients with Modic type 1. As a Preliminary experiment, we report two cases of LBP with Modic type 1.
Patients and Methods: PRP was administered intradiscally to two LBP patients with Modic type 1. PRP was obtained from the patients' anticoagulant blood. Primary endpoints were physical condition, laboratory data and X-ray for safety evaluation. Secondary endpoints were pain score using the visual analogue scale (VAS), Oswestry disability index (ODI) and Roland Morris disability questionnaire (RDQ) to evaluate the efficacy of PRP. The observation period was 6 months after PRP injection. In addition, we evaluated changes in Modic type 1 using MRI.
Results:
Case 1
A female, aged 69 years old, presented with complaints of chronic LBP, that had lasted for 8 months. She reported a pain intensity of 7 on the VAS, the RDQ on 13 and the ODI score of 40%. MRI showed Modic type 1 at the L2/3 level, and PRP was administered to the intervertebral disc. There were no adverse events in physical condition, laboratory data, or lumbar X-rays after injection. Comparing MRI before and 6 months after PRP administration, the STIR high-signal volume decreased from 19.2 ml to 14.5 ml. Her VAS temporarily improved to 4 but returned to pre-treatment levels 6 months after injection. The ODI score decreased to 30% and the RDQ decreased to 10 at the last observation.
Case 2
A 57-year-old male presented with chronic LBP, which continued for 2 years. MRI showed Modic type 1 at the L4/5 level. His VAS was 5, the RDQ was 6 and the ODI score was 24%. PRP was administered to the intervertebral disc. No adverse events were observed after PRP administration. Follow-up MRI showed the STIR high-signal volume decreased from 17.7 ml to 16.3 ml. The VAS rose to 6 at 1 week after injection, but then gradually declined, eventually improving to 2. The ODI score decreased to 18% and the RDQ was 4 at 6 months after injection, showing an improvement from before treatment.
Discussion: In both cases, the pain scores tended to improve after PRP injection. In addition, follow-up MRI of two cases showed a decrease of high signal intensity on T2WI compared to before PRP administration. These results suggest that PRP injection for the intervertebral disc of LBP patients with Modic type1 might be safe and effective.

O430

Bone union and strength effect of romosozumab: An imaging and mechanical study using a rat posterolateral lumbar fusion model

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In this study, we investigated the effect of romosozumab on bone strength at the fusion site in rats that underwent posterolateral lumbar fusion. For bone grafting, autogenous bone was harvested from the spinous process and grafted between the intervertebral joint and transverse processes of the 4th, 5th, and 6th lumbar vertebra bilaterally along with 40 mg of demineralized bone matrix. Rats were matched by body weight and divided equally into R (romosozumab, 25 mg/kg) and C (control, saline) groups. Subcutaneous injections were administered twice a week until 10 weeks post-operation. Computed tomography was performed 10 weeks post-operation to measure bone fusion rate, fused bone volume, and bone density. The fused area bone strength was also measured using 3-point bending. Results showed that group R rats had significantly higher bone fusion zone volume, bone mineral density, and bone strength than group C rats. Thus, the results demonstrated that romosozumab administration not only promoted osteogenesis at the bone graft site but also affected bone strength.
Conclusion: We demonstrated that romosozumab administration not only promoted osteogenesis at the bone graft site but also affected bone strength.

O431

Effects of a probe with an electrical conductivity-measuring device on pedicle screw insertion in patients with severe syndromic or neuromuscular scoliosis

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Introduction: Pedicle screw insertion is challenging in syndromic and neuromuscular scoliosis surgery because of severe spinal deformity, poor bone quality, and narrowed pedicles. A probe with an electrical conductivity-measuring device (EDC) has recently been developed to aid making accurate bone holes for pedicle screws. Only a few papers have reported the usefulness of EDC-guided probing for idiopathic scoliosis surgery. However, little evidence exists regarding its efficacy on syndromic and neuromuscular scoliosis surgery in which pedicle screw insertion is much more difficult.
Aim: To clarify the efficacy of ECD on pedicle screw insertion in patients with severe syndromic or neuromuscular scoliosis.
Patients and Methods: Between 2010 and 2016, 21 patients with syndromic or neuromuscular scoliosis (age, 21.5 ± 11.0 years; 11 men and 10 women; Cobb angle, 82.9 ± 26.3º; thoracic pedicle diameter, 3.3 ± 1.9 mm; lumbar pedicle diameter, 5.3 ± 2.9 mm) underwent segmental fixation surgery using the single instrumentation (screw diameter ≥4.5 mm) by the same surgeons in our institute. While pedicle screw insertion was performed with a conventional probe by free hand in the initial 10 cases ("non-ECD" group), it was done with an ECD probe in the last 11 cases ("ECD" group). Even in pedicles with the diameter <4.5 mm, screw insertion was performed based on the pedicle expansion concept and in-out-in screw insertion technique. We finally inserted screws only when no obvious violation of the medial wall at the pedicle and vertebral body at the bottom were confirmed. We assessed rates of screw-inserted pedicles and of malpositioned screws by preoperative and postoperative multi-planar reconstruction computed tomography (CT). The chi-squared test, Fisher's exact test, or Student's t-test was used with significance of $p < 0.05$.
Results: No obvious differences in the patient age, sex, Cobb angle, and pedicle diameter were detected between "ECD" and "non-ECD" groups. Preoperative and postoperative CT analysis revealed that the ECD reduced the abandonment rate of pedicle screw insertion due to abnormal bleeding, liquorrhea, or perforation (12.3% in "ECD" group versus 26.7% in "non-ECD" group, $p < 0.01$). Then, no significant differences in the non-perforation rate of pedicles in every direction was observed (50.2% in "ECD" versus 42.2% in "non-ECD", $p = 0.09$). However, more acceptable pedicle screw insertion without any perforation or located <2 mm laterally was shown in "ECD" group (67.1%) than in "non-ECD" group (56.9%) ($p = 0.02$). Furthermore, although no difference in the medial perforation rate was found (18.1% in "ECD" versus 20.4% in "non-ECD", $p = 0.53$), medial perforation of ≥5 mm was seen in no pedicle (0.0%) of "ECD" group but in 2.4% of "non-ECD" group ($p = 0.01$). In addition, the perforation distance was significantly shorter in "ECD" group (2.2±1.1 mm) than in "non-ECD" group (2.6±1.7 mm) ($p = 0.02$).
Conclusion: The ECD is a useful support tool to provide safer, more accurate pedicle screw insertion, leading to substantial reduction in critical malposition, even in severe syndromic and neuromuscular scoliosis surgery.

O432

Posterior spinal fixation for thoracolumbar fractures with diffuse idiopathic skeletal hyperostosis using the penetrating endplate screw technique

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Introduction: Diffuse idiopathic skeletal hyperostosis (DISH) is a noninflammatory skeletal disorder characterized by ossification of anterior longitudinal ligaments and entheses. DISH–related vertebral fractures essentially require operative treatment due to severe fracture site instability with long lever arms that may induce delayed paralysis after injury. Surgical treatment with early and strong fixation is recommended, and several studies have shown that posterior spinal fixation at least 3 levels above and below the injury provides reliable fracture healing. However, the optimal surgical procedure remains to be established. We experienced cases of implant failure after 3 above and below spinal fixations using conventional percutaneous pedicle screws for DISH-related vertebral fractures. After that, we have applied the transdiscal penetrating endplate screw (PES) technique for spinal fixation for DISH-related thoracolumbar fractures since 2015.
Materials and Methods: We aimed to validate the effectiveness of posterior spinal fixation with PESs for DISH-related thoracolumbar fractures. The study included 26 patients with DISH-related thoracolumbar fractures treated with posterior spinal fixation using either conventional percutaneous pedicle screws (PS group, n = 8) or a combined PES technique (PES group, n = 18) in our hospital between 2013 and 2019. Age, sex, BMI, bone mineral density, fracture level, use of the antithrombotic drug, blood loss, operation time, fixation range, perioperative American Spinal Injury Association Impairment Scale score, implant failure, revision surgery, complications, and mortality were compared retrospectively. We also evaluated screw loosening and bone healing using radiographs and CT scans of 22 patients who were available for follow-up for more than 6 months.
Results: There was a difference in the distribution of fractured vertebrae between the two groups with the more lumbar spine (L2-4) in the PS group than in the PES group (3 vs 0; $p = 0.019$). Patients in the PES group had less blood loss (63 vs 173 ml; $p = 0.048$) and shorter range of fixation (5 vs 5.5 levels; $p = 0.041$). The screw loosening rate was significantly lower in the PES group than in the PS group (3% vs 49%; $p < 0.001$). All screw loosening in the PES group occurred only at the site where conventional PSs were inserted.
Conclusions: Posterior spinal fixation with PES technique may be an ideal surgical procedure for thoracolumbar fractures with DISH, enabling us to provide more rigid and less invasive fixation than PS.

O433

Comparing MIDLF and PLIF c PS for clinical outcome including sagittal balance: Degenerative lumbar spine disease in geriatric patients over 80 years old: A single-center, one-decade experience

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Introduction: With the increase in the elderly population and the development of geriatric medicine, the elderly patient group is classified as a separate patient group in research and clinical trials. However, comparative studies of Midline lumbar fusion (MIDLF) and conventional fusion surgery in aging patients are rare. Additionally, unlike the 60-70 years old group, in the super-aged patient group over 80 years old, we hypothesized that differences in operating time and bleeding volume during fusion surgery could be prognostic factors.
Aim: We aimed to retrospectively analyze clinical and surgical outcomes following MIDLF and posterior lumbar interbody fusion plus pedicle screw fixation (PLIF c PS) in elderly patients (80 years or older) with degenerative lumbar spine disease.
Patients and Methods: The study groups comprised 68 patients aged 80 years or older who received lumbar fusion surgery and were diagnosed with degenerative lumbar spinal disease at our medical center from January 2011 to December 2020. Among them, 44 underwent MIDLF, and the remaining 24 underwent PLIF c PS. The study included 29 men and 39 women, and the mean age was 81.6 years. The mean follow-up duration was 27.4 months. Of the 68 patients, 38 received one level of lumbar fusion, and 30 received two levels.
Results: No significant intergroup differences were found regarding age, sex ratio, follow-up duration, and surgical level. The Visual Analog Scale for lower back pain on postoperative day seven significantly differed between the two groups (P=0.049). The Oswestry Disability Index (ODI) was significantly different between the two groups after one week of follow-up (P=0.05)(Table 1). The estimated blood loss (EBL) and operation time were significantly different (P<0.05)(Table 2). There was a statistically significant difference in postoperative morbidities between the groups (P=0.049)(Table 3). The sagittal balance improvement between the two groups showed no significant difference (Table 4).
Conclusion: Although the clinical outcomes were not significantly different among the two groups, intraoperative variables and postoperative morbidities were better in the midline lumbar fusion groups. Therefore, we concluded that MIDLF is not inferior to PLIF c PS if there is a need for fusion in elderly patients over 80.

Table 1. Postoperative patient characteristics of two groups

		MIDLF (N=44)	PLIF c PS (N=24)	*P*-value
VAS for LBP	Preop	3.7 ± 3.0	3.7 ± 2.8	0.980
	POD 7d	1.1 ± 1.5	2.2 ± 2.4	0.049*
	Final f/u	1.0 ± 1.8	0.8 ± 1.3	0.589
VAS for leg pain	Preop	5.5 ± 2.3	5.3 ± 2.2	0.746
	POD 7d	1.9 ± 2.5	1.7 ± 2.3	0.745
	Final f/u	1.1 ± 2.2	0.9 ± 1.6	0.702
ODI	Preop	52.3 ± 16.5	51.9 ± 16.3	0.916
	POD 7d	15.2 ± 15.7	25.1 ± 21.1	0.050*
	Final f/u	14.1 ± 16.1	13.9 ± 15.4	0.952
Bridwell Grade one fusion	1 year f/u	79%	82%	0.188

Data are presented as mean ± standard deviation or percentage
PLIF+PS: posterior lumbar interbody fusion + pedicle screw fixation
MIDLF: midline lumbar fusion
VAS: visual analog scale
ODI: Oswestry disability index
*P < 0.05

Table 2. Intraoperative patient characteristics of two groups

	MIDLF (N=44)	PLIF c PS (N=24)	*P*-value
Estimation of blood loss	488.6 ± 570.3	908.5 ± 707.0	0.017*
Operation time (min)	158.9 ± 46.3	253.1 ± 76.0	0.000***
Hospital stay (day)	14.8 ± 12.8	16.8 ± 7.8	0.505

Data are presented as mean ± standard deviation or number (%)
PLIF c PS: posterior lumbar interbody fusion + pedicle screw fixation
MIDLF: midline lumbar fusion
*P < 0.05
***P < 0.001

Table 3. Postoperative morbidities and late complications of two groups

	MIDLF (N=44)	PLIF c PS (N=24)	*P*-value
Postoperative complications	1 (6.8%)	4 (16.7%)	0.049*
Pulmonary complications	0	1 (4.2%)	
Cerebral infarction	0	1 (4.2%)	
Angina	0	1 (4.2%)	
Hematoma	0	1 (4.2%)	
Infection	1 (6.8%)	0	
Late complications	4 (9.1%)	4 (16.7%)	0.439
ASD	3 (6.8%)	1 (4.2%)	
Fusion or hardware failure	1 (2.3%)	3 (12.5%)	

Data are presented as mean ± standard deviation or number (%)
PLIF c PS: posterior lumbar interbody fusion + pedicle screw fixation
MIDLF: midline lumbar fusion
ASD: adjacent segmental degeneration
*P < 0.05

Table 4. Comparison of patients' sagittal balance between two groups

		MIDLF (N=44)	PLIF c PS (N=24)	*P*-value
Pelvic tilt (°)	Preop	24.4 ±9.9	23.1 ± 9.3	0.605
	POD 7d	23.0 ± 8.8	20.2 ± 8.0	0.201
	Final f/u	23.2 ± 8.5	22.3 ± 9.1	0.659
Pelvic incidence (°)	Preop	55.7 ± 13.6	53.9 ± 13.6	0.590
	POD 7d	54.4 ± 11.8	49.8 ± 22.4	0.274
	Final f/u	55.3 ± 12.9	53.6 ± 12.2	0.592
Sacral slope (°)	Preop	31.3 ± 11.1	30.7 ± 12.0	0.841
	POD 7d	31.4 ± 10.0	29.6 ± 18.5	0.604
	Final f/u	32.1 ± 10.3	31.3 ± 13.4	0.797
PI–LL mismatch (°)	Preop	16.0 ± 13.0	15.7 ± 11.4	0.923
	POD 7d	14.0 ± 12.1	11.2 ± 8.3	0.311
	Final f/u	15.4 ± 12.5	12.8 ± 11.8	0.395

Data are presented as mean ± standard deviation
PLIF+PS: posterior lumbar interbody fusion + pedicle screw fixation
MIDLF: midline lumbar fusion
PI-LL: pelvic incidence – lumbar lordosis

O434

History of cortical bone trajectory, a modified version of pedicle screw placement

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Introduction: Cortical bone trajectory (CBT) for pedicle screw fixation is a fusion technique that has been gaining popularity in the last decade. The idea of CBT involves a medial to lateral, inferior to superior trajectory placement of the pedicle screw to maximise screw purchase in the cortical bone. Unlike traditional placement of pedicle screws, the CBT technique was theorised to be not inferior if not beneficial in patients with decreased bone quality such as osteoporosis.

Methods: An electronic search on 3 online databases (PubMed, Medline, embase) was carried out. Articles describing the CBT techniques were chosen and a descriptive timeline for the progress of CBT technique was made.

Results: Attempts for spinal fusion started as early as the late 19th century which comprise of wiring, rods, interbody spacers and screws. The first attempt of pedicle screw fixation was carried out in 1959 and since then, pedicle screw fixation has been one of the most common technique for spinal fusions. However, the traditional approach for pedicle screw fixation generally requires a larger cut for adequate exposure of the vertebrae to accommodate for screw entry. First explored by Bucks in 1970, the notion for an altered trajectory for screw placement was used for pars repair. Since then, various attempt for alternate pedicle trajectories were explored including the Medio-Latero-Superior Technique (MLST) published in 2004. In 2009, the CBT technique was introduced using a caudocephalad, medial-lateral trajectory. Progress was further made in 2016 using a less medial-lateral angle to accommodate for longer and wider screws.

Conclusion: The CBT technique is still in its early stages with potential room for improvement. Further clinical studies and comparative studies with traditional pedicle trajectories including biomechanical and prospective trials should be carried out to evaluate the efficacy and outcomes of the CBT technique.

O435

Patient satisfaction does not depend on radiographic reduction in adult scoliosis with primary lumbar curves

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Introduction: Adult scoliosis is a challenging condition particularly in female patients above the age of 60years. In the future the incidence will steadily increase in line with expected population demographic changes. If surgery is indicated, one, two or three stage procedure may be required based on curve type, severity and patient frailty. At present there is uncertainty about the ideal amount of postural correction and the relationship of functional outcome.
The aim of this study was to analyse the correlation between surgical adult scoliosis correction and functional outcome.
Methods: A retrospective study was conducted using the prospective collected data from the Australian Spine Registry. All patients above the age of 18 years were included. Patients were asked to complete the Oswestry Disability Index (ODI), EQ-5D-3L before surgery and then after 6, 12 and 24 months. In addition, demographics, comorbidities and complications were noted. All pre- and post-operative EOS scans were analysed measuring the pelvic incidence, pelvic tilt, sacral slope, lumbar lordosis, thoracic kyphosis, hip occipital angle, sagittal vertical axis, upper and lower cobb angles, coronal list, and number of fusion levels. The number of surgical stages were recorded. A Pearson correlation test was performed to analyse the correlation between postoperative PROMs and change in radiographic measurements.
Results: A total of 48 patients at a mean age of 52.3±14.8 years met the inclusion criteria between 2018 and 2021. The lumbar primary curve had a preoperative Cobb angle of 46.5±18.9° on average and a thoracic Cobb angle of 29.3±16.2°. The coronal list was 24.5±21.0mm and the sagittal vertical axis -62.7±80.6mm. After surgery, the lower cobb angle improved -28.2±18.4° to 20.3±14.0 and the upper cobb angle by -11.0±16.2° to 17.6±12.3°. After surgery, the coronal list was 20.3±16.2mm (a change of -2.4±23.6mm) and the sagittal vertical axis was -17.0±42.8mm (a change of 50.0±69.3mm). Lumbar lordosis was improved by 20.1±18.9° to 45.1±12.7° and thoracic kyphosis by 17.7±13.7 to 52.8±15.9°. No significant changes in, pelvic tilt or sacral slope were noted.
Before surgery, the ODI was 32.9±16.3 and this improved to 25.6±20.3 after 6 months, 26.0±17.7 after 12 months (p=0.182), and 19.6±12.5 after 24 months (p=0.012). For the EQ-5D-3L this was 62.3±18.5 preoperative, 72.9±19.6 after 6 months, 74.4±11.4 after 12 months and 73.4±12.7 (p=0.024) after 24 months (p=0.050). No significant correlation was observed between the patient related outcome measures and radiographic measurements.
Conclusion: Satisfaction of degenerative scoliosis patients does not require a full anatomical reduction. Even if a remaining scoliosis was present patients were still highly satisfied. Therefore, the current concepts recommending anatomical reduction needs to be correlated with PROMs results.. The functional outcome should be prioritized in the upcoming studies.

O436

Effect of non fusion anterior scoliosis correction on shoulder balance in Lenke type 1 adolescent idiopathic scoliosis patients: Is it detrimental or beneficial?

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Introduction: Cosmesis of the back and shoulders with a coronally balanced spine are the critical factors for any Adolescent idiopathic scoliosis (AIS) correction surgery. All the existing literature reports the importance of post-operative shoulder balance following posterior fusion surgery and factors to be considered for the same. There is an evident dreath in the clinical data describing the effect of Anterior Vertebral Body Tethering (AVBT) on shoulder balance. Furthermore, we in our center use a modified technique of VBT, termed as Non Fusion Anterior Scoliosis Correction (NFASC) where we use segmental compression, de-rotation, apical translation and sequential tensioning of cord to achieve maximum intraoperative correction. This differentiates it from the actual AVBT technique which is mere tethering of the cord.

Aim: Evaluate the effect of NFASC on shoulder balance in Lenke type 1 AIS patients.

Materials & Methods: Single center, single surgeon retrospective study of 30 patients with Lenke type 1 AIS curve treated with NFASC at 2 years postoperatively (follow-up range: 21–48 months). Clinical photographs were compared pre and post operatively and shoulder angle, axilla angle, inner and outer shoulder heights were analysed. Image analysis software such as Image J (National Institute of Health, Bethesda, Maryland) was used. Radiologically, changes in the curvature, clavicular angle, T1 tilt angle and radiographic shoulder height were investigated. Statistical analysis was done using SPSS version 21.

Results: Of the 30 patients, 95.56% were female with preoperative age 14.96 ±2.69 years. The mean thoracic cobbs angle was corrected by 69% at last follow up, 52.11˚ ± 7.74˚ preoperative compared to 16.92˚ ± 5.06˚ post-operative cobbs. Axilla and shoulder angle clinically were 6° ± 2.7° and 5.5° ± 1.8° pre-operatively and 2.1° ± 0.8° and 1.8° ± 0.5° post operatively respectively ($p<0.001$) [Fig 1]. Radiological paramaters showed significant improvement [Table 1, Fig 2]. Preoperatively, absolute shoulder height averaged 19.6 ± 7.4 mm, and 16 (40%) patients had shoulder imbalance. At 1-year follow-up, absolute shoulder height averaged 5.2 ± 2.63 mm, and 4 (10%) patients had shoulder imbalance [Fig 3].

Discussion. Achievement of shoulder balance is one of the most important factor for patient satisfaction, in-turn measure of a successful scoliosis surgery. Samdani et al[1]. reported two cases of overcorrection following AVBT requiring repeat surgery. We didn't encounter this, since majority of our cohort were Risser 4 and above. Matsumoto et al[2]. reported similar clavicular and T1 tilt angles in Lenke type 1A patients following fusion (clavicular angle:1.8° ± 2.1°, T1 tilt angle: 3.4° ± 5.5°). Firoz Miyanji et al[3] concluded that postoperative shoulder imbalance in AIS undergoing AVBT was seen in 16% of patients, a reduction from 30% preoperatively.

Conclusion: NFASC offers promising curve correction and stabilization of curve progression in AIS cases with low risk of complications, preservation of spinal mobility, sagittal parameters and proves to be a favourable alternative to fusion modality. Shoulder balance improved in 66% of patients who had pre-operative shoulder imbalance. These results reflect that NFASC has a beneficial effect on shoulder balance in patients with Type 1 AIS.

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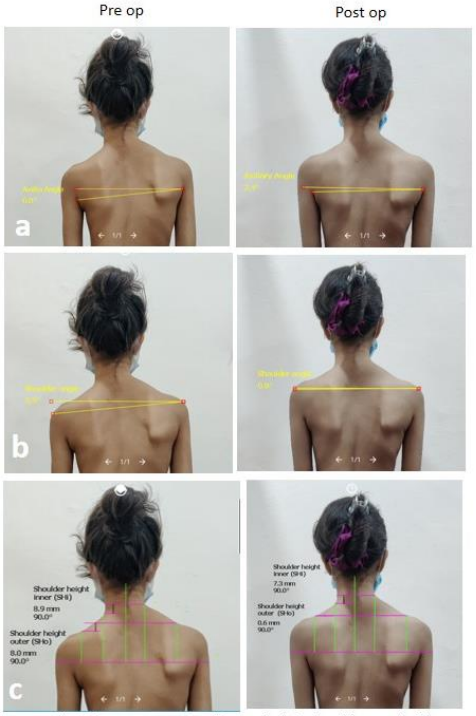


Fig 1- Clinical parameters- Axillar angle (a), Shoulder angle (b), Shoulder height (c)

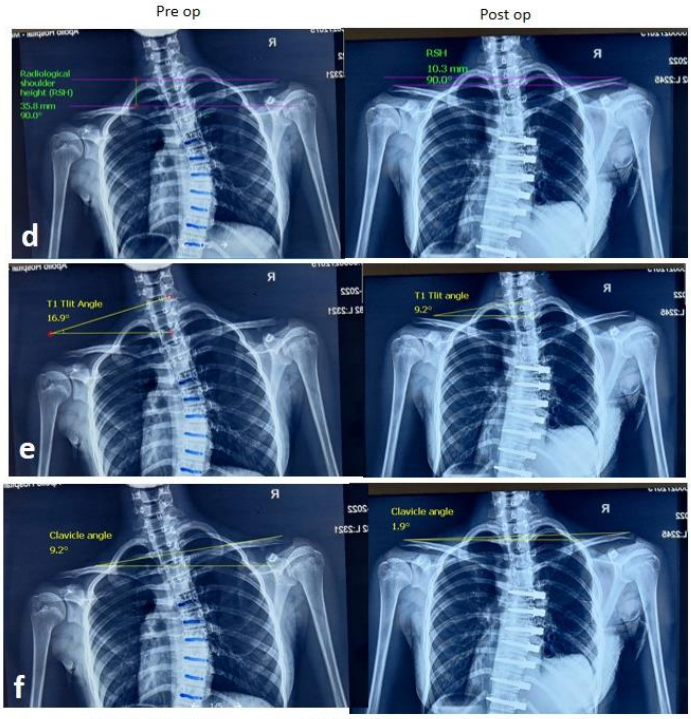
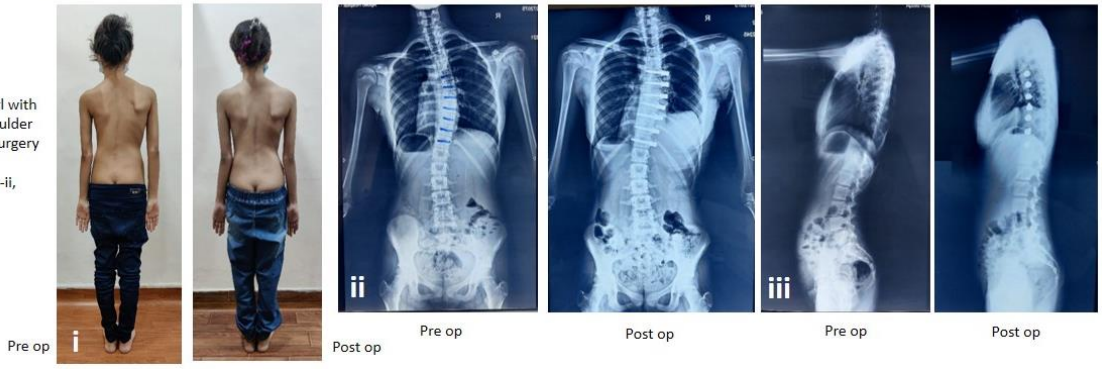


Fig 2- Radiological parameters- RSH (d), T1 tilt angle (e), Clavicle angle (f)

Table 1- Statistical analysis of various clinical and radiological parameters

	Pre Operative	Immediate Post Operative	1 yr Follow up	P Value
MT curve cobbs (Degree˚)	52.11˚ ± 7.74˚	13.28˚ ± 4.12˚	16.92˚ ± 5.06˚	0.0001
Clinical Parameters				
- Axillary angle	6° ± 2.7°	2.6° ± 1.2°	2.1° ± 0.8°	p<0.001
- Shoulder angle	5.5° ± 1.8°	2.1° ± 0.9°	1.8° ± 0.5°	p<0.001
- Shoulder height				
SHi (inner)	8.9° ± 1.3°	7.6° ± 2.7°	7.2° ± 2.3°	0.3
SHo (outer)	7° ± 2.0°	3° ± 0.9°	2° ± 1.2°	0.04
Radiological parameters				
- RSH (Radiological Shoulder Height)	19.6 ± 7.4 mm	4.8 ± 1.3 mm	5.2 ± 2.63 mm	p<0.05
- T1 Tilt angle	10.7° ± 3.4°	4° ± 2.2°	2.8° ± 1.7°	p<0.05
- Clavicle angle	8.6° ± 2.1°	2.6° ± 1.7°	1.8° ± 0.7°	P>0.05

Fig 3- 11yr old girl with correction of shoulder imbalance post surgery clinically (i) and radiologically (AP-ii, Lateral-iii)



O437

Can muscle size (a)symmetry be quantified using magnetic resonance imaging in adolescent idiopathic scoliosis

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Introduction: Adolescent Idiopathic Scoliosis (AIS) is a 3D spine deformity where progression occurs during growth. An asymmetry in paraspinal muscle size and therefore force generation capacity, may contribute to asymmetrical forces being applied to the growing spine and facilitate asymmetrical vertebral growth. We aimed to i) quantify muscle volume asymmetry in the presence of AIS, and ii) determine if asymmetry magnitude is associated with skeletal maturity, disease severity and/or age.
Methods: 3T Magnetic resonance images (MRIs) [T1-weighted 3D Gradient Echo sequence, voxel size: 0.5x0.5x0.5mm, FOV: major thoracic curve (~T4-L1)] were performed on 25 female adolescents who had right thoracic scoliotic curves; mean major curve Cobb angle: 29±8.9°; mean age: 12.6±1.4 years; adjusted mean height:150±11cm; mean Risser Grade: 0-2, who were recruited from the Queensland Children's Hospital (and formerly Mater Children's Hospital) Spine Deformity Clinic between 2012-2017. The same MRI protocol was also performed on 22 participants with healthy symmetrical spines, matched with mean age: 12.5±1.4 years; mean height: 152±10cm; Risser Grade: 1-4.
Superficial (iliocostalis and longissimus) and deep (multifidus, semispinalis and rotatores) paraspinal muscle cross-sectional areas (CSA; mm2) were determined by manually delineating muscle boundaries from the MRIs. CSAs of consecutive slices, from the upper to the lower vertebral body boundaries, were multiplied by MRI slice thickness (0.5mm) and summed, to calculate the muscle volume (mm3) associated with individual vertebral segments. A muscle volume asymmetry index [Ln(concave/convex volume)], was determined for the level of the curve apex and lower-end vertebral (LEV: the most tilted vertebra below the apex) of the scoliotic curve, and the matched vertebral levels of the control group.
Results: Intra-rater reliability of our asymmetry index was strong [ICC(3,1): 0.974; muscle volume of 8124mm3 (166.8 SEM)]. The asymmetry index of superficial muscle volumes at the apex and LEV, and deep muscles at LEV were not different between the groups. However, the deep paraspinal muscle volume at the level of the curve apex was 16±20% greater on the concave compared to the convex side of the curve in the AIS group. This asymmetry was larger ($p<0.05$) than that observed in the control group -7±3% (Fig 1). The magnitude of asymmetry identified in AIS participants was positively correlated with their Risser grade ($r=0.50$, $p<0.05$) and major curve Cobb angle ($r=0.45$, $p<0.05$), but not chronological age ($r=0.34$, $p>0.05$).
Conclusions: This work highlights that the asymmetry in the AIS participants' deep paraspinal muscles lies outside the typical asymmetry range observed in adolescents with symmetrical spines and highlights the need for further exploratory work into the potential role of paraspinal musculature as a pathological driver of AIS progression. Follow up studies will enable quantification of an asymmetry for more paraspinal muscles and consider more factors that contribute to muscle force generation capacity including muscle quality and activation.

O438

Posterior scoliosis correction with thoracoplasty: Effect on pulmonary function with a mean follow-up of 4.8 years

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Introduction: There is controversy with regards to the long-term effects of thoracoplasty on pulmonary function with concerns that it impairs pulmonary function. We performed a study looking at the clinical, radiological and pulmonary function outcomes after posterior scoliosis surgery with thoracoplasty with a minimum follow-up of two years.
Methods: This was a retrospective observational study of thirty-seven patients with AIS who underwent posterior instrumented surgical correction with thoracoplasty. There was a minimum of two years follow-up. Clinical outcomes were measured using the SRS-22 questionnaires. Radiological outcomes were evaluated using standing posteroanterior and lateral radiographs. All patients had pulmonary function tests to evaluate pulmonary volume and flow (forced expiratory volume in the first second (FEV1) and forced vital capacity (FVC)) both before surgery and at the final follow-up.
Results: There were three males and thirty four females. The mean age of patients was 14.6 years (range, 11 – 21 years). The mean length of follow was 58 months (range, 24-124 months). The average main thoracic Cobb angle in the coronal plane was corrected from 50.0°**±** 12.4° preoperatively to 16.6° ± 6.3° postoperatively. The average thoracolumbar Cobb angle in the coronal plane was corrected from 28.2° ± 10.6° preoperatively to 10.1° ± 7.2°. The average thoracic kyphosis angle was corrected from 17.4° ± 11.0° preoperatively to 21.8° ± 10.5°. In terms of the Quality of life Outcomes (QoL), there was a significant increase ($p<0.001$) in the mean SRS 22 scores from 3.8 preoperatively to 4.3 postoperatively. A statistically significant increase in the absolute forced expiratory volume in one second (FEV1) from pre-operative values with a p value < 0.001 was seen. There was a statistically significant increase in percentage predicted forced expiratory volume in one second from preoperative values with a p value of 0.008. There was also a statistically significant increase in the absolute forced vital capacity (FVC) from preoperative values with a p value <0.001. The average percentage predicted forced vital capacity did increase on final follow-up from before surgery, but the increase was not statistically significant.
Conclusions: We have demonstrated that pulmonary function post-thoracoplasty not only reaches pre-operative levels, but significantly surpasses it with regards to the majority of the pulmonary parameters measured in this study. We also demonstrated satisfactory radiological correction and clinical outcomes.

O439

Are we looking at a paradigm shift in the management of adolescent idiopathic scoliosis- comprehensive retrospective analysis of 75 patients of non-fusion anterior scoliosis correction (nfasc) with 2-5 years follow up: A single centre experience

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Introduction: The gold standard for surgical management Adolescent idiopathic scoliosis (AIS) patients remains spinal fusion, but recently NFASC has gained interest. NFASC is a new, motion preserving treatment method for surgical management of idiopathic scoliosis, but there is a visible dearth in clinical data related to the procedure. Many of the literature are on the usage of NFASC on skeletally immature children, with no conclusive guidelines regarding case indications, proper technique and evidence on possible complications. The present study aims to evaluate the clinical and radiological outcomes in patients who underwent non-fusion anterior scoliosis correction surgery (NFASC) for Idiopathic scoliosis and comprehensive analysis of principles of NFASC.
Methods: A retrospective cohort study of 75 patients who underwent the NFASC with a mean follow up of 26 ±12.2 months (12 -60 months). These patients were managed for structural major curve, between 40°and 80° having >50% flexibility on dynamic x rays. Pertinent clinical and radiological data collected regarding skeletal maturity, curve type, cobb angle, surgery details and SRS-22r questionnaire. A Post hoc analysis following repeated measures ANOVA test was used to examine statistically significant trends.
Results: 75 patients (70 Female, 5 Male) were enrolled, with a mean age of 14.96 $\pm$ 2.69 years. The mean Risser score and Sanders's score was noted to be 4.22 ± 0.7 and 7.15 ±0.74 respectively. The mean Main thoracic (MT) Cobb angle at first follow-up (17.2 ± 5.36) and last follow-up (16.92 ± 5.06) were significantly lower than the preoperative cobb angle (52.11 ± 7.74), ($p<0.05$). Similarly, the mean Thoracolumbar/lumbar (TL/L) cobb angle significantly improved from preoperative (51.45 ±11.26) to the first follow-up (13.48 ± 5.11) and last follow-up (14.24 ±4.85) ($p<0.05$). Mean preoperative and postoperative SRS-22r scores were 78.0±3.2 and 92.5±3.1 respectively ($p<0.05$). None of the patient had any complications till the recent follow up. Figure 1, Figure 2
Conclusions: Non-fusion anterior scoliosis correction (NFASC) offers promising curve correction and stabilization of curve progression in cases with idiopathic scoliosis with a low risk of complications with preservation of spinal mobility and sagittal parameters of spine and proves to be a favorable alternative to fusion modality.

Acknowledgements: No external funding source was used for the study.

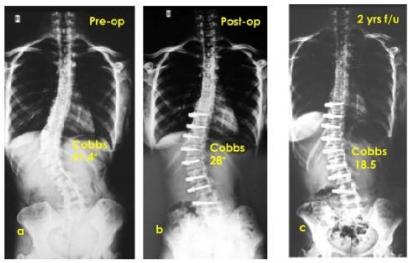

Fig 1- Case 1: 14-year-old girl with Risser 5 and Sanders 7 presented with Lenke 5CN (a) pre-op radiograph shows a Cobb angle of 51.4°.(b) shows immediate post-op erect radiograph with Cobb measuring 28.0°(46% correction). (c) at 2 year follow up, the deformity corrected to Cobb measuring 18.5° (further 33 % correction).

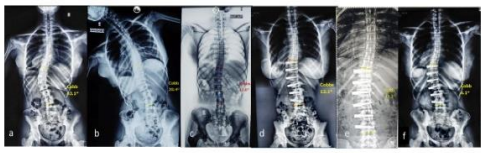

Fig 2- Case 2: Serial radiographs of 14 year girl with Sanders 7 and Risser4 showing: a) pre op Major Thoracic Cobbs (D10-L3) of 43.1°, b) Lt bending film 20.4°, c) traction of 11.6°, d) first erect of 12.1°, e)1yr follow up of 11.3° and f) 2yr follow up of 6.1° (85% correction).

O440

Development of a patient-oriented smartphone application (myScoliosis) to improve the healthcare journey of paediatric patients with scoliosis

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Introduction: Scoliosis is a paediatric spinal deformity, with a prevalence around 5%. Clinical management of scoliosis focuses on stabilizing the deformity and avoiding progression. But scoliosis from the child's perspective is often about coping with clinical appointments, their prescribed treatment (surgical or non-surgical), and dealing with their changing body appearance. These holistic patient-focussed care considerations are not currently central in the patient's clinical management journey. This project focused on development of a new patient-oriented smartphone app, *myScoliosis*, developed specifically for adolescent scoliosis patients.
Methods: The ubiquity of smartphones provides a unique approach to aiding patients and families in managing and understanding scoliosis through mobile tools which enable them to track their symptoms, keep a record of their own radiographs and changing appearance, journalise their thoughts and experience, and importantly, provide reliable informational resources to explain their spinal condition. To enable this, the development of an accessible, multiplatform smartphone application has been completed, enabling simple patient journaling of quantitative clinical metrics and qualitative personal healthcare experiences, as well as radiographs and user-captured imagery. The application has patient privacy as paramount, with no recorded information transmitted to/from the phone. Said data is also explicitly excluded from automatic device backup processes unless explicitly desired by the user.
Results: *myScoliosis* has successfully been pilot tested via open access distribution on the Google Play Store and iOS App Store and offered to patients attending the Queensland Children's Hospital (QCH) Spine Clinic. A small group of adolescent spine deformity patients provided qualitative feedback using a voluntary in-app questionnaire. Feedback indicates that the *myScoliosis* app is reliable, readily understandable, helpful, educational, and improves the overall patient healthcare experience (Likert score mean >3 on 5-point scale).
Conclusions: *myScoliosis* has been designed to be both easy to use and accessible, thus maximising the patient userbase. *myScoliosis* will be offered to all scoliosis patients by their treating orthopaedic specialist at QCH as well as being publicly available on both iOS and Android devices. The *myScoliosis* app is a patient-focussed support tool that is currently not provided through other scoliosis-centred smart-device applications. Qualitative and quantitative assessments to understand patient experiences and the benefits wrought from it will continue to be analysed to drive continuous improvements and to ensure its maximum benefit to scoliosis sufferers' healthcare journey.

Acknowledgements. Partial funding for app development from QCH SERTA Grant.

O441

Surgical site infection in paediatric spine deformity surgical: A review of 933 procedures in a tertiary children's hospital

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Introduction: Despite extensive efforts to reduce its occurrence, surgical site infection (SSI) remains an infrequent but devastating complication in paediatric spine deformity surgery. Established infection typically results in prolonged hospital stays, re-admission, re-operation, increased healthcare costs, as well as great emotional distress to patients, their careers, and treating teams.
The *Queensland Children's Hospital* (*QCH*) is a 359-bed facility with a team of eight fellowship-trained paediatric spinal surgeons. It is the major specialist children's hospital for Queensland and Northern New South Wales. It. This retrospective audit aimed to identify all cases of SSI which had occurred following paediatric spinal deformity surgery at QCH since the hospital was opened six years prior. The audit aimed to define patient demographics, infection rates, microbiology and treatment, and ultimately compare local practice against international benchmarks.
Methods: Cases of SSI were identified by accessing departmental records, clinical coding and National Surgical Quality Improvement Program (NSQIP) infection data.
Results: The search identified that between January 2015 and August 2021, 933 surgical procedures were performed on 580 patients. The mean age at the time of the procedure was 13.8 years.
Thirty-nine percent of patients had an underlying neuromuscular condition, 29% had idiopathic deformity and 20% had congenital deformity.
Of the 933 patients, 35 developed SSI, resulting in an overall infection rate of 3.75%. Of these infections, nine were found to be deep to fascia (0.96%) and 26 superficial (2.79%). Notably, patients with underlying neuromuscular conditions were found to be at a greater risk of infection (6.1% vs 2.07%).
The predominant microorganisms cultured were staphylococcus aureus (40%), Coagulase-negative staphylococci (20%), pseudomonas aeruginosa (17.1%), and propionibacterium sp. (8.6%). Of the 26 superficial infections, all received antibiotics: nine required admission for intravenous therapy. The median duration of treatment was 14 days. Five patients (19%) required debridement and lavage in theatre. All cases of superficial infection clinically resolved.
All patients with deep infection required surgical management. Partial or complete removal of metalwork was required in five of the nine patients, however was able to be retained in four.
Discussion/Conclusions: Risk factors for SSI are multi-factorial and can generally be classified as pre-operative, intra-operative and postoperative. Typically, surgical teams go to great lengths to reduce the risk of SSI at each of these time points.
Measures routinely practised at QCH to prevent SSI include the use of pre-operative chlorhexidine bodywash, pre-operative education sessions, routine dosing of IV antibiotics prior to induction, use of patient warming devices, betadine-soaked swabs applied to wound edges, copious irrigation prior to closure, impervious dressings, and attempts to minimise unnecessary dressing changes: these measure being in keeping with standard international protocols.
SSI rates presented in this series are comparable to other datasets within the literature. As reported by Smith et al.[1] The Scoliosis Research Society morbidity and mortality database was queried for all reported spine surgery cases from 2004 to 2007 showing an overall infection rate of 2.5%, and a rate of 5.5% in neuromuscular patients. Similar rates were reported by the American College of Surgeons NSQIP dataset with an overall infection rate of 2.3% and a deep infection rate of 1.2%[2].

References:

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O442

Intraspinal anomalies associated with complex spine deformity: Different approach, different measures to achieve optimum outcome

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Introduction: Intraspinal anomalies are often associated with early onset scoliosis which can result in a neurologic deficit and propagation of the spinal deformity. Most common anomalies encountered are Arnold Chiari malformation, tethered cord syndrome, split cord malformation.
Aim: To formulate the management protocol for idiopathic scoliosis with intraspinal anomalies and to canvass the complications encountered to achieve the best possible outcome by inculcating necessary intraoperative strategies different from normal spine deformity surgeries.
Materials and Methods: Retrospective analysis of 30 patients operated in tertiary care centre(apex government institute) from January 2019 to December 2020 was done with mean follow up of 8months having scoliosis with Cobb's angle>40, age>10years and presence of intraspinal anomaly. All the patients were operated for spinal anomalies first, followed by deformity correction surgery.
Results: Mean age of the patients was13.6 years with average gap between two procedures being 8.1 months. Mean pre-operative Cobb's angle was 86.6 which increased to 92 before 2nd surgery. Mean post-operative cobb's angle was.29.7. Anomalies encountered were n ACM with syrinx - 5, Tethered Cord - 3,Split cord malformation - 2. Complications encountered: Death - 1,DIC - 1, infection-1.
Conclusion: Treatment of intraspinal anomaly takes precedence over deformity as it decreases development of neurological deficits and reduction in the tension of neural elements which may stabilize/regress spinal deformity. Treatment should be staged and spaced by 6months preferably. Spinal deformity correction is quite challenging in such cases. Hence proper patient counselling, multispeciality team approach and adequate instrumentation (reduction screws, towers, Cobalt chromium rods) can yield most favourable results. Proper attempts to reduce the surgical duration and blood loss even if it means getting a suboptimal correction can give optimum results overall.

O443

Patient reported outcomes vs radiographic measurements with a hybrid anterior lumbar reconstruction for the management of symptomatic low-grade L5-S1 isthmic spondylolisthesis

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Introduction: Defects in the isthmus of the L5 pars are a common occurrence (4-8% of the general population) and many develop a degree of spondylolisthesis. However, only a small portion of these become symptomatic. At the time of symptomatic presentation, patients often have an MRI suggestive of degenerative change in the L4-5 or further cranial lumbar intervertebral discs. If appropriate non-operative management has been unsuccessful, then surgical reconstruction may be considered. Better post-operative outcomes may be related to greater angular correction achieved in the reconstruction.
Aim: Evaluate whether the degree of angular correction obtained in an anterior lumbar hybrid reconstruction influences the change in patient reported outcomes measures (PROMs) for patients with L5-S1 isthmic spondylolisthesis with adjacent segment degenerative disc disease.
Methods: A hybrid construct, in the form of combined anterior lumbar interbody fusion and total disc replacement was studied in the treatment of 35 patients with low-grade isthmic spondylolisthesis with radiculopathy and positive provocative discography. Radiographic measurements were compared to PROMs at 12 months. Slip percentage, sacral slope, lumbosacral angle (L5-S1), lumbar lordosis (L1-S1) and the angle of the supra-adjacent motion segment were compared prior and post-reconstruction. The PROMs collected included Visual Analog Score, back and leg, Oswestry Disability Index (ODI) and Roland-Morris Disability Questionnaire (RMDQ), as well as a patient post-operative satisfaction score. Repeated measures correlation (rmcorr) analysis was used to evaluate the association between the changes in radiographic alignment and PROMs.
Results: There was moderate and strong correlation between improvements in the radiographic measures and the PROMs at 12 months. Increase in sacral slope and lumbosacral angle had rmcorr results of 0.77 or greater when compared to change in ODI and RMDQ ($|r|$≥0.5 = strong correlation). On all PROMs patients reported substantial clinical benefit. Over 90% of patients reported patient satisfaction scores of “Good” or “Excellent” at 12months post-op.
Conclusions: Anterior lumbar hybrid reconstruction for symptomatic low-grade L5-S1 isthmic spondylolisthesis has good early PROMs and these outcomes are correlated with larger degrees of angular correction achieved.

O444

TANGO: Development of consumer information leaflets to support TAperiNG of Opioids in older adults with low back pain and hip and knee osteoarthritis

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Introduction: Globally, the rate of opioid prescription is high for chronic musculoskeletal conditions despite guidelines recommending against as their adverse effects outweigh their modest benefit. Deprescribing opioids is a complex process that can be hindered by multiple prescribers and patient-related barriers. Thus, involving patients, their carers, and HCPs in the development of consumer materials can ensure that the resources have high readability, usability, and acceptability to the population of interest.

Aim: This study aimed to (i) develop two educational consumer leaflets to support opioid tapering in older people with low back pain (LBP) and hip or knee osteoarthritis (HoKOA), and (ii) evaluate the perceived usability, acceptability, and credibility of the consumer leaflets from the perspective of consumers and health care professionals.

Participants: thirty consumers (and/or their carers) and 20 health care professionals were included in the study. Consumers were people older than 65 years of age, currently experiencing LBP, HoKOA, and with no health care professional background. Carers were people who provided unpaid care, support, or assistance to an individual meeting the inclusion criteria for consumers. Health care professionals included physiotherapists (n=9), pharmacists (n=7), an orthopaedic surgeon (n=1), a rheumatologist (n=1), nurse practitioner (n=1) and a general practitioner (n=1), all with at least three years of clinical experience and who reported working closely with this target patient population within the last 12 months.

Methods: Prototypes of two educational consumer leaflets (a brochure and a personal plan) were developed by a team of LBP, OA and geriatric pharmacotherapy researchers and clinicians. The leaflet prototypes were evaluated by two separate chronological review panels involving (i) consumers and/or their carers and (ii) health care professionals. Data collection for both panels occurred via an online survey. Outcomes were the perceived usability, acceptability, and perceived credibility of the consumer leaflets. Feedback received from the consumer panel was used to refine the leaflets, before circulating the leaflets for further review by the health care professional panel. Additional feedback from the health care professional review panel was then used to refine the final versions of the consumer leaflets.

Results: Both consumers and health care professionals perceived the leaflets and personal plan to be usable, acceptable, and credible. Consumers rated the brochure against several categories, which scored between 53% - 97% positive responses. Similarly, the overall feedback provided by healthcare professionals was 85-100% positive. The modified system usability scale scores obtained from healthcare professionals was 55-95% positive, indicating excellent usability**.** Feedback for the personal plan from both healthcare professionals and consumers was largely positive with consumers providing the highest positive ratings (80-93%). Whilst feedback for HCP was also high, we did identify that prescribers were hesitant to provide the plan to patients frequently (no positive responses).

Conclusions: This study led to the development of a leaflet and personal plan to support the reduction of opioid use in older people with LBP, HoKOA. The development of the consumer leaflets incorporated feedback provided by health care professionals and consumers to maximise clinical effectiveness and future intervention implementation.

O445

Lumbar total disc replacements for degenerative disc disease: A systematic review of outcomes with a minimum of 5 years follow-up

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Introduction: Lumbar degenerative disc disease (DDD) is a spinal condition commonly associated with low back pain, caused by wear-and-tear on an intervertebral disc. Currently, spinal fusion is considered to be the gold standard treatment for lumbar DDD. However, there have been reports of spinal instability and adjacent segment degeneration after the spinal fusion procedure. Consequently, total disc replacement (TDR) is once again gaining traction as an alternative procedure to restore and maintain spine biomechanics and motion. The purpose of this study was to systematically review the clinical outcomes, efficacy, re-operation, and complication rates of different lumbar TDR devices at mid- to long-term follow-up studies for the treatment of lumbar DDD.
Methods: A systematic search was conducted on three electronic databases (PubMed, SCOPUS, and Google Scholar) to identify follow-up studies that evaluated clinical outcomes of lumbar TDR in patients with DDD. The included studies met the following criteria: prospective or retrospective studies published from 2012 to 2022; reported data on lumbar TDR patients with degenerative disc disease; a minimum of 5 years post-operative follow-up; a study sample size of greater than 10 patients; patients > 18 years of age; containing clinical outcomes with at least one of, Oswestry Disability Index (ODI), Visual Analog Scale (VAS), complication or reoperation rates. The exclusion criteria included: other treatment methods in combination with lumbar TDR; non-English manuscripts; case reports, reviews, or animal studies. A total of 22 studies were included for final analysis.
Results: This study investigated the outcome data for lumbar TDR from 2284 patients from 22 published studies. The mean follow-up time for this study was 97.31 months and the mean follow-up rate was 86.90%. The mean age of this study was 42.34 years, and the study population comprised 54.97% female. The mean VAS and ODI pain score improvements were 50.71 ± 6.91 and 30.39 ± 5.32 respectively. The mean clinical success and patient satisfaction rates were 60.93% ± 6.26% and 69.36% ± 4.38%, respectively. The mean reoperation and complication rates were 20.46% ± 4.12% and 21.70% ± 6.80%, respectively. Furthermore, there was no statistical difference when comparing clinical outcomes (Table 1) of mid-term (5 years) and long-term (≥ 10-years) follow-up studies ($p>0.05$, Student's t-test).
Conclusions: This study demonstrated mid-to-long term improvements in clinical outcomes of lumbar TDR for the treatment of lumbar DDD. Mid-term follow-up data on clinical outcomes, complication and reoperation rates of lumbar TDRs were maintained at long-term follow-up. Clinical outcomes from patients with lumbar TDR were similar to spinal fusion data.

Acknowledgements:
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Table 1. Mean Improvement of VAS and ODI pain scores compared between 5-year and ≥ 10-year follow-up studies

	5-year follow-up	95% CI	≥ 10-year follow-up	95% CI	P-value*
VAS	44.68	27.33 - 62.03	40.38	32.98 - 47.77	0.45
ODI	30.76	15.55 - 45.97	24.58	10.48 - 38.67	0.33

*Student's t-test was used to compare data between groups

O446

Incidence of temporary intra-operative iliac artery occlusion in anterior spinal surgery

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Introduction: Thromboembolic complications in anterior lumbar spinal surgery are uncommon but potentially catastrophic resulting in limb loss. There have been multiple case reports of iliac artery thrombosis, and a single case series which estimated the incidence of iliac artery thrombosis requiring vascular intervention as 0.45%. Retraction of the iliac vessels to facilitate exposure of the target level/s can temporarily occlude the iliac artery which risks thrombosis or embolic sequelae. Brief intraoperative heparinization can potentially mitigate this risk.
Aim: We aimed to quantify the incidence of temporary iliac artery occlusion (IAO) during anterior lumbar exposure and examine the effect of the gender, target disc level and the spinal prosthesis.
Methods: We performed a multi-center, prospectively collected, retrospectively analyzed study of consecutive patients undergoing anterior lumbar spinal surgery by a single vascular surgeon and five neurosurgeons between January 2009 and August 2022. The procedures performed were a single or double level Total Disc Replacement (TDR); single, double or triple level Anterior Lumbar Interbody Fusion (ALIF); or Hybrid procedure (combination cranial TDR and caudal ALIF/s). All patients had oxygen saturation meters placed on the first or second toes bilaterally with the waveform monitored throughout the case. A loss of the signal waveform combined with an impalpable external iliac artery pulse distal to the retractors defined occlusion of the ipsilateral iliac artery. Heparin was administered on IAO (50-75 units/kg), which was reversed with protamine on return of the signal waveform. Pedal pulses were checked pre- and post-operatively in all cases.
Results: A total of 605 patients were included (287 Female, 318 Male). The overall rate of IAO was 29.1% (Male 26.1%, Female 32.4%). At the L5/S1 level, IAO was uncommon (ALIF 2.8%, TDR 4.5%). L4/5 was the key level associated with IAO. The addition of the L4/5 level to the procedure increased the incidence of IAO significantly (ALIF 45.7%, TDR 73.4%, Hybrid 66.1%). TDR was associated with higher rates of IAO at L4/5 compared to ALIF (74.6% vs 48.5%), and IAO in females compared with males (80.6% vs 67.9%). Hybrid procedures were commonly associated with an IAO rate of 66.1% (Male 61.3%, Female 71.4%).
Conclusions: These results support the use modalities to monitor limb perfusion during anterior spinal surgery at lumbar levels, particularly with TDR, and at L4/5. The use of foot digital saturation meter monitoring to detect iliac artery occlusion allows the use of targeted intraoperative heparinization to protect against this complication.

O447

Surgical, radiographic and patient-reported outcomes following multilevel lumbosacral fusion utilising a novel minimally invasive multi-incision technique

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Introduction: Anterior lumbar interbody fusion (ALIF) with or without posterior instrumentation is a common, effective and well-described treatment option for several lumbar pathologies, including degenerative disc disease, trauma and infection. Multilevel lumbar pathologies, particularly those spanning the lumbosacral regions, are often complex, require sagittal alignment corrections and carry significant risk of complication. Hence, there is a need to improve surgical time and invasiveness. Anterolateral minimally invasive interbody fusion techniques include the extreme lateral interbody fusion (XLIF), oblique lumbar interbody fusion (OLIF) and ALIF. Each technique has advantages and disadvantages and is limited in their suitability to address all L1-S1 levels. Building on these techniques, we report a novel minimally invasive multi-incision lumbar interbody fusion technique for the treatment of multilevel lumbosacral pathologies.
Methods: Demographic, perioperative, patient reported outcome measures (PROMs) and sagittal alignment parameters were retrospectively assessed for participants who underwent minimally invasive surgery (MIS) multilevel multi-incision lumbosacral fusion between June 2020 and October 2022. PROMs were collected pre-operatively and 12-months post-operative and included the EQ-5D-5L to assess health related quality of life, Visual Analogue Scale (VAS) to assess neck and arm pain intensity and the Neck Disability Index (NDI) to assess neck-pain related disability. Sagittal alignment parameters were determined from radiographic imaging and reports.
Results: Thirty-seven participants (66% female and mean age of 67.4 years) underwent surgery on a mean of two and four levels for single- and two-stage surgeries, respectively. Mean surgery duration and blood loss were 271 minutes and 252ml for single-stage and 323 minutes and 550ml for two-stage surgeries. Four (11%) participants who underwent single stage procedures developed post-operative complications; persistent radiculopathy n=2, cement extrusion causing radiculopathy n=1, persistent CSF leak n=1). Pre-operative sagittal alignment parameters were within normal ranges and were preserved post-operatively. All PROMs significantly improved ($P<0.05$) and minimally clinically important differences were achieved at the 12-month follow-up.
Conclusions: This minimally invasive multi-incision anterolateral approach allowed access to L1-S1 for multilevel lumbosacral fusion. This technique was safe, reproducible and resulted in good radiographic, surgical and patient-reported outcomes.

O448

Lateral single position anterior-posterior (AP) Lumbar Fusion outperforms conventional AP Fusion with patient repositioning at 2-year minimum follow-up

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Introduction: Previous literature has demonstrated the advantages of Lateral Single Position surgery (L-SPS) in the perioperative period; however, 2-year postoperative outcomes of this novel technique have not yet been compared to traditional circumferential anterior-posterior fusion (FLIP).

Aim: Evaluate the feasibility and safety of L-SPS technique against the conventional FLIP.

Methods: Patients undergoing primary AP (ALIF or LLIF) fusions with bilateral percutaneous pedicle screw fixation between L2-S1 with minimum 2-year follow up at 3 institutions. Patients were grouped as L-SPS if anterior and posterior portions of the procedure were performed in the lateral decubitus position, and FLIP if patients were repositioned from supine or lateral to prone position for the posterior portion of the procedure. Groups were compared in terms of demographics, intraoperative, perioperative and radiological outcomes, complications and reoperations up to 2 years follow-up. Measures were compared using independent samples or paired t-tests and chi-squared analyses with significance set at $p<0.05$.

Results: 442 pts met inclusion, including 352 L-SPS and 90 FLIP pts. Significant differences were noted in age (62.4 vs. 56.9; p=<0.001) and smoking status (7% vs. 16%; p=0.023) between the L-SPS and FLIP groups. No differences between L-SPS and FLIP were noted in gender (57.4% female vs 57.8% female, p=1.000), BMI (30.0kg/m2 vs 29.3kg/m2; p=0.318). No differences were noted in number of levels fused between L-SPS and FLIP (1.45vs 1.50; p=0.533), proportion including ALIF (38% vs 39%; p=0.809), or the proportion of surgeries including L5-S1 (38%vs 31%; p=0.222).

Perioperative Outcomes: L-SPS demonstrated significantly lower Op time (97.7min vs 297.0 min; $p<0.001$), fluoro dose (36.5mGy vs 78.8mGy; $p<0.001$), EBL (88.8mL vs 270.0mL; $p<0.001$), and LOS (1.91 days vs. 3.61 days; $p<0.001$) compared to FLIP. L-SPS also demonstrated significantly fewer post-op complications than FLIP (21.9% vs 34.4%; p=0.013), specifically regarding rates of ileus (0.0% vs 5.6%; $p<0.001$). There was no difference in remaining surgical site, neurological, or medical complications between groups.

Reoperation: No differences in reoperation were noted at 30-day (1.7% L-SPS vs 4.4% FLIP, p=0.125), 90-day (5.1% L-SPS vs 5.6% FLIP, p=0.795) or 2-year follow-up (9.7% L-SPS vs 12.2% FLIP; p=0.441). The most common reason for return to OR was Adjacent Segment Disease, and this was (L-SPS 3.1% vs. FLIP 7.8%; p=0.067). Pseudarthrosis rates were similar between groups (0.0% L-SPS vs. 1.1% FLIP; p=0.204).

Radiological Outcomes: No significant differences were noted in rates of radiological fusion (94.3% L-SPS vs 97.8% FLIP; p=0.266) or subsidence (6.9% L-SPS vs 12.2% FLIP; p=0.260). There were no differences noted between L-SPS and FLIP in change in LL from Baseline to 1-year (3.5^{o} vs 2.8^{o}; p=0.466) and post-op to 1yr (-0.18^{o} vs -0.51^{o}; p=0.777), or in PI-LL from Baseline to 1-year (-3.5^{o} vs -3.2o; p=0.835) and from post-op to 1-year (0.71^{o} vs 0.71^{o}; 0.998).

Conclusions: L-SPS improves safety, improves operative efficiency and reduces complications in the perioperative period while maintaining similar efficacy of AP fusion at 2-year follow-up in treating degenerative lumbar spinal conditions.

O449

Reverse pedicle subtraction osteotomy – Rationale and early experience of a novel PSO technique

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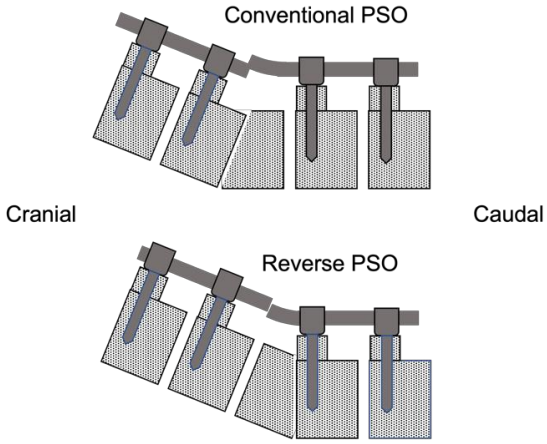
Introduction: Pedicle subtraction osteotomy (PSO) is a powerful but demanding surgical technique for the correction of sagittal plane deformity. The conventional technique involves pedicle excision and 'orthogonal triangular' resection of the cranial aspect of the vertebral body, with or without excision of the adjacent intervertebral disc/interbody fusion. Closure of the osteotomy involves approximation of the relatively shorter cranial margin (the Base of the triangle) to the longer, oblique resection margin (the Hypotenuse). Approximation of these unequal length surfaces may impose added stress or tension to the construct. The author has refined the conventional PSO technique by reversing the direction of the osteotomy plane ('Reverse PSO'). This may improve correction of sagittal balance by lowering the axis of correction and generating less tension when approximating the cut surfaces (see Figure).
Aim: To present the rationale and technique for 'Reverse PSO' with early clinical and radiological results in 10 patients, in whom the procedure was part of multi-level surgery.
Patients and Methods: Retrospective, observational study of prospectively recorded data - operative, clinical outcomes (VAS pain scores, ODI and SF-36) and radiological outcomes (measures of sagittal alignment) - in consecutive patients. The 'Reverse PSO' technique involves pedicle excision followed by orthogonal triangular resection of the inferior aspect of the vertebral body, including the inferior end-plate/adjacent disc and interbody fusion across the disc spaces above/below the osteotomy vertebra. Results are presented as Median values and Ranges (in parentheses).
Results: 10 patients between September 2020 and April 2022, whose multi-level procedures included a 'Reverse PSO'. The PSOs were at single levels in 9 patients: one upper-thoracic, one lower-thoracic and seven lumbar - 3 were at L5, including an un-united, previously fused Grade-3 lytic spondylolisthesis. A 2-level PSO was at L1 and L3. Age: 74years (48-84years); Previous surgeries: 2 (1-7); number of levels fused 5 (2-23); Operative time: 517minutes (305-720); Operative blood-loss: 3050mls (900-6300); Follow-up (F/U): 12-months (4-24); VAS back pain: Pre-op 6.3 (1-9) and last F/U 3.8 (0-6); VAS leg pain: Pre-op 4.1 (0-6) and last F/U 0 (0-3); ODI: Pre-op 47 (14-68) and last F/U 25 (11-56); SF-36 PCS: Pre-op 31 and last F/U 43 (31-49). Correction of focal lordosis/kyphosis: 25-degrees (6.5-31degrees) @ 10-months. Complications and patient satisfaction: One patient, aged 78-years and seriously disabled pre-operatively following multiple previous surgeries and with total lumbar kyphosis of 43-degrees, whose surgery and 2-level PSO was prolonged (11-hours and 6300mls blood loss), has done poorly and remains severely disabled. Of the remaining 9 patients, despite the major nature of their surgery, at last f/u all believe the procedure was worthwhile with 6 rating their outcome as 'Good' and 2 as "excellent'. 8 affirmed they would repeat the surgery under similar circumstances. Except for the severely disabled patient, all appear to have achieved solid fusions.
Conclusions: 'Reverse PSO' is a novel refinement to the conventional PSO technique, in which the direction of the osteotomy plane is directed inferiorly (reversed). It appears to offer some mechanical advantages. Satisfactory clinical and radiological outcomes were achieved in 9 of 10 patients.


Conventional PSO
Cranial
Caudal
Reverse PSO

O450

Surgical and patient-reported outcomes support anterior lumbar interbody fusion for the treatment of low back pain

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Introduction: Historically, lumbar fusion has not been supported for low back pain. A randomised controlled trial reported in 2005 that the outcomes of spinal fusion were equivalent to an intensive rehabilitation program. However, most procedures were performed via posterior approaches and approximately 28% of the rehabilitation group progressed to surgical treatment. Anterior Lumbar Interbody Fusion (ALIF) allows for restoration of anterior disc height and lumbar lordosis while preserving paraspinal musculature. Recent systematic review of lumbar fusions via anterior approaches demonstrates statistically significant reductions in back pain over 1–4-year follow-up. However, back pain was not the primary complaint for this cohort. Here, we investigated the surgical and patient-reported outcomes following anterolateral lumbar fusion for the treatment of predominantly low back pain.
Methods: We performed a multi-surgeon, multi-centre retrospective analysis of demographic, perioperative and patient reported outcome measures (PROMs) collected in a prospective database. Participants who underwent lumbar fusion utilising an anterolateral approach (with or without posterior fixation) between April 2019 and September 2022 for treatment of predominantly back pain (Visual Analogue Scale [VAS] for back pain intensity greater than leg pain intensity) were included. PROMs were collected pre-operatively and 12-months post-operatively and included the EQ-5D-5L to assess health related quality of life, VAS to assess back and leg pain intensity and the Oswestry Disability Index (ODI) to assess back-pain related disability.
Results: A total of 138 participants with a mean age of 58.7 years, a body mass index of 30.1 and 55.1% female underwent lumbar fusion with an anterolateral approach and had completed pre-operative PROMs. The mean number of levels fused was 1 and 82 participants (60%) had supplemental posterior fixation. The mean surgery duration and estimated blood loss was 172 minutes and 190mls. Fourteen (9.4%) participants developed post-operative complications (dural leak, n=1; implant malposition/failure, n=3; wound infection, n=3; urinary tract infection, n=1; bleeding/haematoma, n=2; persistent radiculopathy, n=3; incisional hernia, n=1) of which 4 (2%) required surgical treatment. Fifty-six participants (41%) had completed PROMs at the 12-month follow-up. The mean improvement was 3.6 for the VAS for back pain intensity and 18.3 for the ODI, achieving the minimum clinically important differences of 2.5 for VAS for back pain intensity and 15 for the ODI.
Conclusions: In this cohort, ALIF for the treatment of predominantly back pain was a safe treatment option that achieved good surgical and patient-reported outcomes, supporting the use of lumbar fusion via an anterolateral approach for the treatment of back pain. An international randomised control trial to assess this treatment strategy against a conservatively managed control group is planned.

O451

A hybrid atlantoaxial fusion technique utilising a transarticular and C1 lateral mass screw technique: Investigation of surgical and patient-reported outcomes and finite element analyses of the biomechanical properties

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Introduction: Atlantoaxial fusion is an important surgical technique used to treat a variety of C1-2 pathologies. Fusion at this level has challenges due to rotational mobility and proximity to the vertebral artery. A surgical fixation technique that provides greater stability, strength and resistance to strain would reduce the risk of fixation failure and subsequent failure of fusion, likely becoming widely adopted as a preferred surgical technique. A hybrid technique combining a transarticular screw and a C1 lateral mass screw as in the standard Magerl/transarticular and Goel-Harms techniques has recently described. However, no patient reported outcomes or biomechanical properties were reported. Here we compare perioperative, patient-reported and *in silico* biomechanical properties of this hybrid technique with the Magerl and Goel-Harms techniques.
Methods: Demographic, perioperative and patient reported outcome measures (PROMs) were retrospectively analysed for participants who underwent atlantoaxial fusion utilising the Magerl, Goel-Harms or the hybrid technique between June 2020 and December 2021. PROMs were collected pre-operatively and 12-months post-operative and included the EQ-5D-5L to assess health related quality of life, Visual Analogue Scale (VAS) to assess neck and arm pain intensity and the Neck Disability Index (NDI) to assess neck pain-related disability. The biomechanical properties were assessed computationally. A 3-dimensional finite element model for the C1-2 segment was developed using computerised tomography scan data and physiological forces applied and assessed for each of the three atlantoaxial fixation techniques.
Results: Fourteen participants (71% female, mean age 71.7 years) underwent atlantoaxial fusion; hybrid n=4; Magerl n=3 and Goel-Harms n=7. Blood loss and surgery duration were 248ml and 132 minutes for the hybrid technique, 480ml and 132 minutes for the Goel-Harms technique and 233ml and 130 minutes for the Magerl technique. One participant in the hybrid group experienced an iliac crest wound infection requiring surgical debridement and one participant in the Goel-Harms group had a post-operative wound infection which was treated conservatively. The mean VAS score for neck pain intensity and NDI score improved at 12 months post-operatively by 4.3 and 30.0 points for the hybrid technique, 6.1 and 34.0 points for the Magerl technique and 4.3 and 20.8 for the Goel-Harms technique. Finite element analyses data will be presented.
Conclusions: This hybrid technique is safe, reproducible and results in good surgical outcomes and clinically important improvements in patient-reported outcomes. Results of finite element analyses may shed light on the biomechanical properties of the hybrid, Magerl and Goel-Harms techniques and aid in establishing a model for future development, testing and implementing of spinal surgical devices into routine treatment practices.

O452
Retrieval analysis of interbody cages

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Introduction: Extensive retrieval analyses of failed hip and knee arthroplasty has helped improve implant design and clinical outcomes. Interbody cages and graft materials are used in spinal surgery to restore disc height and help achieve arthrodesis. Cages vary in size, geometry, materials and manufacturing. While, in most cases, fusion is achieved using intervertebral cages, some do fail clinically and there is scarce information that describes the details of the retrieved, failed devices. This study describes our research unit's ongoing study on the radiographic and histological (decalcified and non-decalcified) responses, of the retrieved clinically failed interbody cages containing graft materials from human patients.
Methods: Ten interbody cages were retrieved during revision surgeries for failure analysis based on optical inspection, micro computed tomography (μCT), PMMA histology of the cage and graft, and decalcified paraffin histology of the graft within the aperture. Histology images were analysed for cage failure, viable and necrotic bone, fibrous tissue, cartilaginous and fibrocartilaginous tissue, bone graft presence and overall appearance of the fusion.
Results: All revisions were PLIFs and were performed due to continued clinical symptoms and lack for fusion radiographically. PEEK cages with autograft (8/10) and 3D printed titanium alloy cages with no aperture (2/10) were reviewed. Implant damage to the teeth in contact with endplates was a common finding in the PEEK cages. μCT confirmed the non-unions within the graft material inside the cages while detecting of any new bone with μCT on the 3D titanium implant was not reliable. Histology confirmed the fibrous non-unions present in the PEEK cages and the lack of any bone within the titanium cage.
Conclusion: Further analysis of retrieved, clinically failed, interbody cages containing graft materials should be considered on a regular basis. Analysis of retrieved cages is important in understanding the nature of non-unions and failed interbody cage devices.

O453

Characteristics of baseline frequency data in spinal RCTs do not suggest widespread fraud

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Introduction: Fraud in clinical research is a reality. A recent scandal identified apparent non-genuine data in a set of randomised clinical trials investigating cognitive therapy in back pain. This has highlighted the risk of fraud impacting the assessment of treatment effects. In this case, fraudulent data appears to have exaggerated treatment efficacy in recent meta-analyses. Clinical treatment of spinal conditions is guided by such influential RCT evidence, so it is urgent to understand whether the conclusions of other RCTs published in spine journals are genuine or infected with fraud. We sought to investigate whether evidence of non-random baseline data in purportedly randomised studies in spine was a widespread problem or if the previously identified case was an anomaly.
Methods: We performed a PubMed search to identify all papers published in 4 major spine journals (Spine, The Spine Journal, the Journal of Neurosurgery Spine, and the European Spine Journal) classified by the journal as RCTs between 2016 and 2020. We extracted all baseline covariates which were reported as frequencies and calculated p-values using a Pearson Chi squared test of independence. Individual variable p-values were combined into a study wise p-value using the Stouffer method. We calculated the proportion of studies with a study wise p-value of <0.01, <0.05, >0.95 and >0.99. All studies with p-values >0.99 or <0.01 were examined for possible explanations.
Results: Our literature search returned 228 studies, of which 169 were included. In total, we extracted 938 variables. After calculating all study wise p-values and looking at the proportions that presented a study wise p-value of <0.01, <0.05, >0.95 and >0.99, we observed only small differences between our results and the number of studies that would be expected to fall into these categories by random chance.
Conclusions: We conclude that the overall distribution of frequency baseline similarities between study arms in RCTs published in major spine journals is not suspicious. No evidence of systemic presentation of false data was found. While research fraud is a threat requiring vigilance, we did not find any evidence that it is common in spinal RCTs. However, these results were derived from major spine journals and may not be applicable to research published in non-spine journals or predatory journals. We will examine continuous variables in future work.

O454
Cooled radiofrequency ablation of the sacroiliac joint a retrospective case series

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Introduction: Sacroiliac (SI) joint dysfunction is a common source of back pain. Recent evidence from different parts of the world suggest that cooled radiofrequency ablation of sacral nerves supplying the SI joints has superior pain alleviating properties than currently available treatment options for SI joint dysfunction.
Aims: Assess the benefit of SIJ cooled radiofrequency ablation to patients with SIJ dysfunction with patient reported outcomes, redo procedures and progression to fusion
Patients and Methods: after obtaining institutional review board approval, the medical records of 81 patients who underwent cooled radiofrequency ablation in a single institution and by a single surgeon were analyzed retrospectively, recurrence of pain, progression to fusion and functional outcomes were noted. The patients operated on between June 2020 and December 2021 included 59 females, 22 males, 22 patients had previous lumbar fusions, and the average age was 55.4±17.3. They had at least 6 months follow up.
Results: 7 patients progressed to fusions, 6 patients had to have the procedure done again to relieve their pain. Student t-test was used to compare between preop and postop values of NPRS (numerical pain rating score) and ODI (Oswestry disability index). It showed significance with P-value <0.001 in both.
Conclusions: Sacroiliac joint radiofrequency ablation is a good option in the treatment of SI joint pain showing good results in the short term follow up period. It is a simple procedure that can be done under 30 minutes and is capable of providing significant pain relief for patients.

O455

Use of cannulated pedicle screws for posterior spinal fixation in fractures are correlated with higher blood loss in some groups

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Introduction: In posterior spinal fusion, cannulated pedicle screws have the advantage over non-cannulated screws of being able to be used for percutaneous guided insertion as well as cement augmentation. To reduce inventory and save costs these are often supplied in place of solid screws. There is concern that once the screws are inserted and the bone is well perfused that there may be an ongoing bleeding through the cannulation. This case control study aimed to analyse the blood loss of cannulated pedicle screws compared to non-cannulated pedicle screws.
Methods: A single-centre retrospective case control study was undertaken. The clinical, surgical and cell saver reports as well as the laboratory results were searched to assess the intraoperative and postoperative blood loss. Anticoagulation intake was noted and all patients with incomplete records were excluded. The cannulated screws (Everest MI, Lifehealthcare) were compared with non-cannulated Nuvasive screws (Reline, Nuvasive). The patients undergoing posterior fixation using cannulated screws were matched to age +/-10 years, administration of anticoagulant and number of screws +/- 1.
Pre-operative and post-operative hemoglobin levels, operation time, number of levels fused, as well as estimated blood loss and cell saver returns were recorded. Imaging and operation reports were used to confirm the number of screws placed.
Results: A total of 54 cases, 27 cannulated and 27 non-cannulated, were included in the analysis. The average age of patients in the cannulated screw was 44.2±16.8 years in the cannulated group compared to 43.6±15.5years in the control group (p=0.884). A median of 4 levels were fused, inserting 8.6±2.2 screws per case.
Overall haemoglobin fall from pre- to post-operative was 24.11±13.23g/l versus 22.78±12.17g/l (p=0.355). This was extrapolated to a mean haemoglobin decrease of 2.89±2.18g/l per screw inserted in the cannulated group, compared to a haemoglobin decrease of 2.62±1.33g/l per screw inserted in the non-cannulated group (p=0.300). When examining 3 level constructs using a total of 6 screws and a sublaminar hook (n=6), a mean haemoglobin loss of 4.69±3.4g/l was observed in the cannulated group versus 1.85±1.7g/l (p=0.045) in the solid. Likewise a significant difference existed in patients above the age of 40 years of any construct with a mean haemoglobin loss of 4.29±3.02g/l compared to 2.75±2.25g/l (p=0.048). The intraoperative blood loss was 1024.5±339.0ml per case for cannulated screws compared to 1086.3±557.5ml for solid screws (p=0.377). The subgroup analysis of blood loss for 3 level constructs and patients over 40 did not yield significant differences.
Discussion and Conclusion: The universal use of cannulated screws is helpful economically and although differences in blood loss and haemoglobin decrease were observed, the surgery itself is likely to be the major contributor to the blood loss. This may explain why in only short posterior spinal fusions significant differences were found. Likewise in elderly patients a significant higher blood loss was noted which may correlate to the intake of anticoagulants. In those two cohorts cannulated screws should be avoided.

O456

The effect of progressive herniation on lumbar intervertebral disc six degree of freedom mechanics

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Introduction: Irreversible changes in disc structure caused by compressive overload towards progressive herniation can alter six degree of freedom (6DOF) mechanics. These changes alter how the disc withstands loads and may leave the disc more suspectable to herniation or other injuries. Studies have shown that disc injuries can alter the discs mechanical response and may also be a predictor of herniation[1-2]. However, there are no studies on progressive mechanical changes in the disc leading up to herniation. This study aimed to compare changes in disc mechanics leading to and after herniation under combined flexion, axial rotation and compressive overload.
Methods: Initial 6DOF mechanics from intact sheep lumbar segments (L2-L3, n=9) were measured in a hexapod robot using a standardised testing protocol. Specimens were then randomly assigned into one of three compressive overload displacement groups: 1, 2, or 3 mm. Prior to overload, specimens were postured at 13° flexion and 2° left axial rotation with no initial compressive force applied. After posturing, each group of specimens were failed at 400 mm/min to their respective compressive displacements. Finally, the same 6DOF testing protocol was repeated. Differences in 6DOF stiffness and phase (a measure of energy absorption), after overload within each group were assessed using repeated-measures ANOVA with a statistical significance of $p<0.05$, with marginal significance defined as $0.05<p<0.07$. Presence of disc herniation was determined visually.
Results: Herniation was observed in two of three specimens from the 3 mm group and not observed in the others. Analysis of results (Table 1) showed for the 1 mm group, stiffness in anterior shear and flexion significantly decreased ($p<0.0009$) and marginally decreased in left lateral shear and right axial rotation ($0.05<p<0.065$). Phase for the 1 mm group increased in flexion, right and left lateral bending ($p<0.041$). Specimens in the 2 mm group showed decreased stiffness in flexion and right axial rotation ($p<0.018$) and increased phase in flexion, left lateral bending and right axial rotation ($p<0.03$). In the 3 mm group, stiffness decreased in posterior shear, flexion, left and right axial rotation ($p<0.035$). For the 3 mm group, phase increased in right and left lateral shear, compression, flexion, and extension, left lateral bending, and right and left axial rotation ($p<0.049$). Phase also marginally increased in posterior shear ($p=0.068$).
Conclusions: Compressive overload for all groups influenced disc mechanics where either stiffness or phase, or both, were significantly affected. Although the present sample size is small and visible herniation did not occur in two of the groups, significant disc mechanical changes occurred. These findings may be used as mechanical indicators of early-stage herniation in future studies.

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Table 14: Stiffness and phase p-values from comparison of before and after overload data using a Repeated Measures ANOVA. Green indicates significant change ($p<0.05$), yellow indicates marginal significance ($0.05<p<0.07$) and red indicates no significance ($p>0.07$)

		Right Lateral Shear	Left Lateral Shear	Anterior Shear	Posterior Shear	Compression	Extension	Flexion	Right Lateral Bending	Left Lateral Bending	Left Axial Rotation	Right Axial Rotation
Stiffness	1 mm	0.5447	0.0645	0.0277	0.4273	0.1765	0.9899	0.0011	0.6461	0.1423	0.4412	0.0625
	2 mm	0.8754	0.0991	0.1675	0.8533	0.1758	0.2018	0.0022	0.2437	0.1646	0.1429	0.0174
	3 mm	0.1739	0.1016	0.1728	0.0170	0.1501	0.6181	0.0056	0.7467	0.0958	0.0342	0.0068
Phase	1 mm	0.6132	0.3406	0.9889	0.8365	0.8386	0.1897	0.0163	0.0104	0.0398	0.8928	0.4059
	2 mm	0.4445	0.9970	0.5293	0.7024	0.1795	0.1300	0.0295	0.7161	0.0218	0.2626	0.0290
	3 mm	0.0225	0.0484	0.2233	0.0685	0.0072	0.0451	0.0115	0.0841	0.0412	0.0137	0.0026

O457
Development and validation of a virtual digital scoliometer

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Introduction: Adolescent Idiopathic Scoliosis (AIS) is a 3D spine deformity, characterised by lateral spine curvature and axial rotation of the vertebrae and ribcage. Axial rotation is observed externally as a ribcage prominence in the posterior torso, most pronounced when the patient is in the forward flexion position. Clinically, the maximum Angle of Torso Rotation (ATR) is measured using an analog Scoliometer, which prior studies have shown has an average error of 5-8°, relating either to user-error, atypical patient anatomy, or the device limitations. We believe these errors can be significantly reduced with the use of a virtual approach to collect digitised ATR measurements - a method yet to be investigated for AIS. Here we present the development and first validation of a semi-automated measurement tool to evaluate ATR from 3D surface scans (3DSS) of AIS patients.
Methods: An existing 3DSS database of 35 pre- and post-operative AIS patients being treated at the Queensland Children's Hospital Orthopaedic Spine Clinic was used to create calibrated 3D virtual models of each patient's external torso shape in the forward flexed position (ie. Adam's forward bend test). A semi-automated measurement tool was developed to measure ATR from the 3D models (Rhinoceros-Grasshopper Vsn7, Robert McNeel and Associates, USA).
The tool includes four different methods to measure ATR:

i) 'Scoli' (traditional Scoliometer, measures ATR relative to gravity),
ii) 'Scoli_ext' ('Scoli' with length extended),
iii) 'Scoli_MP' (multiplanar scoliometer, measures ATR relative to cross-sectional plane of spine rather than gravity)
iv) 'Scoli_MP_ext' ('Scoli_MP' with length extended).

InterClassCorrelations (ICC) assessed algorithm reliability (two users, three measurement sets each). Correlation and Bland-Altman analyses investigated the relationship and bias, respectively, between the algorithm and the clinical ATR measurements.
Results: Using the semi-automated tool, ATR was measured by means of user-selected input from a new graphical interface (Fig 1). The reliability of all four versions of the algorithm was excellent (intra-rater ICC>0.98, inter-rater ICC>0.96). High positive correlation was found between each virtual Scoliometer and the clinically-measured ATR ('Scoli'=0.722, 'Scoli_ext'=0.720, 'Scoli_MP'=0.681, 'Scoli_MP_ext'=0.678). Bland Altman analysis indicated a small average bias between measurements of each virtual Scoliometer and the clinical values ('Scoli'=-0.15°, 'Scoli_ext'=-0.12°, 'Scoli_MP'=1°, 'Scoli_MP_ext'=1.03°). For each comparison, 85% of algorithm measures were within the clinical limits-of-agreement of ±8°.
Discussion and Conclusions: 3DSS and automation were implemented in a virtual digital scoliometer to improve ATR measurement accuracy. The tool produces consistent and reliable measurements regardless of user, and these measurements are comparable to what is obtained in clinic. Lengthening the scoliometer did not prove useful – the measurements were not significantly different from the scoliometer versions with normal length. Unlike the traditional gravity-based scoliometer measurements, the multiplanar versions are advantageous as they don't rely on the patient's ability to bend forward to make accurate measurements. Outliers identified in the Bland-Altman analysis were predominantly from post-op scans in the multiplanar vs the traditional scoliometer comparisons, where the patients were stiff and could not align their torso parallel to the ground. This will be investigated in future work to determine a threshold for flexion angle, beyond which the traditional scoliometer is not accurate.

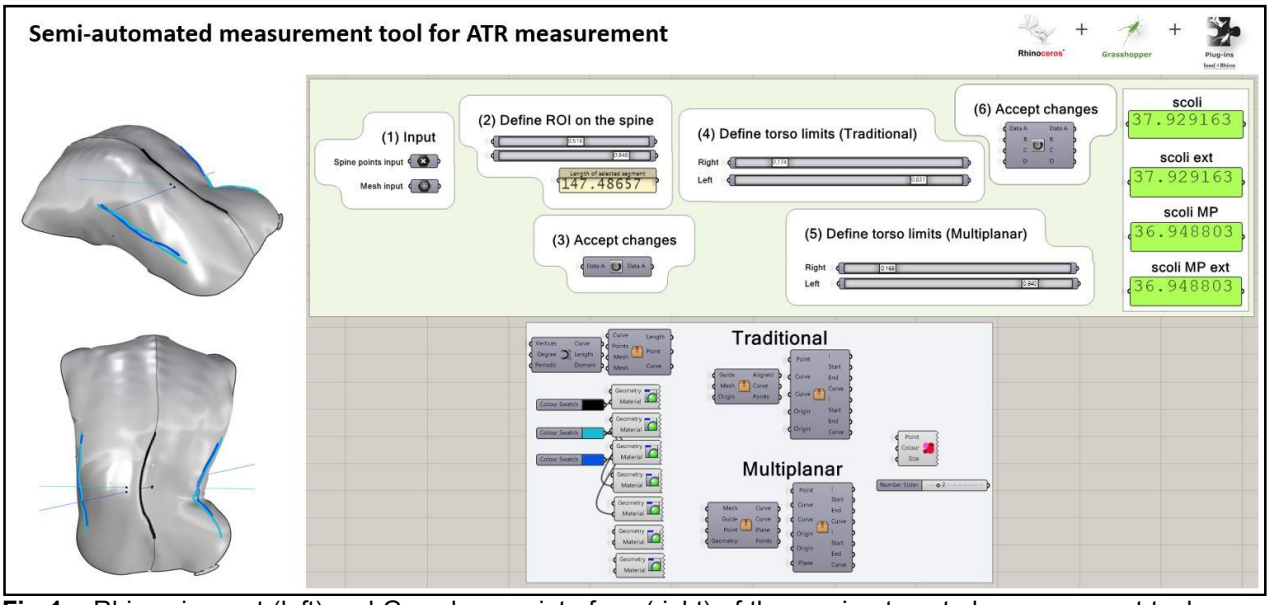

Fig 1 – Rhino viewport (left) and Grasshopper interface (right) of the semi-automated measurement tool. The user need only interact with input boxes 1-6 in the Grasshopper interface.

O458

Spinal cord Stimulation for treatment of neuropathic pain in failed back surgery syndrome: A fifteen years experience using percutaneous leads insertion

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Introduction: Chronic pain in failed back surgery syndrome (FBSS) is one of the most important cause of pain in our society. Spinal cord stimulation (SCS) is one of the latest treatments for these patients. A test (4 weeks in Belgium) is done before final implantation to evaluate benefits of the treatment. Surgical laminotomy or percutaneous leads placement are the two techniques commonly used.
Methods: From January 2007 to January 2022, we analysed the results of a series of 327 patients who underwent a surgery of SCS for FBSS. All surgeries were done by inserting a single percutaneous lead (octade and Vectris Medtronic) under local anaesthesia. Anatomical data, parameters of stimulation, complications, and benefits were collected and analysed during the test but also on long term follow-up (1 year minimum) after impulsed generator (IPG) placement**.**
Results: All the patients leaved the clinic the day after implantation. 296 patients had a succesfull test and were implanted with IPG. 32 patients (9,7%) were not implanted at the end of the test. 21 patients (6,4%) with no benefits et 11 patients (3,3%) with infection. 1 patient (0,3%) had lead migration and needed a reoperation. There was no lead breakage during the test but 22 patients needed lead revision for breakage on the long-term follow-up. We have no major complication instead cutaneous infection. At the end of the test, 319 patients (97,6%) had the same parameters introduced during the surgery. At one year, 262 patients (80,1%) needed changes in the parameters of stimulation to sustain the benefits.
Conclusions: The percutaneous leads placement is a safe and accuracy procedure for SCS. It avoids reoperation for leads misplaced and in case of failure, no laminotomy and no scared tissue or muscle damages have been done. Long term follow-up shows good results, that´s why we prefer the use of percutaneous leads placement in the FBSS in first intention.

O459

3D-printed patient specific interbody implants in anterior lumbar interbody fusion: A case series and review of early clinical and radiological results

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Introduction: Since the incorporation of 3-Dimentional Printing (3DP) in medicine, there has been rapid growth in all areas of medicine. In particular the use of 3DP technology in spinal surgery has exponentially increased. As the technology remains nascent there is a lack in the literature regarding the applicability of this technology in different aspects of spinal surgery, with the majority of literature focusing on spinal reconstruction after oncological resection. Literature remains sparce with regarding to the use of this technology in anterior lumbar spinal procedures such as Anterior Lumbar Interbody Fusion (ALIF).
Herein, we present radiographic and clinical data for a 35 patient case series, where the use of a 3DP ALIF Patient Specific Implant (PSI) was employed.

Methods: A multi-surgeon, multi-institution case series was conducted in patients with lumbar degenerative disc disease with other associated pathologies such as: myelopathy, radiculopathy and spondylolisthesis. All these patients requiring discectomy and fusion to address their pathology. All patient sunderwent an ALIF procedure with insertion of a 3DP PSI.

Results: Between 2017-2022, 35 patients underwent the ALIF procedure with insertion of a 3DP PSI (interbody cage). In this cohort there were no intra-operative complications nor any postoperative complications. In the delayed post-operative setting, all patients had improvement in their symptoms and radiologically no significant subsidence was observed.

Conclusion: In the cohort reported, the surgery allowed for improvement in patient reported outcome measures, with radiological endpoint assessment being comparable or better than those reported in literature from “off the shelf” ALIF implants. There were no device related complications in this cohort. The used of 3DP PSI in ALIF is shown to be a viable option in the treatment of lumbar degenerative disc disease. As the technology and manufacture of 3DP PSI becomes more economically viable, the future of ALIF surgery may see a rise in the adoption of 3DP technology in implant design, offering patient a personalised option in spinal surgery.

O460

Improved productivity using deep learning augmented reporting for MRI lumbar spine

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Introduction: Lumbar spine MRI studies are widely used for back pain assessment. Interpretation involves grading lumbar spinal stenosis, which is repetitive and time consuming. Deep learning (DL) could provide faster and more consistent interpretation. The aim of this study was to evaluate the time taken and interobserver agreement for reporting lumbar spinal stenosis with and without a DL model.
Materials and Methods: In this retrospective study, a DL model designed to assist radiologists in the interpretation of spinal canal, lateral recess, and neural foraminal stenoses on lumbar spine MRI scans was utilized. Randomly selected lumbar spine MRI studies obtained in adult patients with back pain over a 3-year period, from September 2015 to September 2018, were included in an internal test set. Studies with instrumentation and scoliosis were excluded. Eight radiologists reviewed studies with and without DL model assistance, and a 1-month washout period and crossover study design were used to limit recall bias. The radiologists included two musculoskeletal radiologists (7- and 11-years of experience), four general radiologists (2-, 5-, 12- and 13- years of experience), and two second year trainee radiologists, with limited exposure to spine MRI studies. Time to diagnosis (seconds) and interobserver agreement (Gwet's kappa) were assessed for stenosis grading for each radiologist with and without the DL model and compared with an external musculoskeletal radiologist (32 years of experience) as the reference standard.
Results: Overall, 444 images in 25 patients (mean age, 51 years ±20[SD]; 14 women) were evaluated in a test set. DL assisted radiologists had a reduced interpretation time per spine MRI. Overall, the mean interpretation time per spine MRI study with the DL model (mean range=47–71 seconds [SD=24–29 seconds]) was lower than without the DL model (mean range=124–274 seconds [SD=25–88 seconds])($P<0.001$). This difference was seen for all experience levels. Musculoskeletal radiologists had a mean time saving of 62% (77 of 124 seconds) using the model, with mean times of 47 seconds ±24 and 124 seconds ±25 with and without the model, respectively. General radiologists had a mean time saving of 69% (156 of 226 seconds) using the DL model, with mean times of 70 seconds ±29 and 226 seconds ±61 with and without the model, respectively. In-training radiologists had the largest mean time saving of 74% (203 of 274 seconds) using the model, with mean times of 71 seconds ±28 and 274 seconds ±88 with and without the model, respectively. DL-assisted radiologists had either superior or equivalent interobserver agreement for all stenosis gradings compared with unassisted radiologists. DL-assisted general and in-training radiologists improved their interobserver agreement for four-class neural foraminal stenosis, with kappas of 0.71 and 0.70 (with DL) versus 0.39 and 0.39 (without DL), respectively (both $P<0.001$).
Conclusion: Radiologists who were assisted by deep learning for interpretation of lumbar spinal stenosis on MRI scans showed a marked reduction in reporting time and superior or equivalent interobserver agreement for all stenosis gradings compared with radiologists who were unassisted by deep learning.

O461

Bimodal artificial intelligence differentiating spinal tumors based on integrated magnetic resonanc e imaging and patient information

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Introduction: Spinal cord tumors can cause Activities of Daily Living disability in patients, with 80% being intradural extramedullary in location. Schwannoma and meningioma are reported to account for 90% of primary intradural extramedullary tumors and need surgical procedures. There are some artificial intelligence (AI) models to differentiate spinal tumors based on images, but has been no AI model based on integrated images and patient information.
Aim: We aim to build a bimodal AI model based upon integrated magnetic resonance (MR) images and patient information for differentiating spinal tumors and to evaluate its performance.
Methods: We retrospectively reviewed the medical records of the patients with spinal tumors who had undergone tumor resection at 10 centers. Diagnoses were made upon histology of the surgical specimens. We collected MR images and patient information (age, gender, tumor location) of 158 schwannomas and 101 meningiomas. We developed two AI models (conventional *unimodal* AI and new *bimodal* AI) and compared the performance (Figure 1). The conventional *unimodal* AI model learned only from MR images. On the other hand, the *bimodal* AI model learned from both MR images and patient information. In addition, we compared the performance of the *bimodal* model to that of six clinicians.
Results: The new *bimodal* model was superior to the conventional *unimodal* model in both the area under the receiver operating characteristic (AUC) (0.91 vs. 0.84, p=0.003, Figure 2) and accuracy (0.85 vs. 0.81, P=0.18). The *bimodal* model outperformed all of six clinicians and there was a significant difference between the mean of clinicians and our proposed *bimodal* model in AUC (0.93 vs. 0.82, p=0.01).
Conclusions: We can improve AI performance by integrating images and patient information to make decisions, as humans do.

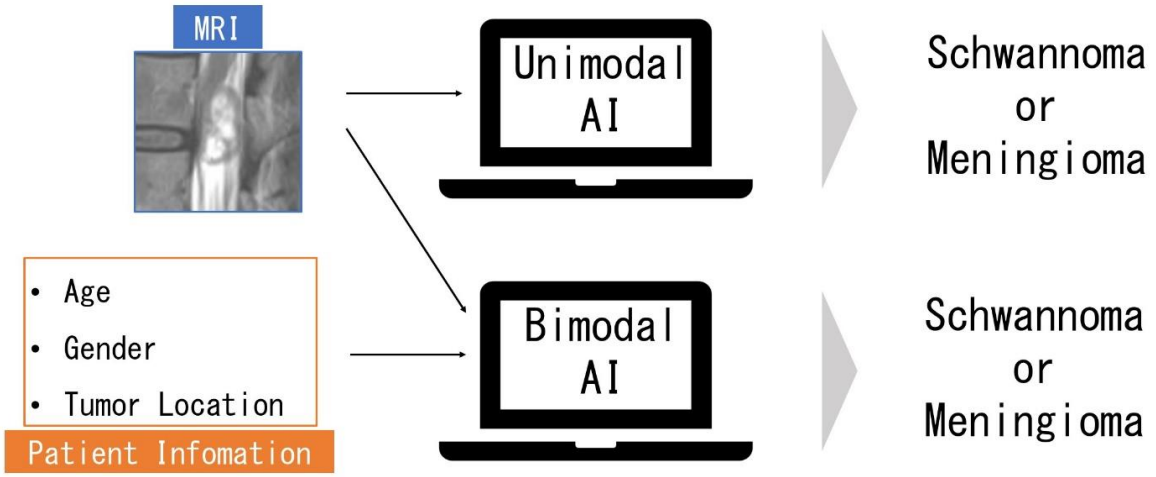

Figure 15

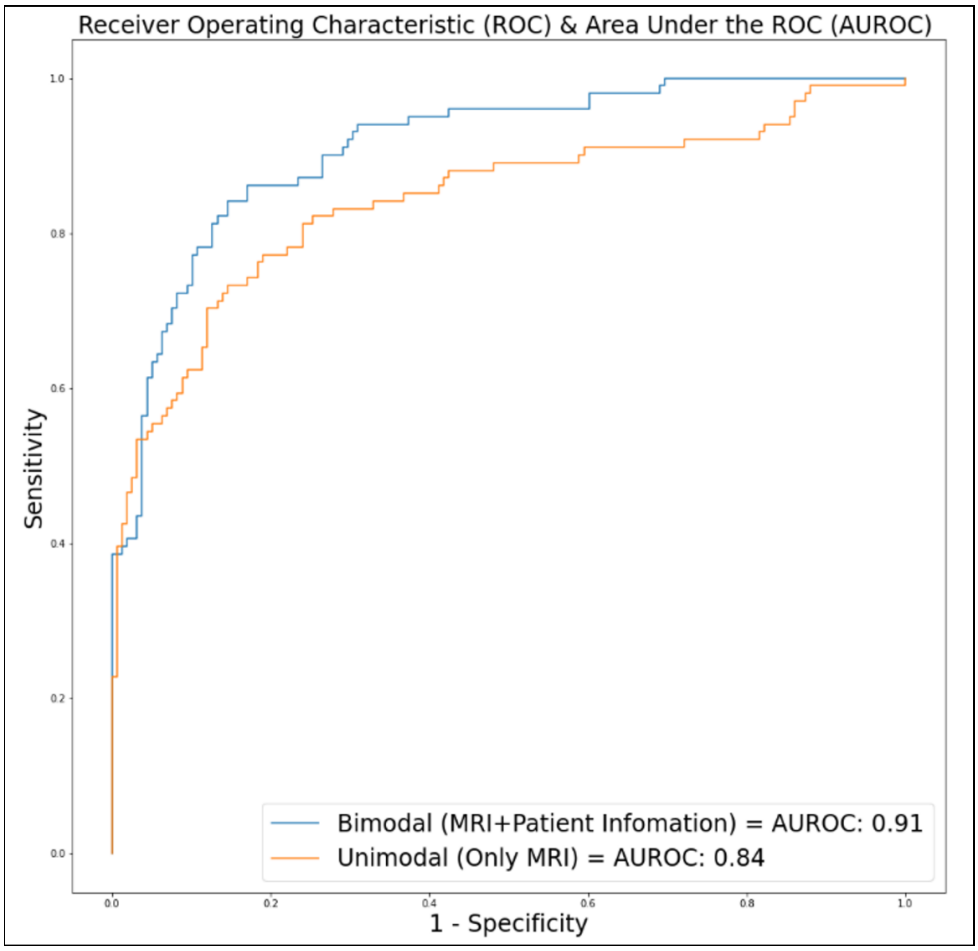
Receiver Operating Characteristic (ROC) & Area Under the ROC (AUROC)
Sensitivity
1 - Specificity
0.0
0.2
0.4
0.6
0.8
1.0
Bimodal (MRI+Patient Infomation) = AUROC: 0.91
Unimodal (Only MRI) = AUROC: 0.84

Figure 16

O462

A diagnostic machine learning model for primary bone tumors and tumor-like lesions

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Introduction: The advent of artificial intelligence (AI) is rapidly shaping the scope and practice of healthcare. Developments in machine learning algorithms and computational capabilities have resulted in numerous healthcare AI applications. One promising application is computer-aided diagnosis, wherein machine learning models are trained on the unstructured data found in medical images like tissue microscopy. In the field of musculoskeletal pathology, patients with a suspected bone tumor must undergo a tissue biopsy subsequent histological evaluation to confirm tumor diagnosis prior to initiating cancer treatment. This diagnostic process is challenging and can last weeks, which delays patient care. Our research team sought to expedite this process by training a model identify the histologies of several benign and malignant bone tumors.

Methods: Our team compiled a dataset consisting of histology images from 16 tissue types including healthy cortical bone (n=1), benign primary bone lesions (n=9) and malignant primary bone lesions (n=6), as depicted in figure 1. All images were oriented and resized to fit uniform dimensions of 416x416 pixels, forming an initial dataset of 2,618 histology samples. All image resizing involved adding white edges to the periphery of non-square images to maintain the aspect ratios of original imaging. The images were then augmented to increase the number of novel training data points for our model, producing three output images per sample. This was achieved by applying randomized editing effects to the original training images, including rotating and reflecting images, adjusting image exposure between -10% and +10% of original, and adjusting image hue between -10° and +10° of original. The images were then divided into training (70%), validation (20%), and test (10%) datasets for model training. The final dataset included 6,265 total images belonging to 16 classes of healthy, benign, and malignant bony tissue varieties.

Results: The described dataset was used to train a multi-class image classification model via transfer learning methods, using starting checkpoints pre-trained on ImageNet. The trained deep learning model was then tested against a validation data set comprised of 518 histology images belonging to the same classes the model was trained on. The trained model demonstrated 99.4% diagnostic accuracy on this validation dataset, correctly categorizing 515 out of the 518 images to their corresponding tissue types.

Conclusions: These results demonstrate the potential for machine learning technology in expediting the diagnosis of bony tumors. These results are preliminary, yet they emphasize the potential of AI in expediting cancer diagnosis from tissue sample.

Malignant Tissue Histologies	Samples (n = __)	Benign/Healthy Lesions	Samples (n = __)
Adamantinoma	137	Compact Bone	160
Chondrosarcoma	141	Aneurysmal Bone Cyst	118
Chordoma	225	Chondroblastoma	168
Ewing Sarcoma	152	Enchondroma	112
Multiple Myeloma	147	Fibrous Dysplasia	209
Osteosarcoma	272	Giant Cell Tumor	173
		Hemangioma	181
		Non-ossifying Fibroma	185
		Unicameral Bone Cyst	81

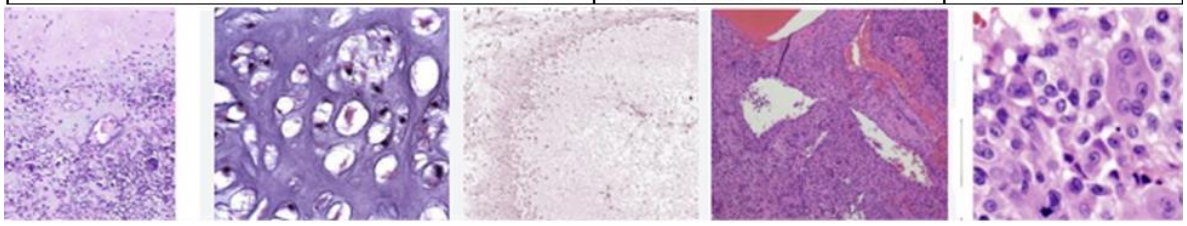

Figure 1. Healthy and pathological subtypes of bone tissues included in the dataset.

O463

Comparison of CTA and MRI for C1 instrumentation presurgical planning

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Introduction: Atlantoaxial fusion poses a significant risk of direct vascular injury to the internal carotid artery (ICA) and presurgical imaging plays an essential role in mitigating this risk. Prior CTA based studies assessing the anatomical relationship of the ICA to key surgical landmarks at C1 have identified a wide variation in ICA anatomy relative to C1 and recommend preoperative CTAs for a bicortical fixation. One study discusses the role of CT imaging in deciding between unilateral vs bicortical fixation based on the distance between the anterior border of C1 and the ICA. Despite the surgical risks, CTA imaging is not widely obtained preoperatively, and surgical planning is often based on an MRI. However, prior studies have not compared CTA and MRI imaging for assessing C1 osseous and vascular anatomy. One study assessing the risk of ICA injury at C1 even included patients with either a CT, MRI or MRA, without demonstrating an equivalency between these modalities. This study aims to address this gap by comparing CTA and MRI based measurements to assess C1 anatomy prior to surgical instrumentation.

Methods: 209 patients who underwent both a CTA and MRI, for any reason, at a single academic institution between 2007 and 2018 were assessed. Exclusion criteria was any prior cervical surgery or MRIs that did extend cephalad to the atlas. 10 standardized measurements were made in each imaging modality assessing osseous and vascular anatomy. Intraclass correlation coefficients and correlations were calculated for each of the 10 measurements.

Results: A total of 119 patients fit the inclusion criteria; the mean age at CTA was 65.1 years. The agreement between CTA and MRI for the 10 standardized measurements was less than moderate, with intraclass correlation coefficients (ICC) ranging from 0.427 to 0.006. The bone to bone measurements of distance from the origin of the ideal screw trajectory to the posterior cortical surface of C1 and the AP dimension of C1 had the highest ICCs, 0.427 and 0.375 respectively. Measurements of the distance from the origin of the ideal screw trajectory to ICA and a straight line from the ICA to the anterior surface of C1 had ICCs of 0.193 and 0.213, respectively. Of the 10 measurements, only the distance from the end of the ideal screw trajectory to the anterior plane of C1 was not statistically significant ($p>0.05$) between CTA and MRI.

Discussion: These findings demonstrate a lack of agreement between MRI and CTA based measurements at C1. Interestingly, the measurements with the highest ICCs and correlation coefficients were bone to bone measurements, demonstrating that although MRI can guide preoperative planning, the low ICCs for measurements of ICA position relative to C1 strongly support the use of CTA to assess the ICA safety margin when using bicortical C1 lateral mass screws.

O464

Correlation between MRI canal dimensions and clinical severity in Lumbar canal stenosis: A cross sectional study

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Introduction: Surgical management of lumbar canal stenosis needs planning and localization of symptomatic levels. MRI findings help to identify pain source and pathoanatomical changes leading to stenosis. Many studies have correlated clinical severity with MRI measurements of AP and transverse diameter in patients with lumbar canal stenosis but were inconclusive. Recently, there has been interest in correlating cross sectional area with clinical severity, but only a limited data is available. In view of this lacunae, this study was conducted to correlate AP diameter, transverse diameter and cross-sectional area of lumbar spine in axial image at the stenotic area with the clinical severity of lumbar canal stenosis.
Methods: Patients with lumbar canal stenosis diagnosed using clinical criteria were included in the study and subjected to MRI examination of lumbar spine. Clinical severity was assessed using VAS, ODI, neurological status, six-minute walk test and thread mill walking test. From the axial images at stenotic level, AP diameter available for dura, transverse diameter available for dura, cross sectional area available for dura and percentage of canal compromise were measured on PACS using standard criteria. Correlation between clinical severity and dimensions in MRI of lumbar canal patients is evaluated by using Pearson correlation coefficient and ANOVA test.
Results: This study included 27 patients with mean age of 53.9 (25 to 74) years, 17 (63 %) were males and 10 (37 %) were females. Mean VAS score was 7.06, ODI score was 58.11, mean 6-minute walk test distance was 48.89 meters and mean thread mill walking test time was 1.64 minutes. Among the clinical parameters, VAS and ODI correlated well with 6-minute walk test, thread mill walk test (p value 0.001 and 0.005, 0.001 and 0.001 respectively). VAS and ODI showed significant correlation with cross sectional area measured in MRI (p value 0.015 and 0.043 respectively) compared to AP and transverse diameter (p value 0.190, 0.267 and 0.773,0.894).
Conclusion: This study concludes that circumferential cross-sectional area available for spinal cord can better predict the clinical severity compared to transverse and AP diameter.

O465

The clinical application of individualized digital surgical planning and precise execution and 3D printing guidance templates in the treatment of severe adult rigid deformity

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Introduction: Severe rigid adult deformities are composed of the characteristics of the complexity of anatomy, rigidity, and severe kyphosis or scoliosis, with or without neurological dysfunction, which may lead to physical disability or even death. The treatment strategy for such severe deformities is comprehensive. Different levels of spinal osteotomy have been developed and applied rapidly with good correction outcomes. However, due to the complex anatomy of spine structure, the screw insertion, vertebrae osteotomy, correction, and decompression procedures increase the incidence of intra- or postoperative neurological complications significantly. This study is to report the preliminary outcomes utilizing of
Individualized pre-operative digital planning and three-dimensional printing (3DP) guidance template in the treatment of severe and complex spinal deformity.
Materials and Methods: After being approved by the Institutional Review Board of our hospital, 8 adult patients with severe rigid kyphoscoliosis were included. Based on the preoperative radiological data, the surgery planning was simulated by software, and screw insertion and osteotomy guidance templates were designed and manufactured utilizing 3D printing techniques. The designed osteotomy and correction surgeries were performed utilizing the guidance templates. The perioperative, and radiological parameters and complications were collected and analyzed, including surgery duration, estimated blood loss, pre-and post-operative cobb angle, trunk balance, the ratio of osteotomy simulation and execution, screw accuracy, etc.
Results: Of the 8 patients, the primary pathology consisted of 2 adult idiopathic scoliosis (ADIS), 4 congenital scoliosis (CS), 1 ankylosing spondylitis (AS), and 1 kyphosis secondary to tuberculosis (TB). There are 5 kyphoscoliosis and 2 kyphosis regarding deformity characteristics. The pedicle subtraction osteotomy (PSO) in 3 patients and vertebral column resection (VCR) osteotomies in 5 patients were performed with the application of the guidance templates. The average surgical duration is 361.25 mins, average blood loss of 800 ml, and no surgery and instrument-related complications occurred. The main cobb angle was corrected from 99.33° to 34.17°, the kyphosis was corrected from 110.00° to 42.00°. The match ratio of osteotomy simulation and execution was 94.67%. The average screw accuracy rate was 93.04% in the cohort.
Conclusions: The clinical application of individualized digital surgical planning and precise execution and 3D printing guidance templates in the treatment of severe adult rigid deformity is feasible, effective, and easy to promote. The preoperative osteotomy simulation is executed with high precision by utilizing the described guidance templates. It could be used to reduce the surgical risk and difficulty of screw placement and high-level osteotomy.

O466

Beware of positive SPECT/CT findings when investigating pain generators in patients with scoliosis: Hospital cohort of cancer patients shows high prevalence of high uptake degenerative changes

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Introduction: Scoliosis can affect the general population at all ages via a wide range of configurations and presentations. Degenerative de novo scoliosis develops as an adult rather than during adolescence. Although not always painful, the unevenly distributed biomechanical axial overload could contribute to pain and accelerate degenerative spondylosis (DS). SPECT/CT is typically used as a second line of investigation for defining the features of a metabolic abnormality particularly in screening for metastatic cancer. It can also provide the exact location and nature of a pain generator in spondylosis.
By examining a hospital cohort of oncological patients with or without back pain being screened for metastases, we estimated the prevalence of high uptake osteoblastic SPECT/CT activity in spinal spondylosis with scoliosis. This study analysed the prevalence of scoliosis, DS, and associated pain, in oncologic patients undergoing SPECT/CT for possible metastases and analysis of pain generators.
Material and Methods: 1182 SPECT/CT reports of oncology patients between 2015-2019 were analysed. Exclusion criteria: inflammatory disorders, metastases, trauma, infection, age>80 (n=274), non-cancer (n=312). Inclusion criteria: scoliosis, DS, spinal pain.
Results: 596 made the inclusion criteria and their reports were analysed with patient's mean age of 65 years (4-80). The 6.2% (n=37) of presented with scoliosis, of which 46% (n=17) had spinal pain, usually lumbalgia and 97% (n=36) had DS. This can be seen in Table 1 and 2.
Conclusion: Prevalence of scoliosis in our cohort coincided with the general population. Our data shows for the first time that almost 70% of 70-year-olds have degenerative spondylosis with high uptake on SPECT/CT in at least one region in patients with scoliosis. DS affected almost all scoliosis patients, with a 1:1 ratio between painful vs non-painful cases. This is in line with the general asymptomatic population, ranging from 50–96% in ages 40-80 years. Although CT and MRI can satisfactorily investigate pain generators, SPECT/CT can highlight triggering factors in complex cases requiring higher accuracy. Nevertheless, it is not used for routine investigation due to the cost and radiation exposure. Further analysis is required to ascertain sensitivity and specificity of pain and positive SPECT/CT findings.

Table 1: *Percentage of patients with scoliosis with or without pain in each age group. n = total number of patients per category.*

Clinical Presentation	Age Groups				
	≤40 (n=18)	41-50 (n=46)	51-60 (n=108)	61-70 (n=201)	71-80 (n=223)
Scoliosis	**-**	**4%**	**7.5%**	**7%**	**6%**
Painful	-	4%	5.5%	2.5%	2%
Non-painful	-	0%	2%	4.5%	4%

Table 2: *Distribution of DS in scoliosis patients in each age group. n = number of scoliosis patients per category.*

DS location in Scoliosis (%)	Age Groups				
	≤40 (n=0)	41-50 (n=2)	51-60 (n=8)	61-70 (n=13)	71-80 (n=13)
Cervical	-	50%	0%	8%	8%
Thoracic	-	100%	50%	46%	54%
Lumbo-sacral	-	0%	12.5%	69%	69%
Sacro-iliac	-	0%	0%	8%	8%
Whole spine	-	0%	50%	31%	23%

O467

Role of high sensitive c-reactive protein as a prognostic marker in determining functional outcome after interlaminar epidural steroid injection in cervical radiculopathy

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Introduction: Inflammatory cytokines like IL-6, TNF-α, etc. produced at the site of disc herniation are considered as pain generators in patients with cervical radiculopathy. Whether high sensitive C-reactive protein (hs-CRP) assay can be used for predicting the quantum of inflammation around nerve roots is a matter of investigation. This study aimed to evaluate the association of hs-CRP level and functional outcomes measured by Neck Disability Index (NDI) before and after epidural steroid injection (ESI) in patients with cervical radiculopathy.
Methods: This was a prospective study with 45 patients in the study group and 41 participants in the control group. Baseline hs-CRP levels were measured for both. Study group patients received a single cervical ESI using interlaminar approach and were subjected to detailed pre- and post-procedure evaluation using NDI scores. For them, hs-CRP levels were measured at one, two and three months after injection.
Results: Out of 45 patients, 33 had acute and 12 had chronic radicular pain. 21 patients with acute pain had significant improvement while 12 had insignificant response to ESI. None of the chronic cases had a significant response. The mean baseline hs-CRP (in mg/L) among study group (12±8.281) was significantly higher than controls (2.42±1.88). The mean baseline hs-CRP among acute cases where post ESI NDI score at 3 months had significant reduction, was 12.71±7.008 and those with insignificant reduction was 5.592±3.879.
Conclusion: Baseline hs-CRP levels can be used to prognosticate the outcome following cervical ESI in patients with acute cervical radicular pain refractory to physiotherapy and analgesics.

O468

Re-revision rate of revision surgery for rod fracture after surgical correction with pedicle subtraction osteotomy in adult spinal deformity - comparison of rod change only, lateral lumbar interbody fusion around pedicle subtraction osteotomy site, and accessory rod constructs

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Introduction: Rod fracture (RF) is the most common cause of revision surgery after sagittal correction with long posterior spinal fusion (PSF) in patients with adult spinal deformity (ASD). Previous studies did not sufficiently compare the methods of revision surgery. Therefore, we aimed to determine the most useful of the following three methods of revision surgery: surgery for rod change only, lateral lumbar interbody fusion (LLIF) around pedicle subtraction osteotomy (PSO), and accessory rod constructs.
Methods: One hundred thirty-nine patients who had ASD with sagittal malalignment were retrospectively analyzed and followed up for more than 5 years after receiving long PSF with PSO. RF occurred in 49 patients and revision surgery was performed by one of the three methods: rod change only (n = 16), LLIF around PSO with rod change (n = 8), and rod change with accessory rod constructs (n = 25).
Results: The mean age for all patients was 70.4 years old. RF occurred (35%) on the average of 30 months after the surgery, so that revision surgery was performed. Re-RF occurred in 5 of 41 (10.2%) cases; 4 in patients who received rod change using the 2-rod constructs method at 15, 24, 27 and 35 months postoperatively, 1 patient who received rod change using the 2-rod and accessory rod constructs at 23 months postoperatively, and there was no re-RF in LLIF around PSO with rod change group (P = 0.042).
Conclusions: Our study showed that LLIF around PSO and accessory rod constructs are preferable to rod change with 2-rod constructs. Therefore, our research can provide an effective guideline for revision surgery for RF that occurs after long PSF with PSO.

O469

Effects of sustained locomotion training rehabilitation on the spine–pelvis–lower extremity alignment in outpatients with locomotive syndrome: A prospective >2-year cohort study

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Introduction: Locomotive syndrome is a degenerative condition of reduced mobility due to the impaired musculoskeletal system, which has received increasing attention as a Japan's national health policy target. The Japanese Orthopaedic Association recommends locomotion training (basically squatting and single-leg standing) to be effective in preventing locomotive syndrome. However, the extent to which locomotion training affects the whole body alignment is unknown. Therefore, we designed a locomotion training-based rehabilitation program and performed a prospective >2-year cohort study.
Aim: To clarify effects of locomotion training on the spine–pelvis–lower extremity alignment in outpatients with locomotive syndrome.
Patients and Methods: Outpatients who fulfilled the criteria for locomotive syndrome (≥risk level 1) were enrolled and prospectively followed (n=261: age, 76.7±5.9 years; male:female, 23:238). While 63 outpatients completed our locomotion training-based rehabilitation program once per week for 24 months (20-min stretching and self-exercise achievement evaluation), 70 those denied the exercise participation but received clinical follow-up. Additionally, 73 dropped out of rehabilitation but visited the follow-up. Total 206 outpatients took >2-year follow-up (78.9%). Standing radiographs for the spine–pelvis–lower extremity axis and the presence of vertebral fracture, Oswestry disability index (ODI) questionnaire, and the severity (risk levels 1–3) of locomotive syndrome were evaluated at 0, 6, 12, and 24 months. The chai-squared test, Student's t-test, or multi-way repeated measures analysis of variance with Tukey's post-hoc test was used.
Results: No significant differences in baseline demographics and radiographic characteristics including the sagittal vertical axis (SVA) were detected between the rehabilitation and observation groups (p=0.104). The rehabilitation group presented time-course decreases in SVA [mm] from 49.5 at baseline, 40.8 at 6 months, 41.9 at 12 months, to 39.5 at 24 months (p=0.006) whereas the observation group increased SVA [mm] from 38.3, 42.1, 44.6, to 51.8 (p=0.001), indicating anti-aging effects of sustained locomotion training. Then, the dropped-out group during 12–24, 6–12, and <6 months presented increases in SVA [mm] from 34.6 at 12 months to 46.5 at 24 months (p=0.188), from 36.2 at 6 months to 44.2 at 12 months (p=0.252), and from 42.7 at baseline to 54.1 at 6 months (p<0.001), respectively; thus, the trend toward the deterioration in SVA after dropping-out of rehabilitation is relatively consistent. While the increased lumbar lordosis (LL) and thoracic kyphosis and decreased pelvic incidence (PI) minus LL, hip flexion angle, and knee flexion angle were observed in the rehabilitation group (p<0.05), the observation group showed the increased pelvic tilt and PI−LL and decreased LL and sacral slope (p<0.05), suggesting the improved whole body alignment potentially resulting from the lumbar spine−pelvis−lower extremity axis. Furthermore, 60.3% of the rehabilitation group and 14.3% of the observation group improved locomotive syndrome risk levels (p<0.001). The rehabilitation but not observation group improved ODI. Outpatients with vertebral fracture had greater baseline SVA and limited SVA improvement by rehabilitation.
Conclusion: This study highlights the importance of sustained locomotion training to protect against locomotive syndrome-associated whole body alignment failure including positive SVA shift. Therefore, setting-up of the social system capable of continuous rehabilitation is desirable.

O470

Clinical characteristics of early-stage lumbar spondylolysis detected by magnetic resonance imaging in male adolescent baseball player

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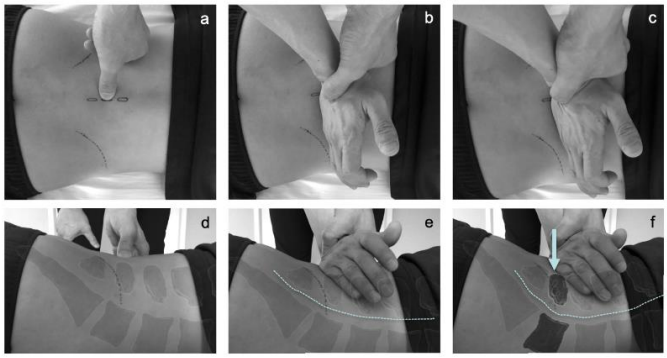
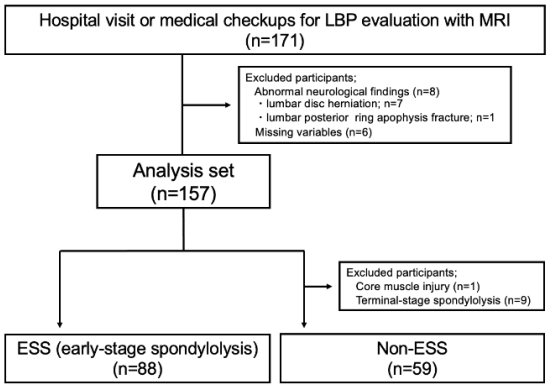
Introduction: Many adolescent athletes experience low back pain (LBP); the most common cause is lumbar spondylolysis. Although early identification of lumbar spondylolysis in adolescent athletes is critical, few studies have focused on identifying the early stages of spondylolysis (ESS) in baseball players. This study aimed to investigate the clinical characteristics of ESS in male adolescent baseball players.
Methods: The participants comprised male junior and high school baseball players (aged 13–18 years) who visited our hospitals and clinics between January 2018 and April 2022 with complaints of LBP. We excluded those with neurological symptoms or findings such as muscle weakness, sensory disturbances, and positive supine straight-leg raising test with reproduction of pain into the lower leg. We also excluded those with a history of lumbar surgery. Before magnetic resonance imaging, we recorded their demographic data, LBP characteristics, and physical findings (lumbar flexion, extension, Kemp's test, and the provocative tenderness of a spinous process (Figure 1)). After the imaging evaluation, the association among LBP characteristics, physical findings, and the final diagnosis (ESS or not) were investigated using univariate and multivariable analyses.
Results: One hundred seventy-one players were included in this study (Figure 2). Eight participants who had neurological symptoms or deficits and six participants for whom data were missing were excluded. After evaluating both physical findings and MRI, 88 of the 157 participants were diagnosed with ESS, and 69 were diagnosed with non-ESS. One participant who showed specific lesions on MRI, and 9 participants who showed terminal-stage spondylolysis were excluded from the non-ESS group. The affected vertebral levels were L1, L3, L4, L5, and L6 (transitional vertebra) in 1, 12, 27, 45, and 1 patient, respectively. We found bilateral active spondylolysis on MRI in 20 patients and unilateral active spondylolysis in 68 patients. The LBP duration of the ESS and non-ESS groups was as follows: <1 week in 8 and 9 players, 1–4 weeks in 18 and 23 players, and ≥4 weeks in 62 and 27 players, respectively. Univariate analyses indicated that the characteristics associated with early-stage spondylolysis were longer duration of LBP (P=0.0085), LBP-related interference while running (P=0.0022), LBP starting with laterality (P=0.0001), lumbar extension (P=0.022), positive Kemp's test (P=0.020), and the tenderness of a spinous process (P=0.0003). After adjusting for confounding factors (age and position), we found that early-stage spondylolysis was significantly associated with LBP duration ≥4 weeks (odds ratio 3.13, 95% confidence interval 1.42–6.92; P=0.0048), LBP-related interference while running (odds ratio 2.89, 95% confidence interval 1.30–6.46; P=0.0094), LBP starting with laterality (odds ratio 2.78, 95% confidence interval 1.24–6.27; P=0.0133), and the tenderness of a spinous process (odds ratio 3.00, 95% confidence interval 1.36–6.57; P=0.0062).
Conclusions: Male adolescent baseball players with early-stage spondylolysis might have LBP duration of more than four weeks, LBP-related interference while running, and a history of LBP starting with laterality. The tenderness of a spinous process might be helpful in the diagnosis of early-stage spondylolysis in male adolescent baseball players.

Figure 1. The tenderness of the vertebral spinous process.



The examiner palpates each spinous process with the thumbs (a, d), places the hypothenar on that process (b, e), and presses inferiorly to produce extension movement of the lumbar spine (f, e).

Figure 2. Study flowchart



O471

Causes of residual low back pain in patients with osteoporotic vertebral fractures without poor prognostic factors on MRI

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Introduction: We have recommended early surgical intervention for osteoporotic vertebral fractures (OVF) with poor prognostic factors (a confined high intensity or a diffuse low intensity area in the fractured vertebrae on T2-weighted MR images) at the time of injury. However, there are some cases who have had residual low back pain even in patients without poor prognostic factors on MRI who are treated conservatively.

Aim: In this study, we investigated such cases and discussed the causes of residual low back pain.

Patients and Methods: This prospective cohort study included 55 patients with an acute OVF treated conservatively for more than 6 months (mean age 75.1 years, 47 women). Patients with poor prognostic factors on T2 weighted MR images and patients with compression of the cauda equina or nerve root were excluded. We defined the residual low back pain as visual analog scale (VAS) for low back pain ≥40mm at 6 months in this study. Then enrolled patients were divided into two groups: "residual pain group" (15 cases) and "control group" (40 cases). The evaluation items were vertebral body compression rate and vertebral body motion angle on dynamic films, sagittal plane parameters on whole spine X-ray, low back pain VAS value, and buttock pain VAS value at the initial examination and at 6 months. To detect the risk factors of residual low back pain, each evaluation item at the first visit was compared between groups by univariate analysis, and multivariate analysis was performed.

Results: Univariate analysis revealed significant differences in VAS values for buttock pain (p=0.002), posterior wall vertebral body compression rate (p=0.048), vertebral body motion angle (p=0.047), thoracic kyphosis (T5-T12) (p=0.046), and lumbar lordosis (T12-S1) (p=0.031) at the initial examination. Multivariate analysis showed that severe buttock pain (p=0.017) was an independent factor associated with residual low back pain at the initial visit. The patients with residual back pain had significantly higher VAS values at 1 month (p=0.037), SVA at 6 months (59.3±34.4mm/35.9±36.6mm, p=0.046), vertebral body motion angle (2.4±3.3°/0.32±2.8°, p=0.048), and a confined high-signal area on T2-weighted MR images (26.7%/2.56%, p=0.006), and the rate of change in bone mineral density of femoral neck (-5.0±6.5%/0.07±3.9%, p=0.001). (residual pain group / control group, respectively)

Conclusion: The residual low back pain at 6 months after OVF was associated with buttock pain at the initial examination. Patients with residual low back pain at 6 months after injury had severe low back pain at 1 month after injury, showed higher nonunion rate at 6 months, and decreased bone mineral density of femoral neck. In the case of a patient who had buttock pain at the initial visit and severe back pain at the 1-month follow-up visit, therapeutic intervention such as vertebroplasty should be considered.

O472

Association between opioid utilization and patient reported outcome measures following lumbar spine surgery

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Introduction: Patient-reported health related quality of life measures have important utility in quantifying changes in health status and clinical outcomes. The Patient-Reported Outcomes Measurement Information System (PROMIS), created by the National institute of Health, is a reliable and valid survey for patients with lumbar spine pathology. Preoperative opioid use is an important predictor variable of self-reported health status in patients with spinal disorders. The purpose of this study is to investigate the impact of preoperative opiate use on self-reported health status.

Methods: Retrospective study of a prospectively maintained database. The cohort included consecutive patients who underwent lumbar decompression ± ≤ 2 level fusion at a single institution between March 2019 and January 2021. Patients completed PROMIS Anxiety, Depression, Fatigue, Pain Interference (PI), Physical Function (PF), Sleep disturbance (SD), and Social Roles (SR) surveys at preoperative intake with subsequent follow up at 6 and 12 months postoperatively. Patients were categorized according to preoperative opiate use. Chronic Opioid Users (COU) had prescribed opioid use of ≥3 continuous months prior to surgery. Between cohort comparison of the mean for each PROMIS measure was performed using simple t-test. We controlled for variables that may be independent predictors of self-reported health status including age, gender, co-morbidities, length of stay, duration of surgery, American Society of Anesthesiology (ASA) score, number of prior surgeries, length of hospital stay, and surgical invasiveness index.

Results: 121 patients completed PROMIS surveys at the designated timepoints, 94 were non-chronic Opioid Users (NOU) and 27 were COU prior to surgery. Analysis of preoperative patient-reported health outcomes shows that long term opioid use correlated with worse ODI and PROMIS scores, with exceptions in PROMIS SD where the difference between the two groups was insignificant and PROMIS SR where the COU cohort had a higher baseline status (Table 1). At 1 year follow-up, patients in the COU continued to have significantly worse ODI, PROMIS PF, and PROMIS PI scores and better PROMIS SR measures compared to the NOU cohort. There is a statistical difference in the magnitude of change in health status between the two cohorts in PROMIS Anxiety (-7.62 ± 7.18 vs -2.90± 8.5, p = 0.006), Depression (-5.73 ± 7.07 vs. -1.72 ± 8.29, p=0.016) and Fatigue (-8.90 ± 9.12 vs. -4.14 ± 11.0, p= 0.017) at one year follow-up, with the COU cohort experiencing greater improvement in these domains. Mean improvement in PROMIS scores for the COU cohort exceeded minimal clinically important difference (MCID) in all domains except PROMIS Sleep Disturbance and Social Roles. The NOU cohort was able achieve MCID on in PROMIS PF and PI domains (Table 2).

Conclusions: Patients with chronic opioid use status have worse baseline PROMIS scores and longer LOS after surgery. However, patients in the COU cohort displayed significant postoperative improvement in multiple PROMIS domains. These results show that chronic opioid users may benefit greatly from surgical intervention and will allow physicians to better set expectations with their patients. Further work is needed to understand the role opioid weaning as part of rehabilitation for surgery.

Table 1: Outcomes of health-related quality of life measures

Patient-reported Outcome Measure		**COU**	**SOU**	**NOU**	**p-value**
ODI	Pre-op	53.8 (17.7)	44.8 (18.8)	32.6 (15.2)	<0.001*
	6 months post op	30.7 (19.1)	18.4 (15.9)	18.7 (15.4)	0.004*
	1 year post op	31.8 (20.1)	17.6 (17.9)	15.9 (16.3)	<0.001*†
PROMIS PF	Pre-op	34.1 (5.39)	36.2 (6.83)	39.1 (6.38)	0.002*
	6 months post op	41.4 (7.97)	43.9 (6.21)	44.9 (7.80)	0.122
	1 year post op	40.0 (7.66)	45.6 (7.33)	46.3 (8.63)	0.003*†
PROMIS Anxiety	Pre-op	58.0 (10.1)	55.6 (7.26)	52.5 (8.27)	0.016*
	6 months post op	51.8 (9.69)	50.7 (8.48)	48.9 (8.82)	0.334
	1 year post op	50.3 (9.97)	52.1 (8.98)	49.8 (9.43)	0.597
PROMIS Depression	Pre-op	55.7 (9.05)	52.3 (8.12)	49.9 (7.68)	0.009*
	6 months post op	50.0 (9.91)	49.4 (7.91)	48.4 (8.10)	0.694
	1 year post op	49.9 (10.2)	48.2 (7.10)	49.0 (8.48)	0.784
PROMIS Fatigue	Pre-op	60.1 (10.0)	53.4 (11.0)	51.7 (10.0)	0.002*†
	6 months post op	51.3 (9.06)	49.5 (9.60)	48.5 (10.5)	0.483
	1 year post op	51.2 (11.4)	50.6 (10.1)	47.1 (10.1)	0.147
PROMIS Pain Int	Pre-op	66.1 (7.87)	64.6 (8.27)	61.2 (7.12)	0.01*
	6 months post op	57.9 (9.86)	55.0 (6.14)	54.0 (8.52)	0.121
	1 year post op	59.4 (8.12)	53.2 (9.10)	53.0 (8.83)	0.004*†
PROMIS Sleep Dist	Pre-op	52.1 (2.37)	53.4 (2.77)	52.4 (2.57)	0.136
	6 months post op	51.5 (3.58)	52.8 (2.71)	52.1 (3.74)	0.405
	1 year post op	51.9 (2.85)	51.4 (5.28)	52.8 (2.87)	0.177
PROMIS Social Roles	Pre-op	50.0 (8.08)	46.9 (10.0)	42.9 (7.75)	0.001*
	6 months post op	42.1 (7.62)	37.8 (6.47)	38.6 (8.57)	0.101
	1 year post op	42.7 (8.84)	36.8 (8.36)	36.3 (8.42)	0.004*

*Statistical significance

†Inter-cohort Minimal Clinically Important Difference

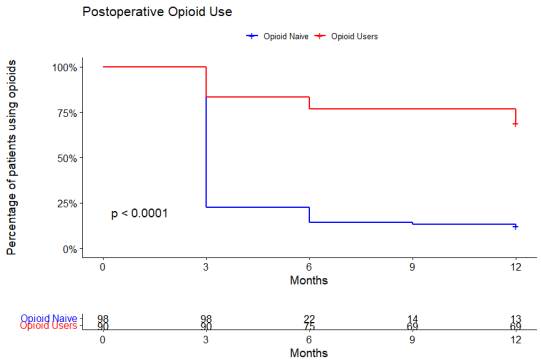
Table 2: Change in health-related quality of life measures at one year follow-up

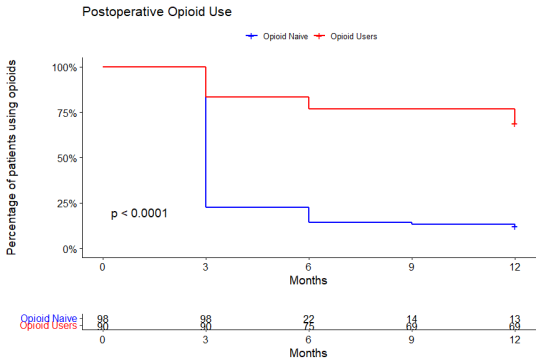
	COU	SOU	NOU	p-value
Δ ODI	-22.00 (19.9)†	-27.25 (22.0)†	-16.71 (19.6)†	0.077
Δ PROMIS Anxiety	-7.62 (7.18)†	-3.49 (9.24)	-2.69 (8.30)	0.033*
Δ PROMIS Depression	-5.73 (7.07)	-4.08 (8.49)	-0.91 (8.12)	0.02*
Δ PROMIS Fatigue	-8.90 (8.12)†	-2.80 (8.69)	-4.60 (11.7)	0.092
Δ PROMIS Pain Int	-6.66 (8.20)†	-11.40 (9.82)†	-8.28 (9.80)†	0.197
Δ PROMIS Physical Function	5.91 (6.68)†	9.42 (7.34)†	7.25 (10.3)†	0.384
Δ PROMIS Sleep Disturbance	-0.16 (3.40)	-2.08 (6.65)	0.37 (3.31)	0.051
Δ PROMIS Social Roles	-7.29 (7.05)	-10.15 (8.51)	-6.61 (9.58)	0.243

Δ 1 year postoperative score – preoperative score

*Statistically significant

†Intracohort Minimal Clinically Important Difference





O473

Changes of the posterior paraspinal and psoas muscle in patients with low back pain: A 3-year longitudinal study

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Introduction: To date, there is limited data on the longitudinal changes in the posterior paraspinal muscles (PPM; *m erector spinae and multifidus*) and psoas muscle in patients with low back pain. The available literature evaluating paraspinal muscles is mostly based on cross-sectional investigations. This study aimed to investigate the changes in the PPM and psoas in patients with low back pain over time.
Materials and Methods: Patients with low back pain who had a repeat lumbar MRI a minimum of three years apart at a tertiary referral center were analyzed. MRI-based quantitative assessments of the PPM and the psoas muscle were conducted at the upper endplate of L4 for the baseline and follow-up MRI. The cross-sectional area (CSA), the functional cross-sectional area (fCSA) and the fat area (FAT) were calculated using a dedicated software program. The fatty infiltration (FI, %) of the regions of interest was calculated. The difference between the 1st and 2nd MRI was calculated for all assessed muscular parameters (e.g. Δ FI = $FI_{2nd\ MRI}$-$FI_{1st\ MRI}$). Additionally, patients were grouped into five age groups (10-year increments) to determine different muscular aging patterns. All analysis were stratified by sex.
Results: 353 patients (54.4% female) with a median age of 60.1 years and BMI of 25.8 kg/m² at baseline were analyzed. The mean time between the 1st and 2nd MRI was 3.6 years. The $fCSA_{PPM}$ declined in both sexes significantly from the 1st to the 2nd MRI, whereas the FAT_{PPM} increased. In line with this result, the FI_{PPM} increased in both males (29.9%) and females (19.4%). Females had a higher FI_{PPM} and FI_{Psoas} than males in both MRIs. In females, no significant changes were found for the psoas muscle. The CSA_{Psoas} and $fCSA_{Psoas}$ in males were significantly smaller in the 2nd MRI. With increasing age, a significant trend in a decrease in Δ FI_{PPM} was observed for both sexes.
Conclusion: This is the first study to investigate longitudinal muscular changes quantitatively in patients with low back pain. The study revealed significant muscular changes in males and females with low back pain, especially in the posterior paraspinal muscles in only three years' time.

O474

Widespread degeneration on MRI after the pubertal growth spurt predicts low back pain in adulthood

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Introduction: The life-time occurrence of low back pain (LBP) reaches adult levels by the end of puberty. Childhood LBP has been proposed a significant risk factor for LBP in adulthood.
Disc degeneration (DD) on MRI becomes more prevalent with age; a significant increase in DD has been reported after the pubertal growth spurt. As signs of DD are seen in asymptomatic individuals as well, their value in predicting future LBP is debated. However, some evidence suggests that DD in early adulthood predisposes the individual for a more rapid progression of degeneration and may be associated to LBP in later life.
Aim: In the present longitudinal observational study, our objective was to investigate whether findings of DD on MRI are associated with LBP. Hereby we report the association of signs of DD on MRI in early adulthood to self-reported LBP at the age 34.
Materials and Methods: In 1994, we recruited 94 healthy 8-year-old school children for a semi-structured interview, a clinical examination, and a lumbar spine MRI with follow-ups at the ages of 11 (n=81) and 18 (n=71). In January 2021, at the age of 34, all those subjects whose contact details were known (n=89) were invited for a long-term follow-up (n=48). From the MRI investigations at the ages of 18 and 34 we assessed the signal intensity of the lumbar discs using the Pfirrmann classification (Grade 1-5) and calculated the Pfirrmann Summary Score (PSS) for the three lowest lumbar levels (L3/L4, L4/L5, L5/S1) by adding up the scores of the individual discs (PSS range 3-15). Further, we analyzed the association of PSS at the age of 18 and 34 to self-reported LBP at the age of 34.
Results: The mean PSS at the age of 18 was 5.6 (SD 1.2) and 6.8 (SD 1.1) for participants with or without LBP at the age of 34, respectively (p=0.009). The corresponding PSS values at the age of 34 were 6.9 (SD 1.0) for asymptomatic participants and 7.6 (SD 1.6) for participants reporting LBP at the age of 34 (p=0.20). The OR (95% CI) of PSS at the age of 18 for LBP at the age of 34 was 5.46 (1.22 to 24.47) when adjusted for sex, BMI, smoking and level of physical activity. The AUC (95% CI) was 0.73 (0.59 to 0.87). All participants with a PSS greater than 6 at the age of 18 reported LBP at the age of 34. The adjusted OR (95% CI) of PSS at the age of 34 for LBP at the age of 34 was 1.61 (0.76 to 3.42).
Conclusion: Participants reporting LBP at the age of 34 had more widespread disc degeneration at the age of 18 compared to their asymptomatic peers. Every 1-point increase in PSS at the age of 18 increased the risk of LBP at the age of 34 5.5-fold when adjusted for sex, and BMI, smoking and physical activity level at the age of 34.

O475

Objective quantification of physical activity and sleep quality among patients with chronic low back pain

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Introduction: Chronic low back pain (cLBP) adversely affects various components of quality of life, while reduced physical activity (PA) and sleep disturbance are often associated with cLBP. Yet objective quantification of PA and sleep quality and its relationship with pain-related limitations are still sparse. In this study, we aim to investigate the connection between accelerometer-derived PA and sleep quality with cLBP pain-related limitations.
Methods: As part of a clinical trial, 82 CLBP participants (51% female, mean 51.8 yrs old) wore an Actigraph accelerometer (GT3X+, non-dominant wrist) for 7+ days before the intervention and completed the PROMIS self-reported health questionnaires (including measures on physical function, anxiety, depression, fatigue, sleep disturbance, sleep-related impairment, and pain interference). Waking hours (5 am-midnight) accelerometer signals were extracted to derive the following PA data: step count, sedentary time (SED), moderate-vigorous physical activity (MVPA) time, and hourly accumulation of steps. Night-time data were extracted to derive sleep duration, sleep efficiency, wake-up time and sleep onset time using established algorithms. Associations between sensor-derived outcomes and patient-reported outcomes were examined.
Results: Daily total PA metrics (step count, SED, MVPA) were not found to be associated with any pain-related self-reported outcomes. However, further analysis of hourly step accumulation (Fig.1) revealed late morning (9 am-12 pm) step accumulation was positively associated with physical function ($r \in [0.22,0.25]$), and negatively associated with pain interference and depression ($r \in [-0.29,-0.23]$), while late night (10pm-midnight) step accumulation was found to be positively associated with anxiety, fatigue, and sleep-related impairment ($r \in [0.23,0.39]$). From the sensor-derived sleep outcomes, we further observed (Fig.2) early morning (5-8 am) and night (9 pm-midnight) accumulation of steps were negatively associated with sleep duration and sleep efficiency ($r \in [-0.47,-0.22]$), while those who have a higher sleep efficiency also have more steps during late morning period ($r \in [0.26,0.36]$). Delayed sleep onset time was found to be associated with higher step counts during evening-to-night hours (6 pm-midnight, $r \in [0.23,0.65]$), while late wakeup time was found to be associated with lower step accumulation throughout the day (5 am-7 pm, $r \in [-0.65,-0.23]$).
Discussions: We observed a unique morning/evening physical activity accumulation pattern that was associated with self-reported pain outcomes. This dichotomy of when activity occurs also was correlated with sensor-derived sleep outcomes. It is evident that sleep patterns and PA accumulation patterns are associated with health outcomes among cLBP patients, and future research is needed to investigate whether targeted intervention on PA and sleep could be used to optimize individualized cLBP rehabilitation programs.

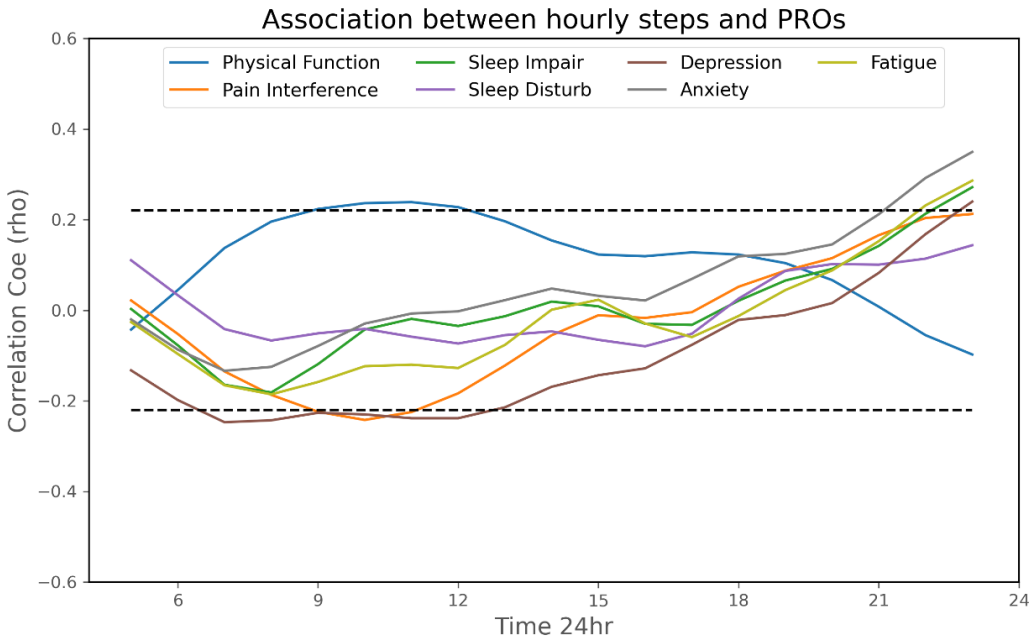

Figure 17. Association between hourly steps and pain-related patient-reported outcomes, Data points exceeding the horizontal dash lines indicate significant associations.

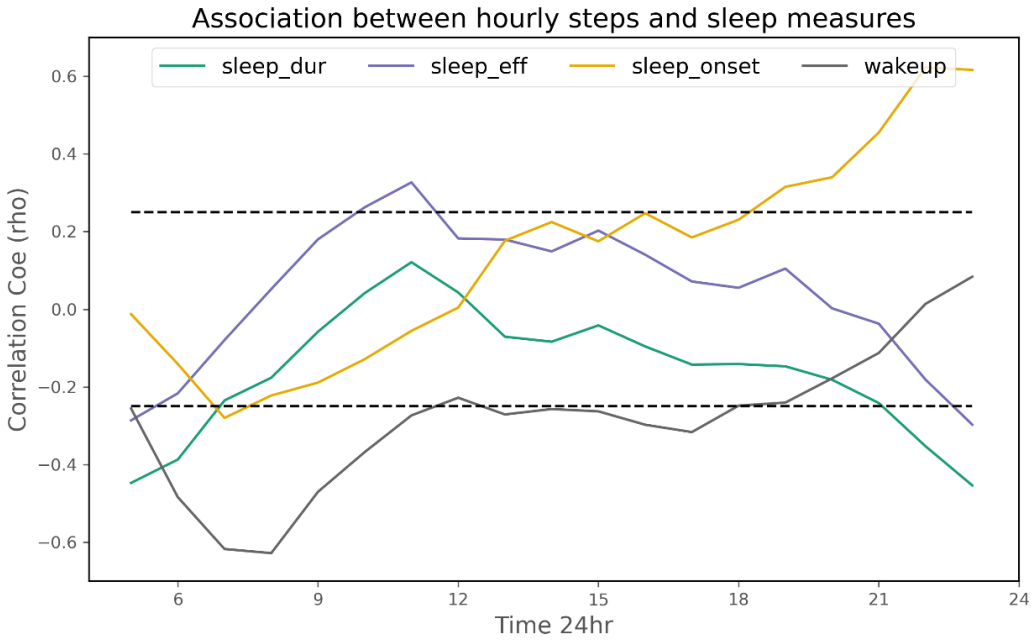

Figure 2. Association between hourly steps and sensor-derived sleep measures. Data points exceeding the horizontal dash lines indicate significant associations.

O476

Physiotherapy aided by a clinical decision support system versus standard physiotherapy for treating persistent low back pain: Results of a pilot randomised controlled trial

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Introduction: Individualised treatment is desired by patients with persistent low back pain, but primary care clinicians struggle to identify and manage all contributing factors in this patient population. We have developed a computerised evidence-based clinical decision support system (CDSS) that helps physiotherapists identify and manage biopsychosocial barriers to recovery relevant to individuals with persistent low back pain.
Aim: To estimate the effectiveness of physiotherapy aided by a CDSS versus standard physiotherapy for persistent low back pain.
Methods: Forty participants with persistent low back pain (symptoms 6 months or longer) in Melbourne, Australia, received 13 sessions of physiotherapy over a 6-month period. Participants were randomly allocated to receive either physiotherapy aided by a CDSS that facilitated assessment and treatment decisions (n=20, 4 treatment centres), or standard physiotherapy at the discretion of the clinician (n=20, 4 different treatment centres). Back pain, leg pain (10-point numerical rating scale) and disability (Oswestry) were assessed at baseline and at 3, 6 and 12 months following randomisation. Between-group treatment effects were estimated using the standardised mean difference (SMD) with values of 0.5 (moderate effect size) or greater considered clinically important. As a pilot study there was insufficient power to establish the statistical significance of effects unless they were large (standardised mean difference > 0.8).
Results: Followup was completed to 12-months by 37 participants (92.5%). Between-group treatment effect size estimates for back pain, leg pain and disability were small (SMD of 0.2 or more) to moderate (SMD of 0.5 or more) in favour of physiotherapy aided by the CDSS, with back pain at 3-months reaching statistical significance: SMD=0.7 (95%CI 0.0 to 1.3). Participants with neuropathic pain symptoms (Neuropathic Pain Questionnaire; n=14) achieved large and statistically significant effects favouring physiotherapy aided by the CDSS over standard physiotherapy: disability at 6 months (SMD=1.4 (95%CI 0.0 to 2.8)) and leg pain at 3 months (SMD=1.4 (95%CI 0.0 to 2.8)), 6 months (SMD=1.8 (95%CI 0.3 to 3.3)) and 12 months (SMD=2.0 (95%CI 0.3 to 3.7)). Participants with symptoms indicative of central pain processing disorders (Central Censitisation Inventory score of 40 or more, n=15) demonstrated the smallest within-group and between-group improvements.
Conclusion: Integrating a CDSS into practice that helps physiotherapists assess and manage persistent low back pain may lead to better outcomes than standard physiotherapy. Physiotherapy aided by the CDSS appears particularly effective for participants with neuropathic pain symptoms. Participants with probable central sensitisation achieved the smallest improvements in both treatment groups, and subsequently modifications to the CDSS or different treatment approaches may be required for this subgroup.

O477

Impact of COVID-19 on bone mass, muscle, and low back pain scores in patients with osteoporosis in Japan

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Introduction: In December 2019, COVID-19 emerged in Wuhan, Hubei, China, and since has spread around the world. In March 2020, WHO declared COVID-19 as a pandemic; the Japanese government strongly encouraged people to stay at home to prevent and reduce the spread of COVID-19 in Japan. However, there were concerns regarding adverse effects on several factors such as bone, muscle, pain, and psychosocial activities in elderly patients due to the resultant decreased physical activity.
Aim: To evaluate the impact of COVID-19 pandemic on bone mass, muscle and low back pain scores in patients with osteoporosis in Japan.
Methods: Overall, 108 patients with osteoporosis (13 males and 95 females) were included, who were administered osteoporosis medication at our institution without delay owing to COVID-19 pandemic. Bone mineral density (BMD) of lumbar spine (LS), femoral neck (FN) and total hip (TH), low back pain score, grip strength, and skeletal muscle mass were retrospectively reviewed in the current study, at baseline, and at 2 and 4 years before baseline. For the low back pain score, the Japanese Orthopedic Association Back Pain Evaluation Questionnaire (JOABPEQ), which consists of 5 functional scores: LBP, lumbar function, walking ability, social life function, and mental health, were evaluated. We calculated change in rate of measurements from 4 to 2 years before baseline as before pandemic, and from 2 years before baseline to baseline as after pandemic. Subsequently, we compared each change rate between before and after pandemic.
Results: The mean change rate of BMD of TH after pandemic was 0.88, which was significantly lower compared to 3.80 that before pandemic($p=0.038$). The mean change rate of mental health score of JOABPEQ after pandemic was 5.09, which was significantly lower compared to 17.27 that before pandemic ($p=0.005$). Moreover, the mean change rate of grip strength after pandemic was -6.56, which was significantly lower compared to 1.06 that before pandemic. ($p=0.017$) Contrarily, skeletal muscle mass between before and after pandemic was not significantly different. ($p>0.05$)
Conclusions: In the current study, the COVID-19 pandemic suppressed the effects of increasing BMD and muscle strength in patients with osteoporosis. Additionally, improvement of mental health score due to low back pain was also reduced because of COVID-19. Physical activity time of the elderly has been reported to decrease by approximately 30% compared to that before pandemic, owing to stay-at-home measures. Additionally, long-term restriction of physical activity has been reported to cause a decrease in BMD. These findings indicate that decrease in activity among the Japanese because of the COVID-19 pandemic may have a negative impact not only on BMD, but also on muscle strength and mental health scores owing to low back pain. Therefore, we should be cautious because the activity level of the Japanese, including the elderly, has not been fully revived to pre-pandemic levels and may further affect BMD, muscle strength, and low back pain scores in the future.

O478

A prospective study comparing lumbar facet arthroplasty to transforaminal interbody fusion in the treatment of degenerative spondylolisthesis with stenosis: 2-year outcomes from the total posterior spine system (TOPS) IDE study

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Introduction: The surgical treatment for lumbar spondylolisthesis has remained somewhat controversial. Posterior lumbar arthroplasty with facet replacement is a novel alternative to lumbar decompression and fusion. There is an ongoing multicenter, prospective, randomized, controlled US Food and Drug Administration (FDA) Investigation Device Exemption (IDE) trial evaluating the clinical and radiographic outcomes of an investigational facet replacement device versus lumbar fusion with interbody fusion with pedicle screw fixation for the treatment of Grade I degenerative spondylolisthesis and stenosis.
Methods: This interim analysis included 299 subjects with Grade 1 spondylolisthesis and moderate to severe stenosis. Subjects were randomized 2:1 to artificial facet replacement versus TLIF using a monolithic PEEK interbody spacer and pedicle screw fixation. The primary endpoint was composite clinical success at 24 months defined as a ≥15-point improvement in the Oswestry Disability Index from baseline, the absence of any surgical reintervention that involved revision, removal, or supplemental fixation, no epidural steroid injection at any lumbar level, no new or worsening neurological deficit, and no implant failure. Secondary endpoints included improvement in back and leg pain and rate of supplemental surgical intervention.
Results: At the time of this analysis 299 subjects have been enrolled (TOPS =206; TLIF= 93) and a total of 140 subjects have 24 month outcomes (TOPS=109, TLIF=46). There were no differences in baseline demographics between the two groups and operative characteristics of length of surgery, blood loss, and length of stay were nearly identical. At 24 months the percentage of subjects meeting the composite clinical success endpoint was significantly better in the facet arthroplasty group versus the TLIF group (p=0.0148). In the facet replacement group 74.3% (84) of 113 subjects met the composite clinical success criteria versus 53.2% (25) of 47 subjects in the TLIF group. VAS scores for back pain also significantly favored facet replacement (p=0.014) with 84.4% of subjects reporting a minimum 20 point improvement compared to 61.8% in the TLIF group. Both groups reported significant improvement in leg pain with 90.6% of subjects reporting a minimum 20 point improvement compared to 88.2% in the TLIF group. Among all 2499 subjects that were enrolled the rate of supplemental surgical intervention (SSSI) for facet replacement and TLIF control was 5.3% and 8.6%, respectively.
Conclusion: The preliminary results of the TOPS System demonstrate good clinical outcomes at the immediate post-operative visit through 24 months. Re-operation rates are consistent with literature for surgical treatments to address spondylolisthesis with stenosis. Lumbar facet arthroplasty appears to be a viable option for treatment of degenerative spondylolisthesis. Continued long-term follow-up is required to validate early findings and evaluate differences between facet arthroplasty and fusion.

Table 1: Demographics			
Demographics	**TOPS (n=206)**	**TLIF (n=93)**	**P Value**
Age (years)	63.3 ± 8.2	63.9 ± 8.6	>0.05
Height (inches)	66.6 ± 4.0	66.8 ± 4.3	>0.05
Weight (lbs)	188.1 ± 38.2	190.4 ± 39.3	>0.05
BMI (kg/m^2)	29.4 ± 4.9	29.9 ± 5.3	>0.05
Sex (Female)	116 (56.3%)	50 (53.7%)	>0.05
Race			
White	191 (92.7%)	86 (92.5%)	>0.05
Black	3 (1.5%)	3 (3.2%)	
Asian	3 (1.5%)	2 (2.2%)	
Other	9 (4.4%	2 (2.2%)	
Use of nicotine products			
No, never smoked	127 (61.7%)	59 (63.4%)	>0.05
No, but prior history	73 (35.4%)	32 (34.4%)	
Current smoker	6 (2.9%)	2 (2.2%)	
Prior Lumbar Surgery			
Yes	12 (5.8%)	6 (6.5%)	>0.05
No	194 (94.2%)	87 (93.5%)	
Level Implanted			
L1/L2	0	0	>0.05
L2/L3	0	0	
L3/L4	10 (4.9%)	6 (6.5%)	
L4/L5	196 (95.1%)	87 (93.5%)	

Abbreviations: Body Mass Index (BMI), pounds (lbs) Continuous variables are displayed as mean ± standard deviation. Categorical variables are displayed as number (percent).

Table 2: Surgical Variables			
	TOPS	**TLIF**	**P Value**
Time in Surgery (mins)	181.7 ± 57.0	176.9 ± 56.7	>0.05
Length of Stay (days)	2.9 ± 3.6	2.9 ± 1.8	>0.05
EBL (cc)	199.6 ± 146.0	214.8 ± 133.4	>0.05
Estimated Blood Loss			
<100 cc	34 (16.5%)	11 (11.8%)	0.54
100 - <250 cc	105 (51.0%)	48 (51.6%)	
250 - <400 cc	44 (21.4%)	19 (20.4%)	
>=400 cc	23 (11.2%)	15 (16.1%)	

Abbreviations: Estimated Blood Loss (EBL) Continuous variables are displayed as mean ± standard deviation. Categorical variables are displayed as number (percent).

Table 3: Primary Endpoint: Composite Clinical Success							
	TOPS (n=113)			TLIF (n=47)			P Value
	N	n	%	N		Mean	
Overall Composite Clinical Success	113	84	74.3%	47	25	53.2%	0.01
Failed to Achieve Primary Endpoint	113	29	25.7%	47	22	46.8%	0.01
Reoperation or Lumbar Injection	206	16	7.8%	93	11	11.8%	
Major Device Adverse Event	105	7	6.7%	39	2	4.9%	
ODI Reduction < 15 points	96	6	6.3%	35	8	22.9%	
New or Worsening Neurologic Deficit	107	3	2.8%	44	5	11.4%	

Table 4: Complications		
	TOPS (n=206)	TLIF (n=93)
Dural Tear	4	2
Infection	1	0
Seroma	1	0
Hematoma	1	0
Implant loosening/migration	2	3
Misplaced instrumentation	1	0
Pseudarthrosis	0	1
Adjacent Segment Disease	0	5
Retained drains	2	0
Reoperation*	11 (5.3%)	8 (8.6%)

Table 5: Reoperations

Patient ID	Surgery	Index Level	Adverse Event	Time from Index Surgery to Reoperation (Months)	TOPS Removed?	Surgical Outcome
1	TOPS	L4-5	Retained drain	1.7	No	Removal of retained drain
2	TOPS	L4-5	Worse LBP	6.6	Yes	Removal of TOPS and conversion to single level posterolateral fusion
3	TOPS	L4-5	Seroma	2.5	Yes	Wound exploration and TOPS removal
4	TOPS	L4-5	Dural Tear Persistent CSF Leak Persistent CSF Leak with severe leg pain Pseudomeningocele	0.6 11.1 11.5 17.4	Yes (replaced) Yes (convert to fusion) n/a n/a	Removal of TOPS, dural repair, placement of new TOPS Removal of TOPS, dural repair, conversion to single level posterolateral fusion Wound exploration Wound exploration and shunt implantation
5	TOPS	L4-5	Unresolved Pain	31.4	No	Spinal cord stimulator placed T12-L2
6	TOPS	L4-5	Loose pedicle screws at L5	17.2	Yes	Two stage revision including removal of TOPS followed by ALIF at L4-5
7	TOPS	L3-4	Wound infection Dural Tear	0.4 0.9	No Yes	Irrigation and debridement Removal of TOPS, dural repair (subsequent ALIF at L3-4)
8	TOPS	L3-4	Hematoma	0.4	No	Hematoma evacuation
9	TOPS	L4-5	Retained drain	0.1	No	Removal of retained drain
10	TOPS	L4-5	Bilateral screw loosening at L4	13.8	Yes	Removal of TOPS, conversion to posterolateral fusion at L4-5
11	TOPS	L4-5	Pedicle screw misplacement	0.2	No	Revision of L4 pedicle screws
12	TLIF	L4-5	Adjacent segment disease Pseudoarthrosis at L3/4	10.0 25.3	-	Decompression L3-4, extension of fusion L3-5 Revision decompression and fusion L3-5
13	TLIF	L4-5	Persistent neurologic symptoms*	0.9	-	Revision decompression
14	TLIF	L4-5	Adjacent segment disease Adjacent segment disease	20.4 23.3	-	Decompression L5-S1, extension of fusion L4-S1 Decompression L3-4, extension of fusion L3-S1
15	TLIF	L4-5	Dural Tear	0.4	-	Dural repair
16	TLIF	L4-5	Adjacent segment disease	4.5	-	Decompression L5-S1, extension of fusion L4-S1
17	TLIF	L4-5	Adjacent segment disease	23.0	-	Discectomy/decompression L3-4
18	TLIF	L4-5	Adjacent segment disease	30.2	-	Decompression L3-4, extension of fusion L3-5
19	TLIF	L4-5	Interbody cage displacement	1.1	-	Revised interbody cage

Abbreviations: Low back pain (LBP), Total posterior spine system (TOPS), Anterior lumbar interbody fusion (ALIF), cerebrospinal fluid (CSF)
*These persistent neurologic symptoms were believed to be secondary to residual lateral recess and foraminal stenosis contralateral to the side on which the complete facetectomy and TLIF were performed.

Table 6: Patient Reported Outcomes									
Oswestry Disability Index									
	TOPS		**TLIF**		**TOPS**		**TLIF**		**P Value**
	N	**Mean**	**N**	**Mean**	**N**	**MCID**	**N**	**MCID**	
Preoperative	206	56.5 ± 12.1	93	55.8 ± 13.1					
Week 6	194	23.5 ± 16.4	84	30.2 ± 17.0	194	84.0%	84	73.8%	0.07
Month 3	183	15.7 ± 16.5	82	22.1 ± 17.8	183	89.1%	82	84.1%	0.31
Month 6	171	13.4 ± 15.5	74	16.9 ± 15.9	171	91.8%	74	90.5%	0.81
Month 12	143	11.6 ± 13.7	65	16.9 ± 17.2	143	94.4%	65	89.2%	0.25
Month 24	96	9.4 ± 14.5	35	21.1 ± 22.3	96	93.8%	35	77.1%	0.01
Visual Analog Scale - Low Back									
	TOPS		**TLIF**		**TOPS**		**TLIF**		**P Value**
	N	**Mean**	**N**	**Mean**	**N**	**MCID**	**N**	**MCID**	
Preoperative	206	68.6 ± 23.3	93	69.5 ± 22.2					
Week 6	194	18.5 ± 18.0	84	27.7 ± 25.3	194	83.5%	84	68.7%	0.009
Month 3	183	16.2 ± 21.3	82	23.1 ± 24.5	183	83.6%	82	79.3%	0.39
Month 6	171	14.7 ± 21.1	74	22.7 ± 24.8	171	86.0%	74	79.7%	0.26
Month 12	143	12.4 ± 19.6	65	24.5 ± 27.6	143	86.0%	65	76.9%	0.11
Month 24	96	11.1 ± 18.1	35	30.9 ± 33.1	96	84.4%	35	61.8%	0.01
Visual Analog Scale - Worst Leg Pain									
	TOPS		**TLIF**		**TOPS**		**TLIF**		**P Value**
	N	**Mean**	**N**	**Mean**	**N**	**MCID**	**N**	**MCID**	
Preoperative	206	82.7 ± 13.5	93	85.1 ± 10.8					
Week 6	194	12.9 ± 20.5	84	17.9 ± 25.2	194	92.8%	84	92.8%	1.00
Month 3	183	13.3 ± 22.5	82	15.9 ± 23.7	183	94.5%	82	92.7%	0.58
Month 6	171	12.9 ± 22.7	74	17.0 ± 24.9	171	92.4%	74	91.9%	1.00
Month 12	143	12.8 ± 22.0	65	18.7 ± 27.8	143	94.4%	65	90.8%	0.38
Month 24	96	13.7 ± 24.2	35	23.3 ± 33.8	96	90.6%	35	88.2%	0.74

Table 7: Radiographic Parameters					
Flexion/Extension ROM					
	TOPS		**TLIF**		**P Value**
	N	**Mean**	**N**	**Mean**	
Preoperative	206	4.1 ± 3.1	92	4.5 ± 3.4	0.41
Month 12	150	3.9 ± 2.8	69	1.4 ± 0.8	<0.001
Month 24	106	3.9 ± 2.9	42	1.2 ± 0.8	<0.001
Δ Preop to 12 Months		-0.1 ± 3.4		-2.9 ± 2.9	<0.001
Δ Preop to 24 Months		0.0 ± 3.3		-3.0 ± 2.9	<0.001
Flexion/Extension Translation					
	TOPS		**TLIF**		**P Value**
	N	**Mean**	**N**	**Mean**	
Preoperative	206	1.0 ± 0.8	91	1.2 ± 1.2	0.10
Month 12	150	0.9 ± 0.9	68	0.3 ± 0.3	<0.001
Month 24	106	0.9 ± 1.0	41	0.2 ± 0.3	<0.001
Δ Preop to 12 Months		-0.1 ± 1.1		-0.9 ± 1.2	<0.001
Δ Preop to 24 Months		-0.1 ± 1.2		-0.8 ± 0.7	<0.001

O479

Decompression and dynamic sagittal tether stabilization vs TLIF for degenerative spondylolisthesis: 24-month follow-up from an FDA IDE trial

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Introduction: Durable surgical outcome for patients with degenerative spondylolisthesis (DS) usually requires decompression and fusion. The addition of fusion increases the complexity of surgery and results in greater stress on adjacent levels with resultant increased incidence of adjacent segment degeneration. A novel dynamic sagittal tether is proposed for segmental stabilization after decompression for DS, as an alternative to fusion. An FDA IDE study (NCT03115983) compares direct surgical decompression and stabilization with the dynamic sagittal tether (treatment group; D+DST) to decompression and instrumented TLIF (control group; D+TLIF) for symptomatic DS.

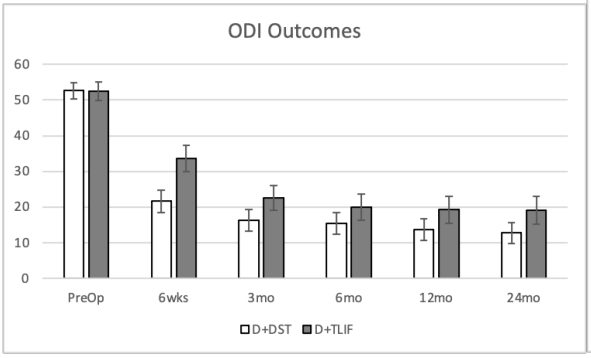
Aim: Compare clinical and radiographic outcomes of D+DST and D+TLIF at 24-months for symptomatic degenerative spondylolisthesis.

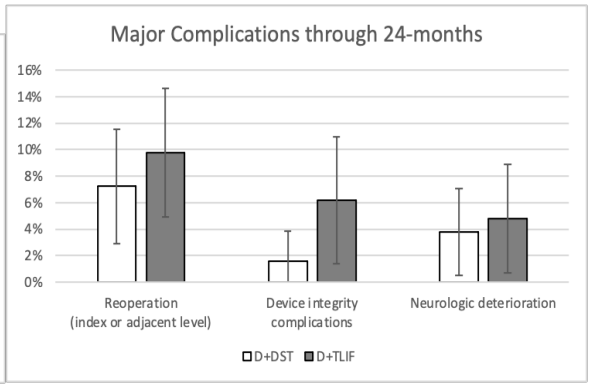
Patients and Methods: All patients had grade I DS and spinal canal stenosis with ODI≥35 and VAS-leg/hip≥50 (full eligibility criteria at clinicaltrials.gov, NCT03115983). Patients received either D+DST or D+TLIF at the level of DS, with or without an adjacent level decompression if indicated. Patient-reported outcomes were collected preoperatively and through 24-months follow-up. Perioperative outcomes were collected and reoperations at the index or adjacent level were tracked through 24-months. A propensity score (PS) model was used to select patients in balanced subgroups based on preoperative variables for comparison in this parallel-assignment, prospective clinical trial.

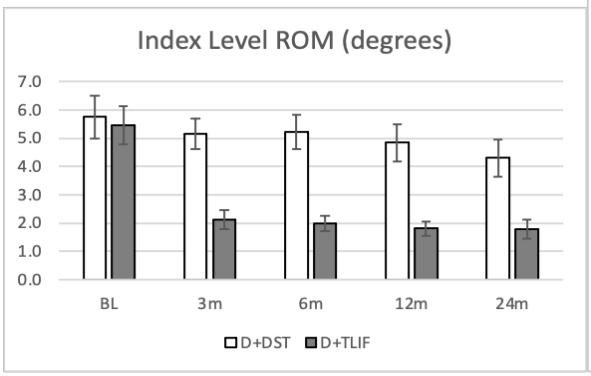
Results: 299 patients were enrolled in the IDE trial, and 287 patients were selected for matching in the propensity score (PS) model. PS-adjusted perioperative outcomes demonstrated no significant demographic differences between groups. In the D+DST group, surgery was 70.1±15.2 shorter, and resulted in 183±44 ml less blood loss and 2.3±0.4 days shorter hospital stay vs the D+TLIF group. Mean improvements at 24 months for the D+DST/D+TLIF groups were 40.0/32.9 ODI, 48.3/41.8 VAS back pain and 58.0/56.1 VAS leg/hip pain, with 91.2%/83.0% achieving 15-point ODI improvement. The D+DST group had significantly lower ODI at 6-weeks and 3-months. Reoperation rates through 24-monhts at the index or adjacent segments were 7.2%/9.8% for the D+DST/D+TLIF groups. At 24-months in the D+DST/D+TLIF groups, ROM was reduced 1.7°/3.7° and translation was reduced 0.4mm/1.0mm, while ROM was more evenly maintained across the index and adjacent levels in the D+DST group.

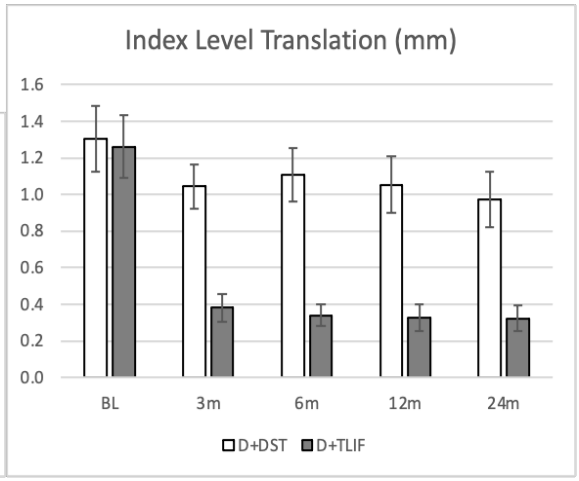
Conclusions: These results suggest that decompression with DST stabilization for degenerative spondylolisthesis can result in quicker but durable clinical improvement compared with fusion, without an increase in reoperations during the 24-month postoperative period. Similarly, statistically significant improvements in patient-reported outcomes were demonstrated in each group, with lower disability scores in the DST group at all postoperative timepoints. Imaging demonstrated no increased instability in the DST group with preserved baseline distribution of motion between the index and adjacent segments. While these groups were PS-selected with PS-adjusted differences, further analyses will include quantitative comparison between groups per the pre-defined composite clinical success criteria for a definitive clinical comparison of outcomes.

Acknowledgements: Empirical Spine (DST manufacturer) sponsored this research.


ODI Outcomes
60
50
40
30
20
10
0
PreOp
6wks
3mo
6mo
12mo
24mo
D+DST
D+TLIF


Major Complications through 24-months
16%
14%
12%
10%
8%
6%
4%
2%
0%
Reoperation (index or adjacent level)
Device integrity complications
Neurologic deterioration
D+DST
D+TLIF


Index Level ROM (degrees)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
BL
3m
6m
12m
24m
D+DST
D+TLIF


Index Level Translation (mm)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
BL
3m
6m
12m
24m
D+DST
D+TLIF

O480

Prospects of returning to work after lumbar spine surgery for patients considering disability pension: A nationwide study based on data from the Norwegian registry for spine surgery

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Aim: To assess if having applied for or planning to apply for disability pension (DP applicant) prior to being operated for degenerative disorders of the lumbar spine is an independent risk factor for not returning to work (non-RTW) one year after the treatment.
Patients and Methods: This population-based observational study from the Norwegian Registry for Spine surgery included 26688 cases operated for degenerative disorders of the lumbar spine from 2009 to 2020. The primary outcome was RTW (yes/no). Secondary patient-reported outcome measures (PROMs) were the Oswestry Disability Index, Numeric Rating Scales for back and leg pain, EuroQoL 5D, and the Global Perceived Effect Scale. Logistic regression analysis was used to investigate associations between being a DP-applicant prior to surgery (exposure) and possible confounders (modifiers) at baseline, and RTW 12 months after surgery (outcome).
Results: The RTW ratio for DP-applicants was 24.6%, compared with 79.6% among non-applicants, and all secondary PROMs were more favorable among non-applicants. After adjusting for all significant confounders (low expectations and pessimism related to working capability, not feeling wanted by the employer, and physically demanding work), DP-applicants with under 12 months preoperative sick leave had 3.4 (95% CI: 1.7-6.9) higher odds than non-applicants for non-RTW 12 months after surgery.
Conclusion: Being a DP-applicant was an independent risk factor for non-RTW 12 months after lumbar spine surgery. For those with a duration of preoperative sick leave of less than 12 months, the odds for RTW were 3.4 times reduced compared with non-applicants.

O481

Multi-centre randomised trial comparing the clinical outcome of trans-foraminal epidural steroid injection to surgical microdiscectomy for the treatment of radicular pain secondary to prolapsed intervertebral disc: NErve Root Block VErsus Surgery (NERVES)

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Introduction: Sciatica is a common condition affecting young, working age adults up to 5% of the population at any given moment. Treatment practices differ across regions and countries with surgical microdiscectomy being the perceived gold-standard management. Nerve root injections are often performed for this condition but their reported efficacy varies greatly throughout the literature.
Aim: We have conducted a multi-centre randomised trial comparing patients with sciatica caused by lumbar disc prolapse of less than 1 year duration treated by either trans-foraminal epidural steroid injection (TFESI) or surgical microdiscectomy.
Materials and Methods: A total of 163 participants (aged 16-65; 86 female, mean age 42 yrs) were recruited from 11 NHS out-patient clinics across the UK and randomised to either TFESI or surgery. Emergency cases of lower limb neurological deficit or threatened cauda equina syndrome were excluded. The study was powered to detect 10 points difference in primary outcome scores of Oswestry Disability Questionnaire (ODQ) at 18 weeks post randomization. Secondary outcomes were VAS leg, VAS back, Modified Roland Morris score for Sciatica (MRM), Likert satisfaction, Core Outcome Measures Index (back, COMI) and ODQ up to 12 months post randomization. Adverse events (AEs) and safety data were recorded. International Standard Randomised Controlled Trial Number ISRCTN04820368 and European Clinical Trials Database EudraCT number: 2014-002751-25
Results: There were no statistically significant differences between the improvements in ODQ at the primary outcome timepoint of 18 weeks although surgery resulted in a slightly greater reduction in ODQ (mean ODQ reduction 26.74 +/- 21.35 for surgery and 24.52 +/- 18.89 for TFESI). There were no significant differences between the two treatments up to 12 months follow up in VAS back/leg and COMI. MRM showed a significant difference with surgery offering a 2.7 points advantage over TFESI but less than the MCID for MRM (3). Likert satisfaction was 2 for surgery compared to 3 for TFESI. There were 4 serious AEs in the surgical group including one foot drop but none in the TFESI group.
Conclusion: This is the first study to report on TFESI vs surgery for sciatica. No significant difference was found between TFESI and surgery for the primary outcome, ODQ at 18 weeks follow up. TFESI is a safe and effective treatment for sciatica secondary to PID of less than 12 months duration.

Reference:

[1]Wilby MJ et al., Surgical microdiscectomy versus transforaminal epidural steroid injection in patients with sciatica secondary to herniated lumbar disc (NERVES): a phase 3, multicentre, open-label, randomised controlled trial and economic evaluation. *Lancet Rheumatol*. 2021; 3: e347-e356

O482

Minimally invasive versus open surgery in the treatment of lumbar spondylolisthesis: One-year results of a randomized, controlled trial

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Introduction: Symptomatic unstable lumbar spondylolisthesis, whether of spondylolytic or degenerative origin, is usually treated with fusion surgery when conservative strategy failed. However, standard open decompression and fusion is invasive surgery, involving a large skin incision, detachment of paraspinal musculature over a long segment, bony reduction and open placement of screws, rods and cages. Therefore, minimally invasive surgical techniques have been developed in recent decades. In theory, minimally invasive techniques may cause less tissue destruction, potentially resulting in decreased peroperative blood loss, quicker wound healing, decreased postoperative pain and earlier resumption of daily activities. In our randomized controlled trial, we compared the standard, open decompression and fusion procedure to minimally invasive fusion procedure in patients with symptomatic spondylolisthesis. The 1-year results will be presented.

Methods: 168 consecutive patients from 2 medical centers in the Netherlands with symptomatic spondylolytic or degenerative lumbar spondylolisthesis were randomized to treatment with mini-open decompression with bilateral interbody fusion and percutaneous pedicle screw fixation (MIS), or conventional open surgery with decompression and instrumented fusion with pedicle screws and bilateral interbody fusion (open). The visual analogue score (VAS) for low back pain at two weeks was the primary outcome measure. VAS for low back and leg pain were recorded at baseline and follow-up after 2 weeks, 6 weeks, 3 months, 6 months and 1 year. The Oswestry Disability Index (ODI) and EQ-5D clinical outcome scores were recorded at the same endpoints. Surgical variables, including blood loss, perioperative complications, length of hospital stay and reoperations were documented.

Results: 81 patients were randomized to the MIS group and 87 patients were randomized to standard open surgery. VAS scores for low back pain and leg pain did not statistically significantly differ between treatment groups at any time point during the 1 year follow-up. The VAS score for low back pain decreased from 60mm (MIS) vs 59mm (open) before surgery to 17mm (MIS) vs 19mm (open) at 1 year. The ODI and the EQ-5D did not significantly differ between groups at follow-up. Duration of surgery (1.49hrs [MIS] vs 1.44 [open]), volume of peroperative blood loss (300ml [MIS] vs 350ml [open]) and length of hospital stay (3 days [MIS] vs 2 days [open]) did not significantly differ between groups. However, more patients in the MIS group (n=6) had postoperative instrumentation related complications such as screw loosening or breakage, compared to the open surgery group (n=3).

Conclusion: Based on our results, there was no difference in outcome between MIS compared to open surgery in patients with spondylolytic or degenerative spondylolisthesis. The hypothetical advantage of reduced low back pain and better surgical outcome could not be confirmed. Therefore, the surgical strategy should be based on patients' and surgeons' preferences with both procedures leading to equivalent outcomes.

O483

Impact of diffuse idiopathic skeletal hyperostosis on surgical outcomes of posterior lumbar interbody fusion for lumbar spinal stenosis with spondylolisthesis

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Introduction: Previous studies have reported that diffuse idiopathic skeletal hyperostosis (DISH) is a risk factor for revision surgery following posterior spinal decompression for lumbar spinal stenosis (LSS) and suggested that the deterioration of spinal instability at the decompressed segment causes revision surgery. However, there have been few studies that investigated surgical outcomes of fusion surgery for LSS patients with DISH. The aim of this study was to evaluate the impact of DISH on surgical outcomes of posterior lumbar interbody fusion (PLIF) for LSS with spondylolisthesis.
Methods: We retrospectively reviewed a total of 324 consecutive patients who underwent 1- or 2-level PLIF for LSS with spondylolisthesis at our institution. Patients with failed back syndrome and/or follow-up <2 years were excluded. PLIF was recommended for LSS patients with anterior slippage of >15%, posterior opening of >5° during flexion, and/or lateral slippage of >3mm. DISH was diagnosed using preoperative standing whole-spine radiographs according to the Resnick criteria. Only vertebral segments with complete bridging of the disc space (Mata score grade 3) were defined as contiguous vertebral segments. We investigated demographic data, perioperative factors, preoperative and postoperative (at 2-year and final follow-up) visual analog scale (VAS) and Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ), and the rates of revision surgery at final follow-up and compared between the DISH (D) group and the non-DISH (N) group.
Results: A total of 129 patients (mean age: 66.0 years, mean follow-up period: 58.4 months) were included for analysis. Of the 129 patients, 33 (25.6%) patients with DISH and 96 patients without DISH were classified as the D group and the N group. Of the 33 patients in the D group, 13 patients (10.1%) had DISH extended to the lumbar segment. There were no statistical differences in age, past history, follow-up period, intraoperative blood loss, and number of fused segments between the 2 groups. In the D group, the proportion of males was significantly larger (D: 54.5%, N: 32.3%, P = 0.023), and intraoperative time was significantly longer (D: 172 min, N: 152 min, P = 0.021). All postoperative VAS scores at 2-year and final follow-up significantly improved compared with preoperative scores in both of the 2 groups, whereas postoperative VAS scores at 2-year and final follow-up were comparable between the 2 groups. Regarding JOABPEQ, the effective rate of all domains at 2-year follow-up showed no statistical differences between the 2 groups. Meanwhile, the effective rate in the walking ability domain at final follow-up was significantly lower in the D group than in the N group (D: 54.5%, N:78.9%, P = 0.007). The revision rate was higher in the D group, but not significant (D: 15.2%, N: 5.2%, P = 0.077).
Conclusions: The surgical outcomes of PLIF for LSS patients with DISH are favorable at 2-year follow-up, although poorer than non-DISH patients at final follow-up, particularly in terms of walking ability. Long-term follow-up is crucial to evaluate the surgical outcomes of fusion surgery for LSS patients with DISH.

O484

Transient Receptor Potential Vanilloid 4 (TRPV4) activation promotes autophagy and increases extracellular matrix synthesis through AMPK pathway in rat intervertebral disc cells

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Introduction: The intervertebral disc is the largest avascular, low nutrient organ in the human body. Autophagy is an important cell survival mechanism by self-digestion and recycling damaged components under stress conditions, primarily nutrient deprivation. Biologically, disc cells and their extracellular matrix are stimulated by physiological range of mechanical loading, and abnormal loading can result in disc degeneration. However, physicochemical factors and their mechanisms which maintain disc homeostasis have not been fully clarified. One possible mechanosensitive regulator in disc homeostasis is Transient Receptor Potential Vanilloid 4 (TRPV4). TRPV4 is a mechanosensitive Ca^{2+}-permeable channel activated by changes in osmotic and hydrostatic pressure. Since the intervertebral disc is exposed to high osmotic and hydrostatic pressure, we hypothesized that TRPV4 contributes to intradiscal homeostasis. Our objective was to elucidate that TRPV4 activation by agonist promotes autophagy and extracellular matrix synthesis in rat disc nucleus pulposus (NP) cells.

Methods: Disc NP cells harvested from 12-week-old male Sprague-Dawley rats were used. (1) Cytotoxicity of rat disc NP cells was evaluated using the Cell Counting Kit-8 (CCK-8) after 24-h treatment of 0–100-nM TRPV4 agonist (Sigma-Aldrich, GSK1016790A) in DMEM with 10% FBS. (2) Ca^{2+} imaging was performed using Fluo-4 AM (Dojindo, #273221-67-3) to detect intracellular Ca^{2+} changes. Ca^{2+} response was measured using a microplate reader (PerkinElmer, EnSpire). (3) To simulate clinically relevant disease conditions, cells were cultured for 24-h in DMEM with 0% FBS or with 0% FBS and 10-ng/ml interleukin-1 beta (IL-1β), a pro-inflammatory cytokine linked to the pathogenesis and severity of disc degeneration. Then, expression of AMPK, autophagy markers (mTOR, RAPTOR, p70/S6K, LC3-II, and a substrate p62/SQSTM1), extracellular matrix molecules (COL2a1 and Aggrecan), catabolic matrix metalloproteinases (MMPs) and tissue inhibitor of metalloproteinases (TIMPs) were assessed by Western blotting. The α-tubulin was used as a loading control. The intensities of the bands were quantified using ImageJ software. Apoptosis was also assessed by TUNEL staining. The P-values of < 0.05 were regarded as statistically significant.

Results: (1) TRPV4 agonist significantly decreased cell viability at 20-nM or higher ($P < 0.05$). Therefore, 10-nM TRPV4 agonist was used for subsequent study. (2) Intracellular Ca^{2+} level increased immediately after the administration of TRPV4 agonist. (3) AMPK expression significantly increased by TRPV4 agonist in DMEM with 0% FBS ($P < 0.05$). In DMEM with 0% FBS and IL-1β, TRPV4 agonist increased AMPK, LC3-II, COL2a1, Aggrecan, and TIMPs, and decreased mTOR, RAPTOR, p70/S6K, p62/SQSTM1, and MMPs ($P < 0.05$), indicating the promotion of autophagy and extracellular matrix synthesis. Lower proportion of TUNEL positive cells was shown in IL-1β stimulation with agonist treatment relative to the control ($P < 0.05$).

Discussion: In rat disc NP cells, TRPV4 activation by agonist promoted autophagy and increased extracellular matrix synthesis through AMPK pathway. The TRPV4 could be a therapeutic target for intervertebral disc diseases via modulating autophagy.

O485

Activation of Nrf2 signaling by 4-octyl itaconate attenuates the cartilaginous endplate degeneration by inhibiting E3 ubiquitin ligase ZNF598

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Introduction: Cartilaginous endplate (CEP) degeneration is the main early manifestations of intervertebral disc degeneration (IVDD), and is closely related to the oxidative stress. Nrf2 (nuclear factor E2-related factor 2, NFE2L2) is a vital transcriptional factor of cellular antioxidant and anti-inflammatory responses, and accumulation of Nrf2 may be beneficial in many diseases. However, it is still unknown whether the high expression of Nrf2 attenuate the IVDD.
Methods: Firstly, we detected the expression of Nrf2 in human degenerative CEPs. Then, we performed in vitro, ex vivo and in vivo (a rat-tail puncture model) experiments to explore the role of 4OI in IVDD. Also, by cell co-culture experiments, we demonstrated 4OI restrained the macrophage-associated inflammatory responses. Finally, through western blotting and IP assay, we clarified the ZNF598-mediated ubiquitination of Nrf2.
Results: We found decreased expression of Nrf2 in human degenerative CEPs. Using a rat IVDD model, 4OI) significantly ameliorated the progression of IVDD by MR images and histological analysis. Immunofluorescence results reveal that catabolism of CEPs and macrophage-associated inflammation are suppressed by 4OI treatment. Mechanistically, the 4OI increases Nrf2 expression and inhibits the secretion of inflammatory factors (IL-1β) by LPS-induced macrophages, thus preventing the inflammatory-related CEP degeneration. Meanwhile, 4OI suppresses the ROS production and catabolism of LPS-induced rat CEP cells. In addition, 4OI inhibits the ZNF598-dependent ubiquitination of Nrf2 in LPS-induced rat CEP cells.
Discussion: In the past couple of decades, many advances have been made in the treatment of IVDD, including pharmaceutical agents, tissue engineering, growth factors, and cell therapy, but limitations to the treatment of IVDD still exist and the further alternative treatments are urgently needed. Recently, some compounds have been shown to prevent the progression of IVDD; however, they do not present the inhibition of pro-inflammation. Due to these issues, new therapeutic approaches should include the inhibition of both IVDD and pro-inflammation. Although 4OI was known to have the anti-inflammatory properties, it remains unknown whether 4OI plays a protective role in progression of IVDD. Our study characterized the lower Nrf2 expression in human CEPs and showed a preliminary investigation of 4OI which attenuates the IVDD by regulating the balance between anabolism and catabolism, and activates the antioxidant and anti-inflammatory response in LPS-induced rat CEP cells, ex vivo discs, and in vivo IVDD model. We demonstrated that administration of 4OI could be a potential therapy for IVDD.

O486

Comparative metagenomics of intervertebral disc nucleus pulposus and endplate provide insights into the genesis of the disc microbiome

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Introduction: There is increasing evidence for subclinical infection by fastidious, low, growing bacteria to be a cause of disc degeneration. Although the presence of bacteria in the Nucleus pulposus has been reported well in literature, the source of bacteria is not clearly proven as the disc is avascular in healthy condition. Documentation of similar bacterial populations in the EP and NP may add proof that bacterial inoculation of NP occurs via the Endplate.
Materials and Methods: Sixteen NP and 16 EP tissues were excised from brain-dead voluntary organ donors with no history of back pain and 20 diseased discs collected from patients undergoing microdiscectomy/ fusion surgery were used for profiling microflora through 16S rRNA amplicon sequencing using primers specific for V1-V9 hypervariable regions. Changes in the bacterial diversity and abundance were analyzed to Identify the key microbial populations that are significantly altered in DD.
Results: NP and EP shared a similar spectrum of microbiome but with varying abundance. The five dominant phyla identified were Proteobacteria, Firmicutes, Actinobacteria, OD1, and Bacteroidetes. Proteobacteria was found to be the most abundant phyla in both NP (62%) and EP (53%) of the normal IVD. This was followed by Firmicutes (16%), Actinobacteriota (11%), OD1 (Parcubacteria) (7.6%), and Bacteroidetes (2%) in NP and Firmicutes (23.4%, OD1 (Parcubacteria) (17.6%), Actinobacteriota (2.8%), and Bacteroidetes (2.6%) in EP respectively. Under diseased conditions, Proteobacteria (68%) was dominant when compared with other phyla. However, there was no significant difference in the abundance of Proteobacteria between the normal and diseased discs. Interestingly, the other dominant phyla such as Firmicutes (Normal-NP: 16.2%; Diseased-NP: 4.02%) and Actinobacteria (Normal-NP: 11%; Diseased-NP: 0.99%) showed a significant reduction in degenerated discs. To understand the key microbial populations that are significantly altered during disease, correlation analysis was performed among the three phyla, which revealed a negative correlation in the ratio of Actinobacteria + Firmicutes vs. Proteobacteria ($p = 0.001$) in DD.
Conclusion: Results of our study clearly demonstrated a similar bacterial diversity but with varying abundance between the EP and NP, suggesting that the endplate could indeed be the gateway for the entry of the microbiome into the nucleus pulposus.

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O487

Is there an association between patient and practitioner characteristics and the selection of therapeutic interventions in a chiropractic clinical encounter? Secondary analysis of the COAST and O-COAST study data

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Introduction: Chiropractors use a variety of therapeutic interventions in clinical practice, including joint manipulation/mobilisation, soft tissue therapies, advice, and exercise prescription. Different patient and practitioner characteristics (e.g., patient age, practitioner experience) are likely to impact the choice of therapeutic interventions; however, it is currently unclear in what way this occurs.
Aim: To describe the frequency of use of different therapeutic interventions for musculoskeletal conditions in patients presenting for chiropractic care and to determine the association between patient and practitioner characteristics and intervention selection.
Materials and Methods: Data were obtained from the Chiropractic Observation and Analysis STudy (COAST) and the Ontario Chiropractic Observation and Analysis Study (O-COAST), practice-based, cross-sectional cohorts based in Victoria, Australia (2010-2012) and Ontario, Canada (2014-2015). Chiropractors recorded data from 100 consecutive patient visits, including up to three individual diagnoses (diagnostic encounters) per visit and the therapeutic interventions used. Diagnoses were categorised by musculoskeletal region (Back, Neck, Head/Jaw, Extremity). Therapeutic interventions were categorised as: high-velocity, low-amplitude (HVLA) joint manipulation; joint mobilisation; other chiropractic techniques (e.g., mechanical/instrument-assisted manipulation, flexion-distraction); soft tissue therapies; education/advice; exercise prescription; and ancillary therapies (e.g. acupuncture, taping). Therapeutic interventions selected for each diagnostic category were analysed descriptively. Logistic mixed models (practitioner as the grouping factor) were used to assess the association between intervention usage and patient/practitioner variables across all diagnostic encounters.
Results: Ninety-four chiropractors collected data on 7,987 patient visits, including 10,731 diagnostic encounters (mean age: 43.7, SD: 20.7; 57.8% female). Most chiropractors had >5 years of experience (87.2%) and were male (69.4%). HVLA joint manipulation was the most common intervention selected across all diagnostic categories (range: 67.0%, 95%CI: 65.8-68.1 to 72.4%, 95%CI: 67.0-77.2) except for extremity problems (37.1%, 95%CI: 34.1-40.1), where soft tissue therapies (64.9%, 95%CI: 61.8-67.8) and ancillary treatment (47.8%, 95%CI: 44.7-50.9) were more common. Across all diagnostic categories, HVLA joint manipulation was less likely to be performed if the patient was female (OR: 0.8, 95%CI: 0.7-0.9), older age (OR: 0.7, 95%CI: 0.7-0.8), new to the clinic (OR: 0.8, 95%CI: 0.6-1.0), had a new complaint (OR: 0.8, 95%CI: 0.7-0.9), had one or more comorbidities (OR: 0.8, 95%CI: 0.7-0.9), or was underweight (BMI<18.5; OR: 0.8, 95%CI: 0.7-0.9) or obese (BMI>30; OR: 0.4, 95%CI: 0.3-0.5). Conversely, mobilisations, advice/education, other chiropractic techniques, and ancillary care were more likely to be used. Exercise prescription was more common among patients new to the clinic (OR: 1.6, 95%CI: 1.2-2.1) or presenting with a new complaint (OR: 1.4, 95%CI: 1.2-1.7), and less likely among underweight (OR: 0.6, 95%CI: 0.4-0.9) or obese (OR: 0.7, 95%CI: 0.6-0.9) patients. Chiropractors with >5 years clinical experience were less likely to provide advice/education (OR: 0.4, 95%CI: 0.1-0.8) and exercises (OR: 0.2, 95%CI: 0.1-0.5).
Conclusion: In more than 10,000 diagnostic encounters with chiropractors, HVLA joint manipulation was the most common therapeutic intervention for spine-related problems, whereas soft tissue therapies were more common for extremity problems. Several patient and practitioner characteristics were associated with intervention selection. These data may be used to support further research on appropriate selection of therapeutic interventions for common musculoskeletal complaints.

O488

Satisfaction and expectations of chiropractic care in patients with lumbar radiculopathy: A mixed methods study

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Introduction: In Denmark, chiropractors offer patients with lumbar radiculopathy treatment in a standardised care package under the collective agreement with the Danish Health Authorities. The care packages describe a management structure and logistics of patient care including time-fixed follow-up sessions. Chiropractic patients generally report high levels of satisfaction with received care, but it is unclear if this applies to the standardised care programs too. This study aimed to investigate patient satisfaction and explore patient perspectives on the standardised chiropractic care packages for lumbar radiculopathy.
Methods: This was an explanatory sequential mixed methods design with two separate phases. Phase one was a quantitative analysis based on a survey in a prospective cohort of patients with lumbar radiculopathy in a standardised chiropractic care package. Patients rated their satisfaction with the examination, information, treatment effect, and overall management of their problem on a scale from 0-10. In phase two, six semi-structured interviews were used to gain further explanatory insights into the findings from phase one. Data were analysed using systematic text condensation. The quantitative and qualitative data were merged in a narrative joint display to obtain a deeper understanding of the overall results.
Results: A total of 238 patients responded to the survey. The mean age of the respondents was 47 years (SD 14), and 52% were female. 80-90% were very satisfied (≥8) when asked about satisfaction with the examination, information, and overall management, whereas about 50% were very satisfied with the treatment effect.
The age range of the interviewees was 26 to 55 years, and three were women. The qualitative analysis led to the emergence of four themes: 'Understanding the standardised care packages', 'Expectations of consultation and treatment effect', 'Information about diagnosis and prognosis', and 'Interdisciplinary collaboration'. The joint display analysis showed that high patient satisfaction with the examination could be explained by the patients feeling carefully and thoroughly examined by the chiropractor and by referrals to MRI. This provided patients with confidence and certainty about the diagnosis. If the examination was rushed or did not meet the patients' expectations of referrals for imaging, satisfaction was low. Patient education and information on variations in symptoms and the expected prognosis were considered reassuring, but patients were less satisfied if the information did not match their understanding of the disease. For example, when information about staying active was given, and this did not fit with the patient's beliefs, it led to patient concerns and distrust in the chiropractor. Satisfaction with the chiropractor's coordination of care and referral to other healthcare professionals was explained by the patients' positive experiences of coordinated care and reduced responsibility on their shoulders.
Conclusions: Overall, patients were satisfied with the standardised chiropractic care packages for lumbar radiculopathy. From a patient's perspective, the consultation should include a thorough examination, focus on communication and information related to symptoms and prognosis, and expectations on treatment content and efficacy should be addressed and aligned. Finally, chiropractors should coordinate interdisciplinary collaboration.

Acknowledgements: This study was funded by the Danish Foundation for Chiropractic Research and Post Graduate Education.

O489

Predictors of disability in older adults with LBP: Findings from the BACE:C-A study

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Introduction: Low back pain (LBP) is older adults is common, with a prevalence rate of 24-27%. Of patients who present to a chiropractor, 12% are aged >65years. There is limited data on the clinical course of LBP in older adults who visit a chiropractor and exploring disability in these patients is also vital to improve knowledge on the impact of LBP on activities of daily living in the elderly.
Aim: To report the baseline cohort profile from the BACE:C – Australia study; to describe the course of disability over a 12 month period; and to identify predictive factors of disability.
Methods: A 12-month, prospective longitudinal cohort study. Inclusion criteria was a 'new' episode of LBP, in community dwelling older Australians who sought care from a chiropractor. The primary outcome variable was low-back pain specific disability, as measured by the Roland Morris Disability Questionnaire (RMDQ). Questions were asked about sociodemographic factors, lifestyle characteristics, health, pain, functional status, cognition and quality of life at baseline and at follow up (12 months). Descriptive statistics report the cohort profile, and paired samples t-test used to compare RMDQ scores at baseline and 12-month follow-up. Inferential analysis determined predictors of disabling LBP in older adults, with sociodemographic, health and lifestyle factors used as independent variables.
Results: 219 chiropractic patients were enrolled into the study, with 48.8% (n = 105) female and a mean age of 67.35 (SD = 7.82) years. 14.7% (n = 32) reported LBP for the first time, and 65.1% (n = 140) described pain that extended into the lower limb. At baseline, mean numerical ratings scales for average LBP in the last week at baseline was 5.67 (SD= 2.39) and mean RMDQ score was 6.65 (SD = 5.35). The highest proportion for Oswestry Disability Index scores was moderate disability (48%). At 12 months, data was analysed for 154 participants (response 70.3%). There was a significant difference in scores for baseline RMDQ and 12 month RMDQ (M = 4.45, SD = 5.20), t(134) = 5.19, < 0.001.. Baseline variables significantly predicting RMDQ disability scores at 12 month follow-up were EQ-5D-3L (p = 0.002), number of comorbidities (p < 0.001), past complaints (p = 0.020), lower limb pain (p = 0.021), average pain in the last week (p = 0.020), pain right now (p=.044), pain intensity
(p = 0.012), and STaRT Back scores (p = 0.002). Significant results remained after controlling for age, gender, marital status, and education level for EQ-5D-3L (p < 0.001), number of comorbidities (p < 0.001), lower limb pain (p = 0.0156), average pain in the last week (p = 0.041), pain intensity (p = 0.012), and STaRT Back scores (p = 0.002).
Conclusions: At baseline, more than 90% of older adults with LBP had a past history of LBP, disability levels were high and lower limb pain was common. Ongoing disability at 12 months was predicted by LBP, quality of life and health conditions.

O490

The use of diagnostic imaging in the management of older adults presenting for chiropractic care for low back pain in Australia. Analysis of data from the BAck Complaints in Elders: Chiropractic - Australia (BACE:C-A) cohort study

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Introduction: Diagnostic imaging is commonly used in the management of low back pain (LBP), with approximately one-quarter of people presenting to primary care with LBP referred for imaging. Imaging is recommended to rule out underlying serious pathology (e.g., tumour, infection, fracture), or when surgical management (e.g., for spinal stenosis) is being considered, conditions that may present more commonly in older adults (>55 years). Current estimates of imaging frequency commonly exclude older adult populations, and it is unclear how frequently older adults are referred for imaging for LBP.
Aim: To determine the frequency and type of diagnostic imaging use in older adults presenting for chiropractic care for LBP in Australia. The secondary aim was to describe the related radiographic findings.
Materials and Methods: Data was collected from the BAck Complaints in Elders: Chiropractic-Australia (BACE:C-A) study, a prospective cohort including people aged 55 or older presenting for chiropractic care for a new episode of LBP. Self-reported use of imaging (X-ray, CT, MRI, bone scan) was collected from participants at baseline, 2-week, 6-week, 3-month, 6-month, 9-month, and 12-month surveys. Frequency of imaging use was reported descriptively by imaging modality. Imaging reports were requested from participants who reported receiving imaging at any time point. Imaging report data was independently extracted by two of the research team and categorised for imaging findings.
Results: The BACE:C-A cohort consisted of 227 participants (48% female; mean age 67.3 years, SD 7.8, range 55-86 years). Diagnostic imaging was performed at least once across the 12-month study period in 56.4% (95%CI: 49.9, 62.7) of participants, with 25.1% (95%CI: 19.9, 31.1) receiving imaging for the current episode of LBP prior to completing the baseline survey. X-ray was most commonly performed (48.2%, 95%CI: 42.5, 54.0), followed by CT (23.8%, 95%CI: 19.2, 29.1) and MRI (13.5%, 95%CI: 10.0, 18.0). Imaging reports were obtained for 71 participants, including 31 X-rays, 23 CT, 15 MRI, and two bone scans. Degenerative changes were present in 51 participants (71.8%, 95%CI: 60.5, 81.0), with combined disc and facet joint degeneration in 38 participants (53.5%, 95%CI: 42.0, 64.6). Eight participants (11.3%, 95%CI: 5.8, 20.7) had compression of the vertebral bodies, with seven associated with old trauma or osteoporosis and one associated with new underlying pathology (myeloma/metastasis). Tumours/cysts were present in six participants (8.5%, 95%CI: 3.9, 17.2), including haemangioma (3/6), Tarlov's cyst (2/6), and myeloma/metastasis (1/6). All participants who received CT or MRI (n=38) had evidence of disc bulge/herniation, and 32 of these (84.2%, 95%CI: 69.6, 92.6) had central and/or lateral recess stenosis.
Conclusion: Within older adults presenting for chiropractic care for LBP approximately 25% are initially referred for diagnostic imaging, a similar proportion to that seen in the general adult population. However, over the course of a year over half of participants received at least one type of imaging. Degenerative changes were the most common finding; however, approximately one in five reports demonstrated vertebral compression, indicating possible osteoporosis, or other pathology of importance to identify in chiropractic clinical practice.

O491

The association between stressful life events and low back pain in older men: The osteoporotic fractures in men study

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Introduction: Stressful life events (SLE), such as loss of a partner or serious accident are more common with increasing age. Within a biopsychosocial framework, SLE may impact the experience of low back pain (LBP). The aim of the current study was to determine the prospective association between SLE and LBP among participants of the Osteoporotic Fracture in Men Study, a longitudinal cohort of older men aged ≥ 65 years. Further, we sought to determine the moderating role of several measures of social integration on this relationship.

Methods: 5,152 participants had self-reported data on SLE for 12 months prior to the year 5 visit. Self-reported LBP was ascertained from triannual postcards for 12 months after the year 5 visit. From these postcards, participants were categorized as having no LBP, any LBP (reported on at least 1 postcard), and persistent LBP (reported on all 3 postcards). Separate age adjusted logistic regression analyses estimated the likelihood of reporting any or persistent LBP with SLE vs. the reference group of no LBP. Moderation of these associations by several measures of social integration (living condition, social engagement, and social network) were formally tested via statistical interaction tests.

Results: 2,930 (57%) participants reported at least 1 SLE at Visit 5. Age-adjusted logistic regression models identified statistically significant and positive relationships between the number of SLE and postcard reporting of any LBP (OR = 1.26 [95% CI = 1.19 – 1.34] and persistent LBP (OR = 1.32 [95% CI = 1.23 – 1.43]). In the subset of men with no LBP in the 12 months before Visit 5, any SLE was associated with increased odds in the next 12 months of both any incident LBP (OR = 1.20 [95% CI = 1.05 – 1.36]) and persistent incident LBP (OR = 1.87 [95% CI = 1.45 – 2.37]). Statistically significant and positive moderation of the association between SLE and LBP was identified in participants who reported living with a spouse at Visit 5; any LBP (p =.02) and persistent LBP (p =.04). All other interaction tests by measures of social integration were statistically non-significant.

Conclusions: In this cohort of older men, the presence of SLE increased the likelihood of prospective reporting LBP. Further, this relationship was strengthened when participants reported living with a spouse, indicating a complex relationship between psychological stressors, living arrangement, and the experience of LBP.

Funding: The Osteoporotic Fractures in Men (MrOS) Study is supported by National Institutes of Health funding. The following institutes provide support: the National Institute on Aging (NIA), the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), the National Center for Advancing Translational Sciences (NCATS), and NIH Roadmap for Medical Research under the following grant numbers: U01 AG027810, U01 AG042124, U01 AG042139, U01 AG042140, U01 AG042143, U01 AG042145, U01 AG042168, U01 AR066160, R01 AG066671, and UL1 TR000128

O492

Trends of low back pain research in older and working-age adults from 1970 to 2022: A bibliometric analysis

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Introduction: Low back pain (LBP) is a leading contributor to disability burden globally. Although research activities focusing on working-age adults with LBP (LBP-W) has been growing, there is no overview of the trends/focuses of these activities. Given the aging population, it is also important to understand whether sufficient studies have investigated the health needs of older adults with LBP (LBP-O). Therefore, we conducted a bibliometric analysis to uncover changes in publication patterns and research trends among LBP-O and LBP-W over the last 52 years to help guide research priorities and foster collaborations among researchers.

Methods: Peer-reviewed LBP-O and LBP-W articles published between 1970 and 2022 were identified and retrieved from Web of Science. Only original articles/reviews were included, without language restrictions. Patterns of annual publication volume as well as prominent authors, journals, institutions, countries, and disciplines were identified by Web of Science. VOSviewer software was used to depict author collaboration networks and detect common keywords. CiteSpace software was used to identify the emerging trends based on the latest burst keywords with a dramatic increase in co-occurrence frequency.

Results: A total of 3,934 LBP-O-related and 50,210 LBP-W-related articles were included in the analysis. There were strong correlations between the annual publication volumes and the years for both LBP-O and LBP-W (R^2=0.85 to 0.90, p<0.05). Compared to the annual publication volume in 1970, the annual numbers of LBP-O-related and LBP-W-related articles increased by 18,150.0% and 16,683.3% over the last 52 years, respectively. The United States has the highest number of prominent researchers and institutions that published relevant articles in both populations, followed by China and the United Kingdom. The journal *Spine* published the highest number of relevant articles for LBP-O and LBP-W combined, followed by *Pain Medicine* for LBP-O and *European Spine Journal* for LBP-W. Articles in both populations fell into the Neurosciences & Neurology and Orthopedics disciplines. The common keywords for LBP-O were related to surgery and medications, whereas those for LBP-W were associated with exercise or physical rehabilitation. We identified an emerging trend of increasing rates of physical activity-related research in LBP-O, and of surgery and intervertebral disc degeneration in LBP-W publications. Prominent researchers in the LBP-O and LBP-W fields seldom collaborated.

Conclusions: This is the first bibliometric analysis to systematically analyse the publication patterns and research trends in LBP-O and LBP-W over the last five decades. The discrepancy in the publication volume between LBP-O and LBP-W highlights the insufficient research attention/resources to LBP-O in the past. The shift in the research trend in LBP-O from surgery and drugs to physical activity suggests the recognition of the importance of physical activity in managing LBP among older adults. Conversely, the growing emphasis on spine surgery and intervertebral disc degeneration in LBP-W research may highlight that intervertebral disc problems remain a common focus among LBP-W. Because the research trends in both populations are dynamic and may affect each other, it is essential to strengthen the collaborations among researchers in both fields to optimize evaluation and management of LBP across the lifespan.

O493

Pain trajectories in patients with lumbar spinal stenosis

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Introduction: Lumbar spinal stenosis (LSS) is considered a degenerative chronic condition and is the primary reason for spine surgery in older adults. However, little is known about the course of symptoms in non-surgically treated patients. This study aimed to investigate trajectories of symptom occurrence and severity in chiropractic patients with LSS.
Methods: This prospective cohort study included patients who were diagnosed with LSS and enrolled in a standardised care program for LSS in a chiropractic clinic. Patients who were included in the project filled out a questionnaire at baseline and one-year follow-up. In addition, patients received up to three weekly text messages over a year with questions about the number of days the last week with low back pain (LBP) or leg symptoms (0-7 days), and the intensity on a 0 (none) to 10 (worst possible) scale. Patients were excluded from the analysis if they had answered less than 20 text messages for a year. Latent Class Growth Analysis was performed and presented graphically, and the emerging trajectory groups were compared on age, sex, LBP and leg pain intensity (0-10), and functional disability measured with Oswestry Disability Index (ODI) (0-100).
Results: Of the 127 included patients 90 (71%) answered ≥20 text messages for one year. The mean age was 70 years (SD 8.7), the age ranged from 47 to 89 years, and 58% were female. The mean LBP intensity was 5.6 (SD 2.5), leg pain was 5.1 (SD 2.8) and ODI was 30 (SD 13.7).
A three-group trajectory model was chosen as the most clinically meaningful: “Improving” (16%), “Fluctuating” (30%), and “Persistent” (54%). (Figure 1)
The proportion of women was 29% (95% CI 11%-56%), 48% (95% CI 30%-67%), and 71% (95% CI 57%-82%) in the “Improving”, “Fluctuating” and “Persistent” groups respectively. ODI was higher at baseline in the “Persistent” group (34.2 (95% CI 29.7-38.8)) compared to the “Fluctuating” 26.0 (95% CI 22.1-29.8) and “Improving” 22.8 (95% CI 16.4-29.1) groups. This was more pronounced at one-year follow-up (ODI 28.1 (95% CI 23.2-33.0) in “Persistent”; 15.2 (95% CI 9.1-21.3) in “Fluctuating”; 4.8 (95% CI 0.1-9.4) in “Improving”). Similarly, pain intensity at follow-up was highest in “Persistent” (LBP 4.6 (95% CI 3.7-5.6); leg pain 4.3 (95% CI 3.4-5.3)) as compared to “Fluctuating” (LBP 2.3 (95% CI 1.5-3.1); leg pain 1.6 (95% CI 0.9-2.3)) and “Improving” (LBP 0.4 (95% CI 0.03-0.8); leg pain 0.6 (95% CI -0.3-1.5)).
Conclusions: Patients with LSS were classified into three groups with different trajectories over one year. Half of the patients had severe symptoms that did not seem to change, whereas the other half either improved rapidly or had fluctuating symptoms. The results need to be interpreted cautiously as the sample was very small. However, the results show that patients have considerably different symptom trajectories over time and that the frequent misconception that LSS unavoidably worsens over time can not be supported.

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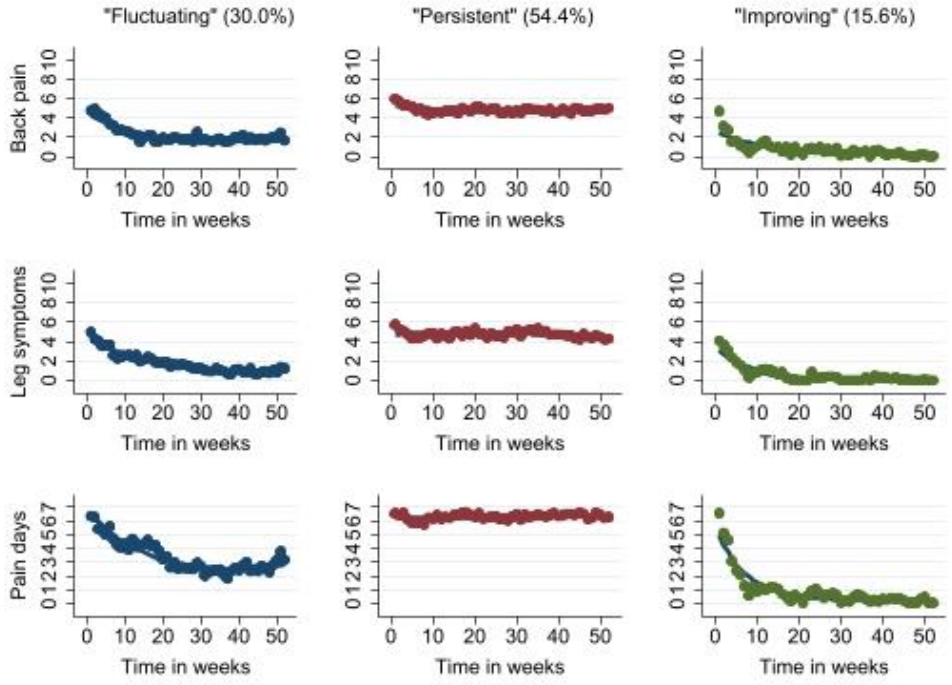
Figure 1 Trajectories for low back pain, leg symptoms, and pain days by group



O494

A comparison of two forward head posture corrective approaches in elderly with chronic non-specific neck pain: A randomized controlled study

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Introduction: Forward head posture (FHP) is a common postural displacement significantly that is significantly associated neck pain, with higher risks of having neck pain in female and older populations. This study investigated the effect of two different forward head posture (FHP) interventions in elderly participants with poor posture and non-specific neck pain.
Methods: Approval was obtained from a University *Ethics Committee* (REC-18-02-27-02-S). A consent form was signed by participants. The study was registered at ClinicalTrials.gov with registration number: NCT05533853. Sixty-six eldery participants with a cervicovertebral angle (CVA) < 50° were randomized into either a Chiropractic Biophyics® (CBP®) or traditional exercise group. The CBP group received a mirror image® exercise specifically designed to improve FHP and a Denneroll™ cervical traction orthotic to stretch the soft tissues of the cervical spine. **Figure 1**. The traditional exercise group performed a protocol of commonly used stretching and strengthening exercises for the neck. Both groups were treated for 18 sessions over a 6-week period. A 3-month follow-up was assessed. The primary outcome was the CVA; with secondary outcomes including: pain intensity, Berg balance score (BBS), head repositioning accuracy (HRA), and cervical range of motion (CROM). The results were examined through a 2-way analysis of covariance. Group and time were used as a single independent factor and group × time as an interaction factor. The level of significance used for the study was set at $\alpha = 0.05$. Pearson correlation coefficient (r) was used to investigate the correlation between FHP and all outcome variables. To impute any missing values for both groups, multiple regression models were constructed including the potentially related variables of missing data correlated with that outcome.
Results: At 6-weeks post-treatment the CBP group had significant improvement in CVA whereas the traditional exercise group did not. Both groups showed improved BBS, HRA and pain intensity; the CBP group also showed improvement in all other outcomes. At the 3-month follow-up, there was statistically significant differences favouring the CBP group for all outcomes. Also, the improved outcomes were maintained in the CBP group while the traditional exercise group experienced regression of the initially improved outcomes. All measured variable change scores in both groups were moderately to strongly negatively correlated (pain intensity and HRA left and right) and positively correlated (all other variables) to the amount of change in the CVA indicating that as FHP decreased, the various outcome variables were found to be improved. Specially, a negative correlation between CVA and pain and HRA indicates that as CVA increases (FHP decreases) pain intensity and HRA decrease. See **Table 1**.
Conclusions: It is suggested that the improvement in the postural CVA (in the CBP group, but not in the traditional exercise group) is the driver of superior and maintained pain and functional outcomes at final follow-up. Therefore, clinical treatments that are known to improve forward head posture should be added to the clinical armamentarium for the rehabilitation of seniors with chronic neck pain and FHP.
Acknowledgements: Support or funding was provided by CBP NonProfit, Inc. (Eagle, ID, USA) for airfare and hotel at accommodation at the conference.

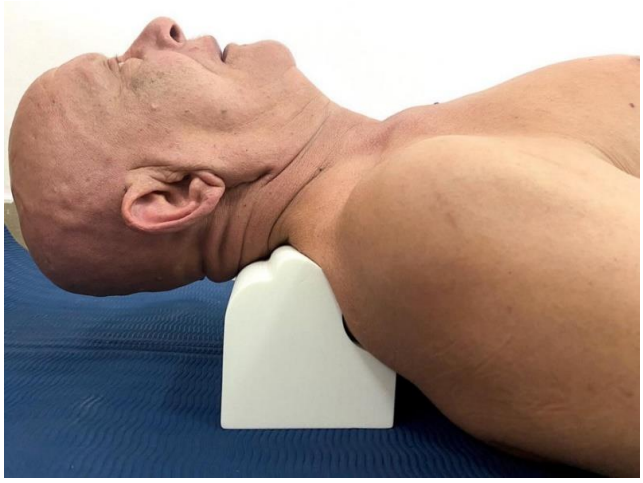

Figure 1. Cervical Denneroll™ traction orthotic device.

Table 1. Correlations (Pearson's *r*) between the amount of change in CVA angle and the amount of change of all measured outcomes (3- month follow up scores -initial scores).

Correlation between variables	**∆ CVA CBP group r (p value) n = 33**	**∆ CVA Traditional Exercise group r (p value) n = 33**
∆Pain intensity	-0.7 (< 0.001)	-0.67 (< 0.001)
∆Berg Balance Score	0.64 (< 0.001)	0.49 (< 0.001)
∆ *Head repositioning accuracy (Right)*	-0.69 (< 0.001)	-0.71 (< 0.001)
∆ *Head repositioning accuracy (Left)*	-0.72 (< 0.001)	-0.72 (< 0.001)
∆ CROM lateral flexion Right	0.49 (< 0.001)	0.61 (< 0.001)
∆ CROM lateral flexion Left	.57 (< 0.001)	.52 (< 0.001)
∆ *CROM rotation right*	0.49 (< 0.001)	0.61 (< 0.001)
∆ *CROM rotation left*	.57 (< 0.001)	.52 (< 0.001)

CVA= Craniovertebral angle; ∆ = change.

O495

Is there an association between diabetes and neck and back pain? An updated systematic review with meta-analyses

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Introduction: Spinal pain, disorders, and spinal pathologies are increasingly common in society and represent a major burden on our population and health system. In their lifetime almost 80% of Australians have experienced low back pain, and 47% have experienced neck pain. In 2017, a meta-analysis of 11 observational studies reported people with diabetes were 1.35 times more likely to report low back pain and 1.24 times more likely to report neck pain (95% C.I 1.20 to 1.52 and 1.05 to 1.47, respectively), compared to those without diabetes. Since 2017, there has been a significant amount of research into the association between diabetes and spinal pain and therefore an update of the systematic review and meta-analysis is warranted.
Aim: To systematically review and appraise the updated literature to explore the magnitude as well as the nature of the association between diabetes and back, neck, or spinal (back and neck) pain.
Methods: Searches were undertaken within four electronic databases: PUBMED, Medline, CINAHL and EMBASE. Studies which assessed the association between diabetes and back or neck pain outcomes, in participants older than 18 years of age were included. Two independent reviewers extracted data on the incidence of pain and reported associations. Meta-analyses will be performed to assess the associations between predictor groups (i.e. participants with diabetes and participants without diabetes) and outcomes of interest (i.e. back or neck pain), using a random effects model.
Results: Database searches identified 4483 studies. 1220 removed as duplicates and 3204 excluded at title and abstract and 39 at full text screening. In total, 20 studies were included, which come from 12 countries and includes 829,685 participants. All studies had data on LBP, with the estimated prevalence of LBP in people with diabetes between 6-60%. Two Studies had data on neck pain, with the estimated prevalence of neck pain in people with diabetes was 25-32.2%. In total, 13 of the 20 studies found a statistically significant association between diabetes and spinal pain. Results on the meta-analyses will be reported.
Conclusion: Since 2017, an additional 20 studies have explored associations between spinal pain and diabetes. This review will report updated prevalence and association between diabetes is associated with low back and neck individually, and spinal pain.

O496

The effect of clinical guidelines on the utilisation of radiographs in chiropractic clinics in Denmark: An interrupted time series analysis

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Introduction: In Denmark, chiropractors have a statutory right to use radiography in the management of patients with musculoskeletal disorders and the government-funded national Health Insurance provides partial reimbursement for these services. Along with international clinical guidelines, Danish National Clinical Guidelines recommend against routine use of imaging for uncomplicated spinal pain. However, it is not clear if the clinical guidelines recommendations have had an effect on the utilisation of spinal radiography.

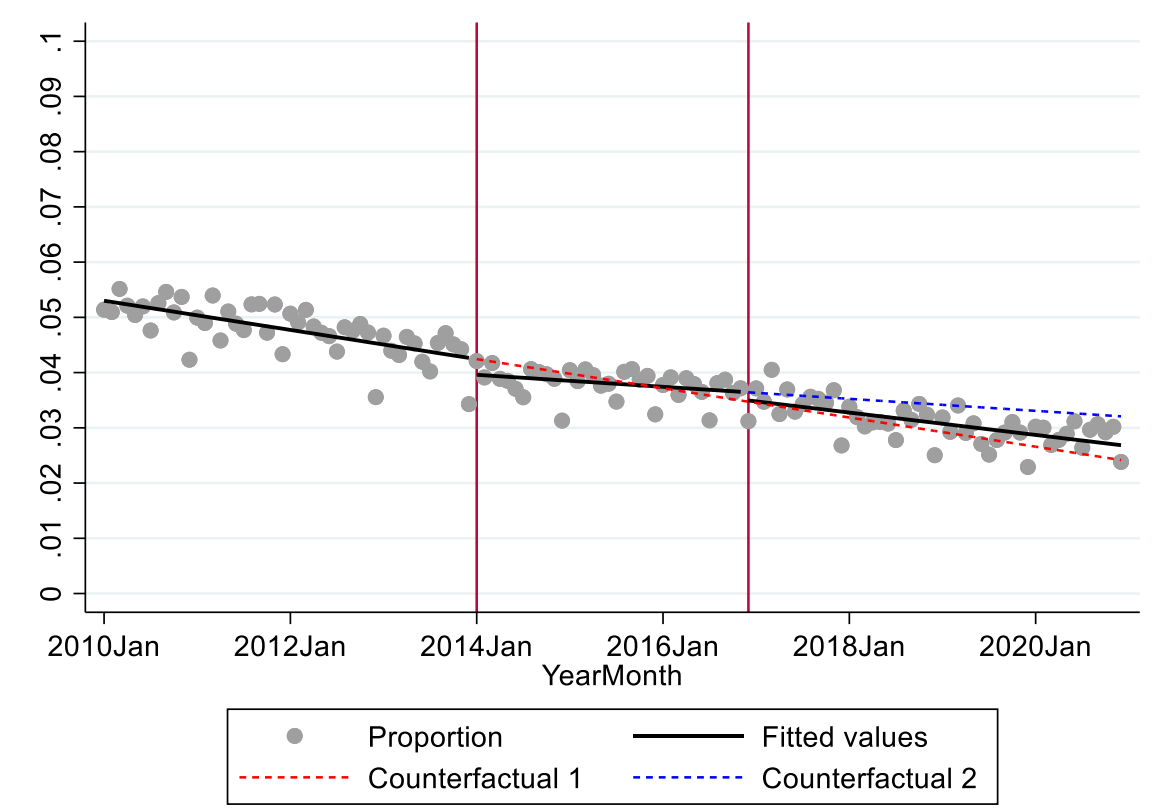
Aim: The aims of this study were 1) to describe the utilisation rate of radiographs per year in Danish chiropractic clinics in the period from 2010 to 2020 and 2) to assess the impact of clinical guidelines and policy changes on the monthly utilisation rate of radiographs in the same period.

Patients and Methods: Anonymised data from January 1st, 2010, to December 31st, 2020, were extracted from the Danish Regions register on health contacts in primary care. Data consisted of the total number of patients consulting a Danish chiropractor and the total number of patients undergoing or being referred for radiography in one of the 254 chiropractic clinics. Data were used to investigate the radiography utilisation rate per month from 2010 to 2020. An 'interrupted time series' analysis was conducted to determine if two interventions, the dissemination of 1) Danish clinical imaging guidelines recommendations and policy changes related to referral for advanced imaging for chiropractors in 2013 and 2) four Danish clinical guidelines recommendations in 2016, were associated with an immediate change in the level and/or slope of the radiography utilisation rate.

Results: In total, 336,128 unique patients consulted a chiropractor in 2010 of which 15% (55,449) had radiography. In 2020, the number of patients consulting a chiropractor had increased to 366,732 of which 8.0% (29,244) had radiography. The first intervention (imaging guideline and collective agreement) showed a statistically significant but small level change and slope change corresponding to 28 fewer radiographs per 10,000 patients per month and an increase in the monthly utilisation rate (slope) of 1.3 radiographs per 10,000 patients. The second intervention (clinical guidelines on low back and neck pain) did not alter the utilisation rates, see Figure 1.

Conclusion: The proportion of Danish chiropractic patients undergoing radiography was halved in the period from 2010 to 2020. However, the dissemination of clinical imaging guidelines recommendations and policy changes related to referrals for advanced imaging showed no clinically meaningful impact on the monthly utilisation rate of radiographs in the same period.

Figure 1: Monthly data from 2010 to 2020 on the proportion of chiropractic patients having diagnostic imaging



Note: Vertical red lines mark the interventions in January 2014 and December 2016. X-axis is months with '2010Jan' representing January 2010, etc. Y-axis represents proportions (0-1) of patients who received radiographs per month and is reduced to 0-0.1 for clarity.

O497

A systematic review of the effectiveness of superficial heat and cold for decreasing pain and improving disability in adults with low back pain

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Introduction: Heat and cold therapy for low back pain is commonly used and recommended in many current clinical practice guidelines. However, these clinical practice guidelines have conflicting recommendations. Neither heat nor cold therapies were considered in the recent Danish National Clinical Guidelines for non-surgical treatment of patients with recent onset low back pain or lumbar radiculopathy. Canadian guidelines for the evidence-informed management of low back pain recommended heat or cold packs for the short term relief of acute low back pain, with no differentiation between each and advising to alternate heat and cold as per patient preference.
Aim: To update our review to determine the effectiveness of superficial heat and of superficial cold therapies in reducing non-specific low back pain and disability in adults, aged 18 years and older.
Methods: Searches were undertaken within eight electronic databases: Cochrane, Medline, CINAHL, PEDRO, SportsDiscuss, EMBASE, ClinicTrials.gov and the World Health Organization (WHO) International Clinical Trials Registry Platform. Randomised controlled trials (RCTs) testing the effectiveness of superficial heat or cold therapy for non-specific low back pain in adults were included. Sets of two independent reviewers each applied eligibility criteria to the search output, extracted data on study design, participants and outcomes, and assessed risk of bias (using GRADE). Meta- analyses will be undertaken where possible. Summary of Findings tables were generated through RevMan Web and GradePro GDT.
Results: The search identified 10,012 new articles since the last review, and 8,818 were removed as duplicates. At title and abstract 1,130 articles were screened, and 64 underwent full text screening. In total, 6 new RCTs were included and combined with 5 RCTs from the original review, 11 RCTs underwent analysis (n=1,395). The range of male participants was 16% to 57% and the mean age of participants (from 9 trials) was 36 years. In ten trials participants had acute low back pain, with only one trial investigating chronic low back pain. Eight RCTs used heat wraps, one RCT used a heated blanket, one RCT used a heated plaster and education and rehabilitation and one RCT used a hot water bottle as the primary intervention. Outcomes of pain were heterogenous and the timing of outcomes varied, making meta-analysis of the outcomes difficult. Results will be reported descriptively. Overall, all studies were susceptible to bias and rated as low quality.
Conclusion: The evidence base to support the common practice of superficial heat and cold for low back pain is limited and there is a need for future higher-quality randomised controlled trials. There is moderate evidence in a small number of trials that heat wrap therapy provides a small short-term reduction in pain and disability. The evidence for the application of cold treatment to low-back pain and heat versus cold for low-back is even more limited, and no strong conclusions can be drawn.

O498

Prognosis of a new episode of low-back pain in a community inception cohort

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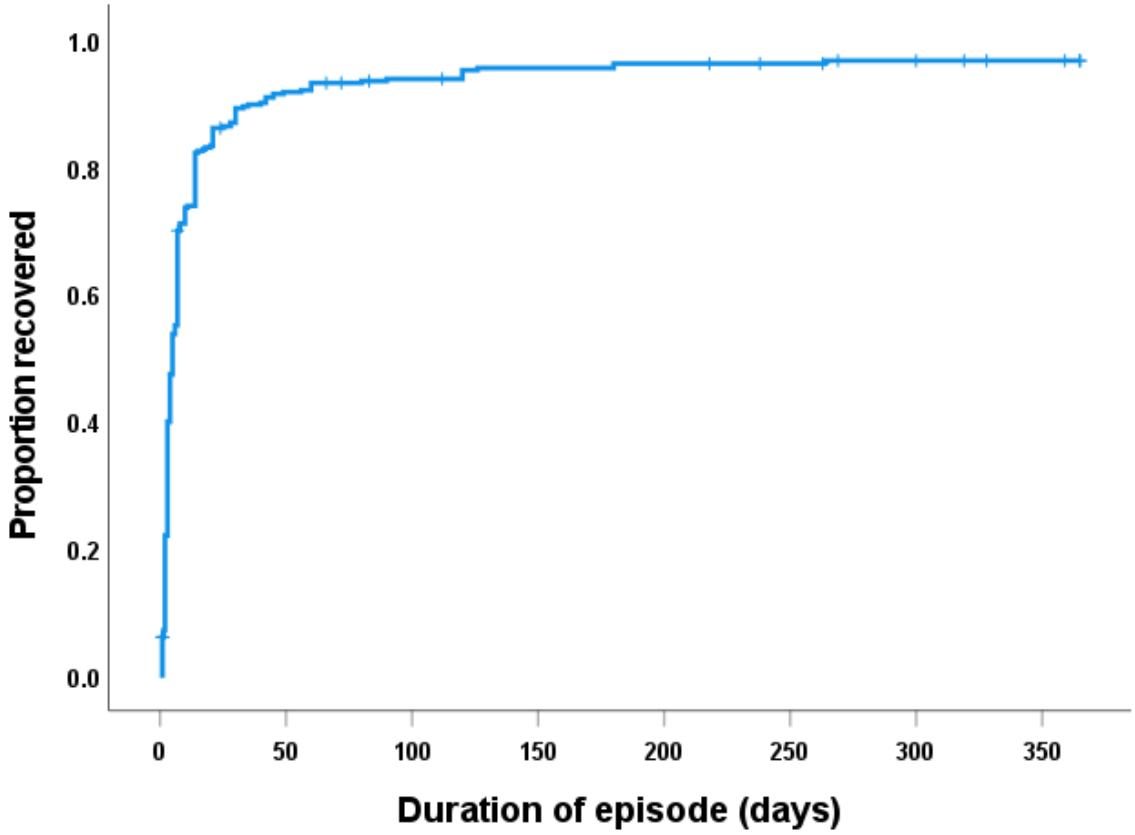
Introduction: Most studies investigating the prognosis of low back pain (LBP) enrol people presenting for care, rather than all people who have an episode of LBP. The prognosis of an episode of LBP for people in the community may be more favourable than in the subset who seek care; however, little data is available from community populations.
Aim: To describe the prognosis of an acute episode of LBP in a community inception cohort.
Materials and Methods: We used data from two previous studies investigating recurrence of LBP. Participants without current LBP were contacted monthly to assess if they had experienced a new episode of LBP. An inception cohort of 366 participants reporting a new episode of LBP were included in the current study. The primary outcome was duration of the new episode of LBP. Secondary outcomes were average and worst pain during the episode and the proportion of participants seeking care. To collect accurate data for the primary and secondary outcomes participants who reported an episode of LBP were contacted via phone call as soon as possible and typically within 1 week. Participants were asked the start date for the episode, whether the episode was ongoing or had already resolved, the duration (days) of the episode if already recovered, the worst and average pain intensity during this episode, and whether they had sought care as a result of the episode. Participants who had not recovered from that episode when contacted, were contacted again by phone between 1 and 3 months later for up to 12 months and asked the same questions. For the primary outcome of duration (days) of the new episode of LBP we used survival analysis. For the secondary outcomes of average pain intensity and worst pain intensity we used descriptive analyses and reported mean (SD).
Results: The median duration of the episode was 5 days (95%CI 4 to 6). The cumulative probability of recovery was 70.0% (95%CI 65.3 to 74.7) before 1 week, 86.1% (95%CI 82.6 to 89.6) before 3 weeks, 90.9% (95%CI 88.0 to 93.8) before 6 weeks, and 93.5% (95%CI 90.8 to 96.0) before 12 weeks (Figure 1). The mean average pain intensity was 3.7 (SD±1.5), and the mean worst pain intensity was 5.6 (SD±1.9). The proportion of patients who sought care was 39.5% (95%CI 33.9 to 46.4).
Conclusions: This study found most episodes of LBP recover rapidly and more quickly than typically reported for clinical populations. The worst pain during the episode was typically moderate to high despite the rapid recovery for most people. Approximately 40% of the participants who experienced an episode of LBP sought care.

Figure 1: Kaplan Meijer Survival curves for the duration of the new episode of LBP



O499

MAINTAIN tool implementation for new spinal pain patients at chiropractic teaching clinics: Cross-sectional findings and impact on treatment plans

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Introduction: Chiropractic maintenance care (MC) is a long-standing, only recently tested, management strategy with a goal to prevent future episodes, progression, and other consequences of spinal pain, most commonly low back pain. This type of care is my commonly introduced after a patient has received optimum treatment benefit from an initial care plan. This strategy has now been tested and found that patients psychological, behavioural, and social characteristics also influence the success of the MC strategy. As such, the MAINTAIN tool was developed to help clinician use the MC management strategy based on patients' characteristics. Implementation of this tool into clinical practice is currently underway.

Aim: To describe patients seeking care from chiropractic teaching clinics with students who are being trained on the use of the MAINTAIN tool and the initial clinician impressions of these patients.

Materials and Method: Patients (between Feb-2022 and Sept-2022) with new spinal pain of recurrent and significant (>30days over the past 12 months) nature were screened at their first visit to chiropractic teaching clinics participating in this ethic-approved study. After patients signed an informed consent document, they were invited to complete a baseline questionnaire in the clinic and their supervising clinician were sent a survey via email seeking their treatment plans impression for this patient, including clinician's expectation of patient responding to treatment (1-Not at all;5-Definitely). This survey piped in the patient's MAINTAIN score and was encouraged to be done by or with the student who is overseeing the patient.

In addition to the MAINTAIN tool (score:-12to48 with >18 as potential MC candidates), other measures collected via REDCap from the patients were: Numerical Pain Rating Scale-NPRS, average past 24 hours (scale:0,no pain-10,worst pain imaginable); Expectation(0,no chance-10,very likely); and general rating of health-GH (excellent-poor).

Results: Of the 586 screened patients, 96 were eligible/interested in participating with 56% having neck pain with an average of 46.0 days over the past year with activity limitations, 38% mid-back pain with 51.8 days of limited activities, and 70% low back pain with 49.7 limited activities days. The average MAINTAIN score was 15.1 (SD:9.03,range:-7to32) with 36 patients having a score $\geq$18; NPRS was 3.8 (SD:2.32,range:0-10); expectation was 6.9(SD:2.81,range:0-10); and 78.1% rated GH as good/excellent with only 4.9% rated as bad/poor.

Only 48 (50%) of the clinicians' surveys were completed (20 by the supervising clinician alone, 6 by the student alone, and 22 by the clinician/student together), of which, all felt their patients were good candidates for manual treatment and exercise intervention. Also, all, but one, stated that their patient would be treated. The average expectation that patient would respond to treatment was 4.3(SD:0.72).

Conclusion: It is well known that there is a need for evidence to support treatment plan decisions. As new evidence is discovered, it is also well known that changing clinical practice is complex and challenging. This study found similar complexity and challenges at chiropractic teaching institutions, including uptake by students and clinicians to engage in survey completion and implementation of the MAINTAIN tool findings into clinical impressions.

References:

[1]Eklund, A., Palmgren, P.J., Jakobsson, U. et al. Development and evaluation of the MAINTAIN instrument, selecting patients suitable for secondary or tertiary preventive manual care: the Nordic maintenance care program. *Chiropr Man Therap* 30, 15 (2022). https://doi.org/10.1186/s12998-022-00424-6

O500

Slippage reduction and patient-reported outcomes following surgical fusion of lumbar degenerative spondylolisthesis: Is less really more?

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Introduction: The relationship between slippage and patient-reported outcomes (PROs) in degenerative spondylolisthesis (DS) has yet to be fully characterized. The slippage based Meyerding classification has long been used in the prognosis and management of spondylolisthesis, but it does not consistently reflect clinical outcomes in DS. A stronger understanding of the relationships between radiographic findings and PROs will aid surgeons in operative planning and long-term prognostication.

Aim: The primary aims of this study are to determine whether lumbar fusion for DS results in significant changes in PROs and if slippage reduction achieved during surgery correlates with changes in PROs. The secondary aims are to characterize the utility of a decile stratified Meyerding classification to predict PROs and determine whether surgical technique impacts the relationship between slippage and PROs.

Patients and Methods: All patients treated surgically for DS at a tertiary care medical center over five years were retrospectively reviewed. PROs including the Oswestry Disability Index (ODI), Sciatica Bothersomeness Index (SBI), and Roland-Morris Disability Questionnaire (RMDQ) were evaluated perioperatively. Slippage percentage was evaluated using lumbar spine radiographs. Regression analysis was used to assess correlation between changes in slippage percentage and PROs. A two-sample t-test was used to compare preoperative and postoperative PROs. Subjects were then divided into cohorts by deciles of slippage preoperatively and postoperatively. Analysis of variance was used to compare PROs across groups at a significance level of 0.05.

Results: Fifty-seven subjects who underwent surgical fusion of lumbar DS and had radiographs and PRO scores preoperatively and one year postoperatively were included. Sixty-six additional subjects who had only preoperative assessments were added for secondary analysis. There were statistically significant improvements in both average ODI (25.8 to 13.8, $p=1.88e^{-11}$) and average SBI (13.1 to 6.0, $p=7.59e^{-9}$) perioperatively. No significant correlation was found between perioperative slippage reduction and changes in ODI ($R^2 = 0.0085$) or SBI ($R^2 = 0.0010$).

Secondary analysis of 123 patients split among five preoperative cohorts based on slippage 0-10% (n=17), 10-20% (n=56), 20-30% (n=36), 30-40% (n=11), and >40% (n=3) revealed no significant differences in ODI (p=0.765) or SBI (p=0.8703). Postoperatively, analysis of 59 patients split among three cohorts based on slippage 0-10% (n=12), 10-20% (n=37), and 20-30% (n=10) revealed no significant differences in ODI (p=0.896), SBI (p=0.656), or RMDQ (p=0.680). When stratified by surgical technique (fusion at all levels, n=45; fusion at fewer levels than decompression, n=14), no significant difference in ODI or SBI was seen across deciles.

Conclusion: Although surgical fusion of lumbar DS resulted in significant improvements in average ODI and SBI, no correlation was found between perioperative changes in slippage and PROs. Additionally, the use of a decile stratified Meyerding classification was not predictive of PROs. These results were consistent across surgical techniques. While surgeons often make clinical decisions based on radiographs, perhaps it's time to move beyond simple radiographs in the objective evaluation of spondylolisthesis. This analysis lays the groundwork for future research into whether other radiographic parameters such as flexion/extension translation and intervertebral disk space are more predictive of PROs in DS.

O501

Lumbar fusion surgery in the era of an aging society: Analysis of a nationwide population cohort with minimum 8-year follow up

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Background: Fusions for lumbar spine diseases are widely performed and have a growing incidence, especially in elderly population.
Objective. The goal of this study was to assess national trends of lumbar spinal fusions and examine the long-term risk for re-operations with a focus on 'epidemiologic transition' relating to age.
Methods: The Korean Health Insurance Review and Assessment Service (HIRA) database was retrospectively reviewed. Patients who underwent lumbar fusions between 2010 and 2018 were reviewed and used to assess trends in operative incidence. Patients who underwent lumbar fusions for degenerative spine diseases between 1/2010 and 12/2011 were enrolled to determine 8-year reoperation rates. Demographic data, reoperation rates, and confounding clinical factors were evaluated.
Results: In total, 278,815 patients underwent lumbar spine fusion. Over time, elderly patients comprised a larger portion of the cohort (2010:24.2%; 2018:37.6%), while operations in younger patients decreased over time (2010:40.3%; 2018:27.0%). In the cohort of patients with a minimum 8-year follow-up (n=37,050), rates of reoperation peaked in patients aged 60-69 years [17.6 per 1000 person-years (HR 2.20 compared to <40years)] and decreased for more elderly patients [14.3 per 1000 person-years (HR 1.80 compared to <40years)]. Age was the most significant risk factor for reoperation. Osteoporosis was also a risk factor for reoperation in post-menopausal females.
Conclusions: Increasing incidence of lumbar fusions in elderly patients was seen however the risk of reoperation decreased in patients aged 70 or more. Lumbar fusion for elderly patients should not be hesitated in the decision-making process because of concerns about reoperation.

O502

The safety of multi-level kyphoplasty of 4 or more vertebral levels in myeloma patients

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Introduction: Vertebral involvement occurs in approximately 70% of multiple myeloma cases. Percutaneous kyphoplasty (PKP) has been proven to improve pain and mitigate spinal deformity in myeloma patients. This can be performed at both single and multi-vertebral level dependent on vertebral involvement. Pan-spinal infiltration is not uncommon, affecting approximately 50% of our patients, emphasising the need for multi-level kyphoplasty. Original guidelines for kyphoplasty have cautioned against performing kyphoplasty on more than 3 vertebral levels because of the risk of multiple mini-pulmonary emboli from cement leakage. This may potentially be due to the fact that each vertebra can hold approximately 5 to 10cc and it is essentially the volume of cement rather than the number of vertebrae which is important. This study aims to determine the safety of PKP for 4 or more vertebral levels.

Material and Methods: This was a retrospective analysis of 43 multiple myeloma cases (mean age= 64.8±1.63, 25 male/18 female) with vertebral involvement of which management involved PKP from January 2019 to August 2022. Cases involving 4 or more vertebral levels (N=15) were compared to cases involving 3 levels or less (N=28), with safety of PKP analysed through 30-day and 1-year mortality as well as intra-operative complications.

Results: For all cases managed with PKP there was a 30-day mortality of 7.31% (N=43) and 1-year mortality of 13.9% (N=36). The 30-day mortality in cases involving 3 vertebral levels or more was 0.00% (N=15) with no intra-operative complications, whereas the 30-day mortality in cases with less than 3 levels involved was 10.7%(N=28). The 1-year mortality for cases involving 4 or more vertebral levels was 10.0% (N=10) compared to 14.3% in cases involving 3 vertebral levels or less(N=28). Comparatively, a similar cohort of patients with multiple myeloma involving the spine that were managed conservatively (N=83) at our centre had a 30-day mortality of 8.43%.

Conclusion: In this study PKP performed at 4 or more vertebral levels was shown to be a safe procedure with no evidence of increased mortality or complications compared to procedures involving less than 4 vertebral levels. We believe that the volume of cement is more important than the number of vertebrae operated on. Therefore, in future patients with pan-spinal involvement may be considered for PKP of more than 3 vertebral levels. Further studies are required to characterise more accurately the safety and efficacy of this procedure for 4 or more vertebral levels.

O503

Onset, progression and risk factors of lumbar disc degeneration: 10-year longitudinal study of a population cohort

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Background: Lumbar disc degeneration (LDD) is a major cause of low back pain (LBP), which affects up to 80% of the general population. Multiple features of LDD, such as disc dehydration, narrowing, bulging and endplate changes, can be measured by magnetic resonance imagining (MRI) of the lumbar spine. However, the temporal sequence of the occurrence of these features, and their associated risk factors, has not been clearly delineated.

Aim: To characterise the pattern of onset and progression of MRI features of LDD, as well as associated risk factors.

Patients and Methods: A population cohort of 3,585 volunteers of southern Chinese ancestry aged 18 to 55 years was recruited in Hong Kong. The subjects were followed up longitudinally with questionnaires and spine MRIs over a 10-year period. Four trained clinicians assessed the MRI scans of lumbar intervertebral discs and rated seven features of LDD: Schneiderman's score (SS), disc bulging (DB), disc narrowing (DN), disc herniation (DH), high-intensity zone lesion (HIZ), Modic change (MC) and Schmorl's node (SN). The blood samples of the subjects were genotyped using the Illumina OmniZhonghua-8 v1.2 BeadChip. The generated single nucleotide polymorphism (SNP) genotype data were used to calculate polygenic scores (PGS) for phenotypes that were potential LDD risk factors.

Results: SS, DB, and DN were the first LDD features to emerge, and form the backbone in a correlation network of all LDD features except SN. In addition to being only weakly correlated with other LDD features, SN was distributed uniformly across disc levels, unlike other LDD features which were more frequent in the lower than upper lumbar levels. DH, HIZ and MC were found to be rarer than SS, DB, and DN, and occurred only in the presence of SS and DB. Thus, we defined the combination of SS and DB to be the core feature of LDD, and considered DH, HIZ and MC to be secondary changes. Core LDD as defined by SS and DB was positively correlated with greater height and body mass index (BMI). Height and BMI also predicted MC, while proneness to injury was associated with Core, MC and DH, and sports activity with HIZ. Mixed model analysis of Core LDD showed significant main effects of PGS for major depressive disorder and the PGS for BMI, and a positive interaction between age and the PGS for back pain.

Conclusion: This large longitudinal cohort MRI study of lumbar intervertebral disc changes provides novel insights into the developmental course and progression in LDD. Our findings lay the groundwork for future studies to deepen our understanding of biopsychosocial risk factors which predict both core and secondary features of LDD, along with critical avenues for prevention efforts.

O504

Analysing gait patterns in degenerative lumbar spine disease using inertial wearable sensors — An observational study

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Introduction: Degenerative diseases of the lumbar spine are associated with measurably altered gait patterns. Recent advances in wearable accelerometry have enabled inexpensive and convenient means of objectively assessing gait in the clinical setting. Objective analysis of gait through inertial wearable sensors gait analysis can inform patient assessment and post-intervention monitoring and recovery.
Aim: Using a chest-based inertial wearable sensor, we aimed to quantitatively examine gait patterns associated with lumbar disc herniation (LDH), lumbar spinal stenosis (LSS) and chronic mechanical low back pain (CMLBP). 'Pathological gait signatures' were reported as statistically significant group difference (%) from the 'normative' gait values of an age-matched control population.
Materials and Methods: A sample of patients presenting to the Prince of Wales Private Hospital (Sydney, Australia) with primary diagnoses of LDH, LSS or CMLBP were recruited. Participants were fitted at the sternal angle with an inertial measurement unit (IMU), MetaMotionC (*Mbientlab Inc., USA*) and walked unobserved, at a self-selected pace for 120m. Spatial, temporal, asymmetry and variability metrics (Figure 1) were compared with age-matched (+/- 2 years) control participants following data processing with an open-source modified Python program (Figure 2).
Results: LDH (n=33), CMLBP (n=33) and LSS (n=22) groups had unique pathological signatures of gait impairment as seen in Figure 3. LDH group involved marked asymmetry in terms of step length (+39.1%, p=0.018), step time (+23.0%, p=0.026), stance (+24.8%, p=0.029) and single-support asymmetry (+35.1%, p=0.016). LDH also involved gait variability with increased step length variation (+29.0%, p=0.029). CMLBP group was not associated with gait asymmetry, however gait variability was present in terms of single-support variation (+49.0%, p=0.031). The gait of participants with LSS was both asymmetric (+24.9%, p=0.039) and variable (+36.3%, p=0.043) in step length.
Conclusion: Wearable sensor-based accelerometry was found to be capable of detecting gait abnormalities present in LDH, LSS and CMLBP patients, when compared to healthy age-matched controls. Objective and quantitative patterns of gait deterioration uniquely varied between these subtypes of lumbar spine disease. With further testing and validation, these pathological gait signatures may aid clinical identification of gait-altering pathologies.

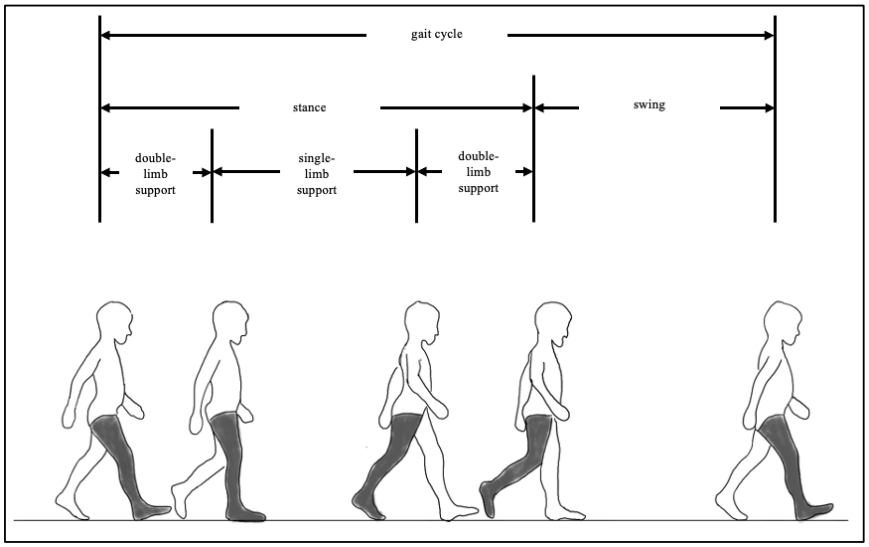

Figure 1. Gait phases for right (shaded) leg.

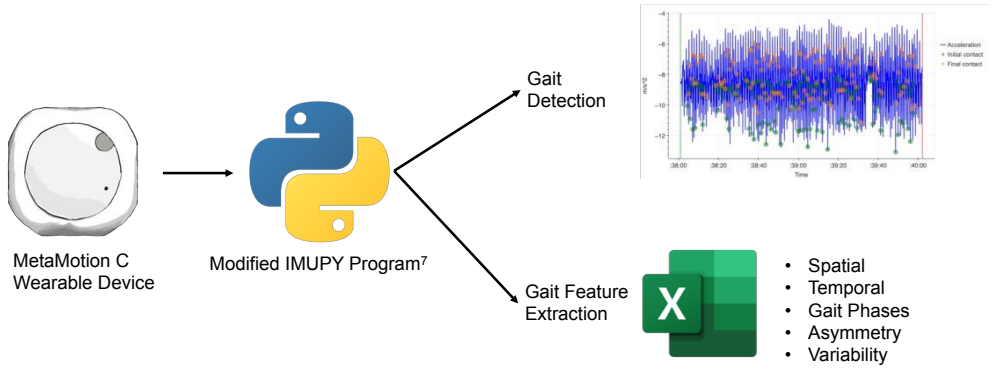

Figure 2. Flow diagram of data capture and processing.

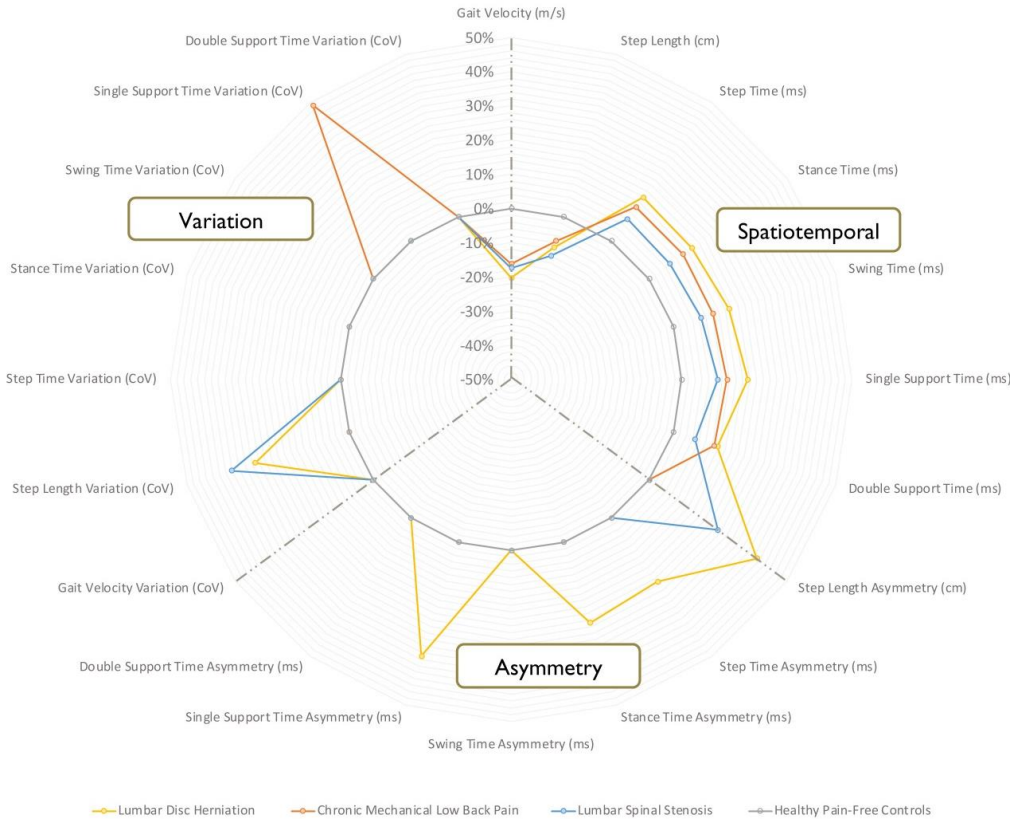

Figure 3. Radar plot of walking metrics of pathology groups compared to age-matched controls. Percentage values represent magnitude of mean/median difference* of walking metrics for lumbar disc herniation (yellow, n=33), lumbar spinal stenosis (blue, n=22) mechanical low back participants (orange, n=33) from normative control participant values (grey, n=88) placed at 0%. *Calculated using Student's Independent t tests or Mann-Whitney U tests with normality confirmed using Shapiro-Wilk tests and inspecting histograms, with statistical significance at $p < 0.05$.

O505

A deep learning algorithm for early detection of lumbar degenerative spondylolisthesis on conventional radiograph

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Introduction: Degenerative spondylolisthesis is a condition most often seen in females over 40 years of age. It is 5x more prevalent at the L4-5 spinal level than any other location. If left untreated, it can progress to cause incapacitating sequalae like pain, progressive motor deficit, and cauda equina syndrome. Despite its prevalence, diagnosis of degenerative spondylolisthesis often is delayed or overlooked until these sequelae arise. Deep learning systems can be integrated into clinical workflows for earlier recognition of degenerative spinal patterns. In this study, we develop a deep learning algorithm for automated detection of lumbar degenerative spondylolisthesis in conventional radiographs.
Methods: A dataset of 523 radiographs of the lumbar spine (339 healthy controls, 184 cases of degenerative spondylolisthesis) was compiled, annotated, and split into training (70%), validation (20%), and testing (10%) datasets. The training images were augmented using affine image transformations to create a more robust collection of training samples. An object detection model based on YOLOv5 architecture was fitted to the dataset for 200 epochs, tracking change in its predictive capabilities over time.
Results: the trained model reported a mAP_{50} of 0.885, precision of 0.860, and recall of 0.790. Model loss functions and training and validation metrics are illustrated graphically in Figure 1A. The trained model was deployed online at https://universe.roboflow.com/logan-nye-4l189/lumbar-sponylolisthesis/model/2, as a publicly available interactive prototype that detects and predicts lumber spondylolisthesis on spinal radiographs, as shown in Figure 1B.
Conclusions: We have developed and published an open-source dataset and deep learning model for early detection of lumbar degenerative spondylolisthesis on plain spinal radiographs. The trained model could be helpful in the developing systems for automated detection of lumbar spondylolisthesis. Development and integration of similar deep learning models in clinical workflows may lead to earlier detection of and intervention for degenerative orthopaedic conditions with fewer sequelae.

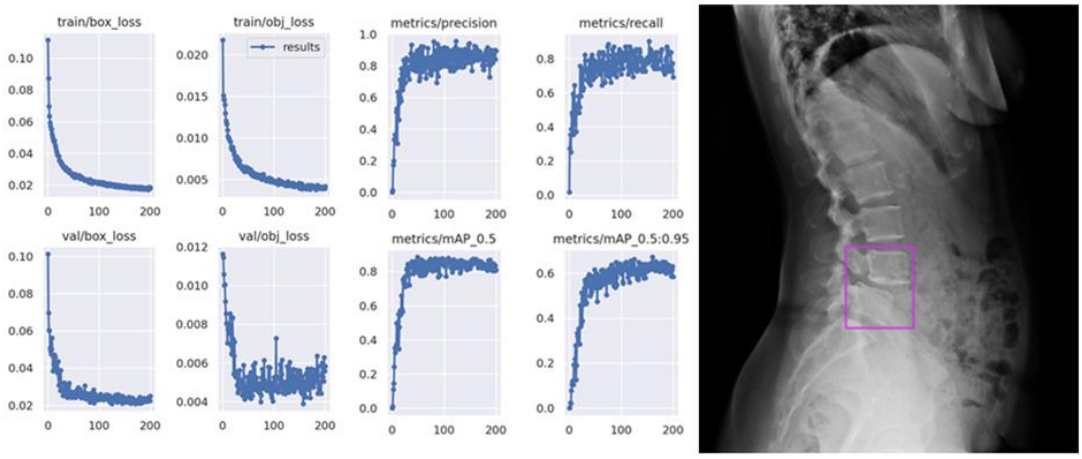

Figure 1A. – Model training and validation performance during 200 epochs of training on the dataset. **Figure 1B**. – Actual output generated by the trained model. When shown lateral views including the lumbar spine, it marks predicted points of spondylolisthesis with a color bounding box.

O506

New axially expandable oblique cage for Anterior to psoas (ATP) stand alone approach. Clinical-radiological outcomes in a series of patients with symptomatic degenerative disc disease (DDD)

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Introduction: ATP approach is a retroperitoneal approach which represents a direct path to lumbar discs. Several studies reported ATP approach as safe, with acceptable clinical-radiological outcomes and complication rates when treating common degenerative conditions. Although large straight cages can be used through this approach, nevertheless their insertion in an oblique fashion is difficult, due to the need to rotate it through an unusual orientation, retracting and manipulating psoas muscle or great vessels. On the other hand, standard oblique cages, compared to those used for lateral lumbar interbody fusion (LLIF) or anterior lumbar interbody fusion (ALIF) approach, cannot cover end-plates side-to-side, which is an important biomechanical factor for reducing the risk of cage subsidence and for restoring a correct segmental lordosis.
Aim of this study is to assess the radiological and clinical results of a new expandable stand-alone oblique cage for ATP approach, in a series of patients affected by lumbar DDD.
Methods: From March 2018 to June 2021, 38 consecutive patients (18 male and 20 females, mean age 67 range 42-81) suffering from pure lumbar DDD, at our Department, were operated on through ATP approach (cohort group) and enrolled prospectively in this study.
All patients underwent single or double level discectomy through an ATP approach, with insertion of a new axially expandable cage (Tsunami), which was used as a stand-alone.
Surgical complications, bed-rest time and time-to discharge were evaluated in all patients. Clinical (VAS, ODI e SF-36) and radiological evaluations were made preoperatively and at 1 year follow-up.
Clinical-radiological results from study group were compared with those from a series of 38 matched patients, retrospectively reviewed, treated previously with a standard stand-alone not expandable oblique cage and followed-up (Control group) (AVILA, Medtronic).
Results: In study group no major surgical complications were recorded during surgical procedures. Mean bed-rest time and time to discharge was not significantly different in two groups. Radiological results showed a less incidence of subsidence and a significative better correction of coronal cobb angle in study group compared to controls (Fig 1). Clinical results were not significantly different, although in control group one major intraoperative complications were recorded and slight improvement of SF-36 scores in study group.
Conclusions: New axially expandable oblique cage for lumbar inter body fusion, specifically designed for ATP approach represents an innovation and a technical improvement. The insertion and the axial expansion technique are safe and easy. It is able to restore segmental lordosis, and thanks to the large foot-print it is able to obtain a solid and effective arthrodesis, used as a stand-alone. Furthermore, the ability to reach both lateral limits of epiphyseal ring, reduces strongly the risk of subsidence and allows to restore also the segmental coronal unbalance. Limitation of this pilot study is represented by the small number of enrolled patients, and larger study are ongoing to confirm our preliminary results.

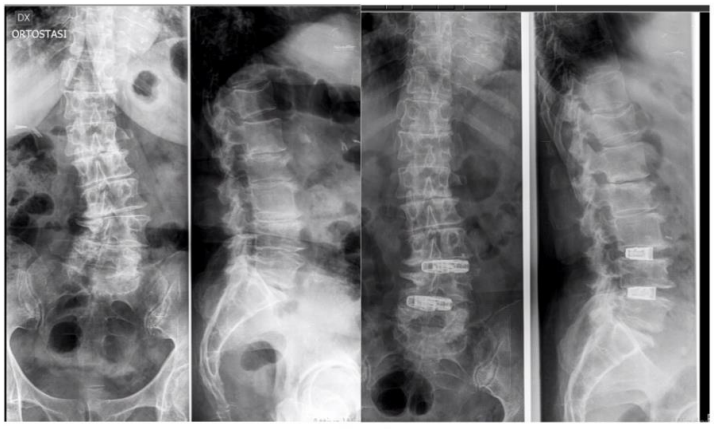

Figure 1

O507

Endoscopic transforaminal lumbar interbody fusion through bi-portal technique: Clinical experience with 2-year outcomes

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Introduction and Aim: Transforaminal lumbar interbody fusion (TLIF) in patients with low back pain (LBP) and unilateral radicular symptoms due to instability has demonstrated encouraging outcomes. However, the open approach can be aggressive with paraspinal muscles, and sometimes preparation of the endplates through the tubular retractor is insufficient. Therefore, we decided to perform a prospective case-control study with a 2-year cohort of 23 patients who underwent a new technique of TLIF, the unilateral bi-portal endoscopic (UBE) TLIF, to present our clinical experience outside of Asia.
Material and Methods: We included 23 patients who underwent UBE-TLIF from May 2018 to May 2020. Inclusion criteria were chronic low back pain treated by conservative strategies without improvement for at least eight weeks, unstable low-grade spondylolisthesis (I or II) with severe degenerative disc disease (<2mm disc height collapsed), foraminal stenosis associated (<15mm foraminal height), and unilateral radiculopathy. We evaluated all patients preoperatively and postoperatively, immediately after surgery and at 1, 3, 6, 9, 12, and 24-mos and each year after surgery using the Visual Analog Scale (VAS) for back and leg pain. The Oswestry Disability Index (ODI) was used in the preoperative and in the 12, 24-mos, and each year postoperative, with MacNab criteria for satisfaction. The radiological outcome also was evaluated. Statistical analysis for comparing changes over time in all the evaluations was done.
Results: All the patients completed the 24-month assessments. The mean age was 53.2 (16 females and 7 males). One L2-L3, eleven L4-L5, and sixteen L5-S1 levels were operated. The mean surgical time was 132 minutes (per level). Eighteen patients were treated for 1 level and 5 for two. The mean intraoperative bleeding was 88 ml overall. All the cases were discharged the next day. No patient required postoperative narcotics for pain control. The scores from both scales (VAS and ODI) decreased from preoperative to postoperative with statistical significance ($P<0.05$), and MacNab criteria resulted in 19 patients referring excellent and 4 good outcomes. Radiological evaluations showed a proper cage location in the intervertebral space and an appropriate direct decompression. Two different surgeons analyzed fusion status using the Bridwell fusion grading scale. Twenty patients reached Bridwell grade 1 and 3 grade 2. An incidental durotomy was experienced and resolved without significant complications.
Conclusion: Despite the small size of the sample, we concluded that unilateral bi-portal endoscopic (UBE) TLIF is a minimally invasive feasible alternative for patients with low-grade spondylolisthesis with axial and unilateral radiculopathy. All patients showed acceptable long-term clinical results and an acceptable fusion rate in the cohort at 24-mos. In addition, the direct visualization of the neural elements, excellent preparation of the endplates under endoscopy, and minimum postoperative pain with rapid mobilization out of bed were some technique related-advantages observed in our study.

O508

Biomechanical assessment of pedicle screw fixation strength in non-osteoporotic and osteoporotic pedicles: Comparison of straight dual-lead versus single- to dual-lead threadforms

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Introduction: Pedicle screw loosening occurs in 1-21% of patients at three to six months post-op and can lead to construct instability. Loosening has been attributed to screw insertion technique, interbody device subsidence, and compromised bone quality. Screw threadform design aims to maximize purchase over the spectrum of bone quality to provide superior fixation strength, resistance to loosening and ease of insertion. Single- to dual-lead threadforms aim to provide increased fixation in dense cortical bone, but its single-lead thread provides no advantage in insertion time. Straight dual-lead threadforms provide uniform pitch over the length of the screw and have inherently decreased insertion times compared to those of single-lead screws.
Aim: Biomechanical assessment of straight dual-lead and single- to dual-lead threadform fixation strength in axial pullout and cyclic toggle to failure, the most clinically relevant mode of pedicle screw loosening.
Materials and Methods: Two pedicle screw designs, a straight dual-lead pedicle screw and a single- to dual-lead pedicle screw, of equal length (45mm) and outer diameter (Ø6.5mm) were biomechanically tested in axial pullout and cyclic toggle to failure. Non-osteoporotic (n=16, BMD>0.80g/cm^2) and osteoporotic (n=16, BMD<0.70g/cm^2) cadaveric vertebrae (T12-L5) were stratified into axial pullout (n=8 each) and toggle to failure (n=8 each) groups. The pedicle trajectory was developed with a Lenke probe and tapped following respective surgical technique before one screw of each threadform was placed in each vertebra (yielding bone quality an internal control). Vertebrae were fully constrained during pullout testing, and the actuator displaced the screw axially from the pedicle at 5mm/min to a total displacement of 10mm; peak load recorded. Vertebral bodies were clamped axially during toggle testing. A rod, secured orthogonal to the screw axis and affixed to the actuator, applied a load-controlled sinusoidal waveform beginning at -100/-10N and increasing -50/-5N each 200 cycles until failure, defined by -4mm of displacement; load at failure recorded. Multiple Wilcoxon signed-rank tests provided statistical comparisons of anchoring capacity (peak load, failure load) based on threadform for each bone quality group. Multiple Mann-Whitney tests provided statistical comparisons of anchoring capacity based on bone quality for each threadform. Significance for all tests set to 0.05.
Results: Neither peak load during axial pullout nor failure load during cyclic toggle were significantly different between threadforms in either bone quality group. Both threadforms yielded significantly larger peak and failure loads in non-osteoporotic versus osteoporotic bone (Figure 1).
Conclusion: Straight dual-lead and single- to dual-lead threadforms yield statistically equivalent anchoring capacity within pedicles of both non-osteoporotic and osteoporotic vertebrae under non-clinical biomechanical test conditions. Time of insertion may be of consideration given equivalent anchoring capacity.

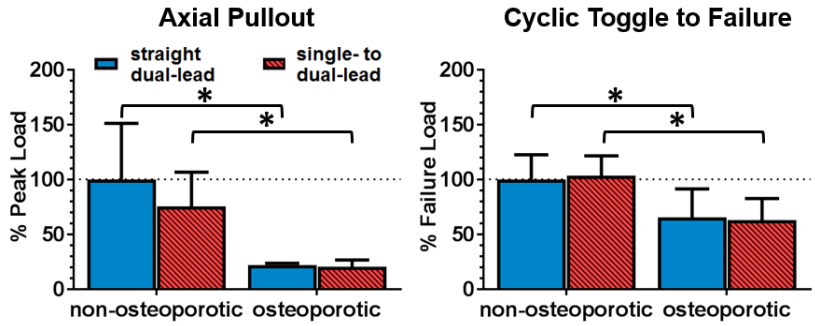

Figure 1. Peak load at failure during axial pullout and failure load during cyclic toggle to failure both reported as percent of straight dual-lead, non-osteoporotic load. Error bars denote standard deviation. Significance *: p<0.05.

Curve progression and Health Related Quality of Life (HRQoL) in idiopathic scoliosis – 40-year follow-up from diagnosis

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Background/Introduction: Treatment of idiopathic scoliosis (IS) in childhood is mainly guided by curve size and location with the aim to prevent curve progression and long-term effects of larger deformities. It is generally accepted that curves >50° will progress throughout adulthood, but less well described what happens with mild to moderate curves and whether curve size and location affects long-term HRQoL.
Purpose: The purpose was to assess long-term curve progression, HRQoL and the rate of incapacity to work in patients with IS and to compare thoracolumbar/lumbar (TL/L) and thoracic curves.
Materials and Methods: We identified 177 patients diagnosed with a pediatric spinal deformity and treated at our institution from 1972 through 1983. Of 129 eligible patients, 91 completed follow-up (71%). Patients had been diagnosed in childhood with juvenile (n=5) or adolescent IS (n=86). We excluded patients with infantile, neuromuscular, syndromic, and congenital scoliosis. Patient files from treatment/observation in childhood were reviewed including detailed descriptions of main curve, type and magnitude. At follow-up, we assessed long standing full-spine radiographs and HRQoL with the SRS22r questionnaire.
Results: Mean follow-up was 40.8±2.6 years and 95% were female. Overall, SRS22r subscore was 3.9 (95%CI: 3.7-3.9) which is lower than an age-matched normal population with a score of 4.4 (95%CI 4.2-4.6) p<0.001) (Figure 1). We found a higher rate of incapacity to work in the patient group at 21% compared to the background with 11% being incapable of working. Eighteen patients underwent Harrington rod instrumentation in adolescence and additional 3 patients underwent surgery later in adulthood leaving 70 patients for analysis of curve progression, 43 (61%) had been treated with a Boston brace. For curves <30° at skeletal maturity (n=32), mean curve progression was 10±12° (range -5 to 44); for curves 30-50° (n=28) mean progression was 19±12° (range -3 to 49); and for curves >50° (n=7) mean progression was 17±6° (range 10-25). This corresponds to a curve progression of 0.3°/year, 0.5°/year and 0.4°/year, respectively. Main curve size at follow-up was larger for thoracic curves 53±18° than for TL/L curves 35±21° (p<0.001); however, we found no difference in SRS22r subscore between the two groups (3.8±0.7 and 4.0±0.7, respectively). We found a greater curve progression for thoracic curves 18±11° than for TL/L curves 12±13° p=0.030.
Conclusions: Long-term curve progression for curves 30-50° at skeletal maturity is substantial and comparable to curves >50° and curve progression is greater for thoracic than for TL/L main curves, however with no difference in HRQoL. Patients' reports lower HRQoL scores and higher rate of incapacity to work than the background population.

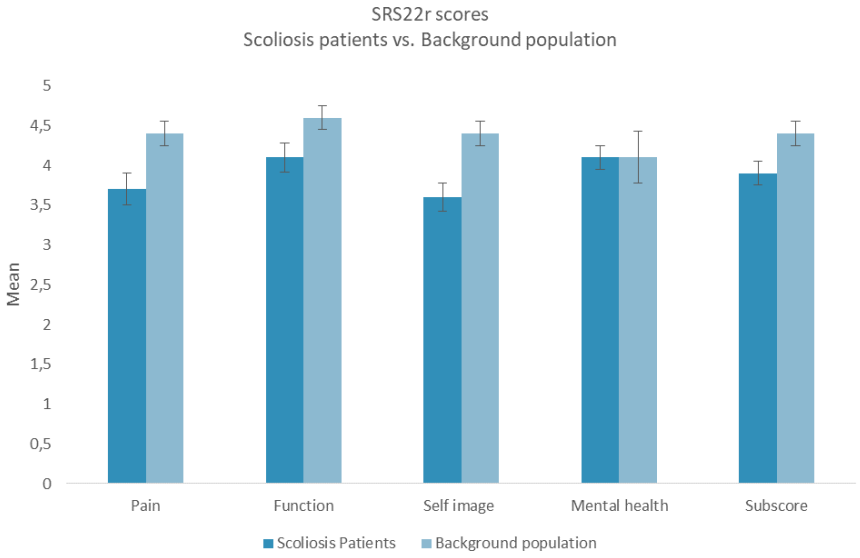

Figure 1

O510

Minimally invasive surgery vs standard posterior approach in the treatment of idiopathic scoliosis: A two years follow-up retrospective study

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Introduction: The purpose of the study is comparing the safety and efficacy of posterior minimally invasive surgery (MIS) to standard posterior spinal fusion (PSF) surgery in adolescent idiopathic scoliosis (AIS)
Methods: We retrospective collected 111 patients with Lenke type 1-6 AIS with Cobb angle curve ≤ 70° who treated with MIS (n=47) or PSF (n =64) between February 2018 and February 2020. All of them attempted an outpatient follow-up consisting of clinical and radiological evaluation for at least two years from surgery. We collected values of Cobb angles degrees to study the correction rate of the structural major curve. MIS technique was applied via 2 midline noncontiguous skin incisions. Smaller incisions and muscle-spearing approach could reduce the blood loss significantly. We obtained an RD maneuver that takes advantages of the flexibility resulting from the rising of the level arm and the consequent force exerted at the caudocranial edges using MIS. Level of apical and distal fusion, operative time, preoperative hemoglobin and second postoperative day hemoglobin, full length of hospitalization and time to accomplish verticalization were recorded. NRS medium score was assessed immediately after surgery and during the whole physiotherapeutic treatment. Complications recorded included: temporary or permanent nerve lesions, intraoperative or postoperative nerve lesions, fever, surgical wound dehiscence and infection, mechanical complication and postoperative pain assessment.
Results: There was no significant difference between the 2 groups in terms of radiographic and clinical features. The correction rates of the structural curve were not observed to be significantly different between group 1 (MIS) and 2 (PSF) (64.6%±11.7 vs 60.9% ±13.2) as for the correction rate of secondary curve (59.1±13.2 vs 59.2±12.4). The two groups had non-significantly longer operative time (209.9±34.8min vs 215.2±45.2). The MIS group had a significantly lower decrease of postoperative hemoglobin in comparison to PSF group (2.8±1.3 vs 4.3±1.5) (p< 0,001). The evaluation of pain using NRS score showed a lower score in MIS group (1,8±0,8 vs 2,8±0,9). PSF group was observed to have significantly lengthier time of hospitalization (5.2±1.4 vs 6.3±2.9) (p= 0,02) than MFS group. Complications were more frequent in PSF group rather than in MFS group (11 vs 3), with no infectious complication in MIS group and 6 events of post operatory infections in PSF group. Only one mechanical complication (breakage of rod) was observed in MSF group. The mechanical complication recorded was successfully treated with a surgical approach.
Conclusions: Posterior MIS is a safe and capable alternative to standard open approach for Lenke Type 2–6 AIS patients with curves < 70°, with analogue capacity of scoliosis correction. The average number of fusion segments in MIS group was lower than in PSF group (9,1 vs 10,2). For these reasons MIS technique could reduce the risk of post-operative adding-on and permits to spare motion segments. Even though there were no difference in term of operative time between MIS and PSF, our results showed that MIS had the advantages of less blood loss, length of stay and pain.

O511

The recent 10-year trends in cervical laminoplasty and 30-day complications, 2008-2017

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Introduction: Laminoplasty is a valid surgical treatment of multilevel simultaneous decompression for cervical myelopathy. To date, surgical techniques have been refined and elderly patients are prevalent. We, therefore, hypothesized that the incidence and details of postoperative complications have changed in the past decade. The purpose of this study is to investigate the recent 10-year trends in cervical laminoplasty and postoperative complications. In particular, we focused on changes in the incidence of C5 palsy in the past decade.

Methods: This retrospective multicenter study included 1095 patients with cervical spondylotic myelopathy (CSM) or cervical ossification of the posterior longitudinal ligament. The primary outcome was the incidence of all-cause 30-day complications, and we compared 5-year early (2008-2012) and late (2013-2017) terms in the 10 years.

Results: There were 542 and 553 cases in the 2008-2012 and 2013-2017 cohorts, respectively. In the 2013-2017 cohort, patients were older at surgery (65.0 years vs. 67.6 years) and more males (66% vs. 73%) ($P < 0.05$), while %CSM (77% vs. 78%) and JOA scores (10.4 vs. 10.1 before surgery; 13.3 vs. 13.0 at final follow-up) were similar compared with the 2008-2012 cohort. The open-door laminoplasty (50% vs. 69%) was preferred with the higher preservation rate of the posterior muscle-ligament complex attached to the C2/C7-spinous process (C2, 89% vs. 93%; C7, 62% vs. 85%), and the number of laminoplasty (3.7 vs. 3.1) significantly decreased ($P < 0.05$). In the past decade, although the 30-day complication rate remained stable (3.9% vs. 3.4%), the details had changed; in the 2013-2017 cohort, C5 palsy tended to decrease (2.4% vs. 0.9%, P=0.059), but infection-related complications (surgical site infection, urinary tract infection, and aspiration pneumonia) significantly increased (0.6% vs. 1.8%, P=0.017) compared with the 2008-2012 cohort.

Conclusions: From 2008 to 2017, there have been trends toward increasing age at surgery, and surgeons' preference for open-door laminoplasty with refining surgical techniques. The clinical outcomes of laminoplasty were constantly favorable while the 30-day complication rate remained stable. In the last five years, the C5 palsy rate halved, but the incidence of infection-related complications increased by three times.

O512
Decision making for bracing in >40-degree curves

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Introduction: There is a dilemma for bracing at >40° for adolescent idiopathic scoliosis (AIS) as they are known for adulthood progression and hence some may suggest earlier surgery while some may recommend bracing. Large curves are particularly susceptible to further progression during brace treatment and may not be as sensitive to forces applied through bracing. However, there are potential benefits to bracing in these individuals. Some patients may experience brace success with curve regression under the 40° threshold. With good brace compliance and more flexible curves, curve regression may occur even in larger curves.
Aim: To determine the prevalence of non-progressive curves and curve regression in brace treatment for patients with curves >40° and to determine the factors associated with these outcomes.
Patients and Methods: This was a retrospective study of patients with AIS with large curves >40° at the time of brace initiation. All patients who were prescribed with Boston underarm bracing and daily thermal sensor compliance of >16 hours were included. Patients were followed-up from the time of brace initiation until the point of surgery, or at the time of brace-weaning. Data collection was performed at when bracing was prescribed, to weaning and 5-year follow-up after weaning. Clinical data includes gender, chronological age, body height and arm span measurements, and brace compliance by thermal sensor. Radiological data includes major curve Cobb angle, supine flexibility prior to bracing and first in-brace Cobb angle (from which curve flexibility and in-brace correction are calculated), curve pattern (thoracic or lumbar major curve), apical vertebral wedging and apical ratio (convex vertebral height/concave vertebral height), trunk shift, and C7-CSVL. Bone age assessment via Sanders staging, distal radius and ulna (DRU) classification and Risser staging is done prior to brace treatment. Outcome measures include curve progression, static curve magnitude and curve regression. Curve progression is defined as at each visit during brace period with any >5° increase in major curve Cobb angle. A static curve is defined as major curve Cobb angle change ≤ 5°. Curve regression is defined as >5° reduction in major curve Cobb angle.
Results: 75 patients (86.7% females and 13.3% males) were studied. Most were thoracolumbar/lumbar curves (74.7%) followed by thoracic curves (20%). The average pre-brace Cobb was 45.5 degrees (SD5.5) with supine Cobb of 33.7 degrees (SD6.7), first in-brace Cobb of 33.6 degrees (SD10.3). The flexibility rate was 24.1% (SD14.2), correction rate was 27.1%(SD17.7) and supine correction index of 1.08 (SD1.04). At brace weaning, 68% had curve progression, 6.7% had curve regression and 25.3% had a stable curve. There were no differences in age, curve type or curve magnitude between groups. Those with regressed or stable curve were all females and 61.1% of them had very good compliance. Flexibility rate was 22% for the progression group and 26.3% for the regression group. Regression and stable curves were generally older, post-menarche and Risser >0.
Conclusion: Not all >40° curves progress. Those with better compliance and higher flexibility at baseline are more likely to have a better outcome.

O513

Spinal osteotomies to treat adult spinal deformity (ASD): Outcome, complications and risk factors from a prospective multicenter study with inclusion of 286 cases in 273 patients

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Study Design: Prospective multicenter study in adults.
Objective To report clinical and radiological outcomes, complications and risk factors after spinal osteotomy in adult population (grades 3 to 6) with at least 1-year follow-up.
Material and Methods: 273 patients (286 osteotomies) were included from 7 European centers. Only adult patients were included (mean age 63 y-old). The following parameters were calculated pre-operatively and post-operatively at 3-6 months, 12 months and 2 years: VAS, ODI, SRS-22, Neurogenic claudication, neurological status, blood loss, operative duration, use of personalized rod and hospital stay, spino-pelvic parameters (on full spine radiographs). Survival rates without complication were calculated at 1-year, 2-years and 5 years.
Results: Grade 3 osteotomy was observed in 211 cases (73.8%), grade 4 in 50 cases (17.5%), grade 5 in 18 cases (6.3%) and grade 6 in 7 cases (2.4%). The osteotomy was achieved at L4 in 53.6%, at L3 in 21.7% and at the TL junction in 17.8%. A personalized rod was used in 18.5%. VAS, ODI and SRS-22 decreased respectively from 7.2 to 3.3; from 54 to 32 and from 2.4 to 3.4, preoperatively versus at 1-year, $p<0.001$. SVA, PT and lack of lordosis decreased respectively from 121 to 58 mm, 32° to 15°, 29° to 15°, preoperatively versus at 1-year, $p<0.001$. 6% of patients met the Schwab criteria pre-operatively versus 16% post-operatively at 1-year, $p<0.05$. 59.2% of patients presented with at least 1 complication, 8.9% encountered 4 complications or more and mechanical complications were the most frequent (35%). Survival complications-free was 57% at 1 year, 47% at 2 years and 30% at 5 years.
Conclusions: Spinal osteotomies were efficient to improve the ASD patients clinically and radiologically however the complications rates were high. BMI, Diabetes, operative time and pre-operative neurological deficits represented risk factors for post-operative complication whereas the use of personalized rod seemed to be a protective factor.

O514

EMG activity shows surgeons risk overuse injury with manual pedicle screw technique, while power-assisted techniques are protective

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Introduction: A survey of 402 POSNA members reported high rates of upper extremity and cervical pain. A systematic review found 68% of surgeons reported musculoskeletal pain in the neck (48%), and the arms or shoulders (43%). A survey of the Scoliosis Research Society reported a rate of neck pain with radiculopathy of 28%, 100 times that of the general population. The use of power-assisted tools may relieve surgeons of some musculoskeletal burden, but to what extent?

Aim: We use surface electromyography (EMG) to quantify a surgeon's muscle exertion from cannulation to screw placement using both manual and power-assisted technique in a simulated surgical environment.

Materials and Methods: Pedicle preparation and screw insertion was performed bilaterally from T9-L5 in two cadavers with both manual and powered techniques. Manual technique included development of the pedicle tract with a Lenke probe, undertapping by Ø1.0mm, and Ø5.5mm pedicle screws; powered technique used a Ø2.4mm drill bit, a Ø3.2mm blunt threaded reamer, and Ø5.5mm screws. EMG sensors recorded the muscle activity from eight muscle groups: flexor carpi radialis, extensor carpi radialis, biceps, lateral triceps, deltoid, neck extensors, upper trapezius, serratus anterior. Muscle exertion for each muscle group was averaged over the task's duration and normalized by its respective maximum voluntary isometric contraction (MVIC), allowing comparisons between muscle groups. As incidence of fatigue may be reduced if muscle exertion remains near 15% MVIC, multiple t-tests were used to determined statistically fatigue-prone muscle groups (exertion >15% MVIC). Significance set to alpha=0.05.

Results: Power-assisted pedicle preparation and screw insertion does not evoke muscle exertion >15% MVIC for each step in isolation for any muscle group (Figure 1). Conversely, the extensor carpi radialis, biceps, neck extensors, and upper trapezius were prone to exertion (>15% MVIC) at every step of manual pedicle preparation and screw placement. Power-assisted technique reduced total neck and shoulder exertion by 50%.

Conclusion: EMG activity of a surgeon's neck and upper extremity suggest surgeons are at risk for overuse injury when preparing a pedicle tract and placing a pedicle screw using manual techniques. Elevated muscle exertion with manual techniques directly correlates with the self-reported diagnoses of lateral elbow epicondylitis, cervical myelopathy, and shoulder pain in surgeons. In contrast, EMG activity with power assisted techniques fell below 15% MVIC, which may reduce the risk of surgeon injury and fatigue.

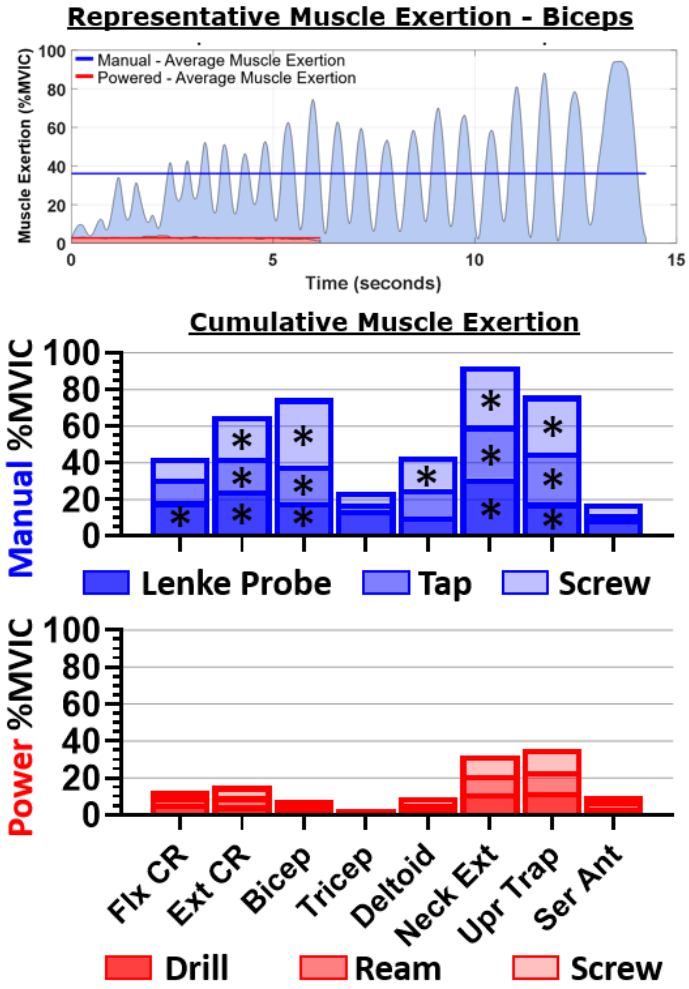

Figure 1. Average muscle exertion was calculated for each muscle group for all steps within manual (probe, tap, screw) and power-assisted (drill, ream, screw) technique. Stacked bars show average muscle exertion for each step; height of the stacked bar shows the cumulative exertion. Every step within the manual technique (probe, tap, screw) yielded average muscle exertion >15% MVIC for the extensor carpi radialis, biceps, neck extensors, and upper trapezius. Significance *: $p<0.05$

O515

Unilateral convex pedicle subtraction osteotomy for correction of lumbar curves in idiopathic adult scoliosis

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Introduction: Adult idiopathic scoliosis often presents with stiff of the lumbar curve and kyphosis of the thoracolumbar junction. Fusion above the sacrum (to L4 or L5) may require revision surgery for distal junctional failure (DJF). Pedicle subtraction osteotomy (PSO) is a powerful surgical technique for destabilizing the spine for deformity correction in both the sagittal and coronal plane. By applying unilateral PSO, neurological risks and intraoperatory blood losses may be limited, providing overall satisfactory correction of the deformity and reduce DJF.
Methods: 22 patients were evaluated respecting inclusion criteria: idiopathic adult scoliosis Lenke 5 or 6, absence of severe sagittal imbalance or fractional lumbosacral curve, with treated curves ranging from 40 to 75°, treated with posterior pedicle screw fusion ending above the sacrum (LIV L4 or L5), unilateral convex PSO at the apical vertebra of the lumbar curve, distal interbody TLIF cage, minimum follow up 2 years. Clinical and radiographic data as well as long term complications are reported.
Results: Mean age was 62.6 years and mean follow up was 2.3 years. Mean operative time was 4.6 hours. Mean intraoperatory blood loss was 0.8 lt and blood transfusion was necessary in all patients. The visual analog scale improved from 8.7 to 2.6. Oswestry Disability index improved from 50.3 to 23.2. Coronal plane scoliosis correction improved from 64.2° to 32.4° for thoracic curves and from 63.1° to 24.4° for lumbar curves. Overall lumbar lordosis improved from 41.3° to a mean 44.5° (this difference was not statistically significant) but kyphosis of the thoracolumbar junction showed a statistically significant improvement from -22.3° kyphosis to 5.8° lordosis. There were no major neurological complications. At 2 years follow up, only 1 patient had to undergo fusion to the sacrum because of DJF (4.5%).
Conclusions: In adult idiopathic scoliosis, fusion above the sacrum may present DJF because of kyphosis of the thoracolumbar junction. Lumbar unilateral convex PSO allows to gain lordosis at the thoracolumbar junction, relieving stress on distal fixation and therefore reducing mechanical complications sparing distal lumbar levels.

O516

Posterior lumbar interbody fusion (PLIF) as a supplement to posterior spinal fusion in patients with adult spinal deformity: A 2 year follow-up on revision rates and sagittal alignment

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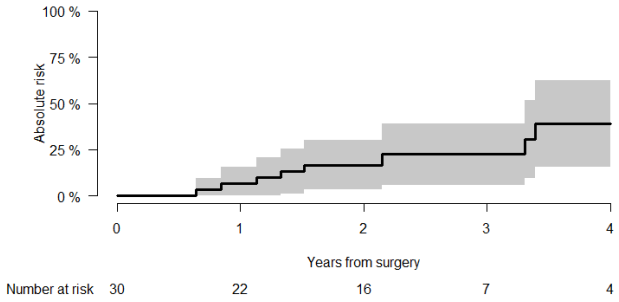
Introduction: Posterior lumbar interbody fusion (PLIF) is a widely used treatment for a variety of spinal disorders. The technique is thought to facilitate restoration of the lordosis and subsequently sagittal alignment, as well as facilitating intercorporal bony fusion thus reducing the risk of mechanical failure. Despite a broad range of indications for the use of PLIF, only few studies have examined the use of supplemental PLIF to posterior spinal fusion (PSF) in patients with Adult spinal deformity (ASD).
Aim: To compare revision rates in patients undergoing PSF with supplemental PLIF compared with PSF at our institution. Furthermore, to report obtained alignment post-operatively and at 2 year follow-up.
Study Design and Materials: In a retrospective study, all ASD patients undergoing PSF with supplemental PLIF during 2016-2020, were included in the study. We defined ASD as posterior fusion of ≥5 levels to the sacrum. Full-spine radiographs were analyzed for spinopelvic parameters; Pelvic Incidence (PI), Pelvic Tilt (PT), Segmental Lordosis at PLIF instrumented level (SL), Lower Arch (Sacral Slope), Upper Arch (Global Lordosis-Sacral Slope), Global Lordosis (GL), L4-S1 lordosis (L4-S1), and Sagittal Vertical Axis (SVA). The rate of revision surgery caused by mechanical failure were obtained an analyzed using competing risk analysis. Mechanical failure was defined as rod breakage, proximal junctional kyphosis (PJK), proximal junctional failure (PJF), or other (screw loosening, screw pullout, dislodgement of cage).
Results: We included 30 consecutive patients with a mean age of 62.7±14.6. In total, 38 levels were treated with PLIF. We had a mean follow-up time of 2.9±1.3 years.
All cause revision rates were 12 (40%) within the follow-up period. Competing risk analysis showed a cumulative incidence of revision surgery of 16.7% (95% CI 3.3-30), within 2 years from operation which is lower, however, not statistically significant from previously reported rates from our institution at 28% (95% CI 22-33).
A significant change was found from pre-operative to post-operative radiograph measurements on; GL (37±14 vs 49±15), SL (14±13 vs 27±10), Upper Arch (8.5±10 vs 15.3±8), SVA (88±46 vs 47±34), (p-value < 0.005). Remaining parameters did not change significantly between pre- and post-operative measures (p-value >0.070).
For patients not undergoing revision, no significant changes were found from post-operative to 2 year follow-up measurements on all parameters (p-value >0.070).
Conclusions: A satisfactory sagittal correction was obtained after PSF with supplemental PLIF, and did not change for patients not undergoing revision within the follow-up time. Supplemental PLIF did not statistically significantly lower the rates of revision surgery within 2 year follow-up compared with PSF alone, however, a lower incidence was observed (16.7% vs. 28%).



O517

The efficiency of preoperative Halo-gravity traction in the treatment of severe spinal deformity

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Introduction: The severe spinal deformity was defined as a coronal or sagittal deformity with a Cobb angle >90°. Without appropriate treatment, it may result in the progress of the curve and a decrease in the patient's quality of life, accompanied by cardiopulmonary dysfunction and curve decompensation. Preoperative Halo gravity traction has been widely used to treat severe spinal deformities, which has been confirmed as a top hit. However, the corrective effect that HGT can achieve is currently unclear, as well as the traction duration and weight.
Aim: To evaluate the efficacy of preoperative Halo-gravity traction in treating severe spinal deformity.
Patients and Methods: This study retrospectively included 33 patients with severe spinal deformity admitted to our department from April 2018 to January 2022, who underwent Halo gravity traction before the correction surgery. The duration of the traction was decided by deformity correction as evidenced by the monthly full-body radiographs, meanwhile taking pulmonary function and nutritional status into consideration. Besides, all patients were divided into two groups according to whether the traction time exceeded three months. We compared the improvement of deformity, lung function, and nutritional status between the two groups.
Results: A total of 33 patients (9 males, 24 females) were recruited for this study with an average age of 17.79±7.96 years. The traction weight started from 1.5kg and raised to 45.2±13.2% of body weight on average progressively. In this study, all patients reached their maximum traction weight within four weeks, with an average traction weight of 45.2±13.2% of patient body weight, and the average traction duration was 129±63 days. After traction, the main curve was corrected from an average of 120.66±3.89° to 94.88±3.35°(Fig.1, $P < 0.05$); PFTs also showed a significant increase in FVC%, FEV1%, and MEF% after traction [43.46 ± 14.76% vs. 47.33 ± 16.04%, 41.87 ± 13.68% vs. 45.19 ± 15.57%, and 40.44 ± 15.87% vs. 45.24 ± 17.91%, Fig.2, $p < 0.05$]. Total protein, Albumin, and BMI were used as indicators of nutritional status. TP and Albumin were significantly improved after traction, from 67.24±5.43g/L to 70.68±6.98g/L and 42.40±3.44g/L 45.72±5.23 g/L, respectively($P < 0.05$). No significant difference was found in deformity correction and lung function improvement between patients with traction for more or less than three months($p>0.05$). Two patients developed brachial plexus palsy during traction. Still, the symptoms gradually disappeared after decreasing their traction weight.
Conclusions: Our study suggests that Halo gravity traction can partially correct deformity and improve pulmonary function and nutritional status to a certain extent, causing an increase in patients' surgery tolerance. So, it can be used as a preoperative adjuvant treatment for severe spinal deformity, but special attention should also be paid to prevent related complications. Besides, traction for more than three months might not be necessary, according to the present study. But it still needs more studies to evaluate its specific traction duration.

Fig. 1

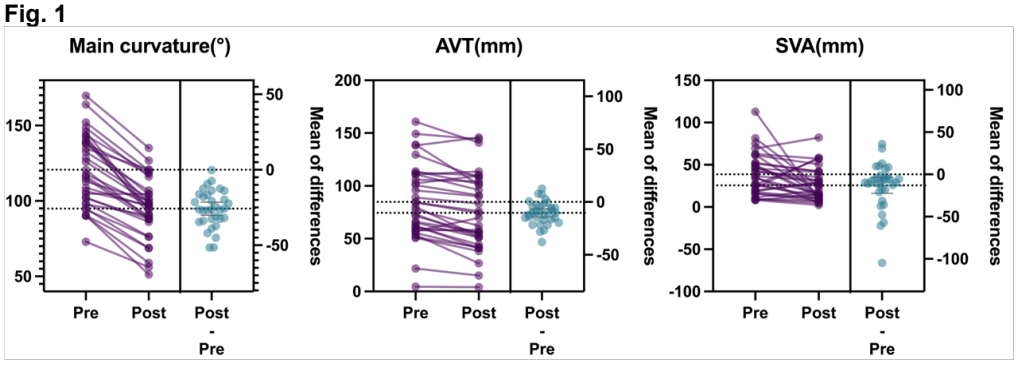
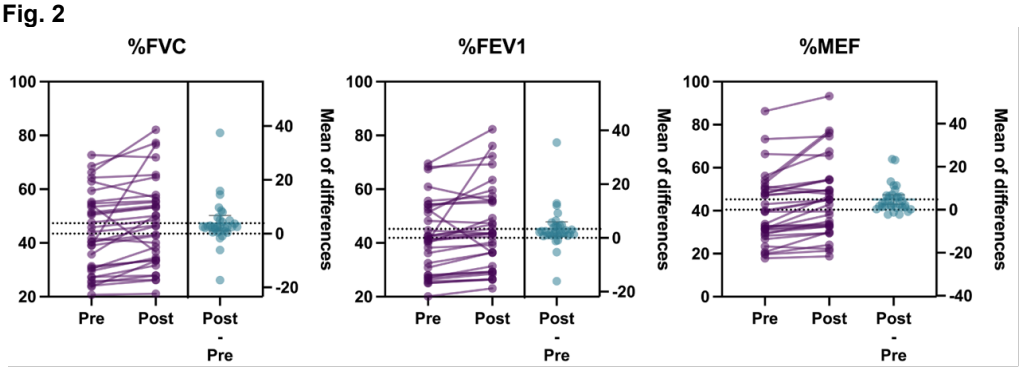


Fig. 2



O518

Distal foundation augmentation enhances the "bridge" role of single traditional growing rod in the treatment of severe early-onset scoliosis

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Background: The implantation of dual traditional growing rod (dTGR) constructs may not always be feasible due to the patient size and severity of the spinal deformity. The concave single TGR (sTGR) could be considered as a starting construct. This study aimed to report the efficiency of distal foundation augmentation (DFA) in patients with severe early-onset scoliosis (EOS) who underwent sTGR treatment, and compared it to sTGR without DFA and the golden-standard dTGR treatment.
Methods: Seventy-four consecutive patients with severe EOS (major curve ≥ 80°) who underwent TGRs implantation (48 sTGR and 26 dTGR) from 2010 to 2021 were recruited. The sTGR cohort was divided into two groups by whether undergoing DFA, which is composed of four pedicle screws with a cross-link. Radiographic parameters, including major curve magnitude, maximal kyphosis (MK), C7PL-CSVL, SVA, T1-T12 height and T1-S1 height, and complications were compared preoperatively, postoperatively, and at the last follow-up before converting to a dual rod instrumentation.
Results: The mean age at the initial TGRs implantation were 32 8.14 ± 1.30 years. The mean follow-up period was 27.17 ± 3.22 months. Twenty-four of the sTGR patients underwent DFA. There was no significant difference in preoperative radiographic parameters among groups. However, compared with the non-DFA group, the DFA group performed better in maintaining the correction of major curve (40.6% vs. 24.0%, P = 0.001), MK (42.2% vs. 22.0%, P = 0.001), C7PL-CSVL (21.00 ± 17.01 mm vs. 31.21 ± 17.84 mm, P = 0.036), and distracting the growing thorax (203.75 ± 24.57 mm vs. 189.19 ± 23.94 mm, P = 0.032) and trunk (340.44 ± 28.99 mm vs. 322.01 ± 31.55 mm, P = 0.044) at the last follow-up. Also, the incidence of implant-related complications (41.7% vs. 75.0%, P = 0.019), especially at distal foundation (8.3% vs. 33.3%, P = 0.033), was significantly lower in the DFA group. There was no significant difference in the outcomes between the DFA and the dTGR group.
Conclusions: For patients with severe EOS who underwent sTGR treatment, DFA could better maintain the deformity correction, distract the growing thorax and trunk, keep the balance, and decrease the incidence of implant-related complications, especially at the distal foundation. This efficiency was similar to the the golden-standard dTGR treatment. Patients could meet the criteria for the conversion to dTGR more earlier after a series of sTGR lengthening with DFA.
Keywords: Early-onset scoliosis; Traditional growing rod; Single traditional growing rod; Distal foundation augmentation; Dual traditional growing rod

O519

Pedicle subtraction osteotomy in the surgical treatment of severe Scheuermann's kyphosis

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Introduction: Severe Scheuermann's kyphosis is typically treated with posterior column osteotomies (PCO) that distribute correction equally among thoracolumbar spinal segments, with potential risk of proximal junctional failure (PJF). Pedicle subtraction osteotomy (PSO) at the apex of the deformity could reduce the risk of PJF by concentrating correction locally and reducing tension at the extremities of the instrumentation.
Methods: We evaluated 18 adolescent patients affected by Scheuermann's kyphosis that were surgically treated with posterior thoracolumbar fusion and pedicle subtraction osteotomy at the apex. Inclusion criteria were adolescent age (12-18 years), kyphosis between 80°and 110°, minimum follow up 2 years. Radiographic evaluation includes pre- and post-operatory kyphosis Cobb angle, apical kyphosis correction (+/-2 levels adjacent to PSO) as well as perioperative and long term follow up complications. Clinical evaluation with SRS-22 questionnaire was performed.
Results: Kyphosis overall correction went from a mean 92° to 43° (46% correction). Mean apical kyphosis correction went from 67° to 29° (43% correction). Correlating mean overall correction (49°) to mean apical correction (38°), we found that almost 78% of overall correction took place at the two levels adjacent to PSO, while the remaining 22% of correction being distributed at the remaining levels towards the extremities. No cases of PJF or mechanical complications were observed. No significant neurological complications were observed. There was significant improvement n HRQL according to SRS scores in all patients from 2.8 pre-op to 2.4 post-op.
Conclusions: In Scheuermann's kyphosis, apical PSO allows to concentrate correction mainly at the apex of deformity, reducing stress at the extremities and potentially preventing PJF.

O520

Intervertebral disc transplantation in the treatment of cervical degenerative disease: An average of 10 years follow-up

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Introduction: To evaluate the clinical outcomes and radiographic changes of intervertebral disc transplantation in human beings in a long-term follow-up.

Methods: Retrospective case series study, 32 consecutive patients with single-level cervical spondylosis underwent intervertebral disc transplantation between March 1, 2000 and December 30, 2015. Clinical outcomes were determined by self-assessment questionnaires, including neck disability index (NDI), visual analogue score (VAS) of neck and upper limbs pain, Japanese Orthopaedic Association (JOA) scoring system, and 36-Item Short-Form Health Survey(SF-36) scores. Any adverse events or revision surgery during the follow up was recorded. All the patients underwent cervical X-ray and magnetic resonance imaging (MRI) to dynamically assess the mobility, stability, alignment and kinematics of the cervical spine and the status of the allograft discs and adjacent segments during the follow up.

Results: Thirty two patients, most of the operated level was C5-6 (n=16), followed by C4-5 (n=9),C6-7 (n=6), and C3-4 (n=1). The average duration of follow up was 10.59±5.44 years. None of the patients developed allograft rejection throughout the follow-up period. 3 patients (9.38%) experienced dysphagia, 1 (3.13%) had hoarseness, and 3 had significant axial pain post-op, that all resolved conservatively. One had radiating pain at 2 years post-op and underwent a posterior unilateral foraminotectomy, after which the pain was gone. Surprisingly, 5 patients showed the allograft discs remodeling with time. Compared with pre-operative values, all the clinical scores (NDI, JOA, VAS, and SF-36) improved significantly and maintained through the follow-up periods. The height of allograft discs declined significantly since 5 years post-op. All the cervical sagittal balance parameters except T1S improved after intervertebral disc transplantation. The allograft discs maintained the ROM of 8.13±2.53° at 5-year post-op and declined to 3.06±2.38°at the final follow-up. The grayscale value of MRI signal of allograft discs improved significantly from 39.12 ±10.78% pre-op to 49.15 ±11.54% immediately post-op, sustained to 46.82±10.59% at 3 years post-op ($P > 0.05$) and declined to 18.75 ±11.66% at the final follow-up ($P < 0.05$). MRI signs of adjacent segment degeneration (ASDeg) were detected in 2 (3.57%) at 3 years, 3 (6%) at 5 years, 8 (21.05%) at 10 years and 9(56.25%) at 10 years. No patients developed adjacent segment disease (ASDis) needing secondary surgery.

Conclusions: Intervertebral disc transplantation is a safe and effective treatment for cervical degenerative disc disease, providing significant improvement and long-term maintenance of clinical efficacy, maintaining the stability of the cervical spine, preserving the segmental mobility, improving cervical sagittal alignment and kinematics, reducing the incidence of adjacent segment degeneration, despite of mild to moderate degeneration of the allograft discs.

O521

Bridging the cervicothoracic junction during multi-level posterior cervical decompression and fusion- a systematic review and meta-analysis

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Introduction: Several studies address the question of whether to extend a long-segment, posterior cervical fusions, performed for degenerative disease, into the upper thoracic spine. Recommendations for appropriate LIV (lowest instrumented vertebra) continue to vary.

Aim: This systematic review seeks to compare fusion, reoperation and complication rates, estimated blood loss (EBL) and surgical time between multilevel instrumented fusions with LIVs in the cervical spine and those that extend into the thoracic spine.

Materials and Methods: A comprehensive computerized literature search through multiple electronic databases without date limits up until April 3rd, 2020 using combinations of key search terms and sets of inclusion/exclusion criteria was performed.

Results: Our comprehensive literature search yielded 3852 studies. Of these, 8 articles consisting of 1162 patients were included in the meta-analysis. In 61.2% of the patients the fusion did not cross the cervicothoracic junction (CTJ) (cervical LIV, CLV). In the remaining 38.8%, the fusion extended into the upper thoracic spine (thoracic LIV, TLV). Overall, mean patient age was 62.5 years (range:58.8-66.1 years). Our direct analysis showed that odds of fusion were not statistically different between the CLV and TLV groups (OR: 0.648, 95% CI: 0.336-1.252, p=0.197). Similarly, odds of reoperation (OR:0.726, 95% CI:0.493-1.068, p=0.104) and complication rates were similar between the two groups (OR:1.214, 95% CI:0.0.750-1.965, p=0.430). Standardized mean difference (SMD) for the blood loss (SMD: 0.728, 95% CI:0.554-0.901, p=0.000) and operative (SMD:0.653, 95% CI: 0.479-0.826, p=0.000) differed significantly between the two groups. The indirect analysis showed similar fusion (Effect Size (ES)$_{TLV}$: 0.892, 95% CI: 0.840-0.928 vs. ES$_{CLV}$:0.894, 95% CI:0.849-0.926); reoperation rate (ES$_{TLV}$:0.112, 95% CI:0.075-0.164 vs. ES$_{CLV}$: 0.125, 95% CI: 0.071-0.211) and complication rates (ES$_{TLV}$: 0.108, 95% CI: 0.074-0.154 vs. ES$_{CLV}$:0.081, 95% CI: 0.040-0.156).

Conclusions: Our meta-analysis showed that fusion, complication and reoperation rates did not differ significantly between patients in whom multi-level posterior fusions ended in the cervical spine versus those of which was extended into the thoracic spine. The mean blood loss, operative time and length of stay were significantly lower in patients with CLV at C6 or C7, compared to their counterparts. These data suggest that, absent focal, C7-T1 pathology, extension of long, posterior cervical fusions into the thoracic spine may not be necessary.

O522

Accuracy and safety in cervical pedicle screw fixation using 3D-printed navigation guides

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Introduction: Cervical pedicle screw is a powerful posterior fixation method but despite repeated efforts for accurate screw placement, screw malpositioning still frequently occurs. This can lead to dramatic vascular and neurological complication due to the close proximity of the vertebral artery and spinal cord.
To avoid this potential complications a new patient-specific screw guide system have been developed.
Aim: This study aims to evaluate the accuracy of cervical pedicle screw placement using a 3D-printed patient-specific guide system.
Patients and Methods: Eleven consecutive patients with degenerative, traumatic and oncologic pathologies were enrolled. They underwent posterior cervical fusion using the proposed guide system. The first step of the workflow was a three-dimensional planning of pedicle screw placement that was done using a simulation software. A screw guide for each vertebra was then printed preoperatively. A total number of 52 screws were inserted using the guides. Postoperative computed tomography was done to evaluate pedicle perforation and the accuracy - according to deviations between the planned and actual screw positions - was measured.
Results: A total of 50 screws (96,2%) were completely inside the pedicle (C2-C7), without neurovascular injuries. Two screws were outside the pedicle (less than 2mm perforation or grade B).
The mean screw deviations from the planned trajectory at the narrowest point of the pedicle and at the entry point in the axial and sagittal planes were both less than 1 mm. There were no significant differences in any parameter at different spinal levels. Angular deviations in the sagittal and axial planes were both less than 2 degrees.
Sagittal angular deviations tended to increase in the cranial vertebra (C3 and C4) compared to the middle cervical spine. The two screws that broke the pedicle were implanted in C3 and C4.
Conclusions: Cervical pedicle screw placement using a patient specific 3D-printed system was found to be an excellent solution for obtaining precise screw insertion and decreasing the incidence of complication. Moreover, given the biomechanical superiority of pedicle screws - compared to lateral mass screws - reduction of the fusion area is a potential big advantage of using cervical pedicle screws.

O523
How does overstuffing affect ROM in cTDA? A biomechanics study

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Introduction: Cervical total disc arthroplasty (cTDA) has become a popular treatment for disc degeneration, as opposed to anterior cervical discectomy and fusion (ACDF). One advantage of cTDA is the ability to restore motion at the operated level rather than restrict it. When motion is restricted at one level, this can lead to stress shielding, overloading at adjacent levels, and adjacent segment disease. A nuance to this concept is sizing of cTDA. For example, biomechanical logic theorizes that over sizing of cTDA devices most likely stiffens cervical joints and diminishes range of motion (ROM). However, the extent of this phenomenon is unknown. In this biomechanical cadaveric study, we set out to determine what effect over-sizing the height or "overstuffing" a cTDA device has on ROM.
Aim: The aim of this study is to measure the biomechanical differences between appropriately sized cTDA device and oversized cTDA in cervical spine specimens.
Materials and Methods: 8 cadaveric cervical spine specimens (C2-T1) were dissected and prepared for biomechanical testing. All specimens were tested in three conditions: native, 2-level cTDA at C4-C5 and C5-C6, and 2-level cTDA at C4-C5 and C5-C6 with one level upsized by 1 mm in height (overstuffing). A mobile core cTDA device (Mobi-C, ZimVie Spine, Westminster, CO) was utilized for all implantations. For the overstuffing intervention, the specimens were split into 2 groups, with half of the specimens overstuffed at C4-C5 and the other half overstuffed at C5-C6. Each specimen was tested after each intervention using a six degree-of-freedom dual gimbal servo-hydraulic spinal simulator (Bionix Spine Kinematics system, MTS Corporation, Eden Prairie, MN, USA). The specimens were driven kinematically in pure-moment flexion-extension (no shear loading) testing up to ± 2 Nm. Range of motion was tracked using optoelectronic motion trackers (Optotrak Certus Motion Capture System; Northern Digital Inc. Waterloo, ON, Quebec). Total ROM (C2-T1) as well as ROM at the index levels (C4-C5) was recorded. Shapiro-Wilk tests were used to determine if the datasets were parametric or not, and the appropriate 1-way ANOVA tests were performed to determine significance ($p<.05$).
Results: Overstuffing significantly decreased ROM, leading to a 15% drop in total ROM at C2-T1 (Figure 1, left). In addition, overstuffing caused a 55% and 53% drop in ROM at the index levels, C4-C5 and C5-C6 respectively (Figure 1, center and right). No significant differences were measured in ROM for the entire cervical spine as well as the index levels between the native and 2-level cTDA interventions. For 100% of C4-C5 levels and 50% of C5-C6 levels, a 6 mm height cTDA device created overstuffing.
Conclusion: Overstuffing of a cervical disc by as little as 1 mm created significant drops in ROM for the entire cervical spine in addition to the creating a quasi-fusion at the index level.

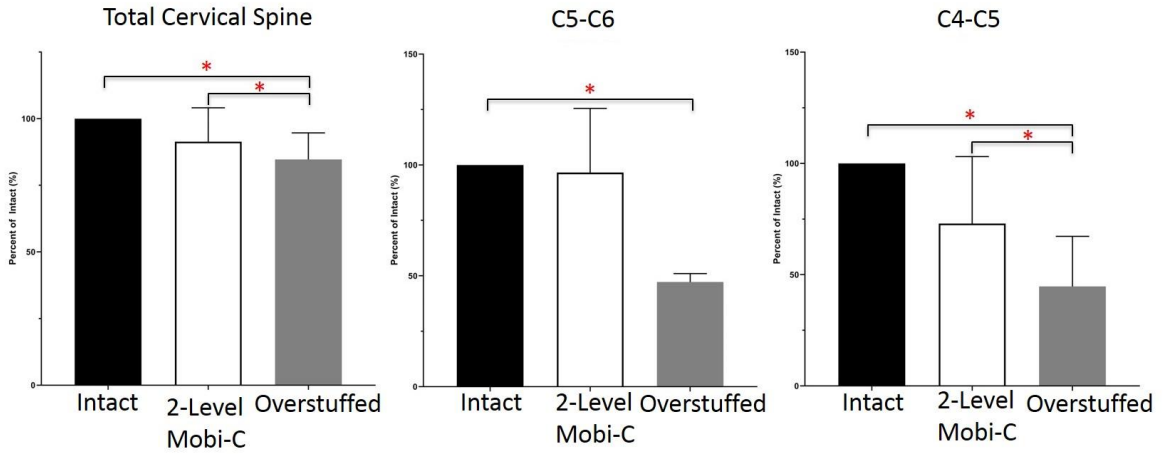

Figure 1: Maximum ROM for the total cervical spine and the index levels (C4-C5) for intact, 2-level Mobi-C, and 2-level Mobi-C with 1 level overstuffed by 1mm.

O524

Removals and revisions of cervical total disc replacement devices in a consecutive series of 1,473 patients beginning with the first case experience in 2003

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Introduction: Cervical total disc replacement (TDR) has gained acceptance as an alternative to fusion in appropriately selected patients. Clinical outcomes have consistently been reported to be similar or superior to anterior cervical discectomy and fusion (ACDF). Initially, there were concerns about the safety or these devices. One measure of safety is the need for subsequent surgery related to problems with the devices.
Aim: The purpose of this study was to investigate the rate of cervical TDR device removal or revision.
Patients and Methods: The consecutive series of 1,474 cervical TDR patients, beginning with the first case experience in 2003 and ending with cases in December of 2019 to allow for minimum 2-year post-operative timeframe, was reviewed. The series included TDRs at one, two, or three levels, and hybrids. Cases of removal/revision were recorded as well as the reason for subsequent surgery, the procedure performed, and the duration from the index procedure. General patient descriptive information was also recorded.
Results: In the series of 1,474 patients, there were 20 cases of TDR removal or revision, producing a rate of 1.36%. Removal was performed in 16 cases (1.09%) and revision in 4 cases (0.27%). Based on the 1,879 devices implanted, the rate of revision/removal was 1.1% (21 devices). Removals included 5 cases of osteolysis with/without P. acnes, 3 involved device displacement/migration, 4 stenosis/facet changes, and one of each of the following: presumed metal allergy, esophageal tear and related complications, malalignment (also included ASD), and subsidence. The 4 revisions included: replacement with a smaller implant design (original device was too large and migrated anteriorly), repositioning of the TDR (positioned off midline and patient had radiculopathy), treatment of persistent stenosis (treated and replaced TDR with a different device design (all 3 of these revisions occurred within 17 days of the index surgery); the remaining revision occurred 39 months post-index and involved replacing the TDR with a different device design due to hypermobility. In all of the removal/revision cases, the procedures were performed as planned without incident. In this series, 157 patients were more than 10 years post-TDR. In this subgroup, there were no removals/revisions. The longest duration from implantation to removal/revision was 67.5 months (performed due to severe osteolysis).
Conclusion: In this large consecutive series of patients, 1.4% of cervical TDRs were removed/revised. This low rate of removal/revision in this large institutional experience over a long period of time provides support for the safety of these devices.

O525

Long-term clinical outcomes after one-level lumbar total disc arthroplasty: 7-21 years follow-up of 772 patients, comparing never operated versus operated and with versus without disc herniation

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Introduction: LBP due to DDD, with or without disc herniation is the most common occupational disorder worldwide. Some patients with 1-level disease present long-history of LBP with or without disc herniation. After unsuccessful conservative treatment the surgical choice has been balanced between discectomy and arthrodesis. But discectomy if it decompresses the root(s) doesn't treat disc degeneration, neither avoid recurrent herniation. Arthrodesis has been indicated, as first option in some advanced degeneration, with or without disc degeneration but more often after prior discectomy. The few published evidence don't compare Total Disc Arthroplasty (TDA) long-term results with or without disc herniation.
Methods: A total of 772 chronic lumbar DDD 1-level patients with a mean age of 41years old underwent lumbar TDA (1999-2013). 550 patients had never been operated on, in those 200 had no disc herniation (Group H0), and 350 had a disc herniation (Group H1) (Table 1). 222 patients had been operated with discectomy at the index level, in those, 124 had a recurrent disc herniation (Group H3), and 98-no recurrent disc herniation (post-discectomy syndrome). Indications for a TDA have been decided on clinical status, long-term LBP and more recent leg pain, resistant to conservative treatment, radiographic explorations and MRI. Patients have been evaluated for ODI, VAS Back and VAS Leg Pain preoperatively, 3-6-12-24-month follow-up (12.1 Years) control visit. They also got preoperative and postoperative static films, pelvic parameters evaluation and dynamic X-Rays.
Results: All groups showed a dramatic and statistically significant ODI reduction by 3months post-surgery ($p<0.001$) with final gain between 28-30 points. Already operated groups(H2-H3), took longer time to reach the non-operated groups (H0,H1).The ODI at follow-up and the gain showed no statistical differences in the different groups (Table 2).Although patients with prior surgery (groups H2,H3) took longer to reach final VAS pain levels: 6 months for the recurrent disc herniation (H2) and 12 months for the post-discectomy syndrome (H3), but there was no statistical difference between groups in pain reduction, back/leg pain, at 24months. Although not-statistically significant, the group with highest preoperative VAS pain (group 2) had the greatest reduction in pain. At 24 months, there is no statistical differences in groups between VAS back/leg pain (Tables 3,4).The presence of disc herniation (Groups H1,H2) has no influence on the result vs the H0 and H3 groups. Out of the 772 patients, 25 had a revision surgery(3.2%), including posterior release(0.25%),2-with hematoma(0.25%),5-index-level revisions(0.36%), patients operated in 2000-2001 (learning curve), and 16 new operations for adjacent level degeneration (2%), in 28 months delay(6-168)(Table 5).This short delay for adjacent level surgery confirms the long-term protection of the adjacent levels after TDA.
Conclusions: One of the largest cohort of 1-level TDA patients, this study demonstrates the robust long-term clinical success of lumbar TDA at 7-21 years postoperatively. The 4-group classification (H0,H1,H2,H3) reflects different clinical preoperative situations: prior surgery or not, presence of disc herniation or not. Already operated patients take between 6-12months to meet the other groups' positive progress. Patients maintained reduction in disability, pain scores over time, and low-rates of index revision/reoperation or ALD when compared to long-term published fusion data.

O526

Mobility parameters in two-level lumbar TDR vs hybrid construct: Clinical results in 235 patients

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Introduction: Lumbar Total Disc Replacement (TDR) is a treatment option with 30 years experience and extensive publications on clinical results. However, there are few publications on mid- and long-term mobility. There is sparse literature on the quality of mobility or the difference between L4-S1 2-level TDR vs TDR/ALIF Hybrid constructs. Objectives: to measure mobility parameters in flexion-extension for both groups; compare motion at L4–L5; participation of pelvis mobility; global lumbar motion; and flexion-extension effectiveness by measuring L1 Race. Besides determining the difference of mobility between TDR and Hybrid, we discussed potential compensations above and below L5-S1 fusion/L4-L5 TDR, as compared to two-level TDR.
Methods: 235patients were operated between 2003-2013: 170 patients received 2-level TDR (TDR group) and 65 received L4-L5 TDR and L5-S1 ALIF (Hybrid group).
Both groups were equivalent in age, body habitus, preoperative clinical parameters (ODI, VAS). Patients' selection for evaluation was based on presence of clinical success criteria and pre- and postoperative sagittal X-rays and dynamic flexion-extension films at minimum 24months follow-up. Data collected included radiographic, neurological/physical assessment, self-evaluation using the Oswestry Disability Index (ODI), Visual Analog back and leg pain Scores (VAS). Complication, reoperation/revision rates, and perioperative data points were also assessed. Pelvic parameters (Incidence, Pelvic Tilt, Sacral Slope) were measured. L4-L5 and L5-S1 flexion-extension range of motion (ROM) was measured pre- and postoperatively. Pelvic motion was determined by measuring sacral slope in flexion-extension. The influence on lumbar lordosis (L1-S1) was also analyzed. To show the effect the lumbopelvic complex has on global motion, we measured L1 Race (flexion-extension L1 ROM).
Results: The absolute motion and relative gain of 2-level TDR shows its superiority over Hybrid constructs in all measured parameters. When L5-S1 is fused, there is no compensation from pelvic motion to overcome the loss of mobility. TDR group shows a pelvi-femoral ROM gain of 16.77º, vs a gain of only 6.11º in the Hybrid group.
L5-S1 fusion also reduces L4-L5 TDR mobility in Hybrid group, compared to 2-level TDR, and decreases flexion compared to baseline. There is a mean reduction in ROM of 1.53° in Hybrid group vs 20.02° gain in TDR group.
L1 Race also reflects the superiority of 2-level TDR vs hybrid with a gain of 32.58° in TDR vs 4.68° in Hybrid, demonstrating that reduced global motion is principally due to loss of L5-S1 motion.
Conclusions: This comparison between 2-level TDR and Hybrid demonstrates a lack of compensation through lumbar mobility and pelvic motion when L5-S1 is fused, and debunks these preconceived ideas. Although clinical measures of activity (ODI) and pain (VAS back and leg pain) are equivalent between the groups, functional superiority of 2-level TDR is confirmed. Two new ROM parameters introduced here-Pelvic motion and L1 Race must be integrated in all ROM studies as they quantify pelvic participation in mobility and the functional effectiveness of motion preservation. In this first long-term comparison of mobility between 2-level TDR vs L4-S1 Hybrid,2-level TDR demonstrates overall superiority. Consequently,2-level TDR must be systematically indicated whenever TDR is indicated for both levels, and accepted as the "gold standard "for reimbursement purposes.

O527

What perioperative factors are associated with high-risk daily morphine milligram equivalent totals in spinal decompressions?

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Introduction: Morphine Milligram Equivalent (MME) dosing recommendations were introduced in 2016 by the Centers for Disease Control and Prevention (CDC) as a guideline for primary care providers to aid in understanding the cumulative effect of opioids and the risk associated with long term use in chronic pain patients. The formula is defined as: Strength per Unit X (Number of Units/Days Supply) X MME = MME/Day. Daily dosages of ≥ 100 MME/day are associated with an almost nine-fold increased risk of overdose. Current general recommendations endorse the lowest effective dose and ≤ 50 MME/day. We sought to understand how many patients undergoing decompressive surgery received opioids at higher risk doses and which patient demographic and historical factors could predict this higher risk.
Methods: Retrospective analysis was conducted on 85 patients that underwent spinal decompressive surgery within a multi-center network over 2 years. Average MME/day was calculated as the sum of qualifying inpatient MMEs administered divided by the sum of inpatient length of stay (LOS). 21 independent variables were collected from demographic, clinical and surgical domains and were subject to comparative analysis. Data was then grouped and coded for logistic regression analysis.
Results: Overall mean MME per day was 56.1 ± 41, with a range of 1.7-220 MME/day. “High MME” was defined as greater than the overall upper quartile value, 75.03 MME/day. A total of 21 patients were determined to have “High MME” during their inpatient stay. Patients with high MMEs were significantly younger (mean age 50.9 ± 17.5) than those with lower MMEs/day (69.2 ± 12.2), p=6.71E-05. Patients with high MMEs were also significantly more likely to carry a psychiatric diagnosis (anxiety, depression, bipolar disorder) (43.8% [n=14] vs 13.2% [n=7], p=0.00156). Additionally, patients who had high MMEs had lower ASA scores (2.4 ± 0.5 vs 2.7 ± 0.6) and reported higher preoperative Visual Analog Scale (VAS) pain scores (4.6 ± 2.8 vs 2.6 ± 3.4) than patients with lower MMEs/day. There were no significant demographic or intraoperative factors between the two groups, nor any significant difference in LOS. When subject to logistic regression, the final model identified for each unit decrease in age grouping increased the risk of high MME 0.31 times or 69.4%. A psychiatric comorbidity increased the risk of high MME by 8.7 times, or 770%.
Conclusions: Patients with high MME/day who underwent spinal decompression were significantly younger with lower ASA scores, and higher preoperative VAS scores than those with lower MME/day. The incidence of psychiatric comorbidity was also higher in those with high MMEs. Psychiatric comorbidity in younger patients predicted a significant increased risk of higher MME. Pre-operative opioid risk education and mitigation strategies should be considered in patients with high MME risk, especially in younger patients and those with psychiatric comorbidities.

O528
Women in spine surgery

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Introduction: The spine is the lowest-ranked fellowship among women in orthopedics at 2%. Exploring the factors that impact the choice of pursuing a spine fellowship can reveal deficiencies due to which there is a low percentage of women pursuing spine surgery.
Aim: To explore the factors that impact the choice of women while pursuing spine fellowship in orthopedic surgery and the experiences they face during the application and interview process.
Methods: A 37-question survey based on a published study by Hansen was developed which explored the negative aspects of pursuing spine fellowship by women. The survey was disseminated to all the members of the American Orthopedic Spine Association, and orthopedic spine fellowship programs, and distributed on social media to both orthopedic surgeons and neurosurgeons.
Results: A total of 62 responses were received out of which 63% were female and 37% were male. 7 (11%) responders were neurosurgeons with 1 (14%) being female, and 54 (87%) being orthopedic surgeons with 38 (61%) being female. All the men that took the survey were married while 68% of the females were married. A total of 53% of respondents reported that they pursued the spine fellowship because they enjoyed the subspecialty, and 69% reported that they were influenced by a role model to go into the spine sub-specialty with only 7% of those role models being female. A total of 94% were not influenced by the physical aspects of performing spine surgery including the perception of strength, case duration, or standing for the majority of the case. Only 4% of women were negatively influenced by case duration/posture or standing for long periods that are involved in spine surgery. Overall, 16% of the respondents were discouraged to do a spine fellowship by an attending or a program director. Among the respondents who were discouraged to pursue a spine fellowship, 10% were women and 6% were men. Out of the female respondents, 22% of them felt that they were discriminated against during their fellowship interview, while none of the men felt they were discriminated against during their interview. Additionally, the women commented that they were bullied, harassed, and taken to a strip club, and one female respondent reported that she was told that she was competing against “the other female”. Twenty-four of the responders were asked negative questions during their fellowship interview of which 16% were male while 84% of them were females. The negative questions included age, pregnancy plans, and marital status/significant other. Eleven answered yes to feeling discriminated against during their fellowship year. Of these individuals, 78% were women and 22% were men who felt they were discriminated against during their fellowship by being bullied, harassed, sexually harassed, or being a DO.
Conclusions: The low percentage of women in spine surgery may be attributable to a lack of role models, the interview process, and experiences during their fellowship year. Women need to be encouraged, supported, and inspired through their medical education to increase the number of females in spine surgery.

O529

External leverage technique for lordosis restauration in minimally invasive Transforaminal Lumbar Interbody Fusion (TLIF). Surgical technique and intraoperative radiological results

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Introduction: Minimally invasive TLIF has been criticized for its kyphosing effect. We believe this is due to the absence of contralateral release and efficient posterior compression techniques for lordosis restauration. Due to lack of space for direct compression, we designed an external technique that allows indirect compression of the instrumented level.
Aim: We describe a two-part technique that allows lordosis restoration in MISS-TLIF patients comprising intraoperative release an external leverage technique.
Material and Method: Prospective descriptive study of a 30 patient cohort with degenerative lumbar disease that underwent posterior one-level MISS-TLIF performed by the same surgeon. The technique comprises a double intermuscular (Wiltse type) approach to insure complete facetectomy in the contralateral side of cage placement, thus allowing posterior release. After rod placement, the proximal screw is closed and both legs are elevated over the pelvis in 45° angle. The distal screw is closed in a forced hyperextended position. Lateral fluoroscopy was performed at T0: Before incision, T1: When all osteosyntheses material is in place and the contralateral facetectomy was done but no external maneuvers where yet performed and T2: After external leverage maneuvers and system closure.
All patients used the same brand and type of cages; boomerang type, porous titanium, but with two lordotic angles (5° and 15°).
Local lordosis was measured considering the superior endplate of the proximal vertebra and the inferior endplate of the distal vertebra, measurements were in Osirix (Pixmeo, Paris, France) by the same person, who was not the surgeon.
Statistical analysis was performed in SPSS (IBM, Chicago IL, USA); two-tailed t-student was used to analyze radiological measurements and ANOVA for cage type at different surgical timing. ($p<0.005$).
Results Between T0 and T1 local lordosis decreased 1.1° (18.66± 9.8/17.56± 8.0) ($p=0.214$); It increased 3.2° from T1 to T2 (17.56± 8.0/21.88± 8.08.63; $p<0.002$) and increased 4.3° from T0 to T2 (18.66± 9.8/ 21.88± 8.6; $p < 0,001$). Regarding cage usage at T0 to T1 $p=0.328$, T1 to T2 $p=0.413$ and T0 to T2 $p=0.466$.
Conclusion: The addition of intraoperative posterolateral facetectomy, allows posterior release which facilitates lordosing maneuvers. External leverage techniques with leg hyperextension over the pelvis are efficient in increasing local lumbar lordosis in patients undergoing MISS-TLIF. Cage lordosis does not impact lordotic restoration. We recommend the use of this technique to avoid a kyphosing result.

O530

Identification of risk factors associated with 30-day readmission of patients undergoing cervical spine surgery by the anterior and posterior routes: A metanalysis

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Aim: To carry out a systematic review of the literature to identify risk factors associated with 30-day readmission of patients undergoing cervical spine surgery via the anterior and posterior routes.

Methods: The database used to select the papers was PUBMED, using the following search strategy: patient AND readmission AND (30 day OR "thirty day" OR 30-day OR thirty-day) AND (spine AND cervical).

Results: Initially, 179 papers that responded to the established search sequence were selected. After reading the titles and abstracts, 46 were removed from the sample for not being compatible with the theme proposed for this review. Of the 133 remaining papers, 109 were also excluded after a detailed reading of their content, leaving 24 that were included in the sample for the meta-analysis.

Conclusions: The average readmission rate in the evaluated studies was 4.85%. Only the occurrence of infections, as well as the presence of patients classified by the American Society of Anesthesiology (ASA) assessment system with scores greater than III, were causal factors that influenced the readmission of patients. No significant differences were noted when comparing the anterior or posterior surgical access routes.

Level of Evidence II; Systematic Review of Level II or Level I Studies with discrepant results.

O531

Surgical blood loss in spinal fusion is related to the brand of tranexamic acid used in the surgery

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Introduction: The use of Tranexamic acid (TXA), is widely spread as means to avoid intraoperative bleeding. Pharmaceutical bioequivalence is often accepted after laboratory testing, however empiric results may differ.
Aim: To analyze two cohorts of patients treated with the same surgical technique in which two different brands of Tranexamic acid (TXA) was used.
Material and Method: Retrospective cohort blinded study in one hospital. 125 patients who underwent 270º instrumented fusion with the *L-TLIF* technique operated between 2010 and 2022. All patients followed the same protocol: IV TXA 30 mg/ kg in bolus, injected 45 minutes before incision. The surgical technique, surgical and anesthesiology team remained unchanged. Unbeknownst by the surgical team, the brand of TXA was changed from the original to a bioequivalent in January 2022. Patients who underwent surgery before this date with the original TXA were classified as TXA1 and those after this date with the bioequivalent brand as TXA2. We analyzed differences in intraoperative blood loss (mL). We searched for explanatory variables for bleeding, and performed regression analysis models.
Statistical analysis was performed using t-student, Mann-Whitney test, chi-square, Kolmogorov-Smirnov for testing uniformity of distribution, and Shapiro-Wilkinson for testing normality of distribution when needed (p-Value 0.005).
Results: Blood loss was significantly less in the TXA1 cohort (table 1). Both groups where demographically similar regarding sex, diagnosis, smokers condition, and ratio of patients operated as a revision surgery. Surgical time did not vary in both groups. Age showed different distribution in both groups. However, after adjusting by age, expected bleeding remained significantly higher in the TXA2 group. Incidental durotomy also showed different distribution in both groups, however, in the multiple regression model, durotomy didn't show significant weight with regard to the bleeding amount, in comparison to the other predictive factors. Variables which showed significant correlation with amount of bleeding where: brand of TXA used, number of segments fused, surgical time, age, intraoperative complications, and diagnostic group. Hospital stay correlated with the amount of surgical bleeding.
The predictive model, using multiple linear regression analysis is:

Bleeding amount (mL) =

α *(Brand of TXA)* + β *(number of fused vertebrae)* + *(1.192 by surgical time in minutes)* + *(4.132 by age in years)* +γ *(preoperative diagnostic group)* + δ *(type of intraoperative complication)* - *159.383 (constant value)*.

R^2= 0.577

Where

α**= 0** for TXA1
283.524 for TXA2

β**= 0** for two vertebrae
128,793 for three vertebrae

γ**= 0 in the degenerative group**
50.94 in the stenosis group
-35.742 in the spondylolisthesis level fusion group

δ**= -57.522 in the no complications group**
0 in the durotomy group

Conclusion: Different brands of TXA are not bioequivalent in clinical situation: we found differences regarding intraoperative bleeding. Surgical teams must be advised of any such changes and a thorough follow up must ensue.

Table 1

	TXA 1 group	TXA 2 (Group)	P. value
Bleeding (ml)	334.286 ±45.505	681.8181 ±179.81	**<0.001**
Sex	60% F, 40% M	60% F, 40% M	0.637
Diagnostic group (Degenerative, stenosis, spondylolisthesis)	Degenerative= 73.7% Spondylolisthesis= 18.4% Stenosis= 7.9%	Degenerative= 81.8 % Spondylolisthesis= 9.1% Stenosis= 9.1 %	0.945
Smokers	29.8%	27.3%	0.859
Revision Surgery	14.8%	27.3%	0.249
Surgical Time (minutes)	200.714 ± 12.176	181.818 ± 25.283	0.346
Age (years)	47.953 ± 2.347	59.897 ± 7.421	**0.003**

O532

The use of o-arm and radioscope in spine surgery: A comparative study

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The great advance in the use of new devices and imaging systems in surgeries aims to reproduce an ideal and safe scenario for the surgeon, the team and the patient. New systems and devices are constantly available to demonstrate and facilitate intraoperative navigation, thereby seeking to reduce errors and avoid complications for the patient and staff. This study aims to evaluate and compare the use of the O-arm® system and the use of radioscopy in the freehand technique in spine surgeries. For this, searches were carried out in PubMed and Embase for randomized and non-randomized studies on the use of the O-arm® system and radioscopy in spine surgery, performing a comparative study regarding procedure time, accuracy of introduction, effective radiation dose, safety and efficacy. It was concluded that the use of the O-arm® is associated with a reduction in the occurrence of malposition of implants and more safety for instrumented procedures, but without evidence that its use can result in less surgical time. Evidence level 1, diagnostic analysis and studies, investigation of a diagnostic test.
Keywords: Dosage, Efficacy, Radiation, Safety, Complications.

O533

The utility of electrophysiological examination measuring F-waves and compound action potentials of upper extremities for prognosis of the symptom of cervical radiculopathy

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Introduction: Most patients with cervical radiculopathy are effectively treated by conventional and non-invasive methods. However, some patients do not respond to these treatments, and there is currently no way to predict which patients will respond.
Aim: The aim of this study was to determine the usefulness of measuring F-waves and compound action potentials (CMAPs) of the upper extremities to predict response to non-invasive treatment in patients with cervical radiculopathy.
Materials and Methods: In this study, we included seventeen patients diagnosed with C6, 7, 8 cervical radiculopathy. We measured F-waves and Erb-point-stimulated CMAPs in all patients and analyzed the relationship between these findings and changes in symptoms over three months. We assessed F-waves in bilateral median and ulnar nerves. Each nerve was stimulated with a supramaximal current intensity using 52 consecutive stimulations. The F-wave parameters included the incidence and chronodispersion of F-waves. We also analyzed the amplitude of Erb-point-stimulated CMAPs in the affected side of upper extremities comparing with unaffected side. Erb-point-stimulated CMAPs were recorded in the muscles with decreased level of MMT (less than or equal to 4) and compared with the opposite side.
Results: Ten patients did not respond to conventional treatment. In these ten patients, five patients needed specific nerve root block, and four patients required surgical treatment following nerve root block. In these non-respond patients, eight patients showed a decreased incidence of F-waves (<70%) or an increased chronodispersion of F-waves (>150%) on the affected side compared with unaffected side. Furthermore, in two of three patients who had surgical treatment, the amplitude of CMAPs on affected side was decreased to <30% compared with unaffected side.
The remaining seven cases, were successfully treated with conventional medication, showed an incidence of F-waves on the affected side of >70%, and no increased chronodispersion of F-waves (<150%) respectively, compared with the unaffected side. They also showed no decreased amplitude of CMAPs in upper extremities.
Conclusion: A decrease in the incidence of F-waves suggests a reduction in the number of anterior horn cells. And an increase in the chronodispersion of F-waves is also influenced by conduction disturbance due to proximal segmental demyelination. In this study, the ten patients who did not respond to conventional treatment had a significantly lower incidence or increased chronodispersion of F-waves on the affected side compared with the unaffected side; this was not seen in patients who responded to the treatment. It is possible that patients with cervical radiculopathy with fewer anterior horn cells and severer conduction disturbance, resulting in a decreased incidence or increase of chronodispersion of F-waves, may be resistant to conventional treatment. In this study two cases with decreased percentage of amplitude of CMAPs in affected side required surgical treatment as muscle strength weakness was continued. This indicated that measuring Erb-point-stimulated CMAPs may be useful for prediction of need of surgical treatment in near future.
The analysis of F-waves and CMAPs in upper extremities of patients with C6,7,8 cervical radiculopathy could be prognostic of changes in symptoms and need for surgery within three months.

O534

Analysis of cervical sagittal parameters in patients with rheumatoid arthritis

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Objective: To analyze the cervical sagittal parameters of patients with rheumatoid arthritis (RA) and compare them with the param- eters obtained from healthy patients in a sample of the Brazilian population.

Methods: Epidemiological data were collected and 72 radiographs of the cervical spine in the sagittal plane were evaluated by measuring the cervical sagittal parameters COG-C7 (distance measured between the center of gravity of the head and the C7 plumb line -cranial offset), C2-C7 lordosis (vertebrae from C2 to C7), T1S (T1 slope), TIA (thoracic inlet angle) and NT (neck tilt). Statistical analysis was performed using the Student's t and chi-square tests.

Results: The TIA and NT values in the RA group were 88.8° ± 12.6° and 54.5° ± 9.3°, respectively, while for the control group, they were 77.7° ± 7.9° and 50.5° ± 7.7°, respectively, the RA group values being statistically higher than the control group values ($p < 0.001$ and $p = 0.050$, respectively). The values obtained for COG-C7, C2-C7 lordosis and T1S for the RA group were 9.4 ± 16.4mm, 25° ± 22.4° and 2.6° ± 10.1°, respectively, while for the control group they were 11.8 ± 17.6mm, 26.8° ± 12.5° and 30.9° ± 8.4°, respectively.

Conclusions: Patients with RA present changes in the thoracic inlet parameters as compared to the control group, with a statistically significant increase in the TIA and NT values, outlining a characteristic compensatory pattern for maintaining cervical sagittal balance. *Level of evidence III; Controlled cross-sectional study*.

O535

Transforaminal endoscopic lumbar discectomy: Learning curve and survival rate of a case series

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Introduction: Transforaminal endoscopic lumbar discectomy (TELD) has well-recognized advantages and disadvantages in the literature. Some of the mentioned disadvantages are insufficient discectomy, higher recurrence rate and long learning curve (LC). The objective of this study is to describe the LC and analyze the survival rate of patients operated through TELD.
Method: Evaluation of 41 cases operated through TELD by the same surgeon from June 2013 to January 2020, with a minimum follow-up of 6 months. Demographic data and information on surgical time (ST), complications, hospital stay, hernia recurrence and reoperations were collected. The survival rate of the TELD was analyzed using a Kaplan-Meier curve.
Results: The mean ST in the first 23 cases was 111 minutes (SD=30) versus 78 minutes (SD=17) in the last 18 ($p = 0.0001$). The hernia recurrence rate was 17%, and 7% in reoperation. Survival rate was 81% at 7 years, being 100% in the last 18 cases against 70% in the first 23 ($p=0.02$). Two complications were found in the first 23 cases, and none in the last 18.
Conclusion: We consider that an adequate LC is achieved as a higher survival rate without complications and with a significant reduction in ST after approximately 23 cases operated through TELD.

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O536

Comparison of two safety methods in the installation of pedicle screws used in minimally invasive spine surgery

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Introduction: The presence of misplaced pedicle screws is a situation that can be associated with different degrees of neurological deficit.
Several techniques have been developed to increase the safety of spine surgery, each one associated with different degrees of misplaced pedicle screws.
The objective of this study is to compare the results in the installation of pedicle screws in minimally invasive spine surgery, with the assistance of electrical screw stimulation vs. the use of dynamic impedance guidance.
Materials and Methods: The positioning of pedicle screws in patients undergoing spinal fixation surgery with minimally invasive technique between 2015 and 2018 is analyzed retrospectively. The group of patients in which intraoperative neurophysiological monitoring with electrical screw stimulation was used was analyzed separately, and a second group in which an impedance measurement system was used as surgical assistance. In all cases, during the postoperative period, computed tomography of the spine with 2 mm cuts was performed, in which the type of medial breach was defined taking as reference the imaging classification defined by Castro et al.
Results: Of a total of 63 patients operated with minimally invasive spine technique, 304 installed screws were analyzed, of which 26 patients were operated with the direct screw stimulation assistance method, and 37 were operated with the assistance method using impedance measurement. In addition to the two methods outlined above, fluoroscopy was used for the installation of all screws.
A total of 304 screws were installed. In the group of patients operated by impedance measurement, 175 screws was in optimal position (97.2%), suboptimal 4 (2.2%), and 1 misplaced (0.6%), while in the patients in which it was used direct electrical stimulation of screws, the amount of screws that remained in optimal position was significantly less 110 (88.7%), increasing in suboptimal position 8 (6.5%), and misplaced 6 (4.8%).
Conclusion: Of the two methods analyzed to add security to minimally invasive lumbar spine surgery, the dynamic impedance guidance system was significantly associated with a lower percentage of suboptimal and poorly positioned screws, which leads us to reflect on the real utility of some previously validated methods in open surgery, which could lose real effectiveness when changing surgical technique, given the physical and anatomical differences with minimally invasive surgery.

O537

Comparison of preoperative quality of life questionnaires in a population with lombar stenosis

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Objective: To correlate the four quality of life questionnaires: Oswestry Disability Index (ODI), SF-36, Swiss Spinal Stenosis Questionnaire (SSS), EQ-5D in patients who have not undergone surgical treatment of lumbar stenosis.
Method: Forty patients with diagnosis of lumbar stenosis accompanied at a university hospital answered four quality of life questionnaires in a preoperative consultation. The scores of each questionnaire were tabulated and then compared. In the statistical analysis, the Spearman correlation was performed.
Results: 17 female patients and 23 male patients with mean age of 56.5 years. ODI had an average dysfunction of 44.9%, the PCS score averaged 29.9, the MCS score of 41.3. The general symptoms of SSS presented a mean of 3.2 and the EQ-5D presented an average of 0.491. The EQ-5D presented the best correlation with the other questionnaires. The score that presented worse correlation with the other questionnaires was the neuroischemic symptomatology of SSS.
Conclusion: quality-of-life questionnaires can be correlated and thus, the evaluation of preoperative patients can be simplified.

O538

Comparative study of the correction of adolescent idiopathic echoliosis using three different techniques

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Introduction: The basic principles of surgical treatment of AIS should optimize coronal and sagittal correction and avoid curve progression.[1] Boucher & Vancouver created the Transpedicular Fixation.[2] These authors studied hundreds of patients operated on for AIS, using Multiple Fixation (FM).[3]
Objective: A retrospective comparative study of the results in the correction of the Sacral Clavicular Angle (**SCA**) and Cobb was performed among three different fixation techniques in the treatment of Adolescent Idiopathic Scoliosis (**AIS**).
Methods: A biostatistical study was carried out of three hundred cases of AIS subjected to transpedicular fixation, demonstrating the results of three different types of fixations: Traditional (**TF**), Selective (**SF**) and Multiple (**MF**). The latter was emphasized for being innovative. Short, apical and multiple fixation was applied to scoliosis with two or more structured curves. Asa observed in the radiological study using forced lateral inclination to the right and left, called the Flexibility Test (FT) curves equal to or above 10 ° were considered secondary residuals. The peak of the curvature where the instrumentation was focused was precisely identified. Targeted accesses were performed, fixing the smallest number of vertebrae possible and promoting greater balance of the coronal plane.
Results: With the use of **MF**, there was a 100% correction referring to the **SCA** median between pre and post op, 66% applying **TF**, and 50% with **SF**, the difference being considered significant. In relation to Cobb, all three types of fixations presented satisfactory corrections, with a difference considered significant between the pre and post op.
Conclusion: In this group of patients studied, FM was superior in ASC correction in the treatment of AIS. Level of evidence III.

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O539

The L-TLIF: A less invasive and blood-sparing technique as an alternative for the TLIF

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Introduction: Since its publication in 1998 by Harms & Jeszenszky, TLIF has become one of the gold standards for posterior lumbar interbody fusion. However, it has some disadvantages, like bleeding, muscle disinsertion, and trauma, with possible damage to proprioceptors, among others.
Aim: To analyze two cohorts of patients treated with the traditional TLIF and the author's variation called L-TLIF, thus, a posterior midline incision, and then a bilateral Wiltse approach to perform the posterior pedicle instrumentation, disc resection, inter-body fusion, and spinal canal decompression when needed.
Material and Method: A retrospective cohort study of 298 patients operated on between 2002 and 2021. Analysis and comparison of differences in intraoperative blood loss (mL), surgery duration, length of hospital stay, Visual Analogue Pain Scale, preoperative and follow-up Oswestry score, complication rates, and fusion rates. The statistical analysis was performed using t-student, Mann-Whitney test, chi-square, Kolmogorov-Smirnov for testing uniformity of distribution, and Shapiro-Wilkinson for testing normality of distribution when needed (p-Value 0.005).
Results: 173 patients underwent the TLIF technique, and 125 the L-TLIF. Both groups were demographically similar regarding sex, age, diagnosis, smoking condition, and the ratio of patients who were operated as revision surgery. Blood loss, surgical time, and length of hospital stay were significantly less in the L-TLIF group (table 1). These differences remained significant after adjusting by the number of segments fused (table 2). Preoperative and follow-up Visual Analogue Pain Scale, Oswestry score, complication rates, and fusion rates were similar in both groups. In both groups, Visual Analogue Pain Scale and Oswestry score showed a significant improvement after surgery (table 1). Fusion rates in both techniques reached over 96% of success.
Conclusion: The L-TLIF, a simple variation of the traditional midline access, by using a Wiltse approach, shows the same clinical and radiological results, with less blood loss, hospital stay, and presumably costs. Cost reduction may be explained by fewer hospital stays and blood loss. The technique doesn't need custom-designed implants or approach instruments, remaining at least as effective and equal o less expensive than the gold standard.

Table 1

	L-TLIF (n=125)	TLIF (n=173)	P. value
Bleeding (ml)	345	1097	**<0.001**
Surgical Time (minutes)	199	280	**<0.001**
Median hospital length of	4	6	**<0.001**
Sex (Female/Male) in %	60/40	58/42	0.779
Diagnostic group (Degenerative, stenosis, spondylolisthesis)	Degenerative= 74% Spondylolisthesis= 18% Stenosis= 8%	Degenerative= 67 % Spondylolisthesis= 24% Stenosis= 9 %	0.374
Smokers	29.6%	31.2%	0.765
Revision Surgery	15 %	22 %	0.159
Age (years)	49	50	0.455
Preop VAS (mean)	7	7	0.892
Postop VAS (mean)	2	2	0.688
Preop Oswestry (mean)	53	53	0.921
Postop Oswestry (mean)	15	17	0.710

Table 2: Blood Loss by Technique & Number of Segments

Blood loss (mL)	L-TLIF	TLIF	p (Mann-Whitney)
1 SEGMENT	272 (+/- 54) n=64	991 (+/- 181) n=109	**<0,001**
2 SEGMENTS	455 (+/- 78) n= 50	1264 (+/- 225) n=56	**<0,001**
3 SEGMENTS	520 (+/-215) n= 10	1367 (+/- 753) n= 7	**<0,001**

O540
Adolescent idiopathic scoliosis: Progression of untreated cases

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Objective: This study aims to evaluate angular value progression of untreated individuals with a diagnosis of AIS that are awaiting surgical procedure and compare to existing literature.
Methods: This is an observational, descriptive study. Data was collected for age of initial surgical indication, initial date and Cobb angle, date and Cobb angle of follow-up consult, time passed between initial and follow-up consult and type of curve. All Cobb angles registered were reviewed by the authors.
Results: 81% of subjects were female. 52.3% of curves were thoracic and overall 80.9% of all curvatures progressed. Annually, thoracic curves were more progressive than thoracolumbar curves at 5.25º/year against 3.7º.
Conclusions: This study showed similar progression per year, in degrees to current literature. Progression rates were much higher overall, but this may account to high valued curves at beginning of observation. Demographic data was similar to other studies, with the exception of types of curvature. Thoracic curves were the most common followed by thoracolumbar curves.

O541

Surgical outcomes in adolescent idiopathic scoliosis (AIS) versus young adult idiopathic scoliosis (YAIS)

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Introduction: There is some debate about the ideal timing for AIS surgery. Patients over 45° undergo fusion based on a high the progression probability (Weinstein 1981. Ascani 1986). Curve progression, physys closure (measured by Sander's and Risser Classification), curve flexibility, pulmonary function, pain, recovery capacity are all facts to be considered in this decision.
Aim: To analyze preoperative characteristics and post operative outcomes in adolescents and young adult patients undergoing posterior spinal fusion due to adolescent idiopathic scoliosis.
Material and Method: Retrospective study of 101 patients (11 - 35 years old) in two cohorts defined by age. AIS: <21 years old (87 patients) and >22 years old (14 patients). All surgeries performed by one surgeon between 2019 and 2021.All patients underwent the same preoperative evaluation protocol consisting of a cardiac, pulmonary, psychological, and laboratory assessment The following pre operative parameters were evaluated: comorbidities, ASA (Classification of risk by the American Society of Anesthesiologist), Allergies, Pre – operative hematocrit (Ht,%,) and Hemoglobin (Hb, grs/dl), pain measured by the Lumbar and radicular Visual Analog Scale, VAS). Intraoperative parameters measured where: Total Blood Loss (BL, mL), Neuromonitoring alerts, number of instrumented levels, type of rods used (Titanim (Ti) or Cromo-Cobalt (CrCo)) and use of osteotomies. Post – operative measured parameters where the need for critic patient units (LOSICU), the length in this unit and LOS in Medico-surgical units.
Statistical analysis was performed with SPSS ver. 19.0 (IBM Corp., Armonk, NY, USA) Univariate analysis was conducted to compare both cohorts using a chi-square or a two-tailed Student test. For non-parametrical associations Pearson's correlations was used. Significance was set at 0.05.
Results: There were no pre- operative differences between both cohorts regarding comorbidities, ASA, Allergies, Pre – operative Ht/Hb or pain (Table 1). Intraoperatively there were more osteotomies in the YAIS group (3.6%/40%, p=0.007). Post – operatively the YAIS had longer stays in critical care patient units (1.7 ± 0.6/ 1.2±0.4, p=0.042).
Conclusion: There is no big difference in surgical results between IAS and YAIS except for a much higher use of osteotomies due to curve rigidity and longer stays in critical patient care units, these two parameters might add higher costs and higher complication rates.

***Table 1**: Pre, Intra and postoperative parameters in both cohorts: Adolescent idiopathic scoliosis (< 21 Years Old and Young adults with Adolescent idiopathic scoliosis (> 22 Years Old)*

Measured Parameter	**< 21 Years Old**	**> 22 Years Old**	**p-value**
Pre – operative			
Comorbidities	0.56 ± 0.86	0.357±0.633	0.392
ASA 1/2	64/7	10/0	0.414
Allergies Y/N	7/73	0/14	0.759
Hb Pre-op (grs/dl)	13.9±1.0	14.2±1.24	0.842
Ht Pre-op (%)	40.9±3.2	41.3±3.4	0.494
LVAS Pre	1.95±2.5	1.8±2.5	0.868
RVAS Pre	0.36±1.3	0.4±0.9	0.494
Intraoperative			
TBL (ml)	536.17±222.6	535±254.3	0.068
Neuromonitoring Alert N/Y	84/3	14/0	0.636
NºLevels	13±10.4	10.5±2.5	0.601
OTT N/Y	84/3	10/4	**0.007**
Rods Ti/CrCo	11/76	3/11	0.301
Vasoactive drugs N/Y	86/1	14/0	0.861
Post-operative			
Hb post op(grs/dl)	10.5±1.0	11.0±1.1	0.402
Ht Post op (%)	30.4±3.6	31.6±2.4	0.782
LOS UCI	1.2±0.4	1.7 ± 0.6	**0.042**
LOS MS	2.4 ± 1.2	1.8±1.2	0.605

O542

Epidemiological portrait of patients with pediatric scoliosis in a tertiary hospital in the region of Campinas – SP

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Scoliosis is defined as three-dimensional curvature of the spine with a Cobb angle of 10°, regardless of etiology.
Scoliosis in the pediatric population is a term adopted by specialists to refer to deformities of the growing spine, which have an increased risk of progression, with potential cardiorespiratory complications and increased morbidity and mortality.
Objective: evaluates the epidemiological profile of patients with pediatric scoliosis in a tertiary hospital in the region of Campinas - SP, seeking to know and evaluate the demand of these patients.
Method: An epidemiological, observational and cross-sectional study was carried out in a digital database, where radiographic evaluation of images were collected to measure the magnitude of the curve through the Cobb angle, in addition to sociodemographic variables and data related to the patient's treatment plan.
Patients aged between 0 and 18 years were included. Patients who were unable to undergo a complete evaluation, with the consent form and/or informed consent form were excluded.
Results: The sample consisted of 30 patients who met the inclusion criteria. The age of the patients ranged from 5 years to 18 years, with a mean of 12.8 years. Congenital scoliosis a was the most prevalent etiology (73.3%), followed by idiopathic scoliosis (26,7%). The patient follow-up time between the first and last consultation has an average of 74.7 months. During the time that the patient is monitored by the specialty, the initial and final Cobb angles were evaluated, in degrees, with a percentage increase of 40.3%. Delay in care (outpatient care, conservative treatment or surgery) was identified in 25 patients (83.3% of the sample).
Conclusion: Most of the patients evaluated showed an evolution of the scoliosis, especially due to the delay in care, the lack of obtaining surgical treatment or even conservative treatment in an adequate time, with an increase in the magnitude of the curve and greater severity of the case.

Keywords: Scoliosis. Child health. Risk.

O543

Comparison between two methods of measuring pelvic obliquity in cerebral palsy and myelo-meningocele

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Objective: To evaluate the intra- and inter-observer reproducibility of the evaluation of the pelvic obliquity (PO) in patients with neuro- muscular deformities via the method that uses the iliac crests and the method that uses the upper endplate of S1 and to determine whe ther there is a relationship between the methods.

Methods: The digitized panoramic radiographies of thirty patients with cerebral paralysis or myelomeningocelein outpatient monitoring were evaluated by four examiners: two experienced spinal surgeons and two fellows. Two radiographs were excluded because analysis was impossible. All exams were obtained in accordance with the periodic monitoring protocol in the sitting position, using digitized film and a film-focus distance of 110 cm.

Results: High intra- and inter-observer agreement was observed both for method that uses the iliac crests and the method that evaluates the S1 endplate. However, no significant relationship between the two methods was observed.

Conclusions: The methods evaluated had good reproducibility and agreement among the observers. It was confirmed that, on account of the existent linear relation, it is possible to estimate the value of the iliac crest method knowing the value obtained by the S1 plateau multiplied by 0.76. There was no agreement between the iliac crest and S1 plateau PO evaluation methods. *Level of evidence IV; Retrospective cross-sectional study*.

O544

Lateral versus posterior approaches to degenerative pathologies: Systematic review and meta-analysis of recent literature

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Introduction: The lateral lumbar interbody fusion arose as a revolutionary approach to treating several spinal pathologies because the techniques were able to promote indirect decompression and lordosis restoration through a minimally invasive approach allowing for reduced blood loss and early recovery for patients. However, it is still not clear, how the technique compares to other established approaches for treating spinal degenerative diseases, such as TLIF, PLIF, and PLF, therefore the aim of the article was to perform a literature revision from articles published in the last 10 years to compare the LLIF approaches to the posterior approaches.
Methods: Systematic Review and Meta-analysis of articles published in the last 10 years comparing lateral approaches to posterior techniques. Were included articles that compared the LLIF technique to one or more Posterior approaches, treating only degenerative pathologies, and containing at least one of the key outcomes of the study. Exclusion: articles that were not original and the ones that the authors could not obtain the full text, also articles, where the standard deviation or mean could not be calculated, were also excluded. The analysis was performed in the R software, for count variables, the odds ratio was used, and for continuous variables, the standard means difference (SMD) was used, and the choice between random or fixed-effects model was made depending on the presence or not of significant ($p < 0.05$) heterogeneity in the sample.
Results: 29 articles were included in the quantitative review. As for the intra/perioperative variables, the lateral approaches showed significant reduction in blood loss (SMD -0.71, $p = 0.03$) and similar operative time (SMD = 0.04, $p > 0.05$). Moreover, the use of the lateral approaches showed a tendency to lead to reduced hospitalization days (SMD = -0.34, $p = 0.059$), with significantly reduced Odds ratios of complications (0.49, $p = 0.01$). As for the clinical outcomes, both approaches showed similar improvement in ODI, but with patients in lateral groups showing reduced ODI values at Last FUP, for the VAS back the results were inverse, with similar values in Last FUP and significantly higher improvement for lateral techniques (SMD = 0.27). Finally, when analyzing the changes in segmental lordosis and lumbar lordosis, the lateral technique promoted significantly higher correction in both outcomes (SMD = 0.68 and SMD =0.47, respectively, $p < 0.05$).
Conclusions: Lateral approaches are capable of promoting significantly radiological correction and clinical improvement while reducing surgical blood loss and postoperative complications.

O545

Use of leverage force in the surgical correction of the sagittal plan of the spine

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Introduction: Statistical mechanical study of the instrumentation of 49 synthetic spines. Present the principle of leverage force for sagittal spine correction, by positioning the pedicle screws in the convergent or divergent direction. Evaluating the database of patients submitted to the correction of thoracic kyphosis through transpedicular fixation, it can be understood that when the pedicle screws were placed convergent to the fixation, they corrected the deformity without great compression force and without screw loosening.[1,2,3.]

Objectives: Present the principle of leverage force for sagittal spine correction, by positioning the pedicle screws in the convergent or divergent direction.

Method: In twenty-four spines, monoaxial pedicle screws were applied at the ends of the approached segments with positioning in the convergent direction to the fixation. In another 25 pieces, the screws were applied in the divergent direction. Straight rods were later fixed to the screws. Compression or distraction force was applied, creating leverage, promoting vertebral rotation in the sagittal plane and correcting hyperkyphosis or hyperlordosis. Monoaxial pedicle screws were inserted in the sagittal plane, divergent from the head, 5 mm above the upper line of the transverse processes in the thoracic spine, and over the upper line in the lumbar spine. The screws converging to the head are inserted in the midline of the transverse processes in the thoracic spine, and in the lower line of these processes in the lumbar spine.

Results: The statistical study showed an average kyphosis in the pre-fixation of minus 0.12°, which was 18.5° after fixation. The average lordosis in the pre-fixation of 2.58° increased to 18.4°.

Conclusion: It was concluded that the difference between pre and post fixation to create kyphosis or lordosis was considered significant.

Level of evidence II C

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O546

Case-matched radiological and clinical outcome evaluation of interlaminar endoscopic versus microsurgical decompression of lumbar spinal stenosis

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Objectives: Endoscopic spine surgery is a globally expanding minimally invasive technique for the treatment of disc herniation as well as spinal stenosis. However, literature on the efficiency of interlaminar endoscopic decompression (IED) versus conventional microsurgical technique (CMT) in patients with lumbar spinal stenosis is scarce. The present study sought to conduct a case-matched comparison for treatment success with consideration of clinical and radiologic predictors.
Methods: We retrospectively reviewed 88 consecutive patients (IED: 36/88, 40.9%; CMT: 52/88, 59.1%) presenting with lumbar central spinal stenosis between 2018-2020. Surgery-related (operation time, complications, time to hospital release (THR), ASA score, C-reactive protein (CRP), white blood cell count, side (unilateral/bilateral), patient-reported outcome measures (PROMs) (ODI, NRS (leg-, back pain), eQ5D, COMI), and radiological (preoperative dural sack cross-sectional area (DSCA), Shizas score (SC), left and right lateral recess heights, left and right facet angle) parameters were extracted at different time points. Surgery-related and radiological parameters were correlated with patient-centered outcomes utilizing a multivariate regression model to determine predictors for propensity score matching.
Results and Conclusion: Complication (most often residual sensorimotor deficits and/or re-stenosis due to hematoma) rates were higher in the endoscopic (33.3%) than microsurgical (13.5%) treatment group ($p<0.05$). Despite this, THR was higher for the microsurgical group (11.2 ± 6.1 days versus 7.1 ± 8.1 days, $p<0.0001$). Age, THR, SC, CRP, and DSCA revealed significant associations with 3 weeks and 1 year postoperatively evaluated ODI, COMI, eQ5D, NRS leg, or NRS back values in our regression model. Consequently, they were used for the propensity score matching process (resulting in n=28 per group). We did not observe significant differences in the endoscopic versus microsurgical group for patient-centered outcomes. COMI scores evaluated 3 weeks postoperatively barely missed significance (2.76 ± 0.53 for endoscopic versus 2.04 ± 0.53 for the microsurgical group, $p=0.087$).
Age, THR, SC, CRP, and DSCA revealed significant associations with patient-centered outcomes and should be considered in future studies. Our first single-center study experience with endoscopic treatment of lumbar spinal stenosis was similarly successful as the conventional microsurgical approach regarding 3 weeks and 1 year follow-up PROMs. However, it was associated with higher complication rates, probably due to the learning curve of the surgeon, inexperienced with endoscopic surgery but trained in microsurgery. Interestingly, postoperative complication rates were not correlated with PROMs. A possible explanation could be shorter THR in the endoscopic group. Future prospective studies should validate these findings. spine, endoscopic, spinal stenosis, decompression, PROMs

O547

The anatomical relationship between the cervical nerve roots, intervertebral discs and bony cervical landmark for posterior endoscopic cervical foraminotomy and discectomy: A cadaveric study

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Introduction: The development of minimally invasive spine surgery (MISS) using a full cervical endoscope enables spine surgeons to avoid approach-related complications or extensive tissue damages associated with open surgeries. Posterior endoscopic cervical foraminotomy or discectomy (PECF or PECD) is a well-established procedure. The objective of this study was to define the anatomical relationship between bony landmark "V point", dural sac, nerve roots, and intervertebral disc for improving operative outcomes and decreasing post-operative complications.
Method: 10 soft adult cadavers were studied. We measured the distance of the V point to the lateral margin of dural sac, V point to the inferior border of intervertebral disc, and the inferior border of cervical nerve root to the inferior border of intervertebral disc. Then we calculated the mean of distance from V point to the inferior border of cervical nerve root. The relationship between these distances at each cervical spine level was evaluated and analyzed
Result: The mean distance from the V point to the lateral margin of dural sac from C3/4 to C7/T1 ranged from 3.1 ± 1.38 mm to 3.37 ± 1.46 mm. The mean distances from V point to the inferior border of intervertebral disc from C3/4 to C7/T1 were 0.19 ± 1.16 mm at C3/4, 0.45 ± 1.23 mm at C4/5, 0.43 ± 1.01 at C5/6, -0.43 ± 1.86 mm at C6/7 and -1.5 ± 1.2 mm at C7/T1. The mean distance from the inferior border of cervical nerve root to the inferior border of intervertebral disc from C3/4 to C7/T1 ranges from 0.25 ± 1.07 mm to 2.97 ± 2.35 mm in an increasing manner from the cranial to caudal levels. The mean distance between V point and the inferior border of cervical nerve root from C3/4 to C7/T1 showed all positive value, ranging from 0.06 ± 1.18 mm to 4.45 ± 2.57 mm. This illustrate that the V point is located more inferiorly to the nerve root at all levels and the distance tends to increase at caudal levels of cervical spine.
Conclusion: In performing PECF or PECD, a 3-4 mm radius of bone removal should be enough for exposure and neural decompression at C3/4 to C5/6. At C6/7 and C7/T1 a more extensive bone cut of more than 4 mm is recommended, especially in cranial direction. Surgeons should consider removing the inferior part of the upper lamina further than the superior border of inferior lamina, starting from the V point.

O548

Applications of biportal endoscopic techniques in revision spine surgery

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Introduction: As spine surgeries were widely performed, an increasing number of patients required revision surgeries due to neglected pathologies, newly developed pathologies, or complications in previous surgeries. Biportal endoscopic technique is a novel minimally invasive technique performed through two small incisions: one for the arthroscope and saline inflow; the other for instruments and saline outflow. The surgeons can perform delicate surgery in a very clear and magnified surgical field with minimal blood loss.
Methods: From Sept 2018 to Dec 2020, 76 patients received revision surgeries in the lumbar spines using biportal endoscopic techniques. They were 36 males and 40 females with an average age of 68.0 (ranged 36 ~ 87). The indications for revision included adjacent segment disease (ASD) following spine fusions in 31 patients, recurrent disc herniation in 11 patients, neglected foramen stenosis and far-out syndrome in 8 patients, re-stenosis in 8 patients, newly developed stenosis in 5 patients, post-decompression instability in 5 patients, inadequate decompression 3 patients, and implants related complication (interbody fusion cages, interspinous devices, and transpedicle screws) in 3 patients. Revisions were performed on previously operated levels in 44 patients and new levels in 32 patients. Three major biportal endoscopic approaches were used: the interlaminar approach in 30 patients, the paraspinal approach in 26 patients, and the revision transforaminal lumbar interbody fusion in 20 patients.
Results: The treatment results were very encouraging with significant relief of neurological symptoms, sciatica, and low back pain in most of the patients. With minimal blood loss and post-operative wound pain, the average hospital stay was only 3.2 days for decompression alone and 4.8 days for revision fusion. Most of the patients start to ambulate on the 1st or 2nd post-operative day. Follow-up MRI showed adequate decompression in most of the patients with minimal new soft tissue injury. Complications including 5 tiny dural tears were treated conservatively. Secondary surgeries were required in 3 patients due to inadequate decompression and post-decompression segmental instability. According the MacNab criteria, 66 patients (86.8%) had good and excellent results, 8 patients (10.5%) had fair results, and 2 patients (2.6%) had poor results.
Conclusions: Using biportal endoscopic techniques in revision spine surgeries is a revolutionary advancement. In selected cases, the revision surgeries could be done successfully with small surgical wounds, minimal soft tissue injury and blood loss. Removal or revision of the old implants was only indicated in patients who required extension of the fusion segments.

O549

Clinical & radiological outcomes of transforaminal lumbar interbody fusion using biportal endoscopic technique & double cages

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Introduction: This study is aimed to report the surgical techniques, clinical, and radiological outcomes of the biportal endoscopic transforaminal lumbar interbody fusion (BETLIF) using two cages.
Methods: This study included 90 patients who received 120 segments of BETLIF from July 2019 to May 2019. They were 17 males and 73 females with an average age of 64.8 (range 35 ~ 85). 1-segment fusion was done in 72 patients, 2-segment in 22 patients, and 3-segment in 2 patients. The diagnoses were spondylolisthesis in 85 patients and degenerative disc disease in 5 patients. Bilateral decompression was accomplished via the unilateral approach. One PEEK cage and one composite PEEK cage with outer Titanium plates along with laminectomy bone chips and demineralized bone matrix were impacted into the disc space. Clinical data including ODI, JOA scores, VAS score, and complications were retrieved from the chart records. Computed tomography (CT) of the lumbar spine was arranged 1 year post-operatively to evaluate the fusion status.
Results: The average follow-up period was 15.5 months (range 12 ~ 31 months). The average hospital stay was 5.7 +/- 1.1 days (range 3 ~ 7 days). At final follow-up, the ODI was improved from 46.7 +/- 17.0 to 12.7 +/- 16.1. The JOA score was improved from 15.6 +/- 6.3 to 26.4 +/- 3.2. The VAS were improved from 5.2 +/- 3.1 to 1.7 +/- 2.1 for low back pain; and from 6.3 +/- 2.5 to 1.7 +/- 2.0 for leg pain. All these improvements were statistically significant with a p-value < 0.005. CT scan was available in 44 patients. Solid interbody fusion was achieved in 43 patients (fusion rate 97.7%). Mild cage subsidence (less than 2 mm) was noted in 9 patients (20.9%) and cyst formation around the endplate was noted in 6 patients (5.0%). Both cage subsidence and cyst formation were more frequently occurred on the pure PEEK cage than the composite cage. Complications included 1 dural tear (1.1%), 2 pedicle screw malposition (2.2%), and 2 epidural hematoma (2.2%). No patient required blood transfusion. Re-operation was required in 2 patients for evacuating the epidural hematoma and adjusting the pedicle screw.
Conclusions: BETLIF with double cages is a safe, effective, and revolutionary minimally invasive technique for the spinal fusion with very high fusion rate and great functional improvement.

O550

Comparative study in operative time between posterior endoscopic cervical foraminotomy and microendoscopic cervical foraminotomy

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Introduction: We reported no significant difference in pain improvement in the numerical rating scale after surgery between patients with posterior endoscopic cervical foraminotomy (PECF), which utilizes full endoscopy, and microendoscopic cervical foraminotomy (MECF) (*Medicina* 2020, 56, 605). PECF has advantages in less intraoperative bleeding, which leads to easily maintaining clear surgical fields, and shorter hospitalization periods compared with MECF. However, PECF requires surgeons of highly technical skills which differ from those MECF needs. Thus, the aim of this study is to compare surgical time of PECF with MECF in terms of technical difficulties.
Methods: 690 patients with cervical radiculopathy underwent PECF or MECF between April 2015 and October 2022 in Iwai Orthopaedic Medical Hospital and Inanami Spine and Joint Hospital. PECF was performed in 393 cases including 353 single-level and 40 two-level cases and MECF was performed in 297 cases including 244 single-level and 53 two-level cases. These 597 single-level PECF or MECF cases were analyzed, focusing on the operation time in this study.
Results: The average operative time of PECF was 63.5 minutes and that of MECF was 62.1 minutes without statistical difference between the two groups. The time of each level was the following (minutes). PECF: C3/4 72.5, C4/5 81.0, C5/6 64.9, C6/7 58.3, C7/T1 74.5; MECF: C3/4 62.75, C4/5 73.4, C5/6 61.6, C6/7 59.3, C7/T1 76.2 (Figure 1). The statistical tests demonstrated no significance between PECF and MECF at the same level and among all levels of MECF. On the other hand, the Steel-Dwass test showed significant difference in the PECF group between C5/6 and C4/5, C5/6 and C7/T1; C6/7 and C4/5, and C6/7 and C7/T1.
Discussions: PECF at C5/6 and C6/7 levels demands less surgical time, which indicates that beginners of PECF should initially perform these two levels to improve their skills. Only eight surgeons performed PECF while 27 surgeons did MECF. This is because our institutions require physicians to acquire full-endoscopic skills and adequate experience for MECF in order to perform PECF. Moreover, one operator experienced larger than forty both surgeries and linear regression analysis showed the relation between the dependent variable of his first forty operation time (T) and the independent variable of the number of cases (N): T_{PECF}=−0.10N+68.0, TMECF=−1.4N+74.6 (Figure 2). This suggests that MECF initially needs operative time, but it rapidly progressed, and that PECF requires less surgical time at first though it doesn't substantially improve.
Conclusions: PECF has a shallow learning curve and novices must train PECF at C5/6 and C6/7 levels in the begging.

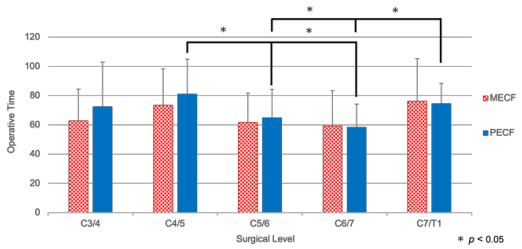

Figure 1 The operative time at each surgical level

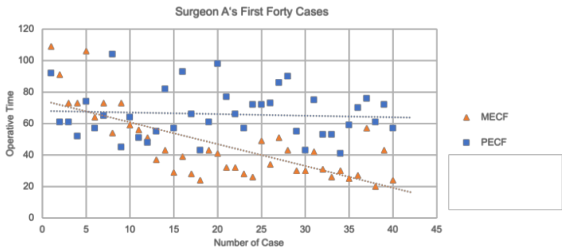

Figure 2: Linear regression between the number of case and operative time of PECF and MECF

O551

Minimally invasive C1-2 robot-assisted posterior instrumented fusion: Technical aspects and case series

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Introduction: Minimally Invasive Surgery (MIS) is being extensively adopted in the field of spinal trauma surgery. The advantages of MIS have been well described in the literature. C1-2 posterior instrumented fusion (PIF) has always been a challenging procedure to perform due to the surrounding vascular anatomy, co-existing degenerative findings and muscular disposition which results in considerable postoperative pain from the dissection. MIS C1-2 PIF could be a possible solution to these problems, especially for the elderly in whom unstable odontoid fractures and failure of conservative treatment is commonly seen.
Aim: To describe the technical nuances of two different MIS C1-2 PIF robot-assisted techniques and the outcomes of our case series.
Materials and Methods: We describe the operative setup, nuances of the operative positioning and the intra-operative technical aspects. In our case series, four patients with unstable type 2 odontoid fractures underwent MIS C1-2 PIF robotic-assisted (Globus ExcelsiusGPS) with the O-arm. Two different techniques were performed: the C2 trans articular screw and lateral mass of C1 plus C2 pars screws (Figure 1).
Results: Successful fusion was obtained in all 4 cases. Two of the patients underwent transarticular screw placement, one patient underwent a C1 lateral mass plus C2 pars screw, and a hybrid technique was performed for the fourth patient. The mean size of the incision was 2.5 cm (Figure 2), and the estimated blood loss less than 50mL. No intraoperative complications were reported. All patients were discharged on the next day. Considerable reduction of postoperative pain was reported. Six months postoperative CT demonstrated a successful fusion rate. Doppler ultrasonography was a reliable and important step during the tubular dissection to identify the exact location of the vertebral arteries, and safer placement of the screws.
Conclusions: MIS in C1-2 PIF offers many benefits compared to open standard techniques. The association with robotic technology might be advantageous to reduce complications, such as screw misplacing, vascular injury, and exposure to radiation. Furthermore, it may be associated with reduced postoperative pain and improved quality of rehabilitation in these patients.

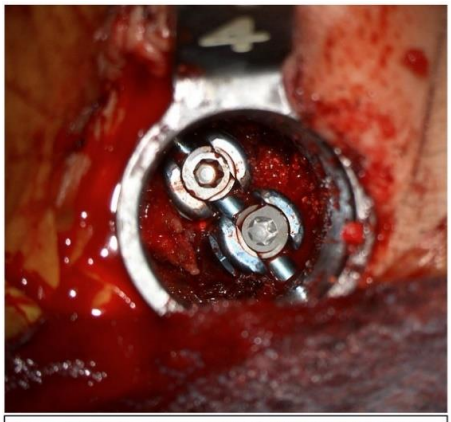

Figure 1. Intra-operative view of the C1-2 screws through the tubular retractor.

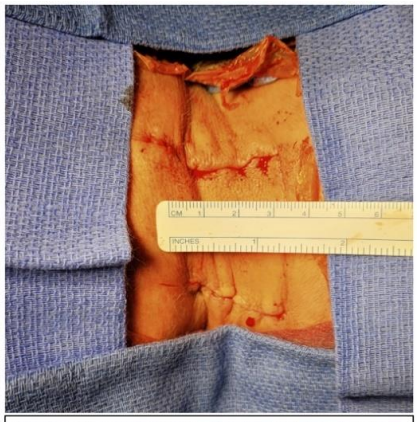

Figure 2. Postoperative view showing the 2.5 cm incision on both sides.

O552

The application of robotic navigation in single position lateral spine surgery - Technical note and surgical experience

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Introduction: Lateral spine surgery in the form of oblique lumbar interbody fusion (olif) is one of the surgical technique that is benefited by the robotic navigation technology. There are three potential benefit from robotic navigation, first it enable the surgeon to insert pedicle screw much more easily in the lateral position without the need to flip to prone. Second, the use of the navigation could also be used with robotic instrument for endplate preparation and interbody cage implantation. Robotic arm could serve as a retractor holder which is very rigid compare to table mounted retractor.
Aim: The aim of this research was to evaluate the result of olif and percutaneous robotic navigation pedicle screw insertion and to introduce the technique of surgery
Patients and Methods: This is a retrospective cohort study of 55 patients underwent olif with robotic navigation percutaneous screw fixation, the patients diagnosis varied from grade 1 or 2 degenerative spondylolisthesis and degenerative disc disease who failed conservative treatment. We evaluate clinical outcome directly after surgery in the form of visual analog scale (VAS) back pain and leg pain, the screw accuracy, skin to skin operating room time, estimated blood loss, post operative length of stay and complication after surgery. Insertion of percutaneous posterior screw were done with robotic navigation, using excelsius GPS from Globus. We used pre-operative workflow in which we registered the pre op CT-scan into the Excelcius GPS and merged the intraoperative C-arm image into the CT-Scan.
Results: Total of 55 patients underwent olif single position with robotic navigation percutaneous screw placement. The diagnosis were grade 1 spondylolisthesis (20 patients), grade 2 spondylolisthesis (17 patients) and degenerative disc disease (18 patients), they were treated due to back pain, lumbar radiculopathy or neurogenic claudication. Their mean age was 62.2 years old (range 43-82 years). The VAS of back pain and leg pain were decrease from mean of 5.4 to 1.4 after surgery, most of the patients mobilized on the first day after operation and discharge on the third day after the surgery. All pedicle screws were 100% accurately placed according to the planned screw position and trajectory. Mean estimated blood loss were 124.5 ml, there was 1 patient with traumatic tear of common iliac vein which lead profuse bleeding until 800 ml. Operating time for both olif and pedicle screw insertion were around 2.3 hours. We had 5 patients with psoas weakness and anterior thigh pain after the surgery, it was resolved after 3 weeks.
Conclusion: Robotic navigation spine surgery was very helpful in single position lateral spine surgery, it eliminates the need for flipping the patient to prone position. The accuracy of robotic navigation was very high and continuous high radiation image intensifier was no longer needed for percutaneous screw insertion.

O553

Intraoperative computed tomography-guided navigation versus fluoroscopy techniques for single-position surgery after lateral lumbar interbody fusion

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Introduction: A typical LLIF uses a dual-position (DP) approach. It consists of flipping the patient from the lateral decubitus position to the prone position and inserting a percutaneous pedicle screw (PPS) after LLIF. Although the DP technique is associated with good clinical results, repositioning of patients may be associated with increased surgery time and blood loss. Against this background, we have performed single-position surgery (SPS), in which posterior fixation is carried out without postural change after LLIF. However, there are no reports comparing fluoroscopy and intraoperative computed tomography (CT) navigation in lateral single-position surgery (SPS) regarding surgical outcomes or implant-related complications. Therefore, the purpose of this study was to use radiological evaluation to compare the incidence of instrument-related complications in SPS of lateral lumbar interbody fusion (LLIF) using fluoroscopy with CT navigation techniques.
Methods: We retrospectively reviewed the data of cases that met the following inclusion criteria: age > 18 years and patients with LDD and degenerative lumbar spondylolisthesis. They underwent a lateral SPS using LLIF and PPS insertion at a single institute from January 2019 to July 2022. We evaluated 145 patients who underwent lateral SPS. 27 patients had a percutaneous pedicle screw (PPS) inserted under fluoroscopy (SPS-C group), and 118 patients had a PPS inserted under intraoperative CT navigation (SPS-O group). We compared patient characteristics, surgical parameters, and radiological findings, including PPS accuracy, using CT.
Results: Average operation time was shorter in the SPS-C group than in the SPS-O group (88.4 ± 24.0 min versus 114.6 ± 32.3 min, respectively, $P<0.05$). However, the two groups had no significant difference in postoperative thigh symptoms or reoperation rate. A total of 637 PPSs in 145 patients were included in this study; 112 PPSs were inserted using conventional fluoroscopic SPS procedures (SPS-C), and the remaining 525 PPSs were inserted CT-navigation SPS procedures (SPS-P) intraoperatively. The PPS insertion angle of the SPS-C group was smaller than that of the SPS-O group, but there was no significant difference in the rate of screw misplacement (4.5% versus 2.5%, respectively, $P = 0.340$). By contrast, facet joint violation (FJV) was significantly lower in the SPS-O group than in the SPS-C group (5.7% versus 20.5%, respectively, $P < 0.001$). While fluoroscopy was superior to intraoperative CT navigation in terms of mean surgery time, there was no significant difference in the accuracy of PPS insertion between fluoroscopy and intraoperative CT navigation.
Conclusions: We found no difference in implant-related complications, and the fluoroscopy technique was superior only in terms of average operation time. Furthermore, there was no significant difference in PPS accuracy between fluoroscopy and intraoperative CT navigation, suggesting that one of the advantages of lateral SPS using intraoperative CT navigation rather than fluoroscopy may be the possibility of preventing the occurrence of FJV.

O554

Influence of multilevel robotic minimal invasive trans foraminal lumbar interbody fusion on spino-pelvic parameters and clinical outcome in lumbar degenerative disc diseases

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Introduction: In 21nd century, lumbar degenerative disc diseases (LDDD) is not restricted only to the aging population and multi-level disc degeneration are encountered even at 30-45yrs age group. Sagittal balance has a strong correlation with health-related quality of life (HrQOL) in adult patients. Trans Foraminal Lumbar Interbody Fusion (TLIF) improves disc height (causing indirect decompression), restores segmental lordosis and aids early inter body fusion. Robotic Minimal invasive surgery-TLIF (MIS-TLIF) has the advantage of less soft tissue dissection, less intra-op radiation exposure, less operative time and higher precision. Restoration of lumbar lordosis, thus improving the sagittal balance is of paramount importance for HrQOL after any multilevel TLIF. Existing literature reported good functional outcomes with 1 or 2 level TLIFs. With anecdotal evidence of poor outcome, there is evident dearth in clinical data specifically on the change of spinal alignment, its effect on spino-pelvic parameters and its clinical significance with 3 or more level Robotic MIS- TLIF.
Aim: The objective of this study is to investigate the clinical and radiological outcomes of multi-level (3 or more) Robotic MIS-TLIF in lumbar degenerative disc diseases (DDD) patients.
Materials and Methods: Single center, Single surgeon observational study with minimum 2-year follow up. 27 patients who underwent 3 or more level Robotic MIS-TLIF were retrospectively reviewed. Standing x-rays were assessed for changes in lumbar lordosis and segmental lordosis, improvement in pelvic parameters, global sagittal and coronal balance improvement. Fusion was assessed in serial follow up period based on Bridwell grading. Clinical assessment parameters included Visual Analog Score (VAS), Oswestry Disability Index (ODI) and Short Form 36 (SF-36). Continuous variables were compared using student t-tests and categorical variables using chi-square in SPSS version 14.0
Results: The average age of the patients were 42yrs (34 to 64) with mean follow up of 25.1 months (2-4 years). Among 27 patients, 7 had 4 level, 20 had 3 level MIS-TLIF. The majority of the cohort had a mean BMI 28.9 ± 3, demographic and operative details were analysed as in Table 1. Lumbar lordosis improved from 20.5˚ ± 4.6° to post-operative 42.1˚ ± 6.4° [Table 2]. Disc height and segmental lordosis at fusion levels significantly increased post operatively ($p<0.05$ and $p<0.001$) [Fig1]. Pelvic tilt was significantly reduced ($p<0.01$) post op with improved global sagittal balance($p=0.07$) [Fig2]. ODI scores improved from 48.9 to 35.4 (27.5%) ($p<0.001$). SF36 scales also had significant improved in all scales except role emotional scores [Table 3]. MIS group had lesser intra operative blood loss, operative time and post op length of hospital stay. 1 case each had post-operative foot drop, cage back out but not necessitating revision surgery were documented.
Conclusion: Multi-level MIS-TLIF for LDDD in young adults with proper patient selection and precise technique can provide significant improvement in ODI by improving the segmental spinal and pelvic balance.

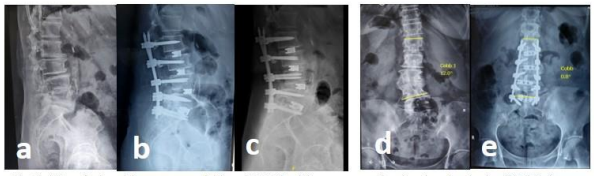

Fig 1- 64yrs lady with severe multi level LDDD with pre operative lumbar lordosis of 7.2°(a), restored to 31.5° post-operatively (b) and showing good union at 2 years follow up (c). Restoration of coronal balance from pre-operative cobbs of 12° (d) to 0.8° post-operatively (e).

Sagittal Parameters	Pre op	Last Follow up	P value
Pelvic Incidence- Lumbar Lodrosis mismatch	23 ± 12.66	10.02 ± 3.4	0.001*
Sacral Slope (degree)	28.6 ± 7.9	38.8 ± 6.3	0.1
Pelvic Tilt (degree)	22.3 ± 7.72	15.75 ± 5.5	0.14
Disc Height (mm)	4.23 ± 1.08	9.33 ± 2.07	0.05*
Sagittal Vertical Axis (mm)	62.5± 7.84	40.2 ± 4.43	0.01*
Coronal alignment (mm)	12.41 ± 3.93	3.8 ± 2.07	0.3

Table 2- Sagittal parameters comparison pre operatively and at last follow up

Particulars	Number
Number of cases	27
Age, mean, years	42yrs (34 to 64)
Sex, M/F	15/12
Levels L2-3 L3-4 L4-5 L5-S1	 11 27 27 23
Pre op Duration of symptoms (Months)	8.6 ± 1.3
BMI, mean ± SD	28.9 ± 3
Diabetes, n (%)	9 (33)
Chronic smoking, n (%)	5 (19)

Particulars	Number
Follow-up, mean (range), months	25.1 (24-41)
Operative time, min	208.6 ± 20.66
Estimated blood loss, mL	186.4 ± 30.8
Length of hospital stay, days	4.3 ± 1.2
Type of TLIF surgery- MIS Robotic TLIF Std Open TLIF	 25 2

Table 1- Patient demographics and operative details

	Pre operative	Post operative	Last follow up	P- value
VAS Back Pain	6.14 ± 0.50	2.07 ± 0.30	1.07± 0.22	>0.05
VAS Leg pain	7.71 ± 0.38	2.14 ± 0.76	0.78 ± 0.25	>0.05
Oswestry Disability Index (ODI) scores	48.9 ± 1.78	35.4 ± 1.19	28.7 ± 1.15	<0.001*
SF- 36 scores Physical Component Score Mental Component Score	 25.5 ± 2.07 41 ± 4.56	 38.6 ± 2.48 50.8 ± 3.11	 40.7 ± 3.37 56.8 ± 4.22	 <0.05* 0.16

Table 3- Clinical outcome measures- VAS, ODI and SF36 scores comparision

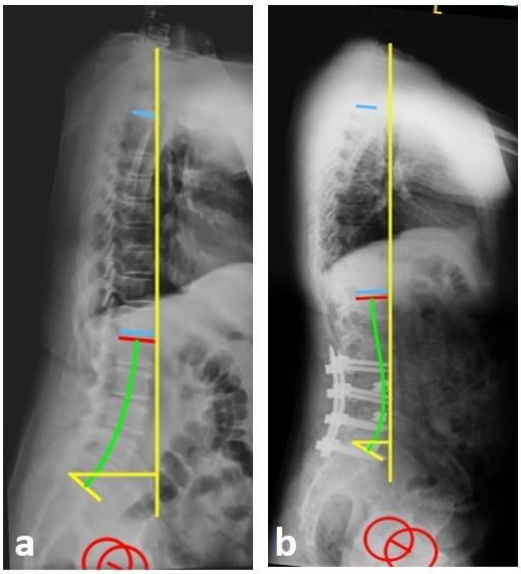

Fig 2- Restoration of global sagittal balance from pre op SVA of 101.1mm (a) to post op SVA of 41.8mm (b)

O555

Vascular and visceral complications following prone transpsoas lateral lumbar interbody fusion: A comparative study to a historical survey study on standard lateral lumbar interbody fusion

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Introduction: Prone transpsoas lateral lumbar interbody fusion (PTP) is a novel modification of standard lateral lumbar interbody fusion (standard-LLIF). To date, no study has compared the vascular or visceral complications between the PTP and standard LLIF.
Aim: This study aimed to compare the vascular and visceral complications between the PTP and standard-LLIF.
Patients and Methods: A retrospective electronic medical records review was conducted across ten centers to compile the patient-, procedural-, and outcomes data related to patients who underwent PTP. Among the data collected from consecutive cases at each site was itemization of intraoperative and postoperative complications. From those, we highlighted the intraoperative vascular and visceral complications in order to compare these outcomes in PTP procedures to the historical results of a published survey (Uribe et al. Eur Spine J 2015;24:S386-96) about vascular and visceral complications following standard-LLIF.
Results: The PTP cohort included a total of 364 patients, and the published standard-LLIF study referenced 13,004 patients. In the PTP cohort, there were no (n=0) visceral injuries and one (n=1) vascular (left common iliac vein) injury. There was no significant difference between the PTP group (n=1) and the published standard-LLIF in terms of vascular injuries (n=13) (p=0.3) or visceral injuries (n=11) (p=0.6).
Conclusion: There was no significant difference in the incidence of vascular or visceral injuries between this multi-center cohort of PTP procedures versus what was previously published on standard-LLIF. This comparison may be premature given that PTP is a more recently adopted procedure with a significantly lower-case volume denominator; however, the safety profile of the early experience has not been concerning, and as PTP case volumes increase, these centers will continue to track and report these important outcomes.

O556

Clinical and radiographic outcomes following 110 prone transpsoas (PTP) surgeries at a single center

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Introduction: The prone transpsoas (PTP) approach has been described as a single-position alternative to the more traditional lateral lumbar interbody fusion (LLIF) technique performed in lateral decubitus. Most of the early reports, however, have focused on description of the technique, its feasibility, and early, i.e., perioperative outcomes, including immediate postoperative radiographic alignment. Longer-term outcomes have been pending the maturity of this PTP experience.
Methods: At a single institution, all consecutive PTP procedures were captured via a prospective institutional registry to document procedural details as well as clinical (patient-reported) outcomes. A retrospective analysis of this prospectively collected data identified 31 patients having undergone a prone lateral approach prior to the proceduralization using procedure-specific positioners and retractor (PTP), and 79 patients having undergone PTP. All cases used saphenous somatosensory evoked potentials (saphSSEP) monitoring of the lumbar plexus.
Results: The total cohort of 110 patients were 53% female, average age 64 years (range: 26-84), had an average BMI of 31 (range: 18-51). Comorbidities included diabetes (27%) and smoking (11%). Diagnoses included spondylolisthesis, scoliosis, flatback, and adjacent level degeneration. One surgery was aborted because of neuromonitoring challenges due to body habitus. In the 109 remaining patients, a total of 169 levels were treated (range 1-5 levels, average 1.5 levels per patient, 76% inclusive of L4-5, with 1-7 levels per patient of fixation. 40% included direct decompression, 7% posterior osteotomies. Operative time averaged 146 minutes, blood loss averaged 47 cc, and length of stay averaged 2.3 days. 78% were without complication; others included 3 cage repositionings, 1 partial ALL rupture, 1 durotomy, 1 epidural hematoma, 1 posterior wound infection, 1 pseudoarthrosis. Postoperative hip flexion weakness was identified in 12%, new lower extremity weakness in 11%, and sensory deficits in the thigh in 10%. Secondary surgeries included 2 adjacent level decompressions, 1 pseudo revision, and 1 evacuation of epidural hematoma. Follow-up averaged 12 months (range 6 weeks-3 years). At last follow-up, back and worst leg pain improved by 54% and 50%, respectively; ODI improved by 44%; 91% of patients said they were improved, 88% were satisfied, and 86% would elect the surgery again knowing the outcome. 97% improved or maintained sagittal alignment with an average 6.3° segmental lordosis gain at PTP levels.
Conclusion: The largest single-center PTP experience with the longest follow-up to date shows that PTP results in few complications, quick recovery, improvements in pain and function, high patient satisfaction, and improved sagittal alignment at an average 1-year and up to 3-years following the procedure. These results are consistent with this surgeon's prior lateral decubitus LLIF experience.

O557

Feasibility of the prone transpsoas (PTP) approach in the obese and morbidly obese

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Introduction: Obese and morbidly obese surgical patients pose a double challenge of health-related conditions and positioning- or approach-related access difficulties. Larger patients have reportedly fared well in lateral-approach (LLIF) procedures where the pannus falls anteriorly away from the exposure due to gravity in lateral decubitus. LLIF in the prone decubitus may offer additional advantages such as single-position circumferential spinal access, a more posterior lumbar plexus, and improved lordosis. When prone using positioners on an open-frame Jackson table, the pannus can also fall anteriorly due to gravity, but the girth may splay laterally, deepening the lateral access corridor. A retrospective analysis of prospectively collected procedural details was performed to compare the safety and efficiency of the prone transpsoas (PTP) approach in the obese and morbidly obese versus that in non-obese patients.
Methods: Prone lateral surgeries performed at multiple centers in the US were prospectively documented to capture procedural details and peri-op outcomes to assess feasibility, efficiencies, and challenges. Comparisons of pre- and post-proceduralization using procedure-specific tools reflecting the demands of operating laterally with the patient prone (PTP) have been previously reported by these authors. The case experience was re-evaluated in a post-hoc analysis to identify whether obese and morbidly obese patients demonstrated measurable differences in these peri-op feasibility metrics compared to the non-obese cohort.
Results: Body habitus was available for 195 patients. BMI averaged 31 across the total population, ranging from 18 – 51, and categorized as follows: 90 (46%) non-obese (BMI<30), 82 (42%) obese (BMI 30-39.9), and 23 (12%) morbidly obese (BMI>=40). Those patients represented 132, 119, and 35 PTP levels respectively. None of the following metrics was significantly different ($p>0.05$) based on body habitus: inclusion of L4-5, positioning time, docking time, retraction time, use of percutaneous versus open fixation, concomitant posterior procedures, operative time, estimated blood loss, or length of stay. The only metric that varied with body habitus was lateral retractor blade length, which averaged 140 mm for non-obese, 155 mm for obese, and 165 mm for morbidly obese ($p<0.0001$).
Conclusion: Multi-center prospective data collection of prone lateral/PTP experience and observational comparison of sub-cohorts based on body habitus shows that prone transpsoas (PTP) surgery is equivalently feasible in patients of varying body habitus, including the morbidly obese. Only retractor blade length (depth of exposure) differed, and did not result in extended operative times or other perioperative challenges. Stable prone positioning that allows for management of the abdominal pannus is a key feature in reproducibly accessing larger patients from a prone lateral approach. Overall health should clearly be considered prior to any surgical intervention, but size alone does not preclude successful lateral access to the spine in prone decubitus.

O558

Single position minimally invasive corpectomy with robotic assisted instrumentation: Technique review and early lessons learnt

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Introduction: The minimally invasive lateral approach to the thoracolumbar spine has evolved and has become an increasingly popular technique for achieving interbody fusion in various spine conditions. However, this technique demands additional time and resources as the patient is required to be repositioned from lateral to prone. Multiple studies have demonstrated the efficacy of single position surgeries. In recent years, robot-assisted spine surgery has also emerged as a viable alternative to facilitate less invasive and higher precision surgery. In this case presentation, we will describe the surgical technique of single position minimally invasive lateral lumbar corpectomy with robotic assisted instrumentation for an osteoporotic burst fracture patient, including the early lessons, pearls and pitfalls.
Methods: The patient is placed in right lateral decubitus position and secured with tapes on Jackson table. The disc spaces above and below the pathological vertebra are identified under fluoroscopic guidance for the skin incision. The retroperitoneal space is accessed via gentle blunt dissection. The anterior margin of the psoas identified and mobilized posteriorly to expose the disc spaces above and below the index vertebra, followed by the guide wires and retractors placement. This is followed by removal of adjacent discs, corpectomy and end plates preparation before introduction of an expandable cage under fluoroscopy. Subsequently, posterior instrumentation is performed with the assistance of robot and real-time intraoperative navigation in the same position. This technique can effectively reduce surgical time by avoiding the need to reposition the patient and minimise intraoperative blood loss via minimally invasive approaches for both corpectomy and instrumentation. Furthermore, this technique allows precise and safe instrumentation in a less familiar position and also allows surgeons to perform direct decompression of the spinal canal when indicated. However, this technique has its limitations, which we will explain further.
Results: Pre- and post-operative radiological imaging, operative approach, patient outcomes and intraoperative limitations are described.
Conclusions: Our experience with the case of single position minimally invasive lateral lumbar corpectomy with robotic assisted instrumentation demonstrated shorter operative time by avoiding the need to reposition the patient. This technique also has multiple benefits, including minimising intraoperative blood loss, facilitating precise and safe instrumentation with robotic assistance and allowing direct decompression of spinal canal when indicated.

O559

Retrospective case series of porous printed titanium cages in anterior to psoas oblique lumbar interbody fusion surgery assessing subsidence and functional outcomes

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Purpose: Implant subsidence is a possible complication of spinal interbody fusion. We aim to evaluate porous titanium cages subsidence, and functional outcomes in patients subjected to oblique lumbar interbody fusion (OLIF) with these novel devices.
Methods: Our institutional review board approved a single-center experience which included 60 patients who underwent OLIF from June 2018 to June 2020 utilizing the porous titanium implants. Data was collected in accordance with the Declaration of Helsinki , and written informed consent was obtained. Imaging studies including radiographs 1, 3, 6 and 12 months and computed tomography (CT) scan at 6 months obtained during routine postoperative follow-up visits, were studied for signs of implant subsidence and clinical parameters to determine the effectiveness of surgery such as Oswestry disability index (ODI).
Results: Radiographic subsidence occurred in 1 out of 89 porous titanium interbody cages (1.1%). No subsidence was observed in the posterior screws and rods fixation group (N=57). However, one case of subsidence occurred in the lateral plate fixation group (N=3). The subsidence occurred in an osteoporotic elderly patient operated for adjacent segment disease, and she was later revised with posterior instrumentation using cemented screws and rods. She had an uneventful recovery. In terms of clinical outcomes, ODI decreased significantly from 20.3 preop to 10.7 postop with a P-value<0.05.
Conclusions: In our study, the subsidence rate was lower than previously reported in the literature. We had no subsidence in the posterior instrumented group and one case in the lateral fixation group with improved clinical outcomes.

Table1. Demographic Characteristics.

Demographic characteristics	Frequency or mean (+SD)	Percentage or range	
Age (years)	70.2 ± 9.09	45-88	
Gender	32 F 28 M	53.33% 46.67%	
BMI (kg/m2)	30.2 ± 5.65	19.6-45.2	
Smoking history	2	3.3%	
ODI preop	20.3 ± 7.29	4-33	P value
ODI postop (at 1 year)	10.72 ± 6.52	1-28	<0.05

Table 2 : Operative characteristics

Operative characteristics	Frequency	Percentage
Radiographic subsidence	1/60	1.7%
Subsidence per implant level	1/89	1.1%
Subsidence grade per implant level Grade 0 Grade I Grade II Grade III	 88 0 1 0	 98.9% 0% 1.1% 0%
Number of cages 1 2 3 4	 38 17 3 2	 63.3% 28.3% 5% 3.3%
Spinal levels L1/L2 L2/L3 L3/L4 L4/L5	 9 13 31 36	 10.2 % 14.6% 34.8% 40.4%
Supplemental fixation per patient Pedicle screws Lateral plate	 57 3	 95% 5%

O560

Comparing Anterior to psoas lumbar interbody fusion with stand alone implant and posterior lumbar interbody fusion for the treatment of adjacent segment lumbar disease

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Aim: The purpose of this study, is to compare between two surgical approach (Anterior to psoas retroperitoneal approach and PLIF) for adjacent segment disease
Methods: 36 symptomatic ASD patients after lumbar fusion surgery from November 2017 to November 2019 Half of the group underwent Anterior to psoas lumbar interbody fusion with stand alone cage with lateral plate and screw fixation (ATP group) and the other group underwent posterior lumbar interbody fusion surgery (PLIF group) was assessed by clinical outcome and radiographic parameter
Results: Clinical outcome Total blood loss(250/50), Operative time(71.61±18.05/164.67±12.19),VAS back pain at 3 months(1.78±0.43/2.44±0.51; p<.001*) and Radiographic parameter (Foraminal height improvement ratio20.14±2.40/17.93±1.33;p=.002*) in ATP group better than PLIF group significantly
Discussion Comparing Anterior to psoas lumbar interbody fusion with stand alone implant and posterior lumbar interbody fusion for the treatment of adjacent segment lumbar disease.
Conclusion: Compared to PLIF, Anterior to psoas approach with stand alone cage and lateral plate and screw fixation has advantages of less bleeding, fast recovery and better restore foraminal height of symptomatic adjacent segment disease patients
Keywords: Adjacent segment disease, ASD,Anterior to psoas, ATP, OLIF

O561

Comparing Anterior to psoas lumbar interbody fusion with stand alone implant and posterior lumbar interbody fusion for the treatment of adjacent segment lumbar disease

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Keywords: Adjacent segment disease, ASD, Anterior to psoas, ATP, OLIF

O562

A novel repositioning system for use in lateral and prone surgeries for single position surgeon procedures

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Introduction: Lateral surgery including trans-muscular and anterior to psoas has become increasingly popular in the surgical methods of spine surgeons. Single Position Lateral and Single Position Prone methods have evolved to eliminate the flip time, energy and cost associated with manually repositioning the patient from lateral to prone. However, in the Single Position Lateral, screw trajectories are difficult and primarily only percutaneous while decompression is quite limited and difficult. In the Single Position Prone, the Interbody cages must be placed from a less desirable prone position with a sometimes inaccessible L4/L5 level and loss of access to the L5/S1 level. Both levels are critical to maintaining and restoring sagittal alignment. The Single Position Surgeon patient positioning system enables screw placement and decompression in the prone position and cage placement in the lateral position while maintaining a sterile field and facilitating simultaneous access.
Aim: To report the initial results of this feasibility study to determine if patients can be moved safely from lateral to prone and back while maintaining a sterile field permitting simultaneous access.
Materials and Methods: The patient positioning system was utilized during Lateral to prone and prone to lateral positioning in 317 patients (157 male, 160 female). Mean age of 63.9. Patient weight ranged from 141lbs to 292lbs (mean 182lbs) and height ranged from 4'11" to 6'4" (mean height of 5'7"). Degenerative and deformity cases ranged from single level screw fixation and Lateral interbody fixation to fixed sagittal plane deformity requiring thoracolumbar multilevel fixation, ACR and corpectomy as needed. All cases required a lateral and prone surgical approach combination. Within this series, there were 7 surgeries requiring posterior-anterior-posterior approaches due to the need to remove hardware prior to revision. Operating times saved by modulation of the flip were measured, cost of materials saved as well as any complication recorded resulting directly from this method were reported.
Results: There were no cases of wound breakdown, abrasion nor ulceration identified. No cases of loss of airway, foley catheter or IV line occurred. SSEP and MEP monitoring was performed in all cases. There were no cases of common peroneal, ulnar nor brachial plexus postoperative findings. Average time from completion of lateral procedure to starting prone procedure was less than 8 minutes compared to the 45 minutes used when patients were repositioned. The estimated savings for materials and OR time was $2,500 US per case.
Conclusions: This is the first patient positioning system that successfully and safely enables bidirectional movement or repositioning of the patient between Lateral and Prone positions while maintaining a sterile field for the benefit of simultaneous access to all three columns of the spine. Surgeons can ergonomically operate in one position while the patient experiences a beneficial physiological movement throughout the surgery versus the compromises and costs that are currently seen with non-sterile flip, single position lateral and single position prone options.

O563

Risk factors for post-arthroplasty subsidence: Retrospective analysis of Bryan disc arthroplasty

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Introduction: Cervical disc arthroplasty (CDA) is currently used for preserving cervical spine motion instead of fusion. Subsidence of the cervical artificial disc is one of the possible complications after CDA. Because the subsidence mechanism is different from traditional fusion, the risk factors for implant subsidence need to be studied.
Methods: We retrospectively reviewed the clinical data as well as the postoperatively images of 125 patients who underwent CDA between June 2006 and September 2016. All patients were operated on by a single neurosurgeon, exclusively using the Bryan Disc (Medtronic Sofamor Danek USA, Inc.). Parameters were measured via lateral radiographs of the patient in the neutral position. Implant subsidence was defined as greater or equal to 3mm decrease in height of the functional spinal unit (FSU) on lateral radiograph. Patients with incomplete follow-up radiographic data or less than one year were excluded from the study. Preoperative disc height (DH) and postoperative implant height (IH) were measured from the operative level. The difference between the endplate and implant was measured using the difference and ratio of width (ΔAP and AP ratio) and depth (ΔLat and Lat ratio). The expansion magnitude for Bryan Disc implantation was measured with ΔDH (IH-preoperative DH) and DH ratio (IH/preoperative DH). The assumptive coverage area of Bryan Disc was measured using the AP ratio*Lat ratio.
Results: A total of 104 patients with 153 operative levels of CDA with the Bryan Disc were enrolled. Mean follow-up duration was 51 months. Eighty-three (54.2%) were operated at C5-C6 level, 55 (52.9%) received single level CDA. Thirty-five implants (22.9%) presented subsidence, and 33 of them (94%) subsidence occurred at the anterior edge of the vertebrae. Binary Logistic regression showed follow-up duration, preoperative DH, ΔDH and DH ratio were potential risk factors for artificial disc subsidence in single variate models. However, we found only preoperative DH which served as an independent risk factor for subsidence in the multivariate analysis (95% CI 0-0.073, p=0.018) (figure 1). ROC curve analysis (AUC=0.852, sensitivity 84.7%, specificity 77.1%) revealed a cut-off value of 4.48 mm for preoperative DH in risk of artificial disc subsidence. The coverage area of implant showed no statistical significance related to implant subsidence.
Conclusions: In the current study, the subsidence rate significantly increased once oversized artificial discs were used (approximately>4mm) from preoperative DH. Furthermore, the incidence of implant subsidence was higher than shown in previous studies, which may be related to the over-preparation of the endplate or over distraction of the disc space during the placement at this same height as the Bryan Disc (8.5 mm). Today, new artificial discs have been developed without the necessity for excessive endplate preparation, and different size implants are now available. The possible risk factors for implant subsidence should be considered and studied.

Figure 1. Independent risk factors of Bryan disc subsidence identified by logistic regression

	Simple regression			Multiple regression (Forward)		
	OR	95 % CI	p value	OR	95 % CI	p value
Age	1.003	(0.948, 1.061)	0.916			
Gender	1.127	(0.432, 2.938)	0.807			
Smoking	0.814	(0.292, 2.265)	0.693			
Preoperative Mean-DH	0.186	(0.103, 0.336)	<0.001**	0.151	(0.059, 0.391)	<0.001**
ΔAP-mm	35.557	(0.862, 1467.464)	0.06			
ΔLat-mm	1.059	(0.056, 20.097)	0.969			
ΔDH-mm	2.616	(1.707, 4.011)	<0.001**	0.797	(0.395, 1.61)	0.528
AP ratio	0.001	(0, 2.301)	0.078			
Lat ratio	0.66	(0, 1470.868)	0.916			
DH ratio	183250	(279.48, 120153167,1)	<0.001**	0.646	(0.001, 50408.9)	0.939
Area of ADR	0.016	(0, 6.824)	0.18			

P value <0.05 was consider statistically significant. 95 confidence interval range in the brackets. P <0.05*, p <0.01**. DH, disc height; AP, anteriorposterior; Lat, lateral; ADR, prosthetic disc replacement.

Figure 1: Preoperative DH served as an independent risk factor for subsidence in the multivariate analysis.

O564

Lactate in lumbar discs – metabolic waste or energy biofuel? Insights from in-vivo MRS and T2r analysis following exercise and nimodipine in healthy volunteers

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Introduction: The exact etiology of disc degeneration is still elusive; studies have increasingly focused on understanding disc biology and disc milieu interior at the molecular level. Although lactate is considered a key metabolite of disc metabolism, its exact role in the mechanically stressed, nutrient-depleted, hypoxic, and acidic metabolic environment is not fully clear. There are still large gaps in knowledge of its function and fate. Hence the study proposes to quantitatively assess the dynamic changes of Lactate in lumbar discs under different physiological conditions using MRS and T2r.
Methods: In step1, MRS and T2r sequences were standardized in 10 volunteers **(Figure 1).** Step2, analyzed the effects of high cellular demand. 66 discs of 20 volunteers with no back pain were evaluated pre-exercise (EX-0), immediately after targeted short-time low back exercises (EX-1), and 60minutes after (EX-2). In Step 3, to study the effects of high glucose and oxygen concentration, 50 lumbar discs in 10 volunteers were analyzed before (D0) and after ten days of intake of the calcium channel blocker, Nimodipine (D1).
Results: Lactate showed a distinctly different response to exercise in that Grade 1 discs with a significant decrease in EX-1 and a trend for normalization in Ex-2. In contrast, Pfirrmann grade 2 and 3 and discs above 40 years showed higher lactate relative to proteoglycan in EX-0, an increase in lactate EX-1, and a mild dip in Ex-2. Similarly, following nimodipine, grade 1 discs showed an increase in lactate which was absent in grade 2 and 3 discs. In contrast, exercise and Nimodipine had no significant change in T2r values and MRS spectrum of proteoglycan, N-acetyl aspartate, carbohydrate, choline, creatinine, and glutathione across age groups and Pfirrmann grades.
Conclusions: This is the first study to document the molecular changes of 14 metabolites and levels of hydration by quantitative imaging under different physiological conditions. We found MRS and T2r to be reliable research tools to document the dynamic changes at required points in time. Our results document that short-term nimodipine or short-time intensive exercises do not have a significant effect on Proteoglycan content or hydration and so will not be suitable as biological markers for short-term changes in disc biology and health. Lactate showed dynamic changes both with exercises and nimodipine, and it differed between Pfirrmann-1 and higher grades. This change in the response can be a viable non-invasive radiological biomarker for very early degeneration. Lactate changes, being sensitive, can also be used to assess the therapeutic response to exercise regimens and drugs. The response pattern added further proof of the presence of the 'Lactate Symbiotic pathway' in the discs. Lactate can no longer be considered a dead-end metabolic waste but a rich biofuel molecule catering to high energy requirements.

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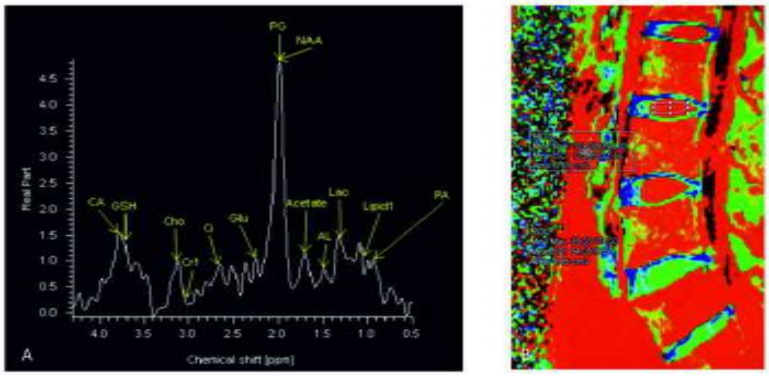
Figure 1. Normal MRS spectrum of the lumbar IVD and T2r of the discs.



O565

Comparison of degenerative MRI features of the intervertebral disc between those with and without chronic low back pain - An exploratory study of 2 large female populations using automated annotation

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Introduction: It is recognised that MRI detects a high prevalence of disc degeneration in subjects both with and without back pain. There remains uncertainty whether these degenerative features are related to back pain symptoms. A systematic review by Brinjikji et al. (2015) found that in those aged 15-50yrs, the overall prevalence of degenerative features was noticeably greater in those with LBP, than in comparable asymptomatics. Specific features, such as Modic changes, are reported to be strongly associated with LBP. This review also recognised most studies were small and that annotation of degenerative features is subject to variations in practice.

Here we overcame differences in imaging gradings between groups by determining the prevalence of age-related disc degeneration in asymptomatic and symptomatic subjects by re-annotating MRIs from asymptomatic and symptomatics onto the same objective grading system allowing direct comparisons between them.

Methods: In an exploratory cross-sectional study, we analysed prevalence of MRI features of disc degeneration in a large group of asymptomatic subjects (TwinsUK; 701 participants) and in two groups of subjects with chronic low back pain recruited from secondary care spinal clinics (OSCLMRIC 724, and Genodisc, 874 participants). TwinsUK is ~90% female. We therefore recruited only female subjects from all symptomatic groups to avoid sex-bias. We re-annotated all MRIs onto the same grading system to overcome difficulties in reconciling differences in reporting of degeneration levels between groups (Pfirrmann 5-point grading scheme for Genodisc; routine radiological reports for OSCLMRIC; 4-point in-house system for TwinsUK). We used a verified and rapid automated MRI annotation system (SpineNet) to report disc degeneration on the Pfirrmann 5-point scale, and other degenerative features (herniation, endplate defects, marrow signs, spinal stenosis) as binary present/absent. The prevalence of severe and of mild degeneration and of degenerative features was compared in relation to age in the rostral (L1-L3) and caudal (L4-S1) lumbar discs between asymptomatic (TwinsUK) and symptomatic (OSCLMRIC) subjects, and calculated odds ratios to indicate the probability of a degenerative feature being associated with a state of chronic low back pain.

Results: Severe degenerative changes were markedly more prevalent in discs of symptomatics than asymptomatics in the caudal (L4-S1) but not the rostral (L1-L3) lumbar discs in subjects <60years. We found high co-existence of several degenerative features in both populations. Degeneration was minimal in around 30% of symptomatics < 50years. Average Pfirrmann degeneration grades in relation to age and spinal level were very similar for the two independent symptomatic groups.

Conclusions: Automated analysis, by rapidly combining and comparing data from existing groups with MRIs and information on back pain, provides a way in which epidemiological analysis could be advanced without the expense of collecting new groups. Here, by using SpineNet to re-annotate degenerative gradings, we show age and disc level are significant in determining MRI differences between asymptomatic and symptomatic populations and should not be ignored. By distinguishing between symptomatics whose discs have structural defects, and symptomatics with minimal degenerative changes, MRI could provide a means of clinical stratification, and a useful pathwO566ay to investigate possible pain sources.

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O566

Age- and sex-related differences in lumbar intervertebral disc degeneration between patients with chronic low back pain and asymptomatic controls

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Introduction: Clinical management of disc degeneration in patients with chronic low back pain (cLBP) is hampered by the challenge of distinguishing pathologic changes relating to pain from physiologic changes related to aging. The goal of this study was to use imaging biomarkers of disc biochemical composition to distinguish degenerative changes associated with cLBP from normal aging.

Methods: T1ρ MRI data from 133 prospectively-enrolled subjects (80 cLBP, 53 asymptomatic controls) were collected for this observational study. The mean T1ρ relaxation time in the nucleus pulposus (NP-T1ρ; n = 650 discs) was used as a quantitative biomarker of disc biochemical composition. Linear regression was used to assess associations between NP-T1ρ and age, sex, spinal level, and study group, and their interactions.

Results: The cLBP and control groups had similar age and sex distributions (43.9 ± 13.5 vs. 43.9 ± 13.3 years, cLBP vs. control, p = 0.98; 44% female and 56% male vs. 49% female and 51% male, p = 0.55). On average, NP-T1ρ values were lower in cLBP patients than controls (70.8 ± 22.8 vs. 76.4 ± 22.2 ms, p = 0.009). At levels L1–L2 through L4–L5, group differences in NP-T1ρ were relatively small (range: 3.8–5.6 ms, p = 0.049–0.19 depending on level, Fig. 1). Conversely, at L5–S1, group differences were large (ΔT1ρcLBP-control = -11.3 ms, p <.0001), representing biochemical deterioration typically observed over a 9–12 year period (NP-T1ρ declined by 0.8–1.1 ms per year [95% CI]). NP-T1ρ values were lower in females than males (68.6 ± 20.1 vs. 76.8 ± 24.1 ms, females vs. males, p = 0.0001).

At levels L1–L2 through L4–L5, the relationships between NP-T1ρ and age were similar in both groups, i.e. similar regression slopes (p > 0.33; Fig. 2). However, at L5–S1, there was a statistically significant interaction between age and group (p = 0.0008), indicating that the age-dependence of disc degeneration differed between groups. In the asymptomatic group, NP-T1ρ was strongly correlated with age at all levels (r = 0.6–0.7, p <.0001 each; Fig. 2). The cLBP group also exhibited strong correlations at all levels (r = 0.6–0.7, p <.0001), except for at L5–S1, where the correlation was weak (r = 0.3, p = 0.02). At L5–S1, group differences in NP-T1ρ were larger in younger subjects and decreased with increasing age.

Conclusions: At L5–S1, we found substantially lower NP-T1ρ values in cLBP patients than controls in age-adjusted models, suggesting that age-adjusted NP-T1ρ values could be used to distinguish pathologic degenerative changes associated with cLBP from normal disc aging, particularly in younger individuals. This suggests that aging effects on the L5–S1 disc may involve a relatively uniform set of factors from which many cLBP patients deviate. We also found sex differences indicating that males have higher NP-T1ρ values than females for a given age. We conclude that NP-T1ρ biomarkers at L5–S1, used in multivariate prediction/classification models incorporating sex, may be highly relevant to clinical phenotyping, particularly in younger individuals.

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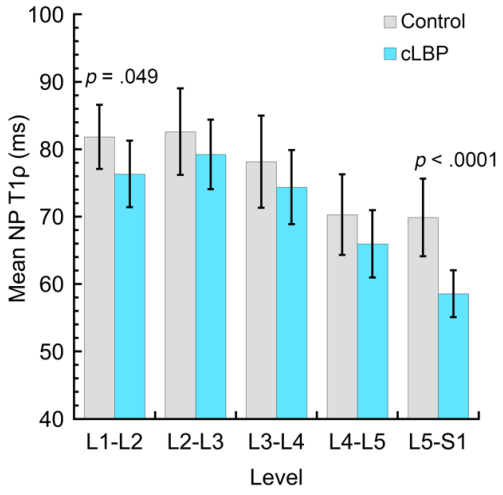

Fig. 1 Mean (95% CI) NP T1ρ by level

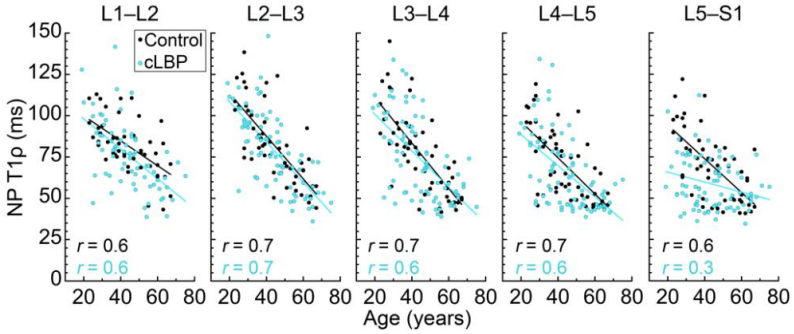

Fig. 2 NP T1ρ as a function of age at each lumbar level (p <.0001 each except cLBP at L5–S1, for which p = 0.02). At L5–S1, there was a statistically significant interaction between age and group (p = 0.0008), indicating that the relationship between age and disc degeneration (regression slope) differed between groups

O567

Lumbar spinal stenosis is a risk factor for the development of dementia: Locomotive syndrome and health outcomes in the Aizu cohort study (LOHAS)

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Introduction: An association between dementia and musculoskeletal disorders has been demonstrated in recent years. Cross-sectional studies have reported an association between lumbar spinal stenosis (LSS) and dementia[1]. However, there have been no longitudinal studies, and it is unclear whether LSS is a risk factor for developing dementia. We hypothesized that LSS could be a risk factor for the development of dementia through lower extremity pain and numbness, intermittent claudication, muscle weakness, and associated physical inactivity. This cohort study of community-dwelling individuals aimed to determine the impact of LSS on the development of dementia.

Methods: We included participants aged ≥65 years from the Locomotive Syndrome and Health Outcomes in the Aizu cohort study (LOHAS)[2]. LSS was diagnosed using the validated LSS diagnostic support tool[3]. Dementia development between 2008 and 2015 was investigated using official long-term care insurance certification data. We analyzed the effects of LSS on dementia development after adjusting for potential confounders, like age, sex, diabetes, depressive symptoms, hip and knee joint osteoarthritis, daily activity, and smoking habit.

Results: We included 1220 patients in the final analysis. The incidence of dementia was significantly higher in the LSS group [48 of 444 (10.8%)] than in the control group [34 of 776 (4.4%)] (Fig.1). Multivariable analysis using multiple imputations revealed that the confidence interval for the adjusted odds ratio of LSS for dementia development was 1.87 (95% confidence interval; 1.14–3.07) (Table 1).

Conclusions: We clarified that LSS is an independent risk factor for dementia development. Our findings suggest the importance of considering the risk of dementia in the decision-making process for the treatment of LSS.

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Fig. 1

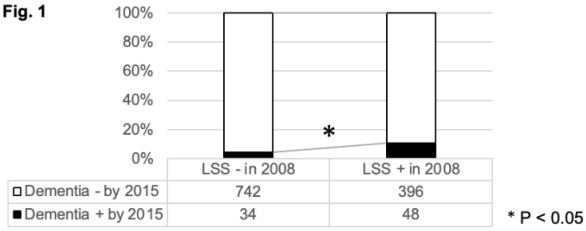

Table 1. Crude and Adjusted Odds Ratio for Development of Dementia

	Crude OR[a]	[95% CI]	*P* value	Adjusted OR[a]	[95% CI]	*P* value
Age (y)	1.15	[1.11–1.20]	**<.001**	1.15	[1.10–1.20]	**<.001**
Female Sex	1.55	[0.94–2.54]	.085	1.70	[0.98–2.94]	.057
LSS (positive)	2.65	[1.68–4.17]	**<.001**	1.87	[1.14–3.07]	**.013**
Diabetes	1.65	[0.82–3.30]	.159	1.69	[0.82–3.49]	.156
Depressive symptoms	1.26	[0.78–2.02]	.341	1.41	[0.86–2.34]	.176
Hip, knee OA	1.02	[0.65–1.61]	.917	0.66	[0.40–1.07]	.094
Daily activity	1.09	[0.61–1.97]	.764	1.15	[0.62–2.16]	.652
Smoking habit (current)	0.85	[0.34–2.12]	.731	1.19	[0.43–3.26]	.735

[a] The crude analysis used single-variate logistic regressions whereas the adjusted analysis used multivariate logistic regression including all explanatory variables

OR: Odds ratio, CI: Confidence interval, LSS: Lumbar spinal stenosis, OA: Osteoarthritis

O568

The role of remote working in patients affected by low back pain: A cross-sectional study

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Introduction: With the coronavirus disease 2019 (COVID-19) pandemic, remote working has been ubiquitously implemented to reduce disease transmission via minimization of in-person interactions.Yet, while preserving productivity and prosecution of both public and private services, prolonged remote working has demonstrated to negatively impact on workers' physical and mental wellbeing. Indeed, decreased physical activity and the sedentary lifestyle associated with social confinement and working from home have been related to a higher risk of several systemic and musculoskeletal disorders, including low back pain (LBP). The aim of this cross-sectional study was to investigate the role of remote working in an adult population affected by LBP. We hypothesized that diverse working conditions, home office equipment as well as perceived advantages, disadvantages and impact on job satisfaction, productivity, well-being and stress may differentially influence the incidence and severity of LBP in this subset of workers.
Methods: A cross-sectional study was performed at Campus Bio-Medico University of Rome through an online questionnaire. The target population consisted of working-age adults diagnosed with LBP due to degenerative disc disease after attending the Spine Clinic of Campus Bio-Medico University Hospital Foundation. All patients underwent a thorough history-taking and physical examination, as well as lumbar spine imaging evaluation, to confirm the diagnosis. Participants were recruited if they reported a history of LBP and worked remotely from home in the previous 18 months. Demographic data, remote working features and tasks, and LBP burden were analyzed through an online questionnaire. The psychological burden of remote working was evaluated with the World Health Organization Five Well-Being Index (WHO-5) and the Patient Health Questionnaire-2 (PHQ-2). LBP severity was evaluated using a visual analog scale (VAS). LBP-related disability was assessed using the Oswestry Disability Index (ODI). The effect of LBP on working capacity was examined with the Occupational Role Questionnaire (ORQ). Independent risk factors related to LBP worsening were identified using a multivariate logistic regression model.
Results: The questionnaire was delivered to 136 participants and a total of 101 responses were received. 8 were excluded because participants did not meet one of the inclusion criteria. Eventually, 93 suitable questionnaires were included in the final analysis. LBP severity was significantly higher compared to previous in-person working ($p<0.0001$, Fig. 1) as well as average weekly work hours ($p<0.001$, Fig. 2). Furthermore, the risk of LBP deterioration was associated with being divorced (OR: 4.28, 95% CI: 1.27-14.47; p=0.019) or living with others (OR: 0.24, 95% CI: 0.07-0.81; p=0.021), higher ill-being (OR: 0.91, 95% CI: 0.83-0.99; p=0.035) and depression scores (OR: 1.38, 95% CI: 1.00-1.91; p=0.048), as well as having reported unchanged (OR: 0.22, 95% CI: 0.08-0.65; p=0.006) or decreased job satisfaction (OR: 0.16, 95% CI: 0.05-0.54; p=0.003) and increased stress levels (OR: 3.00, 95% CI: 1.04-8.65; p=0.042).
Conclusions: The sedentary lifestyle, reduced physical activity, poorer workspace conditions and decreased social interactions associated with remote working may increase the severity of LBP in individuals working from home. These findings highlight key factors to consider for improving remote workers' physical and mental wellbeing and decrease their LBP burden.

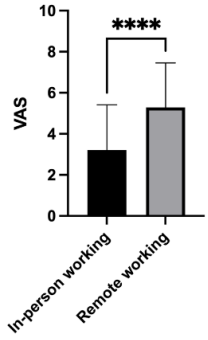

Figure 1

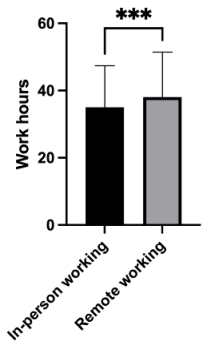

Figure 2

O569

Prevalence of lumbar spondylolisthesis and its association with low back pain, physical activity, and sarcopenia in the general population : The 2nd survey of the ROAD study

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Background: Lumbar spondylolisthesis (LS) is a disease that adversely affects low back pain (LBP) and lower extremity symptoms in the elderly. However, the epidemiological information on LS and its association with clinical symptoms has been hampered using the general population in the past.
Purpose: In this study, we aimed to determine the prevalence of LS and its association with LBP, walking speed, grip strength, and muscle mass in the general population.
Methods: The participants were 1,525 general population (511 males and 1,014 females, mean age: 65.8 ± 12.3 years old) who joined the 2nd ROAD (Research on Osteoarthritis/osteoporosis Against Disability) study conducted in Wakayama Prefecture from 2008 to 2010. All participants were examined by an orthopedic surgeon and X-ray at the lumbar spine. A diagnosis of spondylolisthesis was established when slip was ≧3mm in the lateral views. Logistic regression analysis (adjusted for sex, age and BMI) was performed with LS as the objective variable and LBP, walking speed and grip strength as explanatory variables. Regarding SMI, body weight was used rather than BMI in the logistic regression analysis.
Results: The prevalence of LS was estimated to be 269 (17.6%) in total, 69 (13.5%) in men and 200 (19.7%) in women, with a significantly higher proportion of women (Chi-square test, P=0.003). The LS group were more likely to have LBP than non-LS group. (LS group:45.3%, non-LS group:36.1%, Chi-square test, P=0.005) The LS group also had significantly slower walking speed (LS group: 1.14m/s, non-LS group: 1.09m/s Student t-test, P=0.008) and lower grip strength (LS group: 28.03kg, non-LS group: 30.95kg Student t-test, P<0.001) than the non-LS group, and there was no significant difference in SMI (LS group: 6.74 kg/m2, non-LS group: 6.62 kg/m2, Student t-test, P=0.10), although the LS group tended to have lower SMI. In the logistic regression analysis adjusted for age, sex, and BMI, LS was the associated factor for LBP, (Odds Ratio (OR) 1.39, Confidence Interval (CI) 1.06-1.83) for walking speed, (OR1.00, CI 0.97-1.02) for grip strength, and (OR1.00, CI 0.97-1.03) for SMI(OR1.29,CI 1.02-1.62).
Conclusion: Based on this general population, those with LS had tendency to have more LBP and less muscle mass as compared with those without LS.

O570

Muscle strength and trunk muscle mass rather than appendicular skeletal muscle mass might affect spinal sagittal alignment, low back pain, and health-related quality of life

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Introduction: Add a full Purpose: Sarcopenia is defined as decreasing in muscle strength and mass, and dynapenia is defined as decreasing in muscle strength and maintained muscle mass. This study elucidated the prevalence of sarcopenia and dynapenia and evaluate whether muscle mass or muscle strength affect clinical outcomes and spinal sagittal alignment in elderly spinal disorders patients.

Methods: 1039 spinal disorders patients (445 men and 594 women) aged ≥65 years (mean age, 74.6 years) were included. We measured age, grip strength, appendicular skeletal muscle mass, body mass index (BMI), the percentage of body fat (%BF) and for spinal sagittal alignment parameters including pelvic tilt (PT), sagittal vertical axis (SVA), and pelvic incidence minus lumbar lordosis (PI−LL). Additionally, we investigated low back pain scores including Oswestry Disability Index (ODI) and visual analogue scale (VAS) of LBP and the EuroQol 5 Dimension (EQ5D) for health-related quality of life scores. Based on the classification from the Asian Working Group for Sarcopenia, patients were categorised into normal muscle mass/normal muscle strength (normal group: NG), decreased muscle mass/normal muscle strength (pre-sarcopenia group: PG), normal muscle mass/decreased muscle strength (dynapenia group:DG), and decreased muscle mass/decreased muscle strength (sarcopenia group: SG).

Results: The prevalence of pre-sarcopenia, dynapenia, and sarcopenia was 9.7%, 24.0%, and 8.8%, indicating that 42.5% of elderly patients with spinal diseases showed decreased muscle mass or muscle strength. Additionally, the age in PG, DG and SG was significantly higher compared with that in NG. Regarding the spinal sagittal plane alignment and clinical outcomes, patients in DG and SG had a significantly higher PT, PI-LI, SVA, ODI scores, and VAS of LBP score than patients in NG and PG ($p<0.05$) In contrast, no significant differences in these measurements from spinal sagittal alignment parameters and clinical outcomes were observed between NG and PG ($p>0.05$). In contrast, for the body composition, statistically significantly lower the BMI, %BF, and appendicular skeletal muscle mass were observed in PG and SG than in DG and NG. However, interestingly, patients in PG, DG, and SG had significantly lower TMI compared with patients in NG ($p<0.05$). No significant difference in the TMI was observed between PG and DG ($p>0.05$).

Conclusions: In conclusion, the current study showed that approximately 20% and 10% of the patients with spinal disorders had dynapenia and sarcopenia, respectively. In addition, patients with low muscle strength had low trunk muscle mass, poor outcomes of LBP, poor HRQoL, spinal sagittal malalignment, but elderly patients with low appendicular skeletal muscle mass alone did not. Thus, interventions for muscle strength and trunk muscle mass may be a treatment option for spinal malalignment and LBP.

O571

Backing down? Lumbar disc herniation surgery for the sad and nervous

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Background: Pre-operative anxiety and depression have been suggested to have a detrimental impact on the outcome of spine surgery and have even been considered as a warning sign against a successful surgical outcome. However, by alleviating physical pain, patients may be able to recover from pain-induced depression and anxiety, thus increasing also mental aspects of quality of life following a lumbar discectomy.
Aim: To examine the impact of stated preoperative depression and anxiety on patient reported outcome measures after lumbar disc herniation surgery in a large national spine register.
Method: This is a national register-based study examining patients that reported themselves as extremely anxious or depressed using the mental domain within the EQ-5D questionnaire in the Swedish national spine register (Swespine) and having a lumbar discectomy 2013-2017. The patients were compared to patients without mental complaints. Patient reported outcomes including residual leg pain (NRS), disability (ODI) and quality-of-life (EQ-5D) were analysed.
Results: The preoperatively self-assessed extremely anxious or depressed patients did not reach the same mental or physical improvements as controls following lumbar disc herniation surgery. The group had almost twice as many (7.0% vs 4.0%) patients with severe post-operative residual leg pain and only 41.2% stated minimal residual disability (ODI <20) versus 65.8% for the mentally unaffected group of patients. The rate of post-operative dissatisfaction (15.3%) was three times higher among depression/anxiety patients than controls (5.6%). Patients with self-reported anxiety and depression had a higher risk of dismal results in all PROMs measured. However, the vast majority of depressed and anxious patients still improved following a discectomy.
Conclusion: Patient-reported depression or anxiety stated on the EQ-5D mental health dimension is associated with an increased risk of reporting feeling dissatisfied with the surgical outcome. Furthermore, a significant higher level of residual leg pain (NRS) and disability measured by ODI was observed among patients with pre-operative depression/anxiety compared to other patients. Regardless of pre-operative mental health status, the vast majority of patients improved significantly. A pre-operative feeling of being depressed or anxious should not exclude a patient from surgery. However, the surgeon should have an awareness that an increased proportion of dissatisfied patients is to be expected when performing surgery on this subgroup of patients.

Key words: Anxiety, depression, Spine, Lumbar disc herniation, mental outcome, PROMs.

O572

A study on the usefulness of MRI new imaging method "FRACTURE" in the diagnosis of lumbar spondylolysis

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Introduction: In the diagnosis of lumbar spondylolysis, staging is essential in determining the treatment strategy for lumbar spondylolysis. It has been performed mainly based on the classification by CT images. However, from the viewpoint of radiation exposure, CT scan should be avoided as much as possible. Recently, Philips has developed a new MR imaging technique called FRACTURE (Fast Field Echo Resembling CT Using restricted echo-spacing), which enables CT-like bone images. It is beginning to be used for diagnosing bone lesions. In this study, we aimed to investigate the usefulness of FRACTURE in diagnosing lumbar spondylolysis.

Subject and Methods: Of the 117 teenage patients with low back pain who were underwent FRACTURE imaging, 31 patients performed CT were included. (From July 2022 to October 2022). Mean age was 15 years (12-18). Males are 23 cases and female 8. After staging them with MRI including FRACTURE images (sagittal and transverse images), we classified them by CT scans and collated them. We used Philips 1.5T MRI models. The imaging conditions were; Scan mode: 3D FFE, TR: 22ms, TE: in-phase 4.6ms, Flip angle: 15, slice orientation: Sagittal. Generally, in CT scan, oblique axial images parallel to the lamina were used for the transverse images, but in FRACTURE, a normal axial slices were used for the transverse images due to image quality problems.

Results: Spondylolysis was observed in 26 of the 31 cases. Fourteen cases were unilateral and 12 bilateral. There were total of 38 sides of spondylolysis. Diagnosis by MRI was very-early stage 7 sides, early stage 18 sides, advanced stage 5 sides, terminal stage 3 sides and healing 5 sides. However, one case of very-early stage by MRI was revealed slight crack of ventral lamina with CT. In addition, there was one patient who was considered union but judged non-union with CT scans. Therefore, accuracy of FRACTURE was 94.7%.

Conclusions: FRACTURE is a new imaging method that can visualize bones, ligaments, tendons and calcifications in high definition. It may well be a substitute for CT in the diagnosis of lumbar spondylolysis. It helps greatly in reducing radiation exposure. However, because the bone is visualized a little too much, CT might be necessary only when strict judgment of bone healing is required.

O573

How does diffuse idiopathic skeletal hyperostosis affect the sagittal spinopelvic alignment in lumbar spinal stenosis patients?

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Background: Several studies have reported the effect of diffuse idiopathic skeletal hyperostosis (DISH) on spinopelvic alignment in patients with lumbar spinal stenosis (LSS). However, the specific differences of sagittal alignment between LSS patients with DISH and normal elderly are not well recognized.
Purpose: The aim of this study was to compare the differences of spinopelvic morphology among LSS patients with DISH, LSS patients without DISH and normal elderly. Differences of Roussouly classification between DISH and Non-DISH, T-DISH and L-DISH were also investigated, respectively.
Methods: LSS Patients with DISH and without DISH aged >50 years which required surgery were enrolled in our cohort. Also, we collected age-matched normal old outpatients as a control group. DISH was defined by Resnick's criteria on preoperative standing anteroposterior and lateral radiographs of the spine. For analysis, we divided the patients and normal elderly into three groups (DISH group, Non-DISH group and Normal group). We further divided DISH patients into two subgroups (T-DISH subgroup and L-DISH subgroup). Spinopelvic alignment was measured by T1 slope, C2-C7 lordosis, C2-C7 sagittal vertical axis, thoracic kyphosis, lumbar lordosis, pelvic tilt, pelvic incidence, sacral slope, S1 overhang, sagittal vertical axis, T1 pelvic angle, C7 tilt, spinosacral angle, spinopelvic angle. We also investigated the differences of Roussouly classification and distribution of kyphotic apex vertebrae between DISH and Non-DISH group, T-DISH and L-DISH subgroup, respectively.
Results: A total of 429 patients (300 males and 129 females) were enrolled in our study, with a mean age of 64.1±5.8 years. We observed significant differences between three groups in most of the parameters. Compared to the Normal group, DISH and Non-DISH groups both had significantly higher CSVA, PT, OH, SVA, TPA and lower LL, SS, C7 Tilt, SSA, SPA. Compared to Non-DISH group, DISH group, T-DISH and L-DISH subgroups all had significantly higher T1 slope, CSVA, TK and SVA. Besides, T-DISH subgroup showed significant higher LL, PI, SS and SSA than L-DISH subgroup. There were significant differences of Roussouly classification between T-DISH and L-DISH subgroup. In terms of distribution of kyphotic apex vertebrae, DISH group showed a variety of distribution from T5 to T11 whereas Non-DISH group mainly showed in upper thoracic(T5-7). Compared to upper thoracic kyphotic apex vertebrae in T-DISH subgroup, L-DISH subgroup predominantly showed lower thoracic kyphotic apex vertebrae.
Conclusion: Sagittal spinopelvic alignment can be affected by the presence of DISH, predominantly manifest as increased thoracic kyphosis and forward trunk. Those with L-DISH patients manifest not only as increased thoracic kyphosis and forward trunk, but also as insufficient lumbar lordosis.

O574

Automatic classification of the endplate lesions in MRI images by deep learning model

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Introduction: A novel classification scheme for endplate lesions, based on T2-weighted images from MRI scan, has been recently introduced and validated[1] (Figure1, left panel). In this scheme, the intervertebral spaces are classified as 'normal', 'wavy/irregular', 'notched', and 'Schmorl's node'. The presence of such lesions has been found as associated with spinal pathologies like disc degeneration and osteochondrosis. The exploitation of an automatic tool for the detection of the lesions would represent an advantage in the clinical practice by reducing the workload and the diagnosis time. In this regard, an increasing number of studies has applied Artificial Intelligence techniques in the last years to predict parameters from biomedical images, with the aim of providing reproducible and reliable evaluation. The present work exploits a deep learning application based on convolutional neural networks to automatically classify the type of lesion.

Methods: T2-weighted MRI scans of the sagittal thoraco-lumbar spine of 300 consecutive patients were retrospectively collected (age ranging from 18 to 65 years). The middle slice was manually processed to identify the intervertebral spaces from T12L1 to L5S1, with labelling of the corresponding lesion type. A total number of 1559 gradable discs was obtained, distributed as follows: 'normal' (567 discs), 'wavy/irregular' (485), 'notched' (362), and 'Schmorl's node' (145). The images of the intervertebral spaces were resized at 128x128 pixel, with gray padding to fill the image height (Figure1, left panel). Training- and validation-set (1248 and 311 discs, respectively) were randomly defined, preserving in each set the original distribution of the lesion types. Pre-trained network for image classification (ResNet18) from ImageNet was exploited. The net was retrained (fine-tuning) by progressively unfreezing the weights of the deepest layers up to half of net length, in consecutive steps with increasing number of epochs. Sample weighting correction for unbalanced groups (characterized by different number of samples) was accounted for. The validation-set was processed with the retrained net to evaluate the overall accuracy (number of correct predictions divided by the total number of samples in the validation-set), and the accuracy for the specific lesion type (number of correct predictions divided by the number of samples in the considered type).

Results: The overall accuracy was found equal to 0.88 (Figure1, right panel). The accuracy for the specific lesion type was found as follows: 0.91 (normal), 0.82 (wavy/irregular), 0.93 (notched), and 0.83 (Schmorl's node).

Conclusion: The automatic classification based on deep learning approach provided strong accuracy overall. Moreover, similar high percentage of correct predictions was confirmed for every lesion type. Further improvements can be achieved in the next steps by accounting for larger datasets and more balanced groups. As concerns the potential clinical applications, the developed implementation can be exploited as part of a tool for the automatic detection of pathological conditions characterized by the presence of endplate lesions, such as spinal osteochondrosis.

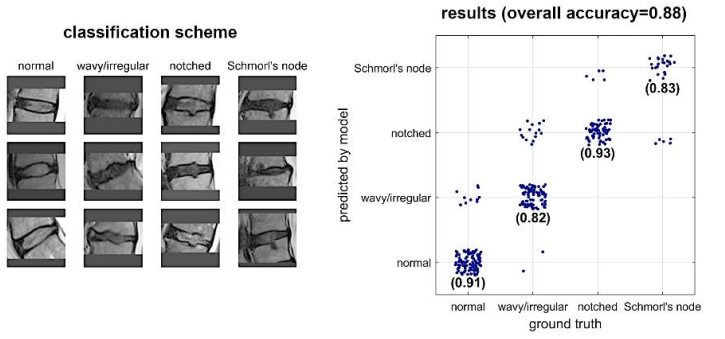

Figure 1. Left panel: examples of labelling for the classification of the endplate lesions. Right panel: results of the classification model (ground truth type versus predicted type). Each point represents one single validation sample.The percentage values indicate the accuracy of the prediction for the specific type.

References:

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O575

A machine learning algorithm for automated detection of lumbar disc degeneration on MRI

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Introduction: Herniated intervertebral discs can exert pressure on nerve roots, causing pain in the low back and leg(s). Early detection of lumbar disc degeneration on imaging can help providers and patients preempt pain syndromes with early intervention. However, subtle disc bulges can easily go overlooked, particularly when healthcare providers are not trained in spine care. Artificial intelligence has the potential to assist in detecting subtle disc bulges that may go unnoticed. Here we calibrate and evaluate the performance of a neural network for detecting subtle bulging lumbar discs on spinal imaging.
Methods: 714 lateral view lumbar spine MRIs were annotated using bounding boxes around bulging discs, as in figure 1. All images were resized to 416x416 pixels and divided among training, validation, and test data subsets in 70:20:10 ratio, respectively. The training data was augmented to create 3 training outputs per original image using horizontal flipping, random rotations, and varying degrees of image exposure. A resulting dataset including 1.5k training images, 143 validation images, and 71 test images was used to train a neural network for object detection over 75 epochs. Performance metrics of training loss, validation loss, mean average precision (mAP), overall precision, and recall rates were tracked over time, as shown in figure 2..
Results: The model's overall average precision on validation data and test data was 96% and 95%, respectively. The completed model had a mAP of 97.0%, precision of 90.1%, and recall of 94.3%. Byproducts of this study include a trained model, performance benchmarks, and an annotated dataset – all made publicly available at https://universe.roboflow.com/my-workspace-tbzeh/ldh/model/2.
Conclusions: Neural networks can be trained to localize subtle lesions on standard spine imaging with considerable accuracy and precision. Clinicians may benefit from integrating such models into clinical workflow.

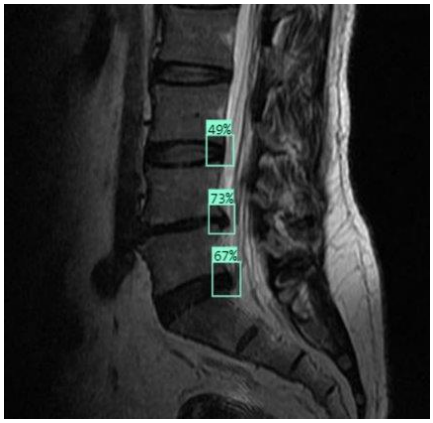

Figure 1. Examples of bounding box annotation.

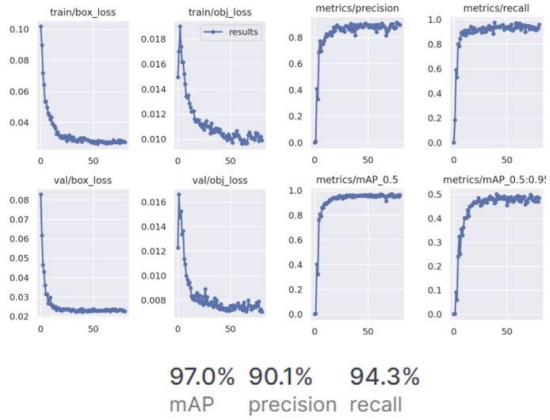

Figure 2. Model performance metrics during training and validation.

O576

Learning a model of lumbar disc degeneration progression from a cross-sectional population cohort

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Introduction: The purpose of this study was to develop a method for understanding lumbar disc degeneration (DD) progression using only cross-sectional data. We aimed to automatically extract radiomic features from Deep Learning (DL) based segmentations of T2-weighted MRI. Subsequently, we proposed a discriminative event-based model (DEBM) of DD progression, which discovers the most likely ordering of radiomic feature changes contributing progressively to lumbar DD.

Methods: We used data from Northern Finland Birth Cohort 1966 participants who underwent lumbar spine T2-weighted MRI scans at age 46-47 and who had consensus Pfirrmann grade evaluations (n=1315). Only intervertebral discs (IVD) at levels L5-S1 and L4-L5 were used due to their higher prevalence of severe DD.

We extracted 284 first and second order pixel intensity statistics from DL-segmented IVD regions in the sagittal plane. Aggregation across slices (average, min and max per feature) increased this total to 852 features. We removed those with zero variance and high correlation ($R \geq 0.99$; one removed per pair) and then applied Lasso logistic regression to obtain a final set of 20 radiomic features.

The DEBM method estimates an event ordering per sample, where each event corresponds to a change in imaging feature from normal to abnormal. The placement of samples along an event order is normalized from 0 to 1 and represents a hypothetical DD stage for each IVD. Using the PyEBM package, separate DEBM models were trained for L4-L5 and L5-S1 IVDs to ensure independence of the samples. The data were split participant-wise into train (70%) and test (30%) sets, with the computed radiomic features and anthropometric covariates (sex and BMI) used as input. The IVDs were labelled “abnormal” if they were graded Pfirrmann grade 5, and “normal” otherwise. Each model was trained for 100 bootstrap repetitions to estimate uncertainty in discovered DD progression.

The trained DEBM was used to infer DD stage for each IVD in the test set. We used the area under the receiver operator characteristic curve (AUC) as an evaluation metric with bootstrapped 95% confidence intervals.

Results: Figure 1(left column) shows the ordering of imaging features and the frequency of discovered events across the bootstrap sample. **Figure 1** (right column) shows the event centre variances and distances between events in the model (normalized DD progression stage; scale 0-1). On the test set, the AUCs for the L4-L5 and L5-S1 models were 0.92 (0.86-0.97) and 0.85 (0.79-91), respectively (**Figure 2** left column). The inferred stages from both models are plotted against Pfirrmann grades (**Figure 2** right column).

Conclusion: Our study has shown the first fully data-driven approach to modelling DD progression from cross-sectional data. Qualitatively, we observed that the discovered continuous DD stage follows change in Pfirrmann grades, and the numerical results show good ability to identify abnormal IVDs.

We hope that our study will set the stage for future work modelling degenerative musculoskeletal conditions from cross-sectional cohorts. DEBM is particularly attractive because it is interpretable, and the validity of the discovered progression model can be examined from a biological and clinical perspective.

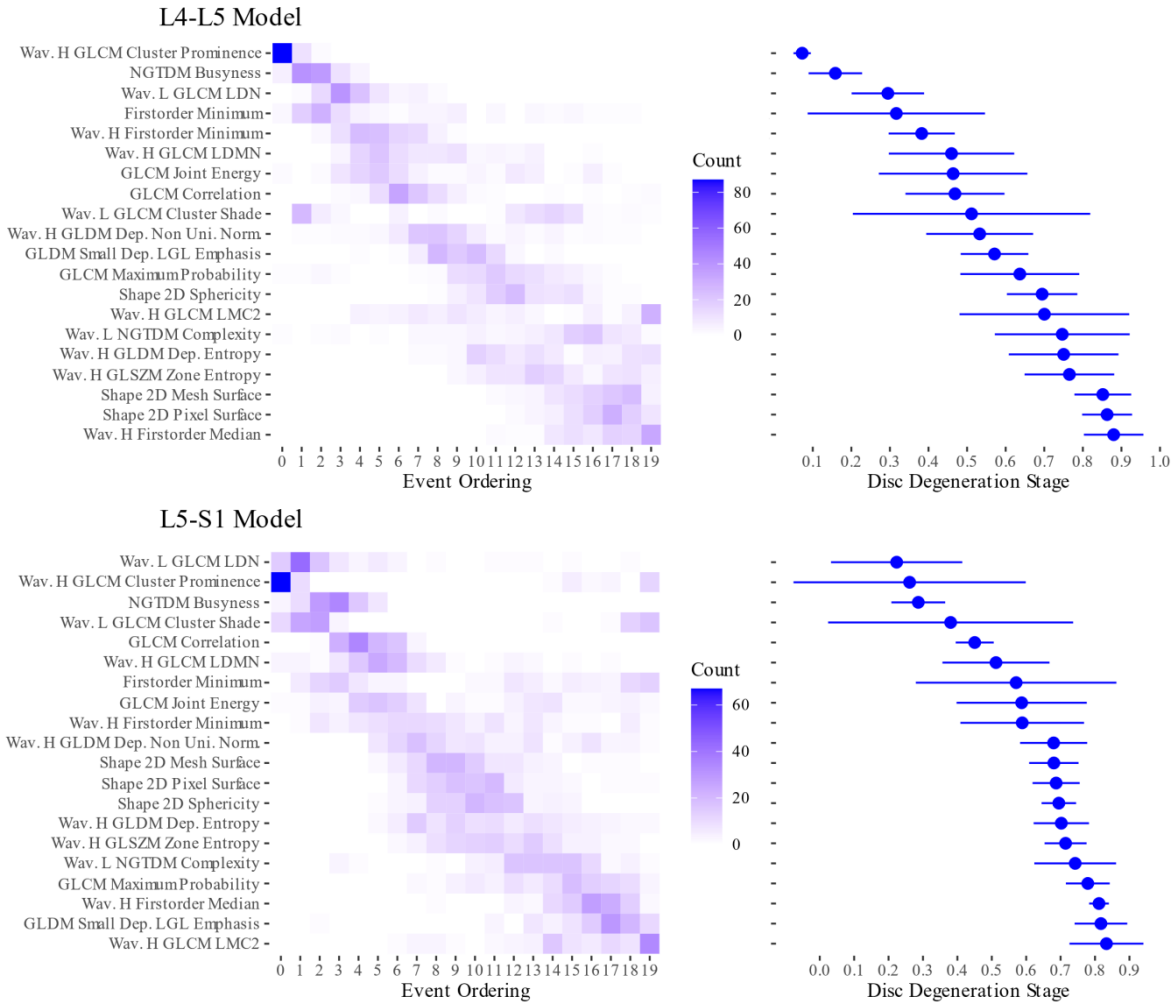

Figure 18. *Two DEBM models for L4-L5 and L5-S1 respectively, each using the same 20 radiomic features. The positional variance diagram (left column) shows the uncertainty in estimating the event ordering and the event centre variance diagram (right column) shows the standard error of estimated event-centres as measured by bootstrapping. Wav.: Wavelet.*

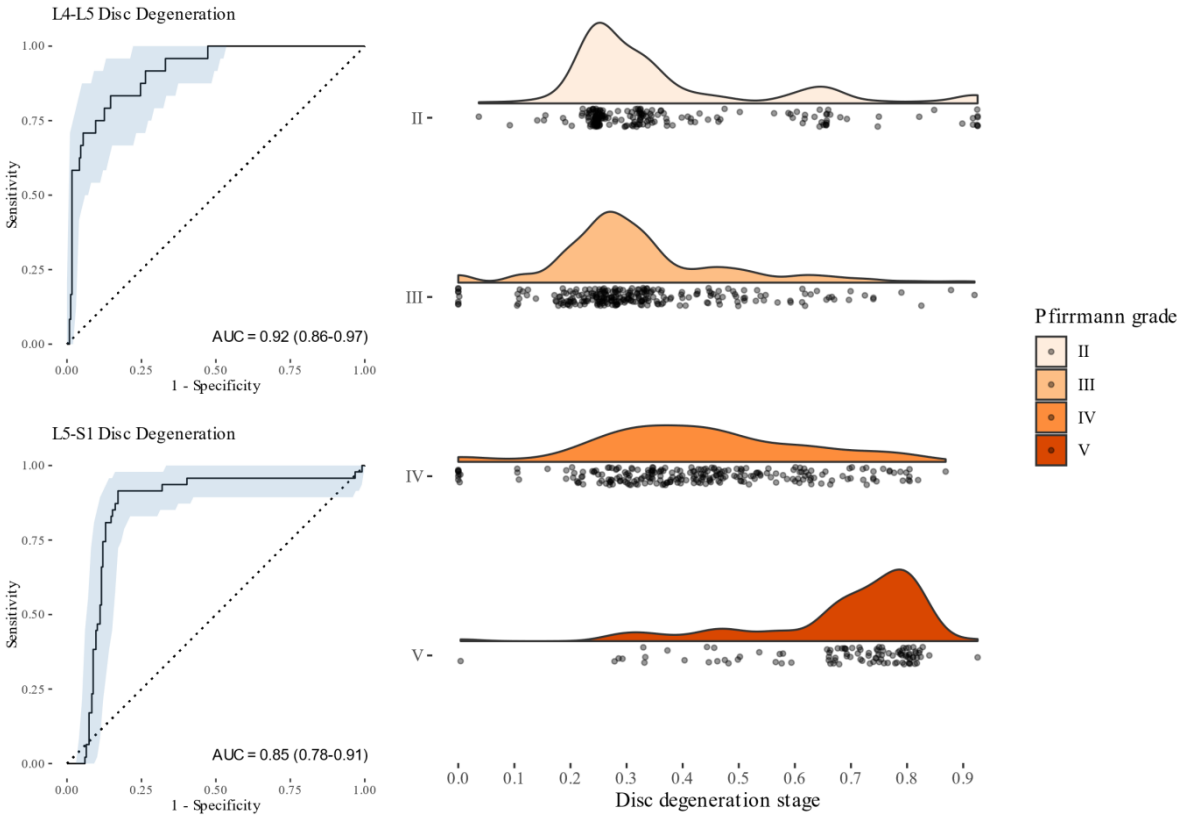

Figure 19. *ROC curves and AUC for Pfirrmann grade V prediction on the test set at L4-L5 and L5-S1 with bootstrapped 95% confidence intervals (left column); concatenated results of the predicted DD stages from both models plotted against all Pfirrmann grades (right column).*

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O577

Effect of central sensitization on the surgical outcome of lumbar spinal canal stenosis patients: A multicenter prospective study

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Introduction: Central sensitization (CS) is defined as an amplification of neural signaling within the central nervous system that elicits pain hypersensitivity1. There is growing evidence that CS is responsive for the underlying mechanism of musculoskeletal disorders. We have previously reported that CS had a significant association with preoperative neurological symptoms and health-related QOL for patients who received lumbar spine surgeries2. However, the influence of preoperative CS on postoperative clinical outcomes following lumbar spine surgeries of the patients with lumbar spinal stenosis (LSS) remains unknown.
This study aimed to investigate whether preoperative CS has a significant effect on the surgical outcome of patients with LSS following lumbar surgeries in a multicenter prospective study.
Methods: 197 consecutive patients with LSS (mean age 69.3) who received lumbar surgeries were included in this study. Posterior decompression (fenestration) was performed in 135 patients (68.5%), and lumbar fusion surgeries was performed in 31 patients (31.5%). The participants completed CS inventory (CSI), a patient reported screening tool scores of CS, and the following patient-reported outcome measures (PROMs) preoperatively (Pre) and 12 months postoperatively (Post 12M): the Japanese Orthopaedic Association (JOA) score for back pain, visual analogue scale (VAS) of LBP, leg pain and leg numbness, JOA back pain evaluation questionnaire (JOABPEQ), Oswestry Disability Index (ODI). CSI severity was classified into three groups: subclinical (0 to 29 points); mild (30 to 39 points); and moderate to extreme (≥40) in this study. The association of preoperative CSI scores with preoperative and postoperative PROMs was analyzed, and their changes were statistically evaluated.
Results: 1. The preoperative CSI score (21.8±11.3) was significantly decreased at 12 months postoperatively (17.9 ± 13.5, P<0.01), and it was significantly associated with the all the PROMs at Pre and at Post 12M (r=0.2-0.5). 2. Preoperative all the PROMs scores showed general trends to be worst in the 'moderate to extreme' group followed by 'mild' and 'subclinical' groups and those of each group decreased at Post 12M without change in order (representatively shown in Figure. 1). 3. Multiple-regression analysis revealed that the preoperative CSI was significantly associated with the change in JOA score, % change in VAS in 'leg numbness', 'low back pain' and 'mental health' domains of JOABPEC at Post 12M and those changes.
Conclusions: The preoperative CS evaluated by CSI influences on the postoperative neurological symptoms, disability and QOL of the patients with lumbar canal stenosis. Preoperative screening for CS is useful for predicting the treatment outcome of lumbar spine surgeries for the patients with LSS.
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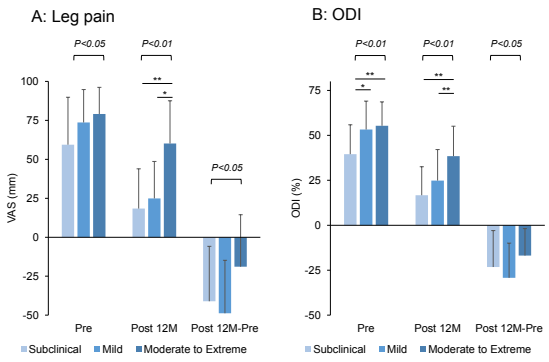

Figure 1. Change in VAS of leg pain (A) and ODI (B)

O578

Effects of the severity of stenosis on clinical outcomes of indirect decompression using oblique lumbar interbody fusion

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Introduction: Oblique lumbar interbody fusion (OLIF) is a safe and effective treatment for lumbar spinal stenosis (LSS). However, indirect decompression may be less effective in patients with endplate osteophytes, foraminal osteophytes, and severe facet arthropathy. Thus, there is no consensus regarding the efficacy of OLIF in severe spinal stenosis.
Aim: This study aimed to determine whether the clinical results of indirect decompression through OLIF differ according to the morphological grading of central stenosis and foraminal stenosis on preoperative magnetic resonance imaging (MRI) in patients with LSS.
Patients and Methods: During the study period, OLIF was selected as the primary surgical option for treating LSS when lumbar fusion surgery was required. We retrospectively reviewed the data of patients with LSS who underwent single- or two- or three-level OLIF and posterior stabilization, with a 1-year follow-up period. Relevant clinical scores obtained preoperatively and at 3, 6, and 12 months postoperatively were collected and analyzed. The severity of central and foraminal stenoses on the initial MRI was assessed using qualitative grading systems. Logistic regression models were used to identify risk factors for inferior clinical outcomes.
Results: A total of 145 patients were included in the study with a mean age ± standard deviation of 68.93 ± 7.72 years. When patients were stratified according to the severity of central stenosis, there was no significant difference in clinical scores between the groups. However, the group with severe foraminal stenosis showed significantly higher ODI scores (mean ± SD: 21.7 ± 8.0 versus 18.9 ± 6.4; P = 0.024), lower lumbar function score in JOABPEQ (mean ± SD: 51.8 ± 29.6 versus 41.1 ± 30.8; P = 0.009), and lower walking ability score in JOABPEQ (mean ± SD: 72.6 ± 34.8 versus 86.4 ± 21.3; P = 0.004) at postoperative 1-year than those without severe foraminal stenosis. (Figure 1). The presence of foraminal osteophyte of SAP was a significant risk factor responsible for not achieving SCB in ODI score and walking ability score in JOABPEQ at postoperative 1-year (odds ratio [95% confidence interval]: 0.20 [0.05-0.81] and 0.22 [0.06-0.86], respectively).
Conclusion: In this study, patients with severe central stenosis showed clinical outcomes comparable to those with mild-to-moderate central stenosis. The improvement in ODI and walking ability score in JOABPEQ after OLIF was limited to patients with severe foraminal stenosis. Direct decompression can be considered in patients with the foraminal osteophyte of SAP contributing the foraminal stenosis.

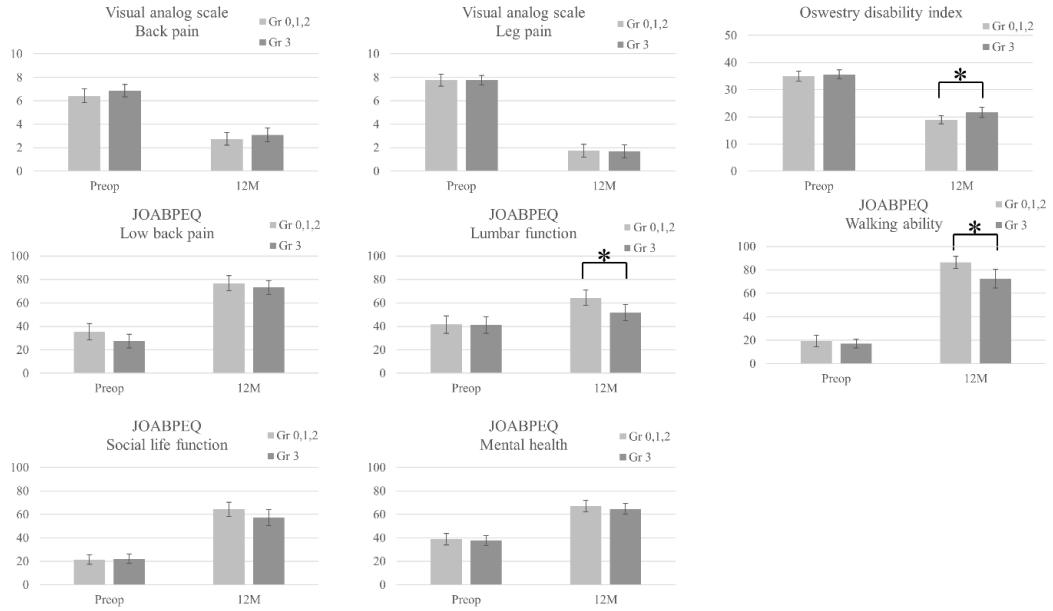

Figure 1. VAS, ODI, JOABPEQ scores at preoperative and postoperative 1-year stratified by the existence of severe foraminal stenosis. The group with severe foraminal stenosis showed significantly lower walking ability score in JOABPEQ than that by the other group (P = 0.004).* Error bars showed range of 95-percentile confidence interval.

O579

Is there a correlation between degree of facet degeneration and increase in spinal canal volume after a minimally invasive pre-psoas interbody fusion? A minimum 2 year follow up study

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Introduction: The first stage of circumferential minimally invasive (cMIS) correction of adult spinal deformity (ASD) involves lateral or oblique lumbar interbody fusion (OLIF). These techniques indirectly decompress the spinal canal, lateral recess, and neural foramen and subsequently resolve the radicular symptoms when properly performed. However, one of the surgeons' concerns has been the presence of facet arthropathy which may impede the success of an interbody fusion that is not supplemented by a posterior decompression or facetectomy.
Aim/Objectives: We assessed the clinical and radiological success of the indirect decompression after CMIS correction for ASD.
Methods: We review our prospectively collected data registry of 254 ASD patients who underwent staged CMIS correction From Jan 2011 to Jan 2020. Inclusion criteria of having ASD (Cobb>20,SVA>50mm,(PI-LL)>10) and 3+ levels fused, identified 147patients. 104 patients who had at least 2-yr follow-up with pre-op and post-op lumbar MRI/CT scans for evaluating facets and spinal volume on each lumbar level (L1-S1) were included for this study. Total of 824 facets were reviewed, and we assigned a pre-op grading (0-3) to the severity of the facet arthropathy using CT/ MRI described by Weishaupt et al. We then assessed the success of the indirect decompression by evaluating spinal canal volume on post-op MRI/CT scans.
Result: Mean age was 66.6(22-84). Mean follow-up was 69 months(24-132). Total of 412 interbody levels were fused. Total of 824 facets were graded as: 51 Grade 0, 218 Grade 1, 404 Grade 2 and 151Grade 3. All preop clinical parameters, including the visual analog scale score(5.9, 2-10, SD 2) and Oswestry Disability Index(42.1, 0-78, SD 16.4) significantly improved postoperatively to (2.8, 0-7, SD 2.6) and (28.8, 0-62, SD 20) respectively. The radiological evaluation showed that the spinal canal volume was significantly improved at all lumbar levels($p<0.05$) with grade 1, grade 2 and grade 3 facets after LIF surgery. Only 4 patients had the same radiculopathy as pre-op and underwent revision decompression surgery during the second stage. Of these 4 patients needing decompression, 1patient had a Grade 3 facet, 2 patients had Grade 2 facets and 1 other patient had Grade 1 facets.
Conclusion: Our study suggests that if the facets are not fused, the success of lateral/oblique interbody fusion in cMIS for ASD is independent of the severity of facet arthropathy posteriorly.

Table 1: Grading of lumbar facet joint degeneration using CT/ MRI described by Weishaupt et al.

Facet Grade	Definition	Number
Grade 0	Normal facet joint space (2–4 mm width)	51
Grade 1	Narrowing of the facet joint space (<2 mm) and/or small osteophytes and/or mild hypertrophy of the articular process	218
Grade 2	Narrowing of the facet joint space and/or moderate osteophytes and/or moderate hypertrophy of the articular process and/or mild subarticular bone erosions	404
Grade 3	Narrowing of the facet joint space and/or large osteophytes and/or severe hypertrophy of the articular process and/or severe subarticular bone erosions and/or subchondral cysts	151

Table 2: Facet Grading

Level	Grade 0	Grade 1	Grade 2	Grade 3	Total
L1-L2	8	35	71	8	122
L2-L3	7	58	88	23	176
L3-L4	13	45	98	40	196
L4-L5	10	50	81	37	178
L5-S1	13	30	66	43	152

Table 3: Spinal Cross-sectional area

	Total LIF done	Pre-op	Post-op	P value
L1-L2	61	2.3 (1.1-3.7) SD 0.64	3.4 (2.1-5.1) SD 0.69	P< 0.05
L2-L3	88	1.97 (0.83-4.10) SD 0.66	3.44 (1.9-5.8) SD 0.83	P< 0.05
L3-L4	98	1.82 (1-3.70) SD 0.63	3.53 (1.9-6.5) SD 0.89	P< 0.05
L4-L5	89	1.95 (1-4.9) SD 0.7	3.86 (2-6) SD 0.84	P< 0.05
L5-S1	76	2.50 (1.1-5.3) SD 1.09	5.08 (2.7-7.5) SD 1.05	P< 0.05

Spina volume in pre-op Grade 1 Facets

	Pre-op	**Post-op**	**P value**
L1-L2	2.5 (1.3-3.2) SD 0.6	3.6 (2.8-4.5) SD 0.6	P< 0.05
L2-L3	2 (0.8-4.1) SD 0.89	3.6 (2.4-5.4) SD 0.95	P< 0.05
L3-L4	2 (1.1-3.1) SD 0.61	3.9 (2.9-5) SD 0.64	P< 0.05
L4-L5	2.1 (1.3-3.9) SD 0.92	3.7 (2.8-5.2) SD 0.65	P< 0.05
L5-S1	2.1 (1.2-3.7) SD 0.88	5.1 (3.6-6.1) SD 0.85	P< 0.05

Spina volume in pre-op Grade 2 Facets

	Pre-op	**Post-op**	**P value**
L1-L2	2.3 (1.2-3.7) SD 0.5	3.4 (2.1-5.1) SD 0.7	P< 0.05
L2-L3	2 (0.8-3.3) SD 0.61	3.5 (2-5.8) SD 0.73	P< 0.05
L3-L4	1.6 (1-3.4) SD 0.54	3.4 (2.1-6.5) SD 0.82	P< 0.05
L4-L5	2 (1.1-3.6) SD 0.60	4.1 (2.1-6) SD 0.85	P< 0.05
L5-S1	2.4 (1.1-5.3) SD 1.1	5.5 (3.2-7.5) SD 1.3	P< 0.05

Spina volume in pre-op Grade 3 Facets

	Pre-op	**Post-op**	**P value**
L1-L2	2.3 (1.2-3.5) SC 0.9	2.9 (1.9-3.6) SD 0.5	P< 0.05
L2-L3	1.8 (1-3) SD.54	3.2 (2.2-5.2) SD 0.89	P< 0.05
L3-L4	2.1 (1-3.7) SD 0.68	3.6 (1.9-5.3) SD 0.91	P< 0.05
L4-L5	3.4 (2.3-4.2) SD 0.55	5.1 (3.2-7.5) SD 1.2	P< 0.05
L5-S1	2.8 (1.3-4.8) SD 1.04	4.8 (2.7-6.2) SD 0.80	P< 0.05

O580

Does preoperative sagittal imbalance affect the clinical outcomes in short-segment lumbar interbody fusion?

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Introduction: In the case that neurological deficits is predominant, selective decompression and fusion surgery might be performed regardless of preoperative sagittal imbalance. However, it is unclear whether preoperative sagittal imbalance affects the clinical outcomes in short-segment lumbar interbody fusion.
Aim. The aim of this study is to investigate the influence of preoperative sagittal imbalance on the clinical outcomes in short-segment fusion.
Materials and Methods: A total of 261 patients who underwent short-segment lumbar interbody fusion from 2011 to 2017 were reviewed retrospectively. There were 86 men and 175 women, with a mean age of 69 years. The mean follow-up period was 49 months. Short-segment fusion was defined as one- or two-segment fusion in this study, and was performed for single level in 182, and two levels in 79 patients. Radiographic parameters included thoracic kyphosis (TK), lumbar lordosis (LL), sacral slope (SS), pelvic tilt (PT), pelvic incidence (PI), sagittal vertical axis (SVA), T1 pelvic angle (TPA), and segmental lordosis (SL). These parameters were evaluated using standing whole spine radiographs preoperatively, immediately after surgery, and at the final follow-up. Clinical outcomes were evaluated using visual analog scale (VAS) of lumbar and leg pain, Oswestry Disability Index (ODI), Roland-Morris Disability Questionnaire (RDQ) and satisfaction rate. The rate of additional surgery was also reviewed. Patients were divided into two groups: preoperative SVA ≥50 mm (imbalanced spine group) or <50mm (balanced spine group). The change of radiographic parameters and clinical outcomes were compared between the two groups.
Results: A total of 124 patients were included in the imbalanced spine group, and 137 patients were in the balanced spine group. Immediately after surgery, improvement of the following parameters were significantly larger in the imbalanced group than the balanced group; ΔLL (6.2 degrees vs 2.0 degrees), ΔSVA (-29 mm vs 2 mm), ΔTPA (-4.0 degrees vs 0.5 degrees), and ΔSL (5.0 degrees vs 2.7 degrees). However, loss of improvement at the final follow-up was also significantly larger in the imbalanced group; ΔLL (-4.5 degrees vs -1.4 degrees), ΔPT (3.3 degrees vs 1.4 degrees), ΔSVA (22 mm vs 6 mm), and ΔTPA (5.1 degrees vs 1.9 degrees). There were no significant differences regarding clinical outcomes; VAS of lumbar pain (26 vs 23), VAS of leg pain (19 vs 20), ODI (25% vs 20%), RDQ (5.6 vs 5.0), satisfaction rate (72 vs 74). The rate of additional surgery was 15% in the imbalanced group and 12% in the balanced group.
Conclusion: Although there were several differences in the change of radiographic parameters, clinical outcomes after short-segment fusion were almost similar between balanced and imbalanced spine groups. In the case that neurological compromise is predominant, selective decompression and fusion surgery might be useful method to achieve successful clinical outcomes irrespective of preoperative sagittal balance.

O581

The influence of bone health on the risk of mechanical complications after lumbar spinal fusion for degenerative disease: A systematic review

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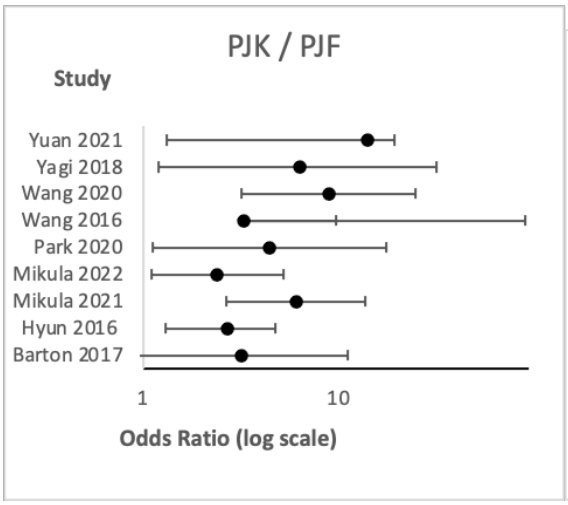
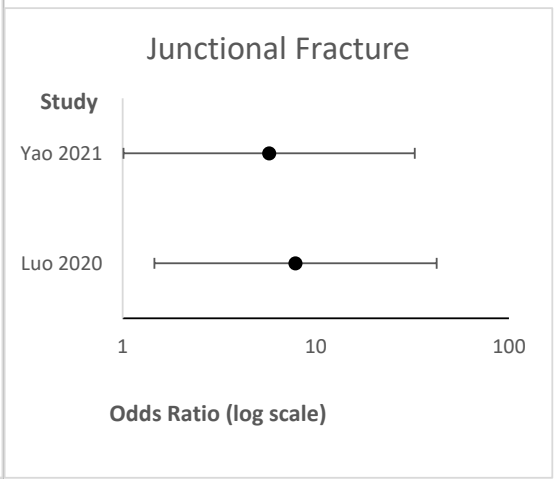
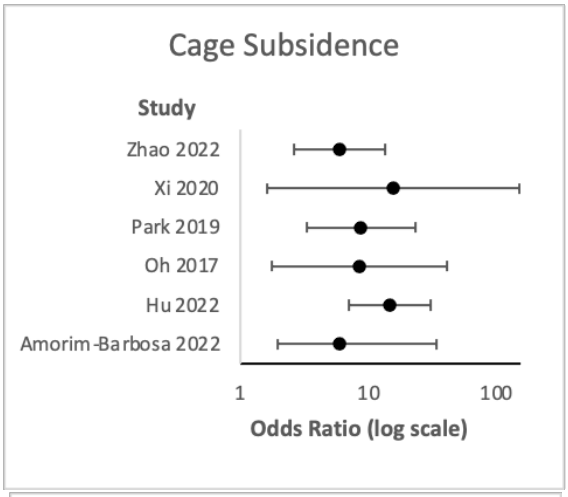
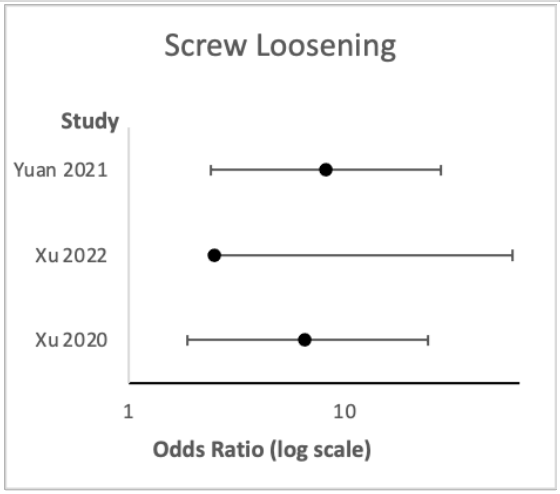
Introduction: Osteoporosis is frequently observed in adult patients with degenerative spinal disease and may be associated with higher rates of mechanical complications after reconstructive surgery. The impact of osteoporosis on mechanical complications in spine surgery has been studied inconsistently. We present the first systematic review of the literature regarding osteoporosis and the risk of mechanical complications and reoperation. The purpose of this study is to clarify the relationship between bone health and mechanical complications of spinal fusion.
Methods: Following PRISMA guidelines, PubMed, Embase, and Web of Science databases were searched for original clinical research articles reporting on bone health and spinal fusion. Eligible studies comprised at least 10 patients and evaluated measured bone health as a predictor of complications in adults undergoing lumbar fusion for degenerative pathologies. Cervical operations and those performed for tumor, trauma, or infection were excluded, as were cadaveric or biomechanical experiments. The quality of evidence was assessed using the GRADE method.
Results: Of 1397 identified citations, 58 articles comprised of 10,622 patients (63.78% female) were included in this review. The articles had moderate to very-low quality evidence. Overall, there was considerable variation in methods of bone health assessment, surgical approach, and complications evaluated. In terms of bone health, 30 authors provided DEXA-measured BMD for all patients. Citing limited availability of preoperative DEXA data, 32 authors performed indirect assessments of bone density or quality using CT or MRI-based metrics. Among the 14 studies presenting data from multiple modalities, site-specific measures were often more predictive of mechanical complications than traditional DEXA T-scores.
Bone health was identified as a risk factor for mechanical complications including interbody cage subsidence (17 studies), pedicle screw loosening (12 studies), pseudarthrosis (4 studies), junctional disease (21 studies), and vertebral fracture (6 studies) as well as for all-cause reoperation (4 studies). Osteoporosis was associated with an increased risk of cage subsidence (max OR=15.69, p=0.017) and screw loosening (max OR=8.19, p=0.001), which were often identified with concomitant pseudarthrosis on subgroup analysis. Higher rates of proximal junctional kyphosis (max OR=14.12, p=0.028), particularly in cases secondary to vertebral fracture, were also observed in patients with poor bone health.
Conclusions: This is the first systematic review to demonstrate the relationship between bone health and mechanical complications of lumbar spinal fusion. Our findings suggest that patients with osteoporosis are at increased risk for instrumentation-related complications including implant failure, pseudarthrosis, junctional pathology, and reoperation. As bone health is a modifiable risk factor, these results emphasize the importance of incorporating BH assessments into pre-operative evaluations to identify high-risk patients and design low-risk management strategies. Our assessment of available evidence also highlights current practical challenges with osteoporosis surveillance. Routine screening has faced numerous obstacles related to cost, access, and technical inaccuracies of DEXA-measured BMD in patients with spinal disorders. Alternative techniques using CT, ultrasound, or MRI may be useful for identifying osteoporosis prior to surgery. Further prospective studies using standardized methods of assessing bone health and reporting complications are necessary to strengthen current evidence and determine optimal practices.

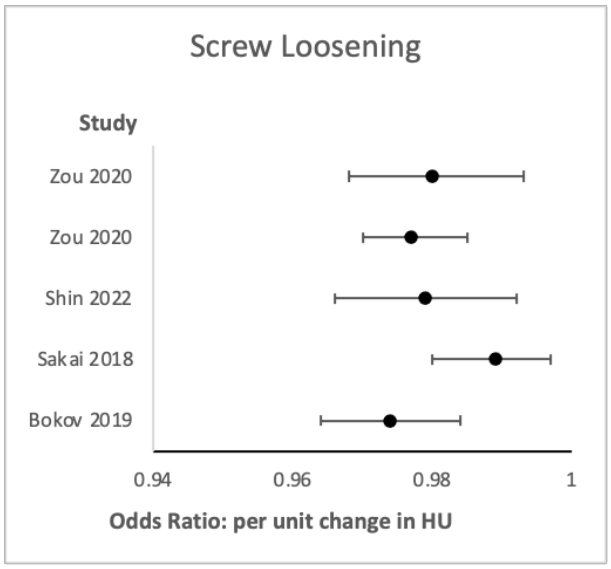
Figure 1: Osteoporosis as a Risk Factor for Different Mechanical Complications
Forest plots of reported effect sizes for each primary outcome in which at least 2 studies provided relevant statistics. Calculated odds ratios, represented on a logarithmic scale, are depicted of osteoporosis as a risk factor for complications of (A) PJK or PJF, (B) junctional fracture, (C) cage subsidence, and (D) screw loosening. Notably, many studies evaluating CT-based Hounsfield Units (HU) as a predictor for screw loosening described the influence of bone health as an odds ratio per unit change in HU; these results are separately depicted in (E).


PJK / PJF
Study
Yuan 2021
Yagi 2018
Wang 2020
Wang 2016
Park 2020
Mikula 2022
Mikula 2021
Hyun 2016
Barton 2017
1
10
Odds Ratio (log scale)


Junctional Fracture
Study
Yao 2021
Luo 2020
1
10
100
Odds Ratio (log scale)


Cage Subsidence
Study
Zhao 2022
Xi 2020
Park 2019
Oh 2017
Hu 2022
Amorim-Barbosa 2022
1
10
100
Odds Ratio (log scale)


Screw Loosening
Study
Yuan 2021
Xu 2022
Xu 2020
1
10
Odds Ratio (log scale)


Screw Loosening
Study
Zou 2020
Zou 2020
Shin 2022
Sakai 2018
Bokov 2019
0.94
0.96
0.98
1
Odds Ratio: per unit change in HU

O582

Assessing the importance of radiographic and clinical parameters when choosing decompression without fusion for LDS: Results from the CSORN prospective LDS study

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Introduction: The decision to decompress without fuse in lumbar degenerative spondylolisthesis surgery is partially based on an assessment of stability. Traditionally, recognized indications for fusion included more than 25% slip (≥grade II), dynamic instability defined by >3mm motion between pre-op standing versus supine or flexion-extension views, significant pre-op back pain, facet effusion, and lordotic disc angle. Despite meeting those fusion indications, a subset of patients within a multi-centred prospective study have been treated without fusion. This study compares a cohort of decompressed patients with radiographic instability (>3mm translation on lateral film) to a stable cohort of decompressed patients with respect to patient-reported outcomes (PRO) and radiographic measures in decompressed patients.

Methods: The CSORN multi-centred prospective study on the assessment and management of LDS database was retrospectively reviewed to identify patients who had decompression surgery. Out of 567 patients enrolled across eight centres, 109 patients that underwent decompression alone between 2015 and 2020 and had radiographic measures were included in the present study. Subjects were defined as unstable if there was 3mm or more of translation between supine and standing preoperative lateral x-ray. Demographic, clinical and radiographic characteristics were compared at baseline. Operative details were compared between the groups. Patient-reported outcome measures (ODI, SF36 PCS and MCS, back pain and leg pain) were compared between the groups at baseline and 3 months and 1 year after surgery.

Results: Out of the 109 patients, 81 were considered stable and 28 unstable. At baseline, the stable group was older in relation to the unstable groups (70.6 vs 66.3, p=0.045), and the number of patients with grade II spondylolisthesis was higher in the unstable group (25% vs 7.4%, p=0.032). Otherwise, there were no baseline demographic or radiographic differences between the groups.

Surgical time was longer in the unstable group (103 vs 84 minutes, p=0.011) despite the number of multilevel procedures being higher in the stable group (30.8% vs 10.7%, p=0.007). Using a mixed-model repeated measures analysis for the PROMs, patients in the unstable group had worse SF36-MCS at baseline (46.2 vs 50.9, p=0.047) but were not different at 3 months and 1 year after surgery. No differences were found between groups for ODI, SF36-PCS, and back and leg pain at any time point.

Conclusion: Our study identified that surgeons are becoming more liberal in their decision not to utilize fusion. Despite some indication of instability, no significant difference was found between the groups regarding PROMs and preoperative radiographic parameters.

O583

Patients treated by magnetic growing rods for early onset scoliosis reach the expected average growth

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Introduction: Magnetic growing rods (MGRs) are one of the most common procedures to treat early-onset scoliosis (EOS). However, this technique is controversial and not entirely accepted worldwide. One of the major concerns is that patients treated with MGRs do not reach an adequate height at the end of the treatment. According to the study by Dimeglio et al., the thoracic spine of healthy subjects should grow from 11 to 13mm/year according to age. To our knowledge, few studies tried to report if MGRs could allow patients to gain an adequate height. According to the recent literature, the present study has one of the largest sample sizes of EOS patients treated by MGRs. This study aims to demonstrate the efficacy of the treatment with MGRs in EOS patients, comparing our results with the estimated growth.
Methods: a single-centre retrospective study. Patients were consecutively enrolled at the Children's Hospital bambino Gesù in Rome from July 2011 to July 2022. The same surgical equipe performed all the procedures. The mean length of the patients was assessed by X-ray (T2-T12 and T2-S1 distance) by a team of expert radiologists. The estimated growth by Dimeglio was compared with the mean elongation obtained by year. The patients were divided into group 1 (patients in treatment) and group 2 (patients who underwent final surgery). In the analysis was included the length obtained with the first surgery. A comparison of the results obtained was performed by an independent t-test.
Results: 65 patients were included in the study. 16 patients underwent final surgery. In group 1, patients reached a growth of 3.6±8.7mm (T2-T12) and 9.6±27.6mm (T2-S1). In group 2, patients grew 5.4±5.7mm (T2-T12) and 9±9mm (T2-S1).81% of the estimated elongation during the treatment was obtained during the first surgery. The difference between Dimeglio estimated growth and the value obtained by MGRs was -4.3±8.7mm (T2-T12) and -12.3±12.2mm (T2-S1) in group 1 ($p<0.001$); and -1.1±4.2mm (T2-T12) and -6.6±6.0mm (T2-S1) in group 2 ($p=0.001$).
Conclusions: Therefore, it is possible to conclude that MGRs patients reached and overlapped the target of growth according to the score by Dimeglio. However, the value of growth tended to reduce over the years. Lastly, obtaining the largest elongation possible at the first surgery is mandatory, as it consists of 81% of the total value.

O584

Nerve root retraction time during lumbar endoscopic discectomy surgery: Association with post-operative radiculitis

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Introduction: Endoscopic discectomies reduce tissue retraction and incision size, however the procedures require scope placement and substantial nerve root retraction. Nerve root retraction time have impacted neurological outcomes in other surgical techniques. The aim of the current study was to evaluate the relationship between nerve root retraction time, post-operative radiculitis and patient reported outcomes (PROs).
Methods: A retrospective review of prospective patients who underwent single or multi-level lumbar discectomy between 2020-2022. Demographic and intra-operative variables were recorded. Data on post-operative complications, pre- and post-operative PROs (VAS, ODI and CAT) were collected. Paired sample two-tailed t-test was used to compare changes in pre- and post-operative outcomes with $p<0.05$ being significant. Multivariate regression and mixed models will be used to analyze the correlation between 5-minute increments of nerve retraction time and post-operative outcomes, as well as the changes in radiculitis severity while controlling for demographics and approach side.
Results: The current study included 157 patients who underwent single or multi-level endoscopic lumbar discectomy between 2020 and 2022. 112 (71.3%) of the discectomies were single-level procedures, 44 (28.0%) were two-level, and one (0.7%) was three-level. 43 (27.4%) were performed via an interlaminar approach, 5 (3.2%) were performed via a sublaminar approach, and 107 (68.2%) were performed via an extraforaminal approach. Average surgical time was 29.4 minutes and average estimated blood loss was 7.05mL. Average patient age was 44 years of age, and 64% were male patients. Nerve retraction time was between 4 and 15 minutes. Twenty-four patients (18%) reported a new neurological deficit - radiculitis at 2-weeks post-operatively. In patients with radiculitis 86% reported significantly worse VAS leg at 2 weeks post-op (4.2 vs 8.3, $p<0.001$) compared to 14% who had improved VAS leg (9.3 vs 7, $p=0.1181$). Patients with radiculitis and worse VAS scores had substantially longer nerve retraction time (13.8±7.5 min) than patients with improved VAS leg (6.7±1.2 min). In radiculitis patients with longer nerve retraction time VAS leg remained higher than the pre-operative values at later time points. At 6 months in patients with longer nerve retraction time there was no significant improvement in the ODI score (0.52 vs 0.46, $p=0.306$). Similar trends were observed for CAT domains for Pain interference, Pain intensity and Physical function.
Conclusion: This is the largest study to our knowledge that has looked at the nerve root retraction time as a risk factor for radiculitis and diminished patient outcomes in the endoscopic discectomy literature. The initial findings show that patients with new onset radiculitis who had longer nerve retraction time have worse VAS leg outcomes at early and later time points, and minimal improvement in ODI and CAT scores.

O585

Adding sacral anchors through an S1 alar screw and multi-rod construct as a strategy for lumbosacral junction augmentation: an in vitro comparison to S1 pedicle screws alone with sacroiliac fixation

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Introduction: Achieving solid fusion of the lumbosacral junction continues to be a challenge in long-segment instrumentation to the sacrum. We aimed to test the condition of adding sacral anchors through S1 alar screw (S1AS) and multi-rod construct relative to using S1 pedicle screws (S1PSs) alone with sacroiliac fixation in lumbosacral junction augmentation.
Methods: Seven fresh-frozen human lumbar-pelvic spine cadaveric specimens were tested under non-destructive moments (7.5 Nm). The ranges of motion (ROMs) in extension, flexion, lateral bending (LB), and axial rotation (AR) of instrumented segments (L3-S1), the lumbosacral region (L5-S1), and the adjacent segment (L2-3) were measured, and the axial construct stiffness (ACS) was recorded. The testing conditions were (1) intact; (2) bilateral pedicle screw (BPS) fixation at L3-S1 (S1PS alone); (3) BPS and unilateral S2 alar iliac screw (U-S2AIS) fixation; (4) BPS and unilateral S1AS (U-S1AS) fixation; (5) BPS and bilateral S2AIS (B-S2AIS) fixation; and (6) BPS and bilateral S1AS (B-S1AS) fixation.
Results: The ROMs of L5-S1 and L3-S1 were significantly reduced in B-S1AS and B-S2AIS conditions, compared with intact and S1PS alone. There was no significant difference in reduction of the ROMs of L5-S1 between B-S1ASs and B-S2AISs. Greater decreased ROMs of L3-S1 in extension and AR were detected with B-S2AISs than with B-S1ASs. Both B-S1ASs and B-S2AISs significantly increased the ACS compared with S1PSs alone. The ACS of B-S2AISs was significantly greater than that of B-S1ASs, but with greater increased ROMs of L2-3 in extension.
Conclusions: Adding sacral anchors through S1ASs and a multi-rod construct was as effective as sacropelvic fixation in lumbosacral junction augmentation. The biomechanical effects of using S1ASs in the control of long-instrumented segments were better than S1PSs alone but weaker than sacropelvic fixation. This strategy is appropriate for patients requiring advanced lumbosacral fixation, and the risk of sacroiliac joint violation can be reduced.

O586

Reassurance for low back pain in primary care: A scoping review

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Introduction: Multiple clinical practice guidelines recommend that reassurance is delivered to patients with low back pain (LBP). Reassurance is when a healthcare provider attempts to de-escalate the patient's concerns. However, there is significant variability in the content and delivery of reassurance for LBP. There is no current published review that describes reassurance interventions. In addition, it is unclear which tools are available to measure the degree to which a patient feels reassured and which health outcomes are being used to investigate reassurance interventions.
Aim: The aim of this scoping review is to describe: (i) how reassurance is currently being delivered; (ii) interventions to increase the delivery of reassurance; and (iii) how reassurance is measured in primary care for patients with LBP.
Materials and Methods: We conducted this review in accordance with the Joanna Brigg's Institute (JBI) recommendations. We searched CINAHL, MEDLINE, EMBASE and Cochrane Central from inception. Publications were screened for inclusion in duplicate independently. Inclusion criteria included: (i) populations with LBP +/- leg pain with no serious underlying pathology; (ii) concepts that described reassurance interventions and/or measurement of reassurance; (iii) studies conducted or able to be applied in a primary care setting; and (iv) published in a peer-reviewed journal and able to be translated to English. Data was charted in accordance with the study aims. Our protocol was registered with the Open Science Framework.
Results: We included 83 studies. Nineteen studies described aspects of reassurance delivery, including the information provided during delivery, frequency of delivery, challenges in delivery, and importance of individualising reassurance delivery. Interventions to increase the delivery of reassurance were reported in 59 studies. Delivery of reassurance was only the primary aim in 13 studies. Interventions included the delivery of information, either face-to-face (n=37) or through printed resources such as the Back Book (n=22). The extent to which reassurance was delivered during consultations was measured in 5 studies, using the Consultation Based Reassurance Questionnaire (CRQ). Seven studies directly measured outcomes that aimed to quantify how reassured the patient felt using individual likert-scale questions. Forty-four studies measured more indirect constructs that have been linked with reassurance, such as fear, worry, anxiety, catastrophisation, and healthcare utilisation. Health outcomes (e.g. disability, pain intensity) were measured in 59 studies.
Conclusion: This review highlights that while the delivery of reassurance to patients with LBP in clinical practice has been explored, there are limited studies investigating interventions to primarily improve the delivery of reassurance. There are also a limited number of studies that investigate how well reassurance was delivered and whether patient's feel reassured after reassurance is delivered.
Keywords: low back pain, reassurance, primary care

O587

What are medical attitudes and inclinations towards chiropractic? A universal review of the literature

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Purpose: The purpose of this study was to investigate medical practitioner attitudes towards chiropractic, and uncover major themes which influence practitioners attitudes.
Design: This research was conducted as a narrative review
Methods: A systematic search of online electronic databases identified twenty eligible studies relevant to the scope of the review. Critical appraisal of the twenty studies included in this review was completed using the STROBE and PRISMA checklists.
Results: A broad variety of medically orientated attitudes towards chiropractic were uncovered from the period of 1998-2018. Twenty studies represented study locations across Australia, New Zealand, Europe, South Africa, America and North America. Study participants were practising general practitioners or speciality physicians.
Synthesis: Attitudinal trends towards chiropractic ranging on a scale from negative, to neutral, or positive were revealed. Lack of evidence, concerns of safety, lack of knowledge, redundancy (due to physiotherapy), scepticism and low-referral rates are likely factors associated with negative clinician attitudes. Subjective beliefs that chiropractic is effective, high referral rates, interest in learning more about chiropractic, openness to communication, value of patient preferences, and belief that chiropractic is safe are likely factors facilitating neutral-positive clinician attitudes.
Conclusions: A representative medical attitude consensus is not currently definitive in the literature due to heterogeneity across studies and limited data of varying quality. Medical attitudes towards chiropractic appear to be multivariable in nature. Additionally, reoccurring themes which may influence attitudes have been established which warrant future research in these domains to allow improved interprofessional relationships and impact patient management in the healthcare system.

Keywords: Medical Attitude, Chiropractic, Complementary Alternative Medicine, Attitudes

O588

Does sedentary behaviour cause spinal pain in children and adolescents? A systematic review with meta-analysis

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Introduction: Sedentary behaviours in young people have increased over the last two decades. Sitting is negatively associated with overweight and obesity, cardiometabolic risk and adverse mental health including anxiety and depression. Sedentary behaviour is widely thought to also affect the risk and prognosis of spinal pain negatively in young people. It is unknown whether sedentary behaviour relate to spinal pain via a biomechanical (i.e. sustained poor posture, increased cervicothoracic angle or lumbar lordosis) or other mechanism (i.e. sleep disturbance, poor mental health).

Aim: To measure the; 1) risk, 2) prognosis, and 3) association between sedentary behaviour and spinal pain in children and adolescents.

Methods: Peer-reviewed longitudinal and cross-sectional studies were eligible for inclusion if they reported an association between sedentary behaviour and non-specific spinal pain in participants whose mean age was ≤19 years at study enrolment. Studies were included for syntheses as follows: 1) Longitudinal studies whose participants had no spinal pain at enrolment (or spinal pain was adjusted for) and that measured the association between sedentary behaviour at baseline and the onset or recurrence of spinal pain at follow-up, 2) Longitudinal studies whose participants had spinal pain at study enrolment and that measured the association between sedentary behaviour at baseline and spinal pain persistence (compared to spinal pain cessation) or pain-related impact (compared to no impact) at follow-up, and 3) Cross-sectional studies that reported a measure of association between sedentary behaviour and spinal pain. We searched MEDLINE(OvidSP), Embase(OvidSP), CINAHL(Ebsco) and Web of Science on 28.08.2019 without language or publication date restrictions. We applied a modified QUIPS tool to assess each study's risk of bias across five domains. We present a narrative review, data summary table and inverse variance weighted random effects meta-analyses, data permitting, for each review aim. Registration PROSPERO 2020 CRD42020148254.

Results: From 10,125 search returns we screened 393 full-texts and included 106 articles. Included studies by review question; 1) Seven longitudinal studies, one ranked low risk of bias. Four estimates included in meta-analysis: pooled OR1.27(0.86-1.87), chi^2 0.77, p=0.856, I^2 0.0%, tau^2 0.00. 2) Zero longitudinal studies. 3) Ninety-nine cross-sectional studies, two ranked low risk of bias. Fifty-nine *unadjusted* estimates included in meta-analysis: pooled OR1.28(1.20-1.37), chi^2 570.51, p=0.000, I^2 89.8%, tau^2 0.0257. Forty-three *adjusted* estimates included in meta-analysis: pooled OR1.20(1.14-1.26), chi^2 253.70, p=0.000, I^2 83.4%, tau^2 0.0113.

Conclusion: There is a lack of high quality evidence available, this severely limits our certainty in the relationship between sedentary behaviour and spinal pain in children and adolescents. The best evidence draws doubt on sedentary behaviour as a risk factor for the development of spinal pain at this young age and there is no data available to assess sedentary behaviour as a prognostic factor. From the majority of heterogeneous cross-sectional data we cannot be sure of reverse causality or the inclusion of all important confounders. This review does not account for long term follow up or adult health behaviours established earlier in life.

O589

Reassurance for low back pain in primary care: A qualitative study

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Introduction: Clinical practice guidelines consistently recommend that patients with low back pain (LBP) of any duration should receive reassurance, defined as the de-escalation of fears and concerns, from their healthcare provider (HCP). Despite this, only one-quarter of patients receive reassurance during a consult for LBP. Recommendations for providing reassurance are limited, with minimal detail on the best method to deliver. To improve implementation of reassurance it is essential to understand the challenges in delivering reassurance from HCPs perspectives.
Aim: We aim to explore HCP (physiotherapists and chiropractors) experiences delivering reassurance for patients presenting with LBP in relation to: i) how and what reassurance is delivered, and ii) the barriers and enablers that influence the delivery of reassurance.
Materials and Methods: We recruited 32 HCP (16 chiropractors, and 16 physiotherapists) through professional networks, and social media. Participants were eligible if they were: 1) registered with the Australian Health Practitioner Regulatory Agency, and 2) managed at least 1-2 LBP cases per week. The research team invited HCPs who represented a spread of demographics to a 30-minute semi-structured interview. Interviews were conducted and transcribed using Microsoft Teams. Framework thematic analysis was used to analyse the results and develop themes related to the aims.
Results: HCPs clinical experience ranged from 0.5 - 47 years, 37.5% were female (n=12), and locations were metropolitan (n=23), regional (n=7), and rural (n=2). All HCPs reported frequently delivering reassurance, and the majority reported reassurance was “extremely important” to provide for LBP (n=28).
Preliminary coding of data revealed themes around identifying the causes for patient fear about their LBP. HCPs discussed the utilisation of affective reassurance (reassurance through feeling cared for) through building rapport, active listening, physical cues, and clinic environmental factors. Cognitive reassurance (reassurance via education) was most frequently used to reassure the patient about: i) their LBP diagnosis; ii) a realistic prognosis (factoring in previous episodes, and yellow flags); iii) ability to self-manage; and iv) encouraging movement. HCPs also provided insight into how they modify reassurance for individual patients. Key barriers to delivering patient reassurance were: i) patients’ prior beliefs or previous information from other HCPs; and ii) patients who place more emphasis on seeking passive care treatment modalities. Conversely, enablers were: i) patients who were more receptive to education and self-management strategies; and ii) where rapport with the HCP was easily established.
Conclusion(s): HCPs most frequently discussed cognitive reassurance. HCPs identified key challenges were prior beliefs about LBP. Affective reassurance and individualising reassurance appeared to be utilised to varying degrees. These findings will inform the development of a reassurance intervention to implement into primary care.
Keywords: low back pain, reassurance, primary care

O590

Investigation of the factors influencing spinal manipulative therapy force transmission through the thorax: A cadaveric study

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Introduction: Spinal manipulative therapy (SMT) force-time characteristics (e.g., total peak force and loading rate) are believed to be associated with SMT's therapeutic effects. Previous studies have reported that the magnitudes of SMT forces measured at the patient-table interface are most commonly larger than the ones applied by the clinician, measured at the clinician-patient interface[1,2]. While this is consistent with deformable body models[1], it remains unknow what factors contribute to this "force amplification" phenomenon.
Aim: The objectives of this study were 1) to quantify the difference in force magnitude measured at each interface during standardized and controlled SMT applications in cadaveric models, and 2) to evaluate the relationship between the difference of force magnitudes and both the SMT force-time characteristics and the cadaveric model characteristics.
Methods: Twenty-five simulated SMTs with different force-time characteristics were delivered at the T7 vertebra of 9 human cadaveric specimens by a servo-linear motor (SLM) device. Cadavers were lying prone on a treatment table with an embedded force plate located at the thoracic region (FSTT®, Toronto Canada). The difference between the force applied by the SLM device and the force measured by the force plate was calculated (F_{diff}). Difference in force measured at the device-cadaver and cadaver-table interfaces was also expressed as percentage of the applied force ($F_{diff\%}$). Infrared retro-reflective markers were inserted into T6 to T8 spinous and transverse processes to evaluate vertebral displacements during SMT thrusts (relative and total displacements) by an optoelectronic motion capture system (OptiTrack®, USA). Mixed-effects linear models were conducted to evaluate the variance in F_{diff} and $F_{diff\%}$ explained by SMT characteristics (total peak force, thrust duration and loading rate), T6 to T8 relative and total displacements, and specimens' characteristics (BMI, height, weight, kyphosis angle, thoracic thickness).
Results: The difference in force ranged from an increase of 76.6 N to a decrease of 114.3 N with 40% of the trials showing higher forces measured by the force plate at the cadaver-table interface. F_{diff} was significantly predicted (marginal R^2 = 0.54) by total peak force, thrust duration, thoracic thickness and T6-T7 relative displacement in the z-axis (perpendicular to force plate). $F_{diff\%}$ was significantly predicted (marginal R^2 = 0.56) by the loading rate, thoracic thickness and T6 and T8 total displacements. For both dependant variables, thoracic thickness showed the highest marginal R^2 when tested as the only specimen's predictor (F_{diff} R^2 = 0.52 and $F_{diff\%}$ R^2 = 0.55).
Conclusion: Difference in force between the clinician-patient and the patient-table interfaces is influenced by SMT characteristics as well as by the thoracic thickness. How the difference in force is associated with vertebral displacements within the contacted area vicinity remains unclear. These findings contribute to better understanding the human body mechanics during SMT dynamic loading. Future studies will investigate how this can be used to potentially enhance SMT's clinical use, for example to prevent adverse events, such as rib fractures, following SMT.

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O591

Young patients and chiropractors' observation and analysis study (Young-COAST): A feasibility study

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Background: Young people (0-17 years of age) commonly receive chiropractic care. Before evaluating efficacy of chiropractic care for this sub-population, researchers need to establish the key reasons young patients (or their carer/guardian) seek care and describe the characteristics of healthcare provided by chiropractors. Previous studies have described the characteristics of the general population seeking care from chiropractors, but there is a paucity of information on the characteristics of the younger population and their reasons for seeking chiropractic care. Given the clear knowledge gap, observational health services research is required to investigate chiropractic healthcare encounters of young patients. Given healthcare encounters may differ based on the perspective of the patient and practitioner, rigorous evaluation requires capturing both patient and practitioner perceptions of the clinical encounter. Prior to embarking on a definitive study, the feasibility of our methods to observe complex healthcare encounters must first be established.
Aim: The main objective was to develop and test the feasibility and clinical utility of an electronic data collection system to capture encounter data electronically from the perspective of the chiropractor and young patient.
Materials and Method: This feasibility study used an observational study design to observe chiropractor and young patient healthcare encounters. Chiropractors were included if they were registered and working in private practice within Australia. We included young patients aged 0-17 years seeking chiropractic care for any reason, were an existing or a new patient of the participating chiropractor. Each included chiropractor aimed to recruit up to 10 young patient participants over a four-week period. All data were collected in an electronical format via REDCap surveys.
Results: Thirty-five chiropractors (12 males, 23 females) with a mean age of 42 years and mean years in clinical practice of 17.3 years were recruited. Of the included chiropractors two chiropractors dropped out due to non-response. There was a total of 242 young patient encounters collected with a mean young patient age of 7.4 years. The most common primary reason for seeking care as reported by both the chiropractors and the young patients/their carer/guardian (38%) was for a well child visit/maintenance care or check-up (19% reported by chiropractor and 38% by young patients/their carer/guardian), follow by lower extremity issue (10% reported by chiropractor and 11% by young patients/their carer/guardian). Many of the chiropractors reported on the ease of the study process with minimal disruption to clinical practice.
Conclusion: The information gathered in this study will inform a definitive large-scale study that describes chiropractic health services utilisation for young people in Australia. Future research will inform the development of curriculum and post graduate education programs to better prepare chiropractors for the contemporary healthcare needs of young populations and lead way to study efficacy of chiropractic care for this population.
Acknowledgements: This research is funded by The Macquarie Chiropractic Alumni Research Fund (MtCaRF).

O592

Physical activity promotion among Australian chiropractors: what are we doing or not doing? Results from a cross-sectional survey

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Introduction: Physical activity (PA) is associated with a lower risk of noncommunicable diseases and mortality. Despite the proven benefits, physical inactivity continues to be a major global pandemic. The healthcare sector is well placed to incorporate individual PA counselling (or alike) into routine treatment and care for change. Many factors influence PA promotion in routine healthcare practice, such as the type, quantity, barriers, perceptions, and feasibility of PA promotion as well as knowledge of the PA guidelines. Within the healthcare sector, chiropractors are well-positioned to promote PA, however no studies have investigated the extent to which PA is currently promoted by chiropractors Australia-wide.
Aim: To explore PA promotional capacity and knowledge of PA guidelines among Australian chiropractors.
Materials and Methods: Between February and May 2021, registered Australian chiropractors were invited to complete a cross-sectional online survey. Items assessed by Likert scale included: frequency of PA promotion, as well as the type, quantity, barriers, perceptions, and feasibility of PA promotion. Familiarity and knowledge of Australia's PA and Sedentary Behaviour Guidelines for Australian Adults was also explored as well as chiropractors' own engagement with PA and whether they met PA guideline recommendations. Survey responses were descriptively reported. Univariable logistic regression models were used to identify candidate factors that may explain frequent PA promotion among chiropractors.
Results: A total of 217 Australian chiropractors (59.3% Male, 40.7% Female) participated in the study. Of these, 64.1% (Confidence Interval [CI]: 57.5%, 70.2%) reported that they frequently (≥70% of patients) recommended a more physically active lifestyle in the past month. Resistance exercise was the most frequently prescribed type of PA promoted by chiropractors 72.9% (CI: 66.7%, 78.5%). A lack of time was the most frequent barrier for chiropractors to promote PA 18.8% (CI: 13.9%, 24.5%). Whereas recommending established community-based PA programs (e.g., Tai Chi class, dance programs, walking groups, Get Healthy Program) was considered the most highly feasible facilitator by chiropractors 69.8% (CI: 63.2%, 75.7%). Some 36.6% (CI: 30.2%-43.3%) of chiropractors reported being not at all familiar with the Australian PA guidelines for adults. Univariable logistic regression models found male chiropractors we more likely to promote PA (Odds ratio [OR] 2.33 CI: 1.32-4.12) and chiropractors that frequently treat children 0-3 years (OR 0.5 CI: 0.28-0.87), children 4-18 years (OR 0.42 CI: 0.21-0.86), and pregnant women (OR 0.5 CI: 0.26-0.94) were least likely to promote PA. Chiropractors who were familiar with the Australian PA guidelines (OR 2.9 CI: 1.32-6.41), and confident in providing general advice to patients about a physically active lifestyle (OR 11.6 CI: 1.37-98.71) and specific PA programs to patients (OR 4.5 CI: 2.03-9.99), were more likely to promote PA.
Conclusion: PA promotion appears feasible and is regularly integrated by Australian chiropractors, however current practice is hampered by a lack of time. While more than a third of chiropractors report poor knowledge of the PA guidelines, those familiar with the guidelines were confident in recommending PA programs and offering advice, thus providing evidence that chiropractic has considerable potential in this space.

O593

Reliability of the biomechanical assessment of the sagittal lumbar spine and pelvis on radiographs used in clinical practice: Design of a systematic review of the literature

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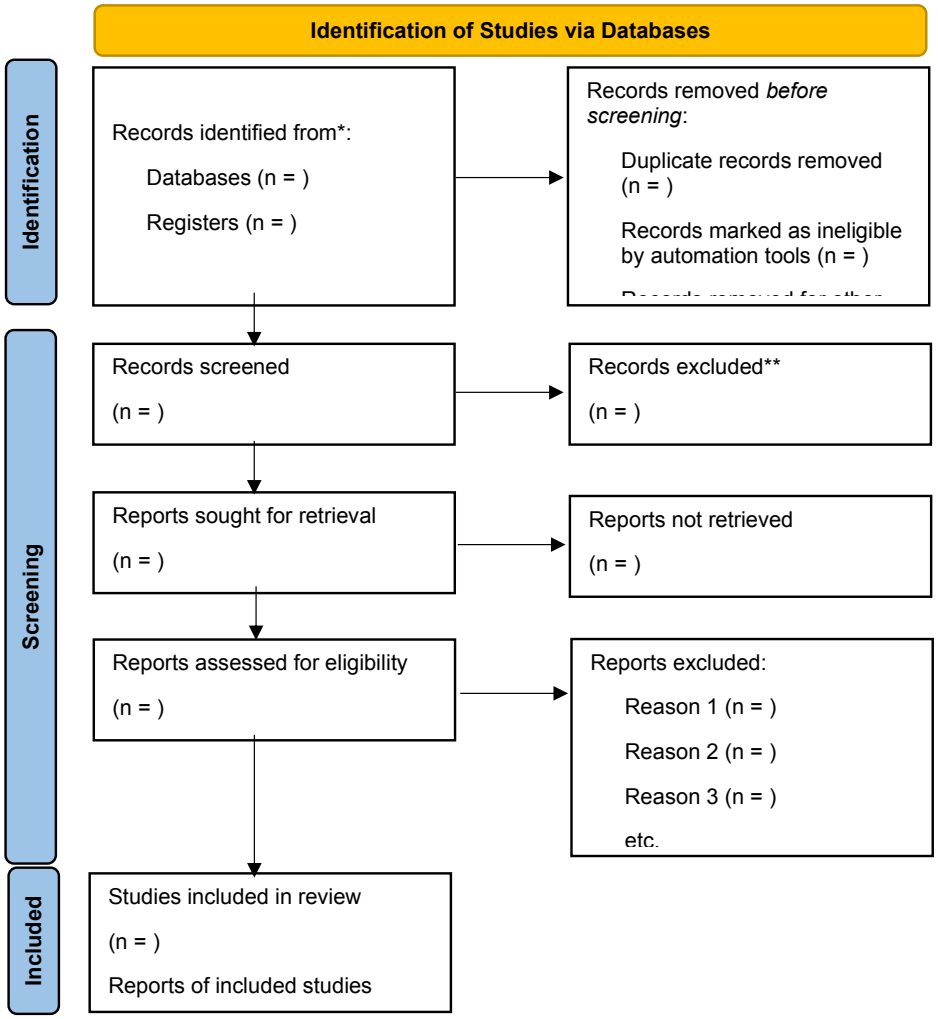
Biomechanical analysis on the alignment of the sagittal lumbar spine and pelvis is common in clinical practice including in chiropractic care and orthopedic surgical planning particularly in assessing pelvic morphology and the relationship with sacral slope and lumbar lordosis. The current state of the literature on the reliability of common methods quantifying these parameters is unknown. The objective of this systematic review is to identify and review the reliability of different methods of biomechanical analysis commonly used in clniical practice. This review is being conducted using the Peer Review of Electronic Search Strategies (PRESS) checklist to organize the search strategy. We will use a combined approach using Medical Search Headings (MeSH) search terms and a SROL search strategy. Our review will follow the recommendations of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Databases to be searched include PubMed, Cinahl, Index to Chiropractic Literature, Google Scholar, SCOPUS, ScienceDirect, Medline, BioMed Central and a grey literature search. Studies regarding biomechanical assessment of the sagittal lumbar spine and pelvis which reported reliability anlaysis will be included. These studies will then be independently assessed by two of the authors for methodological quality using the 11-item Quality Appraisal of Diagnostic Reliability (QAREL) tool for reliability studies. Discrepencies in methodologiccal quality will be evaluated by a third author and a consensus wil be reached between the 3 reviews.

Keywords: spine; lumbar; pelvis; lordosis; radiography; X-ray; reliability; subluxation; chiropractic



*Will report the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools are used, we will indicate how many records were excluded by a human and how many were excluded by automation tools.
From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

O594

Evaluating test-retest reliability of the flexion-relaxation ratio within and between days

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Introduction: Recent systematic reviews have suggested that the flexion-relaxation ratio (FRR) is a potential biomarker to assess physical function in patients with non-specific chronic low back pain. Specifically, the FRR is derived using electromyographic signals obtained from the spine's extensor muscles during the task of forward bending. Most studies that employ the FRR have focused on matters related to validity and changes in response to exposures. Comparatively fewer studies have focused on the test-retest reliability and measurement error of the FRR.

Aim: To quantify the test-retest reliability and measurement error, within and between days, of the FRR in adults with or without low back pain.

Materials and Methods: Participants between the ages of 18 and 65 were recruited. Each participant attended two data collection sessions that were separated by one week. Sagittal plane kinematics of the lumbar spine were obtained using accelerometers placed over the spinous processes of the first lumbar and sacral vertebrae. Electromyographic signals were obtained bilaterally from the erector spinae at the level of the third lumbar vertebra. Each data collection session was comprised of two sets of three trials of pace-controlled full forward spine flexion. Lumbar spine flexion/extension angles were derived from the accelerometers and used to identify the start and end of the flexing and extending phases of each full forward flexion trial. Electromyographic data were processed to produce linear envelopes for the left and right erector spinae. The FRR, defined as the peak electromyographic signal during the flexing phase divided by the average electromyographic signal between the end of the flexing and start of the extending phases, was determined separately for the left and right erector spinae (LLES and RLES) muscles and for each trial. The median of the FRR from each set of three trials was determined. Intraclass correlation coefficients ($ICC_{2,1}$) were calculated to assess within-session and between-session reliabilities. These estimates were used to determine the standard errors of measurement and minimal detectable change.

Results: Data were collected from 40 participants (18 female, age = 26.0±2.9 years, height = 1.73±0.09 m, mass = 75.2±14.5 kg). Respective group averages of the FRR for the LLES and RLES were 3.9±2.1 and 4.2±2.8. Poor to moderate test-retest reliability of the FRR was observed both within-session (RLES = 0.71 and 0.41; LLES = 0.78 and 0.57) and between-sessions (RLES = 0.48; LLES = 0.57). Standard errors of measurement of the average FRR within-session were 26% to 48%, and between-sessions were 43% (RLES) and 47% (LLES). This produced minimal detectable changes within-session that were 73% to 132%, and between-sessions that were 119% (RLES) and 131% (LLES), of the average FRR.

Conclusions: Currently, these data present the most complete assessment of test-retest reliability, and the first report of measurement error within and between sessions, for the FRR of the lumbar erector spinae muscles. Low test-retest reliability and minimal detectable changes that approach, or exceed, the average FRR likely limit the use of this measurement as a biomarker to assess physical function in patients with non-specific chronic low back pain.

O595

Prospective randomized control trial to compare the role of injection cerebrolysin for 10 days duration against placebo in operated cases of degenerative cervical myelopathy

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Study Design: Prospective randomized control trial.
Objective: To analyze the outcomes of use of injection cerebrolysin in surgically treated patients of degenerative cervical myelopathy (DCM).
Summary of Background Data: A single center randomized control pilot study has been published recently that concludes that superior functional outcomes are achieved with the use of cerebrolysin in surgically treated patients of DCM for 21 days. Our study has been conducted to analyze the use of the drug for shorter duration- that is 10 days and compare the clinical efficacy.
Result: Ninety patients enrolled in the study were randomly distributed into two groups. The first group had 60 patients who received injection cerebrolysin for 10 days (group C) and the second group had 30 patients that received placebo for 10 days (group P). The baseline demographic data did not have any statistical significant. Preoperative mJOA scores and VAS were similar ($P>0.05$). Anterior surgery was done in 50 patients and 40 patients underwent posterior decompression. Both groups showed statistically significant improvement in mJOA score and VAS score post-operatively at follow-up as compared to their pre-operative values($P<0.05$). However, analysis between two groups has shown that improvement in mJOA score was significantly better in group C as compared to group P at one year follow up ($P<0.0001$). Post-operative neurological recovery was found to be improved with group C. Complete neurological recovery was seen in 63.6% patients in group C whereas group P showed improvement of 56.2% on one year follow up. This difference is statistically significant as $P=0.023$. Hand functions were better in group C as compared to group P.
Conclusion: Injection cerebrolysin when administered for ten days postoperatively can result in significant better neurological improvement and hand function in operated cases of degenerative cervical myelopathy.

O596

The risk of getting worse after surgery for cervical myelopathy - A population-based study of 1097 patients

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Introduction: Degenerative cervical myelopathy (DCM) is the most common cause of spinal cord impairment. Surgical treatment is typically offered to patients with progressive neurological deficits and those with moderate or severe myelopathy. Functional status, pain and quality of life usually improve, but a subset of patients get worse after surgery.

Aim: The aim of this study was to identify sociodemographic-, clinical-, and imaging factors associated with worsening 12 months after surgery for DCM.

Methods: We analysed prospectively collected data of 1097 consecutive patients operated for DCM and recorded in the Norwegian Registry for Spine Surgery. The primary outcome was the neck disability index (NDI) percentage difference between baseline and 12 months scores. Receiver operating characteristics (ROC) curve analyses were used to obtain cut-off values for non-worsening and worsening, using the global perceived effect (GPE) scale as an external anchor. Univariable- and multivariable analyses were performed using mixed logistic regression to evaluate the relationship between potential prognostic factors and the primary outcome.

Results: The cut-off value for worsening was a NDI percentage change of 3.3 (area under the curve: 0.83 (95% confidence interval (CI) 0.79 – 0.86) from baseline to 12 months follow-up. According to this criteria, 780 (71.1%) patients were classified as non-worsened and 317 (28.9%) as worsened. Multivariable analysis showed that low educational level (odds ratio (OR) 7.7; 95% CI 2.7 – 22.1; $p < 0.001$) and smoking (OR 4.3; 95% CI 1.5 – 12.5; $p = 0.007$) were associated with worsening after surgery. Patients with more severe neck pain (OR 0.7; 95% CI 0.6 – 0.9; $p = 0.006$) and arm pain (OR 0.7; 95% CI 0.6 – 0.9; $p = 0.003$) at baseline had greater improvements.

Conclusion: The prognostic factors associated with worsening after surgery for degenerative cervical myelopathy are lower education and smoking. High neck- and arm pain intensity prior to surgery was associated with less risk for worsening.

O597

Managing risk in degenerative cervical myelopathy: A service review in response to covid-19 delays

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Introduction: Degenerative cervical myelopathy (DCM) is associated with progressive neurological deterioration. Surgical decompression can halt but not reverse this progression. The Modified Japanese Orthopaedic Assessment (MJOA) tool is recommended by international guidelines to grade disease severity into mild, moderate and severe, where moderate and severe are both recommended to undergo surgical intervention. Nottingham University Hospitals (NUH) NHS Trust identified DCM patients as high risk for sustaining permanent neurological damage due to surgical delay as a result of COVID-19. The Advanced Spinal Practitioner (ASP) team implemented a surveillance project to evaluate and record deterioration whilst waiting on a surgical list, and reprioritise surgical urgency where necessary. The aim of the project was to highlight the irreversible effect surgical delays could have on this patient group, in order to raise the risk profile of DCM within the Trust.
Methods: In October of 2021 a spreadsheet was compiled of all patients on a DCM surgical waiting list. All patients on the surgical waiting list were telephoned by ASPs between Oct-Nov 2021 to establish clinical status. Where deterioration subjectively or through the MJOA was noted, face to face review was arranged via a same day emergency care pathway. Incident forms were completed for clinical deterioration and recorded as severe harm and presented weekly (Nov 21 – Jan 22) to the serious incident reporting forum. Acute, progressive neurological deterioration was considered for emergency surgical decompression and categorised by a multi-disciplinary team of spinal surgeons, ASPs and nurses for urgent (P2) or emergency (P1) surgical decompression. The records of those telephoned were monitored on the spreadsheet, and data collected included age, gender, MJOA, referral pathway into the service, date of listing, date of surgery.
Results: A total of 46 patients were monitored (average age 66 years (range 39 -86), 46% female (n=21)). Of these, majority were referred into the service by their GP (21/46, 46%) or consultant neurologist (10/46, 22%). 12/46 (26%) were referred from other consultants in various specialities, and 3 (7%) from the emergency department. Only 22/46 patients (48%) were referred with a diagnosis of DCM.
Most patients had deteriorated when contacted (n=23, 50%), and 46% (n=21) remained stable, 4% (n=2) were recorded as unclear. Of those that deteriorated, the average MJOA deterioration was 2.6 points (range 1-5) (15 of 23 patients). Of the 23, 18 underwent urgent surgical decompression, two await surgery, two declined surgery and one patient has died as a result of a fall. Those who had deteriorated were sent a formal apology and duty of candour letter.
Conclusion: This service evaluation demonstrated that most patients with DCM deteriorate over time. Post-pandemic demand on healthcare will require rationing of both elective and emergency services to ensure those at risk of serious harm are recognised and treated timeously. For those with DCM, baseline assessment should be clearly documented and a scoring system such as MJOA considered for effective monitoring. Written safety netting for deterioration should be standard practice, and a clear pathway for emergency presentation and surgical decompression identified.

O598

Prognostic factors for cervical spinal cord injury without major bone injury in elderly patients: Multicenter study in Japan

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Introduction: In the current aging society, there has been a marked increase in the incidence of cervical spinal cord injury (CSCI) without major bone injury. In the recent nationwide survey in Japan, CSCI without major bone injury accounts for 70.7% of CSCI cases and is often caused by minimal trauma due to events such as a fall on a level surface, which increases with age. Factors affecting the prognosis for motor recovery after SCI have been identified, but few studies have focused on CSCI without major bone injury. This multicenter study aimed to identify predictors of neurological improvement in patients aged 65 years or older with CSCI without major bone injury and examine therapeutic interventions for increased neurological improvement.
Methods: A multicenter study was performed by the Japan Association of Spine Surgeons with Ambition (JASA) as a retrospective analysis. The participants were 591 patients aged 65 years or older with CSCI without major bone injury from 33 medical centers between 2010 and 2020, with a minimum follow-up period of 3 months. Neurologic status was defined using the American Spinal Injury Association (ASIA) impairment scale (AIS). The patient background, imaging findings, comorbidity, treatment, and post-injury complications were obtained. Univariate and multivariate analyses were performed to identify prognostic factors for walking recovery (recovered to AIS D or E) in AIS A-C cases and full upper extremity motor recovery (AIS motor score = 50) in AIS D cases. A sub-analysis of AIS B-C cases was also performed based on the influence of data for AIS A cases on the results.
Results: Among AIS A-C cases at admission, 154 patients (55.0%) (11.8% in AIS A, 22.6% in AIS B, and 66.5% in AIS C) had walking recovery at follow-up. In AIS D cases at admission, 64 patients had a full upper extremity ASIA motor score (50). Of the remaining 247 AIS D cases, 107 (43.3%) patients recovered with full upper extremity motor function at follow-up. In AIS A-C cases, body mass index (odds ratio (OR): 1.112), magnetic resonance imaging signal change (OR: 0.240), AIS on admission (OR: 3.497), comorbidity of dementia/delirium (OR: 0.365), and post-injury pneumonia (OR: 0.194) were identified as independent prognostic factors for walking recovery. The prevalence of ossification of the posterior longitudinal ligament (OPLL) (OR: 0.494) was also found to be an independent prognostic factor in AIS B and C cases only. The rate of patients with OPLL was higher (34.3%) than the general prevalence. In AIS D cases, age (OR: 0.937), upper extremity ASIA motor score on admission (OR: 1.230 [per 5 scores]), and operation (OR: 0.519) were independent prognostic factors for full motor recovery.
Conclusion: The severity of paralysis on admission has a major impact on functional outcomes, but the promotion of rehabilitation through measures to reduce cognitive changes, post-injury pneumonia, and unhealthy body weight changes can also contribute to greater neurological improvement in AIS A-C cases. In AIS D cases, careful consideration of the need for surgical treatment is required for motor recovery.

O599

Clinico-radiological risk factors associated with inability to achieve minimum clinically important difference in operated cases of cervical spondylotic myelopathy

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Introduction: Only few studies have evaluated the outcomes of surgery using minimum clinically important difference (MCID) on modified Japanese Orthopaedics Association (mJOA) scale in cervical spondylotic myelopathy (CSM).
Aim: We aim to identify the clinico-radiological risk factors associated with inability to achieve MCID on mJOA Scale.
Patients and Methods: We retrospectively analysed 124 operated cases of CSM from March 2019 to April 2021 for preoperative clinical features, cervical sagittal radiographic parameters and MRI signal Intensities (SI). Patients were divided into two groups- those who could achieve MCID (good outcome) and those who could not achieve MCID (poor outcome) on mJOA scale. The risk factors associated with missing the MCID (poor outcome) at final follow-up were identified using binary logistic regression. Multivariate analysis was used to find significant risk factors and Odds ratios (OR) were computed.
Results: Analysis consisted of 110 (89.2%) men and 14 (10.8%) women with an average age of 53.5±13.2 years. At last follow-up, 89 cases (72.1%) achieved MCID (meaningful gains following surgery) while 35 (27.9%) could not. Final model identified following parameters as significant risk factor for poor outcome - increased duration of symptoms OR 6.77, p=0.001; lower preoperative mJOA scale OR 0.75, p=0.029; presence of multilevel T2 weighted (T2W) MRI SI OR 4.79, p=0.004; larger Δ cSVA (change in cervical sagittal vertical axis) OR 1.06, p=0.013. Increase in cSVA postoperatively, significantly correlated with reduced functional recovery rate. (r=-0.4, p<0.001).
Conclusion: Surgery for CSM leads to significant functional benefit. However, poorer outcomes are seen with greater duration of symptoms, higher preoperative severity with presence of multilevel T2W MRI SI and a larger increase in the postoperative cSVA (sagittal imbalance).

O600

A prospective randomized controlled multicentre study of ProDisc–C vs anterior cervical discectomy and fusion for treatment of symptomatic cervical disc disease in Asian population: A 4-year outcome

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Background: The current standard surgical treatment option managing symptomatic cervical disc disease(SCDD) is anterior cervical discectomy and fusion(ACDF). Even though ACDF results in high clinical success and low complications, it could lead to hypermobility and increased intradiscal pressure at adjacent levels secondary to rigid immobilization at fused vertebral levels, resulting in adjacent disc degeneration. ProDisc–C is a cervical total disc replacement (TDR) designed to potentially preserve the motion at involved cervical vertebral segment, while reducing pain and neurological symptoms. Currently, literatures comparing ProDisc–C versus ACDF in Asian population is limited. It was noted that race is an important component that influences complication rate, length of hospital stay and mortality after cervical spine procedures.
Objective/Aim: To evaluate safety, efficacy, and the overall success of ProDisc-C versus ACDF at 48-months post-surgery in Asian patients in treating single-level symptomatic cervical disc disease(SCDD).
Methods: This multicentre, prospective, randomized controlled trial was conducted with patients with single-level SCDD involving C3-C7-vertebral segments. The patients were randomized into group-A treated with ProDisc-C and group-B with ACDF(treated with standalone cage with bone autograft) at 2:1 ratio. 120 patients consisting of 80 patients in group-A (ProDisc-C) and 40 in group-B (ACDF) were enrolled. Assessments conducted at baseline, 6-weeks, and 3-, 6-, 12-, 18-, 24-, 36- and 48-months post-surgery and annually till 84 months. The overall success at 48-months was composed of: (1)$\geq$20% improvement in neck disability index (NDI); (2)neurological success (maintained/improved); (3)absence of secondary surgery at index level; and (4)absence of device-related adverse events.
Results: Of 120 patients, 76-patients in group-A and 37-patients in group-B were treated as per protocol (PP). Overall success in PP last observation carried forward analysis was 79% in group-A and 75.7% in group-B at 48-months(p=0.0122), demonstrating non-inferiority of ProDisc-C to ACDF. Additionally, ProDisc-C demonstrated non-inferiority to ACDF at 18-months(81.6% vs 83.8%, p=0.0398) and at 36-months(80.3 vs 78.4, p=0.0156). Both groups had similar results in (i)NDI success(97.2% in group-A vs 100% in group-B), (ii)neurological success(83.3% in group-A vs 87.5% in group-B), (iii)absence of secondary surgery at index level(97.2% in group-A vs 100% in group-B) and (iv)absence of device-related adverse events(97.2% in group-A vs 193.75% in group-B) at 48-months(pp). Both groups had similar secondary outcomes(VAS-pain scores&SF-36). However, the range of motion was preserved in group-A and was significantly reduced in group-B at 48-months.
Conclusion: The use of ProDisc-C is feasible, safe, and effective for treatment of SCDD in Asian population. ProDisc-C demonstrated non-inferiority to ACDF in overall success at 18, 36 and 48-months. Both groups had similar secondary outcomes, future large-scale studies focusing on Asian population are required to establish clear non-inferiority of ProDisc-C to ACDF in terms the secondary outcomes in addition to overall success.

O601

Long term clinical and radiological outcomes of cervical disc arthroplasty at a tertiary level spine center: A retrospective cohort analysis with minimum 2 years of follow up

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Introduction: Advent of newer technologies and surgical techniques had a significant improvement in cervical spine patient outcomes in the recent years. After failure of conservative treatment in patients with cervical degenerative disc disease, anterior cervical discectomy and fusion (ACDF) was the traditional standard surgical procedure. ACDF typically relieves pain significantly, but elimination of motion at the index level, adjacent level degeneration and pseudoarthrosis remains a procedure specific complication. Cervical disc arthroplasty is a viable alternative to ACDF for the treatment of single-level cervical spine disease. A theoretical advantage of CDA is the capacity to preserve physiological range of motion (ROM) and index level, thereby potentially reducing adjacent level stresses and degeneration.
Aim: Our aim was to assess long-term clinical and radiological outcomes over time in all the patients who underwent cervical disc arthroplasty from 2009-2020 at our Institute.
Method: From our centre, retrospective review of patients who underwent cervical disc arthroplasty from 2009-2020 with minimum 2 year follow up was carried out. Analysis of medical, surgical and radiological records were done to assess functional outcomes, range of motion and index surgical level and adjacent segment degeneration.
Result: 48 patients underwent cervical disc arthroplasty from 2009 to 2022. The minimum follow-up was 2 years. The diagnoses included cervical disc herniation with radiculopathy (n=35), Cervical spondylotic myelopathy without instability (n=13). 45 patients underwent single level procedure, 3 patients underwent double level surgery. The mean NDI scores reduced significantly in last follow up (10.34±5.76) compared to preoperative period (66.49±12.56) ($p<0.05$) and mean VAS score reduced in last follow up (1.06±0.94) compared to preoperative period (8.97±1.682) ($p<0.05$). The improvement in VAS score was 88.1 and NDI was 84.4%. Motion at index level increased significantly from 4.23° preoperatively to 5.38° at final follow up, and 86.4 % of the implanted segments were still mobile (ROM > 3°). Heterotrophic ossifications are responsible for the fusion of 3/51 levels at final follow up. Distal and proximal adjacent disc degeneration occurred in 47.91% and 36.1% of patients, respectively**.** No implant migration was observed on radiographs.
Conclusion: Our study showed favourable clinical outcome of Cervical Disc Arthroplasty with adequate ROM at index surgical level with low rate of adjacent segment degeneration compared to literature.

O602

Treatment strategy for lateral atlantoaxial osteoarthritis

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Introduction: Lateral atlantoaxial osteoarthritis (AAOA) is a degenerative cervical disease causing posterior neck pain or occipital neuralgia; its prevalence is between 4% and 4.8%. However, there have been little reports of treatment for AAOA due to difficulty of diagnostic approach. The purpose of this study was to report the clinical outcomes of treatment for AAOA.
Material and Methods: Patients who underwent conservative or operative treatment for AAOA from November 2013 to March 2021 were analyzed retrospectively. Exclusion criteria were patients with cervical trauma, tumors, infectious diseases, or past histories of cervical fusion. All patients were classified as osteoarthritic grade. Medication including nonsteriodal anti-inflammatory drugs was the first-line treatment. Atlantoaxial joint or interlaminar epidural steroid injection were performed in case of failure of medication. Atlantoaxial fusion using posterior screw and rod was done for patients who do not improve with conservative treatment. Visual analogue scale for posterior neck pain, occipital headache, and neck disability index were measured for clinical outcomes at the initial and final follow-up.
Results: Of the 31 patients, 3 were allocated to medication (group M), 19 to injection (group I), 9 to atlantoaxial fusion (group F). Group I received an average of 1.4 injections. Group F received an average of 1.8 injections followed by atlantoaxial fusion. All patients in group F were grade 3 AAOA and all fusion surgery was performed within 9 months after diagnosis. The odds ratio for fusion in grade 3 was 2.182. All clinical outcomes had improved significantly at final follow-up compared with initial visit ($P<0.05$).
Conclusion: For patients with AAOA, medication could be the first-line treatment. Atlantoaxial joint or interlaminar epidural steroid injection would be effective in case of no improvement with medication. Atlantoaxial fusion would be better for patients who do not response to conservative treatment.

O603

The AO Spine thoracolumbar injury classification system and treatment algorithm in decision making for thoracolumbar burst fractures without neurologic deficit

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Introduction: Thoracolumbar burst fractures are common traumatic injuries which result from a combination of axial loading and rotation. Most commonly occurring at the junction of the relatively rigid kyphotic thoracic spine and more mobile lordotic lumbar spine, these fractures have the potential to cause devastating neurological sequelae. The contemporary management of thoracolumbar burst fractures without neurological deficit remains controversial. On one hand, some have argued that there are equivalent functional outcomes between operative and non-operative treatment thereby inherently favoring the avoidance of surgical management and its attendant complications. On the other hand, surgical stabilization affords immediate surgical correction and obviates the purported delayed risks of post-traumatic deformity. According to the current AO Spine Thoracolumbar Injury Classification and Severity Score, an uncomplicated burst fracture in a neurologically intact patient is awarded four points and non-operative or operative management is possible. Hence at present this represents a situation of true equipoise for clinicians and has formed the basis for our need to develop a more detailed universally applicable and validated thoracolumbar fracture classification system and treatment algorithm.

Aim: We aim to determine the alignment between the AO Thoracolumbar Injury Classification System and Treatment Algorithm with contemporary surgical decision making.

Materials and Methods: 183 cases of thoracolumbar burst fractures were reviewed by 22 expert AO Spine Knowledge Forum Trauma surgeons. These experienced clinicians classified the fracture morphology, suspected integrity of the posterior ligamentous complex and degree of comminution. Each surgeon was then asked to recommend operative or non-operative management. Recommendations were compared to the actual treatment enacted in the real world.

Results: The classification system demonstrated a stepwise statistically significant increase in rates of operative management as fracture severity progressed from type A0/A1/A2, to type A3/A4 then type B1/B2 and type C injuries ($p<0.001$). There was an excellent association between recommended expert management and the actual treatment of each category of injury: A0/A1/A2 (OR 1.09, 95% CI 0.70-1.69, $p=0.71$), A3/4 (OR 1.62, 95% CI 0.98-2.66, $p=0.58$) and B1/B2/C (1.00, 95% CI 0.87-1.14, $p=0.99$). Thoracolumbar A4 complete burst fractures were more likely to be surgically stabilized than A3 fractures according to the recommended treatment by the algorithm (68.2% versus 30.9%, $p<0.001$). The use of a modifier to indicate that there may be indeterminate ligamentous injury increased the rate of operative management when comparing type B and C injuries to type A3/A4 injuries (OR 39.19, 95% CI 20.84-73.69, $p <0.01$ versus OR 27.72, 95% CI 14.68-52.33, $p<0.01$).

Conclusion: The AO Spine thoracolumbar injury classification system is a rational and hierarchical method of introducing fracture morphologies of escalating severity. This translated from expert recommendation into the clinical setting across the type A, type B and type C injury categories. Thoracolumbar A4 complete burst fractures were more likely to be operatively managed than A3 fractures. Flexion-distraction type B injuries and translational type C injuries were much more likely to be fixated than type A fractures regardless of the M1 modifier. The presence of a suspected posterior ligamentous injury did increase the likelihood of surgeons recommending surgical stabilization.

O604

Percutaneous pedicle screw fixation without arthrodesis of 368 thoracolumbar fractures: Long-term clinical and radiological outcomes in a single institution

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Purpose: Traumatic thoracolumbar (TL) fractures are the most common vertebral fractures. Although a consensus on the preferred treatment is missing, percutaneous pedicle screw fixation (PPSF) has been progressively accepted as treatment option, since it is related to lower soft tissues surgical-injury and perioperative complications rate. This study aims to evaluate the long-term clinical-radiological outcomes after PPSF for TL fractures at a single tertiary academic hospital.
Methods: This is a retrospective cohort study. Back pain was obtained at preoperative, postoperative and final follow-up using Visual Analog Scale. Patient-reported outcomes, the Oswestry Disability Index and the 36-Item Short Form, were obtained to asses disability during follow-up. Radiological measures included Cobb angle, mid-sagittal index, sagittal index (SI) and vertebral body height loss. A multivariate regression analysis on preoperative radiological features was performed to investigate independent risk factors for implant failure.
Results: A total of 296 patients with 368 TL fractures met inclusion criteria. Mean follow-up was 124.3 months. The clinical and radiological parameters significantly improved from preoperative to last follow-up measurements. The multivariate analysis showed that Cobb angle (OR = 1.3, $p < 0.001$), SI (OR = 1.5, $p < 0.001$) and number of fractures (OR = 1.1, $p = 0.05$), were independent risk factors for implant failure. The overall complication rate was 5.1%, while the reoperation rate for implant failure was 3.4%.
Conclusions: In our case series, PPSF for TL injuries demonstrated good long-term clinical-radiological outcomes, along with low complication and reoperation rates. Accordingly, PPSF could be considered as a valuable treatment option for neurologically intact patients with TL fractures. Additionally, in this cohort, number of fractures ≥ 2, Cobb angle ≥ 15° and sagittal index ≥ 21° were independent risk factors for implant failure.

O605

Genesis and evolution of the ao spine sacral and pelvis classification system: A comprehensive systematic review

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Introduction: The AO Spine Sacral and Pelvis Classification System is a universal scheme that reorders historical fracture morphologies into a rational hierarchical system for the first time.

Aim: We aim to review all existing historical sacral and pelvic classification systems and demonstrate the value of the pioneering AO Spine Sacral and Pelvic Classification System in comparison.

Materials and Methods: A systematic review and meta-analysis of the MEDLINE, EMBASE, Cochrane Databases and Google Scholar databases adherent to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines was conducted to identify all documented sacral and pelvic fracture classifications published.

Results: 49 articles were included in this review comprising 23 pelvic classification systems and 17 sacral grading schemes. The AO Spine Sacral and Pelvis Classification System represents both the evolutionary product of these historical systems and also a reinvention of classical concepts in five ways. Firstly, the classification introduces fracture types in a gradated order of biomechanical stability while also taking into consideration the neurological status of patients. The traditional belief that Denis central zone III fractures has the highest rate of neurological deficit is not supported as this subgroup often includes a broad spectrum of injuries ranging from a benign sagittally oriented undisplaced fracture to an unstable 'U' type fracture. Thirdly, the Isler 1990 lumbosacral system is adopted in its original format to divide injuries based upon their likelihood of affecting posterior pelvis or spino-pelvic stability. Fourthly, new discrete fracture subtypes are introduced and the importance of bilateral injuries is acknowledged. Lastly, this is the first integrated sacrum and pelvis classification to date.

Conclusion: The AO Spine classification is the first to introduce every documented sacral and pelvic fracture morphology identified to date in a progressive hierarchical manner based upon biomechanical stability and neurological status. Adoption of this standardized classification will facilitate further trials.

O606

Long-term follow-up after vertebroplasty: A prospective 10-years control study

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Introduction: Osteoporotic compression fractures affect millions of people every year with increasing numbers due to demographic changes. Although vertebroplasty is an established method and has been around since 1987, there are to our knowledge surprisingly no published long-term results. Randomized controlled trials published since 2009 have demonstrated conflicting results regarding benefit in pain reduction and functional improvement.
Methods: All patients who underwent vertebroplasty in our initial prospective monocenter case series from May 2007 until July 2008 were contacted for a minimum-10 years follow-up in July 2018. Patients were evaluated regarding radiologic outcome and self-reported outcome parameters (PROs). Gathered parameters remained unmodified to the initial ones analyzing QoL improvement (EQ5D 3L and NASS score) and pain alleviation (VAS, NRS). Taking into account the high patient age, mortality was defined as an additional endpoint. Exclusion criteria was additional instrumentation, use of additional devices such as kyphoplasty balloons/ stentoplasty, cognitive impairment, insufficient radiology or absent re-consent.
Results: Out of 241 patients eligible from the initial study (all patients) 186 (77.2%) deceased in the meantime. 49 (20%) were available for re-assessment with a mean follow-up of 10.5 years (9.9-11.1). Of those 30 (12.4%) were assessed clinically and radiologically, 16 (6.6%) in written form and three (1.2%) by phone only. 6 patients were LTFU. At 10 years patients reported a consistently improved quality of life (EQ-5D; $p<0.01$) and global satisfaction (NRS). Vertebroplasty had a significant impact on back pain over 10 years ($p<0.001$). 50% experienced a fracture free period since the index procedure.
Conclusion: Vertebroplasty has an early impact on quality of life and back pain, which is still significant at 10 years follow-up. Patients over 80 years of age undergoing such an intervention have a 10-year mortality rate of 77%.

O607

Increased incidence of traumatic spine injury in elderly patients in the Netherlands

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Introduction: The global elderly population is growing rapidly and will increase to an estimated 30% in Europe by 2050. In addition, elderly patients are increasingly active despite their comorbidities. Consequently, more elderly patients with traumatic spine injury are seen in emergency departments worldwide. In the Netherlands, where currently 18.5% of the population is >65 years, the incidence of traumatic spine injury among elderly patients has significantly increased between 1994-2010. However, it is currently unknown how the incidence of traumatic spine injury has evolved during the past decade. Moreover little is known regarding the differences of sociodemographic and clinical characteristics between young and older patients.
Aim: The aim of this study was to determine the incidence and characteristics of traumatic spine injury among patients <65 and >65 years in three time periods, 2009/2010, 2014/2015 and 2019/2020.
Patients and Methods: All patients with traumatic spine injury in the Netherlands from three periods 2009-2010, 2014-2015 and 2019-2020 were identified from the Dutch National Trauma Registry (DNTR). Patient and injury characteristics were obtained for the subgroup of patients that were treated in our level 1 trauma center. Details regarding the treatment, complications and 1 year mortality were retrieved from the electrotonic patient files.
Results: On a national level 25.737 patients with traumatic spine injury were identified. When compared to 2009/2010 the percentage of elderly significantly increased from 37% (n=2482) to 43% (n=4077) in 2014/2015 ($p<0.0001$), and 47% in 2019/2020 (n=4422, $p<0.0001$).
In our level 1 trauma center 1.054 patients with traumatic spine injury were seen. When compared to 2009/2010 the percentage of elderly increased from 26.1% (n=67) to 30.9% (n=116) in 2014/2015 ($p=0.185$ NS) and 33.9% (n=143) in 2019/2020 ($p=0.033$).The most common trauma mechanism in patients >65 years was a low energy fall (64.1%, n=209), the cervical spine was most frequently injured (50.6%, n=165), and the AO Spine type A fracture pattern was most prevalent (64.7%, n=211). Patients > 65 years had a higher 1-year mortality rate compared to patients < 65 years 22.7% vs 9.2% respectively, OR [95%CI] 2.9 [2.0 – 4.2]).
Conclusion: The incidence of traumatic spine injury in elderly patients in the Netherlands has significantly increased the past decade. In 2019/2020 almost half of all patients with traumatic spine injury was >65 years. Based on the predicted growth of the elderly population in Europe, the majority of patients with traumatic spine injury will be >65 years in the upcoming 10-20 years. The increased incidence and high mortality rate of spinal injury in elderly emphasizes the need of specifically developed treatment protocols for this patient category.

O608

Complications and risk factors in en bloc resection of spinal tumors: A retrospective analysis on 298 patients treated in a single institution

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Introduction: En bloc resection consists in the surgical removal of a vertebral tumor in a single piece with a sufficient margin, to improve survival and reduce recurrence rate. This procedure is technically demanding and correlates with a high complication rate. The purpose of this study is to investigate the risk factors for complications in en bloc resection and evaluate if benefits overcome the risks in term of overall survival.
Methods: We retrospectively analyzed prospectively collected data of patients treated with en bloc resection between 1980 and 2021. Adverse events (AEs) were captured and classified according to SAVES-V2 system[1]. Overall Survival was estimated using Kaplan-Meier method and the impact of AEs and of disease recurrences on Overall Survival was evaluated. The risk factors for the occurrence of AEs were detected by univariate and multivariate logistic regression models.
Results: A total of 149 patients out of 298 (50%) suffered from at least one AE. Moreover, 220 adverse events were collected (67 intraoperative, 82 early post-operative, 71 late post-operative), 54% of these were classified as grade 3 (in a severity scale from 1 to 6). Ten years overall survival was 67% (95% CI 59–74). The occurrence of relapses was associated to an increased risk of mortality with OR 3.4 (95% CI 2.1–5.5), while complications did not affect the overall survival.
Regarding the risk factors for complications, the multivariate analysis confirmed the association of complications with the type of surgery, previous treatments and previous surgery, but also age higher than 50 years old resulted to be as a risk factor in this model.
Conclusion: En bloc resection of primary spinal tumors or metastatic lesions is a challenging procedure which correlates with a high complication rate and, therefore, it should be carried out by specialized surgeons. Within a multidisciplinary management of spinal tumors, it is important to enhance integration between surgery and other treatments, focusing on timing and proper planning, to reduce the risks and maximize the efficacy of each treatment. Adjuvant therapies, such as chemotherapy for osteosarcoma and Ewing's sarcoma or Denosumab for giant cell tumor, can facilitate en bloc resection, by reducing the tumor volume and inducing ossification, which makes the lesion margins more identifiable.
Further studies should investigate how complications and relapses impact on the quality of life of patients who underwent en bloc resection in order to generate more specific recommendations and guidelines and inform the patients correctly.
Despite all the risks, our findings confirm that en-bloc resection remains the gold standard surgical procedure for selected patients in order to achieve better survival rates and better local control of disease.

Reference:

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O610

Surgical treatment of spinal meningiomas in the elderly (75 years): Which factors affect the neurological outcome? An international multicentric study of 72 cases

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Introduction: With the increasing life expectancy in the Western world, an increasing number of old patients presents with spinal meningioma. Considering the benign nature of these tumors, the functional outcome remains of great importance, since more people reach old age in general conditions of well-being and satisfactory autonomy.

Patients and Methods: We conducted an international multicenter retrospective study to investigate demographic, clinical and radiological data in a population of elderly patients (75 years of age) undergoing surgery for SM from January 2000 to December 2020 in four European referral centers. The aim was to identify prognostic and predictive factors for a good postoperative functional outcome.

Results: 72 patients were included in the study. Complete tumor resection (Simpson I or II) was achieved in 67 (95.7%) cases. Intraoperative complications were reported in 7 (9.9%) patients while postoperative complications were found in 12 (16.7%). An excellent general postoperative status (McCormick I and II) was achieved in 65.3%. Overall, surgical resection had a good impact on patients’ functional outcome (86.1% either showing an improvement or maintaining a good preoperative status). Uni- and multivariate analyses found that both age and preoperative modified McCormick independently correlated with relative outcome (coeff = -0.058, $p = 0.0251$; coeff = 0.597, $p < 0.0001$) and with postoperative status (coeff = 0.058, $p = 0.02507$; coeff = 0.402, $p = 0.00027$), respectively.

Conclusions: Age and preoperative modified McCormick were found to be independent prognostic factors. Nevertheless, advanced age (75), per se, did not seem to contraindicate surgery, even in those with severe preoperative neurological deficits. The functional results sustain the need for surgical resection of SM in the elderly.

O611

Deep learning model for grading metastatic epidural spinal cord compression on staging CT

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Introduction: Metastatic epidural spinal cord compression (MESCC) is a devastating complication of advanced cancer. MRI is the current gold standard imaging test, but it is expensive and not suitable for screening. Staging CT scans are commonly performed for cancer diagnosis and treatment follow-up, and represent a window of opportunity for earlier diagnosis of MESCC. Deep learning (DL) models for automated MESCC classification on staging CT were developed to aid earlier diagnosis.
Materials and Methods: Retrospective collection of staging CT scans and corresponding MRI spines from patients with suspected MESCC was conducted from September 2007 to September 2020. Exclusion criteria were scans with instrumentation, no intravenous contrast, extensive motion artefacts and non-thoracic coverage. The internal CT dataset split was 84% for training/validation and 16% for testing. An external CT test set from a different institution was also utilised. Internal training and validation sets were labelled by radiologists with spine imaging specialization (6 and 11 years of experience), and were used to develop a DL model for MESCC classification on CT. The spine imaging specialist (11-years expertise) labelled the staging CT test sets (axial portal venous phase images) in conjunction with the matched MRI spines (axial T2-weighted images) to serve as the reference standard. MESCC was classified using a modified Bilsky MESCC scale; normal/no epidural disease, low-grade (epidural disease with no contact of the spinal cord), and high-grade disease (spinal cord contact or compression). For evaluation of the DL model performance, internal and external test sets were independently reviewed by four radiologists; two spine specialists (Rad1 and Rad2, 7 and 5 years of experience, respectively) and two body radiologists with experience in oncological CT scan assessment (Rad3 and Rad4, 3 and 5 years of experience, respectively). Inter-rater agreement (Gwet's kappa) and sensitivity/specificity/AUCs were calculated.
Results: Overall, 420 CT scans were evaluated from 225 patients (mean age=60 ±11.9[SD]); 354 (84%) CT scans were used for training/validation and 66 (16%) CT scans were used for internal testing. The external test set consisted of 43 CT scans from 32 patients (mean age=60 ± 13[SD]). The DL model showed almost-perfect inter-rater agreement for three-class MESCC grading with kappas of 0.87 ($p<0.001$) and 0.84 ($p<0.001$) on the internal and external test sets, respectively. On the internal test set the DL model inter-rater agreement (κappa=0.87) was superior to Rad 2, a spine imaging specialist (κ=0.80) and Rad 3, a body radiologist (κ=0.72) (both $p<0.001$). The DL model kappa of 0.84 on the external test set was also superior to Rad 3 (κ=0.72) ($p<0.001$). For detection of high-grade MESCC the DL model showed high kappa/sensitivity/specificity/AUC of 0.94/93.4/95.47/0.94 on the internal test set and 0.95/96.6/96.0/0.96 on the external test set, respectively.
Conclusion: A DL model for detection of metastatic epidural spinal cord compression (MESCC) on CT showed comparable or superior inter-rater agreement compared to radiologists on internal and external testing. This DL model could provide earlier diagnosis and treatment of MESCC, resulting in improved patient outcomes including preservation of ambulation.

O612

Can the baseline clinical status and surgical strategy influence early good to excellent results in spinal lumbar fusion? A machine learning approach

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Introduction: The study aims to create a preoperative model from baseline demographic and health-related quality of life scores (HRQOL) to predict a good to excellent early clinical outcome using a machine learning (ML) approach.
Methods: A single spine surgery center retrospective review of prospectively collected data from January 2016 to December 2020 from the institutional registry (SpineREG) was performed. The inclusion criteria were age 18 years, both sexes, lumbar arthrodesis procedure, a complete follow up assessment (Oswestry Disability Index—ODI, SF-36 and COMI back) and the capability to read and understand the Italian language. A delta of improvement of theODI higher than 12.7/100was considered a "good early outcome". A combined target model of ODI (D 12.7/100), SF-36 PCS (D 6/100) and COMI back (D 2.2/10) was considered an "excellent early outcome". The performance of the ML models was evaluated in terms of sensitivity, i.e., True Positive Rate (TPR), specificity, i.e., True Negative Rate (TNR), accuracy and area under the receiver operating characteristic curve (AUC ROC).
Results: A total of 1243 patients were included in this study. The model for predicting ODI at 6 months 'follow up showed a good balance between sensitivity (74.3%) and specificity (79.4%), while providing a good accuracy (75.8%) with ROC AUC = 0.842. The combined target model showed a sensitivity of 74.2% and specificity of 71.8%, with an accuracy of 72.8%, and an ROC AUC = 0.808.
Conclusions: The results of our study suggest that a machine learning approach showed high performance in predicting early good to excellent clinical results.

O613

Can the addition of robotic terminal cleaning via pulsed-xenon ultraviolet light reduce bioburden in the operating room compared to traditional manual methods alone?

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Introduction: In the spine field, antibiotic selection and wound protection and drainage techniques have steadily improved. Yet, methods for operating room (OR) cleaning has seen little innovation. Pulsed-Xenon Ultraviolet (PX-UV) disinfection is an opportunity for standardized, touch-free disinfection that may augment current manual terminal cleaning protocols. The combination of manual and PX-UV disinfection may provide the greatest reduction in OR bioburden, as measured by Colony Forming Units (CFUs), and frequency of site contamination.
Aim: This study explores whether the addition of PX-UV robotic disinfection can significantly reduce bioburden in the operating room following terminal cleaning.
Materials and Methods: Fifteen ORs were sampled at three time points – before terminal manual cleaning, after terminal manual cleaning, and after PX-UV. For each OR, at each time point, five high-touch surfaces were cultured using a Tryptone Soy Agar touch plate. A total of 225 touch plate samples were acquired. Samples were incubated and the number of CFUs reported. Distinct colonies were identified and counted. Descriptive statistics and Rank Sum Testing with a Bonferroni correction were used to analyze results.
Results: There was a 26.8% reduction of CFUs after manual cleaning ($p>0.8014$) and a further 81.0% reduction of CFUs after PXUV ($p = 0.0086$). Overall, the combination of manual and PX-UV disinfection resulted in an 86.1% reduction in CFUs ($p = 0.004$). The frequency of sites with CFUs prior to cleaning was 26.7%. There was no change in frequency of sites with CFUs after manual cleaning. Following PX-UV cleaning, the frequency of sites with CFUs reduced to 8.0%, which is a 70.0% reduction in sites with CFUs. Interestingly, the frequency of sites with an increase in CFUs after manual cleaning was 20.0%. There was no occurrence of an increase in CFUs after PX-UV disinfection.
Conclusion: The combination of PX-UV with manual cleaning yields the greatest reduction in OR bioburden as measured by CFUs. Manual cleaning alone resulted in a low reduction of CFUs and almost no change in the frequency of site contamination. The increase in CFUs following manual cleaning may represent cross contamination due to inconsistent manual terminal cleaning.
The use of PX-UV disinfection resulted in a significant reduction in CFUs when compared to both the pre- and post-manual cleaning time points. There was no cross-contamination with PX-UV disinfection. This reduction in bioburden may contribute to a decreased risk of surgical site infection. Further research into the benefits of combining between case and terminal PX-UV disinfection, as well as the relationship between reduced bioburden and surgical site infection, are needed.

O614

Integrating 2D radiographs and 1D clinical data in the AI prediction of adolescent idiopathic scoliosis progression

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Introduction: Adolescent idiopathic scoliosis (AIS) is the most common form of scoliosis, attributing to about 70% of all cases, and is usually diagnosed during puberty. One can imagine a curved spine can detrimentally affect the patient's daily activities, quality of life and even cardiopulmonary function. The progressive nature of AIS warrants an early diagnosis and treatment to prevent progression as soon as possible and to save the patient from more aggressive interventions. Many studies have investigated how structural deformity parameters, and even biomarkers, may contribute to the likelihood of AIS progression. But no study has been done so far that utilizes a convolutional neural network (CNN) to combine information from raw two-dimensional (2D) radiographs and one-dimensional (1D) clinical parameters in the research of AIS progression prediction.
Aim: By using capsule network as a backbone, this study aims to develop a CNN model that is able to predict the probability of AIS progression at the patient's first visit by integrating 2D radiological images with 1D clinical data.
Patients and Methods: A total of 513 patients have been recruited with the exclusion of 43 patients due to lack of follow-up. Clinical parameters were recorded at specialist clinics and bi-planar radiographs of the full body were scanned. Three different crops of the original radiographs are generated -- (1) whole-spine crop, (2) upper end vertebra crop of major curvature, and (3) lower end vertebra crop of major curvature, all of which are used as the 2D inputs of the CNN model. The clinical parameters used in this study included sex, age, weight, sitting height, standing height, arm span, Risser sign, and distal radius and ulna classification. Categorical data are represented as 1D unit vectors, whereas numerical data are normalized to a number between 0 and 1. The processed vector then served as the 1D input of the CNN model. The presence of AIS progression was defined by a minimum increase of 5 degrees major curve Cobb angle, which can happen as soon as 2 months after the initial consultation. This definition is used to verify the predicted outputs from the CNN model.
Results: The CNN model achieved a 92.6% sensitivity and 90.6% negative predictive value (NPV) with an overall accuracy of 72.8%. In addition, it also achieved 56.9% specificity and 63.3% positive predictive value (PPV). The ROC AUC is 0.76.
Conclusion: The high sensitivity and NPV make this AI model a great *screening* tool to exclude those without the risk of AIS progression. With a negative risk predicted by the model, treatment resources can then be spared and reassurance can be given to the patient. With a positive predicted progression risk, the specialist can decide to more closely monitor AIS progression of the patient by increasing the frequency of follow ups to significantly speed up the diagnosis and management of AIS progression and further optimize appropriate allocation of healthcare resources. Limitations of this study include a small data size and occasional missing clinical data.

O615

Application of modest hypothermia in patients with acute traumatic cervical spine injury: A pilot study

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Introduction: This prospective randomized controlled study aimed to examine the role of modest systemic hypothermia in individuals with acute cervical spinal cord injury (SCI) regarding neurological improvement. Studies have shown that the application of hypothermia is safe and that it improves neurological outcomes in patients with traumatic spine injury. Hypothermia helps in decreasing a secondary damage to the cord.
Methods: Twenty cases of acute post-traumatic cervical SCI with AISA were selected and randomly divided into two treatment groups: Group A—Hypothermia with surgical decompression and stabilization; and Group B—Normothermia with surgical decompression and stabilization. American Spinal Injury Association (ASIA) motor and sensory scores were evaluated at presentation; post-surgery; and at a 2-week, 6-week, and 12-week follow-up.
Results: At the final follow-up, the change in ASIA motor scores of Group A was 46 (11.5– 70.5) and Group B 13 (4.5–58.0), whereas ASIA sensory scores were 118 (24.75–186.5) and 29 (15.25–124.0) in Group A and Group B, respectively. ASIA scores between the two groups were statistically significantly different at a 2-week follow-up (ASIA motor p=0.04, ASIA sensory p=0.006), showing early improvement in the hypothermia group. There was no significant difference between the two groups on further follow-up.
Conclusion: Hypothermia can be applied safely to subjects with acute SCI. Our study showed that hypothermia was beneficial in the early improvement of functional outcomes in acute cervical SCI.
Keywords: hypothermia; cervical; spinal cord injury; hypothermia; improvement; American Spinal Injury Association score

O617

Power-assisted pedicle screw placement decreases pedicle screw wobble

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Introduction: Retrospective analyses of clinical outcomes show pedicle screws placed with power-assisted instruments fail less than screws placed using manual technique. An explanation of these findings may be found by studying screw wobble, where wobble is defined as the deviation of the screw from its intended trajectory. A screw succumbing to wobble may erode the bone at the bone/screw interface, which may decrease screw purchase and reduce screw pullout strength.
Aim: This cadaver study quantifies screw wobble over the duration of insertion using manual versus powered pedicle screw placement technique.
Materials and Methods: Pedicle preparation and screw insertion using two cadaver torsos and both manual and powered techniques was performed by one spine surgeon experienced in both manual and power techniques. Pedicles of T9-L5 vertebrae were prepped and screws inserted bilaterally using either manual or powered technique (n=18 pedicles/technique). Manual technique included development of the pedicle tract with a Lenke probe, undertapping by Ø1.0mm, and driving Ø5.5mm x 40mm or 45mm length pedicle screws; powered technique used a Ø2.4mm drill bit, a specially designed dull threaded reamer (Ø3.2mm), and screws of matched diameter and length. Inertial measurement units (IMUs) affixed to both manual and powered drivers recorded the angular rotation of the instruments about three planes at 100Hz over the duration of screw placement. Within the angular rotation data, a LOESS filter identified the intended trajectory, and wobble was deemed the rotational deviation from that intended trajectory. Rotational data was converted to displacement data through geometrical calculations using the screw length. Wobble path length was quantified as the cumulative displacement of extraneous screw motion, wobble area as an ellipse fit to the in-plane projection of the wobble path. Three one-way ANOVAs with multiple comparisons and Tukey's correction assessed outcomes as a function of both technique and screw length. Significance set to $p<0.05$.
Results: Power significantly reduces wobble path length and wobble area (Figure 1). Wobble path length of the 45mm screw using manual technique was 53% greater (68.7±13.5mm) than the screw's length, whereas the matched powered wobble path length was 87% reduced (5.9±3.4mm). Powered technique reduced wobble area by 62% and 47% for 40mm and 45mm length screws, respectively ($p<0.05$).
Conclusion: Powered pedicle screw placement decreases screw wobble by metrics of wobble path length and wobble area. Therefore, the use of power-assisted tools for screw placement may reduce OR time, work of placing screws, and the propensity of screws to loosen.

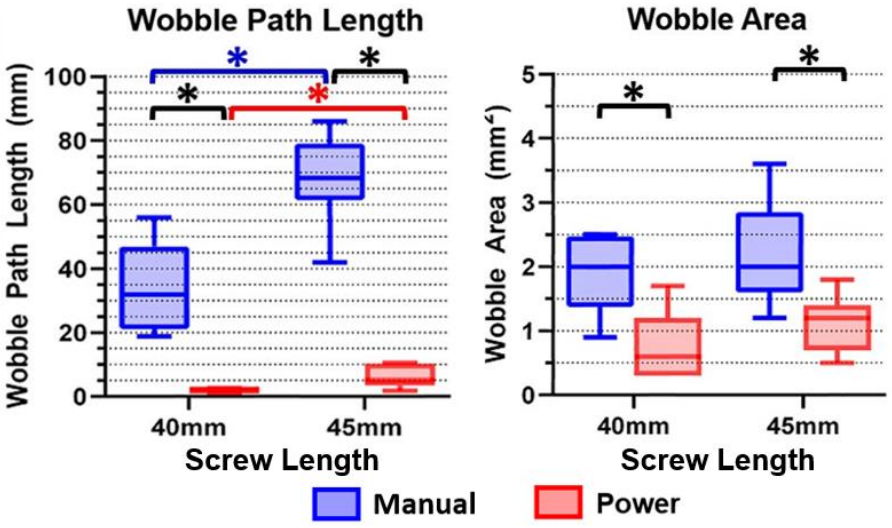

Figure 1. Pedicle screw wobble assessed via metrics of wobble path length and wobble area. Power significantly reduces wobble path length, and wobble path length increases with screw length within both techniques. Power significantly reduces wobble area.

O618

Proposed objective scoring algorithm for clinical evaluation of walking asymmetry in lumbar disc herniation, based on relevant gait metrics from wearable devices: The Gait Symmetry Index (GSi™) – observational study

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Introduction: Lumbar disc herniation (LDH) can result in asymmetric walking patterns. Objective evaluation of gait asymmetry can guide clinical assessment and management of patients with LDH. Wearable sensor-derived gait metrics facilitate objective gait scoring tools offering insight into patient function and streamline clinical decision-making.
Aim: The proposed *Gait Symmetry Index (GSi)* aims to objectively evaluate the walking impairment associated with LDH. The GSi score measures deviation gait velocity, step time asymmetry and step length asymmetry from mean 'normative' values of an age-matched control population (Table 1). Clinical performance of the GSi score was assessed in a single surgeon series of 33 patients with a diagnosis of LDH.
Materials and Methods: Participants were fitted at the sternal angle with a chest-based wearable sensor, MetaMotionC (*Mbientlab Inc., USA*) and walked unobserved for 120m along a hospital corridor. Statistical analysis of gait metrics and GSi scores between LDH participants (surgical management and conservative management and pooled groups) and control participants were calculated using Kruskal-Wallis H test or one-way analysis of variance (ANOVA) tests following analysis of histogram and Shapiro-Wilks testing for normality. Correlation of GSi scores with ODI and VAS Pain scores was assessed by simple linear regression.
Results: The present study comprised of 33 participants with LDH (mean age, 44 $\pm$ 13 years) and 33 age-matched controls (mean age, 44 $\pm$ 13 years). LDH participants were further sub-grouped into surgical (n=14) and conservative care (n=19) groups. GSi scores (median, range) were 16.7% lower (p<0.001) in LDH participants (83, 29-100) compared to controls (100, 71-100) as seen in Figure 1. This shortfall was greater in the surgical care subgroup (-38.7%, p<0.001) compared to the conservative care subgroup (-10.6%, p<0.001). GSi scores also correlated with functional status according to Owestry Disability Index, with a slope of -0.7345 (r squared = 0.5325, p < <0.0001).
Conclusions: Wearable sensors are sufficiently accurate and capable of detecting gait abnormalities in LDH. GSi is capable of detecting patients with symptomatic LDH requiring intervention (both conservative and surgical) from a control population.

Table 1. Scoring of GSi

Gait Velocity (GV)		Step time asymmetry (STA)		Step length asymmetry (SLA)	
$GV < 1.35\ m/s$	$\left\{\frac{GV}{1.4}\right\} \times 40$	$STA > 32$ ms	$\left\{\frac{32}{STA}\right\} \times 30$	$SLA > 5.4$ cm	$\left\{\frac{54}{SLA}\right\} \times 30$
$GV > 1.35\ m/s$	40	$STA < 32$ ms	30	$SLA < 5.4$ cm	30

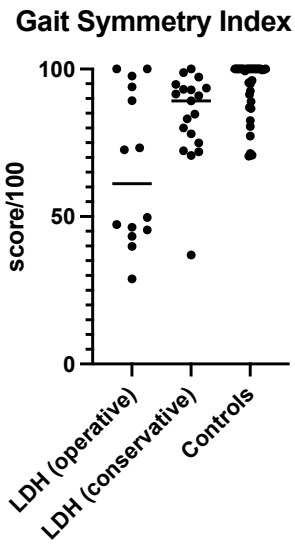

***Figure 1*. Distribution of Gait Symmetry Index for lumbar disc herniation based on operative (n= 14) and conservative management (n=19) subgroups, as compared to control participants (n=33).** GSi = Gait Symmetry Index, LDH = lumbar disc herniation, n= number of participants.

O619

Evaluation of an artificial intelligence (AI) based scoliosis measurement program

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Introduction: Scoliosis refers to the three-dimensional deformity of the spine with one or several segments of the spine bent laterally with vertebral rotation. Reliable measurement of spinal curve is crucial for determining therapeutic decision for scoliosis patients. Cobb Angle is the gold standard, but it is an objective measurement with variant from surgeon to surgeon. A solid and reliable measurement tool is needed. Artificial Intelligence has showed great potential in image measurement.
Aim: To compare the performance of an AI based scoliosis measurement tool with senior scoliosis surgeons in Denmark.
Methods: Trained the AI algorithm with 650 scoliosis X-ray images by using Convolutional Neural Network (CNN). Another 100 scoliosis X-ray have been assigned into two groups randomly. Each group has been measured by AI and two surgeons. All four surgeons measured Cobb angles twice with minimal 3 weeks interval. Intraclass correlation coefficients (ICC) were used to determine the interobserver and intraobserver reliabilities. (ICC can range from 0 to 1, where 0 means no reliability and 1 means perfect reliability, ICC between 0.9 to 1 means excellent reliability). The correlation of scoliosis curve angle measurements between AI program and senior surgeons have been tested with Pearson correlation coefficient and the mean absolute error.
Results: (**Table 1**) ICC is 0.96 in group 1 and 0.90 in group 2, which means excellent reliability. Pearson Correlation coefficient was 0.956 in group 1 and 0.930 in group 2. Spearman rank-order correlation was 0.960 ($p < 0.001$) in group 1 and 0.900 ($p < 0.001$) in group 2. The absolute error between AI and surgeons are 3.5°±3.1° in group 1 and 5.0°±3.8° in group 2. In total the absolute error is 4.2°± 3.3°(**Figure 1**). In 67% of all cases, there were only 0°-5° different between AI program and spine surgeons.
Conclusions: There is statistic correlation of Cobb angle measurement between our new developed AI program and senior spine surgeons. The reliability is statistic excellent in both patients' groups. Our new AI program can provide reliable Cobb angle measurement as good as senior spine surgeons.

Acknowledgements: Central Region Denmark Research Foundation, and A.P. Moeller Foundation.
(See table 1 and figure 1 in next page)

Table 1. Comparison of the Cobb angle measurements between spine surgeons and AI

	Group 1		Group 2	
Variable	Surgeon	AI	Surgeon	AI
Cobb angle	47,7°±15,7°	48,1°±16,1°	61,9°±14°	58,2°±13,3°
Cobb angle Range	11°-78,0°	14,5°-82,6°	40,8°-103,0°	33,3°-92,0°
ICC	0,96		0,90	
Pearson correlation coefficient	0,956		0,930	
Spearman rank-order correlation	0,960		0,900	
Average absolute error	3,5°±3,1°		5,0°±3,8°	

Figure 1. The differences between AI and spine surgeon in Cobb angle measurement

O620

Safe exposure of the lumbosacral plexus via the pararectal approach: A technical note on this novel technique

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Introduction: Surgical exploration of the lumbosacral plexus is challenging. The procedures described to date range from invasive open techniques with osteotomy of the ilium to laparoscopic techniques. We present the pararectus approach as a safe approach with excellent visualization for exploration, decompression, neurolysis, and repair of the lumbar extraforaminal plexus.
Methods: We retrospectively evaluated four patients with pathology or injury to the lumbosacral plexus between 2017 and 2019. The median follow-up time after surgery was 23.5 (range 11-52) months. All patients underwent neurolysis of the lumbosacral plexus via an intrapelvic, extraperitoneal, and pararectal approach with a single incision.
Results: In all patients, lumbosacral plexus pathology was successfully visualized, demonstrating the feasibility of the extraperitoneal pararectus approach for this indication. No major complications occurred, and all patients recovered well.
Conclusions: The pararectus approach provides excellent visualization of the lumbar plexus and intrapelvic lesions of the femoral and sciatic nerves.

O621

Clinical experience of occipito-cervical fixation in hypermobile patients

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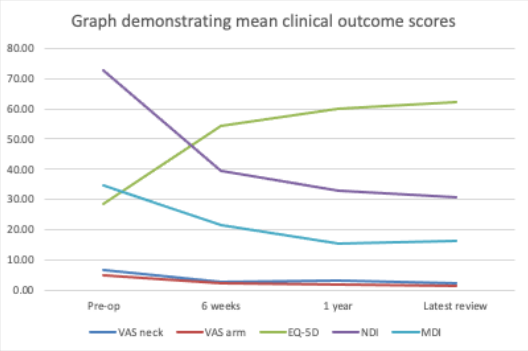
Introduction: Surgery for patients with hypermobility is controversial. Patients present with often bizarre symptoms with relatively normal radiology. Hypermobility due to Ehlers-Danlos (EDS) can cause ligamental laxity at the cranio-cervical junction which may result in deformation of the brainstem. There is little evidence in the literature that surgery improves outcomes1.
Methods: A total of 16 patients were operated on between 2017 and 2021. Symptoms included severe occipitocervical headaches, postural orthostatic tachycardia, dizziness, fatigue, and brain fog. Two-thirds had hyper reflexia on examination. Radiological examination included MRI brain cervical spine, Rotational CT scan and dynamic x-rays. Surgery involved an occipital-C2 fixation, correction of the CXA to 150^0 or over plus duraplasty if no pulsation of the dura. VAS, EQ-5D, Myelopathy Disability Index and Neck Disability Index, outcomes were recorded. Mean follow up was 24.4 months.
Results: There was a female preponderance of 94% and mean age of surgery was 34 years old. There was improvement in all outcome parameters (see table) particularly in EQ-5D and NDI which occurred by 6 weeks and was sustained over one year.
Conclusions: Although surgery is controversial, selected hypermobile patients may be suitable for surgery if conservative measures fail. In our limited cohort of patients, the results suggest occipito-C2 surgery does have a place after detailed counselling and mirrors the results of a previous study.



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O622

Risk factors of global spinal mal-alignment after osteoporotic vertebral fracture

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Introduction: It is well known that osteoporotic vertebral fracture is one of the causes of spinal malalignment. However, it is not known how sagittal spinal alignment will worsen and the risks of spinal malalignment after osteoporotic vertebral fracture (OVF).
Aim: Aim of this study is to show the change of global spinal alignment after OVF and to clarify the risk for progression of global spinal malalignment.
Patients and Methods: Conservative treatment was conducted for fifty-three patients for 96 weeks after new single-level thoracolumbar OVF. These patients were treated with soft lumbosacral orthosis in the first 24 weeks. Patients were divided into two groups depending on the change of pelvic incidence minus lumbar lordosis (PI - LL) from 24 weeks to 96 weeks after OVF. Stepwise multinomial logistic regression analysis was used to identify associations between the risk of worsening global spinal alignment and the patients background status as age, past vertebral fracture, local kyphosis at fractured vertebra, union status, and global spinal alignment containing the distance between C7 plumb line to the center of OVF (C7PL-OVF) at 24 weeks.
Results: PI-LL was recovered from 19° ± 15° at 24 weeks to 10° ± 17° at 96 weeks after OVF. Bimodal change in PI-LL was observed from 24 weeks to 96 weeks after OVF. The improved PI-LL group (n = 28) was defined as the change of PI-LL over 10 degrees, and the worsening PI-LL group (n = 25) was defined as the change of PI-LL under 10 degrees, respectively. The risk factors for worsening PI-LL showed were age (71.7 ± 1.3 and 75.5 ± 1.4, p = 0.060), pelvic tilt (20.2 ± 1.5°, 26.2 ± 1.6°, p = 0.008), sagittal vertical axis (36.4 ± 8.2 mm, 72.6 ± 8.8 mm in (p = 0.004), and C7PL-OVF (43.9 ± 7.6 mm, 70.5 ± 8.1 mm, p = 0.020). Stepwise multinomial logistic regression analysis showed the risk factors for worsening PI-LL as C7PL-OVF > 60mm (odds ratio; 12.6 (95%CI; 2.5 - 63.3), p = 0.002) and past vertebral fracture (odds ratio; 8.7 (95%CI; 1.5 - 49.7), p = 0.015).
Conclusion: Bimodal change in PI-LL was observed from 24 weeks to 96 weeks after OVF. About a half of the patients with OVF resulted in difficulty of recovery or worsening their sagittal spinal alignment. C7PL-OVF over 60 mm was the candidate for worsening global spinal alignment. Patients with greater local kyphosis caused by OVF did not result in worsening PI-LL, however, past vertebral fracture was another candidate for worsening global spinal malalignment. It might be considered that past vertebral fracture limited the ability to compensate spinal malalignment through limiting the segmental mobility by making fusion with adjust vertebra. It might also be also explained in the same manner that the change of local kyphosis by balloon kyphoplasty will not affect global spinal alignment as reported.

O623

Scoliosis among children in Qinghai-Tibetan Plateau of China: A cross-sectional epidemiological study

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Introduction: The average altitude of the Qinghai-Tibetan Plateau is 4,500m and most of the residents are of Tibetan ethnicity. The purpose of this study was to investigate the prevalence of scoliosis and associated factors among children in this region through a scoliosis screening program.
Methods: A cross-sectional study was performed between May 2020 and December 2020 in Qinghai-Tibetan Plateau. A total of 9,856 children aged 6–17 years from schools and nearby villages were screened using visual inspection, the Adams forward-bending test, the angle of trunk rotation, and radiography. A self-designed questionnaire was used to collect demographic data. The prevalence of scoliosis and associated factors were analyzed.
Results: The overall prevalence of scoliosis among children in Qinghai- Tibetan Plateau was 3.69%, with 5.38% for females and 2.11% for males. The prevalence of scoliosis was 3.50% in children who resided below 4,500m while 5.63% in those resided above 4,500m(P = 0.001). The prevalence of congenital scoliosis (2.14 vs. 0.42%, P<0.001) and neuromuscular scoliosis (0.34 vs. 0.07%, P = 0.041) were significantly higher in the altitude above 4,500m. 50.00% of
patients resided above 4,500m were recommended for surgery while 16.24% in those resided below 4,500m (P < 0.001). Independent associated factors were detected as female (OR = 2.217, 95 CI% 1.746–2.814, P < 0.001), BMI < 18.5 (OR = 1.767, 95 CI% 1.441–2.430, P = 0.005), altitude of residence ≥ 4,500m(OR = 1.808, 95 CI% 1.325–2.483, P = 0.002), and sleep time < 8 h (OR = 2.264, 95 CI% 1.723–2.846, P = 0.001).
Conclusion: The prevalence of scoliosis among children in Qinghai-Tibetan Plateau was 3.69%. With increasing altitudes, the prevalence of scoliosis and its major type were different from that at lower altitudes. Female, BMI < 18.5, altitude of residence ≥ 4,500m, and sleep time < 8 h were independently associated with the prevalence of this disease. Early screening should be carried out before the age of 7 years, especially in high-altitude, underdeveloped, and rural areas.

O624

Developing a spine surgery training curriculum using entrustable professional activities

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Introduction: Most training programs in spine surgery around the world are based on surgical apprenticeships through fellowships at hospitals specializing in spine surgery, supplemented by continuing medical education activities. Very few of these fellowships have a curriculum or formal training program. The starting point for a curriculum planning process using *entrustable professional activities (*EPAs*)* begins with analyzing the professional work of the specialist medical practitioner. This analysis identifies the essential activities that can be entrusted only to those who have acquired the requisite abilities to work independently in a given healthcare context, to achieve a desired outcome.
Methods: We decided to use the framework of EPAs, beginning with the final level of autonomous practice that describes what spine surgeons do in their day-to-day professional lives and what are the core competencies they must have to treat patients with spinal problems to achieve good outcomes. For our curriculum development, we engaged with a group of twenty-six spine surgery experts from around the world to create a list of EPAs, then refined the list through an iterative Delphi-like process over several face-to-face and virtual meetings.
Results: Figure 1 shows the original list of EPAs. These were then refined to a core list of seven: make a diagnosis, formulate a treatment plan, explain treatment options to patients, collaborate with multidisciplinary teams, perform an appropriate procedure when indicated, review patient progress and prevent or manage complications, and participate in quality improvement activities. Each core EPA is elaborated by key competencies under the domains of pathology: trauma, degeneration, deformity, tumours, infection, inflammation, and metabolic disorders (see figure 2 for trauma).
Conclusions: All AO Spine educational events are linked to the curriculum. The curricular competencies to be covered are specified before the event so that learners can provide input into their current and their desired level of experience. This informs the pre-event preparations and reinforces the link between the event content and the AO Spine curriculum. Each event is aimed at a specific domain or competency within the curriculum, and the event content relates directly to the learning objectives, learning methods, and resources of that educational experience. In 2022, a new AO Spine global online training program was launched using the curriculum as the template for the program syllabus.

Figure 1

EPAs	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7
Diagnosing spinal conditions	Interview & examine the patient	Obtain relevant information from family & primary care physicians	Make a clinical diagnosis	Order appropriate investigations	Interpret the results	Make a provisional diagnosis	Communicate with the patient, family and carers
Planning patient management	Consider the treatment options using EBM	Consider the best option for the individual patient	Formulate a treatment plan	Discuss it with the patient and carers	Obtain informed consent	Communicate the plan to the treating team	Collaborate with other clinicians for non-surgical treatment
Performing spinal surgery	Assess the patient pre-operatively	Brief the surgical team and complete a pre-op checklist	Document the procedure & post-op plan	Visit the patient post-operatively	Identify & manage any complications	Plan discharge & rehabilitation	Follow up after discharge
Being on call for acute care	Take phone calls from hospitals and GPs	Identify the need for an emergency procedure	Give advice to the resident or fellow	Prioritise the after-hours OR schedule	Attend the OR when required	Arrange roster swaps & leave cover	Cover other colleagues' patients
Being a teacher	Get educational training	Supervise/assist/ coach trainees	Give lectures	Lead case-based discussions	Give feedback	Be a role model and mentor	Reflect on teaching practice
Participating in quality improvement	Use outcome measures to monitor treatment	Audit outcomes with colleagues and teams	Contribute to outcome databases	Establish & follow treatment protocols	Contribute to clinical research	Maintain CPD compliance	Reflect on clinical practice
Running a clinic	Select, develop and manage private clinic staff	Manage the financials	Do marketing	Maintain a practice management billing system	Establish a digital medical record system	Purchase medical indemnity insurance	Establish a risk management system
Leading a hospital department	Meet with health administrators	Plan budgets	Select, develop and manage clinical staff	Manage rosters	Attend committee meetings	Manage OR schedules & waiting lists	Perform team appraisals

Figure 2

Trauma

EPA	Key competencies
Make a diagnosis	Examine the patient for a possible spinal cord injury and reexamine serially if a neurological deficit is found
	Suspect a spinal injury in the unconscious polytrauma patient
	Maintain spinal immobilization until spinal trauma is excluded
	Arrange appropriate imaging
	Recognize the radiographic features of instability and cord injury
Formulate a treatment plan	Classify the spinal injury using the AO Spine classification systems
	Use evidence-based decision-making for treatment of the spinal injury, including spinal cord injury management
Explain treatment options to patients	Describe the risks and benefits of surgical versus conservative management and consider the patient's preferences and expectations
Collaborate with MDTs	Be involved in rehabilitation planning
Perform appropriate procedures	Reduction/stabilization/decompression/fusion when indicated
	Use safety protocols to protect the patient and team members
	Preserve function at uninjured levels where possible
Manage or prevent complications	Postinjury, intraoperative, and postoperative
Participate in quality improvement	Perform surgical audit on outcomes and complications
	Enroll patients in a trauma registry/database

O625

Power-assisted versus manual pedicle screw tract preparation: Safe use and proprioception

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Introduction: Manual techniques of pedicle preparation and screw insertion remain labor intensive and repetitive, putting surgeons at increased risk of overuse injuries of the hand, wrist, shoulder, and neck when compared to the general population. Sophisticated power-assisted tools that maintain tactile feedback may reduce repetitive stress injuries, making the technique safer for surgeons, but are power-assisted techniques safe for patients?
Aim: This cadaver study evaluates the incidence of pedicle breach using power-assisted versus manual techniques in a simulated surgical environment.
Materials and Methods: Pedicle preparation and screw insertion were performed by four spine surgeons, three new to the power-assisted technique, using four cadaver torsos. For power-assisted pedicle preparation, drill bits (Ø2.0mm or Ø2.4mm) and specially designed reamers (Ø3.2mm) were used. For manual pedicle preparation, the pedicle tract was developed with a Lenke probe, then undertapped by Ø1.0mm. Pedicles were prepped bilaterally either using manual or power-assisted technique (n=58 pedicles each). All screws were inserted with power with size chosen by each surgeon. Surgeons provided retrospective procedural evaluations. Breach incidence and distance were assessed quantitatively by blinded researchers through analysis of post-op CT scans. Breach incidence was compared with Fisher's exact test, and breach distance was compared with Mann-Whitney's rank test. Significance set to $p<0.05$.
Results: Surgeons reported power-assisted tools for pedicle preparation had better tactile feedback than the Lenke probe, and no difficulties were reported in either preparation or insertion. Power-assisted pedicle preparation resulted in significantly fewer breaches (3.4% [2/58], $p<0.05$) compared to those from manual preparation (20% [12/58], Figure 1). All breaches in the power group were lateral and located in the thoracic spine in an "in-out-in" trajectory with the screw tip within the vertebral body, which is clinically acceptable. In contrast, 3/58 screws in the manual group were inferior to the pedicle or anterior to the vertebral body. Mean lateral breach distance from manual (2.6±1.8mm) and power-assisted (2.7±0.9mm) preparation techniques were not significantly different. Mean inferior pedicle breach in the manual group only was 2.4±0.5mm.
Conclusion: Surgeons reported feeling more proprioception using a power-assisted preparation compared to manual pedicle preparation. There were fewer pedicle screws violating the pedicle cortex with power-assisted pedicle preparation compared to manual pedicle preparation. The power-assisted breaches were only lateral and would not be clinically relevant; in contrast, the manual group had breaches inferior to the pedicle and anterior to the vertebral body.

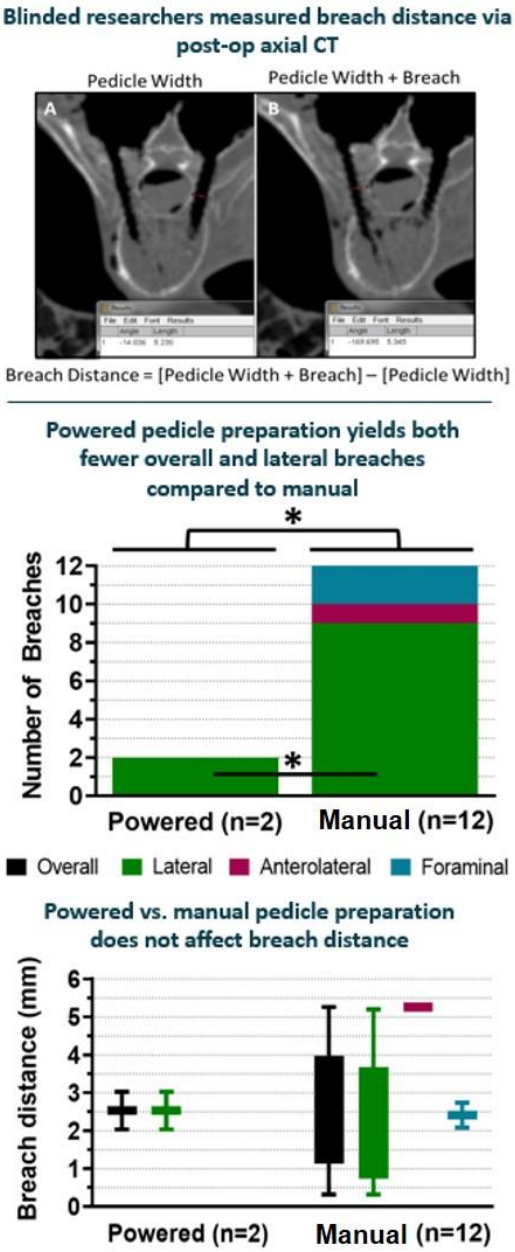

Figure 1. Breach incidence, location and distance were determined by blinded researchers via inspection and measurement of post-op CT scans. Power-assisted pedicle preparation yielded fewer overall and lateral breaches compared to manual. Breach distance was unaffected by technique. Significance *: $p<0.05$.

O626

A summary of development, methods used and results from NORspine: The Norwegian national quality registry for spine surgery

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Introduction: The Norwegian registry for spine surgery (NORspine) is a comprehensive national clinical quality registry for spine surgery. It includes patients operated for degenerative disorders in the lumbosacral and cervical spine in all Norwegian hospitals. It is argued that value-based health care would increase quality and reduce cost in healthcare, and a core concept in this funding model is reporting of outcome. NORspine's objective is to surveil and improve the quality of care for patients with degenerative conditions in the spine and to facilitate research.
Aim: To review and describe NORspine's rationale, development, concepts, methods, results and future perspectives.
Development: In 2001 the Norwegian Spinal Surgeon Society commenced development of a national registry at the University Hospital of North Norway (UNN) of patients operated in the lumbar spine. Financing and a formal mandate were acquired from the public Norwegian health authorities and NORspine was operational from 2007.
Methods: NORspine has no support form industry or other stakeholders. It is organized in the UNN and has four employees (full-time equivalent 180 %). All Norwegian hospitals providing spine surgery report to the registry and designated employees at each reporting unit have responsibility for data processing and reporting. An advisory board guide data collection, management, analysis and presentation. The registry cohort is consecutively recruited in the Norwegian healthcare setting, a single-payer tax-based system with universal access. Registration is mandatory for healthcare personnel, and voluntary for the patients based on informed consent. Exclusion criteria is surgery for cancer, trauma, scoliosis or removal of implants. Reoperations within 90 days are considered a complication. Data are prospectively collected form patients and surgeons at baseline, 3- and 12-months follow-up. Approximately 350 baseline-, process- and outcome-variables are collected. These include sociodemographic data, health- and disease-related data including PROMs and PREMs, comorbidity, previous spine surgery, indication for and type of surgery, complications and administrative data. The main outcome measure is the Oswestry Disability Index (ODI), as of which benchmarks for successful operations are established. NORspine evaluates and improves data quality in the dimensions *completeness*, *timeliness*, *accuracy, relevance* and *comparability* annually and have conducted numerous validation studies. Eleven quality indicators are recommended, and measures to quality improvement in the field have been suggested annually since 2011.
Results: At the end of 2021, 60647 operations were registered. The proportion of women is 47,6 % and the mean age is 55 year. 26557 and 26545 were operated for lumbar disc herniation and lumbar spinal stenosis, respectively, with a success ratio of 63,2 % and 60,4 %. 7417 had fusion surgery. The registry has contributed to at least 55 publications, eight ph.d.-degrees, twelve ongoing ph.d.-projects and nine master degrees.
Discussion: NORspine's design is comparable to registries assessed as well-designed. The registry cohort is large and representative, and the registered data is of high quality. Governmental funding reduces risk of reporting bias related to external stakeholders such as industry.
Conclusions: NORspine is a well-designed clinical quality registry for Norwegian spine surgery and a high-quality data source for research.

O627

Complications in spinal surgery: An unsolved problem… possible solutions

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Introduction: Adverse events (AEs) are still a major problem in spinal surgery, despite advances in surgical techniques, innovative technologies available and the introduction of checklist and predictive score systems aimed at reducing surgical complications.
We previously analyzed the results of the introduction of the WHO Safety Surgical Checklist (SSC) in our Institution, comparing the incidence of AEs between two periods: from January to December 2010 (without checklist) and from January 2011 and December 2012 (with checklist), in order to assess the checklist effectiveness.
Methods: The sample size of our study population was 917 patients with an average of 30 months of follow-up. AEs were observed in 107 patients (11.6%) among 917 spinal surgery procedures performed, with 159 (17.3%) complications in total.
Results: The overall incidence of AEs for trauma, infectious pathology, oncology, and degenerative disease was 22.2%, 19.2%, 18.4%, and 15.3%, respectively. We observed a reduction of the overall incidence of AEs following the introduction of the WHO Surgical Checklist: in 2010 without checklist, the incidence of AEs was 24.2%, while in 2011 and 2012, following the checklist introduction, the incidence of AEs was 16.7% and 11.7%, respectively (mean 14.2%) ($p<0.0005$).
Thus, the SSC appeared to be an effective tool to reduce complications in spine surgery.
We also believe that a correct capture and classification of AEs is fundamental to generate a clinical decision support system aimed at improving patients' safety in spine surgery.
In the period between January 2017 and January 2018 we prospectively recorded the AEs of patients undergoing spinal surgery in our department, without using any validated collection system. Then we retrospectively recorded the intraoperative and postoperative AEs of surgically treated patients during the same one-year period, using the SAVES v2 system introduced by Rampersaud and collaborators to classify them[1].
In the one-year period from January 2017 to January 2018 a total of 336 patients underwent spinal surgery: 223 for degenerative conditions and 113 for spinal tumors. Comorbidities were collected (Charlson Comorbidity Index [CCI]).
Overall, a higher number of AEs was recorded using SAVES compared to the prospective recording without the use of any capture system and the increased number was statistically significant for early postoperative AEs (210/336 vs 97/336, $p<0.001$).
210 AEs were retrospectively recorded using the SAVES system (30 intraoperative adverse events, 138 early postoperative and 42 late postoperative adverse events). 99 patients (29.5%) on the cohort had at least one complication.
Furthermore, the correlation between some risk factors and the onset of AEs or the prolonged length of stay was statistically analyzed.
Conclusion: Considering that the improvement of technical skills is not associated to a reduction of AEs and SCs in spinal surgery, we hypothesize that non-technical skills could be relevant for the occurrence of these events, and we suggest that teamwork, interprofessional collaboration and communication should be implemented in order to improve patients' safety. We think that Health organizations in western countries are committed to improving patient safety through education of staff and teamwork education programs, including the use of checklists and other tools elaborated to highlight risk factors for AEs and SCs, and address them. Thus, we propose to introduce in surgical departments one or more professional figures dedicated to patients' safety, who monitor the critical points where AEs and SCs could arise and support surgeons and other healthcare professionals in the application of preventive measures to reduce them, during surgery but also in the pre-operative and post-operative periods.

Reference:

[1]Rampersaud YR et al. J Neurosurg Spine 2016 Aug; 25 (2): 256-63

O628

'Holding them back': Is posterior C2-3 fusion, a more rational way to realign unstable Hangman's fracture?

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Introduction: No consensus exists on the preferred surgical approach for unstable Hangman's fracture. The associated soft tissue injuries add to the complexity of its etio-pathogenesis and are not addressed in an anterior approach. Also, the presumed efficacy of the recent motion-preserving pars-pedicle screw is doubtful. Furthermore, biomechanical studies suggest that posterior C2-3 fusion possibly has superiority over other techniques, with very few clinical studies available in literature.
Aim: We evaluated the clinico-radiological characteristics and outcome of patients managed by posterior C2-3 fusion.
Patients and Methods: Ten patients with unstable Hangman's were prospectively studied. The pattern of displacement of fractured fragments and C2-3 dislocation was studied in various planes. C2 pars-pedicle screw was placed to bring fractured fragments together (lag effect), which was then fused with C3 lateral masses to achieve reduction. Post-operative clinical outcome was assessed in terms of VAS pain score/ neurological status, and followed up at periodic intervals.
Results: Pain was the predominant symptom (VAS, 8.2). Mean VAS score improved significantly in postoperative period (1.3). About 70% had atypical Hangman's. Six patients had fracture segments malaligned in multiple planes (axial rotation, lateral translation and superior translation). Four had adjacent level injuries. Multiplanar reduction and realignment of fractured fragments as well as C2-3 could be achieved in all. Follow-up ranged from 6 to 22 months (mean, 12.8) with good bony fusion evident in 9 to 12 months.
Conclusion: Displacement occurs in multiple planes in Hangman's fracture. The fragments can show axial rotation, lateral translation and superior translation apart from the usually described antero-posterior plane. Posterior C2-3 fusion is an effective way to achieve reduction and multiplanar realignment of bony fragments. It also addresses the instability resulting from soft tissue injury. The rationale behind such approach is also discussed.

O630

Is BESS (biportal endoscopic spinal surgery) an efficient method for cervical disc herniation treatment?

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Introduction: Traditionally, Anterior cervical discectomy and fusion (ACDF) has long been the standard surgical strategy for cervical disk herniation (CDH) treatment. However, significant complications associated with this surgical approach have led to a demand for safer and less invasive alternatives. Recently, attempts have been made to increase the efficiency of endoscopic decompression. Among many minimal invasive surgery strategies, Biportal endoscopic spine surgery (BESS) has been reported as a treatment strategy for lumbosacral disk herniation and stenosis. However, BESS has been rarely reported as the treatment of CDH. The aim of the article is to describe BESS as a posterior approach for CDH and report the preliminary outcomes and complications.
Method: We performed a retrospective review of 100 patients who underwent BESS for symptomatic CDH, Foraminal stenosis at a single center between February 2021 and September 2022. Only patients who had unilateral radicular symptoms for at least 3 months and had undergone conservative management for at least 1 month were considered for cervical BESS. Clinical outcomes, including the visual analog scale, neck disability index, Macnab criteria, the motor function of the involved arm, complications were evaluated at 4, 8, 12, and 24 postoperative weeks.
Result: Visual analog scale and neck disability index improved significantly at 24 weeks postoperatively (P <.03). According to the Macnab criteria, “excellent,” “good,” and “fair” results were obtained for 37%, 45%, and 10% of patients, respectively. The post 24-week distribution of the involved upper extremity strength grade was significantly improved compared to the initial value (P =.02). 3 patient had a motor weakness with a decreased grade over 4 weeks, 2 patient performed Artificial disc replacement (ADR) as additional surgery due to persistent pain.
Conclusion: BESS for the cervical spine is associated with favorable outcomes. However, the study findings should be interpreted with care due to the relatively small sample size and short follow-up period. Symptom improvement was not inferior to that associated with ACDF there were few complications, and quick recovery was expected. However, this procedure is challenging. With more research and exploration, a safe and minimally invasive approach, along with selective and effective decompression, will enable successful surgery.

Acknowledgements: biportal endoscope, cervical disk herniation, cervical decompression

O631

Performance of artificial intelligence-based algorithms to predict prolonged length of stay after lumbar decompression surgery

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Background: Decompression of the lumbar spine is one of the most common procedures performed in spine surgery. Hospital length of stay (LOS) is a clinically relevant metric used to assess surgical success, patient outcomes, and socioeconomic impact. This study aimed to investigate a variety of machine learning and deep learning algorithms to reliably predict whether a patient undergoing decompression of lumbar spinal stenosis will experience a prolonged LOS.
Methods: Patients undergoing treatment for lumbar spinal stenosis with microsurgical and full-endoscopic decompression were selected within this retrospective monocentric cohort study. Prolonged LOS was defined as an LOS greater than or equal to the 75th percentile of the cohort (normal versus prolonged stay; binary classification task). Unsupervised learning with K-means clustering was used to find clusters in the data. Hospital stay classes were predicted with logistic regression, RandomForest classifier, stochastic gradient descent (SGD) classifier, K-nearest neighbors, Decision Tree classifier, Gaussian Naive Bayes (GaussianNB), support vector machines (SVM), a custom-made convolutional neural network (CNN), multilayer perceptron artificial neural network (MLP), and radial basis function neural network (RBNN) in Python. Prediction accuracy and area under the curve (AUC) were calculated. Feature importance analysis was utilized to find the most important predictors. Further, we developed a decision tree based on the Chi-square automatic interaction detection (CHAID) algorithm to investigate cut-offs of predictors for clinical decision-making.
Results: 236 patients and 14 feature variables were included. K-means clustering separated data into two clusters distinguishing the data into two patient risk characteristic groups. The algorithms reached AUCs between 67.5% and 87.3% for the classification of LOS classes. Feature importance analysis of deep learning algorithms indicated that operation time was the most important feature in predicting LOS. A decision tree based on CHAID could predict 84.7% of the cases.
Conclusions: Machine learning and deep learning algorithms can predict whether patients will experience an increased LOS following lumbar decompression surgery. Therefore, medical resources can be more appropriately allocated to patients who are at risk of prolonged LOS.
Keywords: length of stay; spine surgery; decompression; spinal stenosis; machine learning; deep learning; artificial intelligence; prediction, endoscopy

O632
Endoscopic revision surgery after sacroiliac joint fusion

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Sacroiliac (SI) joint dysfunction has been recognized as one of the common causes of chronic low back pain with a significant impact on quality of life and daily activities. SI joint fusion has been shown to be an effective treatment for patients who failed non-surgical strategies. Pain recurrence, radiographic pseudarthrosis, and pedicle screw loosening are compelling evidence to consider revision. The incidence of revision surgery is likely no higher than 3.8% at 2 years. However, the need to revise a surgically fused joint is a topic of interest to surgeons and their patients. Presented here are some cases of endoscopic revision surgery after SI joint fusion to illustrate a technical innovation to utilize the advanced endoscopic spine procedure to assist the revision fusion surgery. Implementation of endoscopic revision surgery after SI joint fusion may help to reduce intraoperative blood loss and the length of hospital stay.

O633

Biportal endoscopic decompression of ossification flavum ligament. Is it enough to improve the clinical outcome?

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Introduction: Thoracal canal stenosis caused by ossification of flavum ligament (OFL) is not common in the population, the condition has higher incidence among Asian population and it is most reported in Japan, Korea and China. Symptoms of OFL in the form of myelopathy is sometimes misdiagnosed as a lumbar or cervical problem, therefore making accurate diagnosis for this condition is not easy and leads to delay treatment. Surgery is the only option for managing thoracal OFL. Endoscopic decompression, even though a technically challenging surgical option, is the least invasive procedure for managing OFL condition that could prevent post operation complication such as late kyphosis and deterioration of neurological state.
Aim: We would like to evaluate the result of thoracal OFL decompression using biportal endoscopy.
Patients and Methods: This is a retrospective case control of patients with thoracal myelopathy caused by OFL managed by open surgery and biportal endoscopic procedure from January 2018 – December 2022. We did open laminectomy in open group and endoscopic laminectomy in the biportal endoscopy group. We could relieved the spinal canal compression and making sure the duramater was free by looking at the pulsation.The diagnosis of ossification flavum ligament were confirmed by CT scan and MRI. We evaluate the motoric function pre and post operation using JOA score for thoracal myelopahty pre, 1 month, 3 months, 6 months and 12 months post operation.
Results: A total of 35 patients eligible for this series, consist of 16 male patients and 19 female patients. There were 25 patients in biportal endoscopic and 15 patients in open surgery group. The JOA score were 6.8 in the open group and 7.1 in biportal endoscopic group. Most of the patients showed improvement within 1 year follow up. JOA score improved in both group from mean of 6.8 in open group and 7.1 in endoscopic group to mean of 14.5 and 15.2 respectively. Post operation there were 3 patients in endocopic group and 1 patient in open group with neurologic deterioration, these patients had fused type OFL which was very adhere to the duramater. The neurology improved after 3 months in these group. There were dural tear in 3 patients with fused type OFL, one patient in biportal endoscopic group and 2 patients in conventional open group.
Conclusion: The result showed biportal endoscopy is adequate and possible in management of thoracal OFL. Improvement of neurologic symptoms is better if the surgery was done in early stage of the disease. Choice of the surgery depend on the surgeon preferences.

O634

Full-endoscopic lumbar discectomy (FELD) reaches non-inferior clinical improvement as standard surgery for lumbar disc herniations measured by minimal important change (MIC) and patient acceptable symptom state (PASS) in leg pain (NRS) and oswestry disability index (ODI)

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Introduction: Microscopic discectomy has been the gold standard method to treat symptomatic lumbar disc herniations before the introduction of FELD. During the last 15 years, FELD has emerged as the fastest growing spinal procedure in the world. Several new studies have investigated the concept of non-inferiority regarding FELD, but little emphasis have been placed on comparing the probability of patients achieving relevant medical changes in patient reported outcome measures.
Aim: The Purpose of this study was to investigate if FELD is non-inferior to other surgical methods for lumbar disc herniation surgery in the most common patient reported outcomes measures (PROMs), including postoperative leg pain and disability, while still reaching the necessary thresholds for relevant clinical improvements.
When comparing the two methods; a statistically significant difference does not automatically mean that medically relevant changes and differences have been observed. This study was constructed to compare medically relevant changes and differences between FELD and microscopic surgery for lumbar disc herniations,
Patients and Methods: Patients having a FELD procedure at the Sahlgrenska University Hospital, Gothenburg, Sweden 2013- 2018 were included. A total of 80 (41 men and 39 females) were enrolled. The FELD-patients were matched to 400 controls from the Swedish spine register that had a standard microscopic or mini-open discectomy surgery. PROMs including the Oswestry Disability Index (ODI) and the Numerical Rating Scale (NRS) as well as Patient Acceptable Symptom States (PASS) and Minimal Important change (MIC) were used to compare the efficacy of the two surgical approaches.
Results: The FELD-group achived medically relevant and significant improvements, non-inferior to standard surgery within the pre-defined thresholds of MIC and PASS. No differences could be found in ODI (FELD -28.4, SD 19.2, -61.7%; vs standard surgery -28.7 SD 18.9, -62.9%; ns) or NRS_{Leg} (FELD -4.35 SD 2.93, -60.2%; vs standard surgery -4.99, SD 3.12, -65.3%; ns). All other measured PROMs had similar findings.
Conclusion: The FELD results could not be considered inferior to standard surgery one year postoperatively for lumbar disc herniation. There were no significant differences regarding MIC achieved or final PASS in the measured PROMs between the surgical methods.

Key words: Lumbar disc herniation; full-endoscopic lumbar discectomy; minimal invasive spine surgery, FELD; PROMs

O635

Comparative analysis of full endoscopic anterior and posterior cervical approaches in the management of cervical intervertebral disc herniation - A retrospective evaluation of clinical and radiological outcomes

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Introduction: Neck pain and cervical radiculopathy are the common presentations of such degeneration. Most cases are treated by pain medications, physical therapy and selective blocks. Surgery is reserved for recalcitrant cases. The surgical options available are decompression from anterior approach or posterior approach. While anterior approaches are associated with complications like injury to great vessels and aero digestive tract, posterior approaches carry a concern of post-operative instability or loss of kyphosis. We conducted this study to evaluate the outcomes of both the approaches and examine if there is any significant advantage of one approach over the other.

Methods: The database was searched retrospectively for the patients who received surgical treatment for cervical disc herniation. All the patients who were treated endoscopically by either anterior (AECD) or posterior approaches (PECD) were identified between Jan 2015 and Dec 2018 were included in the study. The patients were divided in to two groups AECD(anterior) and PECD(posterior) group. The clinical data like Visual Analogue Score (VAS), Neck disability Index, and complications were recorded. The radiological outcomes like the cervical lordosis, disc height changes of treated level, segmental lordosis and sagittal rotation angle were evaluated. After the data was collected and tabulated, descriptive statistics were used for continuous variables. t-test was used to find the significance in changes of VAS, NDI scores before and after surgery.

Results: There were a total of 79 patients with 83 vertebral levels in AECD group and 26 patients with 28 levels in PECD group. The mean age in AECD group was 42.4 yrs where as it was 47,6 yrs in PECD group. Mean follow-up in AECD group was 19 months and it was 14.3 months in PECD group. The pre-operative VAS score for neck and arm in AECD group improved significantly in the post-operative period and was maintained at the last follow-up. The pre-operative VAS score for neck and arm in PECD group significantly improved and was maintained till the last follow-up. Majority of the patients in both the groups had excellent outcomes according to Macnab criteria. The change in the cervical lordosis and movements in the AECD group in the post-operative period when compared to pre-operative period was not statistically significant $p>0.05$ but the PECD group showed significant increase in the movements $p<0.05$. The anterior disc height and segmental lordosis was significantly reduced in the AECD group whereas no significant difference was observed in the PECD group.

Conclusion: The clinical outcomes in both AECD and PECD group showed Significant improvement in the post-operative period and the improvement was maintained till the final follow-up. The anterior disc height and segmental lordosis were reduced in the AECD group but the extension angle, range of motion and segmental lordosis increased in the PECD group. Both the approaches provide good decompression and clinical relief and can be chosen according to the needs of the patient.

O636

Usefulness of percutaneous correction with LIF and ALL PPS for severe adult spinal deformity

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Introduction: The purpose of this study is to evaluate the usefulness of percutaneous correction using Lateral Interbody Fusion (LIF) and All Percutaneous Pedicle Screw (PPS) for severe adult spinal deformity.
Materials and Methods: The study included 56 adult patients (3 males and 53 females) who had undergone percutaneous correction using LIF and All PPS between October 2013 and February 2021 at a single institution by a single surgeon with at least 1 year of follow-up. Patients with bony fusion between multiple vertebrae on preoperative images were excluded. The mean age at surgery for all patients was 72 years (58-83 years), and the mean follow-up period was 54.6 months (14-102.8 months). The range of fixation was from lower thoracic to iliac in all cases, and the number of fixed intervertebral levels was 8 (T10 to iliac) in 53 cases and 9 (T9 to iliac) in 3 cases. All screws during posterior correction were PPS, and iliac screws were used for iliac anchors. Basically, transforaminal lumbar interbody fusion was performed for L5/S, but osteotomy was not combined except for L5/S. These patients were classified into two groups: the severe group (S group), in which the preoperative Cobb angle or the preoperative pelvic incidence (PI)-lumbar lordosis (LL) mismatch was greater than 50 degrees, and the mild group (M group), in which both parameters were less than 50 degrees. The preoperative and postoperative radiographic parameters (coronal Cobb angle, LL angle, PI-LL mismatch, sagittal vertical axis (SVA), and pelvic tilt (PT)), operative time, intraoperative blood loss, and complications were retrospectively evaluated between the two groups.
Results: The mean age of patients in the S and M groups was 72 and 71 years, respectively. In the S group, the mean Cobb angle was corrected from 54 to 15 degrees, mean LL from 2 to 49 degrees, mean PI-LL mismatch from 50 to 1 degree, SVA from 172 to 11 mm, and PT from 36 to 18 degrees. In the M group, the mean Cobb angle was corrected from 35 degrees to 9 degrees, the mean LL from 22 degrees to 52 degrees, the mean PI-LL mismatch from 30 degrees to -1 degree, SVA from 81 mm to -6 mm, and PT from 30 degrees to 19 degrees. Statistically, all parameters were significantly improved in the S group, and both groups had good correction. The mean operative time was 390 and 361 minutes in the S and M groups, respectively, and the intraoperative blood loss was 462 and 372 ml, with no statistically significant difference between the two groups. Postoperative complications, such as muscle weakness and sensory disturbance of the lower limbs, were observed in 9 patients in the S group and 5 patients in the M group, but most of them improved within 6 months after surgery, except for one patient of intradural hematoma in the S group.
Conclusions: Percutaneous correction was successful in both groups, regardless of the degree of deformity. We consider this minimally invasive technique is useful even in severe adult spinal deformity.

O637

Innovative percutaneous endoscopic transforaminal lumbar interbody fusion of lumbar spinal stenosis with degenerative instability: A non-randomized clinical trial

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Introduction: Lumbar spinal stenosis (LSS) with instability is most common lumbar degenerative diseases for people with low back pain. The objective of this study was to compared the clinical effects for the treatment of lumbar spinal stenosis (LSS) with degenerative instability between the innovative percutaneous endoscopic transforaminal lumbar interbody fusion (PE-TLIF) technique and posterior lumbar interbody fusion (PLIF) technique.
Methods: Between April 2019 and April 2020, 114 patients with singlesegment LSS were prospectively included in our study (ChiCTR1900022492). Visual Analogue Scale (VAS) on lumbar and leg pain (VAS-LBP, VAS-LP), Oswestry Disability Index (ODI), serum creatine kinase (CK), the maximal cross-sectional area of multifidus muscle (Max-CSA) and the peak intensity of sulphur hexafluoride microbubble contrast agent (PI) around the surgical incision by contrast-enhanced ultrasonography were evaluated preoperatively, post-operatively and at regular follow-up.
Results: All patients were followed up. The VAS-LBP, VAS-LP, ODI after operation were improved significantly compared to these data before operation in all the patients ($P<0.05$). The VAS-LBP at 1 weeks, 3 months after operation in PE-TLIF group were significantly lower than these in PLIF group ($P<0.05$). The injury degree of multifidus muscle evaluated by MAX-CSA and PI was significantly less in PE-TLIF group after operation ($P<0.05$). There was no significant difference on the complication rate between these two groups ($P>0.05$).
Conclusions: Our results presented PE-TLIF technique could obtain comparable effective outcomes as conventional PLIF for the treatment of LSS with degenerative instability. The patients with PE-TLIF had less muscle injury, less pain and quicker postoperative rehabilitation.

O638
Position of the major vessels: Prone versus lateral

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Introduction: The position of the vessels regarding the LLIF are usually not an issue. However, when the performance of the anterior longitudinal ligament release are required, the position of the vessel might be of importance, as in some cases those vessel can be localized very close to the anterior border of the vertebral body. Therefore, the objective of this work was to check for changes in the areolar space between the lateral and prone position.
Methods: 25 patients who underwent MRI in lateral and prone positions were added to the study. The distance between the anterior edge of the vertebral body and the vein or artery was measured at the levels of L2L3, L3L4 and L4L5. At the levels where there was iliac bifurcation, the shortest distance was considered. Statistical analysis was performed using the R Software. The paired Wilcox test was used to compare groups. The description of the data was made using the mean, standard deviation and confidence interval.
Results: 300 measurements were performed, 150 from the arteries and 150 from the veins. Regarding the arteries, the level that presented the greatest distance between the vertebral body and the artery was L4L5 with 1.96 or 2.26, in prone and lateral, respectively. In relation to the vein, the L2L3 level was the one that presented the greatest distance between the vertebral body with distances of 2.38 and 2.19, respectively. There was no significant difference between the position of the vessels at any of the levels between the lateral or prone positions.
Conclusions: There was no significant difference between the distance between the vertebral body and the vessels between the prone and lateral positions. This might imply that both positions are safe regarding the vessels.

O639

Comparison of clinical outcome and radiologic parameters between OLIF51 and L5/S1 TLIF in adult spinal deformity correction surgery

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Introduction: We have experienced over 190 cases of OLIF51 surgery since 2015 and expanded the application for spinal deformity from 2019, aiming at ideal lumbosacral correction and minimally invasive surgery. In this report, we compared the clinical outcome and radiologic parameters between OLIF51 and L5/S1 TLIF in adult spinal deformity surgery.
Methods: The subjects were 106 patients who underwent anterior-posterior corrective surgery using OLIF25 after 2015, with a mean age of 76 years (51-86). 82 patients in the L5/S1 TLIF surgery group (TLIF) were treated with 18-degree lordotic cage and DBM. 24 patients in the OLIF51 group (OLIF51) were treated with a 12-18 degree cage and posterior correction using cMIS. The following parameters were examined: operative time, intraoperative blood loss, local and global radiologic parameters (including LLL), and complications.
Results: The mean follow-up was 55 months (13-98), and the mean number of fixed intervertebral segments was 8. Mean operative time and intraoperative blood loss were 480, 430 minutes (NS) and 1077, 512 ml ($P<0.05$) for TLIF and OLIF51; LL (preop/fup) was 7.6/45.4 and 9/48 (NS); PI-LL at fup was 6.9 and 0 degrees ($P<0.01$); fup LLL was 28.8 and 35 degrees ($P<0.01$); L5/S1 lordosis (preop/fup) was 10.5/16 and 11.5/20 ($P<0.01$); coronal tilt of L5 was 4.3 and 2.3 degrees ($P<0.01$). Complications were 13% and 8% for PJK, and 5% and 8% for implant failure at L5/S1, respectively (all NS).
Discussion: The introduction of OLIF51 in adult spinal deformity surgery resulted in additional decrease of surgical invasiveness and improved correction in both the coronal and sagittal planes. At the L5/S1 segment, segmental lordosis was increased and harmonious lordosis with over 70% of LLL was achieved. The OLIF51 serves as a safe and effective tool for adult spinal deformity surgery.

O640

Does the use of porous printed titanium cages in lateral lumbar interbody fusion surgery lead to less cage subsidence? A retrospective age-, gender- and levels-of-surgery-matched case control analysis

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Introduction: Lateral lumbar interbody fusion (LLIF) facilitates the restoration of disc height and the indirect decompression of neural elements. However, these benefits are partially lost when the cage subsides into the adjacent endplates. The novel 3D-printed intervertebral porous titanium cage maximises bone to implant contact and decreases stress shielding and subsidence risk. No study has compared its rate of subsidence and functional outcomes to a matched control sample of PEEK cages.
The aim of this study was to compare the rate of early subsidence and patient reported functional outcomes in an age-, gender- and levels-of-surgery-matched sample of TI vs PEEK cages. We hypothesise that Titanium (TI) cages lead to less cage subsidence and comparable functional outcomes, as compared to Polyetheretherketone (PEEK) cages.
Methods: A retrospective review of a consecutive, prospectively collected, single-surgeon database of patients who underwent lateral lumbar interbody fusion (LLIF) was performed.
There were 11 consecutive cases of TI cage implant matched with previous cases of PEEK cage implants. Patients were retrospectively matched for age, gender and levels of surgery using a prospectively collected database. There was a minimum of 6 months of follow-up. Cage subsidence was assessed on post-operative radiographs. Validated patient reported outcome scores (Oswestry Disability Index [ODI]) were compared. Post-op complications were also recorded.
Results: There were 7 males and 4 females in each group, with an average age of 68.8 in the Ti group and 68.9 in the PEEK group. In each group, there were 5 of cases of 1 level fusion, 5 cases of 2 level fusion and 1 case of 3 level fusion. A total of 18 levels were analysed in each group.
ODI for TI group improved from mean of 52.3 ± 21.7 to 37.3 ± 16.5 after surgery. ODI for PEEK group improved from mean of 51.6 ± 16.6 to 22.8 ± 29.0 after surgery. There was no statistically significant difference between pre-op ODI (p=0.918), post-op ODI (p=0.071) and change in ODI scores (p=0.299).
There were no cases of subsidence in the TI group and 3 cases in the PEEK group. In the PEEK group, 1 of the patients with cage subsidence had persistence of leg numbness and weakness after surgery. Another patient had eventual non-union with loosening of the posterior pedicle screws. No such complications were noted in the TI group. All patients in the TI group rated the surgery “good”, “very good” and “excellent”.
Conclusions: The use of a porous printed Titanium cages in LLIF leads to less cage subsidence and comparable functional outcomes, as compared to PEEK cages. Early results are promising but longer follow-up is required. This will certainly be key in long term maintenance of sagittal parameters.

O641

Residual exposed endplate effect on heterotopic ossification after cervical Baguera C disc arthroplasty

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Introduction: The heterotopic ossification (HO) is related to adverse effects on patients after cervical disc arthroplasty (CDA). This retrospective study is designed to evaluate the incidence, predisposing factors for HO and relation to the prosthesis location.
Methods: This retrospective study included patients under CDA with 1- or 2-level with Baguera C (Spineart, Geneva, Switzerland) by a single neurosurgeon between November 2014 and April 2020. The routine radiographic assessment included ratio of distance between the implant to edge (residual exposed endplate, REE), ratio of width and length, segmental range of motion, and shell angle. The HO grade was recorded according to the McAfee classification. The HO grade was adapted and observed in computed tomography at 1 year post-operative after CDA.
Results: The 82 patients and 130 artificial disc levels were categorized to 2 subgroups including grade 0 and grade 1 to 3 HO. There was no grade 4 HO in these 82 patients. HO was observed in 27 patients (33%) and in 58 levels (44.6%). The REE ratio (the ratio of the residual endplate to the whole endplate, represented as the ratio of the residual length to the whole length) showed statistical significance. The REE ratio for the no HO group was 0.88 (95% CI, 0.85-0.92) and for the HO group was 0.86 (95% CI, 0.83-0.88). Nevertheless, the ratio and value for the posterosuperior REE showed statistical significance (P=0.011 for ratio, 0.035 for value). The posterosuperior REE for the no HO group was 0.06 (95% CI, 0.02-0.09) and for the HO group was 0.08 (95% CI, 0.05-0.10).
Conclusions: The HO etiology is still unknown so far. In the present study, the occurrence of HO was correlated positively to the posterosuperior REE. According to the results above, the better the prosthesis size fit to the endplate, the less posterosuperior REE was suggested for HO prevention.

O642

Does UIV level influence the development of PJK/PJF in Patients undergoing circumferential minimally invasive surgery (CMIS) for adult spinal deformity (ASD)? A 13-year analysis with minimum 2-year follow-up

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Introduction: Proximal junctional kyphosis(PJK) is a commonly encountered clinical and radiographic phenomenon after spinal surgery that may lead to post-operative deformity, pain, and dissatisfaction. The exact mechanism underlying PJK remains unclear. It has been theorized that use of CMIS with posterior pedicle screw instrumentation without posterior osteotomies limits dissection of the posterior muscular structures/tension band and may decrease the incidence of PJK compared to traditional posterior column osteotomy and open pedicle screw placement. However, this has not yet been conclusively demonstrated.
Aim/Objectives: Does the UIV in the thoracolumbar junction influence the incidence of PJK in patients undergoing CMIS correction for ASD?
Material and Methods: A single center study from a registry of patients who underwent CMIS correction of ASD(Cobb>20°,SVA>5.0cm,(PI-LL)>10°)from Jan2007 to Jan2021 was queried. PJK was defined as angle>10o and at least 10o greater than the baseline when measuring UIV to (UIV+2). PJF was defined as any type of symptomatic PJK which required surgery. Only patients instrumented at 3+ levels with full length 36″ films and a minimum 2-year follow-up were included. The groups were compared in terms of PJK rates using Chi-squared analyses.
Results: We identified 230patients with UIV in T10-L2 region. Mean follow-up was 97months (13-180, SD46). Mean age:67years(21-85years, SD 10). Total of 1389 levels were fused with average of 6 levels/patient (3-8levels, SD 2). UIV of the cohort was as follows: 63 at T10, 26 at T11, 54 at T12, 36 at L1 and 51 at L2. A total of 25patients (10.8%) met PJK criteria. Only 11 (4.8%) were symptomatic and underwent revision surgery. The Incidence of PJK/PJF in the groups (T10, T11, T12, L1, L2) was 19.1%, 15.3%, 7.4%, and 5.7%(p<.05). Comparing PJK to non-PJK patients: preop SVA was 7.9cm and 6.0cm latest SVA 4.7cm and 4.0cm, delta-SVA 3.9cm and 3.3cm, preop PI-LL mismatch 19° and 18°, latest PI-LL mismatch 12° and 10°, and delta PI-LL mismatch 11° and 10°(all P>0.05).
Conclusion: Our study would suggest that in the appropriately selected and well-optimized patient, CMIS deformity correction is associated with a lower prevalence of PJK/PJF than reported for open surgery. Stopping fusion at T10 showed the highest incidence of PJK, whereas fusion to T12 or below showed the least incidence of it. Also, magnitude of correction did not seem to have an influence on developing PJK/PJF. More importantly there were no catastrophic early failure and all 11 symptomatic patients had delayed slow onset of sagittal decompensation over the years.

Table 1: PJK/PJF incident per level

UIV	Radiographic PJK	PJF	NONE	Total
L1	1 (2.7%)	2 (5.6%)	33 (91.7%)	36
L2	1 (1.9%)	1 (1.9%)	49 (96.2%)	51
T12	2 (3.7%)	2 (3.7%)	50 (92.6%)	54
T11	1 (3.8%)	3 (11.5%)	22 (84.6%)	26
T10	9 (14.3%)	3 (4.8%)	51 (80.9%)	63
TOTAL	14 (5.2%)	11 (5.6%)	205 (89.2%)	230

The chi-square statistic is 7.9207. The p-value is.04768. The result is significant at p <.05.

Table 2: Radiographic outcomes

	PJK patients	Non-PJK patients	P value
Pre-op SVA	79.35 (9.55-177.8) SD 44.80	60.4 (3.3-267) SD 51.5	P>0.05
Post -op SVA	47.57 (4.2-146.34) SD 42.6	39.7 (0-149) SD 30.4	P>0.05
Delta SVA	38.7 (4.2-96.6) SD 30.3	33.4 (0.5-192.2) SD 34.3	P>0.05
Pre-op PI/LL mismatch	19.5 (1.7-49.15) SD 12.7	18.4 (0.2-62.6) SD 14.7	P>0.05
Post-op PI/LL mismatch	11.6 (0.6-32.5) SD 8.4	10.2 (0.1-37.4) SD 7.2	P>0.05
Delta PI/LL Mismatch	11.3 (0.6-37.2) SD 10.4	9.9 (0-34) SD 7.7	P>0.05

O643

Autologous platelet rich fibrin (aPRF) as a novel multilayer sealant for persistent cerebrospinal fluid leaks in spinal surgery

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Introduction: Persistent cerebrospinal fluid (CSF) leak is a common complication after spinal surgery. When conservative strategies fail, an operative revision aims to locate the dura matter defect and augment its closure with sutures and autologous or commercial sealants.
Platelet-rich fibrin (PRF) is an autologous biomaterial that is easily prepared in the operating theater from patients' blood, composed of a fibrin matrix with high concentrations of growth factors. It can be prepared after a single cycle of angulated centrifugation in two forms, solid membranous (s-PRF) and injectable (i-PRF). Its regenerative and adhesive properties have been previously demonstrated in other disciplines such us maxillo-facial, plastic, and orthopedic surgery.
This work is a technical note and a case series on its novel application for the treatment of persistent cerebrospinal fluid leaks after spinal surgery.
Methods: 14 patients with persistent CSF-leak after lumbar spinal surgery have been referred to our medical center for treatment. MRI scans revealed the level of the leak. All patients presented persistent symptoms of intracranial hypotension. Revision surgery was indicated in all cases.
During surgery, dural defects responsible for the CSF leak were identified and in a first step sutured with Premicron 4-0 running simple closure suture. In a second step, the sutured defect was initially covered with a flattened s-PRF membrane. Another layer of sealing was accomplished by covering it with i-PRF, which was gradually polymerized further and created a gelatinous on lay. The watertight closure was evaluated intraoperatively with two cycles of short Valsalva manoeuvres.
Results: In all patients, CSF-leak was successfully treated with the PRF approach. The postoperative course was uneventful and during a 12-month follow-up period, no CSF leak recurrence or adverse effects were recorded.
Conclusion: The novel autologous PRF multilayer augmentation of dural lacerations is a safe and effective strategy for treating persistent CSF-leaks after spinal surgery.

O644

Management of incidental durotomies in an integrated orthopedic and neurosurgical spinal unit

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Introduction: Incidental durotomy (ID) is an unwanted and unexpected event that can happen during spinal surgery. Its incidence ranges from 1.1 to 20% depending on the type of surgical procedure. It is more frequent during repetitive lumbar surgeries and during procedures performed by less experienced surgeons. Minimally invasive (MISS) and endoscopic spinal surgeries are beneficial when reducing the occurrence of ID. ID can have a wide range from mild to severe sequelae: it is associated to prolonged bed rest, antibiotic use and leg pain. Different protocols for management of IDs have been proposed. Direct suture repair of the dural tear during the operation is the gold standard prioritised in most institutions. Early mobilization is recommended, with no more than 72 hours of bed rest during the postoperative recovery period. The aim of this study is to analyse differences in management of ID by neurosurgeons (NS) and orthopaedic surgeons (OS) in an integrated Spinal Unit and to develop an agreed protocol for management of ID according to this analysis.

Methods: 1064 patients were operated in the Spinal Surgery Unit of Hospital del Mar (Barcelona) from April 2018 to March 2022. 79 patients (7.4%) had ID during surgery, 35 caused by NS and 44 by OS. ID was significantly associated to lumbar surgeries. Redo procedures were significantly more frequently performed by OS. Cervical and anterior / lateral approaches were significantly more frequently performed by NS. 83.5% of ID happened during surgeries jn lumbar/lumbosacral, 10.1% in thoracic and 6.4% in cervical/craniocervical region. 59.5% happened during instrumentations, and 40.5% in simple decompressive procedures. Just three cases of IDs happened during MISS surgeries. 20 of ID developed postoperative cerebrospinal fluid leak.

Results: 30.4% of ID were linked to other postoperative complications: infections, nerve root damage, intracranial hypotension, and medical complications related to prolonged bed rest (deep venous thrombosis) Longer courses of postoperative antibiotics, prolonged postoperative bed rest, higher doses of analgesia and the use of cafein and epidural blood patches as treatment for intracranial hypotension syndromes were noticed. Direct repair of the dural tear during the operation was achived in 49% of ID. All but one case of suture repair under surgical microscope were performed by NS. A graft was used to reinforce the repair in 21 cases of the 79 ID. Sealants of fibrinogen and thrombin contained in glues and sponges were used in 78.5% of surgical repairs. Bed rest was almost systematically used during the postoperative admission of ID. Pseudomeningocele and/or CSF leak happened in the postoperative period of 27.8% of ID, with just two of them resolved with compressive wound dressing and prolonged bed rest. External lumbar drain was implanted in 14% of ID. In eight cases a re-do surgical repair of the ID was required, all of them performed under surgical microscope, using 4-0 Prolene as suture, autologous fat as graft, and sealant over the durotomy,

Conclusions: Direct surgical repair of ID under surgical microscope is strongly recommended during the surgical procedure. Early mobilization is recommended, during the recovery period.

O645

Does the severity of facet arthropathy limit the sagittal re-alignment in circumferential minimally invasive surgical correction of adult spinal deformity?

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Introduction: The first stage of circumferential minimally invasive (cMIS) correction of adult spinal deformity (ASD) involves lateral or oblique lumbar interbody fusion (OLIF). Success of this stage is measured by the achievement of indirect decompression and improvement of alignment. Improvement in alignment can be measured by observing increases in both disc space height and segmental lordosis. We conducted this study to evaluate if the severity of facet arthropathy limits the radiological improvement after CMIS correction for ASD.
Aim/ Hypothesis: If the facets are not fused, the success of anterior/lateral/oblique interbody fusion in cMIS for ASD is independent of the severity of facet arthropathy posteriorly.
Methods: We review our prospectively collected data registry of 294 ASD patients who underwent staged CMIS correction From Jan 2011 to Jun 2021. Inclusion criteria of having ASD (Cobb>20,SVA>50mm,(PI-LL)>10) and 3+ levels fused, identified 161pts. 130 pts who had pre-op lumbar MRI/CT scans to evaluate the facet joints on each lumbar level (L1-S1) were included for this study. Total of 1024 facets were reviewed, and we assigned a preoperative grade (0-3) to the severity of the facet arthropathy (Table 1). We then assessed the success of the improvement in alignment by evaluating post-op Posterior disc space height and Segmental lordosis.
Result: Mean age was 66.6(22-84). Mean follow-up was 69 months(24-132). Total of 512 interbody levels were fused. Table 2 shows the facet arthropathy grading in each lumbar level (L1-S1). The radiological evaluation showed that the pre-op posterior disc space height (Table 3) and segmental lordosis (Table 4) improvements were not compromised by the severity of the facets arthropathy and were significantly increased at all lumbar levels($p<0.05$) after LIF surgery.
Conclusion: Our study suggests that if the facets are not fused, the success of lateral/oblique interbody fusion in realignment for adult spinal deformity correction is independent of the severity of facet arthropathy posteriorly.

Table 1: Grading of lumbar facet joint degeneration using CT/ MRI described by Weishaupt et al.

Facet Grade	Definition	Number
Grade 0	Normal facet joint space (2–4 mm width)	67
Grade 1	Narrowing of the facet joint space (<2 mm) and/or small osteophytes and/or mild hypertrophy of the articular process	245
Grade 2	Narrowing of the facet joint space and/or moderate osteophytes and/or moderate hypertrophy of the articular process and/or mild subarticular bone erosions	513
Grade 3	Narrowing of the facet joint space and/or large osteophytes and/or severe hypertrophy of the articular process and/or severe subarticular bone erosions and/or subchondral cysts	199

Table 2: Facet Grading

Level	Grade 0	Grade 1	Grade 2	Grade 3	Total
L1-L2	15	39	82	10	146
L2-L3	16	60	118	30	224
L3-L4	18	51	135	48	252
L4-L5	10	61	98	57	226
L5-S1	8	34	80	54	176

Table 3: Posterior disc space height

	Pre-op	**Post-op**	**Delta Change**	**P value**
L1-L2	4.0 (0.3-7.1) SD 1.6	6 (3.1-14.8) SD 2.7	1.0 (-3.0 to 9.1) SD 3.1	P< 0.05
L2-L3	3.8 (0.6-9.4) SD 1.7	5.7 (0.9-10.9) SD 2.4	1.6 (-4.7 to 8.3) SD 2.5	P< 0.05
L3-L4	3.8 (0.8-9.7) SD 1.7	7.1 (1.4-12.9) SD 2.6	3.3 (-1.4 to 10.9) SD 2.7	P< 0.05
L4-L5	4.2 (1-13.1) SD 2.1	7.2 (2.3-11.5) 2.2	3.2 (-1.5 to 8.4) SD 2.4	P< 0.05
L5-S1	4.3 (1.2-12.6) SD 1.7	7 (2.3-12.6) SD 2.6	3.1 (-1.0 to 8.9) SD 2.3	P< 0.05

Table 4: Segmental lordosis

	Pre-op	Post-op	P value
L1-L2	4.9 0-16 SD 4.1	8.1 1-20.3 SD 4.1	P< 0.05
L2-L3	4.7 0-13 SD 3.6	10.2 0-31 SD 5.1	P< 0.05
L3-L4	5.5 0-22 SD 4.4	10.5 1-29.4 SD 4.9	P< 0.05
L4-L5	6.9 0-23 SD 4.8	11.7 2-25 SD 4.9	P< 0.05
L5-S1	10.4 0.5-31 SD 6.6	15.6 2-31.7 SD 7.0	P< 0.05

O646

A prospective multicentric study of controlled thermal energy and rotational capsular tissue shaving system in patients with facet joint syndrome

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Introduction: Facet Joint Syndrome (FJS) is among the leading causes of low back pain and affects millions globally. Typically manifesting from spinal osteoarthritis (OA), FJS is a painful, chronic condition where treatment options, often temporary in nature, have remained unchanged in the past four decades. A novel, minimally invasive system has been developed to provide potential long-term relief via a combination of controlled thermal energy and rotational capsular tissue shaving off the facet capsule to disrupt nociceptive signals and receptors.
Aim: To evaluate the effectiveness of this novel system in sustained pain relief and improvement in health metrics associated with mobility.
Materials and Methods: Prospective study that included patients with chronic intractable pain of the low back resulting from FJS who had failed conservative treatments for pain. Period of study is from July 2017 and August 2022. Assessed for joint groupings treated, pain and quality of life as measured by the visual analog score (VAS), medication log, Oswestry Disability Index (ODI) and EQ-5D-5L. Follow-up was conducted at 1, 6, 18 and 24 months, post-treatment data reported correspond to these times.
Results: A total of 60 patients were included in the current study. A total of seven joint groupings were treated, with L3 – S1 and L4 – L5 being the most common. VAS for back pain decreased from a score of 6 on a Likert Scale (range 0 to 10), down to a score of 3 at 3 months postoperatively. For leg pain remained constant at 2 on the Likert Scale. Furthermore, the pain score remained same after 24 months of follow up. Statistical significance on increase in HTS scores at 95% confidence level. There was a downward trend in EQ5D5L across all categories.
Conclusion: Rotational capsular shaving and controlled thermal ablation is effective in treating back pain and improving physical functioning in patients with facet joint syndrome. Outcomes achieved at 3 months show statistically significant improvement across all scores. Follow up till 24 months is long enough to suggest economic viability, which would help in establishing this form of treatment for FJS.

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O647
Endoscopic approach in spondylodiscitis

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Introduction: Diagnosis of infectious spondylodiscitis is difficult considering traditional biopsy methods. Isolation of causative organism by culture using Fluroscopy or CT guided biopsy material have yield of only 30% to 38%. We present our case series of 18 patients for obtaining endoscopy biopsy for spondylodiscitis.
Materials and Methods: Patients presenting with features of spondylodiscitis such as back pain, fever, signs of neurological compression were included in the study. Pre-operative Xray, CT scan and MRI were evaluated for confirmation of radiological diagnosis. Patients included in the study were neurologically intact and no signs of spinal instability were present- as absence of this would warrant decompression and instrumentation. Biopsy material was sent for culture and histopathology. Pre-Op and Post-Op VAS, ODI scores, ESR, CRP were recorded. Patients were followed up for minimum of one year or until complete resolution of infection.
Results: 18 patients were included in study- 10 were males and 8 females. Mean age of presentation was 44.78 years (Range 25 to 67). PreOp VAS score 7.77±0.97 and PostOp VAS was 3.78±1.22. This difference is statistically significant (p=0.0002). Clinical diagnosis for microbial identification was established in 88.89% patients (16 out of 18). 62.5% had Mycobacterium tuberculosis infection. Among the rest Staphylococcus aureus was most common. ODI scores improved statistically at 6 month and 1 year follow up. ESR and CRP values normalized with institution of appropriate drug therapy.
Conclusion: Use of Endoscopy for biopsy in Spondylodiscitis is far efficient than traditional methods. It has a targeted approach to the site of pathology. Debulking and wash of the abscess gives immediate pain relief to patient. This procedure can be done under local anaesthesia. This turned out to be especially helpful for post-covid patients with poor lung functions and impaired immunity by steroids causing spondylodiscitis.

O648

Enhanced recovery after an innovative percutaneous endoscopic transforaminal lumbar interbody fusion for the treatment of lumbar spinal stenosis: A prospective observational study

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Introduction: The objective of this study was to investigate the enhanced recovery clinical effects of an innovative percutaneous endoscopic transforaminal lumbar interbody fusion (PE-TLIF) for the treatment of patients with LSS and degenerative instability.
Methods: From January 2019 to March 2020, 51 patients with single-segment LSS and degenerative instability were prospectively included in our study (ChiCTR1900020679). The Oswestry Disability Index (ODI), the visual analogue scale (VAS) on lumbar and leg pain (VAS-LBP and VAS-LP), serum creatine kinase (CK), the peak intensity of sulphur hexafluoride microbubble contrast agent (PI), and the maximal cross-sectional area of multifidus muscle (Max-CSA) around the surgical incision were assessed preoperatively, postoperatively, and at regular follow-up.
Results: All patients were followed up. The mean postoperative bedridden time was 20.45±2.66 hours. The ODI, VAS-LBP, and VAS-LP were improved significantly after operation compared to these data before operation in all the patients ($P<0.05$). The CK at 1 day after operation was higher compared to the data before the operation ($P<0.05$), and there was no significant difference on CK at 1 week after operation ($P>0.05$). The PI at 1 week after operation was higher compared to this item before operation ($P<0.05$), and there was no significant difference on PI at 1 month or 3 months after operation ($P>0.05$). The Max-CSA at 1 week after operation was higher compared to this item before the operation ($P<0.05$), and there was no significant difference in Max-CSA at 1 month or 3 months after operation compared with before the operation ($P>0.05$).
Conclusions: Our results and systematic review presented the innovative PE-TLIF technique could obtain satisfactory and effective outcomes for the treatment of patients with LSS and degenerative instability. Our PE-TLIF technique also had the ability to decrease the MF injury and obtain an enhanced recovery.

O649

The application of artificial intelligence and custom algorithms with inertial wearable devices for gait analysis and detection of gait-altering pathologies in adults: A scoping review of literature

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Background: The purpose of this scoping review was to explore the current applications of objective gait analysis using inertial measurement units, custom algorithms and artificial intelligence algorithms in detecting neurological and musculoskeletal gait altering pathologies from healthy gait patterns.
Methods: Literature searches were conducted of four electronic databases (Medline, PubMed, Embase and Web of Science) to identify studies that assessed the accuracy of these custom gait analysis models with inputs derived from wearable devices. Data was collected according to the preferred reporting items for systematic reviews and meta-analysis statement guidelines.
Results: A total of 23 eligible studies were identified for inclusion in the present review, including 10 custom algorithms articles and 13 artificial intelligence algorithms articles. Nine studies evaluated patients with Parkinson's disease of varying severity and subtypes. Support vector machine was the commonest adopted artificial intelligence algorithm model, followed by random forest and neural networks. Overall classification accuracy was promising for articles that use artificial intelligence algorithms, with nine articles achieving more than 90% accuracy.
Conclusions: Current applications of artificial intelligence algorithms are reasonably effective discrimination between pathological and non-pathological gait. Of these, machine learning algorithms demonstrate the additional capacity to handle complicated data input, when compared to other custom algorithms. Notably, there has been increasing application of machine learning algorithms for conducting gait analysis. More studies are needed with unsupervised methods and in non-clinical settings to better reflect the community and home-based usage.

O650

Ligamentum flavum sparing unilateral laminotomy for bilateral recess decompression (ULBRD): Surgical technique and clinical results

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Objective: Interlaminar endoscopic lateral recess decompression (IE-LRD) has been introduced and utilized for lumbar lateral recess decompression. We modified this technique and utilized it for bilateral lateral recess stenoses (LRSs) without significant central stenosis. The unique surgical details and clinical outcome of Ligamentum Flavum (LF) sparing IE-LRD are presented.
Methods: Prospectively collected registry for full-endoscopic surgeries was reviewed retrospectively. 182 consecutive cases from a single center between September 2015 and March 2021 were reviewed and 57 of them whom underwent LF sparing bilateral IE-LRD were enrolled for analysis. Basic patient demographic data, peri-operative details, surgery related complications and clinical outcome were reviewed. The detailed surgical technique is presented as well.
Results: Among the 57 patients enrolled, 37 were males while the other 20 were females. The mean age was 58.53±14.51 years, and a bimodal age distribution at the age of mid-fifties and mid-sixties or older was noted. The later age-peak was related to co-existence of degenerative scoliosis. The average operative time per lamina was 70.34±20.51 minutes and mean length of stay was 0.56±0.85 days. Five peri-operative complications were reported (7.0%) and the overall re-operation rate at the index level within 1-year was 10.5%. The pre-operative back/leg VAS scores and functional outcome scales including EQ5D, ODI presented significant improvement immediately after surgery and were maintained until final follow up.
Conclusion: Our modified bilateral IE-LRD for bilateral LRSs without significant central stenosis presented good clinical outcomes with acceptably low peri-operative complications rates. Sufficient decompression was achieved with the central LF being preserved.

O651
Endoscopic-assisted anterior cervical disc replacement

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Cervical myelopathy and radiculopathy are commonly caused by degenerative changes such as disc herniation and/or uncovertebral syndesmophytes. For patients who have failed non-operative treatments, surgery can be considered to decompress the cervical nerve roots and thus relieve pain. Since its first introduction in 1950s, anterior cervical discectomy and fusion (ACDF) continues to be the most popular procedure for treating these conditions. However, recent literature showing potential advantages of artificial disc replacement being equal in producing good outcomes, yet allowing mobility and hence reducing adjacent segment disease, is surmounting.
In the early 2000s, shortly after the application of endoscopy in lumbar discectomy, the mono-segmental anterior cervical endoscopic discectomy (ACED) technique to manage cervical radiculopathy was introduced. Since then, promising clinical outcomes of endoscopic approaches being comparable to open or mini-open techniques was shown in recent literature. When treating complex cases which are expanded indications for artificial disc replacement, there may be concerns on the ability to accurately assess nerve compression using a microscope resulting in suboptimal decompression or unnecessary over decompression hence risking prosthesis subsidence. Therefore, our team combined the skillsets of cervical endoscopy as well as artificial disc replacement to ensure best outcomes in patients with complex cervical spinal conditions requiring artificial disc replacements, to aid our decompression decision-making and strategy. A retrospective review of the patients who had undergone this approach will be reported and discussed.

O652

Outpatient minimally invasive transforaminal lumbar interbody fusion surgery: Assessing safety, efficacy, feasibility, and learning curve

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Background: Minimally Invasive Transforaminal Lumbar Interbody and Fusion (MI-TLIF) offers a myriad of proposed benefits including: reduced paraspinal muscle dissection, estimated blood loss (EBL), length of stay, post-operative narcotic consumption, and improved cost savings. The objective of this study was to evaluate the safety, efficacy, and feasibility of the MI- TLIF as an outpatient procedure. The secondary objective was to evaluate any possible learning curve.
Methods: A retrospective chart review was performed including eighty-seven consecutive patients who underwent single level MI-TLIF, two level MI-TLIF, and single level MI-TLIF with adjacent level decompression(s) by a single surgeon. The first half of procedures were performed as inpatient, and the second half were performed as outpatient. All patients had a minimum 3 month follow up. Patient demographics, operative time, time spent in the post- anesthesia care unit (PACU), length of stay (LOS), EBL, complication rate, frequency of ER visits/readmissions, and clinical outcomes were analyzed. Data was compared between outpatient and inpatient cohorts and learning curve was evaluated based on a negative exponential model.
Results: In the inpatient cohort 24 patients underwent single level MI-TLIF, 4 underwent two level MI-TLIF, and 16 underwent single level MI-TLIF with adjacent level decompression(s). In the outpatient cohort 22 patients underwent single level MI-TLIF, 11 underwent two level MI-TLIF, and 10 underwent single level MI-TLIF with adjacent level decompression(s). In the inpatient cohort mean LOS was 25.869hours, mean surgery duration was 191.23minutes, and mean EBL was 51.59ml. In the outpatient cohort mean LOS was 3.737hours, mean surgery duration was 179.91minutes, and mean EBL was 35ml. A statistically significant difference exists between sex, LOS, and PACU time between cohorts. A statistically significant relationship between BMI category and increased duration of surgery was observed. A statistically significant learning curve was not observed when examining LOS, PACU time, or surgery duration but a weak curve was found in EBL based on chronological patient order.
Conclusions: The MI-TLIF appears safe, feasible, and efficacious when performed in an outpatient setting. Demographic and post-operative outcomes were similar between inpatient and outpatient cohorts. Physical therapy was implemented in the outpatient cohort which is illustrated by an increased PACU time. BMI should be considered in patient selection to possibly reduce the length of surgery. Provided a surgeon has a history of experience with open (O) TLIF and tubular surgery, it may be feasible to consider transitioning from O-TLIF to MI-TLIF with a minimal learning curve.

O653

Selective thoracolumbar fusion in adult spinal deformity double curves with Circumferential Minimally Invasive Surgery (CMIS)

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Introduction: CMIS correction for ASD with double curves has typically been for very experienced MIS surgeons or considered for open surgery under recent MISDEF-2 criteria. Further, level selection for adult spinal deformity remains controversial. While selective fusion attempts have been described for fractional curves or adolescent curves, no one has described selective fusion performance for ASD with double curves.
Aim: To evaluate selective CMIS thoracolumbar fusion for ASD patients with double curves deformity
Methods: We retrospectively reviewed our adult spinal deformity (Cobb>20,SVA>50mm,(PI-LL)>10) database of 438 patient who underwent CMIS correction from Jan 2007 to Nov 2021. Inclusion criteria were ASD double curves (lumbar cobb >35 degrees and thoracic cobb >30 degrees), four or more levels fused, and minimum 1-year follow up. We assessed radiographic data (Lumbar cobb, thoracic cobb, coronal balance) as well as spinopelvic parameters (PI, PT, SS) both pre- and post-operatively. We also assessed pre and post-intervention clinical data (VAS, ODI, SRS22, and SF36). Complications were recorded.
Results: Twenty-three ASD double curve patients underwent selective thoracolumbar correction with mean follow up of 84 months (12-174 months; SD 47). A total of 156 levels fused with a mean of 7 levels fused (4-8, SD 1.3). T10 was the most proximal and most common UIV instrumented. Pelvic fixation was performed in 14 patients (61%). Statistically significant improvements in lumbar cobb, thoracic cobb, coronal balance, lumbar lordosis, SVA, and PI-LL mismatch were achieved (Table 1). Table 2 shows the improvements in VAS ($p<0.05$), ODI ($p<0.05$), SRS-22, and SF-36 post operatively. Four patients needed revision surgery including a wound infection requiring irrigation and debridement, bilateral L5 pars fractures requiring L5-S1 ALIF and pelvic fixation, adjacent segment degeneration at L5-S1 requiring ALIF and pelvic fixation, and PJK requiring revision fusion to include the thoracic curve.
Conclusion: Selective CMIS thoracolumbar fusion for ASD patients with double curves provides significant clinical improvements. Despite correcting only the lower thoracic and/or lumbar spine, significant thoracic curve correction was achieved. Mechanical related complications were low, but inclusion of the lumbosacral junction may help limit mechanical complications requiring revision surgery.

Radiographic Data

	Pre-op	Post-op	P Value
Lumbar Cobb Angle	51.2 35-74.7 SD 11.5	19.3 1.3-48.2 SD 13.1	**<0.05**
Thoracis Cobb Angle	42.9 30-56.3 SD 10.6	17.3 5.9-27.8 SD 9.1	**<0.05**
Coronal Balance	32.4 19.1-69.8 SD 17	13.5 0-22 SD 7.3	**<0.05**
Lumbar Lordosis	35.1 9.1-54.3 SD 14.9	46.9 24-71.6 SD 8.9	**<0.05**
SVA	47.7 24.9-114.7 SD 41	18.6 5-69.2 SD 18	**<0.05**
PI-LL Mismatch	19.4 3-49.5 13.3	10.8 0.1-47.3 11.6	**<0.05**
PI	53.4 39.3-74.1 SD 8.8	52.7 40.1-71.3 SD 8.7	**>0.05**
PT	26.7 13.3-38.3 SD 8.7	23.8 3.1-39.1 SD 9.7	**>0.05**
SS	26.6 10.5-48.6 SD 11.2	29.8 16.4-42.7 SD 6.8	**>0.05**

Clinical Data

	Preop	3m postop	Last FU	P value
VAS	5.1 2-10 SD 2.6	2.3 0-8 SD 2.8	2 0-7 SD 3	**<0.05**
ODI	41.8 13.3-80 SD 19.7	31.2 0-62 SD 25.2	20.3 0-60 SD 23.7	**<0.05**
SRS 22	3.1 2.1-3.7 SD 0.5	3.6 2.2-4.5 SD 0.8	3.9 2.4-4.8 SD 1.1	**>0.05**
SF 36	45 16-98 SD 22.2	49.2 10-96 SD 22.6	49.9 20-70 SD 15.6	**>0.05**