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# 대한척추외과학회지

# Journal of Korean Society of Spine Surgery

## KSSS 2024

## The 43th International Congress of Korean Society of Spine Surgery

May 22(Wed)~24(Fri), 2024
Lotte Hotel Seoul, Seoul, Korea

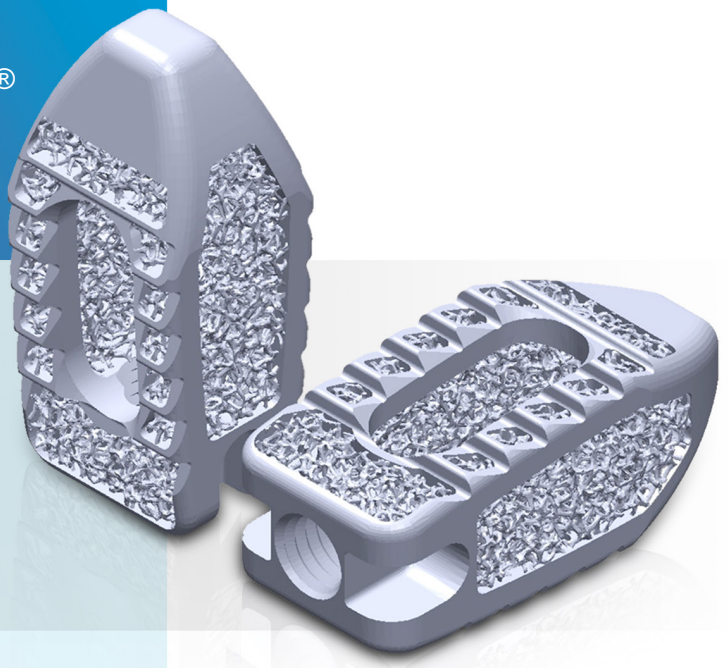
KOREAN SOCIETY OF SPINE SURGERY

Journal of Korean Society of Spine Surgery
Volume 31 • Number S1 • May 2024

pages S1-S127

GS Medical

# AnyPlus®



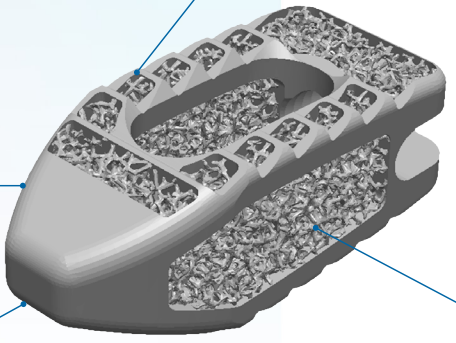
## 3D printing PLIF cage

### Minimized Sharp Edge

: Designed smooth edge for minimizing damage

### Smooth Wedge-Shaped Design

: Easy Insertion



### Bullet-tip Nose

: The nose designed easy to rotational insertion

### Interconnected Irregular Porous Structure

: Irregular porous structure provide optimized cellular adhesion and proliferation

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# Journal of Korean Society of Spine Surgery

## About the Journal

Journal of Korean Society of Spine Surgery is the official journal of Korean Society of Spine Surgery and is published four times year on March 31, June 30, September 30, and December 31. Supplementary abstracts will be published for annual Spring and Fall congress. The Journal is devoted to research and treatment related to the spine surgery and high-quality, ethical, evidence-based spine care, including basic science and clinical investigations. Read the full text of the first ever issue of Journal of Korean Society of Spine Surgery, published on 1 April 1994.

## Aims and Scope

Journal of Korean Society of Spine Surgery (J Korean Soc Spine Surg, JKSSS) is an international journal in all fields of basic spine science and spine surgery, including anatomy of the spine, biology, biomechanics and pathophysiology, diagnostic procedures, and neuroscience. The aim of "Journal of Korean Society of Spine Surgery" is to provide an integrated, ethical and balanced view of diagnostic, research and treatment procedures affecting spine specialists worldwide.

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# 대한척추외과학회 임원명단

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| 편집위원회 (위원장 김영훈) | 3년: 고상봉, 김상범, 김영훈, 김형민, 남우동, 민우기, 양재준, 장봉순 |
| | 2년: 김태균, 박시영, 박현진, 홍창화, 황창주 |
| | 1년: 박예수, 서형연, 송광섭, 신동은, 양재혁(총무), 정남수, 최병완 |
| 영문판 편집위원회 (위원장 김학선) | 3년: 김상일, 김성규, 김호중, 박상민, 박형열, 이근우, 이병호, 장동균, 장삼열, 장해동, 최성훈 |
| | 2년: 권지원, 김학선, 박세준, 박세한, 박진성 |
| | 1년: 김성수, 박건보, 이재철, 조재환(총무) |
| 학술 및 의료평가위원회 (위원장 염진섭) | 2년: 권지원(총무), 김성수, 김영율, 김호중, 남대진, 민우기, 박세준, 석경수, 손홍문, 안동기, 이근우, 이동호, 이재협, 장동균, 정남수, 홍재영 |
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# 대한척추외과학회지 편집위원회

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## Journal of Korean Society of Spine Surgery

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### <May 22 (Wed) Belle-Vue Suite>

## KSSS 2024 Basic Research Symposium I



## KSSS 2024 Basic Research Symposium II



### <May 23 (Thu) Crystal Ballroom A>

## Free Paper: Basic Research (1)



## Free Paper: Basic Research (2)



## Free Paper: Basic Research (3)

## Invited Lecture I



## Plenary Lecture I



## Asian Spine Society Presidential Session



## Symposium I. Deformity: ASD, Debate and Upcoming Issues



## Invited Lecture III



## Free Paper: Deformity (1)



## Free Paper: Deformity (2)

## Free Paper: Deformity (3)



**<May 24 (Fri) Crystal Ballroom A>**

## Best Paper Candidates Presentation I (Domestic)



## Best Paper Candidates Presentation II (Domestic)



## Best Paper Candidates Presentation III (Domestic)

## Best Paper Candidates Presentation IV (International)



## Best Paper Candidates Presentation V (International)



## Best Paper Candidates Presentation VI (International)



## Invited Lecture V



## Plenary Lecture II

## Symposium III. Lumbar: L5-S1, Unique and Special Site



## Free Paper: Deformity (4)



## Free Paper: Tumor



## Asian Traveling Fellowship Reports (Crystal Ballroom A)



**<May 23 (Thu) Crystal Ballroom B>**

## Free Paper: Cervical (1)



## Free Paper: Cervical (2)

## Free Paper: Cervical (3)



## Invited Lecture II



## Asian Spine Society Presidential Session



## Symposium II. Cervical: Current Concepts in Cervical Laminoplasty



## Invited Lecture IV



## Free Paper: Cervical (4)

## Free Paper: Lumbar (1)



## Free Paper: Lumbar (2)



**<May 24 (Fri) Crystal Ballroom B>**

## Free Paper: Lumbar (3)



## Free Paper: Lumbar (4)



## Free Paper: Lumbar (5)

## Free Paper: MIS (1)



## Free Paper: MIS (2)



## Free Paper: MIS (3)



## Invited Lecture VI



## Symposium IV. MIS (Which Better) Endoscopic Lumbar Decompression



## MIS: Which Better Lumbar Foraminal Stenosis

## MIS: Which Better Multi-level Lateral Lumbar Interbody Fusion



## Free Paper: Miscellaneous



## Free Paper: Trauma



## <Video Session>

### Cervical



### Lumbar



### MIS



### Deformity



### Tumor

## <E-Poster Session>

## E-Poster

J Korean Soc Spine Surg. 2024 May;31(S1):S1-127. http://dx.doi.org/10.4184/jkss.2024.31.S1.S1

# KSSS 2024 Basic Research Symposium I

## Relationship between Autophagy and Apoptosis in IVD Degeneration

Young-Yul Kim, Abdul Khaleque

*Department of Orthopaedic Surgery, Daejeon St. Mary's Hospital College of Medicine, The Catholic University of Korea, Seoul, Korea*

**Backgrounds and Introduction:** The intervertebral disc is a leading avascular organ in the body that may gather nutrition through diffusion. It maintains homeostasis using autophagy and apoptosis to survive unfavorable conditions such as stress and mechanical force. Therefore, excessive force and pressure beyond normal conditions may cause intervertebral disc degeneration.

**Main Body:** The purpose of this study was to examine which model is advantageous for observing autophagy and apoptosis, external fixator (EF) or saline injection (SI), in rat tail disc degeneration. The EF group showed more insidious NP cell degeneration than the control (Ctrl) group. Degeneration was elevated with increasing compression duration of the EF group, whereas the SI group could not distinguish the margin of annulus fibrosus (AF) and NP cells. LC3, beclin-1, and P62 showed the highest lateral expression, while MMP-2, MMP-3, and TIMP-1 showed up-regulated central expression in both groups. Cells in their second generation were utilized. To assess the effects of nutritional deprivation, a comprehensive analysis was performed, encompassing evaluations of cell morphology, cell viability, total DNA content, and cellular metabolic activity. Additionally, a range of techniques were employed. Western blotting was conducted to examine the levels of LC3, P62, HMGB1, Cleaved caspase-3, and PARP. Fluorescence-activated cell sorting (FACS) analysis was employed to quantify apoptotic cells and assess cell cycle arrest. Immunofluorescence staining targeting LC3, P62, and Cleaved caspase-3 was carried out to elucidate autophagic and apoptotic activities. Cell viability declined with decreasing serum concentration accompanied by altered morphology and reduced metabolic activity. Reduced serum triggered autophagy and apoptosis, peaking at 48 hours with 0% FBS. Chloroquine treatment inhibited autophagy by trapping LCII protein.

**Conclusions:** Using rats as a model may not precisely replicate human disc degeneration processes, potentially affecting the relevance of findings. Further comprehensive research is necessary to fully elucidate the underlying factors behind the elevated P62 protein expression in vivo after compression The increase in autophagy and apoptosis with reduced serum concentration, peaking at 48 hours at 0% FBS, highlighted the interplay between nutrient deprivation and cellular stress responses. Chloroquine treatment provided insights into autophagy regulation, inhibiting autophagolysosome formation via LCII protein trapping. Altered P62 levels after serum deprivation underscored autophagy's role in nutrient deficiency response. Increased Cleaved caspase-3 and HMGB1 markers upon serum reduction further emphasized apoptosis and autophagy involvement.

**Keywords:** Disc degeneration, Autophagy, Apoptosis, Nutrients deprivation

## Basic and Preclinical Studies of Bioactive Bone Cement: Whitlockite Ceramic as Bone Cement Additive

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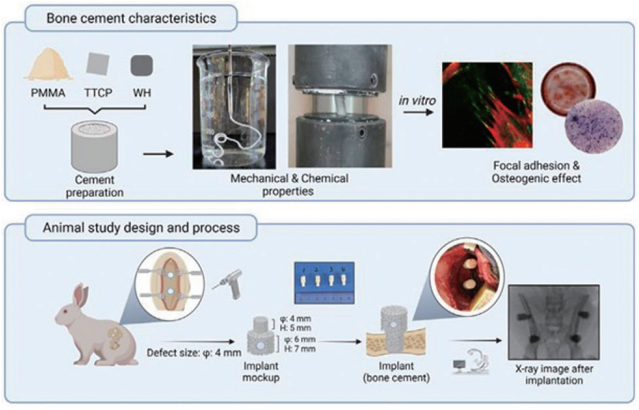
**Backgrounds and Introduction:** Polymethyl methacrylate (PMMA) bone cement is widely employed as a filling material in orthopedic procedures. Nonetheless, its efficacy is significantly hampered by limited biological activity and a high elastic modulus, particularly in the context of managing osteoporotic vertebral compression fractures (OVCF), thus necessitating the exploration of alternative solutions.

**Main Body:** In response to these challenges, a novel functional bone cement was meticulously synthesized to address and improve those shortcomings. In this study, Tetracalcium phosphate (TTCP) and Whitlockite (WH) were incorporated with PMMA cement to prepare a novel bone cement (TTCP/

WH) and systemically evaluated its characteristics such as the operational working time and mechanical properties, etc. based on the International Standardization Organization standard (ISO 5833). Also, the biocompatibility and osteogenic activity of TTCP/WH bone cement were analyzed in vitro, and the rabbit ilium bone defect model was also used to evaluate osteoconduction and osseointegration with native bone tissue as in vivo experiment.

**Conclusions:** Our results showed that TTCP/WH functional bone cement exhibited good osteoconductivity compared with bio-inert PMMA bone cement, facilitated new bone formation, and was histocompatible with surrounding bone tissue while maintaining its original purpose of supporting. So, TTCP/WH functional bone cement may be a promising alternative to overcome PMMA cement's limitations in treating OVCF.

**Keywords:** Whitlockite, Tetracalcium phosphate, Functional bone cement, Biocompatibility, Osteoconductivity




## Extracellular Vesicles from Mesenchymal Stem Cells: From Bench to Bedside

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**Backgrounds and Introduction:** Mesenchymal stem cells (MSCs)-based therapy has been spotlighted as a promising approach for a variety of pathologies, including spine diseases, has been widely studied in recent years. Recent MSCs- related studies have reported encouraging outcomes on inflammation and other properties for spine, but several studies have concerned about the limitations of MSCs use, such as heterogeneity, cultivation, storage and transportation, and ethical issues.

**Main Body:** To date, advances in nano-sized fractionation studies that identified active components in media within the 50–150 nm range characterized biologically active substance such as extracellular vesicles (EV), which is so called exosome. Some recent studies demonstrated that MSC-mediated growth factors and cytokines are transmitted by MSCs-derived EV. MSC-derived EVs are involved in the regulation of cell migration, proliferation, differentiation, and extracellular matrix synthesis. Moreover, recent papers have demonstrated that MSC-derived EVs may contribute to specific regeneration by regulating immune responsiveness, reducing cell apoptosis, and increasing proliferation. However, despite of those strength points of EV over MSC, there are still lots of things to overcome for developing therapeutics with EV in a use at real clinics, including heterogeneity, quality control, production system, and so on.

**Conclusions:** In this presentation, we aimed to review the characteristics of MSC-derived EVs and its therapeutic potential on musculoskeletal pathologies, to share the ways to overcome the EV-related issues, and to introduce our research experiences and outcomes with MSC-derived EVs.

**Keywords:** Mesenchymal stem cell, Extracellular vesicle, Regeneration, Inflammation, Therapeutics

## Top 5 Important Translational Biology Research in the Spine Field

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While spine surgeons focus on technical decompression and surgical stabilization using various implants. There have been continued developments in translational research using molecular biology in the post-genomic era. This talk will cover important topics on bone homeostasis (osteoporosis), pathological bone loss (osteolytic bone

cancers), intervertebral disc biology (developmental biology, disc degeneration, and regeneration), vertebral pain (nerve ablation), and intervertebral fusion biology. Newest spine research information will be important for rapidly evolving minimally invasive spine surgery in Korea.

**Keywords:** Bone, Osteoporosis, Intervertebral disc

# KSSS 2024 Basic Research Symposium II

## Optimization of Irregular Porous Structure Applied to Additive Manufactured Spinal Implants

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**Backgrounds and Introduction:** Additive manufacturing, specifically Powder Bed Fusion (PBF), has introduced the capability to design spinal implants with complex, irregular porous structures. These structures are vital in facilitating biological processes essential for effective spinal regeneration. The primary challenge in designing these implants is optimizing pore size distribution, pore shape, and surface topography to meet the diverse biological demands of bone and vascular tissue integration.

**Main Body:** Our comprehensive analysis centered on the biological response of osteoblasts and endothelial cells to implants fabricated from titanium with varying irregular porous structures. We manipulated pore size ranges from 400 μm to 1000 μm to understand their influence on osseointegration and neovascularization. Key findings indicate that larger pores (approximately 1000 μm) significantly enhance osteoblast proliferation and differentiation, crucial for bone ingrowth. Conversely, smaller pores (around 400 μm) are more favorable for endothelial cell activity, which is essential for forming vascular networks within the implant. Our designs incorporated gradients in pore sizes to bridge the gap between the needs for mechanical stability and optimal biological performance. This strategy was shown to foster a conducive environment for simultaneous osseogenesis and vascularization, demonstrated through enhanced cell activity and tissue integration in vitro. Additionally, the study delved into the impact of pore shape and surface topography on cellular attachment and proliferation. The results showed that the curvature radii and local surface roughness were changed according to pore shape because of the characteristics of PBF. Our findings confirmed that differences in local surface topography and pore shape led to differences in cell proliferation and differentiation.

**Conclusions:** The study underscores the potential of additive manufacturing in creating spinal implants with tailored irregular porous structures that align with the physiological requirements of the spinal environment. By optimizing the pore architecture—considering size distribution, shape, and surface topography—these implants can significantly enhance biological performance, promoting effective osseointegration and vascularization. The findings advocate for a design paradigm that not only supports mechanical integrity but also actively facilitates the complex biological interactions necessary for successful spinal tissue engineering.

**Keywords:** Additive manufacturing, Spinal implants, Irregular porous structures, Pore size distribution, Vascularization

## Intraoperative Stress Analyses Using Wearable Devices: Spine Surgeon, Orthopaedic Surgeon and Nurses

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**Background and Introduction:** Intraoperative stress poses significant challenges in surgical settings, impacting both surgical outcomes and the well-being of medical personnel. Various studies have explored the dynamics of intraoperative stress, focusing on orthopedic surgeons and surgical nurses during spinal surgeries. While stress among surgeons has garnered attention, the stress levels

of nurses and the occurrence of postoperative delirium in patients after spinal surgery remain underinvestigated areas. Utilizing electroencephalography (EEG) signals and heart rate variability (HRV) through wearable devices offers a real-time insight into stress patterns, facilitating a comprehensive understanding of stress dynamics during surgery.

**Main Body:** The first study conducted a pilot investigation into intraoperative stress among orthopedic spine surgeons, analyzing EEG signals and HRV. Results indicated significantly higher stress levels among less experienced surgeons, with stress parameters correlating positively with surgery duration and intraoperative bleeding. Furthermore, operators exhibited higher stress levels compared to assistants, emphasizing the need for careful scheduling to optimize surgical conditions. The second study extended this inquiry, exploring factors influencing intraoperative stress among orthopedic surgeons. Novice surgeons showed elevated stress levels, particularly evident through increased beta 3 waves, while senior surgeons exhibited higher LF/HF ratios, indicative of physical stress demands. Prolonged operation time and intraoperative blood loss correlated positively with stress parameters, underscoring their impact on surgeon stress levels. The third study shifted focus to surgical nurses, revealing higher concentration and tension levels among circulating nurses during all surgical stages. Scrub nurses demonstrated elevated physical stress reflected in BPM and LF/HF ratios, which decreased with increased surgical experience. These findings underscore the importance of understanding nurse stress dynamics for enhancing surgical team coordination. The fourth study investigated postoperative delirium after spinal surgery, utilizing EEG signals from wearable devices. Patients with delirium exhibited heightened anxiety- and stress-related EEG waves within the first week post-surgery, emphasizing the potential of EEG patterns for early delirium detection and intervention.

**Conclusions:** Intraoperative stress among orthopedic surgeons and nurses during spinal surgeries poses significant challenges, influenced by factors such as experience, surgery duration, and intraoperative conditions. Understanding and mitigating these stress dynamics are crucial for optimizing surgical outcomes and ensuring the well-being of medical personnel and patients alike.

**Keywords:** Intraoperative stress, Orthopedic surgery, Electroencephalography, Heart rate variability, Surgical nurses, Postoperative delirium

## How to Prepare the Most Competitive Research Grant Proposal? Dos and Don'ts

Francis Y. Lee

*Yale School of Medicine, Yale University*

All of you conduct or are associated with high-impact research that advances the field of Plastic Surgery and related science. Research mission is inevitably linked with a good team habit of generating ideas, preparing data, submitting grants, and conducting research. I heard the phrase "No money, No mission" so many times. Submitting the most competitive research grants and getting grants are the main activities of the Principal Investigator and research team. I would like to share key elements and important points that will make your research proposal stronger. Many grant reviewers in Korea did research and have worked in the U.S. academic institutions. I will discuss 'Dos and Don'ts' in grant writing.

- NIH Research Proposal Elements & Review Criteria
- Navigating NIH Websites for Funded Projects (NIH Reporter Example for Skin Regeneration: https://reporter.nih.gov/search/c46XnAqIekC-1oFYnt6HQg/projects)
- Research Proposals: R01 (Standard Research Grants) and R21 (Exploratory Grant: High Risk-High Rewards) Grants
- Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs: Non-dilutive funding
- Critical mistakes that should be avoided.

**Keywords:** Research, Grant, Spine

# Free Paper: Basic Research (1)

## Evaluating the Diagnostic Utility of AI Trained on Axial, Coronal, and Sagittal CT Scans for Traumatic Lumbar Spinal Fractures

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**Purpose:** Spinal fractures are associated with serious complications such as paralysis and pulmonary complications in patients with multiple trauma. CT scans are increasingly becoming the standard method for screening spinal fractures. CT scans have high accuracy in diagnosing spinal fractures, but due to the large number of images, reviewing them all requires significant time and manpower, often leading to missed fractures. Recently, advancements in AI in the field of medical imaging have led to the development of algorithms that help overcome these limitations, although such developments in the area of spinal fracture detection are very rare. The aim of this study was to investigate the diagnostic accuracy of an AI system trained on axial, coronal, and sagittal CT scans specifically for identifying traumatic lumbar fractures.

**Materials and Methods:** The study included a total of 408 consecutive patients diagnosed with thoracolumbar fractures on CT scans at a level one trauma center. The ground truth dataset for these fractures was verified by two experienced musculoskeletal radiologists and one spine surgeon, using MRI for confirmation. The fractures were classified into three types: vertebral body fracture and posterior element fracture. For the development of the AI system, ResNet deep learning networks were utilized. To assess diagnostic accuracy, the area under the curve (AUC) was calculated. We compared the diagnostic accuracy of AI algorithms developed based on axial, coronal, and sagittal images, and also verified the accuracy of an ensemble combining all three algorithms.

**Results:** The AI system trained on axial, coronal, and sagittal CT scans achieved an AUC of 0.9244, 0.8987, and 0.9413 for vertebral body fracture. The AI system trained on axial, coronal, and sagittal CT scans achieved an AUC of 0.9227, 0.959, and 0.9534 for posterior element fracture. When the three algorithms were ensembled, the AUC for vertebral body fractures and posterior element fractures increased to 0.9463 and 0.9695, respectively, compared to individual models.

**Conclusions:** For lumbar fracture detection, among the AI developed based on each axial, coronal, and sagittal CT image, the sagittal image-based AI was the most accurate for vertebral body fracture detection, while the coronal image-based AI showed the highest accuracy for posterior element fracture detection. The performance was highest when the AI developed based on all three types of images was combined.

**Keywords:** AI, Deep learning, CT, Lumbar fracture

## Biological Intervention using Umbilical Mesenchymal Stem Cells Delivered by PVA/Chitosan Scaffolds in Canine Spinal Cord Injury Model: Histopathological Evaluation of Neuro-Regeneration

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**Purpose:** Spinal cord injury (SCI) has various detrimental impacts on affected individuals and results in enormous national economic burden. Intervention following spinal cord injuries is vital to limit the extent of direct damage as well as secondary injury through inflammation, hemorrhaging and apoptosis within the cellular platform.The current consensus on the clinical management of SCI is the mechanical decompression and stabilization of the spine function to limit severity, with minimal expectations for improving neuro-regeneration. Combinations of PVA/Chitosan scaffolds with Mesenchymal stem cell (MSC) shows promise, and hypothetically could address the processes involved during the secondary injury phase thus helping augment the neuronal regeneration process. Histopathological evaluations can aid in confirming outcomes through the observation of neuro-regeneration, inflammation and hemorrhaging.

**Materials and Methods:** Canines (Canis lupus familiaris) were

used in this study with weights between 10-20 Kg. Subjects were then grouped based on the intervention: control injury model (n=6), instrumentation (n=7), and instrumentation in combination with PVA/Chitosan scaffolds and Umbilical Cord Mesenchymal Stem Cells (UC-MSCs) (n=4). The Balloon compression technique was conducted to induce SCI for 6 hours in all the subject at the T-10 level. After 7 days, both intervention groups underwent mechanical decompression and instrumentation using rod and pedicle screw, and UC-MSCs-seeded scaffolds were implanted on the injured duramater in the combination group. Subjects were observed for 56 days and were subsequently euthanized at the end of the observational period. The spinal cords were then harvested for histopathological evaluation. Inflammation and haemorrhage grading was observed using Hematoxylin-Eosin staining. Neuro-regeneration was evaluated by myelination grading using Luxol Fast Blue staining.

**Results:** Evaluations of hemorrhage grading showed significant differences in the intramedullary section (p=0.030) with post hoc Mann Whitney U analysis showing significance in both therapeutic groups when compared to the injury model control. Luxol fast blue evaluations showed a significant result through the Kruskal-Wallis analysis on anterior sectional samples (p=0.038), right lateral samples (p=0.048) and left lateral samples (p=0.027). Further post hoc analysis showed a significant result in the combination group through a higher myelination grading ($p<0.05$) when compared to the remaining 2 groups.

**Conclusions:** A significant increase in axonal myelination in the combination group was also observed, implying an augmentation in neuro-regeneration when compared to mechanical instrumentation therapy only.

**Keywords:** Spinal cord injury, Stem cells

## The Risk of Pulmonary Embolism in Bone Cement-reinforced Pedicle Screw Fixation with High Viscosity Low-pressure Technique

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**Purpose:** The use of side-window screws for pedicle screw reinforcement is increasing in popularity due to their convenience. As confirmed in percutaneous vertebroplasty, complications due to bone cement leakage are thought to be unavoidable. This study aimed to improve safety by enabling high-viscosity, low-pressure injection using screws with a 2.5mm inner diameter. Using this technique, we aimed to prove the frequency and risk factors of pulmonary embolism.

**Materials and Methods:** A single-center retrospective study was involving patients who underwent screw reinforcement using bone cement with lateral window pedicle screws from January 2017 to December 2022. Bone cement reinforcement was performed on 920screws in a total of 182patients. Pulmonary embolism caused by bone cement was investigated, local leaks were classified into intravenous, intradiscal, spinal canal, and extravertebral leaks. And differences in leak occurrence were then analyzed based on the condition of the inserted vertebral body.

**Results:** Pulmonary embolism caused by bone cement was confirmed in 3 out of 182 cases (1.6%), and none of them developed symptoms. Bone cement leakage was confirmed in 58 out of 182 cases (31.9%), with 7 cases (3.7%) having leakage in two or more areas. Among leaks in each area, intravenous leak, which was the prerequisite condition of pulmonary embolism, was the most common as 38/182 cases (20.9%), followed by intradiscal leak as 21/182 cases (11.5%), extravertebral leak as 3/182 cases (2.2%), and spinal canal leak as 2/182 cases (1.1%). There were no cases of symptomatic leakage. In comparing analysis of the cases with and without bone cement leakage, there was a significant difference only in the number of screws with bone cement reinforcement. When the subgroups of intravenous and intradiscal leaks, which account for the majority, were analyzed for individual vertebral bodies with bone cement-reinforced, intravenous leaks occurred more often in non-

fractured vertebral bodies (p=0.002, OR=3.774), and right side (p=0.001, OR 3.364). After all, intradiscal leakage occurred more often in fractured vertebral bodies (p<0.001, OR=7.074).

**Conclusions:** High viscosity & low-pressure bone cement pedicle screw reinforcement surgery frequently causes asymptomatic bone cement leakage, however, the possibility of pulmonary embolism is very low. Venous leakage was more frequent when injecting into the non-fractured vertebral body and when injecting on the right side. Therefore, the risk of pulmonary embolism is also expected to be higher under the same conditions.

**Keywords:** Pulmonary embolism, Bone cement, Leakage, Pedicle screw, High viscosity

## Circumferential Bone Fusion in Adult Spinal Deformity via Combination of Oblique Lateral Interbody Fusion and Grade 2 Posterior Column Osteotomy

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*Malaysia Spine Society*

**Purpose: T**he combination of oblique lateral interbody fusion (OLIF) with grade 2 posterior column osteotomy (PCO) is an effective treatment for adult spinal deformity. However, grade 2 PCO may lead to pseudoarthrosis because it involves complete removal of the bilateral posterior facet joints. The main study objective was to determine the achievement rate of anterior and posterolateral fusion resulting in circumferential fusion in patients who underwent combined OLIF and grade 2 PCO.

**Materials and Methods:** This retrospective study included consecutive patients who underwent OLIF and grade 2 PCO. The group comprised a long fusion group, with fusion from the thoracic level to the ilium, and a short fusion group, with fusion within the lumbar region. The OLIF with percutaneous pedicle screw insertion group was also used for reference. The Brantigan-Steffee-Fraser classification was used to assess interbody fusion and Lenke classification for assessment of posterolateral fusion.

**Results:** Sixty-six patients with 109 lumbar levels were included in the study. We observed 100% anterior fusion in all 3 groups. The fusion rate for posterolateral fusion between the OLIF-grade 2 PCO group was 97%, with very low (3%) non-circumferential fusion (pseudoarthrosis only at the osteotomy site). In most cases, solid posterolateral fusions (Lenke A) occurred within 24 months.

**Conclusions:** The combination of OLIF and grade 2 PCO resulted in circumferential fusion for most (97%) of the cases within 24 months. OLIF and grade 2 PCO are considered a good combination treatment to achieve sufficient lumbar lordosis and solid bone fusion.

**Keywords:** Adult spinal deformity, Anterior fusion, Circumferential fusion, Grade 2 posterior column osteotomy, Oblique lateral interbody fusion, Posterior fusion, Pseudoarthrosis

## Mixed Reality Based Surgical Navigation System for Pedicle Screw Placement

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**Purpose:** The traditional image guidance method for pedicle screw placement has been intraoperative fluoroscopy, providing two-dimensional information. The continuous development of three-dimensional imaging technologies for intraoperative use has paved the way for surgical navigation in spine surgery. We suggest pedicle screw placement supportive system with Mixed Reality to resolve these issues and enhance intuitiveness of visual guidance for surgery

**Materials and Methods:** The purpose of this study is to evaluate the accuracy, usefullness in lumbar pedicle surgery using 2 dimensional visualized navigation, 3 dimensional mixed reality navigation. The 3 dimensional mixed reality navigation system integrates widely used optical tracking camera and Microsoft Hololens Gen2 for tool tracking and visualization, also supports surgeon to perform surgery more intuitiveness with visualizing a virtual guidance of surgical tool. A navigated drill guide and screwdriver (VIPER, DePuy Synthes) were calibrated to the navigation system and for each screw placement positioned along the

planned trajectory. The pedicle was drilled with a 5.0 mm diameter tapper. The navigated screw driver was then used to place a 6.0 mm diameter screw in the pedicle. We check the preoperative CT scan to identify the ideal pedicle screw trajectory and postoperative CT scan to check the accurary of pedicel screw insertion Pedicle screws position are classified according to the Gertzbein-robbins scale.

**Results:** In this operation, a total of 16 pedicle screws were inserted. According to the Gertzbein–robbins scale, all of these screws were accurately implanted. In 2 dimensional visualized navigation, the accuracy of Grade A is 100%. In 3 dimensional mixed reality navigation the accuracy of Grade A is 100% also.

**Conclusions:** We confirmed this concept of the system can work and provide proper functions for the surgery.

**Keywords:** Mixed reality, Surgical navigation system, Pedicle screw placement

# Free Paper: Basic Research (2)

## Current Trends of Artificial Intelligence in Spine Surgery: A Systematic Review and Algorithm

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**Purpose:** The popularity of artificial intelligence has grown significantly, demonstrating its benefits in computer-assisted surgery and advancements in the area of spinal treatment. This systematic review aims to summarise the existing evidence and outline the stated benefits and drawbacks of artificial intelligence-assisted spine surgery.

**Materials and Methods:** This research adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), a set of reporting guidelines specifically designed for systematic reviews and meta-analyses. The search strategy with MeSH terms was "MeSH (Artificial intelligence), "Spine" AND "Spinal" Filters: in the last 10 years, English— from January 1, 2013, to October 31, 2023. A total of 442 articles fulfilled the first screening criteria. A detailed analysis of those articles identified 220 that matched the criteria, of which 11 were considered appropriate for this analysis after applying the complete inclusion and exclusion criteria.

**Results:** A total of 11 studies met the eligibility criteria. Analysis of those studies found that all types of artificial intelligence-assisted spine surgery. There was no evidence to suggest the superiority of with or without artificial intelligence-assisted spine surgery in terms of outcomes. In terms of feasible, accurate and safe, and facilitating lower patient radiation exposure compared to standard fluoroscopic guidance., this artificial intelligence-assisted spine surgery produced satisfactory and superior outcomes. Additional research is required to compare the quantity of artificial intelligence.

**Conclusions:** Artificial intelligence established innovative measurements of surgical proficiency and delineated degrees of training in a virtual reality spinal simulation technique.

**Keywords:** Artificial intelligence, AI, Spine surgery, Virtual reality, Augmented reality

## A Finite Element Analysis of Hip Joint Stress Based on a Finite Element Analysis of Hip Joint Stress Based on Sagittal Pelvic Tilt After Correction in Non-ambulatory, Flaccid Neuromuscular Scoliosis Patients

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**Purpose:** In cases of non-ambulatory flaccid NM scoliosis, it has been observed that hip pain and subluxation have worsened even after correction. There was a statistically significant relationship between the decrease in SA-PT, increase in pelvic anteversion, and increase in hip subluxation. The above-mentioned clinical retrospective research results were substantiated by conducting an analysis of hip joint mechanical stress using Finite Element Analysis

(FEA) based on sagittal pelvic inclination.method

**Materials and Methods:** Pelvic tilt angles of -30°, -15°, 0°, 15°, and 30° were used to create five distinct Finite Element Analysis (FEA) model types for the analysis of hip stress amount and distribution. The model has been configured with a coronal pelvic tilt, with the right side positioned lower and the left side higher. Considering a non-ambulatory flaccid neuromuscular scoliosis condition, the femur was fixed at a 90° angle in a sitting position, simulating a 60 kg patient's upper body weight, and applying a vertical force of 400N on the upper area of the sacrum. The acetabular cartilage was set to 1mm, and the finite sliding friction coefficient between the acetabular cartilage and femoral head cartilage was set at 0.02

**Results:** The peak von Mises stress applied to the acetabulum of the hip joint was observed to vary with pelvic tilt (PT) angles as follows: -30° PT resulted in 22.44 MPa, -15° PT in 21.57 MPa, 0° PT in 18.15 MPa, 15° PT in 16.83 MPa, and 30° PT in 9.41 MPa. It was noted that as the pelvic tilt angle decreased, hip stress increased. Additionally, a decrease in PT led to a concentration of hip stress on medial sides in both hip areas.

**Conclusions:** Through the Finite Element Method (FEM) study, we were able to confirm that, similar to the findings in existing clinical research, a decrease in pelvic tilt (PT) is associated with an increase in hip joint stress. Moreover, the distribution of hip stress becomes uneven with a decrease in PT, potentially leading to increased hip pain and subluxation.

**Keywords:** Scoliosis, Hip joint stress, Finite element analysis, Pelvic tilt, Sagittal pelvic inclincation

## Spontaneous Fusion Phenomenon in the Healing Process of Osteoporotic Vertebral Fractures

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**Purpose:** Spontaneous fusion of the vertebra is uncommon, but it can be caused by open surgeries (e.g., laminoplasty, disc arthroplasty, and lumbar decompression surgery) and minimally invasive procedures such as needle biopsy and cement augmentation. In osteoporotic vertebral fractures, (OVFs) over time, spontaneous fusion with adjacent vertebrae is often observed. In this study, we aim to describe the phenomenon of spontaneous fusion in OVFs and investigate whether there is a difference in the spontaneous fusion rate based on the treatment method for OVFs (bed rest or percutaneous vertebroplasty).

**Materials and Methods:** From 2005 to 2020, a total of 160 patients admitted for the treatment of OVFs and followed up for at least 2 years were included in the study. Among them, 81 patients underwent bed rest, and 79 patients underwent vertebroplasty. Spontaneous fusion was defined as a case in which at least three bony bridges were obviously connected between two adjacent vertebrae on anteroposterior and lateral radiographs. Age, sex, bone mineral density, smoking status, past medical history, body mass index, follow-up period, level of OVF, and the incidence of spontaneous fusion were assessed. Furthermore, the compression rate and anterior wedge angle at the OVF were analyzed both at the initial and final follow-up. A statistical comparison between the bed rest and vertebroplasty groups was conducted.

**Results:** Spontaneous fusion occurred in a total of 28.8% of OVF patients, and it was significantly higher in the ABR group (30/81, 37.03%) compared to the VP group (16/79, 20.25%, $p=0.019$). Within the ABR group, subgroup analysis revealed that the age (75.3) and final compression rate (47.1%) in the spontaneous fusion group were significantly higher than those in the non-fusion group (69.4, $p=0.019$; 32.78%, $p<0.001$).

**Conclusions:** Spontaneous fusion is a phenomenon that can clearly occur not only in surgery but also in the natural course of OVFs. Particularly, in the elderly population where collapse is more prevalent, cases of spontaneous fusion tend to occur more frequently during the healing process of OVFs.

**Keywords:** Osteoporotic vertebral fracture, Spontaneous fusion, Vertebroplasty, Bed rest, Bony bridge

## Can Cement Augmented Screws Prevent Implant Failure without Adjacent Segment Degeneration in Multi-level Lumbar Interbody Fusions?: Analysis Using Finite Element Model

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**Purpose:** This study employed finite element analysis to predict the improvement effect of screw loosening with cement augmentation during multi-level fusion and compared the outcomes under osteoporosis (OP) conditions.

**Materials and Methods:** A three-dimensional normal spine finite element model was verified through previous studies and was used in this study. OLIF Cage for L2-5 levels and PLIF Cage for L5-S1 level were used for interbody fusions. A total of four surgical models were implemented based on the presence of Cement augmentation and the application of osteoporosis for the Pedicle screw inserted at L2 (Type A: No Cement; Type B: L2 Cement augmentation; Type A-OP, Type B-OP). A follower load of 400 N and a pure moment of 10Nm were applied to the upper endplate of L1 to perform six spinal motions (flexion, extension, left lateral bending, right lateral bending, left axial rotation, right axial rotation) reproduced. The degree of screw loosening was assessed by deriving the peak von Mises stress (PVMS) generated at the interface between L2 and pedicle screw of each type compared to the yield stress of the vertebral body (16MPa, Type A) and cement (92 MPa, Type B). In addition, the possibility of degeneration of adjacent segments was evaluated by analyzing the motion of adjacent segments (L1-L2) based on normal spinal motion.

**Results:** The stress values for cement augmentation (Type B: 17.43 MPa, 18.91%; Type B-OP: 24.42 MPa, 26.49%) were found to be lower than those for conventional multi-level fusion (Type A: 6.41 MPa, 39.32%; Type A-OP: 14.67 MPa, 90%). Particularly in the model with osteoporosis, the stress values decreased by approximately 70%. The motion of adjacent segments showed similar results in both groups compared to normal spine (Type A: 98%, Type B: 98%), suggesting that cement augmentation does not affect the degeneration of adjacent segments. This indicates that the injection of bone cement effectively reduces stress at the pedicle screw insertion site, lowering the risk of screw loosening, with even more significant benefits for osteoporosis patients.

**Conclusions:** The possibility of screw loosening can be reduced without affecting the motion of adjacent segments when cement augmentation is performed in upper instrumented vertebra (UIV). Although further trials are needed to validate our results in clinical situations, cement-augmented screws in UIV can be considered in multi-level lumbar interbody fusions to prevent implant failure.

**Keywords:** Cement augmented screws, Adjacent segment degeneration, Multi-level lumbar interbody fusions, Finite element model

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## Influence of Barium Sulfate Contrast Agent in Bone Cement on its Physical and Mechanical Properties in the Vertebra of an Animal Model

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**Purpose:** To know the optimum amount of Barium Sulfate and bone cement mixture that would achieve a balance between mechanical strength and acceptable radio-opacity.

**Materials and Methods:** Bone cement was mixed with Barium Sulfate contrast agent in a 0%, 5%, 10%, 15%, 20%, and 25% weight of the bone cement. There were 6 lumbar vertebra isolated from a pig. Each of the 6 bone cement mixture was injected into each of the 6 lumbar vertebra under fluoroscopy. Three persons observed the fluoroscopy printout and graded the radiopacity of the bone cement and determined which vertebra had the most radiopaque bone cement on 3 different days. Intraobserver and interobserver variability were computed using Fleiss Kappa statistics. Intraobserver variability showed slight to fair agreement. Interobserver variability showed fair agreement. Bone cement was again mixed with the same concentration of Barium Sulfate to make 6 cubes of bone cement-Barium Sulfate mixture. The 6 cubes underwent compression testing. The bone cement without barium sulfate had the strongest

compressive load.

**Results:** The compressive load showed non-consistent results as the amount of Barium Sulfate increased which means that the compressive strength of the bone cement is not affected by increasing the amount of Barium Sulfate. The bone cement with a 20% Barium Sulfate concentration had an optimum radiopacity under fluoroscopy and at the same time had an optimum compressive strength.

**Conclusions:** Grading of the radiopacity under fluoroscopy is observer dependent as showed by the different grading and ranking of the 3 observers. The compressive load is not affeted with the increasing amount of Barium Sulfate used in this study.

**Keywords:** Kyphoplasty, Vertebroplasty, Radiopacity, Bone cement, Barium sulfate

# Free Paper: Basic Research (3)

## Utilizing Artificial Intelligence assisted DEWS (deep learning-based early warning score) to Predict Blood Transfusion Requirements in Posterior Lumbar Spine Surgery

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**Purpose:** The deep learning-based early warning score (DEWS), an artificial intelligence (AI) assisted system, could be utilized in various clinical practices and for prevention of cardiac arrest. This study investigates the utility of DEWS in predicting intraoperative hemorrhagic risk in spinal surgeries, a critical factor for patient safety and surgical outcomes. Prior research predominantly focused on intraoperative determinants such as fusion levels and blood pressure to predict surgical blood loss. Our research expands this scope by examining the influence of both intraoperative variables and DEWS on blood loss during spinal surgeries. Additionally, we assess the correlation between DEWS scores and the necessity for transfusions in patients undergoing posterior lumbar spine surgery.

**Materials and Methods:** This retrospective study encompasses 48 patients who underwent posterior lumbar spine surgery at Pusan National University Hospital. We collected demographic data, American Society of Anesthesiologists (ASA) scores, pre-operative and post-operative DEWS scores, and complete blood count (CBC) results as primary variables. The DEWS scoring system was employed pre- and postoperatively. Primary outcomes, including the volume of intraoperative blood loss and transfusion status, were meticulously recorded. Supplementary surgical parameters such as duration, fusion levels, estimated blood loss, and total concealed hemorrhage were also incorporated. Patients requiring transfusions (Hb<7.0) were categorized as Group A, while those not requiring transfusions formed Group B.

**Results:** Comparative analysis revealed no significant statistical difference in preoperative hemoglobin (Hb), hematocrit (Hct), and ASA scores between the groups. However, the preoperative DEWS score was notably higher in Group A (p=0.032). Intraoperative fusion levels showed no significant variance (p=0.073), but Group A exhibited longer surgery duration (p=0.039). Postoperative Hb and Hct levels were significantly lower in Group A (p=0.017, 0.031), and postoperative DEWS scores were elevated (p=0.043). The study elucidates a substantial association between elevated pre- and post-operative DEWS scores and increased transfusion requirements. The Receiver Operating Characteristic (ROC) analysis between postoperative DEWS scores and transfusion necessity yielded an area under the curve of 0.752.

**Conclusions:** Through rigorous retrospective analysis, we discerned the significant prognostic utility of postoperative DEWS scores in forecasting transfusion needs post-spinal fusion surgery. These findings underscore the imperative of integrating postoperative DEWS evaluations in clinical decision-making processes to enhance resource optimization and patient care during the perioperative phase.

**Keywords:** Artificial intelligence, Lumbar spine surgery, Blood transfusion, Blood loss

## Role of Molecular Diagnostics in Spinal Infections: Our Experience

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**Purpose:** Pyogenic spinal infection is a worldwide disease that manifests as pyogenic spondylitis, spondylodiscitis and epidural abscess. These commonly occur as a result of a patient's comorbid condition, spreading through the bloodstream, but iatrogenic infections as a result of invasive spinal procedures are not uncommon. The objectives of the study were to know the detective capabilities of molecular diagnostics in spinal infections and their correlation with conventional methods such as culture and histopathology and to know the response to treatment.

**Materials and Methods:** This study is on a prospective observational design. Fifty patients presenting with spinal infections to the Department of Orthopaedics from Nov 2019 to Sep 2021 were included. The patient underwent clinical assessment and workup, including Erythrocyte Sedimentation Rate (ESR), C-Reactive Protein (CRP), Complete blood counts (CBC), Brucella agglutination test and radiograph and Magnetic Resonance Imaging. Patients underwent surgery/biopsy depending on the severity of the infection and neurological status. Samples were sent for staining, aerobic/anaerobic cultures, GeneXpert®, Mycobacteria growth Incubator Tube (MGIT) culture and histopathology. The molecular diagnostic tests were compared with conventional culture with histopathology as the gold standard. ESR, CRP reports and X-rays were done at 6 months. Paired t-test and independent t-test were used to compare the variables.

**Results:** Most of the spinal infections were Tubercular in origin (64%). Other bacterial pathogens isolated were Brucella (14%), Methicillin-sensitive Staphylococcus aureus (13%), Methicillin-resistant staphylococcus aureus (6%) and Salmonella typhi (2%). Out of the 32 cases of Mycobacterial tuberculosis, GeneXpert was found to be positive in all the cases (100%), while MGIT culture was found to be positive in 16 cases (50%). All the Brucella infections were diagnosed with a positive Brucella Antigen Test and culture sensitivity (100%). Out of the 37 follow-up patients, 34 patients (91.8%) showed serial improvement in ESR/CRP values. Radiologically all patients showed healing by sclerosis month.

**Conclusions:** Diagnostic tests like GeneXpert can yield a faster result to initiate early treatment and improve outcome. Brucella Antigen test can be used as a sole diagnostic method in some cases to get considerable clinical outcome.

**Keywords:** Molecular diagnostics, GeneExpert®, Brucella agglutination test, Spinal infections

## Effects of Atrophy and Fatty Degeneration of Paraspinal Muscle on Segmental Kyphosis after Osteoporotic Compression Fractures in Postmenopausal Women

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**Purpose:** Osteoporotic vertebral compression fractures (OVCFs) are very common in postmenopause elderly patients and prevalence is expected to increase with aging era. OVCF accelerate kyphosis, and progressive kyphosis can lead to adjacent compression fracture , chronic pain, walking disability. There are many study that muscularity and FI of paraspinal muscles was related to kyphosis development after OVCF, but non consensus. In this study, we aimed to investigate the effects of muscularity and fatty infiltration (FI) of the muscle around spine on kyphosis and clinical features in OVCF in postmenopausal women

**Materials and Methods:** 200 patients who diagnosed OVCF of postmenopause women at the author's clinic from 2012 to 2022 were retrospective analyzed. All patients in this study could be followed up more than 1 years and this patients were completed X-ray image and MRI. Degree of kyphosis was defined as segmental kyphosis by measuring the Cobb angle of the segment above and below the fracture level using X-ray image, at a follow-up period . New developed compression fractures defined as newly occurring compression fractures within the follow-up period compared to the initial X-ray Clinical features were measured through

the drug demand and koval grade through chart review. The muscularity of paraspinal muscles (Psoas major [PS], Quadratus lumborum [QL], erector spina [ES], Multifidus [MM]) was measured through freedraw following the outline of target muscle. There are difference in muscles size depending on the body size of each patient. To correct this, CSA were defined that target muscle area was dividing by target level CSA. FI of paraspinal muscles were measured using previously known method. FCSA defined amount of muscle that can functionly, that was measured exclude fatty degeneration from total amount of muscle. All of this measurements were analyzed by using T2-weighted axial images in the AVIEW Research™, Coreline Soft Inc

**Results:** Total 200 postmenopausal women was analysed. At kyphosis development, in univariate regression analysis, BMI and FCSA, FI of ES, MF was clinical significant with segmental kyphosis development. In ordinal regression analysis, BMI, FI of MF and ES showed significant results. At new developed compression fx, in univariate analysis, Age, QL CSA, FI of MI was significant. In multivariate regression analysis, there were no significant result

**Conclusions:** FI of MF,ES are clinical significant with kyphosis after OVCF. Hence using MRI for measuring FI can be used effectively as a decide to postmenopause OVCF patient treatment plan.

**Keywords:** Osteoporosis, Compression fracture, Sarcopenia

## Lumbar Lordosis Curve and Psoas Major Muscle Angle in Magnetic Resonance Imaging Analysis

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**Purpose:** Using axial MRI image, the psoas major muscle is known to work as an anatomical femoral head stabilizer and increases lumbar lordosis keeping the iliopsoas muscle in place at the lumbosacral region. The purpose of this study is to investigate psoas major muscle correlation with lumbar lordosis by analyzing the psoas major angle, which represents the psoas major muscle's effect on pelvic alignment using sagittal MRI imaging.

**Materials and Methods:** A total of 1064 patients were included in this study. On lateral standing radiography, three pelvic parameters (sacral slope [SS], pelvic tilt [PT], pelvic incidence [PI]) can be measured. In the sagittal MRI imaging, the point where the psoas major muscle direction changes (the top of superior pubic ramus) was marked and the angle between the line connecting the two points and the proximal part of the psoas major muscle (Psoas major angle: PMA) was measured.

**Results:** The average age was 63.88±13.52 (20-89) years old in total; 62.52±15.24 in 426 male patients and 66.12±11.72 in 638 female patients. The average age was older in female patients ($p<0.05$). Using the structural equation, the correlation coefficient between PMA and SS was 0.237 ($p<0.001$), between PMA and PT was 0.339 ($p<0.001$), and between PMA and PI was 0.749 ($p<0.001$). PMA has a statistically significant correlation in relation to PI, PT, and SS ($p<0.001$).

**Conclusions:** PMA has a higher correlation with PT, which is related to pelvic compensation, than SS which is closely related to lumbar lordosis. It means that the psoas major muscle's role of influencing spinopelvic alignment in the supine position is to maintain spinopelvic alignment by adjusting the pelvic tilt rather than by lumbar lordosis using the upper and lower muscle attachments.

**Keywords:** Psoas major muscle, Lumbar lordosis, Iliopsoas muscle, MRI

## Visceral Fat: Protective Factor for Sarcopenia?

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**Purpose:** To explore the potential mitigating effects of visceral fat and retroperitoneal fat on sarcopenia. Verification of this hypothesis is sought through empirical investigation; AI measuring technique.

**Materials and Methods:** We conducted a study involving 982 patients who underwent health examinations, utilizing abdominal CT scans to employ AI deep learning for 3D assessment of skeletal muscles, psoas muscles, erector spinae muscles, multifidus muscles, subcutaneous adipose tissue, visceral adipose tissue, and extra-peritoneal adipose tissue. Subsequently, we categorized the participants into four groups based on age (below 50 and 50 or above) and gender (male and female). Skeletal muscle loss was defined as samples falling below one standard deviation. We compared the risk profiles between the group with skeletal muscle loss and the group without, based on respective adipose tissue quantities in each group.

**Results:** Although it is true that subcutaneous fat predominantly exhibits a significant protective effect against sarcopenia, according to this study, visceral fat and retroperitoneal fat also function as protective factors against sarcopenia.

**Conclusions:** Visceral fat and retroperitoneal fat may also act as protective factors against sarcopenia.

**Keywords:** Visceral fat, Subcutaneous fat, Obesity paradox, Sarcopenia

# Invited Lecture I

## Biomechanics for Deformity Correction of Adolescent Idiopathic Scoliosis

Manabu Ito, MD, PhD

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**Backgrounds and Introductions:** There has been much debate regarding the surgical treatment of idiopathic scoliosis, including the range of fixation, destabilization procedure, accurate placement of pedicle screw, and the theory of correction. Currently, the mainstream treatment for this pathology is posterior correction and fixation, in which pedicle screws are mainly used as fixation anchors.

**Main Body:** This pathological condition differs from adult spinal deformity in that there is little need to consider decompression surgery for neural elements and spinal deformity correction can be explained simply from a biomechanical perspective. The factors that determine deformity correction are the anchor screw or metallic rod and the mechanical rigidity of the spinal column. Although the rod is made of metal, the mechanical properties of the metal material differ depending on whether it is a cobalt-chromium alloy, a titanium alloy or others. Furthermore, there are large individual differences in deformity, ranging from rigid curves to flexible curves. The spinal column is a viscoelastic body from the viewpoint of material sciences, and it is necessary to consider surgical techniques as a substance with viscoelastic properties. Since the vertebrae of an adolescent child are soft and do not yet have sufficient mechanical strength, it is necessary to understand the amount of stress occurred on the implant during correction procedures.

**Conclusions:** In this lecture, I will talk about the theory of rational and safe deformity correction of the spine, focusing on the biomechanical knowledge necessary for correction of adolescent idiopathic scoliosis.

**Keywords:** Idiopathic scoliosis, Surgical treatment, Biomechanics

# Plenary Lecture I

## Minimally Invasive Pain Control and Stabilization of the Sacral-Pelvic Bones

Francis Lee

*Yale School of Medicine, Yale University*

Sacrum and pelvis osteolytic metastatic lesions cause pain, limitation of ambulation, and neurologic deficits. Chemotherapy, radiation, and pharmacologic agents (denosumab and bisphosphonates) do not always work in osteolytic metastases. Medical oncology underwent major revolutionary improvements with heavy emphasis on ambulatory targeted drug therapies that are frequently modified during the course of treatment. Therefore, open surgeries and prolonged recovery are not really helpful for patients with osteolytic metastases in the sacrum and pelvis. The minimally invasive procedure will consist of Ablation-balloon Osteoplasty-Reinforcement with zoledronate-loaded PMMA bone cement-and percutaneous cannulated screw

fixation (AORIF). This talk will be case-based presentations along with results from the most recently published papers.
**Keywords:** Spine metastasis, Minimally invasive surgery, Osteolysis

### Minimally Invasive Pain Control and Stabilization of Thoraco-Lumbar Spine

Francis Lee

*Yale School of Medicine, Yale University*

Vertebral metastatic lesions cause pain, limitation of ambulation, and neurologic deficits. Chemotherapy, radiation, and pharmacologic agents (denosumab and bisphosphonates) do not always work in osteolytic metastases. Medical oncology underwent major revolutionary improvements with heavy emphasis on ambulatory targeted drug therapies that are frequently modified during the course of treatment. Therefore, open surgeries and prolonged recovery could be debatable in the context of osteolytic metastases. This talk will discuss bone mass changes, recurrent pathological fractures, and development of new lesions in juxta-posed vertebrae. This talk will be case-based presentations along with results from the most recently published papers.
**Keywords:** Spine, Metastasis, Minimally invasive surgery

## Asian Spine Society Presidential Session

### Management of Upper Cervical Spine Conditions

Ronald P. Tangente, MD, MBA, FPOA, FPSS

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**Background:** The management of upper cervical spine conditions is a very complex one. It starts with a thorough physical examination and a well-defined diagnosis. In most cases, it may require both an MRI and CT scan to properly delineate and classify the pathology.
**Main Body:** The conditions that will be described in detail will start from the occipital condyle fracture, basilar invagination, foramen magnum decompression, Jefferson fracture, and C1-C2 instability. It is also imperative to describe the indications of surgical management of each pathology.
**Conclusions:** The recognition and timely management of upper cervical spine pathologies are essential for a successful outcome.
**Keywords:** Upper cervical, Surgery, Basilar invagination

### Approach to Spinal Infection

Binod Bijukachhe

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**Purpose:** Spinal Infection accounts for about 7% of all musculoskeletal infections having male predominance. The clinical presentation, radiological findings and laboratory parameters often confused with spinal tumors. The purpose of this study is to rationally approach spinal infections for diagnosis and treatment.
**Material and Methods:** This retrospective study is based upon 210 surgically treated spinal infections during 2007 and 2022. Clinical presentation, radiological findings, laboratory parameters, culture and biopsy were evaluated. Literature review done to compare findings.
**Results:** There were 165 spinal tuberculosis, 42 discitis and 3 hydatid cysts. Male predominance (m 130 / f 80) was observed with the age ranging from 4 to 82 years. The most common affection was in lumbar spine. Pain was the major complaint in 85% of patients and 34% have neurological deficits. Fever was inconsistent. Common infecting organisms were Mycobacterium tuberculosis, Staphylococcus aureus, streptococcus or gram-negative organisms. Parasitic infections are relatively uncommon. Polymicrobial infection is seen in about 24% cases. Total count was raised in about 60% of patients. C – reactive protein is specific to bacterial infection and raised in 90% of patients. Erythrocyte sedimentation rate increased in 75% of the patients. MRI is gold standard having 96% of sensitivity

and 93% of specificity. Biopsy and culture of an organism is must to have diagnosis and treatment initiation. Aim of treatment is to eradicate infection, preserve neurological function, alleviate pain and restore spinal balance. Non-operative treatment is indicated in patients having normal neurology, no deformity, no instability and in high surgical risk patients. One week course of intravenous antibiotics followed by 5 weeks oral, based upon the sensitivity, is standard treatment for pyogenic infection. One year course of anti-tuberculous treatment consisting of four drugs intensive phase for 2 months followed by two drugs maintenance phase for 10 months is given for spinal tuberculosis. As high as 72 to 85% of success rate has been reported in literatures. Cases with deformity, neurological deficits, epidural abscess or failed conservative treatments are indicated for surgical decompression, debridement and stabilization.

**Conclusions:** Diagnosis of spinal infection require thorough clinical evaluation which should corroborate with radiological and laboratory findings. It must be differentiated with tumors. Biopsy & culture are must for diagnosis and treatment plan.

**Keywords:** Spinal infection, Tuberculosis, Discitis, Diagnosis, Antibiotics

## Correction Strategy for Lenke 5 and Lenke 6 Curves: Surgical Strategy to Achieve a Harmonious Spinal Balance

Chris Chan Yin Wei

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**Purpose:** The aim of this presentation would be to share our principle of surgical correction for Lenke 5 and Lenke 6 curves based on the above pre-operative considerations, intra-operative strategy and how these would be executed during the surgery.

**Materials and Methods:** We will also share our method of assessing the flexibility of the lumbosacral junction. In addition, this lecture will also focus on the compensatory ability of the minor Main Thoracic curves and how to classify Lenke 5 curves based on the MT Side Bending (SB) Cobb angle into Lenke 5 Flexible: MTSB Cobb angle <15° and Lenke 5 Stiff: MTSB Cobb angle 15-24.9°. The application of this knowledge will involve discussion on the pre-operative planning as well as intra-operative strategy which includes the application of the cross bar technique to ensure centralization of the LIV and C7, adjustment of the cross bar to account for structural causes of pelvic obliquity and assessment of the targeted LIV tilt angle and UIV tilt angle.

**Results:** The incidence of post-operative coronal imbalance could be as high as 44% during the immediate post-operative period and up to 9% of them would continue to experience coronal imbalance during follow up. The important pre-operative consideration would be to assess the foundation for the fusion block, the stiffness of the lumbosacral junction as well as the flexibility and compensatory ability of the minor Main Thoracic curves.

**Conclusion:** Assessment of pelvic obliquity, LIV tilt angle and stiffness of the minor Main Thoracic curves are vital in Lenke 5 and 6 curves pre-operatively. The intra-operative crossbar can be used to confirm the targeted LIV tilt angle and the coronal balance. These surgical strategies would help avoid coronal imbalance following surgical correction.

**Keywords:** Adolescent idiopathic scoliosis, Lenke 5, Lenke 6, Coronal imbalance, Pelvic obliquity, LIV tilt angle

## Management Strategies in Irreducible Atlantoaxial Dislocation

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**Background and Introduction:** Management of irreducible atlantoaxial dislocation (IAAD) more so with the component of basilar invagination (BI) has been challenging . Posterior decompression and fixation , anterior odontoidectomy and posterior joint distraction technique has been described. In 2006 Wang et al. described that by doing anterior release IAAD can be converted into reducible AAD. We present our algorithm of managing IAAD.

**Main Body:** It is a retrospective study of 48 patients of IAAD [ 41 congenital , 7 acquired (Tuberculosis – 4, neglected trauma -1 , rheumatoid – 2) - 30 patients had BI] treated from 2007 to 2021.All patients had neurological deficit. Preoperative mJOA score and CCA (clivus canal angle) was measured. Reducibility of dislocation was assessed by dynamic x- ray. Patients were put on skeletal traction in the ward and reducibility was checked. Reducibility was also checked under anesthesia. IAAD were taken for anterior release [transoral (TO) – 12 cases , Retropharyngeal -36 cases] where longus colli , longus capitis and anterior longitudinal ligaments were cut , joint capsule was opened and lateral joints were made supple. Under supervision patient was turned prone on head rest and posterior fixation and fusion was done. In cases of occipitalised Atlas , fixation and fusion was done from occiput to C3.C1-C2 transarticular fixtion was done in 4 patients , C1- C2 separate screw fixation in 8 patients , OC (Occipitocervical) fusion in 36 patients.There were 41 male and 7 female .40 patients had full reduction while 8 patients had partial reduction. The mJOA improved from mean preoperative 10.89 to mean postoperative 16.82.Mean preoperative CCA of 110.4 improved to mean postoperative CCA of 146.4.Maceration of posterior wound occurred in 4 patients which healed by daily cleaning and dressing. Implant breakage on one side was noted after 3 months postoperative in one patient who remained asymptomatic. In a pediatric patient occipital plate backed out at 8 weeks. It was reexplored and plate was fixed to occiput with sublaminar wire. Fusion was achieved in all patients.

**Conclusions:** Pre and intraoperative traction, single stage anterior release and posterior instrumented fusion in IAAD gives desirable clinico-radiological outcome.

**Keywords:** Atlantoaxial, Irreducible dislocation, Transoral anterior release , Retropharyngeal anterior release, Fusion

### Outcomes of Tuberculosis of Cervical Spine

Zaw Min Han, Htay Kyawl, Win Min Tun*

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**Mandalay Orthopaedic Hospital, Mandalay, Myanmar*

**Background and Introduction:** Tuberculosis cervical spine region is not uncommon in developing countries. It can present with pain, functional impairment and neurological deficit. Proper counselling and appropriate treatment can expect best outcomes.

**Mainbody:** Medical treatment of Anti tuberculosis drug is main stay of bacterial Eradication. Surgical treatment can help for decompression, stabilization and eradication of infectious focus. Anterior approach can reach down to T2 level and some cases need combined approach. Autogenous graft is preferred if possible doner site. Rehabilitation program with physiotherapy department and CDC.

**Conclusions:** With Multidisplinary team work and surgical debridement and stabilization, Cervical Spine tuberculosis infection can expect for best outcomes.

**Keywords:** Cervical spine, Tuberculosis, Anterior approach

## Symposium I. Deformity: ASD, Debate and Upcoming Issues

### Does Optimal Restoration of Sagittal Imbalance Prevent Mechanical Failure in ASD Surgery?

Se-Jun Park

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**Backgrounds and Introduction:** It is well-recognized that optimal correction of a sagittal deformity along with minimizing mechanical failure, such as rod fracture, proximal junctional kyphosis (PJF), is of the utmost importance to achieve good clinical outcomes in adult spinal deformity surgery (ASD). In this lecture, I would present the clinical usefulness of the current surgical guidelines in terms

of prevention of mechanical complications.

**Main Body:** There are several guidelines suggesting the optimal surgical target. In the literature, 4 guidelines have been suggested for optimal surgical targets: Scoliosis Research Society (SRS)-Schwab classification, age-adjusted sagittal alignment goals, Global Alignment and Proportion (GAP) score, and the Roussouly algorithm. Any guidelines suggesting the surgical alignment target should provide the benefit in terms of both clinical outcome improvement and prevention of mechanical complications The SRS-Schwab classification was originally developed with a focus on good clinical outcome acquisition rather than avoiding mechanical complications. Therefore, the impact of the SRS-Schwab classification on mechanical failure needs to be investigated. The age-adjusted alignment goal sets the target pelvic incidence (PI) – lumbar lordosis (LL) according to patient age. In the age-adjusted concept, less strict rules for postoperative PI - LL mismatch are permitted in elderly patients. The GAP score evaluates the appropriateness of sagittal correction according to calculated three categories (proportioned, moderately disproportioned, and severely disproportioned) to predict the mechanical failures. The Roussouly algorithm is based on preoperative and postoperative Roussouly type. Two groups (restored and non-restored) were suggested according to postoperative restoration of the suggested Roussouly type. Unlike the SRS-Schwab classification, the age-adjusted alignment goal, GAP score, and the Roussouly algorithm were developed with a focus on prevention of mechanical complications, such as rod fracture and PJF, rather than clinical outcomes.

**Conclusions:** There are four global alignment assessment metrics. Each system suggests the ideal correction target, but their predictive ability for the development of mechanical failure remains controversial. Age-adjusted PI-LL seems to best predict the PJF development. It is reported that the GAP score and Roussouly classification are also reported to be associated with PJF development, but these findings are inconsistent. Meanwhile, rod fracture may not be significantly affected by the appropriateness of sagittal deformity. Under correction is reported as the risk factor of rod fracture, but optimal restoration of sagittal imbalance does not guarantee the absence of rod fracture. It may be more related with local factors (fusion method, osteotomy, Ti vs. CoCr rod, dual vs. multiple rod, ets.) than the global alignment status.

**Keywords:** Adult spinal deformity, Mechanical failure, Proximal junctional failure, Rod fracture

## Risk Factors and Clinical Impact of Postoperative Coronal Imbalance after Long Fusion Surgery in ASD Patients

Nam-Su Chung

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**Backgrounds and Introduction:** Over the last few decades, great progress has been made in the biomechanical analysis and surgical treatment for adult spinal deformity (ASD). SRS-Schwab classification, established in 2012, remains the standard criteria in understanding ASD based on the concepts of spinal alignment, balance, and compensation. However, the SRS-Schwab classification is merely focused on the deformity in the sagittal plane, not the deformity in the coronal plane. As a result, spine surgeons have met another challenge of postoperative coronal imbalance.

**Main Body:** Postoperative coronal imbalance is measured by the displacement of C7 plumb line form the mid-sacrum. The cutoff values are reported differently as 2 to 5 cm, and the evaluation time is also various as at the postoperative 2 weeks, 3 months, or 2 years. Because global correction of coronal deformity cannot induce a compensation mechanism at the proximal and distal segment, the remained deformity can lead to the postoperative coronal imbalance by the "take-off" phenomenon. The incidence was about 20 to 30% based on the study population.

1) Risk factors

Unmatched correction between the main curve and fractional curve would cause the postoperative coronal imbalance. Risk factors were analyzed in terms of the preoperative curve pattern and the postoperative reconstruction pattern. Preoperatively, Bao type C and curve magnitude are consistently reported to be associated with postoperative coronal imbalance. Postoperative remaining deformity, especially at the fractional curve (L4, Lt tilt) is associated with postoperative coronal imbalance.

2) Clinical impact

Clinical implication of postoperative coronal imbalance remains controversial. The different result might come from the different study participants and cut-off criteria. A recent multicenter study demonstrated that the target coronal realignment threshold is 3 cm for minimal disability (ODI<20).

**Conclusions:** Postoperative coronal imbalance is obviously a poor surgical result. Preoperative evaluation of ASD should include the coronal alignment, balance, and compensation. Harmonious correction of the main curve and fractional curve is mandatory for coronal balance maintenance.

**Keywords:** Adult spinal deformity, Degenerative lumbar scoliosis, Postoperative coronal imbalance, Surgical outcome, Correction

## Combined Anterior-Posterior Approach in the Treatment of Adult Spinal Deformity

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**Backgrounds and Introduction:** Adult spinal deformity (ASD) is a high degree of surgical complexity in the elderly patient with various medical comorbidities and high incidence of complications. Owing to the complexity of ASD, the surgical procedure for its treatment should be decided while considering various factors such as perioperative mobility of the patient. Well established techniques of deformity correction are posterior-based bony osteotomies, which is very effective, powerful surgical techniques for correcting severe, stiff coronal or sagittal plane deformities but are associated with significant morbidities. Recently, combined anterior-posterior (A-P) surgery has been performed as an alternative corrective strategies to posterior only surgery.

**Main Body:** Surgical treatment of ASD should aim at the restoration of age-specific alignment to improve the health-related quality of life (HRQoL), while also considering patient's comorbidities and risk factors associated with frequently encountered minor, occasional, and unfortunately catastrophic complications. Access to the anterior column of spine by surgical intervention of combed A-P surgery has excellent advantages compared with the conventional posterior approach; It offers better access to the intervertebral disc than posterior approaches, allowing the insertion of a large cage and improvement of fusion rate. Placement of a large cage increases disc height is effective for the restoration of coronal and sagittal plane deformities and offering indirect nerve decompression. Use of ACR technique has emerged as a powerful technique for spinal deformity correction that may replace 3 column osteotomies via posterior only approach. Additionally, ASD patients with severe deformity should be performed to additional various osteotomies during the additional posterior open surgery. Fusion level also may be shortened at the second staged operation at the check of MRI after anterior surgery.

**Conclusions:** Combined A-P surgery for the treatment of ASD is useful technique for correcting both coronal and sagittal deformities, offering indirect nerve decompression, shortening the fusion level and reducing perioperative morbidities.

**Keywords:** Adult spinal deformity, Combined anterior-posterior surgery, Surgical strategy

## Revision Strategies in Sagittal Malalignment Combined with Previous Lumbar Fusion

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**Backgrounds and Introduction:** Elective lumbar fusion surgeries are increasing due to the increasing prevalence of spinal pathologies, improved understanding of indications for spine surgical treatment, and improvements in perioperative care for elderly patients with multiple comorbidities. However, with the increase in lumbar fusion surgeries, revision spinal surgeries are also on the rise due to stenosis,

non-union, implant failure, infection, adjacent segment disease and flat back deformity. In particular, revision surgery for adult spinal deformity (ASD) patients with sagittal malalignment, which occurs after previous spinal fusion surgery, is technically challenging and carries a higher risk of surgery-related complications.

**Main Body:** Posterior osteotomies including pedicle subtraction osteotomy (PSO), combined anterior and posterior approaches, single-level lordotic cages or multi-level interbody cages, and multi-rod complexes are some of the rescue techniques that surgeons should handle in order to effectively manage revision surgery for ASD patients with sagittal malalignment. Among the options of revision surgery for ASD, PSO is one of the most powerful methods for achieving ideal lumbar lordosis correction, which is fundamental for obtaining and maintaining optimal sagittal balance. However, there remain challenges originating not only from the complexity of the procedure itself but also from complications. Accordingly, methods of increasing the construct stability by improving lumbosacral fusion by combining sacropelvic fixation with long fusion to reduce the complications during deformity correction and the method of load sharing by posterior reinforcement at the PSO site with multiple-rod constructs have been introduced. And an interest on minimally invasive lateral lumbar interbody fusion (LLIF) has been growing, because it allows rounder lordosis correction and decreases complications. Recent studies reported that patients underwent multilevel LLIF with posterior column osteotomy using a stiff rod to treat severe sagittal imbalance, resulting in sagittal balance and lordosis correction at similar levels as obtained from PSO. However, there remains a paucity of literature regarding proper revision surgery technique and method, and long-term follow-up.

**Conclusions:** Revision strategies in sagittal malalignment combined with previous lumbar surgery are challenging fields, and revision surgery should be always carefully planned. Proper patient classification and selection of surgical technique are important in achieving satisfactory outcomes for these patients.

**Keywords:** Adult spinal deformity, Lateral lumbar interbody fusion, Multi-rod construct, Pedicle subtraction osteotomy, Revision strategy, Sacropelvic fixation

# Invited Lecture III

## Less Invasive Laminoplasty and Its Application in Cervical Spondylotic Myelopathy

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**Backgrounds and Introduction:** Cervical spondylotic myelopathy (CSM) is a common degenerative condition that affects the cervical spine, leading to a progressive decline in neurological function, which often need surgical intervention. The conventional surgical approaches including long segments anterior decompression with fusion, laminectomy with posterior instrumented fusion, and laminoplasty. The advantages and disadvantages of these methods are briefly discussed, emphasizing laminoplasty's benefits in preserving motion, preventing perineural fibrosis, and avoiding late kyphosis, against potential postoperative challenges like neck pain and C5 palsy.

**Main Body:** The specifics of laminoplasty was introduced, tracing its evolution from Oyama's expansive lamina-Z-plasty in 1972, Hirabayashi's open door laminoplasty in 1977, Kurokawa's French door laminoplasty in 1982, to the introduction of titanium miniplate augmentation by O'Brien in 1996. The criteria of selecting patients for laminoplasty include those with multilevel cervical stenosis but without segmental instability, kyphosis, major anterior pathology, or preoperative neck pain. The outcomes of conventional expansive open-door laminoplasty (cEOLP) and less invasive modified laminoplasty (mEOLP) were compared . The modified techniques include unilateral muscle dissection, cutting the spinous processes from C3 to C6 to approach the opposite side, creating bony gutter more medially, partial laminectomy, and miniplate fixation securing the elevated laminae from C3 to C6. The semispinalis cervicis was repaired and C7 spinous process preserved. Through detailed statistical data, it highlights improvements in JOA and Nurick scores, demonstrating the surgical technique's effectiveness in enhancing patient recovery while minimizing complications such as C5 palsy and kyphotic changes. This less invasive technique was developed since 2011,

aiming at reducing surgical dissection, preserving paraspinal musculature, and decreasing postoperative neck pain and muscle atrophy.

**Conclusions:** The conclusion summarizes the key findings of the study, stating that mEOLP is a less invasive and effective surgical method for treating MCSM. It effectively decreases postoperative complications such as axial neck pain and loss of ROM while maintaining improvements in cervical lordosis and reducing the incidence of C5 nerve palsy. The study suggests that further research with a larger patient cohort and longer follow-up is necessary to fully understand the benefits of the modified technique.

**Keywords:** C5 palsy, Less invasive surgical method, Modified expansive open-door laminoplasty, Multiple-level cervical spondylotic myelopathy, Postoperative axial neck pain

# Free Paper: Deformity (1)

## Comparative Study for Osteoporosis Treatment Between Teriparatide and Denosumab Following Adult Spinal Deformity Surgery in Osteoporosis Patient: A Prospective, Randomized Controlled Trial

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**Purpose:** The purpose of this ramdomized controlled trial was to compare the incidence of Proximal junctional kyphosis (PJK) in patients with osteoporosis receiving teriparatide or denosumab after adult spinal deformity (ASD) surgery.

**Materials and Methods:** Each 32 ASD patients were randomly assigned to parathyroid hormone group and denosumab group. The treatment with teriparatide or denosumab for both groups was conducted from three months before surgery to three months after surgery, based on the standard regimen for each medication. The primary outcome of this trial was the occurrence of PJK or proximal junctional failure (PJF) within one year post adult spinal deformity surgery. Secondary outcomes included patient-reported outcomes (PROs), bone mineral density (BMD), and dual-energy X-ray absorptiometry (DEXA) t-score.

**Results:** In the primary outcome, regarding PJK incidence, the teriparatide group had a lower rate of 16.7%, compared to 30.8% in the denosumab group, but this difference was not statistically significant (p=0.243 in a modified intention to treat analysis). However, for PJF incidence, the teriparatide group exhibited a significantly lower rate of 0.0%, as opposed to 19.2% in the denosumab group (p=0.024 in modified intention to treat). In the secondary outcome, at the 1-year follow-up, there were no significant differences in hip Bone Mineral Density (BMD) and DEXA t-score between the two groups. Postoperatively, the teriparatide group showed a significantly lower score in the Visual Analog Scale (VAS) for back pain and a significantly higher score in EQ-5D and SRS-22 pain score. There were no significant differences in other patient-reported outcome measures.

**Conclusions:** In patients with osteoporosis undergoing ASD surgery, the rate of PJF was lower in those receiving teriparatide treatment compared to those receiving denosumab treatment. In terms of patient-reported outcomes related to pain, patients who received teriparatide treatment showed better results compared to those who received denosumab treatment.

**Keywords:** Teriparatide, Adult spinal deformity, Proximal junctional kyphosis, Proximal junctional failure, Osteoporosis

## Adolescent Idiopathic Scoliosis: Is the Feasible Option of Minimally Invasive Surgery using Posterior Approach?

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**Purpose:** There is some conflicting data on minimally invasive scoliosis surgery (MISS) in adolescent idiopathic

scoliosis (AIS) compared to conventional open scoliosis surgery (COSS). Therefore, this study was to perform a systematic review and meta-analysis of previous studies on MISS in AIS.

**Materials and Methods:** A systematic literature search was conducted in Medline, Embase, and Cochran library, including studies reporting outcomes for MISS in AIS. The meta-analysis compared the operative, radiological, and clinical outcomes and complications between MISS and COSS in AIS.

**Results:** Of the 208 records identified, 15 nonrandomized studies with 1,369 patients (reviews and case reports are excluded) are finally included in this systematic review and meta-analysis. The mean scale was 6.1, and 8 of the included studies showed satisfactory quality using the Newcastle–Ottawa scale. For operative outcomes, MISS had significant benefits in terms of estimated blood loss (standard mean difference [SMD]; -1.87; 95% CI: -2.94 to -0.91) and hospitalization days (SMD -2.99; 95% CI: -4.45 to -1.53) compared to COSS. However, COSS showed significant favorable outcomes for operative times (SMD 1.71; 95% CI: 0.92 to 2.51). No significant differences existed for radiological outcomes, including Cobb's angle of the main curve and thoracic kyphosis. For clinical outcomes, MISS showed significant benefits on VAS (SMD -0.91; 95% CI: -1.36 to -0.47). Overall complication rates of MISS were similar to that of COSS (SMD 0.96; 95% CI: 0.61 to 1.52).

**Conclusions:** The MISS using posterior approach provides equivalent radiological and clinical outcomes, and complication rates compared to COSS. Considering the lower estimated blood loss, shorter hospitalization days, but longer operative times in MISS, COSS is still the mainstay of surgical treatment in AIS but MISS using posterior approach is also one of surgical options as surgeon's choice in the case of moderate AIS.

**Keywords:** Adolescent idiopathic scoliosis, Minimally invasive scoliosis surgery, Conventional open scoliosis surgery

## Pedicle Screw Migration and Loosening after Long Segments of Lumbosacral Fusion Stopping at L1 or L2

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**Purpose:** To analyze the risk factors that are associated with the pedicle screw migration and loosening after long segments of lumbosacral fusion stopping at L1 or L2

**Materials and Methods:** We enrolled patients who underwent fusion surgery from the lumbosacral region to the upper lumbar level (L1 or L2) for degenerative lumbar disease. The diagnostic criteria for screw loosening developed by plain radiograph include the radiolucent area (thicker than 1 mm) around the screw. Screw migration was defined as a significant movement of screws including angle change, pull-out, and endplate penetration. Patients were separated into "complicated" and "non-complicated" groups based on the presence or absence of any screw loosening or migration. Radiological variables were assessed by the sagittal parameters; lumbar lordosis (LL), sagittal vertical axis (SVA), and pelvic incidence (PI). The PI-LL mismatch was defined as a PI-LL more than 10 degrees. Operative factors included the operation methods and interbody fusion of the uppermost segment.

**Results:** We analyzed 102 patients with a mean age of 68.5 years. A total of 30 patients (29.4%) were included in the complicated group (17 screw migration cases and 13 screw loosening cases), of which five patients finally required additional fusion extension to the thoracic spine. The complicated group showed significantly smaller LL (30.2 degrees, p=0.008) and greater SVA (65.6mm, p=0.012) at immediate postoperative radiograph than those of the non-complicated group (35.3 degrees and 45.4mm). The complicated group showed a significantly higher rate of postoperative PI-LL mismatch (89.7%, p=0.011) and a lower rate of interbody fusion at the uppermost segment (43.3%, p=0.031) than the non-complicated group (64.1% and 77.8%). A multiple logistic regression analysis identified two independent risk factors; the absence of interbody fusion at the uppermost segment (odds ratio (OR) 6.12, p=0.012) and the PI-LL mismatch (OR 3.94, p=0.019).

**Conclusions:** Screw loosening and migration were observed in 29% of patients (30/102) following long segments of lumbosacral fusion stopping at L1 or L2 for degenerative lumbar disease. The upper lumbar region of L1 or L2 does not appear to be an ideal upper end of a long segments lumbosacral fusion. The interbody fusion for the uppermost segment and a sufficient correction of sagittal balance (PI-LL <10 degrees) may help prevent these complications.
**Keywords:** Pedicle screw, Complication, Screw loosening, Screw migration, Upper instrumented verterbrae

## The Impact of Patient Age on Surgical Outcomes in Adolescent Idiopathic Scoliosis: A Comprehensive Analysis

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**Purpose:** This study uniquely investigates the impact of a patient's age at the time of adolescent idiopathic scoliosis (AIS) surgery on both radiological and clinical outcomes, with the aim of optimizing clinical decision-making.

**Materials and Methods:** This retrospective study comprised 168 consecutive AIS patients meeting rigorous inclusion criteria, including Lenke type 1A classification, Cobb's angle within 45-80 degrees, one-stage posterior approach, exclusive use of all-pedicle-screws instrumentation, and a mandatory minimum 2-year post-surgery follow-up. We conducted a comprehensive analysis of patient demographics, surgical details, radiological parameters, and clinical outcomes using the validated Scoliosis Research Society-22 questionnaire. Statistical analyses encompassed chi-square tests, two-tailed Student's t-tests, as well as both simple and multiple regression analyses to elucidate variables affecting post-surgery radiological and clinical outcomes.

**Results:** In this study, 168 patients were categorized into two groups: 37 (Y-14) and 131 (O-14). Both groups had a notable proportion of female patients: 94.6% in Y-14 and 87% in O-14. Significant differences existed in height ($p<0.001$, $\beta=-0.261$), weight ($p<0.001$, $\beta=-0.165$), and operation time ($p=0.017$, $\beta=-0.157$) between groups, with no disparities in EBL, LOS, or fusion levels. Radiological comparisons revealed a significantly greater main thoracic curve ($p<0.001$, $\beta=6.36$) and thoracolumbar/lumbar curve ($p=0.007$, $\beta=3.82$) in Y-14. Main curve flexibility was also higher in Y-14 ($p=0.026$, $\beta=6.53$). The main curve correction rate demonstrated significant differences favoring the Y-14 group in the immediate postoperative period ($p<0.001$, $\beta=5.76$), 2 years postoperative ($p<0.001$, $\beta=6.67$), and the final postoperative period ($p<0.001$, $\beta=6.33$). Simple regression analysis identified age ($p<0.001$, $\beta=-0.784$), height ($p=0.007$, $\beta=-0.261$), weight ($p=0.047$, $\beta=-0.165$), and main thoracic curve (bending) ($p=0.031$, $\beta=-0.157$) as significant factors. Conversely, main curve flexibility exhibited a significant positive effect ($p=0.004$, $\beta=0.129$). Multiple regression analysis confirmed age as the sole significant negative predictor ($p=0.014$, $\beta=-0.203$) for the main curve correction rate.

**Conclusions:** This study underscores the critical role of timing in AIS surgery. Patients undergoing surgery during early to mid-adolescence (Y-14) exhibit superior surgical outcomes, characterized by higher main curve correction rates and improved radiological parameters.
**Keywords:** Adolescent idiopathic scoliosis (AIS), Surgical outcomes, Patient age, Radiological parameters, Clinical decision-making

## Mid- to Long-Term Radiological and Respiratory Outcomes Following Surgery for Older Early-onset Scoliosis Patients with Marfan Syndrome

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**Purpose:** For patients with early-onset scoliosis (EOS),

growth-friendly surgery (GFS) offers a means to acquire sufficient thoracic height. The final thoracic height correlates with final forced vital capacity. However, controversy remains regarding the optimal treatment strategy for older patients with EOS. This multicenter cohort study aims to elucidate the mid- to long-term radiological and respiratory outcomes of older patients with Marfan syndrome and EOS and to gain insights that can inform the optimal treatment for this population.

**Materials and Methods:** We retrospectively analyzed patients with Marfan syndrome and EOS from six institutes in Japan who underwent index surgery between the ages of 7 and 11 years with a final follow-up at or beyond 16 years of age. The primary outcomes were final thoracic height and final percentage of predicted vital capacity (%VC) among patients who underwent pulmonary function tests (PFT) at or beyond 16 years of age.

**Results :** We identified 21 patients (six males and 15 females) with a mean age of 9.9 years and mean follow-up period of 149.3 months. Among them, 15 patients underwent primary definitive fusion (PF), while six underwent GFS. The mean preoperative and final T1–T12 heights were 204.0 mm and 248.0 mm, respectively. Final PFT results were available for 16 patients, and the mean final %VC was 54.0%, with ten patients exhibiting a final %VC of <60%. A significant moderate association was observed between the final T1–T12 height and final %VC (R2=0.48, P=0.003). The predicted final T1–T12 height required for a final %VC of 60% was approximately 260 mm. Comparing the GFS and PF groups, the gain in T1–T12 height was approximately 15 mm more in the GFS group than in the PF group (55.0 mm vs 39.5 mm). Eight unplanned returns to the operating room (UPROR) were identified in three cases among the GFS group, whereas six UPROR in five cases were identified among PF group.

**Conclusions:** Although most older patients with Marfan syndrome and EOS acquired a considerably large final T1–T12 height, it appears that a larger thoracic height was required for satisfactory respiratory function in many cases. Hence, GFS may be indicated even in this population, despite a high incidence of complications.

**Keywords:** Marfan syndrome, Scoliosis, respiratory function, thoracic height, growth-friendly surgery

# Free Paper: Deformity (2)

## Effect of Sacral Slanting on Coronal Spinal Balance and Residual Curve after Correction of Structural Lumbar Curve in Patients with Adolescent Idiopathic Scoliosis: 5-Year Follow-up Results

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**Purpose:** The study aims to elucidate the fate of distal remaining segments and coronal balance in AIS patients with sacral slanting after fusion to L3 and L4 over 5-year follow-up period.

**Materials and Methods:** We studied AIS patients undergoing surgery to L3 and L4 with a 5 to 10-year follow-up at a single hospital. We measured radiologic outcomes, including sacral slanting, C7-CSVL (Central sacral vertical line), disc wedge (angle between LIV and LIV +1) and clinical outcomes using SRS-22 questionnaire both pre and postoperatively. The study compared outcomes between the LIV L3 group and the LIV L4 group. Additionally, Sub-analyses were conducted within the LIV L3 group and LIV L4 group, comparing patients with a high slanting group(pre sacral slanting ≥5°) and a low slanting group (<5°)

**Results:** A total of 118 patients were followed up for 5 years and among them, 34 patients followed up for 10 years. LIV L3 group was 82 individuals, while LIV L4 group had 36 individuals. Preoperative sacral slanting and C7-CSVL did not show a significant difference between the two groups except for disc wedge (LIV L3 group 4.8° , L4 group 8.6°, $p<0.05$). In the sub-analysis of LIV L3, There was no significant difference in C7-CSVL. However, for disc wedge at 5-year follow-up, 3.8±2.4° in the high slanting group and 2.5±2.0° in the low slanting group, and at 10-year follow-up, 5.0±2.5° and 3.1±2.3°, respectively ($p<0.05$). In the sub-analysis of the LIV L4, the high slanting group showed a significant increase in C7-CSVL over time, 9.9mm at 2-year and 13.3mm at 5-year post-surgery. Moreover, C7-CSVL in the high slanting group was significantly larger than in the low slanting group at 5 and 10-year postop. In clinical scores, A notable change of -0.51 in SRS-satisfaction scores was

observed at the 5-year follow-up in the group experiencing coronal decompensation compared to their pre-op scores.

**Conclusions:** It appears that with a higher preoperative sacral slanting, choosing LIV L3 leads to distal adding on, and selecting LIV L4 results in coronal decompensation that tends to increase over time. When coronal decompensation occurs, there is an observed decrease in SRS-satisfaction score. Surgeons may benefit from considering these factors.

**Keywords:** Adolescent idiopathic scoliosis, Sacral slanting, Adding on, Coronal decompensation

## Posterior Selective Thoracolumbar or Lumbar Fusion in Patients with Adolescent Idiopathic Scoliosis: New Criteria for Successful Correction

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**Purpose:** Selective Lumbar Fusion (SLF) feasibility in Lenke 5C cases lacks clear indications, presenting challenges. The intricate task of predicting spontaneous thoracic curve correction (STCC) and managing potential aesthetic concerns arising from a remained thoracic curve underscores the complexity and possible coronal decompensation. Traditionally, guidelines have suggested SLF for thoracic curves measuring <30-40 degrees, bending <20-25 degrees, TL/L:T ratio >1.25, primarily based on outcomes from anterior surgery. Therefore, this study aims to explore new criteria for achieving successful correction in posterior surgery.

**Materials and Methods:** A retrospective analysis of 62 patients undergoing selective lumbar fusion with a posterior pedicle screw construct was conducted. Excluding non-adolescent idiopathic scoliosis (AIS) cases, the study defined two groups based on STCC at 2 year post-surgery: Uncorrected (STCC≤50%) and Corrected (STCC>50%). The study compares pre- and postoperative radiological parameters as well as SRS-22 scores between the two study groups.

**Results:** Among the 62 patients, 23 were in the Uncorrected group, and 39 were in the Corrected group. The mean age was 16.0 years, and the average follow-up duration was 4.7 years. Postoperatively, the Corrected group exhibited a substantial reduction in the thoracic curve (23.44±5.89 to 6.31±5.16 degrees) compared to the Uncorrected group (24.57±8.37 to 13.3±5.90 degrees, $p<0.05$). While preoperative thoracic curves and TL/L curves were similar, significant differences were noted in thoracic bending curves (13.60±6.52 vs. 9.69±6.34, $p<0.05$). In addition, significant differences were noted in AVT of thoracic (9.88±5.77 vs. 5.50±4.73, $p<0.05$) and AVT TL/L:T (8.92±10.02 vs. 21.69±31.09, $p<0.05$). At one-year follow-up, SRS-22 scores showed notable significant difference in the Self-image (2.07±0.35 vs 3.75±0.84, $p<0.001$) domains.

**Conclusions:** In summary, our findings indicate an inverse correlation between preoperative thoracic curve flexibility and Thoracic AVT with postoperative STCC and subsequent patient satisfaction in posterior SLF cases. Given these insights, opting for a more extensive long-level fusion strategy emerges as a prudent choice to optimize outcomes in this patient cohort.

**Keywords:** Selective thoracolumbar fusion, Selective lumbar fusion, Adolescent idiopathic scoliosis, Spontaneous thoracic curve correction

## Medial Pedicle Wall Referencing Extra-pedicular (EP) Screw Insertion Technique in Narrow Dysplastic Pedicles during Posterior Spinal Fusion (PSF) in Adolescent Idiopathic Scoliosis (AIS) Patients

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**Purpose:** Conventional extra-pedicular (EP) screw technique has several limitations such as high medial convergence angle which could increase the difficulty of entry into vertebral body leading to anterior perforation. Lateral entry point of conventional technique requires excessive dissection and could lead to malalignment of the screw heads when EP screws are placed next to intra-pedicular

screws. The objective of this study is to describe a novel technique of medial pedicle wall referencing EP screw insertion method that has a more medial entry point and less convergent trajectory (inserted along pedicle axis) compared to conventional technique. Besides that, we would like to compare the EP chord length of this technique with the conventional technique in AIS patients and report the accuracy of the technique based on computed tomography (CT) assessment.

**Materials and Methods:** Retrospective study whereby 103 patients undergoing Posterior Spinal Fusion (PSF) from 2018 to 2023 were recruited. 2472 thoracic pedicles were analysed on pre-operative CT scan and classified based on Chiu et al. classification. Conventional EP chord length and medial pedicle wall referencing technique EP chord length was measured for all narrow dysplastic pedicles (Type C and D). Post-operative CT scan was used to assess medial perforations using Gertzbein and Robbins classification modified by Rao et al. Anterior perforations were reviewed using Hansen-Algenstaedt et al. grading. Categorical data were analyzed using Pearson Chi-square test. Paired T-test was used to compare continuous data and p-value of <0.05 denoted as statistical significance.

**Results:** The prevalence of narrow dysplastic pedicles in our cohort was 31.3%. Mean EP chord length of this technique was significantly shorter compared to conventional technique. The longest chord length in conventional technique was recorded in left T8 (53.7±3.5 mm) and T9 (53.7±3.7 mm) in contrary with mean left T8 and T9 chord length using the medial pedicle wall referencing technique which was 38.6±3.2mm and 38.3±3.2mm respectively (p<0.001). Total of 434 EP screws were inserted using this technique. 24.4% had medial grade 1 and 4.1% had anterior grade 1 perforations. Only 0.7% grade 2 perforations were found (medial: 0.2%, anterior: 0.5%). None of the perforations were symptomatic and no grade 3 perforations were noted.

**Conclusions:** Medial pedicle wall referencing EP screw insertion technique is a safe alternative method especially in narrow dysplastic pedicles. This technique has shorter chord length and less convergent trajectory with low anterior perforation rate.

**Keywords:** Extra-pedicular screw, Narrow dysplastic pedicles, Medial pedicle wall referencing technique

## A Long-Term Evaluation of Adolescent Idiopathic Scoliosis Deformity Correction based on Lenke Types and Patient's Age at Orthopaedic Hospital Surakarta: Study of 22 Cases in 1 Year

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**Purpose:** Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity with potential adverse long-term physical and psychological impact on young patients. AIS is the most common scoliosis with 0.9 – 12% incidence rate which occurs between 10 to 18 years old. Approximately 10% of AIS patients need to be treated. In order to achieve best result on both subjectively and objectively, multiple approach has been performed from conservative treatment to surgery treatment. This study will provide about the correlation between age and the type of the curves and its' effect on the correction of the deformity both subjectively and objectively in our facility.

**Materials and Methods:** A retrospective, cohort study of scoliosis patients with the inclusion and exclusion criteria has been determined who underwent surgery from January 2022 – December 2022 at Orthopaedic Hospital Surakarta. The patients were grouped into three based on their age. Then, we measure the Cobb's angle before, immediate after and at approximately one year follow-up after surgical procedure to evaluate whether there's an improvement of the Cobb's angle or any loss of correction after deformity correction. The patients also been given questionnaire to assess their satisfaction toward the correction.

**Results:** We evaluate a total of 23 patients whom met the inclusion criterias. The average age was 16 yo. Average Cobb's angle pre-surgery was 64,83±26,51° (29-121°), and post-surgery was 32,47±20,93° (11-60°) in group A (12-13 yo); 54,74±25,42° (30-119°), post-surgery was 32,47 ±20,93° (11- 82°) in group B (14-15 yo); and 69,82±24,31° (30- 121°), post-surgery was 32,47± 20,93° (11-82°) in group C (>15 yo). In Lenke type 1 patients predominantly has fair satisfaction outcome, whereas on Lenke type 2-6 predominantly has good satisfaction outcome from the questionnaire. Choudhry et.al suggested correction percentage was 62% in AIS patients. This study showed the correction 46-59% of the initial Cobb's angle. Kamtsiuris

discovered a prevalence of "adding-on" phenomenon is 6.511.1%. However, there was none in our one year follow-up.

**Conclusions:** In this study, there was a significant correlation between age with the correction outcome, but there was no significant correlation between Lenke type with the correction outcome. There is still limitations and room for further improved research in our study.

**Keywords:** Scoliosis, Age, Deformity, Correction, Satisfaction

### Thoracic Paravertebral Block for Postoperative Pain Control in Adolescent Patients with Scoliosis

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**Purpose:** Posterior correction and fusion are standard surgeries for scoliosis, but they are accompanied by significant blood loss, large scars, and intense postoperative pain. We aimed to evaluate the efficacy of thoracic paravertebral block (TPB) in reducing postoperative pain associated with posterior scoliosis surgery.

**Materials and Methods:** This study was a prospective study. Randomly selected patients of the TPB group are performed TPB with 0.2% ropivacaine on both sides. In contrast, TPB is not performed in the control group. Fifteen patients were enrolled in the TPB group, while the control group consisted of fourteen scoliosis patients. After correction and instrumentation, the surgeon performed TPB at every other thoracic root from the upper instrumented vertebra, as many as possible levels with an anesthesiologist. A 25G spinal needle was inserted through the transverse process of the spine, ensuring passage within 1cm and traversing the costotransverse ligament. After confirming the needle's placement, blood absence was confirmed via aspiration. Then, TPB was performed on each side, ensuring that the maximum dosage of ropivacaine was not exceeded. The VAS (Visual Analog Scale) and IV PCA (Intravenous Patient-Controlled Analgesia) dosages were compared between the two groups after surgery.

**Results:** There were no differences in age, sex, or body mass index between the groups. The flexibility (51.2±24.7%) and correction rate (67.0±14.4%) in the TPB group showed no statistical difference compared to the control group (48.1±28.1% and 65.2±19.5%, respectively; $p>0.05$). Pain scores at pre-operation, postoperative 6 hours, postoperative 12 hours, and postoperative 24 hours showed no significant differences ($p>0.05$). However, the postoperative 1-hour pain score was significantly lower in the TPB group (2.9±2.4) compared to the control group (5.7±2.4) ($p=0.004$). MEPs disappeared in one patient of the TPB group, but SEPs remained unchanged, and there were no neurological issues after awakening from anesthesia.

**Conclusions:** TPB is an effective technique for immediate postoperative pain control following posterior correction and fusion in scoliosis patients. A multimodal pain medication approach may be essential to sustain decreased pain scores.

**Keywords:** Scoliosis, Posterior fusion, Thoracic paravertebral block, Pain

## Free Paper: Deformity (3)

### Risk Factors of Adjacent Segment Disease after Short-Segment Fusion in Patients with de Novo Degenerative Lumbar Scoliosis

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**Purpose:** Short-segment fusion (SSF) is an effective surgical option for appropriately selected patients with de novo degenerative lumbar scoliosis (DNDLS). Considering that DNDLS is frequently accompanied by multi-segment degeneration and potential instability across the entire lumbar segments, it is inevitable that unhealthy segments remain after SSF, thereby increasing the potential risk of adjacent segment disease (ASD) occurrence. Therefore, we aim to identify the risk factors for ASD in patients with DNDLS

who underwent SSF.

**Materials and Methods:** This retrospective study included 80 patients with DNDLS (Cobb angle >10°) who underwent SSF (1 or 2 levels) between December 2010 and July 2018 with a minimum follow-up duration of 5 years. The participants were divided into two groups: ASD and non-ASD. ASD was defined as clinical ASD rather than radiographic ASD. Various patient and operative variables were compared between the groups. Global and regional radiographic parameters (pre- and post-operatively) were also compared between the two groups using plain radiograph and MRI. Consequently, univariate and multivariate analyses were conducted to identify the risk factors for ASD occurrence. The receiver operating characteristic (ROC) curve was used to calculate the cutoff values.

**Results:** The mean age was 67.7±7.2 years at the time of SSF, and there were 62 women (77.5%) enrolled in the study. Thirty patients (37.5%) were in the ASD group and 50 patients (62.5%) were in the non-ASD group. Average time from the surgery to ASD diagnosis was 34.9±28.2 months in ASD group. Thirteen patients required revision surgery at a mean time of 8.8±7.0 months after ASD occurrence. A multivariate logistic regression analysis demonstrated that preoperative disc wedging angle (p=0.001, odds ratio [OR]=1.806, 95% CI=1.255-2.598), presence of facet tropism [defined as ≥10° of facet joint angle between the right and left sides] (p=0.009, OR=5.534, 95% CI=1.528-20.040), and foraminal stenosis ≥grade 2 (p=0.025, OR=5.935, 95% confidence interval [CI]=1.253-28.117) were significant risk factors for ASD development. The cutoff value of the preoperative disc wedging angle was calculated to be 2.5° using the ROC curve.

**Conclusions:** Preoperative disc wedging angle ≥2.5°, presence of facet tropism, and foraminal stenosis ≥grade 2 were identified as significant risk factors for ASD development after SSF in patients with DNDLS.

**Keywords:** De novo degenerative lumbar scoliosis (DNDLS), short-segment fusion, Adjacent segment disease (ASD), Risk factor

## Fused Spinopelvic Angles: Determining the Overcorrection Threshold to Prevent Proximal Junctional Kyphosis

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**Purpose:** Proximal junctional kyphosis (PJK) is a common complication that can occur after surgical treatment for ASD. However, there is still no consensus on how the degree of correction of lumbar lordosis (LL) affects PJK. Recently, a novel and fixed parameter known as the fused spinopelvic angle (FSPA) has been introduced as a method for preventing PJK. In this study, our goal is to determine the threshold of overcorrection using FSPA and validate its effectiveness.

**Materials and Methods:** We retrospectively selected 258 consecutive patients (mean age 71.4 years) with a minimum 2-year follow-up who underwent long segment fixation with sacropelvic fixation. A comparative analysis was performed by dividing the patients into two groups: the non-PJK group (n=135) and the PJK group (n=123). Pearson's correlation coefficient was used to analyze the relationship between parameters, while linear regression analysis and a multivariate logistic regression model were conducted to identify the risk factors for PJK and assess the upper limit of overcorrection.

**Results:** The PJK group exhibited significantly more negative postoperative FSPA (4.9° vs. -0.3°, p<0.05). Logistic regression analysis identified the FSPA as a crucial risk factor for PJK (p<0.05). In ROC curve analysis aimed at preventing PJK, the target value for FSPA was determined to be 2.38°. The FSPA has a strong positive correlation with the postoperative pelvic incidence (PI)-LL (r=0.516, p<0.001). A linear regression model revealed a threshold for the postoperative PI-LL, with FSPA exceeding 2.38°, to be -17.6 (r=0.61).

**Conclusions:** We found that in order to prevent PJK after surgical treatment of ASD, it is important to correct FSPA 2.38° or more. Furthermore, achieving an overcorrection where the PI-LL does not exceed -17.6 can result in clinical and radiological improvements after surgery.

**Keywords:** Adult spinal deformity, Fused spinopelvic angles,

Overcorrection, Proximal junctional kyphosis

## Pleural Effusion after Thoracoplasty Accompanying with Minimal Invasive Scoliosis Surgery (MISS) in Scoliosis Surgery: Is Intervention Mandatory?

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**Purpose:** Thoracoplasty by means of multiple rib resections has been used to treat the rib cage deformity in thoracic idiopathic scoliosis. Thoracoplasty is mostly related to significant postoperative self-image improvement. Major concern regarding thoracoplasty is iatrogenic pulmonary complication, such as iatrogenic pneumothorax or hemothorax (pleural effusion). Previous studies report incidence of pleural effusion after thoracoplasty to 40-70%.

**Materials and Methods:** All data were collected retrospectively. All AIS patients operated by minimal invasive scoliosis surgery for adolescent idiopathic scoliosis in our department between January 2014 and September 2023 were reviewed. Patients who has undergone thoracoplasty and had postoperative pneumothorax or hemothorax (pleural effusion) with blunt costophrenic angle in plain chest X-ray was included. For treatment of iatrogenic pneumothorax or hemothorax (pleural effusion), Chest tube insertion (From January 2014 to December 2016), Pigtail insertion (From January 2017 to December 2019), and Thoracentesis (From January 2020 to May 2022) was performed. Conservative treatment without any intervention was done from June 2022 to September 2023, regardless of severity of iatrogenic pneumothorax or hemothorax (pleural effusion). Patient's lung complication was evaluated on plain Chest AP x-rays at postoperative days 1, 3 and decubitus Chest X-ray when pleural effusion was suspected. In parallel, oxygen saturation was recorded 3 times a day. Severity of as iatrogenic pneumothorax or hemothorax (pleural effusion) was evaluated using interpleural distance at decubitus X-ray. Patient's symptom was investigated. All patient's recovery status was evaluated with whole spine X-ray taken at postoperative 3month open clinic follow up.

**Results:** 23 patients underwent chest tube insertion (Group A), 33 underwent pigtail insertion (Group B), 55 uderwent thoracocentesis (Group C), and 39 patients did not have any intervension (Group D). To confirm homogeneity between the groups, age, gender, height, weight, BMI, Cobb's angle, curve type, fusion extent, amout of correction, pre-operative hemoglobin level was compared. There was no difference between the groups. (All p-values>0.50) The interpleural distance in decubitus view was 4.56 cm, 4.67 cm, 4.39 cm, 4.81 cm in Group A, B, C, D each. An average of 275 ml, 298 ml, 215 ml was drained from Group A, B, C each. None of the patients in any group had remained pleural effusion at postoperative 3 months X-ray.

**Conclusions:** In minimal invasive scoliosis surgery, iatrogenic pleural effusion without symptom. after thoracoplasty does not need intervention as thoracentesis, pigtail insertion, chest tube insertion.

**Keywords:** Adolescent idiopathic scoliosis, Minimal surgery, Thoracoplasty, Pleural effusion

## Effects of Screw Density in AIS Surgery on Restoration of Thoracic Kyphosis and Reduction of Rib Hump

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**Purpose:** The literature on correlation between screw density and deformity correction in adolescent idiopathic scoliosis (AIS) surgery is limited. The aim of this study was to compare the radiographic outcomes including thoracic kyphosis and rib hump in the posterior spinal fusions of different screw densities.

**Materials and Methods:** All patients underwent posterior spinal fusions for AIS at a single institute were reviewed. 38 patients with alternate laterality placement and 37 patients

with consecutive placement of pedicle screws met the inclusion criteria. Patient characteristics and radiographic outcomes were compared preoperatively and at least one year follow-up. Independent sample t tests and Mann-Whitney U tests were used between the two groups, and a p-value <0.05 was considered statistically significant.

**Results:** At final follow-up (average 908 days), the mean main thoracic Cobb angle (25.7 vs. 27.0 degrees, p=0.575), thoracic kyphosis (23.4 vs. 22.8 degrees, p=0.734), T1 to T12 length (26.52 vs. 26.88 cm, p=0.351), and rib hump distance (5.78 vs. 5.64 cm, p=0.617) did not differ significantly between the two groups. Compared with the consecutive placement group, there was a decreased rib hump reduction (0.28 vs. 0.76, p=0.026) and decreased rib hump reduction rate (2.7% vs. 11.5%, p=0.021) in the alternate laterality placement group.

**Conclusions:** Both alternate laterality placement and consecutive placement of pedicle screws achieved satisfactory deformity correction in AIS patients. However, the consecutive placement of pedicle screws showed more reduction of the rib hump.

**Keywords** :Adolescent idiopathic scoliosis (AIS), Posterior spinal fusion, Pedicle screws, Screw-density, Rib hump

### The Effect of Hybrid Screw Insertion Technique at the Upper Instrumented Vertebra on Prevention for Proximal Junctional Kyphosis

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**Purpose:** The hybrid screw insertion technique is the surgical method of placing a pedicle screw on one side and a laminar screw on the other side of the upper instrumented vertebra (UIV) in adult spinal deformity (ASD) surgery. We hypothesized that this technique would increase resistance to compression forces and have a preventive effect on proximal junctional kyphosis (PJK) and proximal junctional failure (PJF) by further preserving the trabeculae within the vertebral body.

**Materials and Methods:** The hybrid screw insertion technique was applied in 37 cases of ASD surgery. We compared the PJK and PJF incidence between this experimental groups and the control group, comprised 63 cases in which the conventional method was used for one year before the trial.

**Results:** There were no significant differences in risk factors for PJK and PJF such as age, pre-operative and post-operative spinopelvic parameters, bone mineral density, and body mass index between the experimental and control groups. In groups where the Hybrid technique was used at the UIV (Upper Instrumented Vertebra), compared to the control group that did not use it, there was a statistically significant decrease in the rate of PJK (Hybrid screw group: 8.1%, Control group: 25.4%, p=0.033). However, there were no significant differences in the rate of PJF between the two groups (Hybrid screw group: 0.0%, Control group: 6.3%, p=0.118)

**Conclusions:** The hybrid screw insertion technique is a promising method for preventing PJK in ASD surgery.

**Keywords:** Hybrid screw insertion technique, Proximal junctional kyphosis, Adult spinal deformity, Upper instrumented vertebra

## Best Paper Candidates Presentation I (Domestic)

### Effect of Bone Morphogenetic Protein (BMP) on Time-to-Fusion after One-Level Transforaminal Lumbar Interbody Fusion Surgery (TLIF) Based on the Difference of Bone Density

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**Purpose:** To evaluate the difference of time-to-fusion after one-level TLIF surgery between BMP usage group and non-usage group according to bone density.

**Materials and Methods:** This study aimed to evaluate the outcomes of one-level transforaminal lumbar interbody fusion (TLIF) in patients with degenerative lumbar disease and spondylolisthesis. A total of 132 patients who underwent TLIF surgery from February 2012 to December 2021 were

included in the study. Patients who had undergone multilevel surgery, revision or extension procedures, or had less than 1 year of follow-up were excluded. Patients were divided into osteoporosis, osteopenia, and normal groups based on L1 vertebral body attenuation values in pre-operative CT with cutoff of 90 Hounsfield units (HU) and 120 HU. Radiologic assessment was performed using CT scans, and fusion was categorized into three grades based on the degree of incorporation and remodeling. The time-to-fusion was compared using the Kaplan-Meier method, and Cox proportional hazard model analysis was used to adjust for covariates.

**Results:** The demographic characteristics of the study participants, including age and gender ratio, were similar between the two groups. The fusion rates were found to be higher in the BMP group, with half of the patients achieving fusion in 2.5 years compared to 4 years in the non-BMP group. The exponential coefficient was 3.969 (95% confidential interval: 2.173<e<7.251) so, this difference was statistically significant. Additionally, the BMP group had higher fusion rates in all bone density groups, particularly in patients with osteoporosis. The exponential coefficient was 2.177 (95% confidence interval: 1.355<e<3.499). Subgroup analysis did not identify any specific factors that significantly influenced fusion speed.

**Conclusions:** The median time to fusion was significantly shorter in BMP-usage group than non-usage group on trabecular bone bridging criteria, especially for patients with osteoporosis.

**Keywords:** Bone morphogenetic protein, Transforaminal lumbar interbody fusion, Osteoporosis

## Reoperation Rates According to Surgical Approach After Operation for Degenerative Cervical Pathology in Athetoid Cerebral Palsy Patients: A Nationwide Cohort Study

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**Purpose:** Continuous neck muscle movement causes loosening of instruments, non-union, instability, and progressive kyphosis which leads to clinical aggravation in athetoid cerebral palsy (CP) patients after cervical spine surgery. Overall complication rate of athetoid CP patients undergoing cervical surgery is known to be significantly higher than those without CP. The current study was conducted to compare reoperation and complication rates of anterior fusion, posterior fusion, combined fusion, and laminoplasty performed for degenerative cervical myelopathy/radiculopathy in athetoid CP patients.

**Materials and Methods:** Korean Health Insurance Review and Assessment Service national database was used for analysis. Patients with diagnose of athetoid CP and who underwent cervical spine operation for degenerative cause between 2002 and 2020 were reviewed. Patients were divided into anterior fusion group, posterior fusion group, combined fusion group, and laminoplasty group for comparison.

**Results:** A total of 672 patients were included in the study. Overall revision rate was 21.0% (141/672). Revision rate was the greatest in anterior fusion group (42.7%). Revision rate of combined fusion (11.1%; hazard ratio [HR], 0.371; p<0.001), posterior fusion (13.8%; HR, 0.614; p=0.017), and laminoplasty (13.1%; HR, 0.466; p=0.040) were significantly less than that of anterior fusion, while combined fusion demonstrated the lowest revision rate. Obesity was associated with increased risk for revision (HR, 2.229; p=0.026) while age of >60 years was correlated with decreased risk (HR, 0.286; p=0.034).

**Conclusions:** Anterior fusion was with greatest reoperation risk after cervical spine surgery for athetoid CP patients which reached 42.7%. Therefore, anterior only fusion in athetoid CP patients should be avoided or provided for strictly selected patients. Combined fusion was with lowest revision risk of 11.1% and could Be safely applied to athetoid CP patients

**Keywords:** Reoperation, Cerebral palsy, Cervical myelopathy, Cervical radiculopathy, National database study

## Clinical Importance, Incidence and Impact on Clinical Outcomes for the Persistent Midfoot Strike Gait Following Adult Spinal Deformity Surgery

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**Purpose:** The midfoot strike gait (MSG) is exhibited by adult spinal deformity (ASD) patients, wherein the process of transferring load to the midfoot after heel strike is indistinguishable. The persistence of MSG post-surgery may lead to unsatisfactory outcomes. This study aims to examine changes in the gait pattern in ASD patients before and after surgery, while also assessing the clinical significance of any continued MSG after surgical intervention.

**Materials and Methods:** This study reviewed 177 ASD patients (mean age 70.1 years) who achieved optimal sagittal balance after surgery. Treadmill-based gait analysis including center-of-pressure trajectory and three-foot-zone analysis was conducted before and after surgery. Based on walking patterns after surgery, the patients were classified into the MSG-negative (MN) group (n=115) and MSG-positive (MP) group (n=61). Clinical outcomes, sagittal parameters, and gait analysis results were compared.

**Results:** Both groups exhibited optimal lordosis correction and sagittal balance without significant differences in spinopelvic parameters(PI-LL -17.8° vs. -14.8°; SVA -20.4 mm vs. -16.4 mm). In gait analysis, except step time, stride time, and cadence, all gait parameters showed significant improvement in the MN group ($p<0.05$). The MN group, postoperatively, exhibited a time change in heel-to-forefoot (%) similar to the normal control group (34.2% vs. 34.7%), and the increase in maximum pressure difference applied to the heel and midfoot after surgery was significantly larger in the MN group (2.17 $N/m^2$ vs. 0.36 $N/m^2$, $p=0.005$). In the analysis of factors related to the persistence of MSG, patients walking while looking at the ground had a significantly higher likelihood of persistent MSG (Odds ratio 10.95). At the last follow-up, the MN group had significantly lower VAS for back pain (2.4 vs. 3.5, p=0.042), ODI (15.3 vs. 19.3, p=0.026), and higher SF-36 PCS (50.9 vs. 43.6, p=0.047).

**Conclusions:** Following surgery and the realignment of sagittal balance, clinical outcomes might remain suboptimal if MSG persists, as it may result in pain and limitations in daily activities. Hence, despite achieving satisfactory radiographic outcomes, if the clinical results are unsatisfactory and a consistent pattern of looking down while walking (eyes upon the ground) is noted in MSG, further research and subsequent studies are warranted to explore and implement solutions for this issue.

**Keywords:** Adult spinal deformity, Gait, MIdfoot strike, Clinical outcome

## Bone Turnover Markers Are Risk Factors with Iatrogenic Endplate Injury During Transforaminal Lumbar Interbody Fusion

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**Purpose:** Spine fusion surgeries performed on the bone of osteoporosis patients require careful attention. We experienced the occurrence of endplate injury (EI) though careful attention. EI can occur during the endplate preparation and cage insertion, which can lead to cage retropulsion, cage subsidence. EI have been described in various surgical procedures; however, risk factors for EI during TLIF, have not been well studied. Especially, none have investigated the correlation of bone turnover markers and endplate injuries. The purpose of this study is to proactively identify risk factors for EI, including bone turnover markers, during TLIF procedures.

**Materials and Methods:** We retrospectively reviewed 184 patients (235 spine levels) from 2019 to 2023. All patients got 1 or 2 level misTLIF in one medical center. All demographic factors including sex were checked. Markers related to bone formation and resorption (hip BMD, spine BMD, osteoporosis diagnosis, vitD, osteocalcin, CTX, P1NP, PTH) were reviewed. We also checked the ratio between bone formation markers and bone resorption markers (P1NP/CTX) and analyzed the subgroup related to the combinations of bone turnover markers. Surgical related factors including lumbar level, preoperative disc height, postoperative disc

space height, cage size etc. were collected. EI was defined as endplate infiltration of more than 1 mm observed on PACS CT taken after 2 days of surgery by two orthopedic surgeons. We did the univariate and multivariate regression study about the risk of endplate injury.

**Results:** The rate of EI was around 38% of endplates. The study showed that as we know, sex and osteoporosis diagnosis by BMD were risk factors. In addition, the spine BMD, femur BMD, CTX, P1NP/CTX, preoperative disc height and the gap between preoperative disc height and cage size were risk factors in univariate and multivariate logistic regression analysis. And the subtypes of bone turnover markers showed the different rate of endplate injuries. Odd ratios between difference subtypes were statistically significant using multivariate analysis adjusted for other factors.

**Conclusions:** As we already know, female and low BMD and high gap between preoperative disc height and cage size were independently associated with an increased risk of intraoperative EI. Even though adjusted for sex and bone marrow density, bone turnover markers including CTX and P1NP/CTX ratio showed the relationship with intraoperative EI.

**Keywords:** Bone turnover marker, Osteoporosis, Endplate injury, CTX, P1NP

## Different Neurogenic Bladders in Patients with Cervical and Thoracic Myelopathy: Direct Comparison from a Prospective Case Series

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**Purpose:** Atraumatic compressive myelopathy, affecting the spinal cord in cervical and thoracic regions, often manifests with urinary dysfunctions. The patterns of urinary dysfunction may differ based on the location of compression in the spinal cord. Therefore, this investigation aimed to identify distinctive characteristics of neurogenic bladders and associated symptoms between cervical and thoracic myelopathy patients through clinical surveys and urodynamic studies.

**Materials and Methods:** Patients with atraumatic cervical or thoracic compressive myelopathy and lower urinary tract symptoms (LUTS) scheduled for decompressive surgery were prospectively enrolled in the study. Preoperative urological symptoms were evaluated using the International Prostate Symptom Score (IPSS) and in Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ). A urodynamic study (UDS) was performed one day before surgery to assess the preoperative urological functions. Postoperative symptom improvement was evaluated at postoperative 1 year using IPSS and JOACMEQ. Comparative tests were performed to identify distinctive patterns of urological dysfunction between cervical and thoracic myelopathy patients.

**Results:** A total of 64 patients (51 cervical myelopathy [CM], 13 thoracic myelopathy [PM]) with a mean age of 63.0 years old (31 males, 33 females) were enrolled in this study. As for the UDS, 5 (7.8%) patients, all with CM, had completely normal UDS results despite having subjective LUTS, and the other 59 had at least one or more abnormal findings in UDS. Based on the International Continence Society (ICS) classification, the underactive bladder was significantly more common in TM patients compared to CM patients (69.2% vs. 19.6%, $p<0.001$) Patients with post-void residual urine more than 50 ml was more common in TM patients, although statistically insignificant (30.8% vs. 19.6%). Regarding the questionnaire, voiding symptom scores in IPSS were significantly worse in TM patients (2.97 vs. 1.65, $p<0.001$), whereas the two groups showed no significant difference in storage symptom scores (2.05 vs. 1.73). Among 53 patients who completed questionnaires at postoperative 1-year, 32.6% of CM patients showed improvement in the IPSS grade, whereas only 1 (10%) TM patient had such improvement.

**Conclusions:** In this prospective study, TM patients complained of worse voiding symptoms and showed more underactive bladder in UDS than CM before decompressive surgery. At the postoperative 1 year, more CM patients had subjective improvements in urinary function than TM patients.

**Keywords:** Myelopathy, Urodynamic study, Voiding difficulty

# Best Paper Candidates Presentation II (Domestic)

## Risk of Blood Transfusion after Spine Osteotomy Compared to Fusion Surgery

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**Purpose:** Spinal osteotomy(SO) is a term for techniques used by spinal surgeons to correct spinal deformity. The purpose of this surgery is to establish normal range spinal curvature, relieve pain, and improve quality of life. Although SO has these advantages, it is known that blood transfusion rates are very high because of aggressive procedures and long operation time. Compared with patients who underwent spine fusion(SF) surgery, we analyzed the risk of blood transfusion of SO.

**Materials and Methods:** In this retrospective, nationwide cohort study, the Korean National Health Insurance database from 1 January 2002 and 31 December 2019 was reviewed. The study population included individuals aged ≥50 years who had undergone SO or LSF. Those patients who had undergone previous any spine surgery were excluded. A blood transfusion was defined as a transfusion code within 1 week after surgery. Other risk factors related with blood transfusion were also evaluated.

**Results:** In the SO group, blood transfusions were administered in 72.59% of cases, while in the SF group, transfusions were performed in 52.68% ($p<0.001$). The mean blood transfusion volume was 1,324cc in the SO group and 667cc in the SF group. The blood transfusion risk in the SO group, compared to the SF group, showed a crude hazard ratio (HR) of 1.416 (95% CI 1.317-1.523) and an adjusted HR of 1.311 (95% CI 1.219-1.411). Among patients who underwent SO, the transfusion group exhibited a 7.25% mortality rate at 1 year post-surgery, whereas the non-transfusion group showed a 4.00% rate ($p=0.043$). At 3 years post-surgery, the transfusion group had a mortality rate of 12.43%, and the non-transfusion group had an 8.07% rate ($p=0.062$). However, beyond 5 years post-surgery, there was no apparent difference in mortality rates based on transfusion status.

**Conclusions:** In comparison to the SF group, the SO group had a higher transfusion rate and increased blood transfusion risk. Among patients who underwent SO, those receiving transfusions had a higher early postoperative mortality rate than those without blood transfusions.

**Keywords:** Blood transfusion, Spine osteotomy, Spine fusion, Death risk

## What Are the Optimal Disc Height Changes for Successful Indirect Decompression with OLIF?

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**Purpose:** Oblique lumbar interbody fusion (OLIF) offers indirect decompression of stenotic lesions of the spinal canal and foramen through disc height restoration. The purpose of this study was to evaluate the associated factors for successful indirect decompression by assessing the changes in disc height and spinal canal width.

**Materials and methods:** This study included 63 patients and 104 involved surgical levels who underwent OLIF without direct posterior decompression between 2018 and 2022. The efficacy of OLIF combined with percutaneous pedicle screw fixation for lumbar spinal stenosis on spinal canal and foramen before and after surgery was analyzed up to 1 year. Radiologic parameters were anterior disc height (ADH), posterior disc height (PDH), lumbar lordotic angle (LL), segmental lordotic angle (SL), foraminal height (FH), crosssectional area (CSA) of the thecal sac, cross-sectional foraminal area (CSF), and subsidence (SD). Clinical parameters were visual analogue score (VAS) and Oswestry Disability Index (ODI).

**Results:** The results showed that OLIF combined with percutaneous pedicle screw fixation effectively restored disc height and increased the spinal canal width. Comparing preand postoperative values, the mean CSA increased from

71.61±47.48 $mm^2$ to 92.81±58.64 $mm^2$ and mean left CSF increased from 46.57±14.75 $mm^2$ to 70.27±19.46 $mm^2$ ($p<0.001$). FH increased from 15.23±3.48 mm to 18.78±2.93 mm and was stable for up to 1 year ($p<0.0001$). The VAS leg and ODI scores significantly improved after surgery, indicating a reduction in pain and improvement in functional disability ($p<0.05$). Changes of immediate postoperative and 1-year FH were significantly related to 1 year ADH, PDH, and VAS leg changes ($p<0.05$). The group showing 1-year FH improvement (positive(+) group) demonstrated significantly larger immediate postoperative ADH and PDH changes compared with the FH negative(-) group (6.46 mm vs. 4.52 mm, $p=0.038$; 3.59 vs. 2.40, $p<0.001$, respectively). The CSF positive(+) group also showed significantly higher immediate postoperative ADH and PDH changes (6.24 mm vs. 4.55 mm, $p=0.043$; 3.00 vs. 1.57, $p=0.010$, respectively).

**Conclusions:** OLIF provided satisfactory indirect decompression with significant improvement of measured parameters for up to 1 year. Considering the increase of foraminal height, we recommend more than 3.0 mm of immediate postoperative PDH increase, avoiding over-distraction of disc space.

**Keywords:** Oblique lumbar interbody fusion, Indirect decompression, Posterior disc ehgith restoration

## Are Being Overweight Preventive to Fracture Occurrence? Age and Site-dependent Different Associations Between Body Mass Index and the Incidence of Hip and Vertebral Fractures

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**Purpose:** Hip and vertebral fractures are major risk factors for rapidly deteriorating quality of life in older patients. Lower body weight is a well-known risk factor of osteoporotic fractures in both men and women. However, no population-based studies have reported the effects of age- and sex-adjusted body weight on hip and vertebral fractures. This study investigated the effects of body mass index (BMI) and age on the incidence of hip and vertebral fractures in a South Korean population.

**Materials and Methods:** The participants underwent regular nationwide health checkups conducted by the Korean National Health Insurance Service in 2009. Patients were followed-up from 2010 to 2018 to identify the incidence of newly developed hip and vertebral fractures. Cox proportional hazards analyses were performed to calculate the hazard ratios for hip and vertebral fractures based on BMI, and the sex concerning normal weight in each group was analyzed to identify the associated fracture risk.

**Results:** A total of 2,515,078 people (M: F=50.9:49.1) were analyzed. Low BMI was a risk factor that increased the risk of fractures in both the hip and spine, and showed a higher association with hip fractures. Compared with that in normal-weight patients, the incidence of hip fractures was 78.9% higher in underweight patients, and the incidence rates were 23.4%, 31.8%, and 23.6% lower in the overweight, mild obesity, and obese groups, respectively ($p<0.001$). There was no difference in the incidence of vertebral fractures between the normal-weight and overweight groups; however, the incidence rates were 14.1%, 2.9%, and 8% higher in the underweight, mildly obese, and obese groups, respectively ($p<0.001$). Subgroup analysis showed that in men and those over 65 years of age, the incidence of vertebral fractures decreased as the BMI increased. However, vertebral fractures in adults aged <65 years and in women showed a high incidence in both the extremely low and high BMI groups.

**Conclusions:** Underweight is a risk factor for hip and vertebral fractures in the general population. However, the effects of age and weight on hip and vertebral fractures were heterogeneous. Regarding the occurrence of hip fractures, high BMI was a fracture preventive factor in all models regardless of sex and age. However, extremely low or high BMI is a provocative factor that increases the incidence of vertebral fractures in women and those under 65 years of age.

**Keywords:** Underweight, Overweight, Body mass index, Vertebral fracture, Hip fracture

## Biomechanical Impacts of Lumbar Facet Joint Degeneration: A Finite Element Analysis Study

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**Purpose:** The biomechanical effects of facet joint degeneration (FJD) on the lumbar spine are critical in understanding spinal disorders. FJD, primarily occurring in the L4–L5 and L5–S1 segments, contributes to stability and axial load distribution in the spine. Degenerative changes in these joints, often exacerbated by conditions like degenerative disc disease (DDD), can significantly alter spinal biomechanics. Recent advances in computational biomechanics have facilitated detailed spinal simulations, yet there remains a gap in understanding the specific biomechanical consequences of varying degrees of lumbar FJD, particularly in isolation from intervertebral disc degeneration.

**Materials and Methods:** This study utilized finite element analysis (FEA) to investigate the biomechanical implications of different levels of lumbar FJD. A normalized shape of the lumbosacral spine (L1–S1) was extracted from CT images and used to create a 3D geometric model. The facet joint degeneration was graded from mild (Grade 1) to severe (Grade 4), and simulations were conducted for single-segment (L4–L5) and double-segment (L4–S1) degenerations. Various spinal motions—flexion, extension, lateral bending, and axial torsion—were simulated under different loading conditions to assess the range of motion (ROM), von Mises stress on intervertebral discs, and facet joint reaction force. The FE model's validity was confirmed by comparing its results with existing biomechanical data.

**Results:** The study revealed that increasing grades of FJD led to a corresponding decrease in the ROM of the lumbar spine, more pronounced in the degenerated segments. In particular, the two-segment degeneration model exhibited a greater decrease in ROM compared to the single-segment model. The maximum von Mises stress on intervertebral discs decreased with advancing degeneration. However, the facet joint reaction force varied, decreasing during extension and increasing during lateral bending and axial torsion. Notably, adjacent segments to the onset of degeneration experienced an increased load, suggesting potential compensatory mechanisms or heightened risk of adjacent segment degeneration.

**Conclusions:** FJD significantly influences the biomechanical behavior of the lumbar spine. With increasing degeneration severity, there is a notable decrease in ROM and altered stress distribution within the spine. The increased load on adjacent segments highlights the potential for compensatory changes or increased risk of degeneration in these areas. These findings underscore the need for a nuanced understanding of FJD in spinal health and provide a basis for further clinical studies to explore treatment strategies and preventive measures for spinal disorders.

**Keywords:** Facet joint degeneration, Spine biomechanics, Finite element analysis, Computer simulation

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## Enhanced Recovery after Surgery (ERAS) in Spinal Fusion: Improving Postoperative Outcomes

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**Purpose:** While ERAS (enhanced recovery after surgery) has been introduced to other orthopedic areas, limited evidence exists in spinal fusion. The purpose of this study was to reveal the clinical effectiveness of ERAS protocol in 1- or 2-level posterior spinal fusion.

**Materials and Methods:** This study included 41 patients who underwent 1- or 2-level posterior lumbar interbody fusion before the introduction of the ERAS protocol (Pre-ERAS group) and 47 patients who underwent surgery under the ERAS protocol (ERAS group). Demographic and clinical parameters were collected. Clinical data included pain numeric rating scale (NRS), Oswestry Disablity Index (ODI), EuroQol 5-dimensional questionnaire (EQ-5D), time to ambulation, opioid consumption, hospital stay and complications. Chi-square test and student t-test were used to compare between two groups.

**Results:** Preoperative NRS showed no difference between 2 groups (p=0.372). However, ERAS group had a significantly lower NRS score on postoperative day 4 (2.83±1.46) compared to Pre-ERAS group (3.85±1.70) (p=0.003). The

ERAS group also had significantly lower total antiemetic dosage, shorter period to initiation of ambulation (2.04±0.20 and 2.90±0.83, p<0.001), and shorter hospital stay (5.21±0.83 and 5.59±1.07, p=0.076), lower complication rate (p=0.024) than the pre-ERAS group. At postoperative 3 months, no significant differences were found in terms of NRS, ODI, and EQ-5D. The fusion rate was also similar between 2 groups.

**Conclusions:** The ERAS protocol is effective in promoting early recovery of patients without increasing complication rates. Therefore, it is recommended for use in spinal fusion surgery.

**Keywords:** ERAS protocol, Spinal fusion, Postoperative recovery, Opioid consumption, Complication rate

# Best Paper Candidates Presentation III (Domestic)

## Exosomes from Epidural Fat-derived Immortalized MSCs Increase Osteoblast Differentiation

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**Purpose:** Mesenchymal stem cells (MSCs) and MSC-derived small extracellular vesicles (sEVs, exosomes) are promising candidates for cell-based regenerative medicine and cell-free regenerative medicine, respectively. MSCs are ideal for bone and cartilage regeneration due to their ability to differentiate into various lineages. This regenerative effect was observed to be due to MSC-derived paracrine factors. Exosomes, which are sEVs that transport lipids, proteins, nucleic acids, etc., have been identified as components of MSC secretions and propagate the main functions and properties of MSCs. However, the effect of exosomes on osteoblast differentiation has not been investigated. In this study, we aimed to reveal the mechanism by which exosome-mediated miRNAs, which regulate the proliferation and differentiation of MSC cells, induce osteoblast differentiation.

**Materials and Methods:** Cells were immortalized Epidural fat derived MSC, The mouse pre-osteoblast cell line, MC3T3-E1 was purchased from the America Type Culture Collection (clone number CRL-2593). Exosomes were isolated using TFF. Characterization analysis was performed using FACS, RT-PCR, Western blot, and NTA. MTT assay was performed to confirm the non-toxicity of exosomes. we used PCR, staining, and Western blot to confirm the effect of EF-MSC line-derived exosomes on osteoblast differentiation.

**Results:** Before confirming the effectiveness of MSC-derived exosomes, toxicity was assessed. The specific concentration was determined, and the effect of exosomes on osteoblast differentiation was confirmed. We observed an increase in osteoblast differentiation markers due to exosome treatment, and we hypothesized that the differentiation of osteoblasts is influenced by miRNAs in exosomes. In MSC-derived exosomes, specific miRNAs increased the expression of osteogenic genes, and the staining levels of alkaline phosphatase (ALP) and alizarin red S (ARS) were increased. Exosome-derived miRNAs induced osteoblast differentiation through activation of AMPK & Smad1/5/9 in MC3T3-E1 cells. Additionally, Compound C, an AMPK inhibitor (Comparative Example C) induced cells, inhibited osteogenic gene expression and AMPK/Smad1/5/9 activation.

**Conclusions:** Overall, our results show that exosome-derived miRNAs promote osteoblast differentiation through phosphorylation of AMPK/Smad1/5/9.

**Keywords:** Epidural fat, Mechenchymal stem cell, Exosome, Osteoblast differentiation

## Incidence and Risk Factors of Proximal Junctional Complications and Rod Fracture after Long-segment Fusion Surgery with Anterior Column Realignment for Adult Spinal Deformity: Minimum 2-Year Follow-up

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**Purpose:** Anterior column realignment (ACR) is a useful surgical procedure for lordosis restoration in adult spinal deformity (ASD) with a less invasive approach during long-segment fusion surgery. Long-segment fusion surgery always carries the potential risk of proximal junctional kyphosis (PJK), proximal junctional failure (PJF) and rod fracture. However, there are few studies on these complications in corrective surgery using ACR. This study aims to investigate the incidence and risk factors of these complications after deformity correction surgery with ACR.

**Materials and Methods:** Patients ≥60 years who underwent long-segment (≥ 5levels) fusion surgery with ACR for ASD with minimum follow-up of 2-year were included in this study. Patients was categorized into two groups based on the occurrence of PJK, PJF, and rod fracture, respectively. Various patient, surgical, and radiographic factors were compared between two groups to identify the risk factors for each complication. Independent risk factors were identified through univariate and multivariate analyses.

**Results:** This study included 74 patients who underwent long-segment fusion surgery with ACR. The mean total fusion level was 6.5±2.2 levels and the mean level at which ACR was performed was 1.9±0.7 levels. After surgery, an average LL angle of 41.9±19.3° was restored. Among the 74 patients with an average follow-up of 29.6±11.9 months, 12 patients (16.2%) developed PJK, 11 patients (14.9%) developed PJF, and 15 patients (20.2%) experienced rod fracture. Regarding the development of PJK, independent risk factors included the presence of osteoporosis (HR 7.34, p=0.018), BMI (HR 2.27, p=0.009), overcorrection (HR 29.7, p=0.032), preoperative PT (HR 1.17, p=0.027) and postoperative SVA (HR 0.92, p=0.012). Concerning PJF, significant risk factors were preoperative LL (HR 0.91, p=0.022), cement-augmented screw at UIV (HR 0.02, p=0.039), and the uppermost screw angle in the cranial direction (HR 1.30, p=0.013). Finally, for rod fracture, preoperative PI (HR 1.10, p=0.024) was found to be significant.

**Conclusions:** After long-segment fusion surgery using ACR in ASD, PJK developed in 16.2%, PJF in 14.9% and rod fracture in 20.2%. The risk factors showed similarities to the outcome observed in previous long-segment fusion surgery without ACR, and the frequency of ACR did not impact the occurrence of these complications.

**Keywords:** Anterior column realignment, Proximal junctional kyphosis, Proximal junctional failure, Mechanical failure, Risk factor

## The Role of CT Hounsfield Units as a Predictive Factor for Progression of Osteoporotic Thoracolumbar Fracture and its Implication for Surgical Treatment

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**Purpose:** To determine the relationship between CT HU and conservative management failure in acute OVFs in thoracolumbar junction.

**Materials and Methods:** A total of 256 patients diagnosed with thoracolumbar OVF at a single institution were retrospectively analyzed. Among them, 36 patients (Group I) who underwent surgical treatment after conservative treatment failure and 40 patients (Group II) who successfully obtained conservative treatment were included. Demographic data, radiographic data including sagittal spinopelvic parameters, and paraspinal muscle degeneration and CT HU around fracture site were analyzed. Relative difference of HU (ΔrHU) was defined as the difference between HU of the fracture site and average value of HU in the vertebral body above and below the fracture site.

**Results:** Patients in Group I underwent surgical treatment

due to fracture progression approximately 8 weeks after injury. There were no significant differences between the two groups in demographic data including BMD, and paraspinal muscle degeneration around fracture site. In terms of radiologic parameters, follow-up height loss (Group I: 60.09%, Group II: 35.74%) and local kyphotic angle (Group I: 26.34°, Group II: 18.27°) were significantly higher in Group I. Logistic regression analysis showed that ΔrHU (OR: 1.08, 95% CI: 1.01-1.17, $p<0.05$) was significant risk factor for fracture progression requiring surgical treatment. On receiver operating characteristic curve analysis, the cut-off value of ΔrHU requiring surgical treatment was 100 (95% CI, $p=0.021$).

**Conclusions:** As a predictor regarding progression of thoracolumbar OVF, CT HU is useful. Especially, relative difference of HU (ΔrHU) is a risk factor for worsening thoracolumbar OVF, and surgical treatment may be necessary when the value is over 100.

**Keywords:** Osteoporotic vertebral fracture, Thoracolumbar fracture, Predictive factor, Hounsfield units, Paraspinal muscle degeneration

## Reoperation Rates after Decompressive Surgeries for Lumbar Radiculopathy Related with Injection Therapy: Korean National Population-based Cohort Study

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**Purpose:** The incidence of reoperation after surgery for lumbar degenerative disease is low, making it difficult to conduct sufficient research to identify risk factors for reoperation rates. National population-based databases provide large longitudinal follow-up cohorts that can help overcome this challenge. Patients undergoing surgery for lumbar radiculopathy often receive preoperative injection therapy for severe pain; however, no studies have evaluated preoperative injection therapy as a risk factor for reoperation. The purpose of this paper is to determine whether injection therapy before the lumbar surgery for radiculopathy is a risk factor for reoperation in a national patient population with long-term follow-up.

**Materials and Methods:** We used the Korean Health Insurance Review & Assessment Service national database to select our study population. We included 38,616 patients who were diagnosed with lumbar radiculopathy and underwent lumbar surgery between January 2008 and December 2008. The follow up period was 8.5±2.5 years (3,097.84±923.78 days). Twenty-eight percent of patients received an injection therapy in the 3 months prior to surgery. Age, gender, presence of diabetes and osteoporosis, associated comorbidities, surgical levels, hospital characteristic, and preoperative injection therapy were considered potential confounding factors.

**Results:** The reoperation rate over the entire follow-up period was 16.7%. In terms of reoperation types, decompression only was the most common reoperation type (67.63%), followed by posterior fusion with/without decompression (32.37%). The risk factors for reoperation were female gender (odd ratio 0.813, 95% CI 0.769, 0.859), presence of diabetes (odd ratio 1.132, 95% CI 1.049, 1.222), presence of comorbidity (odd ratio 1.121, 95% CI 1.052, 1.195), surgical level (two surgical level : odd ratio=1.162, 95% confidence interval 1.068, 1.263; three surgical level : odd ratio=2.069, 95% confidence interval 1.268, 3.377), hospital characteristic (general hospital : odd ratio=1.184, 95% confidence interval 1.050, 1.336; clinic : odd ratio=1.344, 95% confidence interval 1.150, 1.569) and the presence of the injection therapy before operation (odd ratio 1.250, 95% CI 1.131, 1.382).

**Conclusions:** Preoperative injection therapy for severe pain in the patients undergoing surgeries for lumbar radiculopathy may increase the risk of reoperation after surgery. This is essential information when discussing surgery with patients with these factors.

**Keywords:** Lumbar radiculopathy, Reoperation, Injection therapy, Nationwide database, Long-term follow-up

### Association Between Lumbar Interbody Fusion Using Hyper-Lordotic Cage and the Incidence of Adjacent Segment Disease with a Minimum 5-Year Follow-up

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**Purpose:** Restoration of lumbar lordosis is important to prevent adjacent segment disease (ASD) after lumbar fusion surgery. Various shapes and angles of cages in interbody fusion have been used; however, no long-term follow up studies have determined that transforaminal lumbar interbody fusion (TLIF) using hyper-lordotic cage can reduce the development of ASD. The purpose of this study was to compare radiological results and incidence of ASD after TLIF using 15° cages and 4° & 8° cages with a minimum 5-year follow up.

**Materials and Methods:** A 122 patients who underwent 1 or 2-level TLIF from January 2009 to December 2015 were reviewed including 56 patients using 15° lordotic angle cages, 21 patients using 4° cages and 45 patients using 8° cages. Incidence of radiological ASD (R-ASD) and surgical ASD (S-ASD) were evaluated. Radiological measurements were examined preoperatively, 3 months, 2 years after surgery and final follow-up.

**Results:** The lumbar lordosis was 31.7° preoperatively, improved to 37.9° 3month postoperatively, and decreased to 34.6° at the last follow-up in the 15° group. It was 32.1° before surgery, corrected to 35.9° after surgery, and changed to 29.7° at the last follow-up in the 4° & 8° group. The restoration of lumbar lordosis showed significant difference between the two groups ($p<0.01$). The segmental lordosis at fused segments was 9.6° before surgery, 15.8° after surgery, and 12.7° at the last follow-up in the 15° group. It was 10.9°, 11.5°, and 8.3° in the 4° & 8° group, respectively ($p<0.01$). R-ASD was found in 27 patients (48%) in the 15° group and 39 patients (59%) in the 4° & 8° group ($p=0.021$). The average diagnosis period of R-ASD was 6.0 years in the 15° group and 5.1 years in the 4° & 8° group ($p=0.030$). Revision surgery was performed in 6 patients (11%) in the 15° group and 11 patients (17%) in the 4° & 8°group, and the period between primary and revision surgery was 6.7 years and 5.5 years, respectively ($p=0.047$).

**Conclusions:** TLIF using hyper-lordotic cage showed better restoration of lumbar lordosis and achieved satisfactory clinical outcomes with a lower incidence of radiological ASD and surgical ASD during long-term follow-up.

**Keywords:** Hyper-lordotic cage, Adjacent segment disease, Lordotic angle, Lumbar lordosis, Sagittal imbalance

## Best Paper Candidates Presentation IV (International)

### Objective Functional Evaluations Following Endoscopic Spine Surgery: The Prospective Use of Smart Wearable Technology

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**Purpose:** Endoscopic spine surgery has been growing in popularity due to the minimal trauma and blood loss, shorter operation time as well as hospital stay when compared to open surgeries. Patient outcomes following spine surgery are routinely evaluated through standardized scoring such as changes in visual analogue scale (VAS) score, Oswestry disability index (ODI) and the Sciatica bothersome index test for scitica pain. Despite the widespread use of such scoring systems, a high degree of subjectivity is involved depending on a patient's individual interpretations. Advances in technology have brought forth mainstream use of smart wearable technologies such as smart watches. These technologies have the capability of measuring objective parameters relevant to health such as heart rate, and steps count. Step counting as an objective instrument for post-operative adjuvant monitoring and evaluation has not been widely used. We evaluated the quality of life in patients following endoscopic spine surgery by comparing the results between changes in VAS scores, ODI, sciatica bothersomeness index (SBI) and objective measurements of heart rate, and weekly steps taken.

**Materials and Methods:** We evaluated 21 subjects with a mean age of 35.5 years. All subjects were diagnosed with lumbar disc herniations and had undergone interlaminar percutaneous lumbar discectomy (I-PELD) by a single operator. VAS scores, ODI, SBI, heart rate, and steps count were obtained 1 and 2 weeks prior to the procedure, as well as every week following the procedure for 1 month.
**Results:** VAS, ODI and SBI scores were significantly improved following I-PELD procedures (p=0.000). Significant changes of mean heart rate were observed following I-PELD procedures (p=0.009). A significant increase in number of steps was observed between first week and third week following I-PELD procedures (p=0.008). Changes in heart rate, and steps count were weakly correlated with changes in VAS, ODI and SBI scores, however not statistically significant
**Conclusions:** Significant changes in mean resting heart rate following I-PELD procedures was observed. VAS, ODI and SBI was weakly correlated with heart rate and steps count obtained from smart watches following I-PELD procedures
**Keywords:** Smart watch, Lumbar disc herniation

## Efficacy and Safety of Lumbopelvic Fixation in Spinal Metastasis Comparing S2 Alar-iliac Screw and Conventional Iliac Screw

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**Purpose:** To compare the effectiveness of the CI screw technique and the S2AI screw technique in spinal metastasis patients.
**Materials and Methods:** A retrospective chart review analyzed 38 patients with spinal metastasis from April 2014 to April 2022 who indicated lumbopelvic fixation surgery. For twenty-one patients were S2AI screws. Seventeen patients were used CI screws. Patient various demographic and clinical data, including age, gender, BMI, primary cancer origin, and spinal region involvement, reoperation, operative time, estimated blood loss, navigator use, complications, length of stay, survival time were collected.
**Results:** The S2AI group had lower estimated blood loss and shorter operative time, although the differences were not statistically significant. (Estimated blood loss: 1073.53±1122.45 ml in the CI screw group vs 592.86 ml in the S2AI group, p=0.137; Operative time: 207.06±105.69 mins in the CI screw group vs 181.19±47.35 mins in the S2AI screw group). Length of stay was statistically lower in the S2AI screw group than the CI screw. (24.35±21.59 days in the CI screw group vs 13.38±8.35 days in the S2AI screw group). There were 2 cases in the CI screw group without navigation use (N=13). The cause of reoperation was a broken rod in 2 cases.
**Conclusions:** The S2AI technique did not show statistically significant differences when compared to the CI screw technique in rates of reoperation, estimated blood loss, and operative time. Interestingly, there was a statistically significant reduction in the length of hospital stay with the S2AI technique. Using navigation during surgery has the potential to lower the need for further operations, but more data is required to make a definitive conclusion.
**Keywords:** Spinal metastasis, Lumbopelvic fixation, Conventional iliac screw (CI), S2 Alar iliac screw (S2AI)

## Outcomes after Total en Bloc Spondylectomy at a Mean Follow-up of 11 Years

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**Purpose:** Total en bloc spondylectomy (TES) of spinal tumours results in huge vertebral defect. Despite reconstruction and fusion, there is potential concern for long-term mechanical stability.
**Materials and Methods:** Twenty-three patients (mean age: 40.0±15.3 years) underwent TES for either primary spinal tumours or solitary metastasis and reconstruction with instrumented posterior spinal fusion and anterior fusion with titanium mesh cage in our institution from November 2001 to April 2022. The mean follow-up was 11.5±4.9 years. Primary diagnoses include giant cell tumours (13),

primary sarcomas (3), haemangiopericytomas (2), solitary metastases (2), aneurysmal bone cyst (1), haemangioma (1) and chordoma (1). The locations of the tumours were either in lumbar (10) or thoracic (13) spine. Fifteen patients had one vertebral level resected, others were two- (2), three- (4), four- (1), or five-level (1). Ten patients had fixation with both allogenous and autogenous bone grafts, five had autogenous bone graft only and eight had allogenous bone graft only. The mean duration of operation was 751.7±212.6 minutes and the mean intraoperative blood loss was 2864.3±2124.8 ml. The mean length of resected tumour was 51.6±23.3 mm. Cage subsidence at post-operative 1-month and oblique placement of cage were noted in seven and eight patients, respectively. Investigated outcomes were instrumentation failure, revision and post-operative complications.

**Results:** Twelve patients required revision surgery, eight of them had instrumentation failure with rod fracture. The mean time to instrumentation failure was 91.3±47.4 months. Instrumentation failure with rod fracture was associated with long operation time (p=0.031), more blood loss (p=0.022) and longer length of resected tumour (p=0.035). No significant association was identified between the investigated outcomes and the parameters, including sex, pathology, pre-operative neurology, location of tumour, level of vertebra resected, type of bone graft used, surgical approach, tumour margin, radiotherapy, chemotherapy, current disease status, distant metastasis, local recurrence, cage subsidence, oblique cage placement, bony fusion, and number of rods used. According to Kaplan Meier analysis, the overall revision-free survivals were 67.0% and 48.8% at post-operative 5- and 10-year, respectively. The 5- and 10-year instrumentation failure-free survivals were 85.2% and 65.7%, respectively.

**Conclusions:** Instrumentation failure is not an uncommon late complication requiring revision following TES. Longer lengths of resection and longer complicated operations are at risk of future instrumentation failure.

**Keywords:** Total en bloc spondylectomy

## Percutaneous Full Endoscopic Lumbar Discectomy via Transforaminal Approach in L4-5 Disc Herniation with Local or General Anesthesia Techniques – Which One Is Better? - Comparative Study

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**Purpose:** To evaluate the clinical and surgical outcomes of patients who were diagnosed L4-5 disc herniation treated with PELD via transforaminal approach under local vs general anesthesia in two years.

**Materials and Methods:** We retrospectively analyzed 73 consecutive patients who were diagnosed L4-5 disc herniation treated with PTLD in Thabo Crown Prince Hospital from January 2019 to November 2020. Patients were divided into LA group (n=40) and general GA (n=33) depending on the anesthesiologist and patients' preference. The demographic characteristics and surgical results of the two groups were compared. The clinical outcomes were evaluated by VAS for leg pain and back pain, ODI scores and the modified Macnab criteria at 1 day, 6 months, 1 year and 2 years postoperative.

**Results:** 73 patients were enrolled. The majority of gender in LA and GA groups were male and female ($p<0.05$). The majority of technique in LA and GA groups was Inside-out ($p<0.05$). No significant differences in mean ages while mean operation time, intraoperative blood loss and length of stay were significantly lower in LA group ($p<0.05$). The postoperative VAS leg pain and back pain and ODI scores of two groups were significantly lower than those before surgery ($p<0.05$). For VAS leg pain, in LA group was significantly lower than GA group in 1 day postoperative ($p<0.05$). No significant differences between both groups in 6 months, 1 year and 2 years postoperative ($p>0.05$). For VAS back pain, no significant differences between both groups in 1 day, 6 months, 1 year and 2 years postoperative ($p>0.05$). For ODI scores, no significant differences between both groups in 6 months, 1 year and 2 years postoperative ($p>0.05$). According to the Macnab criteria, the satisfaction rate of the LA group was 95.46%, whereas that in the GA group was 100%.

**Conclusions:** Local anesthesia technique had achieved

good clinical efficacy as GA anesthesia technique for L4-5-disc herniation treated. Compared with GA, LA had the advantages of shorter operative time, lower blood loss and shorter length of hospital stay. Moreover, LA provided a better clinical outcome in short term. Nevertheless, case selection for each anesthesia technique will be an important key success factor for good results.

**Keywords:** Endoscopic discectomy under local, Percutaneous full endoscopic lumbar discectomy, Transforaminal approach, General anesthesia, Local anesthesia

### Prospective Randomised Controlled Study to Assess the Difference in Clinical and Biochemical Markers for Patients Undergoing Tubular vs Full Endoscopic Discectomy

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**Purpose:** The study was conducted to assess and compare the soft tissue injury and associated inflammation after full endoscopic discectomy and minimally invasive tubular discectomy for a prolapsed intervertrebral disc. Functional outcomes were also compared to assess the efficacy of one technique over the other.

**Materials and Methods:** A prospective randomised study was undertaken over 1 year to evaluate the two surgeries at a tertiary care spine centre with minimum follow up of 6 months. Both the groups were operated by same team of surgeons. C-reactive protein (CRP) values and Creatinine phosphokinase (CPK-MB) were used to quantify the responses. Additionally, the functional outcomes were assessed using Visual analogue score (VAS), Oswestry Disability Index (ODI), Macnab's score and neurological function. Return to work was also compared.

**Results:** A total of 202 patients were included in the study with 112 operated with endoscopic and 90 operated with tubular methods. There were no baseline differences in the clinical and demographic data between the groups. There was a significant improvement in the VAS score in both the groups with no significant inter-group difference at all follow-ups. However, the ODI improvement was better in the endoscopic group both at post operative and at 6 months follow up. Post operative CRP and CPK-MB were also significantly less raised in that group ($p>0.01$). The return to work was significantly faster and Macnab's score was much better in the endoscopic group.

**Conclusions:** Endoscopic discectomy leads to a significantly less amount of tissue injury and post-operative inflammation as compared to the tubular discectomy. It also causes less post-operative pain and earlier return to work while giving similar clinical outcomes.

**Keywords:** Endoscopic discectomy, Disc herniation, Tubular discectomy, Lumbar herniation, Clinical outcomes



## Best Paper Candidates Presentation V (International)

### Distal Lumbar Lordosis Is Associated with Reoperation for Adjacent Segment Disease after Lumbar Fusion for Degenerative Conditions

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**Purpose:** Recent studies have suggested that distal lordosis (L4-S1, DL) remains constant across all pelvic incidence (PI) subgroups, whilst proximal lordosis (L1-L4, PL) varies. We sought to investigate the impact of post-operative DL on adjacent segment disease (ASD) requiring reoperation in patients undergoing lumbar fusion for degenerative conditions.

**Materials and Methods:** A retrospective review of patients undergoing lumbar fusion for degenerative conditions with the two senior authors from 2007-16 was performed. Demographic and radiographic information was recorded. Univariate analysis was performed using Pearson Chi square for categorical variables and univariate binary logistic regression analysis for continuous variables. Multivariate binary logistic regression analyses were performed to

control for confounders. Model section was optimised using Bayesian and Akaike Information Criterion as well as through assessment of Receiver Operating Characteristic curves. Finally, a Kaplan Meier analysis was performed to assess reoperation free survival.

**Results:** 335 patients were identified and included in the final analysis. Most patients had single (67%) or two (31%) level fusions. The mean follow-up was 64 months. Fifty-seven patients (17%) underwent reoperation for ASD at an average of 78 months post-operatively (R group). There was no significant difference between the R group and the no reoperation for ASD (NR) groups in terms of age, sex, number of levels fused, MIS/open surgery, baseline DL, or adjacent disc lordosis. The R group had a significantly lower mean post-operative DL (27.3 vs 31.1 deg, $p<0.001$) and mean PI (55.5 vs 59.2 deg, $p<0.05$) than the NR group. On univariate analysis, patients with a post-operative DL of <35 deg had higher odds of reoperation for ASD than those with a post-operative DL of ≥35 deg (OR 2.7, $p = 0.016$). In the multivariate model, post-operative DL, low/average PI, and spondylolisthesis were all significantly associated with reoperation for ASD.

**Conclusions:** This study provides preliminary support to an association between post-operative distal lumbar lordosis and risk of reoperation for ASD in patients undergoing fusions for degenerative conditions. This risk may be amplified in patients with a low/average PI and degenerative spondylolisthesis. Further multicenter prospective study is needed to independently confirm this association and identify the impact of restoration of physiological distal lumbar lordosis on long term patient outcomes.

**Keywords:** Distal lumbar lordosis, Adjacent segment degeneration, Re-operation after lumbar fusion, Degenerative lumbar disorders

## Enhancing Visualization of Surgical Tool Through Integrated Motion Tracking System

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**Purpose:** Spine surgeries are associated with various intra-operative complications. Recent advances in the field of spine surgery like Navigation and Robotics have reduced the complication rates significantly. With the advent of extended reality, it is now becoming increasingly possible to employ real and virtual world interactions in a seemingly natural environment. This requires tracking of real world objects to place the virtual objects as overlays on the required positions. Among the various tracking systems available, optical trackers are highly practical and relatively accurate to submillimeter levels. Our proposed system makes use of HoloLens hardware with the integrated motion tracking system for visualization and image analysis to track the positioning of the virtual surgical tool.

**Materials and Methods:** We used a spine model mannequin. The CT scan data is imported to 3D slicer software for segmenting the spine region and exported in FBX format compatible with Microsoft HoloLens for further virtual projection of the anatomical data. An augmented reality environment of the 3D model was created using Unity3D Software, Vuforia, and Microsoft Mixed Reality (MRTK) SDK. The developed AR environment is imported via Holography remote sensing application into the Hololens2 based on augmented vision. We used printed markers in place of IR markers for preliminary results and comparison. The grid consists of uniformly spaced linearized points 3 cm apart. The markers were moved one grid point to the next and the corresponding tool transformation values were measured. The grid provides a reference frame for measuring positional errors.

**Results:** For both X and Y axes, the maximum error observed across the measurements is 0.01 units, indicating the largest deviation from the expected position. On average, the X-axis error is calculated to be 0.0016 units, representing the average deviation across all the readings whereas the Y-axis error is calculated to be 0.0025 units. The low average errors suggest that the tracking system and marker placement

techniques were successful in achieving accurate tool positioning.

**Conclusions:** Our grid based measurement technique proposes that the recorded surgical tool position can be accurately mapped into the actual tool position, so the method could be implemented in tracking surgical tools in real time for surgical planning and navigation. This information is crucial for ensuring precision and reliability in surgical procedures and guiding improvements in the tracking system and tool placement techniques

**Keywords:** Augmented reality, Hololens, Tracker

## Comparison of MIS-TLIF Versus BETLIF in Lumbar Degenerative Disc Disease: Clinical and Radiological Outcomes

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**Purpose:** Minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) is an established surgical procedure with numerous advantages. Using high-definition endoscope with separate portals, biportal endoscopic transforaminal lumbar interbody fusion (BETLIF) provides clear and magnified surgical field to perform direct neural decompression, radical discectomy and preservation of bony endplate, which may contribute to better results. In the past decade, we performed around thousands of fusion surgeries and completely shifted to the BETLIF since 2019. Thus, we conducted a retrospective study to compare the clinical and radiological outcomes between the MIS-TLIF and BETLIF.

**Materials and Methods:** From January 2018 to May 2021, patient who received MIS-TLIF (n=90) and BETLIF (n=89) with double cage insertion by single orthopedic surgeon were included in this study. For the clinical outcomes, we collected the duration of hospitalization, visual analog scale (VAS) of lower back pain and leg pain, Oswestry Disability Index (ODI) score, Japanese Orthopedic Association (JOA) score in both groups. For the radiological outcomes, computed tomography (CT) of the lumbar spine was arranged 1 year post-operatively to evaluate the fusion condition(Bridwell grading system), pre-operative and post-operative disc height and segmental Cobb's angle. All the clinical and radiological data were recorded and statistically compared using the t-score.

**Results:** The average follow-up was 18.8±6.4 months in MIS-TLIF and 17.9±5.8 months in BETLIF. The mean duration of hospitalization was significantly shorter in the BETLIF group (5.7±1.1 vs 7.4±1.6 days, $p<0.05$). The VAS, ODI, JOA after the operation showed significant improvement ($p<0.05$) in both groups. The follow-up CT of lumbar spine disclosed higher fusion rate (93.3% vs 81.4%, $p<0.05$) and lower cage subsidence rate (23.3% vs 44.1%, $p<0.05$) in the BETLIF group with no significant cage subsidence of more than 2 mm in any patients. The post-operative disc height and segmental Cobb's angle showed no difference in these two groups.

**Conclusions:** MIS-TLIF and BETLIF are equally efficient surgical techniques, which both provide promising prognosis. However, with better neural decompression, application of large amount of bone graft, well-preservation of bony endplate, BETLF achieves superior clinical and radiological outcomes with less complications, shorter duration of hospitalization, better bone fusion, lower cage subsidence rate and good post-operative segmental Cobb's angle and disc height.

**Keywords:**Biportal endoscopic transforaminal lumbar interbody fusion, Minimally invasive transforaminal lumbar interbody fusion, Bridwell grading system, Cobb's angle

## Comparison of Clinical and Radiologic Outcomes between Oblique Lumbar Interbody Fusion and Minimally Invasive Transforaminal Lumbar Interbody Fusion in Spondylolisthesis, a Randomized Controlled Trial

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**Purpose:** To compare clinical and radiologic outcomes in grade 1-2 spondylolisthesis patients randomized to treatment with MIS-TLIF or OLIF.

**Materials and Methods:** 60 patients who underwent single-

level surgery were randomly allocated to the MIS-TLIF or OLIF group. Clinical outcomes were assessed using visual analogue scale(VAS) for back and leg pain, Oswestry Disability Index (ODI), EQ-5D-5L, and satisfaction score. Data were collected pre-operatively, post-operatively and at months, 1, 3, 6 and 12. Radiologic outcomes included measurements of disc height (DH), foraminal height (FH), foraminal area (FA), cross-sectional area of spinal canal (CSA), spinal canal diameter (SD) and fusion status. Intraoperative parameters, including operative time and blood loss. Mixed effects models were used to calculate parameter changes from baseline to subsequent timepoints.

**Results:** Demographic and disease characteristics at baseline were comparable between groups. Clinical outcomes in both groups all showed clinically and statistically significant improvements from baseline to each subsequent time point (all $p<0.001$). The differences in MIS-TLIF vs OLIF group over total follow up were not statistically significant: VAS back -0.3 (-0.8 to 0.2); p=0.18, VAS leg: -0.4 (-0.8 to 0.04); p=0.08, ODI: 0.4 (-1.9 to 2.8); p=0.7 and EQ5D5L: 0.1 (-1.9 to 2.2); p=0.9. Radiological parameters significantly improved post-baseline in all patients ($p<0.001$). The changes in DH (-0.4 (-0.7 to -0.1) mm; p=0.008), FH -1(-1.4 to -0.6) mm; $p<0.001$ and FA -6.1 (-10 to -2.2) $mm^3$; p=0.002 were lower in MIS-TLIF vs OLIF group. CSA was higher in MIS-TLIF compared to OLIF group 19 (10-29) $mm^3$; $p<0.001$, and SD change was not different between groups 0.3 (-0.2 to 0.7) mm; p=0.3. Blood loss was significantly lower in OLIF group.(97 vs 141 mL; p=0.013). Operative time and length of stay were similar (120 vs 114 min, 2.5 vs 2.4 day; $p>0.05$).

**Conclusions:** In patient with grade 1-2 spondylolisthesis, patient reported outcomes improved in both MIS-TLIF and OLIF groups: between group differences were minimal and not significantly different. OLIF demonstrated advantages in restoration of DH, FH and FA, lower intraoperative blood loss compared to MIS-TLIF.

**Keywords:** Minimally invasive spine surgery, Lumbar interbody fusion, MIS-TLIF, OLIF

## Machine Learning Web Application for Predicting Functional Outcomes in Patients with Traumatic Spinal Cord Injury Following Inpatient Rehabilitation

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**Purpose:** 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. 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.

**Materials and Methods:** The study included data from the Japan Association of Rehabilitation Database from January 1, 1991 to December 31, 2015. 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 4,181 patients, 3,827 were included in the prediction model for the total motor FIM score. The mean (SD) age was 50.46 (18.78) years, and 3,211 (83.9%) patients were male. There were 3,122 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 0.857 and an accuracy of 0.777 for predicting functional ambulation. Likewise, the CatBoost Regressor performed well, with an R2 of 0.786, a mean absolute error of 9.296, and a root mean square error of 13.485 for predicting the total motor FIM score. The final models were deployed in a web application to provide functional predictions.

**Conclusions:** Our prediction models developed using ML successfully predicted functional outcomes in patients with SCI and were deployed in an open-access web application. The application can be found at http://3.138.174.54:8501/.

# Best Paper Candidates Presentation VI (International)

## Long-Term Results of Modified Expansive Open-door Laminoplasty Adjunct Short Segment Anterior Cervical Fusion for Multilevel Spondylotic Myelopathy

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**Purpose:** Expansive Open-door Laminoplasty (EOLP) is effective for multilevel cervical spondylotic myelopathy (MCSM). To reduce the risk of postoperative neck pain, our lead surgeon, Professor Wen-Tien Wu, developed the modified expansive open-door laminoplasty technique in 2011. Despite the efficacy of this modified procedure, it is important to recognize that laminoplasty alone may not be suitable in certain cases, such as in patients with local kyphotic deformity. Our previous research has confirmed that MCSM combining with segmental kyphosis of one to two levels, employing modified EOLP with short anterior cervical discectomy and fusion (ACDF), leads to favorable short-term neurological recovery and preserves postoperative range of motion (ROM). The objective of this study was to evaluate the long-term clinical outcomes of this procedure.

**Materials and Methods:** A total of 89 patients were enrolled in this retrospective study conducted from January 2011 to December 2015. These patients exhibited MCSM with local kyphotic deformity, and received modified EOLP and short-segment (≤2 levels) anterior fusion. The follow-up period lasted at least 8 years. The radiographic outcomes (C2-7 cobb angle, CSVA, C7 slope, fusion angle/height, adjacent disc height, pavlov ratio, ROM) and functional outcomes (Neck VAS, JOA score) were collected preoperatively and at the last follow-up.

**Results:** The mean Japanese Orthopedics Association recovery rate at the last follow-up was 72.9%. The improvement in functional scores and reduction in neck pain were statistically significant than preoperative functional scores and mostly persisted well during this period. After a minimum follow-up period of 8 years, only 31 patients remained with complete data for subsequent analysis. The average age of these patients is 66. Among the participants, 3 patients underwent a single-level ACDF, while 28 received a two-level fusion procedure, with the majority of fusion levels occurring above C4-6. Comparisons of Cobb angle and the height of the fusion segment revealed no significant changes after 8 years when compared to the postoperative measurements taken at 3 months. The preserved range of motion (ROM) was 42.6%, and the maintained ROM was 95.3%.

**Conclusions:** The modified expansive open-door laminoplasty adjunct short segment anterior cervical fusion is a highly effective surgical approach for multilevel cervical spondylotic myelopathy with segmental kyphosis. Even after an eight-year period, the majority of patients have maintained excellent function and mobility.

**Keywords:** Multilevel spondylotic myelopathy

## Prognosticating Acute Traumatic Spinal Cord Injury using Neurofilament (NF), Neuron Specific Enolase (NSE), Matrix Metalloproteinases-2 (MMP-2), and S-100B as Biomarkers

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**Purpose:** Spinal cord injury (SCI) can result in lifelong disability. Currently, the literature suggests that biomarkers are helpful in prognosticating SCI, but there is no specific

biomarker identified for this till date. This is the first study that predicted the prognosis dynamically using biomarkers. Aim: To elucidate the role of biomarkers in prognosticating acute traumatic SCI.

**Materials and Methods:** Blood samples were obtained from 35 patients of acute traumatic SCI at presentation, immediate post-op, and at 6 weeks. At 6 months follow-up, patients were divided into two groups, i.e, improved and non-improved based on the improvement in the ASIA grade compared to presentation. A non-parametric test was used for comparing mean NSE, MMP-2, S100-B, and NF serum levels at presentation, immediate post-op, and 6 weeks post-op follow-up between the two groups.

**Results:** There was a significant difference (p=0.03) in the NF values at presentation between the two groups. The difference of NSE values at 6 weeks was also significant (p=0.016) between the two groups. S-100B levels were also significantly different between both groups at presentation (p=0.016), and at the immediate post-op stage (p=0.007). MMP-2 levels neither displayed any specific trend nor any significant difference between the two groups.

**Conclusions:** Higher NF values at presentation, and higher S-100B levels at presentation and immediate post-operative period correlated with poor outcome. Also, increased NSE values after surgery are indicative of no improvement.

**Keywords:** Biomarkers, NF, NSE, MMP-2, S100-B, Traumatic, SCI, Prognosis

## Time Course of Changes in Reactive Oxygen Metabolites (ROM) as a Serum Oxidative Stress Marker to Predict Outcomes for Surgical Treatment of Cervical Compression Myelopathy

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**Purpose:** We classified serum oxidative stress marker levels in patients with acutely worsening compression myelopathy (AM) as severe. These oxidative stress markers may influence neurological recovery after surgery for AM (Takahashi H. BMC Musculoskelet Disord, 2019). We hypothesized that the oxidative stress is decreased by surgical treatment. Therefore, we conducted an observational study to determine the time course changes of serum oxidative stress marker in patients with cervical compression myelopathy after surgery

**Materials and Methods:** 40 patients who underwent surgery at our hospital to treat acutely worsening compression myelopathy (AM; n=21) and chronic compression myelopathy (CM; n=19) were included in this study. Serum ROM levels were measured at the time of hematological examinations before surgery and the postoperative follow-up at 3 months, 6 months, and 1 year after surgery. ROM reflect serum hydrogen peroxide levels and a normal ROM level in healthy controls is <300 (U. CARR), respectively. Neurological evaluations using JOA score for cervical myelopathy were performed. The neurological outcomes were classified by the recovery rate of JOA score as good (over 50%) and fair (under 50%) and investigated the relationship between change of ROM and neurological outcomes

**Results:** ROM levels (U. CARR) in AM increased from 407.6±74.3 before surgery to 428.0±94.9 at 3 months after surgery and ROM levels in CM increased from 357.4±74.8 to 379.6±54.9 indicating a significant increase at 3 months after surgery equally in both groups ($p<0.05$) despite the favorable neurological improvement observed in both groups. By contrast, ROM gradually decreased until 1 year follow-up and a significant improvement of ROM was observed at 1 year follow-up in AM group ($p<0.05$). ROM was significantly increased at 1 year after surgery in fair neurological outcome group ($p<0.05$). Furthermore, in 3 patients with cases complicated by C5 palsy, ROM levels increased from 460.7±86.0 before surgery to 519.3±131.6 at 3 months after surgery and were significantly higher than those in other cases ($p<0.05$), and the high ROM levels were maintained until 1year follow-up

**Conclusions:** Serum oxidative stress markers in compression myelopathy did not decrease but increased at 3 months after surgery despite the favorable neurological improvement observed. The residual serum oxidative stress markers reflect fair neurological improvement. Serum oxidative

stress markers were higher and remained elevated in cases complicated with C5 palsy.

**Keywords:** Myelopathy, Cervical

## Clinical Outcome of Vertebroplasty Alone Versus Short-Segment Posterior Instrumentation with Vertebroplasty in Osteoporotic Vertebral Fracture: A Propensity Score-Matched Analysis

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**Purpose:** To compare the radiological outcome (sagittal angle correction, the presence of kyphotic deformity progression at 3 months and 1 year after surgery), clinical outcome (EQ-5D, ODI), postoperative complications, and re-operation rate between vertebroplasty alone (VP) and short-segment posterior instrumentation with vertebroplasty (SS with VP) in osteoporotic vertebral fracture

**Materials and Methods:** The study included patients diagnosed with OVFs undergoing vertebroplasty with or without short-segment posterior instrumentation between 2018-2022. Baseline demographic, and patient-reported outcome scores, including Oswestry Disability Index (ODI) and EuroQol-5D (EQ-5D) were collected at pre-operative and 1 year post-operative. The study also evaluated radiographic outcomes, including sagittal angle reduction after surgery, and the presence of kyphotic progression. Perioperative data were collected. Propensity score matching was performed to compare both groups after adjusting for baseline characteristics, including the preoperative ODI and EQ-5D.

**Results:** 60 patients were included. 19 patients underwent SS with VP and 41 patients underwent VP alone. Patients who underwent SS with VP had better ODI back (30.38±17.12 vs 49.68±19.43, p=0.0025) and better EQ-5D (0.80±0.19 vs. 0.6±0.31, p=0.0018) at 1 year post-operative. Sagittal angle correction was higher in SS with VP group (10.63±6.34° vs. 5.74±5.91°, p=0.0188). SS with VP group had higher blood loss (302.63±230.60 vs. 5.58±2.06, <0.0001) and longer operative time (141.32±47.75 vs. 31.47±8.00, p<0.0001). Peri-operative complication, post-operative kyphotic progression, the presence of adjacent fracture, and reoperation rate were not different between group.

**Conclusions:** This investigation concludes that short-segment posterior instrumentation with vertebroplasty (SS with VP) yields superior patient-reported outcomes and sagittal angle correction for osteoporotic vertebral fractures when assessed one year post-operatively, compared to vertebroplasty alone. Despite the increased blood loss and extended operative time associated with SS with VP, the rate of peri-operative complications, kyphotic progression, adjacent fractures, and the need for reoperation remained similar between the two treatment approaches. These findings suggest that SS with VP may be a more effective treatment option for osteoporotic vertebral fractures compared to vertebroplasty alone, but the increased risks of blood loss and longer operative time should be considered. The treatment choice should be carefully considered, taking into account the greater intraoperative risks

**Keywords:** Osteoporotic vertebral fracture, Vertebroplasty, Short-segment instrumentation, Cement augmentation, Propensity Score-Matched Analysis

## Comparison of Sagittal Alignment and Functional Outcomes in Adolescent Idiopathic Scoliosis Corrective Surgery: A Retrospective Study of UNiD Rods versus Conventional Rods

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**Purpose:** Adolescent Idiopathic Scoliosis (AIS) corrective surgery commonly employs pedicle screws and rods for deformity correction. Traditional intraoperative rod contouring precedes rod placement. UNiD rods enable preoperative rod bending with personalized plans for executing patient-specific sagittal alignment. This retrospective study compares sagittal alignment and functional outcomes in AIS corrective surgery, specifically assessing UNiD rods against conventional rods.

**Materials and Methods:** A cohort of AIS patients undergoing posterior corrective surgery in two state hospitals from 2019 to 2020 was retrospectively analyzed. Patients were categorized into UNiD rod and conventional rod (CR) groups. Radiographic evaluation pre and post-operation involved sagittal vertical axis (SVA), pelvic tilt (PT), and pelvic incidence-lumbar lordosis mismatch (PI-LL). Surgeries targeted SVA <40 mm, PT <20°, and PI-LL <10°. SRS-30 questionnaires were administered six months post-operation for functional outcome comparison.

**Results:** Thirty-three patients were recruited (UNiD group: 18, CR group: 15). In the CR group, the pre and post-operative PI-LL change was significant ($p<0.05$). Mean difference comparison revealed significant differences only in PI-LL between UNiD and CR groups ($p<0.05$). UNiD group achieved a higher percentage of planned correction: 72% in PI-LL, 94% in PT, and 94% in SVA. In the CR group, only SVA had a higher percentage of achieving planned sagittal parameters (93%). Both groups produced comparable functional outcome scores, averaging 4.36 for UNiD and 4.47 for CR, out of a maximum of 5.

**Conclusions:** UNiD rods can attain superior planned sagittal parameters compared to CR. This study highlights the comparison of sagittal alignment and functional outcomes, emphasizing the potential benefits of UNiD rods in AIS corrective surgery.

**Keywords:** Patient-Specific Rods, Deformity Correction, Surgical Rod Contouring, Scoliosis, Preoperative Planning

# Invited Lecture V

## Treatment Strategy for Subaxial Minimal Facet Fracture

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**Backgrounds and Introduction:** Subaxial facet fractures can occur as isolated injuries or be accompanied by other fractures and/or ligamentous injuries. Morphologic presentation of facet fractures is significantly variable. In addition, diagnostic accuracy for facet fractures is also significantly variable. Therefore, proper decision-making for diagnosis and treatment of facet fractures is very difficult. Improper diagnosis or treatment of facet fractures can cause serious complications, such as delayed subluxation, dislocation, or spinal cord injury, which require more extensive and demanding surgeries.

**Main Body:** In 2016, for the first time, AOSpine Knowledge Forum Trauma group proposed AO Spine subaxial facet injury classification system. In this classification, there are 4 types of facet fractures and/or dislocations. 3 types of facet fractures without subluxation or dislocation, which are F1, F2 and F3, is considered as minimal facet fractures. Among the, F1 fracture is considered as stable fracture so can be managed conservatively. However, F2 and F3 fractures are considered as borderline fracture so are very difficult to decide proper treatment strategy.

**Conclusions:** In my talk, I'd like to demonstrate some educational cases and discuss proper decision-making for complicated minimal facet fractures.

**Keywords:** Subaxial, Minimal facet fracture, Treatment strategy

# Plenary Lecture II

## C-arm Free Circumferential MIS for Adult Spinal Deformity

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**Backgrounds:** Oblique lumbar interbody fusion (OLIF) and percutaneous posterior approach for screw fixation (PPS) is the latest minimal invasive treatment for spinal deformity in adult patients (ASD). This study aims to design and highlight key points for ASD correction.

**Mainbodys:** We retrospectively analyzed 54 patients who had undergone OLIF with PPS for ASD from October 2019 to January 2022 (average 71.5 ± 6.2 years-old, male 4, female 50) with a mean follow-up period of 29.2 months. Clinical outcomes are expressed by values including the Oswestry disability index (ODI) and visual analogue scale (VAS) for back pain. The imagistic assessment was also performed

preoperatively and at 12, and 24 months postoperatively. For OLIF51, CT- MRI fusion images were obtained before surgery. Postoperative ODI and VAS were 30.5±18.9% and 31.2±6.9 mm, respectively. The average operating time and blood loss during the surgical exposure was 490.9±85.4 min and 1195.2±653.8 ml. Preoperative SVA, PI-LL, and PT were 96.5±55.9 mm, 39.3±22.1◦, 34.5±11.0◦, respectively. Postoperatively, SVA and PT became normal (24.1±39.0 mm, 17.1±10.3◦) and PI-LL was ideal (2.4±12.6◦). Postoperative ODI and VAS were 30.5 ± 18.9% and 31.2 ± 6.9 mm. For OLIF51, the results revealed gain in L5-S1 lordosis and intervertebral disc height 9.4◦ and 4.2 mm respectively. The complications consisted of PJK in 21 cases (38.9%), rod breakage in 5 cases (9.3%), deep or superficial wound infection in 2 cases (3.7%).

**Conclusions:** Clinical and imagistic results of OLIF and PPS for ASD were excellent. The radiographic measurements revealed that OLIF51 created good L5-S1 lordosis and significant L5-S1 disc height. CT-MRI fusion images were very useful for evaluating vascular anatomy for OLIF51.

**Keywords:** Spine, Deformity, Navigation surgery

### Superiority of MRI for Evaluation of Sacral Insufficiency Fracture

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**Backgrounds:** Retrospective observational study. Background: Sacral insufficiency fractures (SIF) are relatively rare fractures and difficult to diagnose on plain radiographs. The primary objective of the present study was to evaluate the role of lumbar magnetic resonance imaging (MRI) for the diagnosis of SIF. The secondary objective was to identify the classification of SIF by computed tomography (CT).

**Mainbodys:** A total of 77 (Male 11, female 66, mean 80.3 years) people were included in this study. Inclusion criteria for this study were: age ≥ 60 years and no history of high energy trauma. Exclusion criteria were high energy trauma and a current history of malignancy. Differences in the fracture detection and description in the various radiologic procedures were evaluated. Fracture patterns were evaluated with CT. The detection rates of additional pathologies in the MRI of the pelvis and lumbar spine were also recorded. The sensitivities for SIF were 28.5% in radiographs and 94.2% in CT, and all fractures were detected in MRI. MRI showed a more complex fracture pattern compared with CT in 65% of the cases. We observed 71.4% of single SIFs, 9.1% with other spinal fractures, 13.0% with other pelvic fractures, and 7.8% with other fractures. According to the SIF fracture pattern, the H/U type was 40.2%, transverse type was 33.7%, λ/T type was 24.7%, unilateral vertical type was 1.3%, and bilateral vertical type was 0%.

**Conclusions:** an MRI of the lumbar spine including the sacrum with a coronal fat-suppressed T2-weighted image is useful for elderly patients with suddenly increasing low back pain at an early stage. This procedure improves an early SIF detection, recognition of concomitant pathologies, and adequate treatment for the patients.

**Keywords:** Sacrum, Insufficiency fractures, MEI

## Symposium III. Lumbar: L5-S1, Unique and Special Site

### Unique Anatomy and Biomechanics of L5-S1

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**Backgrounds and Introduction:** The L5-S1 spinal motion segment, also called the lumbosacral joint, is the transition region between the lumbar spine and sacral spine in the lower back. In this region, the curvature of the spine changes from lumbar lordosis to sacral kyphosis. L5-S1 helps transfer loads from the spine into the pelvis and legs. The L5-S1 motion segment has distinctive anatomy and receives a higher degree of mechanical stress and loads compared to the segments above. These characteristics may make L5-S1 susceptible to traumatic injuries, degeneration, disc herniation, and/or nerve pain.

**Main Body:** L5 consists of a vertebral body in front and an arch in the back that has 3 bony protrusions: a prominent spinous process in the middle and two transverse processes on the sides. These protrusions serve as attachment points for ligaments. S1, also called the sacral base, is the upper and wider end of the triangular-shaped sacrum. S1 consists of a body on the top with wing-shaped bones on either side, called the alae. At the back, the S1 vertebra contains a long bony prominence called the median ridge. There are bony openings called neural foramina on the right and left sides of this ridge. L5 and S1 are joined by the lumbosacral facet joints lined with articular cartilage. The intervertebral disc provides cushioning and shock-absorbing functions to protect the vertebrae during spinal movements. The L5 spinal nerve roots exit the spinal cord through intervertebral foramina on the left and right sides of the spinal canal. These nerve roots join with other nerves to form bigger nerves that extend down the spine and travel down each leg. The L5-S1 motion segment provides a bony enclosure for the cauda equina and other delicate structures. The L5-S1 situated at the bottom of the vertebral column is typically subject to excessive biomechanical stress, leading to more loads and an increased risk of injury. Lower back disc herniation typically occurs at the L5-S1 level. A steeper inclination of this disc leads to a higher degree of shear stresses and increases the risk disc of injury and degeneration. The lumbosacral joint may develop wear-and-tear arthritis over time due to its high load-bearing function. Facet joint pain may also occur due to inflammatory conditions, such as rheumatoid arthritis or degenerative spondylolisthesis. The L5 vertebra is susceptible to spondylolysis, which is the fracture of the pars interarticularis most commonly due to repetitive stress on the bone. It can occur on one or both sides. Frequently, the bone does not break, but becomes stressed and this condition is called a pars stress reaction. If the pars of L5 fractures on both sides, the vertebra may slip over S1, a condition called spondylolisthesis. Most commonly, spondylolisthesis of L5 is caused by repetitive stress to the pars interarticularis and is most has commonly seen in children and adolescents.

**Conclusions:** L5-S1 has unique anatomical characteristics compared to other spinal regions and is a region where excessive biomechanical stress acts. It is important to implement appropriate treatment through proper understanding of these aspects.

**Keywords:** Lumbosacral region, Anatomy, Biomechanics

## Endoscopic approach on L5S1

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**Backgrounds and Introduction:** Endoscopic spine surgery has emerged as a minimally invasive alternative for treating various spinal disorders, offering advantages such as reduced tissue damage, shorter recovery times, and lower complication rates compared to traditional open procedures. In the past, when referring to endoscopic spine surgery, only uniportal (full) endoscopes were used. However, recently, with the trend towards biportal endoscopy, both uniportal and biportal endoscopes are being utilized in spinal surgery. This paper presents a comprehensive review focused on the application of endoscopic techniques specifically targeting the L5-S1 level of the spine.

**Main Body:** In both uniportal and biportal endoscopic surgery, there are two approaches: the interlaminar approach and the transforaminal approach. The choice between the two approaches depends on factors such as diagnosis, the location of the lesion, and the patient's individual anatomical characteristics. This ensures selecting the most advantageous and safe method tailored for surgeons. The L5-S1 level exhibits anatomical characteristics, including the iliac crest, the morphology of foramen and facet joints, the anatomy of the L5 dorsal root ganglion, and the slope of the disc space. These anatomical features impose limitations on the transforaminal approach in both uniportal and biportal endoscopy. Due to the wide interlaminar space at L5-S1 level, an interlaminar approach is recommended whenever possible in both uniportal and biportal endoscopes. However, in cases of extraforaminal lesions such as foraminal stenosis and extraforaminal disc, a transforaminal approach may be necessary. Particularly, the L5-S1 level, being a transitional zone between the trunk and pelvis, is prone to foraminal stenosis with age. Studies on transforaminal approach for foraminal stenosis suggest that uniportal endoscopy

may result in incomplete decompression, while biportal endoscopy provides good visualization and decompression but may induce instability due to excessive superior articular process resection compared to uniportal approaches. Consequently, recurrent symptoms due to instability are common in the long term, often necessitating fusion surgery. To overcome the drawbacks of the extraforaminal approach, attempts have been made to treat lesions in the subarticular or foraminal zone through contralateral approach.

**Conclusions:** Given the anatomical characteristics of L5-S1, it is recommended to opt for an interlaminar approach including contralateral approach whenever performing surgery endoscopically. Additionally, if a transforaminal approach is chosen, we should be aware of potential complications while the surgery.

**Keywords:** Spine, Surgery, Endoscopy, Procedures

## How to Improve Fusion Rate

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**Backgrounds and Introduction:** The lumbosacral junction has distinctive structural and biomechanical characteristics that are different from those of other lumbar spine segments. Notably, the L5/S1 level exhibits distinct features such as the presence of iliolumbar and lumbosacral ligaments, coronally oriented facets and laminae, a wedge-shaped disc, and its junctional location. Consequently, it necessitates specialized attention during spinal fusion surgery.

**Main Body:** Fusion of the L5/S1 spinal segment is a common procedure performed in degenerative conditions such as spondylolisthesis. Interbody fusion at L5/S1 is favored because of the large surface area available for new bone formation, the load sharing properties associated with anterior column support, and the ability to indirectly decompresses the nerve roots and restore local lordosis. Although this can be performed utilizing multiple different techniques, such as an anterior lumbar interbody fusion (ALIF), transforaminal lumbar interbody fusion (TLIF), oblique lumbar interbody fusion (OLIF) and axial interbody fusion, each has its own set of challenges. Especially, constructs including the L5/S1 level have been of particular interest because of its distinctive anatomy transitioning from a mobile to a fixed segment resulting in high degrees of mechanical stress and loads compared to other segments of the lumbar spine. In terms of biological technologies, autograft bone is still the gold standard for bone grafting in spinal fusion surgery due to its good osteoconductive, osteoinductive, and osteogenic abilities. Accumulating evidence suggests that adding rhBMPs in combination with autograft effectively promotes the fusion rate and improves surgical outcomes. However, the stimulating effect on spinal fusion of other growth factors, including PDGF, VEGF, TGF-beta, and FGF, is not convincing, while Nell-1 and activin A exhibited preliminary efficacy. Furthermore, in terms of systemic therapeutic approaches, the osteoporosis drug Teriparatide has played a positive role in promoting bone healing after spinal surgery, while new medications such as denosumab and sclerostin antibodies still need further validation.

**Conclusions:** Several surgical techniques hold promise for improving spinal fusion rates at the lumbosacral junction. These include: 1) Utilizing a combination of fusion cages, bone grafts, and fixation techniques to ensure optimal fit and stability. 2) Incorporating interbody support to enhance vertebral alignment and fusion success. 3) Sacropelvic fixation, combining long fusion, interbody fusion, and iliac screw fixation, to bolster construct stability and fusion rates. 4) Appropriate application of biological therapeutics to augment spinal fusion.

**Keywords:** Lumbosacral junction, Spinal fusion, Rate, Improvement, Surgical technique

## Revision Surgery in L5-S1

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With the increase in aging population, it is expected that the rate for elective spinal surgery will also increase over time.

Revision rates following primary spinal fusion procedure ranged from 8–45%, which increase with greater follow-up. There are multiple reasons for revision surgery and diagnoses may overlap. Those reasons include recurrence of stenosis, non-union, implant failure, infection, adjacent segment disease and flat back fusion. Surgical options range from decompression employing minimal invasive techniques to open osteotomies, but the optimal approach comes down to two deciding factors: 1) nature of previous surgery and 2) spinopelvic parameters, which are key predictors for functional outcomes in patients with adult spinal deformity. We would like to discuss surgical options and pitfalls for revision L5-S1 surgery.

**Keywords:** Spine, Revision surgery, Pseudoarthrosis

# Free Paper: Deformity (4)

## Comparison of Corrective Surgeries with OLIF and PLIF for Degenerative Lumbar Scoliosis Over 2-Year Follow-up

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**Purpose:** To compare 2-year follow-up outcomes of following two surgeries (group A, AP correction surgery using OLIF; group B, Posterior-only correction surgery using PLIF) for degenerative lumbar scoliosis (DLS), in terms of clinical and radiological outcomes, and complications

**Materials and Methods :** Among 79 patients who were randomly assigned to two groups (group A with OLIF, 35 patients; group B with PLIF, 40 patients), 61 patients (33 in group A and 28 in group B) were followed-up of more than two years and analyzed for the current study. The primary outcome measure was the fusion rate, evaluated by radiographs and computed tomography scans. Secondary outcome measures included: (1) patient satisfaction; (2) clinical outcomes measured with pain intensity using a visual analog scale, the Oswestry disability index, and 12-short health form survey; (3) radiologic outcomes; and (4) complications.

**Results:** At 2-year follow-up, the fusion rate was comparable between the two groups (93% in the OLIF group; 81% in the PLIF group; p>0.71). The patient satisfaction rate at the 1-month follow-up was significantly higher in the PLIF group than in the OLIF group (p=0.03), but in 2 years after surgery, there was significantly higher in the OLIF group than in the PLIF group (p=0.08). Clinical outcomes revealed no significant differences in both groups within 2 years postoperatively. Complications such as screw loosening, cage subsidence, and upper-most or adjacent vertebral fracture were higher in PLIF group than those in OLIF group (p=0.04).

**Conclusions:** We suggest that anteroposterior correction surgery using OLIF may be a great choice for DLS over posterior-only surgery using PLIF.

**Keywords:** Thoracolumbar, Deformity, Anterior column reconstruction, Oblique lumbar interbody fusion, Posterior lumbar interbody fusion

## Intraoperative Pleural Injury Causing Pneumothorax in Scoliosis Surgery- A Rare Complication

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**Purpose:** The aim of scoliosis surgery is to prevent further progression and maintain a overall balanced spine. However, it does not come without risk associated with perioperative complications. Here, we report a rare complication of pneumothorax occurring in conjunction with posterior spinal fusion for the treatment of scoliosis surgery.

**Materials and Methods:** This report presents a 18year old male patient who has been diagnosed with syringomyelia associated with severe scoliosis, developed abrupt compromised hemodynamics secondary to inadvertent pleural tear during surgery. This was managed by chest tube insertion. Post chest tube insertion, patient was stable hemodynamically and surgery proceeded as planned. In view of the severity of scoliosis, cobb angle being 60 degree,

there was rotation of the vertebra at thoracic region causing difficulty in dissection of the thoracic spine prior to pedicle screw insertion.

**Results:** Following the pleural injury, pleura was repaired using a fascia from adjacent spinal musculature. Alongside, chest tube was inserted and showed 150cc of hemoserous fluid. Patient returned to normal hemodynamic after these measures were done. Patient was discharged well on the 7th day after surgery without any complications. During clinic visit at first month, patient was well with no respiratory complaints. Although it is a rare complication, it is important to be aware of its existence, not only to perform a quick diagnosis but to also avoid it.

**Conclusions:** In patients undergoing posterior spinal surgery, if there is any unexplained hemodynamic instability, pleural injury should be highly suspected and managed appropriately.

**Keywords:** Pleural injury, Scoliosis, Posterior spinal fusion

## Factors Associated with Achieving Minimum Clinically Important Difference (MCID) in EQ-5D Scores after surgery for Adult Spinal Deformity

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**Purpose:** This study aimed to identify factors influencing the likelihood of achieving the minimum clinically important difference (MCID) in patient-reported outcomes assessed by the EuroQol-5 Dimensions-5 Levels (EQ-5D) among individuals with adult spinal deformity (ASD) who underwent extensive corrective fusion surgery.

**Materials and Methods:** The data from ASD patients with PI-LL greater than 20°, who underwent extensive corrective fusion surgery from the thoracic spine to the pelvis between 2014 and 2020 were reviewed. The group that achieved MCID in EQ-5D two year after surgery was compared to the group that did not achieve it. Multivariate analysis was used to investigate factors associated with the probability of achieving MCID for EQ-5D. The established MCID values were 0.22.

**Results:** A total of 85 patients with a 2-year follow-up were included in the analysis. The MCID achievement rate was 45%. There were no demographic differences between the MCID achievement group and the non-achievement group. In radiologic outcomes, there were significant associations with preoperative pelvic incidence (PI), sacral slope (SS), and age-adjusted ideal correction. In logistic regression analysis, age-adjusted ideal correction (OR 2.832, 95% CI:1.077-7.450, p:0.035) and PI (OR 1.051, 95% CI: 1.001-1.103, p:0.045) were identified as significant factors. One-way analysis based on age-adjusted alignment showed a significantly lower MCID achievement rate in cases of undercorrection compared to ideal correction, while overcorrection did not show a significant difference.

**Conclusions:** Individuals with a higher PI and closer to ideal correction showed significantly better achievement of MCID of EQ-5D after surgery. Additionally, when undercorrection occurred, the results for EQ-5D were less favorable compared to both ideal correction and overcorrection. These findings should be taken into consideration during the surgical planning process.

**Keywords:** MCID, EQ-5D, Adults spinal deformity, Factor

## Risk Factor of Re-Revision Surgery after Fusion Extension Surgery for Proximal Junctional Failure in Patients with ASD

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**Purpose:** Proximal junctional failure (PJF) after long instrumented spinal fusion for adult spinal deformity (ASD) is a well-recognized complication that often result in deteriorating clinical outcomes and necessitate revision surgery. However, some patients experience recurrent PJF

after fusion extension surgery, requiring re-revision surgery. Re-revision surgery can be a huge burden for both patients and surgeons. This study aims to investigate the risk factors of re-revision surgery for recurrent PJF development after ASD surgery.

**Materials and Methods:** Patients ≥60 years who underwent surgical treatment for ASD were included in this study. Among them, those who underwent fusion extension surgery for PJF were selected. Patients was categorized into two groups (non re-revision group and re-revision group) according to whether the re-revision surgery was performed or not. Various clinical and radiographic factors were compared between two groups to identify the risk factors for re-revision surgery.

**Results:** Among 428 patients with surgically treated ASD, 60 patients who required revision surgery for PJF were included in this study. Of these, 17 patients (re-revision group) underwent re-revision surgery due to recurrent PJF. Pelvic incidence (PI) was significantly lower in the re-revision group (47.9° vs. 52.7°, p=0.011). There were more patients of overcorrection relative to age-adjusted PI-LL in re-revision group (52.9% vs. 14.0%, p=0.002). Time from index to revision surgery and final fusion level after revision surgery were not different. However, the uppermost screw angle (cranial direction) was significantly greater in re-revision group (1.6° vs. -0.5°, p=0.014). Regarding radiographic parameters at the revision surgery, the hounsfield unit at UIV was significantly lower in the re-revision group (143.7 vs. 176.9, p=0.026). The severity of PJK was assessed using Hart-ISSG PJK severity scale (PJKSS), with the severity of neurological deficit and the total sum of PJKSS being significantly greater in the re-revision group. Multivariate analysis revealed that low PI, overcorrection relative to age-adjusted PI-LL, and the total sum of PJKSS were significant risk factors for re-revision surgery.

**Conclusions:** Overcorrection during the index surgery should be avoided especially in patients with low PI. Considering that the total sum of PJKSS tends to increase over time, surgical intervention should be considered in a timely manner in patients with symptomatic PJF.

**Keywords:** Adult spinal deformity, Proximal junctional failure, Revision surgery, Re-revision surgery, Risk factor

## Sagittal Balance after Correction of Structural Thoracolumbar or Lumbar Curve in Adolescent Idiopathic Scoliosis

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**Purpose:** While restoration of sagittal balance and lumbar lordosis is known to be important in adult spinal deformity, the main focus in on the correction of the coronal plane deformity in the surgical correction of adolescent idiopathic scoliosis (AIS). This study is to evaluate sagittal balance and associated factors after correction of structural thoracolumbar or lumbar curve in AIS.

**Materials and Methods:** Consecutive data were collected from 61 patients who underwent surgical correction for structural thoracolumbar or lumbar curve in AIS from 2015 to 2022. All patients underwent deformity correction using minimally invasive scoliosis surgery. Demographic data and preoperative and postoperative radiographic data were collected. Two groups were created, based on the postoperative pelvic incidence minus lumbar lordosis (PI-LL) mismatch. PI-LL mismatch greater than 10 degrees was defined as pelvic imbalance. The two groups were then compared to identify parameters that correlated to postoperative PI-LL mismatch.

**Results:** 43 patients were included in sagittal balance group and 18 patients were included in sagittal imbalance group. Pelvic incidence (49.1º vs. 58.3º, p<0.001) and preoperative PI-LL mismatch (16.3% vs 61.1%, p=0.001) and correction amount of thoracic kyphosis (4.7º vs. 0.0º, p=0.046) were associated factors with postoperative PI-LL mismatch. The preoperative cobb's angle or the lowest instrumented vertebra did not seem to associated postoperative PI-LL mismatch. There was no statistical difference in preoperative sagittal vertical axis (SVA) according to preoperative PI-LL mismatch (-12.51 mm vs. -10.44 mm, p=0.315), there was statistical difference in postoperative SVA according to postoperative PI-LL mismatch (2.9 mm vs. 17.7 mm,

p=0.009).

**Conclusions:** In patients with AIS requiring thoracolumbar or lumbar curve correction, a large PI or preoperative PI-LL mismatch is associated with the development of a postoperative PI-LL mismatch. Instrumentation of the lumbar spine may compromise compensation mechanism that maintain sagittal balance.

**Keywords:** Thoracolumbar or lumbar curve, Adolescent idiopathic scoliosis, Sagittal balance, PI-LL mismatch

# Free Paper: Tumor

## Which Is Better Between Aggressive Debulking Versus Minimal Decompression in Patients with Metastatic Spinal Cord Compression?: Propensity Score Matching Analysis From a Multicenter Study Cohort

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**Purpose:** Metastatic spinal cord compression (MSCC) represents an oncologic emergency, leading to irreversible neurological deficits. Traditional management has involved aggressive debulking with a recent shift towards minimally invasive procedures like decompression alone or separation surgery. Yet, the relative efficacy and results of these methods are not established. This study evaluates the comparative outcomes of these tow surgical approaches for MSCC regarding functional improvement and symptomatic local recurrence.

**Materials and Methods:** In this multicenter, retrospective study from two tertiary hospitals, we analyzed patients with thoracolumbar MSCC treated since 2010 using aggressive debulking (AD group) or minimal decompression (MD group). We examined patient demographics, performance status, primary tumor type, modified Tokuhashi scores, type of surgery, estimated blood loss (EBL), operation time, postoperative complications, and symptomatic local recurrence. We conducted propensity score matching (1:1 ratio) based on age, sex, primary origin, radiosensitivity of the primary tumor, preoperative eastern cooperative oncology group-performance status, Bilsky grade of spinal cord compression, and modified Tokuhashi score for intergroup comparisons. Survival analysis and logistic regression were applied to the matched cohorts.

**Results:** A total of 264 patients were included, with 86 patients receiving aggressive debulking and 178 patients receiving minimal decompression. After 1:1 propensity score matching, a total of 156 matched patients were analyzed (78 patients in AD and MD group, respectively). The estimated median survival was 8.2 (AD group) and 10.3 months (MD group) for matched patients. EBL and operation time were significantly higher in AD group than MD group. The AD group exhibited a higher incidence of medical complications during hospitalization compared to the MD group (37.2% vs. 21.8%, p=0.035). However, the rate of inpatient surgical complications did not significantly differ between the groups. In initially non-ambulatory patients, the rate of regaining ambulatory function did not significantly differ between the AD and MD groups (32.1% and 23.1%, respectively, p=0.210). At the final follow-up, no significant differences were noted in symptomatic local recurrence-free survival (p=0.095). In multivariate logistic regression, higher modified Tokuhashi score was a single risk factor associated with symptomatic local recurrence (Odds ratio: 1.871, p=0.001)

**Conclusions:** This study showed that there were no differences in functional improvement and symptomatic local recurrence rate between AD and MD group, while AD group had a greater surgical burden. Therefore, minimal decompression rather than aggressive debulking seems to be enough in patients with MSCC.

**Keywords:** Metastatic spinal cord compression, Local recurrence, Functional improvement, Debulking, Decompression

## A Multicenter Investigation on the Incidence and Risk Factors of Wound Dehiscence Following Surgical Treatment to Metastatic Spinal Tumor

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**Purpose:** Wound-related problems are a major issue in postoperative care for metastatic spine tumors, with incidence rates as high as 30% in certain studies. Wound-related problems such as dehiscence and infection can delay the treatment of primary tumor and, consequently, may impact overall survival. The aim of this study was to utilize multicenter data to evaluate the incidence and risk factors of wound dehiscence after surgery for metastatic spinal tumors and to analyze their impact on survival.

**Materials and Methods:** A retrospective multicenter study of patients undergoing surgical treatment of metastatic spinal tumors between 2019 and 2022 was conducted. Data on patient demographics, primary tumor, comorbidities, laboratory values, operative details, radiation therapy, chemotherapy and steroid use were collected. Univariate and multivariate analyses were performed to analyze the risk factors associated with wound dehiscence and survival analysis for each factor. Survival analysis based on wound dehiscence was also performed.

**Results:** Among the 277 patients in the multicenter data, 32 (11.6%) encountered wound dehiscence, with an average time to occurrence of 37.09±24.28 days. Among these cases, 11 patient (4.0 %) underwent general revision surgery, while 22 (7.9 %) received local surgical treatment. Additionally, 11 patients (4.0%) developed wound infections. In the univariate analysis, significant factors for wound dehiscence included diabetes, hyperlipidemia, length of surgical segment, and preoperative chemotherapy (preop CTx) within 30 days before surgery. On multivariate analysis, significant predictors for developing wound dehiscence were diabetes (OR: 4.52, 95% CI: 1.81 -11.29, p=0.001), length of surgical segment (OR: 1.31, 95% CI: 1.07-1.60, p=0.009), and preoperative chemotherapy within 30 days before surgery (OR: 4.09, 95% CI: 1.64 -10.21, p=0.003). There was no significant difference in the occurrence of wound dehiscence according to pre- and postoperative radiation therapy, considering the radiation timing, dosage, and frequency of radiation. There was also no difference in overall survival based on wound dehiscence.

**Conclusions:** In the multicenter data of 277 patients, 11.6% experienced wound dehiscence, typically 37.09 days post-surgery, leading to 4.0% undergoing major revision surgery, and 4.0% developing wound infections. Risk factors for wound dehiscence after metastatic spine tumor surgery were associated with diabetes, length of surgical segment and preoperative chemotherapy within 30 days before surgery.

**Keywords:** Metastatic spinal tumor, Wound dehiscence, Incidence, Risk factor

## Clinical Outcome Study of Primary Intra-Spinal Tumour at Yangon Orthopaedic Hospital

Sai Rath

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**Purpose:** To study clinical outcome of primary intra-spinal tumour at Yangon Orthopaedic Hospital

**Materials and Methods:** We conducted a retrospective review of 27 patients with intraspinal tumours who underwent surgical treatment in our institution between June 2020 and December 2021 . Their age, sex, initial presentation, tumour location, level of affected vertebral column, histological diagnosis and clinical outcomes were reviewed and analyzed up-to 6 months.

**Results:** Of these 27 patients,15 (67%) were men and 12 (33%) were women. The mean age was 56.3 years (range 13 to 72 years). All of these were primary tumours, we excluded metastatic tumours. The histological diagnosis of the primary tumour included 15(55.55%) neurofibromas,7(25.92%) schwannomas, 4(14.81%) meningiomas,1(3.7%) ependymomas. The most common site of the tumour is thoracic. The most common clinical presentation of the primary spinal tumours was pain (92.5%). Most of the

patients with nerve sheath cell tumours (schwannomas and neurofibromas) had symptoms of sensory disturbance and pain. All of the patients with meningiomas had symptoms associated with cord compression. Mean VAS score of back pain were reduced after operation and successively reduce to nearly 0 at 3 months follow up. Mean MRC grading of radiculopathy was also increased by one grading at 3 months follow up and nearly normal function at 6 months follow up. In myelopathy cases most of the cases were not significantly improved at 3 months follow up, but at 6 months follow up most of the cases regained to useful functional scale (ie; Frankel D,E).

**Conclusions:** Back pain and roots compression symptoms were the most common presentations in patients with intraspinal tumours. Surgery is the "gold standard" in the treatment of spinal cord tumours. Complete removal of the lesion is the first goal. Postoperative results are dependent on the surgeon's experience, but also on the preoperative neurological status and histology types.

**Keywords:** Primary intra-spinal tumour, Clinical outcome, Yangon Orthopaedic Hospital

## Treatment Outcomes of Stereotactic Body Radiation Therapy for Primary and Metastatic Sarcoma of the Spine

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**Purpose:** This study evaluated the treatment outcomes of spine stereotactic body radiation therapy (SBRT) in sarcoma patients.

**Materials and Methods:** A total of 44 sarcoma patients and 75 spinal lesions (6 primary tumors, 69 metastatic tumors) treated with SBRT were retrospectively reviewed between 2006 and 2017. The median radiation dose was 33 Gy (range, 18-45 Gy) in 3 fractions (range, 1-5) prescribed to the 75% isodose line.

**Results:** The median follow-up duration was 18.2 months. The 1-year local control was 76.4%, and patients treated with single vertebral body were identified as a favorable prognostic factor on multivariate analyses. Progression-free survival at 1 year was 31.9%, with the interval between initial diagnosis and SBRT and extent of disease at the time of treatment being significant prognostic factors. The 1-year overall survival was 80.5%, and PTV and visceral metastases were independently associated with inferior overall survival.

**Conclusions:** SBRT for spinal sarcoma is effective in achieving local control, particularly when treating a single ver- tebral level with a limited extent of disease involvement, resulting in an excellent control rate. The extent of disease at the time of SBRT is significantly correlated with survival outcomes and should be considered when treating spine sarcoma.

**Keywords:** Sarcoma, Spine, Stereotactic body radiation therapy, Oligometastasis

## Is SORG Algorithm Superior in Predicting Survival in Metastatic Spine Disease?

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**Purpose:** Despite the availability of several survival scoring systems for surgical decision making, their reliability and validity is still unclear. It is essential to determine the accuracy and therefore this study we compared the SORG algorithm in predicting survival in metastatic spine disease versus the currently used Revised Tokuhashi and Tomita Scoring Systems.

**Materials and Methods:** We retrospectively recruited a cohort of metastatic spine disease who underwent surgery at a single centre, operated by a single team between August 2020 to December 2022. The optimal AUC was calculated to evaluate the accuracy of 3 scoring systems at 3,6 and 12 months respectively.

**Results:** A total of 54 patients (35 males & 19 females) were included. The analysis of our cohort showed that SORG algorithm was superior in predicting survival as compared to the Revised Tokushashi and Tomita scoring systems. The SORG algorithm had an AUC of 0.86 at 90 days and 0.84

at 1 year. The revised Tokuhashi and Tomita Scores had an AUC of 0.64, 0.70 and 0.59 and 0.62 at 3 moths and 1 year respectively.

**Conclusions:** The predictive ability of the SORG algorithm was superior to currently used preoperative survival estimation scores for spinal metastatic disease.

**Keywords:** SORG, Separation surgery, Spinal metastases, Survival prediction

# Asian Traveling Fellowship Reports (Crystal Ballroom A)

### JSSR 2024 Traveling Fellowship (Japan)

Jiwon Park

*Korea*

### TWSS 2024 Traveling Fellowship (Taiwan)

Sung Cheol Park

*Korea*

# Free Paper: Cervical (1)

### Comparison Between Atlantoaxial and Occipitocervical Fusion: Clinical Implications of Restoring the Atlanto-Occipital Joint

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**Purpose:** Cervical myelopathy originating from high cervical pathology is typically managed through stabilization constructs, with the most common options being atlantoaxial fusion (AAF) and occipitocervical fusion (OCF). However, a well-established comparison of the two techniques in terms of clinical and radiological outcomes has not been made. To address this gap in knowledge, this study aimed to compare the surgical outcomes of AAF and OCF with a minimum follow-up period of 2 years.

**Materials and Methods:** This study included 64 patients who underwent AAF (n=46) and OCF (n=18) as treatment for cervical myelopathy. Neck pain Visual Analogue Scale (VAS), Neck Disability Index (NDI), Japanese Orthopedic Association (JOA) scores and postoperative complications were assessed as clinical outcomes. For the radiological outcomes, cervical sagittal parameters including C0-2 lordosis, C2-7 lordosis, C0-7 lordosis, neck range of motion (ROM), C2-7 sagittal vertical axis, C2 sagittal tilt, T1 slope, chin brow vertical angle and McGregor slope were evaluated.

**Results:** In both the AAF and OCF groups, there was a general decrease in the ROM of the neck after surgery. In particular, the decrease in C2-7 ROM was significantly more severe in the OCF group compared to the AAF group (AAF group, -6.4°; OCF group, -20.1°: p=0.010). Both groups did not show any significant differences in the total NDI score, VAS for neck pain, and JOA score when comparing preoperative and postoperative evaluations. However, at 1 month postoperatively (AAF group, 2.63; OCF group, 8.00: p=0.006) and final follow-ups (AAF group, 3.08; OCF group, 7.82: p=0.003), the OCF group showed a significant decline in the lifting function compared to the AAF group.

**Conclusions:** A significant decrease in ROM at the lower segments of the neck can occur after the OCF. This could act as a major cause for the decline in lifting function after the surgery. Therefore, for highly active young individuals or workers who frequently lift heavy objects, it is recommended to undergo the AAF that preserves the occipitocervical joint, whenever it is feasible.

**Keywords:** Occipitocervical fusion, Atlantoaxial fusion, Cervical myelopathy, Occipitocervical joint, Upper cervical spine

## Does Posterior Cord Compression by Ligamentum Flavum Adversely Affect Clinical Outcome of Anterior Cervical Discectomy and Fusion?

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**Purpose:** Although anterior cervical discectomy and fusion (ACDF) effectively removes anterior cord compressive pathologies, including herniated discs and bone spurs, it cannot address posterior compressive pathologies. Whether ACDF could result in favorable outcomes when posterior cord compression by ligamentum flavum (CCLF) is present remains unclear. The current study was conducted to clarify whether the outcomes of ACDF differ according to presence of posterior CCLF.

**Materials and Methods:** We retrospectively reviewed 195 consecutive patients who had undergone ACDF and had been followed-up for >2 years. CCLF was graded on a scale of 0-2 based on MRI findings. Patients with CCLF grade 2 were classified into the CCLF group, while patients with CCLF grade 0-1 were classified into the no-CCLF group. Patient characteristics, cervical sagittal parameters, neck pain visual analog scale (VAS), arm pain VAS, and Japanese Orthopedic Association (JOA) score were assessed.

**Results:** One-hundred and sixty-seven patients (85.6%) were included in the no-CCLF group, while the remaining 28 (14.4%) were included in the CCLF group. Among the patients in the CCLF group, 14 (50.0%) achieved clinical improvement, while 14 (50.0%) did not. JOA score significantly improved in the no-CCLF group after the operation ($p<0.001$) but not in the CCLF group ($p=0.642$). JOA score at 3 months ($p=0.037$) and 2 years ($p=0.001$) postoperatively was significantly higher in the no-CCLF group. JOA recovery rate at 2 years postoperatively was also significantly higher in the no-CCLF group ($p=0.042$). Multiple regression analysis showed that CCLF was significantly associated with JOA recovery rate at 2 years postoperatively ($p=0.045$).

**Conclusions:** ACDF performed in patients with CCLF grade 2 showed inferior JOA score improvement compared to those of patients with CCLF grade 0 or 1. ACDF cannot remove posterior compressive pathology, limiting its applicability when the ligamentum flavum significantly contributes to cord compression.

**Keywords:**Cervical myelopathy, Cord compression by ligamentum flavum, indirect decompression, Anterior cervical discectomy and fusion

## Functional and Radiological Outcomes Following Craniovertebral Junction Surgery

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**Purpose** Craniovertebral junction (CVJ) pathologies include atlantoaxial instability/deformities resulting in myelopathy, respiratory failure, and even death. Here, we describe the indications, preoperative planning, and intra-operative/postoperative complications following surgical management of CVJ anomalies.

**Materials and Methods:** A prospective analysis of 34 patients with CVJ pathology was evaluated between 2015 and 2022. Their various etiologies included atlantoaxial instability, trauma, tuberculosis, Down's syndrome, Morquio syndrome, os odontoideum, and atlantoaxial abnormalities. Clinical outcomes were assessed using the American spinal injury association (ASIA) impairment scale score and Benzel's modified Japanese Orthopedic Association (mJOA) score. Surgical assessments included length of hospital stay, operative time, blood loss, and intraoperative postoperative complications. Radiological parameters included fusion (i.e., implant loosening/implant failure), preoperative/postoperative atlanto-dens interval (ADI), clivus canal angle (CCA), and space available for cord (SAC).

**Results:** Five patients were managed conservatively, while 29 patients had surgery. Operations included occipitocervical fusion (14 patients), C1–2 fusion (10 patients), C1–2 transarticular screw fixation (four patients), and one patient underwent anterior corpectomy decompression/fusion. Seven patients had vertebral artery anomalies, and 13 patients had atlantoaxial abnormalities. At the final follow-up, atlantoaxial instability (i.e., mean preoperative ADI of 6.6±2.3 mm)

was restored to 4.2±0.6 mm, significant cord compression (i.e., with mean SAC of 8.3±2.9 mm) was relieved to 17.2± 1.6 mm, and the mean preoperative CCA (i.e., 130.2±15.3) was improved to 143.3±8.3°. There was also a statistically significant improvement in the ASIA scale and mJOA score.

**Conclusions:** Surgical management of CVJ abnormalities requires expertise and meticulous planning to avoid devastating complications such as wound dehiscence and catastrophic vertebral artery injury.

**Keywords:** Atlantoaxial instability, Clivus canal angle, Craniovertebral junction, Space available for cord, Vertebral artery abnormalities

## Analysis of the Incidence and Risk Factors of Postoperative Delirium in Patient with Degenerative Cervical Myelopathy

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**Purpose:** The purpose of this study is to analyze various risk factors that can cause postoperative delirium (POD) in degenerative cervical myelopathy (DCM) patients, which may affect normal recovery and outcomes after surgery, and to help deal with them in advance and to take a medical approach.

**Materials and methods:** A total of 148 patients aged 60 years or older who underwent laminoplasty or anterior cervical discectomy and fusion (ACDF) for DCM from 2008 to 2015 were included in this study. Incidence and multiple risk factors for development of POD were analyzed.

**Results:** POD occurred in 24 patients (16.2%). Among the 148 patients, 78 received laminoplasty, of whom 19 patients (24%) experienced delirium; the other 70 patients underwent ACDF, of whom 5 patients (7.1%) experienced delirium. History of Parkinson disease (odds ratio [OR], 178.242; p=0.015), potassium level (OR, 3.764; p=0.031), and surgical approach of laminoplasty over ACDF (OR, 8.538; p=0.008) were found to be significant risk factors in a multivariate analysis. Age (OR, 1.056; p=0.04) and potassium level (OR, 3.217; p=0.04) were significant risk factors in the laminoplasty group.

**Conclusions:** The findings of this study suggest that the incidence and risk factors for POD may vary in patients with DCM. It is necessary to understand multiple factors that affect the development of POD.

**Keywords:** Delirium, Postoperative care, Cervical myelopathy, Laminoplasty

## Incidence and Management of Dural Tear after Posterior Decompression Surgery for Degenerative Cervical Myelopathy

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**Purpose:** Incidental durotomy (ID) is well-recognized frequent complication of spine surgeries with incidence rate of 1% to 17% in various studies. This study focuses on incidence of ID in cervical laminectomy and its management. tomy over 4-year period were included in study. 101 patients were operated with High speed burr and 76 with Ultrasonic scalpel. Total 14 dural tears were encountered. If ID occurred, it was repaired with Prolene 5-0 and fibrin sealant (Duarseal) was placed over repair. If ID was irreparable, onlay collagen matrix sealant (DuraGen) was placed at the site. All wounds-including those that did not have ID, were closed in water tight manner with negative suction drains placed in anti-gravity method and away from wound site. 4 cases develop late CSF leak (intra-operatively missed ID). Drain was not charged for vacuum effect in case of ID. Drains removed on post op day 7 with primary closure of drain site. Clinical symptoms of CSF leak were managed with hydration and analgesics. Mobilization was done when symptoms settled.

**Results:** 124 patients were males and 53 females with mean age of 55.4±12.0 years. The patients had symptoms for 3.8±3.0 months and the BMI were 27.2±5.0 kg/

m2. The commonest symptom was neck pain followed by radiculopathy, gait disturbance and bowel/bladder involvement. Incidence of dural tear was 7.9%. Out of 14 dural leaks, 12 were operated with burr and 2 with ultrasonic scalpel (p=0.024). 3 tears were repaired primarily. 7 tears were found irreparable. 4 tears were missed intra-operatively and were identified in post-operative period. Duration of surgery for Group 1 (no ID) was 125.9±35.5 minutes and for Group 2 (with ID) was 140.1±23.8 (p value 0.95). Intra-operative blood loss for Group 1 was 142.8±42.1 mL and for Group 2 was 154.1±44.1 mL (p-value 0.18). Duration of hospital stay for Group 1 was 10.2±2.7 days and for Group 2 was 11.3±3.5 days (p-value 0.67). Number of levels operated and OPLL had no statistically significant difference. No patient required re-surgery for CSF-leak related complications.

**Conclusions:** This study focuses on dural tear occurring in posterior cervical surgeries and its management for which literature is at paucity. This study establishes method for Successful management of dural leak in cervical laminectomy.

**Keywords:** Dural tear, Cervical myelopathy, Ultrasonic scalplel, High speed burr, Cervical laminectomy

# Free Paper: Cervical (2)

## Proteomic and Genomic Analysis of Human Serum-derived Extracellular Vesicles for Biomarker Discovery in Ossification of the Posterior Longitudinal Ligament

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**Purpose:** extracellular vesicles (EVs) refers to a cell-derived vesicle present in eukaryotic organisms, which contains various genetic material and proteins in vesicles. Ossification of the posterior longitudinal ligament (OPLL) is ossified by various causes and compresses the spinal cord and nerve roots in the spinal canal, causing neurological disorders. Although there is no specific cause or clear pathological mechanism for the disease, it is very important to diagnose it early. We wanted to confirm that EVs, which is relatively easy to obtain from blood and human body fluids and contains genetic material and signal transduction proteins, can be used for early diagnosis.

**Materials and Methods:** Obtain blood from 3 patients with OPLL and 3 controls. The obtained blood is centrifuged to separate the serum, and the EVs is isolated and purified for each individual using an EVs isolation kit (Exo-Quick). The entire gene sequence and protein in the EVs are analyzed by next-generation sequencing (NGS) and liquid chromatography/mass spectrometry (LC/MS), respectively. Among the analyzed sequences and proteins, the sequences and proteins that show more than 2-fold expression compared to the control group are selected, and the combination of genes and proteins is verified as the EVs of the diseased individual.

**Results:** In this experiment, Nineteen highly expressed sequences and proteins and four low-expressed proteins and sequences were identified, and their combinations were validated as biomarkers for early diagnosis of OPLL.

**Conclusions:** Through the EVs of blood, which is relatively easy to obtain, we discovered factors that can screen for OPLL, laying the foundation for early detection of OPLL in the future.

**Keywords:** Ossification of the posterior longitudinal ligament, Extracellular vesicle, Screening test, Genome, Protein

## Better Late Than Never: Clinical Outcomes of Delayed Fixation in Thoracolumbar Spinal Trauma

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**Purpose:** Annually, between 250,000 to 500,000 people experience a spinal cord injury (SCI) globally, with delayed presentation more prevalent in developing countries due to inadequate initial treatment. Neglected thoracolumbar SCI

accounts for a substantial percentage, around 26.6%, notably higher than in developed nations. While some studies support the benefits of early decompression, others find no notable difference in outcomes between early and late interventions. With limited literature on neglected thoracolumbar SCI, forecasting recovery in patients arriving late at healthcare facilities with neurological deficits remains challenging. To comprehend the nature of these injuries, our study investigated the outcomes of delayed fixation with or without decompression in traumatic SCI.

**Materials and Methods:** Retrospective analysis of 52 patients with thoracolumbar SCI who underwent delayed surgery (≥72 hrs posttrauma) with a minimum follow-up of 1 year 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, time interval between trauma and surgery.

**Results:** Mean time interval from injury to spine surgery was 32.60 days. At the end of 1-year follow-up, 28(51.5%), 18(36.36%), and 6(9.1%) patients had ≥1, ≥2, and ≥3-grade ASIA improvement, respectively. The mean LEMS rose to 41.75 from 16.43 ($p<0.001$). 12 out of 26 patients with bladder involvement showed improvement. 6 patients succumbed, 32 were ambulatory, and 14 remained non-ambulatory. On comparing various parameters, pre-operative LEMS score ($p=< 0.001$), cord signal changes ($p=0.002$), and presence of cord transection ($p=0.007$) differed significantly in the above-mentioned three groups, while age ($p=0.442$), average TLICS ($p=0.872$), time from injury to surgery ($p=0.386$) did not differ significantly

**Conclusions:** The widely acknowledged guideline suggests treating spinal injuries within the first 72 hours. However, many less fortunate patients arrive late at hospitals offering spine surgery services due to various medical, socioeconomic, and logistical obstacles. Our study underlines a significant chance of neurological improvement even after delayed surgery. Factors such as cord transection, cord signal changes, and lower initial Lower Extremity Motor Score (LEMS) upon presentation notably impact unfavourable clinical outcomes one-year post-surgery

**Keywords:** Delayed, Neglected, Spinal cord injury (SCI), Spine trauma, Thoracolumbar

## Impact of Preoperative Factors on Range of Motion Reduction Following Posterior Cervical Foraminotomy: A Multivariate Analysis

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**Purpose:** This study investigates the implications of range of motion (ROM) after posterior cervical foraminotomy (PCF), particularly addressing the clinical significance of ROM reduction following foraminotomy. Despite prevalent beliefs about PCF's ability to preserve ROM, literature reviews and clinical observations raise questions regarding this assumption. The study aims to determine the clinical implications of ROM reduction and its associated complications.

**Materials and Methods:** To explore the factors contributing to ROM reduction, this study conducted a risk factor analysis among patients undergoing PCF. Variables such as disc space degeneration (Pfirrmann grade), preoperative segmental ROM, extent of facetectomy, surgery levels, cervical lordosis, preoperative ROM, average foraminal stenosis severity, and percentage of facetectomy were analyzed. The study employs a multivariate regression analysis, focusing on postoperative cervical ROM reduction as the dependent variable.

**Results:** The multivariate regression analysis, with an R-squared value of 0.528, identified two significant factors contributing to postoperative ROM reduction: higher preoperative ROM and an increased number of surgical levels. The regression coefficients for preoperative ROM and the number of levels were found to be 0.879 (standardized $\beta=0.698$) and 11.176 (standardized $\beta=0.360$), respectively. Furthermore, patients experiencing ROM reduction exhibited poorer outcomes in terms of neck pain and Neck Disability Index (NDI) two years post-surgery compared to those

without significant ROM reduction.

**Conclusions:** The findings indicate that the risk of ROM reduction post-posterior cervical foraminotomy increases with higher preoperative ROM and a greater number of surgical segments. Consequently, in patients considering multiple-level PCF, those with higher preoperative ROM may be at an increased risk of adverse clinical outcomes associated with postoperative ROM reduction. This necessitates a warning and careful consideration in surgical planning for such cases to mitigate the potential negative impacts on postoperative quality of life.

**Keywords:** Posterior cervical foraminotomy (PCF), Range of motion (ROM), Multivariate regression analysis, Preoperative risk factors

## Analysis of the Effectiveness of Postoperative Rehabilitation Using Virtual Reality (VR) for C5 Nerve Palsy after Posterior Cervical Spine Surgery: A Randomized Controlled Trial

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**Purpose:** C5 nerve palsy is a common complication post-cervical spine surgery, often leading to significant motor deficits. Traditional rehabilitation approaches are effective but can be slow and patient adherence is variable. This study investigates the impact of Virtual Reality (VR) assisted rehabilitation on recovery outcomes in patients with C5 nerve palsy following posterior cervical spine surgery.

**Materials and Methods:** In a preliminary randomized controlled trial, 12 patients with C5 nerve palsy post-surgery were allocated into two groups: VR-assisted rehabilitation (n=6) and conventional rehabilitation (n=6). The VR group underwent a regimen of immersive VR exercises targeting motor function, while the control group received standard physiotherapy. Outcome measures included Maximum Voluntary Isometric Contraction (MVIC), electromyography (EMG) readings, pain (VAS), and functionality (NDI). Data were collected at baseline, 1 month, and 3 months postoperatively.

**Results:** After 3 months, the VR group demonstrated a 40% improvement in MVIC and a 35% improvement in EMG readings, significantly higher than the 20% (MVIC) and 15% (EMG) improvements in the control group ($p<0.05$). Additionally, the VR group reported a 30% reduction in VAS scores and a 25% improvement in NDI scores, compared to 15% and 10% improvements in the control group, respectively ($p<0.05$).

**Conclusions:** The study indicates that VR-assisted rehabilitation significantly enhances muscle strength recovery (as measured by MVIC and EMG) in patients with C5 nerve palsy post-cervical spine surgery, compared to conventional rehabilitation methods. These findings suggest that integrating VR into postoperative rehabilitation can expedite recovery and improve patient outcomes in this cohort.

**Keywords:** C5 palsy, Cervical, Posterior, Rehabilitation, Virtual reality

## Percutaneous Posterior Cervical Facet Fusion to Augment Multi-level Anterior Cervical Decompression and Fusion for Multilevel Anterior Surgery for Cervical Spondyloradiculopathy and Myelopathy: A Case Series

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**Purpose:** To describe clinical and radiographic outcomes of patients with multi-level cervical radiculopathy and myelopathy treated with a combination of a novel percutaneous posterior facet fusion to augment the standard anterior decompression and fusion.

**Materials and Methods:** Thirty-nine subjects with symptomatic cervical stenosis presenting with radiculopathy and/or myelopathy with multi-level cervical involvement underwent standard anterior decompression and fusion augmented with percutaneous posterior facet fusion using

DTRAX. Improvement of VAS-neck and VAS-arm scores were obtained. For subjects presenting with myelopathy, mJOA scores were obtained at baseline and compared on last follow-up. Radiologic outcomes included changes in alignment and fusion rates. Peri-operative complications were also recorded.

**Results:** Of the 39 patients evaluated, average follow-up was at 28.3 months (1.0-52.75). Average improvement on final follow-up of VAS-neck was at 3.46 and VAS-arm at 3.13points. These improvements were noted to be statistically significant in comparison to the minimally clinical important difference (MCID) in VAS for patients with cervical pathologies. There were no statistical differences in terms of cervical radiologic alignment from baseline measurements. Over-all fusion rate was at 69.3%, with rates lower for patients who underwent 4-level surgery (60%) compared to those who underwent 3-level surgery (81.8%).

**Conclusions:** This surgical technique combining the standard anterior cervical decompression and fusion augmented with a posterior percutaneous cervical facet fusion is a safe and effective alternative to provide circumferential fusion in patients with multi-level involvement in cervical radiculopathy and myelopathy.

**Keywords:** Cervical, Fusion, Spondyloradiculopathy, Posterior

# Free Paper: Cervical (3)

## 3D Multiplanar Reconstruction Analysis of Cervical Lateral Mass Screw Lengths in Roy-Camille, Magerl, and Riew Techniques

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**Purpose:** Laminectomy with lateral mass screw fixation is a well-established procedure, with the Roy-Camille and Magerl techniques being extensively studied. However, there is a paucity of research regarding the Riew technique, which has been introduced recently. Additionally, while sex, height, and Torg-Pavlov ratio are acknowledged as significant factors in cervical spine morphology, their implications for screw length remain underexplored.

**Materials and Methods:** Sixty hospitalized patients (33 males and 27 females), who were treated for various spinal conditions, were selected for this study. Using 3D Multiplanar Reconstruction from CT scans, we meticulously measured the cervical vertebrae from C3 to C7. The measurements were conducted in accordance with the protocols of three distinct techniques: Roy-Camille, Magerl, and Riew. Each technique was analyzed to evaluate and compare the lengths of the screws.

**Results:** The Roy-Camille technique showed the longest screws at C3 (men: 13.1±1.9 mm) and shortest at C7 (men: 10.6±1.7 mm). The Magerl technique had the longest at C7 (17.1±2.3 mm) and shortest at C3 (14.7±1.8 mm). For the Riew technique, screws were longest at C7 (21.9±3.4 mm) and shortest at C3 (18.7±2.5 mm). No statistically significant differences were found related to sex, height, and Torg-Pavlov ratio.

**Conclusions:** The Riew technique allows for the use of longer screws, particularly at C7, which may enhance the rigid fixation of the subaxial cervical spine.

**Keywords:** 3D Multiplanar reconstruction, Cervical lateral mass screw, Roy-camille, Magerl, Riew techniques

## Are We Looking at the Paradigm Shift in the Treatment of Cervical Spondylotic Radiculopathy With the Introduction of Unilateral Biportal Endoscopic Decompression Technique- A Single Centre Prospective Study

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**Purpose:** Unilateral Biportal Endoscopy (UBE) is a minimally invasive approach to treat cervical spondylotic radiculopathy (CSR), which is a common condition caused secondary to disc herniation, disc degeneration, uncal osteophytes, or other conditions and manifesting as neuropathic radicular pain. Anterior cervical discectomy and fusion (ACDF) is the gold standard surgical technique for treating CSR. However,

it has several disadvantages, including loss of mobile segment, adjacent segment degeneration (ASD), implant and approach-related complications, and high hospitalization costs. The current study aims to evaluate the safety and efficacy of UBE decompression for CSR.

**Materials and Methods:** After obtaining IRB approval, we performed a single-center prospective study and included patients who underwent UBE decompression for CSR with a minimum of six months of follow-up. Patient demographics, peri-operative data, and length of hospital stay (LOS) were reviewed. Clinical outcomes were assessed using VAS scores for neck and arm, and NDI scores pre-operatively and at 1 and 6 months. A repeated ANOVA test was performed to measure the difference between VAS and NDI scores.

**Results:** 10 patients (M: 8, F: 2) with a mean age of 56.7± 10.2 were included. The mean follow-up period was 8.4±1.8 months. The average surgical time was 64.3±10.6 mins. The average LOS was 1 day. At the final follow-up, the mean VAS for arm pain improved from 6.4±0.7 to 0.6±0.5 (92% improvement) and the mean VAS for neck pain improved from 3.3±0.4 to 2.0±0.2 (40% improvement).NDI score improved from 23.2±1.95 to 5.7±0.6 at the final follow-up (75% improvement). There were no complications.

**Conclusions:** The current study concludes that UBE is a safe and effective minimally invasive surgical treatment option for patients with CSR with excellent clinical outcomes.

**Keywords:** Ube, Cervical radiculopathy, Miss

## BGS-7 Spacer Versus Allograft Spacer on Multilevel ACDF

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**Purpose:** Bioactive glass-ceramic-7 (BGS-7) has been used as an alternative to allograft spacers, which have been commonly used as cages in anterior cervical discectomy and fusion (ACDF). BGS-7 has demonstrated good fusion rates and clinical outcomes in single-level ACDF. However, there are not many studies on multilevel ACDFs, we compared BGS-7 and allograft spacer on multilevel ACDF.

**Materials and Methods:** The prospective study included patients who underwent multilevel ACDF of 2 or more levels at BRM medical center from January 2012 to December 2023. A total of 77 patients were followed up for at least one year, 33 patients with BGS-7 spacer at 76 levels and 44 patients with allograft spacer at 103 levels. Preoperative CT, MRI, and x-rays were performed, and indications for multilevel ACDF included cervical HIVD, cerival spinal stenosis, and myelopathy etc. Patients were followed up after surgery, 6 months after surgery, and 1 year after surgery with x-ray, CT, MRI, and questionnaires to check clinical outcomes. We evaluated fusion as stable motion with an interspinous gap difference of less than 2 mm on dynamic x-ray at 1 year after surgery, and confirmed bone fusion based on bone bridging due to trabecular bone formation at the fusion level and no radiolucent gap between the cage and vertebral body on CT taken at the same time. JOA, FRI, NDI, and VAS scores were surveyed at each time period to check clinical results.

**Results:** The 1-year fusion rates for the BGS-7 spacer and allograft cage groups on x-ray were 89% and 92%, respectively(p=0.156). Based on CT scans, the fusion rates were 93% and 90%(p=0.319). SL,CL and segmental height also improved significantly in both groups, with a significantly greater increase in lower segmental height in the BGS-7 spacer group compared to the allograft spacer group, which was maintained through 1 year. Clinical outcome was significantly improved in both groups.

**Conclusions:** BGS-7 has a good fusion rate and may be suitable for use as a cage in multilevel ACDF. BGS-7 had similar fusion rates to the allograft spacer and IBG groups, with similar or fewer complications. In addition, the stability was better than that of the allograft spacer, which was more prone to cage fracture and subsidence due to its own stability issues, and the clinical outcomes were significantly improved, showing good results.

**Keywords:** BGS-7, Multilevel ACDF, Fusion

## Effect of Fusion vs. Pseudoarthrosis on Development of Adjacent Segment Degeneration and Disease after Anterior Cervical Discectomy and Fusion (ACDF)

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**Purpose:** Cervical disc replacement has been compared with anterior cervical discectomy and fusion (ACDF) to elucidate the effect of preserved segmental motion on adjacent segment degeneration (ASD). However, the comparative evaluation has inherent limitation in terms of different criteria for patient selection and the cause of ASD is still controversial. The objective of this study is to analyze the effect of fusion on development of ASD by comparing to pseudoarthrosis after ACDF.

**Materials and Methods:** This retrospective cohort study included patients who underwent single or muli-level ACDF to treat cervical radiculopathy or myelopathy. Status of fusion and ASD was determined at 2 years after surgery. Adjacent segment disease (ASDi) was defined as ASD with related symptoms treated with cervical injection or surgery at the ASD level. Radiological parameters and clinical outcomes were compared between fusion group and pseudoarthrosis group. Logistic regression analysis was performed to identify the risk factors of ASD.

**Results:** One-hundred four patients were enrolled in this study. Fusion rate was 62.5% (65/104 patients). There was no difference in demographics between the fusion group and the pseudoarthrosis group except the number of multi-level surgery (42% vs. 72%, p=0.003). There was no significant difference in radiological and clinical outcomes between two groups. ASD rates were 36.9% and 7.7% in the fusion group and the pseudoarthrosis group, respectively (p<0.001). ASDi rates were 20% and 5.1% in the fusion group and the pseudoarthrosis group, respectively (p=0.037). Multivariate logistic regression analysis demonstrated that fusion, decreased bone mineral density (BMD), increased C2-C7 sagittal vertical axis (SVA) were significantly correlated with ASD.

**Conclusions:** Fusion causes significantly more ASD and ASDi after ACDF compared to pseudoarthrosis. Fusion is an independent risk factor of ASD after ACDF and other risk factors include decreased BMD and increased C2-C7 SVA.

**Keywords:** ACDF, Adjacent segment degeneration, Adjacent segment disease, Fusion, Pseudoarthrosis

## Artificial Intelligence Detection of Cervical Spine Fractures Using Convolutional Neural Network Models

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**Purpose:** The convolutional neural network (CNN) is a class of deep neural networks particularly efficient in analyzing visual imagery. These networks consist of convolutional layers that can automatically learn features from images. CNN with the KNIME analytics platform is used in this study to offer a technique for computer-assisted diagnosis of cervical spine fractures from radiographic x-ray imaging.

**Materials and Methods:** This study obtained five hundred lateral radiographic cervical spine x-ray images from standard open-source dataset repositories to develop a classification model using CNN. All the images contained diagnostic information, including normal cervical radiographic images (n=250) and fracture images of the cervical spine fracture (n=250). The model would classify whether the patient was with or without cervical spine fracture. Eighty per cent of the images were training data sets used for model training and twenty per cent for testing. KNIME's graphic user interface-based programming enabled class label annotation, data preprocessing, CNN model training, and performance evaluation.

**Results:** All radiographic X-ray imaging was reported using the KNIME graphic user interface program. The CNN model has performed ten epochs of training. Performance model evaluation by the sensitivity (recall), specificity (predictive value), and f-measure were all 87%, 82.4%, 90.9%, and 88.9%, respectively. The model's accuracy was equal to 92% of the area under the receiver operating characteristic (ROC) curve for detecting and diagnosing cervical spine fractures.

**Conclusions:** Deep learning models were successfully utilized

for computer-assisted diagnosis of cervical spine fractures using radiographic x-ray images. This approach can assist the radiologist in screening or detecting and diagnosing cervical spine fractures.

**Keywords:** Cervical spine fracture, Computer-assisted diagnosis, Machine learning, KNIME

# Invited Lecture II

### Mini Open Lateral Anterior Lumbar Interbody Fusion (LaLIF) Combined with Wiltse Approach Posterior Fixation: A New Option for Minimally Invasive Treatment of ADS

Zhaomin Zheng

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**Purpose:** Adult degenerative scoliosis (ADS) is usually seen in the elderly and has a poor conservative outcome. The traditional surgical approach to ADS is usually open decompression and fusion with a high complication rate. Due to the unique advantages of minimally invasive surgery and high patient acceptance, we designed an original mini-open lateral anterior lumbar interbody fusion (LaLIF), which can be used alone or in conjunction with posterior fixation of the Wiltse access for the treatment of ADS.

**Main Body:** This study reviewed patients with ADS treated at our center since 2016 and found that the use of Mini open Lateral Anterior Lumbar Interbody Fusion (LaLIF) alone or in combination with Wiltse approach posterior fixation, compared to one-stage posterior decompression and fusion, has the advantages of being minimally invasive with less blood loss. This is particularly beneficial for elderly patients with various chronic diseases and comorbidities, as it can better tolerate surgery and reduce surgical risks. Moreover, the postoperative clinical outcomes are comparable between the two approaches, with satisfactory correction of deformities achieved. For elderly ADS patients with more comorbidities, staged surgery significantly reduces the duration of a single surgery and anesthesia, thereby reducing surgical risks and facilitating faster postoperative recovery. Staging the surgery can better leverage the advantages of both lateral minimally invasive surgery and posterior minimally invasive surgery, significantly reducing the incidence of surgical complications, especially neurological injuries.

**Conclusions:** The mini-open LaLIF combined with Wiltse approach posterior fixation in a staged manner is a novel option for the minimally invasive treatment of ADS. It offers a smaller trauma, less blood loss, shorter operation time, simple procedure, a gentle learning curve, shorter hospital stay, faster recovery, and lower risk per surgery. This approach may potentially reduce the number of fusion segments and provide a new choice for minimally invasive treatment of ADS.

**Keywords:** Adult degenerative scoliosis, Lateral anterior lumbar interbody fusion, Wiltse approach posterior fixation

# Asian Spine Society Presidential Session

### Robotic-Assisted and New Technologies in Spine Surgery: Trend or Fad?

Kenny Kwan

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**Purpose:** New technologies including robotic-assisted spine surgeries, flash technology, AI and 3D printing have helped spine surgeons to optimize preoperative planning, improve intraoperative efficiency, increase implant placement accuracy and ultimately these may improve patients' outcome. This presentation will review our experience in a single institution.

**Main Body:** We performed a prospective review of 14 robotic-assisted spine surgeries to review the accuracy of implant placement. We also calculated the set up time of the robot, and the time required per pedicle screw placed. We describe a case series of complex spinal deformity and tumour surgeries and how the use of 3D printing has helped with preoperative planning and intraoperative procedure. We have also used AI in clinical setting for deformity, prognostication

for spinal metastases, and medical imaging.

**Conclusions:** The current technologies in spine surgery are in an infancy stage, but based on the speed of improvement of technologies in other surgical specialties, the future of spine surgeries will likely involve some.

**Keywords:** Robotic-assisted, 3D printing, Flash technology, Spine surgery

## How to Deal with Cervical Kyphosis Deformity Sirichai

Sirichai Wilartratsami

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Cervical kyphosis deformity may develop secondary to advanced degenerative disease, trauma, tumor, infection, inflammatory disease (i.e., ankylosing spondylitis) or after surgery (i.e., post laminectomy kyphosis). It can cause not only neck pain, myelopathy, and radiculopathy, but also problems with horizontal gaze, swallowing or breathing. They may also be relatively asymptomatic. Investigation includes appropriate imaging studies, such as radiographs, including dynamic images, and magnetic resonance imaging or computed tomography. The deformity may be accurately assessed and an appropriate surgical strategy undertaken. It should be evaluating flexibility of the deformity, the presence or absence of anterior and facet ankylosis, neurological deficit from spinal canal compression. The anterior, posterior, or combined approach may be used. The combined approach appears to result in a greater degree of correction and stability than the single approach, and it is more likely to improve the cervical alignment to achieve a lordosis. However, the procedure carries a higher rate of postoperative neurological deterioration, complications, revision surgery, and mortality. All approaches are unique in their ability to correct a deformity and in their associated complications.

## Instrumented Fusion of Strategic Vertebrae Provides Optimum Outcome with Minimum Instrumentation in Adolescent Idiopathic Scoliosis

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**Purpose:** The all-pedicle screw instrumentation method of posterior-only approach arthrodesis, which fuses strategically located vertebrae, avoids the metal and implant-related problems and has a correction rate comparable to other methods. It is also reasonably priced and cost-effective for patients in our setup.

**Materials and Methods:** With minimal instrumentation, we selectively fused certain vertebrae to treat 175 patients with severe adolescent idiopathic scoliosis, whose mean age was 17.5 years. The average scoliosis curve measured 86° Cobb. The same senior surgeon handled every case, using both free hand and C-arm guided techniques along with intraoperative neurophysiologic monitoring.

**Results:** Following surgery, the mean scoliosis curve was 37° Cobb. The average follow-up was two years. At the follow-up, it was noted that three patients experienced surgical site infections, two had post-operative neurological deterioration, and three had post-operative curve progression.

**Conclusions:** Posterior instrumented fusion by minimum level pedicle screw insertion addressing the strategic vertebrae is a good and effective method for stable correction of Adolescent Idiopathic Scoliosis.

## Stem-cell Therapy in Spinal Cord Injury: What is the Current Evidence?

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**Purpose:** Spinal cord injury (SCI) has various detrimental

impacts on affected individuals and results in enormous national economic burden. Intervention following spinal cord injuries is vital to limit the extent of direct damage as well as secondary injury through inflammation, hemorrhaging and apoptosis within the cellular platform. The current consensus on the clinical management of SCI is the mechanical decompression and stabilization of the spine function to limit severity, with minimal expectations for improving neuro-regeneration. Mesenchymal stem cells (MSC) alone or in addition with bioengineered scaffolds show promise in addressing the processes involved during the secondary injury phase thus helping augment the neuronal regeneration process. In this paper, we review the current evidence behind the use of mesenchymal stem cell therapy in spinal cord injuries, as well as share our experiences through clinical and animal studies.

**Main Body:** Material and Methods: Canines (Canis lupus familiaris) were used in this study with weights between 10-20 Kg. Subjects were then grouped based on the intervention: control injury model (n=6), instrumentation (n=7), and instrumentation in combination with PVA/Chitosan scaffolds and Umbilical Cord Mesenchymal Stem Cells (UC-MSCs) (n=4). The Balloon compression technique was conducted to induce SCI for 6 hours in all the subject at the T-10 level. After 7 days, both intervention groups underwent mechanical decompression and instrumentation using rod and pedicle screw, and UC-MSCs-seeded scaffolds were implanted on the injured duramater in the combination group. Subjects were observed for 56 days and were subsequently euthanized at the end of the observational period. The spinal cords were then harvested for histopathological evaluation. Inflammation and haemorrhage grading was observed using Hematoxylin-Eosin staining. Neuro-regeneration was evaluated by myelination grading using Luxol Fast Blue staining.

**Result:** Evaluations of hemorrhage grading showed significant differences in the intramedullary section (p = 0,030) showing significance in both therapeutic groups when compared to the injury model control. Luxol fast blue evaluations showed a significant result on anterior sectional samples (p=0,038), right lateral samples (p=0,048) and left lateral samples (p=0,027). Further post hoc analysis showed a significant result in the combination group through a higher myelination grading (p<0,05) when compared to the remaining 2 groups.

**Conclusions:** A significant increase in axonal myelination was observed in our study with the use of mesenchymal stem cells together with PVA/Chitosan scaffolds. Current guidelines show the promise of mesenchymal stem cells in spinal cord injuries through injury control and increase in regenerative properties.

**Key words:** Spinal cord injury, Scaffold, Stem cell, Umbilical cord mesenchymal stem cell

# Symposium II. Cervical: Current Concepts in Cervical Laminoplasty

## Indication and Contraindication for Focusing on Sagittal Alignment

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**Purpose:** Cervical laminoplasty is a surgical technique used to treat patients with severe myelopathy caused by multilevel cervical cord compression. Especially in cases of OPLL, cervical laminoplasty utilizes indirect decompression, which significantly reduces the risk of complications such as CSF leakage. However, if preoperative cervical kyphosis is severe, the decompression effect may be lessened due to inadequate cord shifting. Therefore, proper patient selection is crucial for achieving favorable treatment outcomes.

**Main Body :** When deciding on cervical laminoplasty, the degree of cervical kyphosis is a critical factor to consider. The most commonly used measure is the C2-7 Cobb's angle. It has been reported that surgical outcomes are not favorable when surgery is performed with a kyphosis of more than 13 degrees without cord signal change, and more than 5 degrees with cord signal change. In cases of severe OPLL or severe HNP, the K line is more frequently used than Cobb's angle. If the K line is negative, it is recommended to perform anterior surgery or use posterior fusion to alter the alignment instead

of laminoplasty. Similar to SVA, PT, and PI-LL are important factors in determining treatment direction and correction goals in the thoracolumbar spine, research is increasingly focusing on CSVA, T1 slope, and T1slope – cervical lordosis in the cervical spine. It is reported that if the CSVA exceeds 2.89 cm, the T1 slope is over 30 degrees, or the difference between T1 slope and cervical lordosis is over 20 degrees, the prognosis post-surgery tends to be poor. In such cases, it is recommended to correct cervical alignment. In the past, the presence of axial pain was considered a contraindication for cervical laminoplasty. It has been reported that laminoplasties that preserve the semispinalis cervicis have seen a reduction in the frequency of postoperative neck pain. More recently, studies have shown that even in cases without severe kyphosis, where only severe neck pain is present, laminoplasty alone can reduce neck pain and yield favorable outcomes.

**Conclusions:** Cervical laminoplasty effectively treats severe myelopathy, particularly in OPLL cases, by using indirect decompression to minimize complications like CSF leakage. Success hinges on careful preoperative evaluation, particularly of cervical kyphosis and sagittal alignment parameters. Recently, even in patients with axial neck pain, cervical laminoplasty can be a good option if patient selection is done carefully.

**Keywords:** Cervical, Multilevel OPLL, Cord compression, Traumatic central cord syndrome, Cervical sagittal

**Main Body:** With the popularization of the laminoplasty procedure, there has been consistent research into the causes and mechanisms of complications occurring after surgery. Well-known complications following laminoplasty include loss of cervical lordosis, motion limitation, axial neck pain, premature reclosure, and the surgical technique for laminoplasty has also evolved towards minimizing these complications. Since Shiraishi et al. announced a reduction in postoperative axial neck pain and malalignment through the posterior cervical approach technique for the preservation of all muscular attachments to the C2 spinous process, the preservation of paraspinal muscle structures has been recognized as the mainstay for preventing complications after laminoplasty and achieving better outcomes. Subsequently, many modified techniques have been developed with the goal of causing less violation of muscular attachments, especially at C2 and C7. Furthermore, there has been progress in the development of surgical techniques and new devices, such as the C3 laminectomy technique to prevent interlaminar impingement and the development of titanium plating systems to prevent premature closure.

**Conclusions:** In this presentation, we aim to introduce the latest trends in the development of surgical techniques for cervical laminoplasty and discuss the future goals and directions for the advancement of laminoplasty techniques.

**Keywords:** Cervical myelopathy, Spinal surgery, Cervical laminoplasty

## Evolution of Surgical Techniques

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**Purpose:** Since its first introduction by Oyama et al. in 1973, after the expansive Z-shaped laminoplasty, the widespread adoption and advancement of laminoplasty as a modern technique have been gradually achieved, based on two major streams: Hirabayashi's unilateral open-door technique (1977) and Kurokawa's spinous process splitting French-door technique (1982).

## Can Multi-level Myeloradiculopathy also Be Solved by Laminoplasty?

Sehan Park, GuMin Jeong, Chang Ju Hwang, Jae Hwan Cho, Dong-Ho Lee

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**Purpose:** Anterior cervical discectomy and fusion (ACDF) combined with uncinate process resection and laminoplasty combined with foraminotomy (LPF) have been used to perform cervical cord and root decompression in patients with combined cervical myelopathy and radiculopathy (CMR). The present study was conducted to compare the

clinical and radiographic outcomes of ACDF with those of LPF for the treatment of CMR.

**Materials and Methods :** Patients with CMR who underwent ACDF or LPF and were followed up for at least 2 years were retrospectively reviewed. C2-C7 lordosis, C2-C7 sagittal vertical axis, and cervical range of motion (ROM) was determined. The visual analog scale (VAS) scores for neck and arm pain, neck disability index (NDI), and Japanese Orthopedic Association (JOA) scores were analyzed. The radiographic and clinical outcomes of the two groups were compared.

**Results:** Eighty-four patients each were included in the ACDF and LPF groups (n=42 in each group) after the application of the inclusion criteria and propensity score matching. A significant decrease in C2–C7 lordosis (p<0.001) and ROM (p<0.001) was observed in the LPF and ACDF groups, respectively. LPF was associated with significant decrease of C2-C7 lordosis (p<0.001) while ACDF caused significant decrease of cervical ROM (p<0.001). ACDF effectively improved neck pain VAS (p<0.001), and NDI (p<0.001) while neck pain did not significantly improve after LPF (p=0.103). Furthermore, neck pain VAS (p=0.026), and NDI (p=0.021) at postoperative 6 months were significantly greater in the LPF group compared to ACDF group. Arm pain VAS, and JOA score both significantly improved after LPF (p=0.003, and 0.043, respectively, respectively) or ACDF (p<0.001, and 0.039, respectively), and postoperative results were not significantly different between the two groups.

**Conclusions:** LPF and ACDF yielded similar outcomes for arm pain and neurological recovery. However, greater postoperative neck pain and postoperative loss of lordosis were observed in the LPF 3 group, whereas early significant improvement in neck pain and decreased postoperative ROM were observed in the ACDF group.

**Keywords:** Cervical myeloradiculopathy, Anterior cervical discectomy and fusion, Laminoplasty, Foraminotomy, Neck pain, Range of motion, Cervical lordosis, Neurological recover

## Complication: Prevention and Management

Min Woo Kim

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**Purpose:** Cervical laminoplasty is a non-fusion, decompression procedure for cervical spondylotic myelopathy (CSM) due to ossified posterior longitudinal ligament (OPLL) and multilevel spondylosis involving three or more motion segments. Expansion of the laminar arch can allow for direct and indirect decompression of the spinal canal. However, several complications are reported in especially postoperative kyphosis, loss of range of motion (ROM), axial neck pain, C5 palsy and hinge fracture.

**Main Body:**

1. Postop kyphosis & loss of ROM

Postoperative kyphosis is most directly related to prolonged immobilization and extensive muscle detachment resulting in weakness and loss of motion. Preserving muscle attachments to the C2 and the C7 laminae plays an important role. Early ROM and limited use of a cervical orthoses are recommended.

2. Axial neck pain

The sources for postoperative axial neck pain have been thought to include facet joint injury, deep extensor muscle denervation, detachment of C2 or C7 muscles, detachment of the nuchal ligament, and prolonged postoperative external immobilization. Several modifications using less invasive and reconstructive techniques have been undertaken during posterior cervical surgery to prevent the occurrence of axial pain after decompression.

3. C5 palsy

One of the most widely accepted mechanisms of C5 palsy is nerve root traction injury as the spinal cord migrates posteriorly after laminoplasty. The other pathogenesis of C5 palsy is segmental spinal cord disorder caused by the ischemia or reperfusion injury. However, specific treatments for postoperative C5 palsy have not been established.

4. Hinge fracture

Hinge failure can result from fracture or from displacement of a floppy hinge. Most fractures at the hinge site occurred without intraoperative recognition, and usually reunified without significant displacement or adverse clinical effects. Therefore, when hinge fractures occur, careful observation without additional intervention is recommended

**Conclusions:** Laminoplasty is an excellent surgical option for patients with multilevel cervical myelopathy. To ensure an optimal result, it is important to aware the causes and preventions of complications after cervical laminoplasty.
**Keywords:** Cervical spine, Laminoplasty, Complication

# Invited Lecture IV

## Postoperative Medial Shoulder and Neck Imbalance in Adolescent Idiopathic Scoliosis (AIS) Surgery. How to Prevent These Phenomena?

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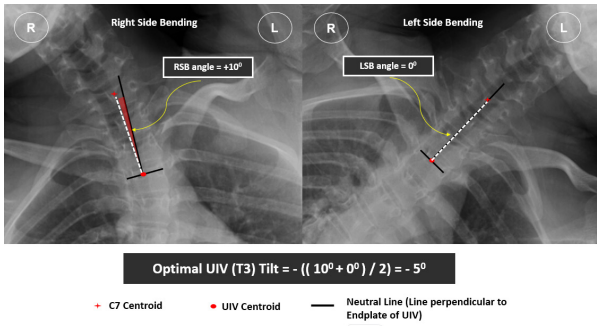
In AIS surgery, overcorrection of the main thoracic (MT) curve beyond the spontaneous correctability of the proximal thoracic (PT) curve will result in an undesirable "asymmetric neck" along with an ugly "trapezius prominence" and shoulder contour. (Winter RB 1989). The selection of the Upper Instrumented Vertebra (UIV) has been well-established. (Trobisch et al 2013) However, studies have shown that PSI occurs despite all correct UIV selection methods (Bjerke et al. 2015). Recent data showed that besides the selection of UIV, the postoperative UIV tilt angle plays an important role in maintaining the post-operative medial shoulder and neck balance. Studies have also shown that postoperative UIV tilt angle is an independent factor which correlates with postoperative T1 tilt, i.e. medial shoulder, and Cervical Axis, i.e. neck imbalances (Chan et al. 2018). The Optimal UIV tilt angle can be calculated using the 'Right and Left Supervised Cervical Supine Side Bending films'. (Figure 1) The mathematical formula for the Optimal UIV tilt angle = − [(RSB angle + LSB angle)/ 2]. (Kwan and Chan. 2016). A post-operative UIV tilt angle within the preoperative calculated Optimal UIV tilt angle will result in less medial shoulder imbalance (MSI) and neck tilt. Patients with +ve (tilted to right) postoperative UIV tilt have 15 times increased odds of developing +ve MSI (T1 tilt ≥ +4°) and 3 times increased odds of developing +ve neck tilt (CA ≥ +4°) (Kwan et al. 2020). Surgical strategies should be designed to achieve premeasured/ preplanned optimal UIV tilt angle. Intraoperatively, the UIV tilt angle can be easily assessed clinically during the surgical maneuvers and the UIV tilt angle can be measured using a custom-made crossbar and fluoroscopy. (Kwan et al. 2019). In conclusion, the UIV selection alone is not the main determinant factor for postoperative medial shoulder and neck imbalance. Current evidence shows that the postoperative UIV tilt angle plays an important role in preventing these phenomena.

**Summary:** Post-operative UIV tilt angle plays an important in achieving a good postoperative medial shoulder and neck balance. The Optimal UIV angle can be calculated preoperatively and applied intraoperatively to achieve a good postoperative medial shoulder and neck balance in AIS surgery.
**Keywords:** UIV tilt angle, Medial shoulder imbalance, Neck tilt, Adolescent idiopathic scoliosis




# Free Paper: Cervical (4)

## Effectiveness of Isotonic Saline Injection at Nerve Entrapment Points for Spinal Accessory and Dorsal Scapular Nerves in Relieving Posterior Neck, Trapezius, and Interscapular Pain: A Retrospective Study

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**Purpose:** Posterior neck, trapezius, and interscapular pain are prevalent issues, often exacerbated by poor postures like forward head and rounded shoulder posture. This study explores the clinical effects of isotonic saline injection at nerve entrapment points (NEP) in the sternocleidomastoid

(SCM) and scalenus medius (SM) muscles, associated with spinal accessory nerve (SAN) and dorsal scapular nerve (DSN) entrapment.

**Materials and Methods:** Retrospectively analyzing 34 patients who received this injection therapy, the visual analog scale (VAS) and percent pain intensity difference (PPID) were used for clinical evaluation.

**Results:** Both the VAS and PPID scores significantly improved at the final follow-up compared to those before injection. The mean pain VAS score (range, 0-10, lower is better) improved from 6.2±1.3 to 2.0±1.0 ($p<0.001$, delta 4.2±1.2), with the changes reaching the minimal clinically important differences (MCID). The mean pain PPID score (range, 0-100, lower is better) improved from 100 to 33.5±17.7 ($p<0.001$, delta 66.5±17.7).

**Conclusions:** Isotonic saline injection at the entrapment points of SAN and DSN within the SCM and SM muscles is effective in relieving posterior neck, trapezius, and interscapular pain associated with nerve entrapment without complications.

**Keywords:** posterior neck pain, trapezius pain, interscapular pain, spinal accessory nerve, dorsal scapular nerve

## Reoperation Rates after Anterior Surgeries for Cervical Radiculopathy Related with Injection Therapy: Korean National Population-based Cohort Study

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**Purpose:** There is a low incidence of reoperation after surgery for cervical degenerative disease. Therefore, it is difficult to sufficiently power studies to find risk factors for reoperation rates. National population-based databases provide large, longitudinally followed cohorts that may help overcome this challenge. Patients undergoing anterior surgeries for cervical radiculopathy receive injection therapy due to their severe pain before operation. However, there has been no study to evaluate the preoperative injection therapy as a risk factor for reoperation. The purpose is to determine whether injection therapy is a risk factor for reoperation in the anterior surgeries for cervical radiculopathy in a national population of patients with long-term follow-up.

**Materials and Methods:** We used the Korean Health Insurance Review & Assessment Service national database to select our study population. We included 5,997 patients with diagnosis of cervical spondylotic radiculopathy who underwent anterior cervical surgeries from January 2009 to December 2009. The follow up period was 8.4±0.9 years (3,070.4±319.0 days). Seventeen percent of patients received an injection therapy in the preoperative period of three months. Age, gender, presence of diabetes, associated comorbidities, surgical levels, hospital types, and preoperative injection therapy were considered potential confounding factors.

**Results:** The reoperation rate over the entire follow-up period was 2.10%. The risk factors for reoperation were female gender (OR 0.716, 95% CI 0.531, 0.964), hospital of hospital types (OR 0.629, 95% CI 0.452, 0.875), and the presence of the injection therapy before operation (OR 2.645, 95% CI 1.491, 4.693).

**Conclusions:** Patients undergoing anterior surgeries for cervical radiculopathy receive injection therapy due to their severe pain before operation, and preoperative injection therapy increase the risk for reoperations following anterior cervical surgeries. The information is essential to discuss the operations with the patients with these factors.

**Keywords:** Cervical radiculopathy, Reoperation, Injection therapy, Nationwide database, Long-term follow-up

## Paired and Matched Analysis of Neurological Outcomes in Revision Surgery for Cervical Myelopathy Following Delayed Neurological Decline

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**Purpos:** To analyze neurological recovery upon revision surgery with relation to the index procedure and a matched control.

**Materials and Methods:** 14 patients underwent both primary

and revision decompression at a single academic center. Peri-operative clinical, radiological, and surgical details were retrieved. Neurological outcomes (change in mJOA, recovery ratio) following the second surgery were compared to i) the primary operation and ii) a control subject receiving primary decompression matched for gender, age, JOA score, and surgical approach. The minimum clinically important difference (MCID) in mJOA score was set at 2.5.

**Results:** Revision decompressions were performed 6.8±4.2 years following the index surgery, when patients were 61.4±11.0 years of age. An increase in mJOA score of 2.7±2.0 following revision surgery was similar to that achieved after the primary operation (2.2±2.1, p=0.616). A recovery ratio of 38.1±25.4% upon revision compared favorably to that following the primary operation (35.0±37.4%, p=0.867). Non-inferiority testing between revision surgery and the first operation (p=0.02) demonstrated a similar capacity to achieve the MCID as did comparison with matched subjects (p<0.01).

**Conclusions:** Patients were able to make up for lost neurological gains following revision surgery. Careful selection of cases for revision likely facilitated recovery. Recovery trajectories should be consolidated upon larger sample sizes allowing for identification of prognostic factors.

**Keywords:** Cervical myelopathy, Delayed neurological decline, Revision

## Clinico-Radiological Outcome of Posterior Decompression vs Posterior Decompression and Lateral Mass Screw Fixation in Multisegmental Cervical Spondylotic Myelopathy

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**Purpose:** To compare the clinical outcomes of posterior decompression versus posterior decompression and fixation in multisegmental CSM using mJOA scoring and recovery rate using the Hirabayashi method. To study the radiological outcome of posterior decompression vs posterior decompression and lateral mass screw fixation in multisegmental CSM.

**Materials and Methods:** Twenty patients with multisegmental CSM were randomized into two treatment groups. One group underwent posterior decompression while other had posterior decompression and lateral mass screw fixation. mJOA score and recovery rate were calculated and radiograph of cervical spine were done at scheduled follow-ups over 6 months.

**Results:** Twenty patients were recruited in this study, 9 patients in group I (posterior decompression) and 11 patients in group II (posterior decompression and lateral mass screw fixation). Both groups had similar improvement in mJOA score; 7.89±3.98 to 11.63±3.58 in group I and 6.73±4.29 to 11.60±4.37 in group II. Recovery rate (mean) was 41.19±13.36 % in group I at 6th month follow-up and 47.82±27.12 % in group II. Two patients in group I had loss of cervical alignment at last follow-up.

**Conclusions:** Lateral mass screw fixation does not improve neurological outcome in multisegmental CSM. In patients with advanced disease with lower mJOA score, neurological recovery is also lower.

**Keywords:** CSM, Laminectomy, Fixation, mJOA, Outcomes, RCT

## Factors Associated with Improvement of Cord Compression by Ligamentum Flavum after Anterior Cervical Discectomy and Fusion

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**Purpose:** The current study was conducted to (1) demonstrate postoperative changing pattern of cord compression by ligaments flavum (CCLF) after anterior cervical discectomy and fusion (ACDF), and (2) elucidate perioperative factors associated with improvement of CCLF.

**Materials and Methods:** A total of 175 patients who underwent ACDF and were followed-up for more than 2 years were retrospectively reviewed. Preoperative CCLF was graded in 0-2 scale as suggested by a previous study. One-hundred and nineteen patients who were assessed as CCLF grade 1 or 2

were included in the study. Patients who CCLF grade improved after ACDF were classified as 'improved group', while patients without improvement were classified as 'unimproved group'. Patient characteristics, cervical sagittal parameters including C2-C7 lordosis, C2-C7 sagittal vertical axis (SVA), segmental lordosis, disc height, spondylolisthesis, and location of allograft within the disc space were assessed.

**Results:** Among 119 patients included, 69 patients (57.9%) demonstrated improvement of CCLF grade and were included in the improved group, while remaining 50 patients (42.0%) who did not show improvement were classified as unimproved group. Patients with postoperative CCLF grade 0 was with significantly better JOA score (15.2±2.0 vs 14.4±2.4, p=0.048) and JOA recovery rate (36.7±33.6 vs 10.2±24.8, p=0.045) at postoperative 3 months compared to patients with postoperative CCLF grade 1 or 2. Improved group showed significantly less spondylolisthesis (7/69, 10.1% vs. 17/50, 34.0%; p=0.002) and postoperative segmental lordosis (4.5±2.7 vs. 6.8±4.3, p=0.001) compared to unimproved group. Spondylolisthesis (odds ratio, 0.252; p=0.009), and postoperative segmental lordosis (odds ratio, 0.835, p=0.008) also demonstrated significant association as a risk factor of CCLF improvement failure in logistic regression analysis.

**Conclusions:** Higher postoperative CCLF grade was associated with poor postoperative JOA score. Higher postoperative segmental lordosis was a risk factor CCLF improvement failure. Increase of disc height with insertion of interbody spacer would have stretching effect to ligamentum flavum. However, with greater segmental lordosis this effect would be eliminated, and only the anterior column of the spinal column would be distracted. Therefore, when anterior operation is favored considered sagittal alignment and preoperative symptoms for patients with preoperative CCLF, efforts should be done to decrease the amount of segmental lordosis.

**Keywords:** Ligamentum flavum, Cord compression, Cervical myelopathy, Anterior cervical discectomy and fusion, Segmental lordosis

# Free Paper: Lumbar (1)

## Dural Sac Cross-Sectional Area Measurement for Predicting Cauda Equina Syndrome in Lumbar Disc Herniation Patients

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**Purpose:** Cauda equina syndrome (CES) can rarely occur due to lumbar disc herniation and may lead to severe complications such as permanent lower limb paralysis, impaired bladder and bowel control, and loss of sexual sensation. However, there has been a lack of research investigating risk factors for predicting CES in patients with lumbar disc herniation. In this study, we assessed the diagnostic value of the dural sac cross-sectional area in predicting CES in lumbar disc herniation.

**Materials and Methods:** From 2014 to 2023, 99 patients who underwent surgery for lumbar disc herniation were included and analyzed retrospectively. The dural sac cross-sectional area (DSCSA) was measured at the narrowest level of the dural sac in the axial T2-weighted magnetic resonance imaging scan. Multivariable logistic regression analysis was conducted on DSCSA and other candidate risk factors, including age, sex, and BMI.

**Results:** Among the included lumbar disc herniation patients, 9 CES patients (9.1%) were identified. In the multivariable logistic regression analysis, only DSCSA was associated with CES, with an adjusted odds ratio of 0.79 (95% confidence interval: 0.65 to 0.95, p=0.015). In the receiver operating characteristic curve analysis, an optimal cut-off value for DSCSA was 31.16 mm², yielding 100% sensitivity, 92.2% specificity, and an area under the curve of 0.974 (95% confidence interval: 0.944 to 1, p<0.001).

**Conclusions:** There was a significant correlation between DSCSA and CES. Patients with lumbar disc herniation and a DSCSA measurement of approximately 30 mm² or less should undergo close monitoring for CES symptoms, and early surgical intervention could be beneficial in averting severe complications of CES.

**Keywords:** Cauda equina syndrome, Dural sac cross-sectional

area, Lumbar disc herniation

## Risk Factors of Revision Operation and Early Revision for Adjacent Segment Degeneration After Lumbar Fusion Surgery: A Case-Control Study

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**Purpose:** Although adjacent segment degeneration (ASD) after lumbar fusion operation is inevitable, an early revision operation signifies a short symptom-free period and increases the risk of successive surgeries. We aimed to elucidate the risk factors associated with revision surgery for ASD after lumbar fusion operation and demonstrate factors associated with early revision due to ASD.

**Materials and Methods:** This case-control study included 86 patients who had revision operations for ASD after lumbar fusion operation in the revision group, while 166 patients who did not warrant revision for ASD for at least 5 years post follow-up were in the no-revision group. Sagittal parameters, Pfirrmann grading, facet degeneration grading, and disc space height (DSH) of adjacent segments were measured. Revision operations within 5 years post-surgery were defined as early revision. A comparison between revision and no-revision, and early revision and late revision groups was performed.

**Results:** The revision group demonstrated a significantly greater preoperative C7-S1 sagittal vertical axis (SVA) ($p=0.001$), postoperative C7-S1 SVA ($p<0.001$), and postoperative pelvic incidence (PI)-lumbar lordosis (LL) ($p<0.001$) than that of the no-revision group. Preoperative DSH of the proximal adjunct segment ($p=0.001$), postoperative PI-LL ($p=0.014$), and postoperative C7-S1 SVA ($p=0.037$) showed significant association with ASD in logistic regression analysis. The early revision group had a significantly greater age ($p=0.001$) and number of levels fused ($p=0.030$) than that of the late revision group. Multivariate Cox regression analysis showed that older age ($p=0.045$), a greater number of levels fused ($p=0.047$), and a narrower preoperative DSH of the proximal adjacent level ($p=0.011$) were risk factors for early revision.

**Conclusions:** Postoperative sagittal imbalance including greater PI-LL and C7-S1 SVA were risk factors for revision operation for ASD but not for early revision, and are more likely to affect long-term risk. Narrow DSH of the proximal adjacent level increased the risks of revision and early revision surgeries. Moreover, increased age and a greater number of levels fused further increased the risk for early revision for ASD.

**Keywords:** Lumbar fusion, Adjacent segment degeneration, Revision operation, Risk factors, Survival analysis

## The Patient-Reported Outcomes of Postoperative Prostaglandin E1 Derivative in Lumbar Spine Surgery: A Randomized, Double-blind, Controlled Trial

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**Purpose:** Postoperative residual leg numbness is a problem in patients undergoing decompressive lumbar spine surgery. Prostaglandin E1 derivatives (PGE1D) are effective in reducing leg numbness in nonoperative patients. However, data about PGE1D efficacy after spine surgery is still limited. The purpose of this study was to compare patient-reported outcomes of postoperative PGE1D with placebo.

**Materials and Methods:** We conducted a randomized, double-blind, controlled trial with 60 patients with degenerative lumbar spine disease undergoing 1-2 levels of decompressive lumbar spine surgery. Thirty patients were randomized to PGE1D postoperatively for 6 months and 30 were randomized to placebo. The primary outcome was VAS leg numbness, and the secondary outcomes were VAS back pain and leg pain, ODI and EQ-5D which were all evaluated at 5 timepoints: preoperatively, immediately postoperative, and months 1, 3 and 6. Data were analyzed using a mixed model.

**Results:** Demographic data and baseline patient-reported outcomes were comparable between randomized groups. The mean (SD) age was 65 (9.3) years, and 45 (75%) participants

were female. Both groups showed a significant reduction in numbness at all postoperative timepoints (all p<0.001). The mean difference in numbness score in the PGE1D versus placebo groups was -0.2 (-0.7 to 0.4); p=0.5. VAS back pain significantly decreased from baseline in both treatment groups at all postoperative timepoints (all p-values <0.001). Compared to placebo participants, those randomized to PGE1D had significantly greater reductions in VAS back pain over all follow-up (mean difference = -1.1 (95%CI -1.7 to -0.5); p<0.001). There were no clinically or statistically significant differences in other patient-reported outcomes between randomized groups.

**Conclusions:** Postoperative PGE1D did not lead to a greater reduction in leg numbness compared to placebo. However, PGE1D may be a useful treatment for reducing back pain following decompressive lumbar spine surgery.

**Keywords:** Prostaglandin E1 derivative, Lumbar spine surgery, Leg numbness, Patient-reported outcome, Randomized controlled trial

## Management of Postoperative Discitis Following Single Level Lumbar Disectomy

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**Purpose:** The incident of postoperative discitis is extremely uncommon. Patient presenting with clinical features of increase back pain following history of disectomy with scarcity in physical examination should raise a high suspicious for the diagnosis of postoperative intervertebra discitis.

**Materials and Methods:** This is an observational study conducted for 5 years in a tertiary level hospital. After matching the inclusion criteria all the patient followed a specific protocol by taking history, clinical features, laboratory test and radiological examination. All the Patients were managed conservatively with broad spectrum antibiotic and rest. All the patients were asked for followup and infection markers were noted. The result were observed after symptomatic improvement and laboratory findings.

**Results:** There were 16 patient in the study. The C-reactive protein is the most sensitive clinical laboratory marker to assess the presence of infection and effectiveness of treatment response. MRI is the imaging modality of choice in the diagnosis of discitis (100%). Most of the patient were managed conservatively with broad spectrum antibiotic and rest. The result of conservative management was found to be good in most of the cases and Operative management were required in two Patient who did not respond to conservative management even after six week of treatment.

**Conclusions:** Post operative discitis is a rare complication. It is diagnosed with high degree of suspicious , appropriate laboratory and imaging studies. Majority of patient show good long term outcome with antibiotics and spine immobilization.

**Keywords:** Discitis, Lumbar disectomy, Postoperative

## Posterior Thoracic Interbody Fusion - When Is It Useful

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**Purpose:** Posterior thoracic interbody fusion (PTIF) technique is not commonly used procedure because of difficulty. And with posterior decompression and exposing spinal cord, PTIF can cause pseudoarthrosis or instrumental failure. So anterior transthoracic procedures are developed, but they have a variety of limitations, especially in cases of chest disease and decreased respiratory function. The purpose of our study is to review our center's PTIF cases and find out indication of this procedure.

**Materials and Methods:** We included 17 patients who underwent thoracic interbody fusion only by posterior approach. PTIF was done to patients whose pathology location was on ventral side of dura. Laminectomy and bilateral total facetectomies were done. After then, subtotal discectomy was done for disc space preparation. After disc space preparation, bone grafts were inserted. And if there enough spaces for cages to enter, disc spaces were filled with

cages and bone grafts.

**Results:** Mean age of the patients is 66.4 yrs. There were 7 male, 10 female patients. The level of operation were T12-L1 & L1-2 together 1, T12-L1 in 5 cases, T11-12 in 5 cases, T10-11 in 1 case, T6-7 in 1 case, T5-6 in 1 case, T2-3 in 1 case, T1-2 in 1 case. There were no intraoperative complications like dura tear or spinal cord injury. Excluding short term follow up data, every patients maintain successful bone fusion quality confirmed by follow up X-ray or CT if available. All of the follow up CT show successful bone union, and there were no pedicle screw loosening or cage migration, halo formation. Patients who had neurologic symptoms before surgery, every patients experienced improvement in function in daily life, back pain and neurologic status like gait disturbance, motor weakness and tingling pain, etc.

**Conclusions:** Posterior interbody fusion in thoracic spine can be successful in patients whose symptom pathogenesis is in ventral side of dura like thoracic disc herniation, proximal junction kyphosis, infectious thoracic disease and OPLL. We performed PTIF with fine surgical outcomes and fusion rates. Therefore, PTIF can be satisfactory surgical treatments of choice for thoracic decompression and fixation surgery.

**Keywords:** Thoracic, Lumbar, Interbody fusion, Cage, Complication

# Free Paper: Lumbar (2)

## The Mid-term Outcomes of Posterior or Posterolateral Fusion Using Escherichia Coli-Derived Recombinant Human Bone Morphogenetic Protein-2(E. BMP-2) : Minimum 3-Years Follow-up

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**Purpose:** To confirm the mid-term clinical, radiological outcomes and the incidence of complications such as rate of cancer development and infection in patients with at least 3 years of follow-up.

**Materials and Methods:** As a case group, total of 65 patients who received surgery for lumbar fusion for lumbar degenerative spinal stenosis or spondylolisthesis applied with E.BMP-2 from July 2017 to January 2021 were included. As a control group, a total of 76 patients who received surgery from January 2015 to June 2017 were included. All patients were completed at least 3 years of follow-up. Clinical and functional outcomes were evaluated using preoperative and final follow-up visual analogue scales for back pain(VAS-BP) and leg pain(VAS-LP), and Korean Oswestry disability index (K-ODI) scores. The rate of malignancy development and infection were evaluated. Fusion rates were evaluated by computed tomography at final follow-up. All patients were received posterior or posterolateral fusion using autogenous iliac bone grafts (Group A, n=76) or E.BMP-2(Group E, n=65).

**Results:** There were no significant differences between preoperative VAS-LP, K-ODI and final VAS-BP, VAS-LP and K-ODI. There was significant difference between preoperative VAS-BP(7.62±2.85 in group A vs. 6.82±4.07 in group E, p=0.009). The PLF rate was 97.4% for Group A and 98.5% for Group E (p=0.692). There were no significant differences of cancer development rate (3% in group A vs. 3% in group E, p=0.863) and infection rate (12% in group A vs. 6% in group E, p=0.248) between two groups.

**Conclusions:** Lumbar fusion with E.BMP-2 is a safe procedure that can achieve high fusion rate without additional risk of malignancy or infection.

**Keywords:** Lumbar fusion surgery, Escherichia coli-derived recombinant human bone morphogenetic protein-2 (E. BMP-2), Mid-term outcomes

## The Impact of Sarcopenia and Gluteal Muscle Index on Clinical Outcomes in Posterior Lumbar Interbody Fusion Surgery: A Prospective Cohort Study

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**Purpose:** The impact of sarcopenia on surgical outcomes has been well-documented, but its specific influence on the

posterior lumbar interbody fusion (PLIF) surgery requires further exploration. In this context, the present aims to investigate the impact of sarcopenia on clinical outcomes following one or two-level PLIF. Additionally, the present study also aims to evaluate if muscle indices, including gluteal muscle index, derived from CT scans, can predict clinical outcomes.

**Materials and Methods:** A total of 115 patient who underwent one or two-level PLIF from December 2021 to December 2022 were enrolled and analyzed prospectively. Sarcopenia was defined according to the 2018 Asian Working Group for Sarcopenia (AWGS) guidelines. Appendicular skeletal muscle mass (ASM) was measured using a full-body DEXA scan, with low ASM defined as < 7.0 kg/m² in men and <5.4 kg/m² in women. Muscle strength was assessed using handgrip strength (HGS), with thresholds of 29 kg for men and 18 kg for women. Poor physical performance was identified using physical performance test, including 6-meter walk speed of less than 1.0 m/s or sit-to-stand time of 12 seconds or more. Muscle indices, including psoas muscle index (PMI), paraspinal muscle index (PaMI), and gluteal muscle index (GMI), were derived from CT scans. Sarcopenia diagnosis, muscle indices, and demographic data were analyzed using regression analysis to identify predictive factors for the Oswestry Disability Index (ODI) 12-month postoperatively.

**Results:** Out of 115 patients, 77 (65.2%) were diagnosed with sarcopenia according to the AWGS criteria. The sarcopenia group had statistically significantly lower BMI, ASM, PaMI, GMI, and poor preoperative ODI compared to the normal group. RM-ANOVA analysis showed significant differences in ODI scores between groups at 3-, 6-, and 12-months postoperatively, with the sarcopenia group exhibiting significant poorer outcomes at 12-months (sarcopenia vs. normal group, 0.183±0.149 vs. 0.107±0.055, p<0.001). Multivariate regression analysis identified poor sit-to-stand test results, weak HGS, lower ASM, and lower GMI as poor predictive factors for ODI 12-month postoperatively.

**Conclusions:** Patients diagnosed with sarcopenia exhibited poorer clinical outcomes 12 months postoperatively. In our study cohort, poor sit-to-stand test results, weak HGS, lower ASM, and lower GMI were identified as predictive factors for poor outcomes. Therefore, the presence of sarcopenia in patients considering fusion surgery necessitates careful consideration, as it may predispose them to poorer clinical outcomes.

**Keywords:** Sarcopenia, Gluteal muscle index, Posterior lumbar interbody fusion surgery, Clinical outcome

## Comparison Between One Stage and Two Stage OLIF Combined with Posterior Stabilization in Treatment of Degenerative Lumbar Stenosis: A Case Series

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**Purpose:** To compare clinical and radiological outcomes of one stage versus two stage oblique lateral interbody fusion combined with posterior pedicle screw fixation (OLIF+PSF) for treating moderate symptomatic degenerative lumbar spinal stenosis (DLSS).

**Materials and Methods:** Retrospective data were collected amongst who underwent single-level OLIF+PSF. Radiological lumbar parameters were measured for changes in posterior intervertebral space height (PISH), intervertebral space foramen height (IFH), intervertebral foramen area (IFA), lumbosacral lordosis (LL), implant migration and/or subsidence. Clinical outcomes, including visual analogue scale (VAS)-leg scores, and Oswestry Disability Index (ODI) were compared before and after surgery.

**Results:** 19 two stage patients were compared with 5 one stage patients, in patient with DLSS. Both group had similar PISH, IFH, IFA and LL, but implant migration was more profound in two stage group on 3 month follow up. The one stage group had longer hospital stays, more intraoperative and postoperative blood loss and higher cost. There were no differences in lower extremity VAS and ODI scores between the two groups.

**Conclusions:** one stage or two stage OLIF+PSF are both safe and effective procedures, capable of restoring lumbosacral lordosis and disc height partly. One stage procedure provide lower rate of implant migration in early stages. Regardless of the cost one stage procedure is move favourable than two stage.

**Keywords:** OLIF, Posterior pedicle screw fixation (PSF), Lumbar degenerative disease, Degenerative lumbar spinal stenosis

## The Effectiveness of Vitamin D3 Supplementation in Improving Functional Outcome of Non-surgically Treated Symptomatic Lumbar Spinal Stenosis: Randomized Controlled Clinical Trial – Pilot Study

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**Purpose:** Although vitamin D is one of the essential nutrients associated with musculoskeletal system function, there is no standard treatment method for vitamin D deficiency. This study aimed to investigate the effects of vitamin D supplementation on the improvement in symptoms, functional recovery of the spine, and changes in the quality of life in patients with spinal stenosis.

**Materials and Methods:** In this prospective study, patients with spinal stenosis and serum 25-hydroxy vitamin D (25OH-Vit D) levels less than 10 ng/mL were randomly assigned to a supplementation group (Group S) and a non-supplementation group (Group NS): 26 participants in Group S (16 females and 10 males) and 25 in Group NS (15 females and 10 males). The degree of lower back pain in both groups was assessed using the visual analog scale; spine function was assessed using the Oswestry Disability Index (ODI) and Roland–Morris Disability Questionnaire (RMDQ); and patient quality of life was assessed using the 36-item Short Form Health Survey (SF-36). We compared and analyzed the values that were measured at baseline, between 4 and 6 weeks (V1), 10 and 12 weeks (V2), and 22 and 26 weeks (V3).

**Results:** No statistically significant difference was observed in lower back pain, spine function, or quality of life between both groups at baseline. In terms of lower back pain in V1, Group S scored 4.15±3.12, while Group NS scored 5.64±1.85 (p=0.045). In V2, Group S scored 3.15±2.38, while Group NS scored 4.52±1.87 (p=0.027). Moreover, in V3, Group S scored 3.58±1.65, while Group NS scored 4.60±1.68 (p=0.033), indicating a statistically significant improvement in each period.

**Conclusions:** If a vitamin D deficiency that does not require surgical treatment exists in patients with lumbar spinal stenosis, high-dose vitamin D injections can improve lower back pain, which is the main symptom of LSS, as well as the functional outcomes of the spine and quality of life.

**Keywords:** Spinal stenosis, Vitamin D, Lower back pain, Spine function, Quality of life

## Novel Technique of Bilateral Diskectomy and Intra-discal Bone Graft Impaction (BiDIGI) in Transforaminal Lumbar Interbody Fusion (TLIF) with Expandable Lordotic Cage

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**Purpose:** The emergence of expandable lordotic cage was proven to improve the spinopelvic harmony and reduce the incidence of adjacent segment degeneration after transforaminal lumbar interbody fusion (TLIF). However, the rate of union of the interbody fusion became a concern. To overcome this issue, we devised a novel technique of bilateral diskectomy and intra-discal bone graft impaction (BiDIGI) to improve the degree of correction of deformity, enhance the fusion rate, prevent implant failure upon over-distraction, and maintain the alignment.

**Materials and Methods:** We first introduced the technique to all cases of TLIF in February 2021. Radiological parameters including disc height, segmental lordosis (SL) and lumbar lordosis (LL) were measured before the operation, right after the operation and at 1-year follow-up. Computed Tomography (CT) of the lumbar spine was taken at 1-year time to assess fusion rate and implant status.

**Results** 24 consecutive cases were included with a total of 40 levels of TLIF were performed. We achieved a gain in disc height from 8.24mm to 11.6mm. SL was restored from 11.1° to 16.5° and LL from 35.3° to 41.0°. At 1-year after

index operation, disc height change was -0.6mm, segmental lordosis -0.6° and lumbar lordosis -1°, which were all statistically insignificant. Union rate of the interbody fusion achieved 95% with reference to Bridwell Fusion Criteria and subsidence in 1 level (2.5%). Incidental durotomy and wound infection were encountered in 1 case (4%) respectively.

**Conclusions:** The improvisation of BiDIGI technique together with the use of expandable hyperlordotic cages could successfully restore the disc height, correct and maintain the alignment, enhance the interbody fusion rate with no additional operative risks imposed on the patients.

**Keywords:** TLIF, Diskectomy, Fusion, Rate, Expandable

# Free Paper: Lumbar (3)

## Early Detection of Surgical Site Infection in Lumbar Spine Surgery: The Diagnostic Superiority of Platelet Count to Mean Platelet Volume Ratio Over Traditional Inflammatory Markers

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**Purpose:** Surgical site infection (SSI) following spine surgery is a critical complication impacting patient recovery. Traditional serum inflammatory markers like C-reactive protein (CRP) and white blood cell count (WBCC) are commonly used to detect SSI. However, the need for earlier diagnostic tools has prompted the exploration of alternative markers. This study investigates the diagnostic potential of platelet count and mean platelet volume ratio as immediate postoperative indicators of SSI, offering a potentially quicker assessment of infection risk than CRP and WBCC.

**Materials and Methods:** In this retrospective study, we analyzed patients who underwent lumbar spine surgery from January 2013 to December 2023. The study comprised 32 patients requiring escalated postoperative care, matched in a 1:3 ratio with 96 control patients based on age, sex, and fusion levels. Parameters measured included CRP, ESR, CRP/albumin ratio, neutrophil to lymphocyte ratio, immature granulocyte count, and platelet count to mean platelet volume ratio, taken immediately after surgery and on POD3. Operation time and estimated blood loss (EBL) were also compared. The study aimed to evaluate the sensitivity, specificity, and likelihood ratios of these biomarkers in predicting SSI.

**Results:** Significant elevations in CRP (p=0.0306) and CRP/albumin ratio (p=0.0297) were observed on POD3 in the patient group, indicating an inflammatory response linked to SSI. Notably, the platelet count to mean platelet volume ratio (p=0.0209) was the only marker that showed a significant increase immediately post-surgery in the patient group, suggesting its effectiveness as an early infection indicator.

**Conclusions:** The platelet count to mean platelet volume ratio stands out as a more immediate and effective marker for early detection of SSI following lumbar spine surgery, compared to traditional markers like CRP. This early detection capability could enable quicker clinical interventions, potentially improving patient outcomes and reducing the incidence of postoperative complications. The study highlights the importance of incorporating this platelet index into postoperative monitoring protocols for spine surgery patients.

**Keywords:** Surgical site infection, Platelet count, Mean platelet volume, Inflammatory markers

## Reconstruction Surgery for Iatrogenic Flatback (≤3 level fusion): Indications for Pedicle Subtraction Osteotomy

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**Purpose:** This study aims to identify appropriate surgical strategies and indications for patients with flatback syndrome after short-level (≤3 levels) fusion.

**Materials and Methods:** From 2011 to 2022, 30 patients who underwent deformity corrective surgery for flatback syndrome that occurred after short-level (≤3 levels) fusion at a single institution were finally enrolled. We divided all patients into group A (n=20, only Anterior column realignment, ACR) and group B (n=10, ACR combined with

Pedicle subtraction osteotomy, PSO) according to surgical procedure. Among group A patients, additional analysis was performed by dividing the patients into two groups: those (Excessive group) who developed excessive distraction of anterior disc height after surgery and those (Adequate group) who did not. Radiological spinopelvic parameters, postoperative complications, and patient-reported outcomes were compared between the two groups.

**Results:** The group A had lesser number of previous fusion levels than group B (1.1±0.2 vs. 2.2±0.8, p<0.001). Preoperative C7 sagittal vertical axis (C7SVA, 219.8±76.4 mm vs. 293.8±90.3 mm, p=0.026) and its correction (-157.9±84.9 mm vs. -263.0±79.9 mm, p=0.003) in group B were greater than those in group A. 7 (35%) patients in group A had excessive distraction of the anterior intervertebral disc space at postoperative, and none in group B. The segmental angulation in extension (SAext) and dynamic segment angle (DA) were significantly smaller in Excessive-group compared to Adequate-group (0.4±5.6° vs. -8.3±5.1°, p=0.003; 2.8±1.1° vs. 9.1±3.4°, p<0.001, respectively). The optimal cut-off values of preoperative radiographic parameters for selecting PSO were: C7-SVA >242.8 mm and DA < 4.28°. Both groups showed significant improvement in VAS (Visual Analogue Scale) and ODI (Oswestry Disability Index), postoperatively (p<0.05).

**Conclusions:** Both only ACR and ACR combined with PSO showed satisfactory outcomes in patients with iatrogenic flat back. In particular, we highly recommend ACR combined with PSO procedure in the patients with preoperative C7SVA > 242.8 mm, or preoperative DA < 4.28°.

**Keywords:** Iatrogenic flatback, Pedicle subtraction osteotomy, Sagittal imbalance, Reconstruction, alignment

## Does Lordosis Distribution Index (LDI) Affect Adjacent Segment Pathology (ASP) Incidence after 1- or 2-Level Lumbar Fusion Surgery?

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**Purpose:** To evaluate the incidence rate of adjacent segment pathology (ASP) after 1 or 2-level lumbar fusion according to lordosis distribution index (LDI).

**Materials and Methods:** Patients that underwent 1 or 2-level interbody fusion for lumbar degenerative conditions between April 2016 and December 2021. Patients with radiologically follow-up for at least 2 years were included. We used standing whole spine posteroanterior and lateral plain radiographs to evaluate radiological results. ASP included spondylolisthesis, instability, facet joint degeneration, herniated disc, etc. Preoperative spinopelvic parameter, C7 sagittal vertical axis (SVA), bone mineral density, and comorbidities, along with perioperative LDI were analyzed. Patients were categorized into normal LDI (n-LDI) and abnormal LDI (a-LDI).

**Results:** A total of 106 patients were enrolled in this study. Twenty-five were male, and the mean age were OO years. Eighty-two patients underwent 1-level fusion and the other twenty-four patients underwent 2-level fusion. The most common diagnosis was degenerative spondylolisthesis (63 patients, 59.4%) followed by foraminal stenosis (20 patients, 18.9%). Index level was most common in L4-5 (56 patients, 52.8%) followed by L5-S1 (20 patients, 18.9%). n-LDI included 62 patients while a-LDI included 44 patients. In 1-year follow up, n-LDI showed 4.8% ASP while a-LDI showed 4.5% ASP. In 2-year follow up, n-LDI showed 16.1% ASP while a-LDI showed 15.9% ASP. In both time points, the difference was not statistically significant.

**Conclusions:** ASP was not more frequently occurred in a-LDI compared to n-LDI in short-term. During the two-year follow up after short-level lumbar fusion surgery, LDI was not a significant factor in predicting the occurrence of ASP.

**Keywords:** Lumbar lordosis, Lordosis distribution index, Lumbar fusion, Adjacent segment pathology

## Age and Level Matched Comparison of Oblique Lumbar Interbody Fusion and Transforaminal Lumbar Interbody Fusion for Degenerative Lumbar Disease

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**Purpose:** For the treatment of degenerative lumbar diseases, oblique lumbar interbody fusion (OLIF) and transforaminal lumbar interbody fusion (TLIF) have produced good clinical and radiologic results. This study aims to compare the clinical and radiological outcomes between oblique lumbar interbody fusion (OLIF) and transforaminal lumbar interbody fusion (TLIF).

**Materials and Methods:** We included patients who underwent a single level OLIF or TLIF surgery between L3-5 from 2017 to 2022: 22 in the OLIF group and 28 in the TLIF group. The radiologic outcomes including lumbar lordosis, segmental lordosis, disc height, foraminal height, and subsidence were measured and compared between two groups. The clinical outcomes measured included Visual Analogue Scale (VAS) for back/leg pain and the Oswestry Disability Index (ODI).

**Results:** Compared to the TLIF group, the OLIF group demonstrated significantly more effective restoration of anterior disc height (5.81 mm vs. 3.46 mm, $p<0.05$), posterior disc height (3.79 mm vs. 2.43 mm, $p<0.05$), and foraminal height (3.29 mm vs. 1.38 mm, $p<0.05$) at the one-year postoperative follow-up. However, there were no significant differences in the improvement of lumbar lordosis and segmental lordosis between the two groups at the one-year postoperative follow-up ($p>0.05$). Both groups exhibited a similar rate of subsidence at the one-year follow-up (30% vs. 31.1%). Additionally, both groups showed significant improvements in VAS scores for pain and ODI at the one-year follow-up, with no discernible differences between the two groups.

**Conclusions:** In summary, OLIF shows better restoration of disc and foraminal height than TLIF at one year post-surgery, but both techniques have similar outcomes in terms of lordosis, subsidence, and clinical improvements.

**Keywords:** Oblique lumbar interbody fusion, Transforaminal lumbar interbody fusion, Radiologic parameters

## Effectiveness of Toothbrushing Technique for Biofilm Removal and Postoperative Infection Control after Spinal Fusion Surgery: A Retrospective Study

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**Purpose:** This retrospective study explores the efficacy of utilizing a common toothbrush for biofilm removal and infection control in spinal infections following spinal fusion surgery. Given the known formation of biofilms on metal implants during spinal fusion, the study aims to compare clinical outcomes between patients using and not using a toothbrush during conventional drainage, curettage, and debridement procedures.

**Materials and Methods:** The study screened 1081 patients who underwent spinal fusion surgery between November 2018 and October 2022. Among them, 60 patients with surgical site infections underwent incision and drainage—20 with a toothbrush and 40 without. Evaluation criteria included infection control failure requiring revision surgery and the rate of additional surgery. C-reactive protein levels were monitored as an indicator of postoperative recovery.

**Results:** In the Toothbrush group, 10% (2/20) experienced infection control failure requiring revision surgery, compared to 35% (14/40) in the No-Toothbrush group ($p=0.039$). The Toothbrush group also showed a significantly lower rate of additional surgery. C-reactive protein levels normalized faster in the Toothbrush group ($p=0.044$). These findings suggest that using a toothbrush for biofilm removal improves clinical outcomes in spinal infections post-spinal fusion surgery.

**Conclusions:** Overall, using a toothbrush for mechanical debridement appears to enhance the effectiveness of conventional surgical procedures in treating spinal infections.

**Keywords:** Spine fusion, Postoperative infection, Toothbrush, biofilm

# Free Paper: Lumbar (4)

## Efficacy of Intramuscular Analgesic Injection after Decompression Surgery for Degenerative Lumbar Spinal Stenosis: A Double-Blind, Randomized, Controlled, Clinical Pilot Trial

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**Purpose:** The current study aimed to identify the efficacy of injecting local anesthetic in the erector spinae muscle area immediately after decompression surgery based on postoperative pain control, functional outcome, and quality of life.

**Materials and Methods:** This was a 3-month prospective, two-group, parallel, double-blind, randomized, controlled clinical trial conducted at a single medical center. In total, 40 patients (n=20 in the study group and n=20 in the control group) were enrolled in this research. In the study group, the injection cocktail comprising 20 mL of lidocaine, 20 mL of bupivacaine, and 20 mL of normal saline was administered to the exposed and retracted paraspinal muscles and surrounding soft tissues after decompression surgery. Meanwhile, 60 mL of normal saline was administered in the control group.

**Results:** Postoperative low back pain (LBP) was assessed using the visual analog scale (VAS) before and at 6 and 12 weeks after surgery. LBP was examined using the VAS every 8 h within the first 3 days after surgery. The ODI and RMDQ were used for the assessment performed before and at 6 and 12 weeks after surgery. The SF-36 PCS and MCS domains were used in the examination conducted before and 12 weeks after surgery. Results showed no statistically significant difference in terms of VAS score improvement between the study and control groups at every interval (all $p>0.05$). Further, the ODI, RMDQ, and SF-36 PCS and MCS domain scores at every interval did not significantly differ (all $p>0.05$).

**Conclusions:** Local anesthetics with lidocaine and bupivacaine infiltration on the bilateral sides of the erector spinae muscle before surgical wound closure was not effective for postoperative LBP control. Nevertheless, this was a double-blind, randomized, controlled, prospective clinical pilot trial. Hence, further studies must be conducted to validate our results.

**Keywords:** Lumbar spinal stenosis, Pain, Pocal anesthetics

## Hemodynamic Changes Following Lumbar Spinal Surgery in Patients Refusing Blood Transfusion: Analysis of 276 Jehovah's Witness Patients

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**Purpose:** To report a case series of surgical interventions for Jehovah's Witness (JW) patients with degenerative lumbar disease.

**Materials and Methods:** A total of 276 JW patients who underwent spine surgery at our hospital were screened, with 72 excluded due to cervical or thoracic pathology, infection, tumor, or trauma. The study cohort comprised 204 JW patients with degenerative lumbar disease between June 2004 and July 2023. The patients underwent perioperative management according to the "Alternative blood management protocol" that is established by our bloodless medicine and surgery center. Demographic and surgical factors were assessed, including hemodynamic analyses of perioperative changes in hemoglobin (Hb, g/dL) and hematocrit (Hct, %) levels.

**Results:** Of the 204 patients, 144 underwent fusion and 60 non-fusion surgeries, with 41 involving revisions. Combined anterior-posterior surgeries totaled 46 cases, and extensive fusion exceeding 3 levels occurred in 25 cases. There were 13 postoperative complications, none related to their refusal of a transfusion. The average drop in Hb and Hct after surgery was 1.5 g/dL and 4%. For the non-fusion surgery patients, Hb and Hct levels were 13.1/38.7 before surgery, 12.4/37.0 after surgery, 11.9/35.4 on day 1, 11/33 day 2, 11.5/34.3 day 3, 11.3/33.8 day 7, and 11.8/35.4 day 14. For the fusion surgery patients, Hb and Hct levels were 13.1/39 before surgery, 11.3/34 after surgery, 10.8/32.1 on

day 1, 10/30 day 2, 10.2/30.7 day 3, 10.5/31.3 day 7, and 10.7/32 day 14. The patient with the lowest postoperative Hb level was treated by an extensive fusion from T10 to iliac fixation due to lumbar degenerative kyphosis. She showed the following hemodynamic flow (Hb): preoperative 12.4, immediate postoperative 6.2, 4.5 on day 1, 4.2 on day 2, 4.4 on day 3, 5.4 day 6, 8.4 day 14, 10.1 day 21.

**Conclusions:** Hemoglobin and hematocrit levels after degenerative lumbar spinal surgery in JW patients decreased to the lowest level on postoperative day 2 and tended to gradually recover from postoperative day 3 regardless of the surgical method. Utilizing our appropriate "Alternative blood management protocol", successful lumbar spine surgery may be possible without hemodynamic complications in patients with religious blood transfusion refusal.

**Keywords:** Transfusion, Blood conservation, Jehovah's Witness, Bloodless operation, Blood loss

## Clinical Outcomes of Spine Surgery in Patients with CKD Undergoing Hemodialysis

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**Purpose:** This study aims to compare the clinical outcomes of spine surgery in patients with chronic kidney disease (CKD) undergoing hemodialysis and those not undergoing dialysis., utilizing a matched cohort analysis.

**Materials and Methods:** The study focused on patients who underwent spine surgery at our institution from February 2010 to June 2023. The Hemodialysis group (HD group) comprised patients receiving hemodialysis. During the same period, a non-HD group was identified among patients undergoing spinal surgery who did not receive hemodialysis. The two groups were matched through cohort analysis based on criteria such as age, gender, type of surgery, surgical site, diagnostic classification, and comorbidities. Complications and clinical outcomes were then compared between the two groups.

**Results:** The HD group comprised 73 individuals, and a 1:1 matching was performed, selecting 73 individuals from a non-HD group population of 2474. In the analysis of postoperative complications, there was no significant difference between the two groups in internal medical complications such as pneumonia, heart disease, cerebrovascular accident (CVA), intensive care unit (ICU) admission, sepsis, and mortality. Surgical complications, including infection and hardware loosening, also did not show statistically significant differences. However, in the long-term follow-up, the HD group exhibited a higher incidence of adjacent segment disease (ASD) and cage subsidence. The Visual Analog Scale (VAS) pain scores in the HD group showed a decrease from 5 points for preoperative lower back pain to 2 points postoperatively, and from 7 points to 2 points for preoperative leg pain. In the non-HD group, preoperative lower back pain decreased from 4 points to 1 point postoperatively, and preoperative leg pain decreased from 6 points to 0 points. The Oswestry Disability Index (ODI) in the HD group decreased from 53.3 preoperatively to 24.4 postoperatively, while in the non-HD group, ODI decreased from 47.0 preoperatively to 22.0 postoperatively.

**Conclusions:** It appears that spine surgery in hemodialysis patients also exhibits clinical improvement comparable to non-hemodialysis patients.

**Keywords:** Chronic kidney disease, Hemodialysis, Spine surgery, Matched cohort analysis, Clinical outcomes

## The Impact of Paraspinal Muscle Changes after Single-Segment Posterior Lumbar Laminectomy

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**Purpose:** Posterior lumbar laminectomy causes muscle damage during approach. This study was to analyze an impact of paraspinal muscle changes after single-segment posterior lumbar laminectomy.

**Materials and Methods:** Thirty-three patients who had preoperative clinical records, lumbar lateral radiographs, and lumbar magnetic resonance imaging (MRI) and were available for postoperative follow-up were enrolled. Paraspinal muscle was calculated using a pseudocoloring technique in laminectomy vertebra. Degeneration of the facet joints on MRI was classified according to the Weishaupt grading system. Changes in paraspinal muscles and facet joint degeneration, radiological parameters, and clinical outcomes were analyzed.

**Results:** The average age of patients was 60.5 years, and 17 patients (51.5%) were male. As a result of the postoperative follow-up, the muscle ratio of the lumbar extensors was 56.4%, which was lower than the preoperative muscle ratio of 70.4% ($p<0.01$). Postoperative follow-up MRI showed that the degenerative changes in the facet joints had aggravated at the laminectomy site ($p<0.01$). At postoperative follow-up, loss of lumbar extensors and facet joint degeneration were associated with back pain (lumbar extensors; $r=0.80$, $p<0.01$; facet degeneration; $r=-0.66$, $p<0.01$, respectively). On the other hand, there was a negative correlation ($r=-0.49$, $p<0.01$) between the loss of lumbar extensors and age, showing that the younger the age, the greater loss in muscle mass.

**Conclusions:** The loss of the extensor muscles and the degenerative changes of facet joint in lumbar spine after the posterior laminectomy could be associated with back pain.

**Keywords:** Lumbar laminectomy, Paraspinal muscle atrophy, Facet degeneration, Back pain

### Newly Developed Probe for Safe Thoraco-Lumbar Percutaneous Pedicle Screw Insertion

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**Purpose:** During insertion of thoraco-lumbar percutaneous pedicle screw (PPS) with C-arm assistance, probe is proceeded by AP view as first step, then will be converted to lateral view. In this first step, there is risk of vascular penetration by too-much depth insertion. To avoid such accident, novel probe is developed.

**Materials and Methods:** The feature of new probe is, the diameter of probe become thicker at the point of 30mm from the tip of probe. By the difference of diameter, the depth can be known. If the probe is inserted 30mm before probe tip reaches medial wall of pedicle, the depth is enough and C-arm is converted to lateral view. And oppositely if the probe tip reached medial wall too shortly, the angle of should be raised. The design and manufacturing were done by TAKAYAMA INSTRUMENT (Tokyo, Japan). Intraoperative C-arm image and postoperative CT scan of the patients received thoraco-lumbar PPS insertion is investigated.

**Results:** 6 cases, 36 PPSs were inserted with this probe. There was no probe insertion beyond anterior wall of vertebral body. Postoperative CT revealed adequate PPS position. Operability was equivalent to existing probes.

**Conclusions:** This newly developed probe is useful for safe PPS insertion. It is recommended for use in C-arm assisted surgery in the lower thoracic and lumbar spine, where the distance from the insertion point to the anterior wall of the vertebral body exceeds 30 mm.

**Keywords:** Minimally invasive surgery, Percutaneous pedicle screw, Safety

## Free Paper: Lumbar (5)

### Feasibility Assessment of an Expandable Lumbar Interbody Cage in Patients with High-Risk Factors for Subsidence: A Propensity Score-Matched Analysis

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**Purpose:** Expandable cages are becoming increasingly popular due to their advantages in restoring disc height and minimizing iatrogenic endplate injury. Despite these benefits, concerns about the subsidence, particularly due to increased endplate pressure during expansion, persist. This study aimed to evaluate the clinical feasibility of expandable cages in patients with high risks of subsidence undergoing posterior lumbar interbody fusion (PLIF).

**Materials and Methods:** This retrospective cohort study analyzed a prospectively collected database using a propensity score-matched analysis. We focused on patients at high risk for subsidence, including those with a hip T-score ≤-2.5, a history of multilevel fusion surgery at adjacent segments (at least 3 levels), or grade 2 or higher spondylolisthesis. These patients underwent PLIF surgery with an expandable cage and were followed up for a minimum of 6 months. For comparison, a control group was selected from a cohort of 387 cases, with 37 patients undergoing PLIF with static cages. Radiological parameters, including segmental lordotic angle (SLA), disc angle (DA), foraminal height (FH), and disc height index (DHI), were measured preoperatively, immediate postoperatively, and at the last follow-up using standing lateral radiographs. The DHI was calculated as the average of the anterior and posterior height of the intervertebral space, normalized to the lower endplate diameter. Subsidence was defined as a reduction of more than 25% in DHI from immediate to the last follow-up.

**Results:** The study included 74 patients, of which 57 (77%) were female, with a mean age of 71.9 ± 5.9 years. There were no significant differences in demographic characteristics between two groups. Notably, the expandable cage group demonstrated significantly higher cage height and lordosis angles ($p<0.001$). The expandable cage group exhibited a higher immediate postoperative DHI and maintained greater disc height at the last follow-up compared to the static cage group. This group also showed a lower ratio of subsidence, indicating better long-term outcomes in maintaining disc height.

**Conclusions:** The present study demonstrated that the expandable cage group showed significantly higher immediate postoperative DHI and maintained it until the last follow-up compared to static cages with significantly lower subsidence ratio. These findings suggest that expandable cages could offer advantages over static cages for patients with a high risk of subsidence in PLIF surgery.

**Keywords:** Expandable cage, Posterior lumbar interbody fusion, Subsidence

## Effect of Facet Effusion on the Prognostic Value of MRI Grading System for Foraminal Stenosis Based on a Minimum 5-Year Follow-up

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**Purpose:** The purpose of this study was to develop a novel MRI grading system for lumbar foraminal stenosis with improved prediction ability for surgical treatment.

**Materials and Methods:** We retrospectively reviewed consecutive patients diagnosed with lumbar foraminal stenosis between 2011 and 2017 at a single tertiary hospital. We excluded patients with central canal stenosis in the MRI at the time of diagnosis. The severity of foraminal stenosis in the initial MRI was assessed using a conventional grading system by Lee et al. Whether the patient underwent surgical treatment for foraminal stenosis during the follow-up period and the time to surgery from initial diagnosis were also recorded. Survival analysis using a Kaplan-Meier curve and log-rank test was utilized to verify the significance of the severity of foraminal stenosis on the surgical treatment. We performed additional survival analysis after modifying the grading system by adding facet effusion assessed in the axial MRI. In the modified grading system, a new grade 3 consisted of only those who showed facet joint effusion among the patients previously classified as grade 3. Patients without excessive facet joint effusion in the conventional group 3 were grouped with the conventional grade 2 patients, consisting of the new grade 2. We also compared the discrimination ability of the modified grading system to the conventional grading system using Uno's C-index.

**Results:** A total of 235 patients were included in this study. During the mean follow-up period of 8.1 years, 63 out of 235 patients (26.8%) underwent surgical treatment. According to the conventional grading system, there was no significant difference in survival between grade 2 and grade 3 (log-rank test, $p=0.104$). After modification, the grading system showed a significant difference in survival between the new grade 2 and 3 (log-rank test, $p<0.001$). The discrimination ability assessed by Uno's C-index was significantly improved from 0.69 (95% CI: 0.64-0.76) to 0.73 (95% CI: 0.67-0.79) after modification. Excellent intra-observer (κ value:

grade1; 0.91, grade2; 0.87, grade3; 0.92) and inter-observer agreement (κ value: grade1; 0.87, grade2; 0.88, grade3; 0.83) was observed.

**Conclusions:** Excessive facet fluid, an indicator of segmental instability, is a significant factor in predicting surgical predictability in foraminal stenosis patients. The modified grading system provides the ability to better predict the prognosis of foraminal stenosis.

**Keywords:** Lumbar spine, Facet effusion, Foraminal stenosis, Natural history, Instability

## Degree of Postoperative Recovery According to the Duration of Mild Motor Deficit in Lumbar Spinal Stenosis

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**Purpose:** Controversy exists surrounding timing and benefits of surgery versus nonsurgical treatment when motor weakness occurs in spinal disorders. Several spine-related societies (NASS) say that motor deficits in lumbar spinal stenosis are not a prompt surgery indication because they do not progress quickly. However, it's not uncommon for old motor deficits not to recover at all even after surgery. We sought to study the relationship between the duration of preoperative motor weakness and postoperative motor recovery.

**Materials and Methods:** Study includes 22 patients who underwent surgery for motor weakness between May 2018 and December 2022 at a single institution. Cases with causes other than lumbar spinal stenosis as well as those with follow-up less than 24 months were excluded. Extent of recovery was assessed by comparing difference between preoperative muscle weakness and muscular strength at last follow-up, categorized as complete recovery, some improvement, no change, and deterioration. For statistical analysis, multiple regression and simple regression analysis were used.

**Results:** Total of 22 cases were identified, comprising 8 men and 14 women. Postoperatively, 10 patients experienced complete recovery, 4 showed improvement, and 8 exhibited no change in muscle strength. There were no cases of worsening weakness postoperatively. Mean age was 68.73(±10.67) and among 22 patients, 15 patients had preoperative MRC grade 4 and the other 7 patients were below grade 4. 10 of 14 patients with weakness duration for less than 2 years made complete recovery, 4 patients made partial recovery and 1 patient made no recovery. However, all patients with symptoms for more than 2 years made no recovery. The mean duration of weakness in patients with complete recovery was 9.4 months (±7.82) and with no recovery was 44.62 months (±19.85). Among 8 patients who made no recovery postoperatively, 5 patients had both MRC grade 4 weakness and weakness duration more than 2 years. In multiple regression analysis, among age, gender, preoperative motor grade and preoperative weakness duration, only duration of preoperative motor weakness was found to be associated with postoperative motor recovery ($p=0.002$), and this association was statistically significant in simple regression analysis as well ($p<0.001$).

**Conclusions:** Even with mild muscle weakness of Grade 4, if the duration of muscle weakness persists for more than 2 years, recovery may not occur. Therefore, even in cases with mild motor deficits, surgical treatment of stenosis as soon as possible can improve the outcome.

**Keywords:** Motor weakness, Timing of surgery, Recovery, Motor grade, Duration

## Effect of Solid Fusion vs. Pseudoarthrosis on Development of Adjacent Segment Degeneration after Posterior Lumbar Interbody Fusion (PLIF)

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**Purpose:** Total disc replacement in the lumbosacral spine

has been compared with fusion surgeries to elucidate the effect of preserved segmental motion on adjacent segment degeneration (ASD). However, the comparative evaluation has inherent limitation in terms of different criteria for patient selection and the cause of ASD is still controversial. The objective of this study is to analyze the effect of solid fusion on development of ASD by comparing to pseudoarthrosis after posterior lumbar interbody fusion (PLIF).

**Materials and Methods:** This retrospective cohort study included patients who underwent one or two-level PLIF to treat lumbar degenerative diseases. Status of fusion and proximal ASD was determined at 2 years after surgery. Adjacent segment disease (ASDi) was defined as ASD with related symptoms treated with lumbar injection or surgery at the ASD level. Demographic data, radiological parameters, and clinical outcomes were compared between the fusion group and the pseudoarthrosis group. Logistic regression analysis was performed to identify the risk factors of ASD.

**Results:** One-hundrest sixty eight patients were enrolled in this study. Fusion rate was 72%. Demographic data compared between the fusion group and the pseudoarthrosis group demonstrated significant differences in the age (68.5 vs 71.8, p=0.037) and the number of multi-level surgery (38% vs 55%, p=0.042). There was no significant difference in radiographic spinopelvic parameters and clinical outcomes between two groups. Proximal ASD rates were 34.7% and 14.9% in the fusion group and the pseudoarthrosis group, respectively (p=0.011). Proximal ASDi rates were 5.8% and 4.3% in the fusion group and the pseudoarthrosis group, respectively (p=0.693). Multivariate logistic regression analysis demonstrated that solid fusion and multi-level surgery were significantly correlated with proximal ASD.

**Conclusions:** Solid fusion causes significantly more proximal ASD after PLIF compared to pseudoarthrosis. Solid fusion is an independent risk factor of proximal ASD after PLIF and other risk factor includes multi-level surgery.

**Keywords:** Posterior lumbar interbody fusion, Adjacent segment degeneration, Adjacent segment disease, Fusion, Pseudoarthrosis

## Early Inflammatory Response of rh-BMP-2 in the Single-Level PLIF Surgery

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**Purpose:** The efficacy of bone morphogenetic protein 2 (BMP-2) in lumbar fusion surgery has been validated from previous studies, and it is now widely utilized in diverse clinical settings. However, complications related to inflammation, including radiculitis and soft tissue swelling, have been reported with the use of BMP-2. The purpose of this study was to evaluate the degree of early inflammatory response in patients undergoing single-level Posterior Lumbar Interbody Fusion (PLIF) with BMP-2, compared to a control group.

**Materials and Methods:** The present study was a multicenter, randomized controlled study conducted from 2018 to 2020. Patients were divided into two groups: the BMP-2 group underwent surgery with BMP-2, and the control group used auto-iliac strut bone as a bone graft. The use of anti-inflammatory drugs, including NSAIDs and steroids, was prohibited from one week before to two weeks after surgery. C-reactive protein levels were measured preoperatively, and on days 1, 3, 5, and 10 postoperatively, and compared between groups using RM-ANOVA. The Leg Numeric Rating Scale (NRS) was also measured to compare early postoperative pain.

**Results:** A total of 82 patients were enrolled, with 40 in the control group and 42 in the BMP-2 group. The average age of patients was 68.1±4.6 years, with no significant differences in sex, operation level, or diagnosis between groups. The BMP-2 group showed a trend of higher CRP at all postoperative time points, with a peak CRP level (105.6±51.8 vs. 91.1±55.2), although this was not statistically significant (p=0.202). There were no differences in clinical leg NRS between groups at any time point up to 10 days postoperatively.

**Conclusions:** The BMP-2 group showed a tendency for higher CRP levels up to 10 days postoperatively. Although no clinical differences were observed between groups, careful observation for early inflammatory reactions in patients

undergoing PLIF with BMP-2 is recommended.

**Keywords:** Early inflammatory reactions, BMP-2, Posterior lumbar interbody fusion surgery

# Free Paper: MIS (1)

## Does Endoscope Have a Better Scope in Sexual Function as Well? - A Comparative Study between Microdiscectomy vs Endoscopic Discectomy

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**Purpose:** One of the most significant factors affecting quality of life is sexual function. Back pain is an established risk factor for sexual dysfunction. Excellent functional outcomes following Microscopic discectomy (MD) and Endoscopic Discectomy (ED) have been demonstrated in various studies. Its effect on sexual function, however, has not received much research. We analysed the sexual function and variables influencing sexuality in both males and females following MD and ED.

**Materials and Methods:** This is a prospective study done in 51 patients (32 males and 19 females). Group A consisted of 27 patients who underwent MD and Group B consisted of 24 patients who underwent ED. Patients with sexual disorders, infections, tumours, trauma, inflammatory pathologies, and psychiatric illnesses were excluded. Sexual function was analysed using the Brief Male Sexual Function Inventory (BSFI) for males and Female Sexual Function Inventory (FSFI) for females, and using additional questions like favourable position, masturbation, and the time of commencement of sex after surgery.

**Results:** All the male patients in both groups had significant improvement in sexual function after the surgery with a slightly better improvement in Group B. However, it was not statistically significant. On the contrary, deterioration of sexual function was noted in females in both the groups which was mainly attributed to fear and anxiety. Majority resumed their sexual activities within 4 weeks after surgery especially in Group B because of early discharge and rehabilitation after ED. However the difference was not statistically different between both the groups. All males started masturbation within 4 weeks but had earlier ejaculation and 50% of females started masturbation within 4 weeks but experienced pain on orgasm in both the groups. Preferred positions were face-to-face for males and missionary positions for females.

**Conclusions:** Following MD or ED, female sexual function declined while male sexual function improved. Improvement of sexual function was slightly better in ED though it was not very significant. One of the main predictors of poor sexual outcomes is fear and anxiety. To enhance the overall functional success and quality of life, treating surgeon should dedicate sufficient time to sexual rehabilitation and counselling.

**Keywords:** Microdiscectomy, Endoscopic discectomy, Sexual function, MSFI, BSFI

## Fusion Rate and Cage Subsidence According to Cage Material and Size in Biportal Endoscopic Transforaminal Lumbar Interbody Fusion

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**Purpose:** Biportal endoscopic transforaminal lumbar interbody fusion (BE-TLIF) is an emerging technique for minimally invasive lumbar interbody fusion performed under biportal endoscopic guidance. However, concerns regarding cage subsidence and sufficient fusion during BE-TLIF imply the importance of selecting an appropriate interbody cage to improve surgical outcomes. We compared the fusion rate, subsidence, and other radiographic parameters according to the material and size of the cage used in BE-TLIF.

**Materials and Methods:** Patients who underwent single-segment BE-TLIF between April 2019 and February 2023 were divided into three groups: Group A, regular-sized three-dimensionally (3D)-printed titanium cages; Group B, regular-sized polyetheretherketone cages; and Group

C, large-sized 3D-printed titanium cages. Radiographic parameters, including lumbar lordosis, segmental lordosis, anterior and posterior disc height, disc angle, and foraminal height, were measured before and after surgery. The fusion rate and severity of cage subsidence were compared among the groups.

**Results:** No significant differences in the demographic data or radiographic parameters were noted among the groups. The fusion rate on the 1-year postoperative computed tomography scan did not differ among the groups. The cage subsidence rate was significantly lower in Group C than in Group A (41.9% vs. 16.7%, p=0.044). Subsidence severity was significantly lower in Group C (0.93±0.83) than in Groups A (2.20±1.84, p=0.004) and B (1.79±1.47, p=0.048).

**Conclusions:** Cage materials did not affect the 1-year postoperative outcomes of BE-TLIF; however, subsidence was markedly reduced with large-size cages. A larger cage may provide a more stable segment postoperatively.

**Keywords:** Fusion rate, Subsidence, Large footprint cage, Polyetheretherketone cage, Three-dimensionally-printed titanium cage

## Surgical Outcomes in Oblique Lumbar Interbody Fusion in Patients with Old Age

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**Purpose:** As the global population continues to age, the demand for spinal interventions in the geriatric population has risen. Among these approaches, oblique lumbar interbody fusion (OLIF) has emerged as a minimally invasive surgical option. However, there were few literatures about the surgical outcomes of OLIF in geriatric populations.

**Materials and Methods :** A retrospective study of 170 patients who underwent oblique lumbar interbody fusion (OLIF) analyzed the impact of age on the procedure's outcomes. Patients were divided into three age groups: <65 years, 65-74 years, and ≥75 years. Older patients (≥75 years) had a higher prevalence of diabetes and hypertension, indicating more comorbidities compared to younger age groups.

**Results:** 170 patients undergoing a standard OLIF procedure, participants were divided into three age groups: less than 65 years old, 65 to less than 75 years old, and 75 years or older. The analysis revealed no significant differences in gender distribution or body mass index (BMI) among the age groups. However, there were notable variations in comorbidities. Patients aged 75 years or older had a higher prevalence of diabetes (p=0.010) and hypertension (80%) compared to younger age groups (40.3% and 51.5%, respectively, p = 0.003). This suggests that older individuals undergoing the procedure were more likely to have these chronic conditions, which could impact their surgical outcomes. Patient-reported outcomes, including Visual Analog Scale (VAS) for pain, Oswestry Disability Index (ODI) for disability, and EQ5D for health-related quality of life, were also assessed. While there were no significant differences in VAS and EQ5D scores between age groups, older patients (≥75 years) had significantly higher ODI scores (indicating more severe disability) than younger patients (p<0.001). Despite this, both age groups experienced substantial improvements in VAS, ODI, and EQ5D scores post-operatively, indicating the OLIF effectiveness in alleviating pain and enhancing quality of life. Regarding surgical outcomes, no significant differences were observed in the number of surgical levels or the occurrence of complications, such as orthopedic readmission, screw loosening, and cage subsidence between the age groups. However, younger patients (<65 years) had longer operation times (p=0.002) and higher blood loss (p=0.004) compared to older patients (≥75 years). Hospital stay duration did not significantly vary based on age (p=0.105).

**Conclusions:** In summary, age impacts comorbidities and some procedural factors, but overall, oblique lumbar interbody fusion is an effective procedure across age groups, especially in elderly groups.

**Keywords:** OLIF, Old age, Surgical outcomes

## Comparative Analysis of Biportal Endoscopic L5-S1 Foraminotomy vs Fusion

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**Purpose:** For patients with foraminal stenosis at the L5-S1 level, there are two surgical options: simple L5-S1 foraminotomy and L5-S1 fusion. With advancements in endoscopic surgery, L5-S1 foraminotomy has become a readily accessible surgical technique. However, symptom relief is often short-lived, and there is a frequent recurrence of foraminal stenosis or symptom relapse due to sinking down. As an alternative, biportal endoscopic fusion at L5-S1 can promote symptom improvement. However, it may be challenging to apply for patients who dislike fusion procedures and can lead to fusion-related complications. Therefore, we aimed to compare which surgical approach yields better short-term results for L5-S1 foraminal stenosis
Materials and methods : Patients with L5-S1 foraminal stenosis were divided into two groups: one group underwent L5S1 foraminotomy via a paraspinal approach from 2017 to 2019 (18 patients), and the other group underwent biportal endoscopic L5-S1 fusion with facet sacrificing approach from 2021 to the present (19 patients). Both groups were evaluated using VAS Back, VAS Leg, ODI, and Mc Nab criteria before and after surgery, and post-surgical complications were recorded. VAS back , VAS leg and ODI score are compared using with student T test. McNab criteria was compared with the Man Whitney U statistical test.

**Results:** Foraminotomy group: The average age was 69±11.6 years, and the mean follow-up period was 46±11 months. Pre-surgery VAS Back improved from 2.9±2.6 to 0.5±0.9 post-surgery, VAS Leg improved from 6.7±1.8 to 5.3±3.1 post-surgery, and ODI decreased from 33.2±8,2 to 20±10.4. Mc Nab criteria showed excellent results in 2 cases, good in 7, fair in 5, and poor in 5.

**Fusion Group:** The average age was 65.2±11.4 years, and the mean follow-up period was 14.3±9.3 months. Pre-surgery VAS Back improved from 4.2±3.0 to 2.3±2.6 post-surgery, VAS Leg improved from 6.8±2.9 to 1.8±1.4 post-surgery, and ODI decreased from 30.9± 6.9 to 16.9±13.1. Mc Nab criteria showed excellent results in 9 cases, good in 6, fair in 2, and poor in 1. The most common complication in the foraminotomy group was symptom recurrence, while the fusion group experienced complications related to multi-segmental fusion, including junctional problems.

**Conclusions:** The clinical improvement in the foraminotomy group was inferior to that in the fusion group.

**Keywords:** Biportal, Endoscopy, Foraminotomy, Fusion, L5-S1

## Outcome of Endoscopic Approach in Management of Spondylodiscitis

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**Purpose:** 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 24 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:** Results- 24 patients were included in study- 14 were males and 10 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 87.5% patients (21 out of 24). 66.6% 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.

**Conclusions:** 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.

**Keywords:** Spondylodoscitis, Endoscopy, Discitis, Biopsy, Spinal tuberculosis

# Free Paper: MIS (2)

## Percutaneous Full Endoscopic Lumbar Discectomy via Interlaminar versus Transforaminal Approach in L4-5 Disc Herniation by using 6.3 mm Foraminoscope: Clinical and Surgical Result Report

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**Purpose:** To evaluate the clinical and surgical outcomes of patients who were diagnosed L4-5 Disc Herniation with PELD via transforaminal vs interlaminar approach treatment in two years.

**Materials and Methods:** We retrospectively analyzed 115 consecutive patients who were diagnosed L4-5 disc herniation treated with PELD in Thabo Crown Prince Hospital from January 2019 to November 2020. Patients were divided into PTLD group (n=58) and PILD group (n=57) according to the surgical methods. The demographic characteristics and surgical results of the two groups were compared. The clinical outcomes were evaluated by the visual analog scale (VAS) for leg pain and back pain, Oswestry disability index (ODI) scores and the modified Macnab criteria at 1 day, 6 months, 1 year and 2 years postoperative.

**Results:** 115 patients were enrolled. No significant differences in mean ages and genders were found between both groups ($p>0.05$) while mean operative time, intraoperative blood loss and length of hospital stay were significantly lower in PTLD group compared with PILD group ($p<0.001$). For VAS of leg pain, no significant differences between both groups in 1 day, 6 months and 1 year postoperative care ($p=0.187$, $p=0.108$, $p=0.08$, respectively) but in 2 years, VAS of leg pain in PTLD group was significantly higher than PILD group ($p=0.004$). For VAS of back pain, in PTLD group was significantly lower than PILD group in 1 day and 2 years postoperative care ($p=0.002$, $p=0.044$) but no significant differences between both groups in 6 months and 1 year postoperative care ($p=0.420$, $p=0.360$). The ODI scores, in PTLD group was significantly lower than PILD group in 6-month, 1 year and 2 years postoperative care ($p<0.001$). According to the Macnab criteria, the satisfaction rate of PTLD group was 98.28%, whereas in PILD group was 96.39%. There were no significant differences between groups ($p>0.05$)

**Conclusions:** PTLD had achieved good clinical efficacy as PILD for L4-5 Disc Herniation treated. Compared with PILD, PTLD had the advantages of shorter operative time, lower blood loss and shorter length of hospital stay. Moreover, PTLD provided a better clinical outcome. Nevertheless, case selection for each surgical technique will be an important key success factor for good results.

**Keywords:** Percutaneous endoscopic lumbar discectomy, Endoscopic discectomy, Percutaneous Full Endoscopic Lumbar Discectomy, Transforaminal approach, Interlaminar approach

## Clinical Outcomes and Complications of Biportal Endoscopic Spinal Surgery in Lumbar Decompression for Unexperienced Surgeon

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**Purpose:** To report clinical outcomes and surgery-related complications of Biportal Endoscopic Spinal Surgery (BESS) in lumbar decompression for naïve to spine surgery and also without spine fellowship training.

**Materials and Methods:** A retrospective study of 40 consecutive patients who underwent BESS for degenerative lumbar disease by a single surgeon from June 2022 to September 2023 was performed. 34 patients underwent a single-level procedure, and 6 underwent surgery at two levels. The mean follow-up period was 8 months (range, 3-15). Total operative time 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

**Results:** The 40 cases included 7 for lumbar disc herniation, 26 for lumbar spinal stenosis, 5 for Adjacent segment disease, 1 for spinal epidural abscess and 1 for hemorrhagic facet cyst. Mean operative time was 129.7 minutes (range, 60-222). Operative time decreased as the number of cases increased. A stable point was noticed on the 34th case after the first BESS was performed. Surgery-related complications were found in 10 cases (6 Dural tear, 2 Symptomatic hematoma, 2 temporary motor weakness, 1 root injury). 38 cases showed improved ODI and VAS scores at the final follow-up. Modified Macnab criteria were 20 Excellent, 13 Good, 5 Fair and 2 Poor.

**Conclusions:** BESS is an effective minimally invasive technique for lumbar degenerative disease and shows satisfying short-term outcomes. However, during the learning curve period, novice surgeon without experience with open procedures have a higher complication rate than surgeon experienced with open procedures. Therefore, it is recommended that you begin BESS after sufficient experience with open procedures or training in a spine fellowship.

**Keywords:** Spinal stenosis, Intervertebral disc, Laminectomy, Diskectomy, Endoscopy

## Biportal Endoscopic Decompression of Multilevel Lumbar Spinal Stenosis

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**Purpose:** Lumbar stenosis can be effectively treated using biportal endoscopic decompression (unilateral laminotomy for bilateral decompression (ULBD) and/or foraminotomy (FT)). We report a retrospective analysis of multilevel lumbar stenosis that were operated for posterior decompression and underwent biportal endoscophic technique to preserve posterior ligament complex integrity for outcome of decompression.

**Materials and Methods:** We collected data on 207 patients, with multilevel lumbar stenosis, operated at our hospital between 2020 and 2022 by the biportal endoscopic technique. We assessed surgical time (ST), estimated blood loss (EBL), complications, and revision surgeries. Furthermore, we provide a stepwise instruction for performing the biportal endoscopid technique in a safe and efficient manner.

**Results:** 207 patients of degenerative lumbar stenosis, with a mean age 71 years (63-89 years), underwent biportal endoscopic multilevel decompression procedure. All patients were followed up from 1 to 3 years. The mean age of the patients was 71 years. The ST per level was 30 minutes with an EBL per level of 50 mL. We had perioperative complications including extradural hematoma (7), surgical site infection (1), and spinal fluid leakage (3), and none of our patients required a revision surgery during a mean follow-up of 12 months.

**Conclusions:** We have shown that this technique is feasible and can be performed safely for multi-segmental lumbar spinal stenosis with minimal tissue trauma and low EBL. Decompression of multi-level lumbar spine stenosis using biportal endoscopic technique is a safe approach for multi-level stenosis, with good outcome.

**Keywords:** Biportal endoscopic spine surgery, Lumbar spinal stenosis, Decompression, Multilevel

## Clinical Outcomes of Unilateral Biportal Endoscopy Decompression for Degenerative Lumbar Canal Stenosis in the Elderly Population - A Single-Center Retrospective Study

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**Purpose:** Unilateral biportal endoscopic (UBE) decompression is a minimally invasive technique for treating degenerative lumbar canal stenosis (DLCS) in elderly patients allowing decompression with minimal spinal trauma and preserving motion. Elderly population is frail and standard open surgeries have increased risk of peri and post-operative complications/morbidities. The current study aims to find clinical outcomes of UBE decompression for DLCS amongst the elderly frail population.

**Materials and Methods:** After obtaining Institutional Review Board (IRB) approval, we performed a single-center retrospective study and included patients who underwent UBE for DLCS from Jan 2022 to Oct 2023 with a minimum of six months of follow-up. Patient demographics, peri-operative data, frailty status using modified Frailty index (mFI), and length of hospital stay (LOS) were reviewed. Clinical outcomes were assessed using VAS scores for back and leg pain, ODI for back pre-operatively and at 1 and 6 months, and the modified Macnab criteria at the final follow-up. A repeated ANOVA test was performed to measure the difference between VAS and ODI scores.

**Results:** 20 patients (M: 8, F: 12) with a mean age of 81.4±3.2 were included. The mean follow-up period was 12.4±3.8 months. The mean mFI score was 0.27. The average surgical time was 69.6±16.8 mins. The average LOS was 1.6±0.5 days. At the final follow-up, the mean VAS for leg pain improved from 7.3±0.7 to 0.8±0.6 (89% improvement) and the mean VAS for back pain improved from 3.7±0.5 to 2.3±0.5 (39% improvement).ODI score improved from 22.9±2.5 to 6.7±0.3 at the final follow-up (71% improvement). The modified Macnab criteria reported 80% excellent and 20% good outcomes. There were 2 dural tears which were repaired primarily with no return to theatre.

**Conclusions:** The current study concludes that UBE is a safe and effective surgical treatment amongst the elderly frail population for DLCS with excellent clinical outcomes.

**Keywords:** Lumbar canal stenosis, Ube, Miss, Degenerative spine

## Management and Prevention of Incidental Dura Tear During Biportal Endoscopic Spine Surgery

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**Purpose:** Overall mean incidence of complications in biportal endoscopic spine surgery was reported to be 6.7%, and most common complication was dura tear. Incidental dura tear occur during the learning curve period, and without proper management can cause fatal result requiring revision surgery. In this study, we aim to assess various risk factors of incidental dura tear and technical point of how to prevent it in biportal endoscopic spine surgery.

**Materials and Methods:** We evaluated 180 patients who underwent biportal endoscopic spine surgery from March 2021 to December 2023 in single institute. Ten cases of incidental dura tear was occured and treated through endoscopic surgery without converting to open surgery. Dura tear site was sealed by sealant patch material and postoperative absolute bed rest was maintained for three to five days. Postoperative neurogenic symptom and MRI was evaluated for CSF leakage and risk factors were evaluated.

**Results:** Among ten patients, three case was revision surgery and others were old age patients with severe stenosis cases. Follow up MRI was checked two days after operation, and showed no sign of CSF leakage. Neurogenic symptoms such as headache or nausea was found in two patients but recovered in few days. Old age patients with anticoagulant medication history showed more thinned dura increasing risk of dura tear. For anatomical factors, multiple epidural ligament around thecal sac is also risk factor of dura tear during flavectomy procedure. Acquiring clear surgical view during operation and cautious use of surgical equipment such high-speed burr and kerrison punch is important to prevent incidental dura tear.

**Conclusions:** By understanding anatomical and technical

risk factors of incidental dura tear is important to prevent such complications during learning curve period. Sealing the dura tear site using sealant patch considered to be safe and effective method. However, if the tear site cannot be sealed quickly, it would be better to convert to open microscopic dura repair.

**Keywords:** Dura tear, Endoscopy, Biportal, Complication

# Free Paper: MIS (3)

## Outcomes Analysis of MIS -TLIF "Minimum Invasion Maximum Relief"

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**Purpose:** Degenerative spinal disease is one of the commonest problems in elderly population leading to back pain, radiculopathy, spinal instability and neurologic deficit. Surgical management is considered if there is further deterioration of neurologic symptoms and failed conservative management. With regards to surgery, with the emerging trends in technology MIS-TLIF has become popular in recent years. This technique helps to minimize iatrogenic soft tissue damage and decreases the risk of atrophy of the multifidus and/or longissimus muscle. This study aims to determine the pre-operative, intra-operative and post-operative findings in patients underwent with MIS-TLIF.

**Materials and Methods:** Retrospective evaluation of 43 patients was done from January 2014 to December 2018 at Spine department of tertiary level hospital. Every patients' demographic data, preoperative and post-operative symptomatology data, clinical findings data on examinations were evaluated. Oswestry disability Index (ODI), Visual Analogue scale (VAS) were used to assess the pain, disability, and health status before surgery and postoperatively for the clinical outcomes. In addition, the operating time, estimated blood loss, and hospital stay were also recorded. The patients with chronic back pain (more than 6 months of disability and refractory to conservative management) with or without leg pain, neurological deficit due to degenerative spondylolisthesis, degenerative disc disease and recurrent lumber disc herniation treated with Transforaminal Lumber Interbody Fusion (TLIF) were included.

**Results:** The male and female numbers were nearly similar and mean age group was 51.4.VAS and ODI scoring were decreased compared to preoperative evaluation. MIS-TLIF has better outcomes in terms of lesser blood loss, dural tear, infection, quicker improvement of back pain, and shorter hospital stay, instrument failure e.g. screw or cage and also lower incidence of Adjacent Segment Disease (ASD) as compared to previously described data on TLIF in literature.

**Conclusions:** A multicentric study with a larger sample size and an RCT comparing outcomes of MIS TLIF with conventional open TLIF will further validate our findings.

**Keywords:** Degenerative spine disease, MIS-TLIF, ODI, VAS

## Outcomes of Percutaneous Endoscopic Lumbar Discectomy via Transforaminal Approach in Stable Low-Grade Single Level Lumbar Spondylolisthesis – A Retrospective Study

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**Purpose:** Lumbar spondylolisthesis (LS) is a common spinal disorder. Fusion procedures have been performed as a gold standard. Now, percutaneous endoscopic lumbar discectomy (PELD) has less traumatization, lower blood loss, shorter hospital stays. Outcomes following PELD for LS patients in many studies provide good results. At the present, there are very few studies of PELD via transforaminal approach evaluated both clinical and radiographic outcomes in the same study. Moreover, there is no study evaluated IPD cost between PELD via transforaminal approach and fusion surgery (TLIF). The purpose of this study was to evaluate the clinical, radiographic outcome of patients with stable low-grade single level lumbar spondylolisthesis who underwent PELD via transforaminal approach in 1 year and IPD cost comparing with TLIF.

**Materials and Methods:** 24 patients who underwent PELD

via transforaminal approach out of the patients who were diagnosed low-grade single level spondylolisthesis were collected since December 2021 to November 2022. The clinical outcomes were evaluated by VAS for back and leg pain, ODI scores, modified MacNab criteria, walking distance improvement and patients' satisfaction at final follow-up. The radiological outcome was evaluated by a percent slippage of spondylolisthesis before treatment and final follow-up. IPD cost between PELD and TLIF were evaluated.

**Results:** 24 patients were enrolled, the majority of male. The mean age was 52 years. The most common level was L4-5. Type of LDH, 50% were extrusion and 50% were sequestration. The most common compression type was paracentral. All cases was Grade 1. The majority of anesthesia and transforaminal technique was GA and Inside – out. The mean operation time was 53.17±26.14 mins, blood loss was 8.29±10.45 mL, length of hospital stays was 2.96±1.16 days and follow up was 6.7 months. All patients significantly relieved back, leg pain and ODI at 1,3 months postoperative and at the final follow-up examination was significantly improved ($p<0.001$). The modified MacNab criteria were rated as excellent (75%) and good (20.8%). The patient's walking distance was improved (87.5%). 93.8% of patients were satisfied. The mean percent slippage was 10.1± 3.25 % and 9.56±3.35 % at preoperative and final follow-up, respectively which was not significantly different ($p=0.458$) and the mean PELD IPD cost was 64,785.95 THB (1,754.69 EUR). The mean TLIF IPD cost was 98,392.36 THB (2,664.90 EUR) which was higher than PELD IPD cost.

**Conclusions:** PELD via transforaminal approach is an effective and safe procedure with favorable results in short term for patients with stable low-grade single level lumbar spondylolisthesis. Almost patients were satisfied. No significant difference in radiographic measurement. IPD cost of PELD via transforaminal approach is less than TLIF significantly. Nevertheless, the efficacy and overall cost effectiveness of this technique require to be further evaluated by a long-term follow-up study and larger number of cases.

**Keywords:** Spondylolisthesis, Percutaneous endoscopic lumbar discectomy, Endoscopic discectomy, Transforaminal full endoscopic discectomy

## Management of Severe Adult Spinal Deformity with Hybrid MIS Correction Strategies without Posterior Column Osteotomies: A 5-Year Result

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**Purpose:** To evaluate the mid-term clinical outcomes of hybrid MIS correction strategies (oblique lumbar interbody fusion (OLIF) and posterior open instrumentation) without posterior column osteotomies for severe adult spine deformity (ASD) correction.

**Materials and Methods:** This retrospective study included all patients with a minimum of 2-year follow-up undergoing hybrid MIS correction of ASD from January 2018 to Feb 2021. All included patients had fusion of 3 or more interbody levels. Patients with severe deformity, Coronal Cobb >30° or at least one SRS-Schwab+sagittal modifier (SVA >40 mm, or PI-LL >10, or PT >20) were included. Radiographic results, patient-reported outcomes including EQ-5D, pain visual analogue scale (VAS) and Oswestry disability index (ODI), and all complications were reviewed.

**Results:** 36 patients met inclusion criteria; mean age of patients was 65.1±7.2 years. The mean follow-up was 36.9±12.9 months. The mean number of levels fused was 5.3±2.0. The major complication rate was 26%, including one proximal junctional failure, two proximal junctional kyphosis, one vascular injury, one postoperative hematoma requiring hematoma retrieval and two residual stenosis. The minor complication rate was 35%. All patients experienced improvements in patient-perceived outcomes (EQ-5D, VAS, ODI) and radiographic parameters at last follow-up when compared to pre-op ($p<0.05$).

**Conclusions:** Without posterior column osteotomies, hybrid MIS correction strategies is an alternative treatment method in treating severe ASD with significant improvements in clinical and functional outcomes, low rates of pseudarthrosis and proximal junctional kyphosis. Rates of major complications are lower than published rates of complications seen with open ASD correction. In the appropriately selected patient, hybrid MIS correction technique may be an excellent alternative approach to treat severe ASD.

**Keywords:** Adult spinal deformity, Minimally invasive spine

surgery, Oblique lumbar interbody fusion

## Cement Leakage in Cement-Augmented Pedicle Screw with Minimally Invasive Screw Cement Augmentation in Pedicle Techniques (MIS CAPT)

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**Purpose:** Cement leakage, a common complication in cement-augmented spinal surgery, can lead to critical complications in patients. The use of cement-augmented pedicle screws for spinal fixation can enhance fixation strength, but it can also cause intraspinal leakage, neurological impairments, and pulmonary cement embolism (PCE). This study aims to clarify the surgical methodology and associated complications of Minimally Invasive Screw Cement Augmentation in Pedicle Techniques (MIS CAPT).

**Materials and Methods:** The study involved 60 patients aged 52–92 who underwent MIS CAPT at Bangkok Hospital. A total of 478 augmented screws were surgically inserted, with each patient receiving a minimum of 4 and a maximum of 20 screws. The patients were categorized into three groups based on their respective diseases. The study documented clinical data, intraoperative CT scans, and radiological reports. Surgical techniques involved percutaneously cannulated pedicle screws and polymethylmethacrylate cement injection. The technique was carried out by four experienced spine surgeons.

**Results:** The study evaluated patients using MIS CAPT, with a mean BMD of -2.6 and the lumbar spine and thoracolumbar junction having the highest frequency of levels. Patients with osteoporotic fractures exhibited reduced mean blood loss and operative time in comparison to those with pathologic and degenerative instability. The average lengths of hospitalization and follow-up were 9.19 days and 455 days, respectively. Cement leakage (CL) occurred in 65/478 (13.6%) screws and 26/60 (43.3%) patients. All of them are minor leakages. No clinical complications due to uncontrolled CL in the spinal canal or PCE were observed.

**Conclusions:** When compared with other studies, MIS CAPT has a minor cement leakage rate and minimal complications. This modified cementation technique for augmenting percutaneously canulated pedicle screws is suitable for elderly patients, particularly those with osteoporosis or fragile bones.

**Keywords:** Pedicle screw, Cement augmentation, Cement leakage, MIS CAPT

## Risk Factors of Cage Subsidence Progression and Its Prognosis after Olique Lumbar Interbody Fusion

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**Purpose:** To report risk factors and prognosis of cage subsidence progression after oblique lumbar interbody fusion (OLIF)

**Materials and Methods:** We retrospectively reviewed records of 171 patients who underwent OLIF for degenerative lumbar spinal disease and were followed up more than twelve months postoperatively between September 2019 and June 2023. We inspected each lumbar vertebral segments of patients. Total 257 segments were enrolled. We investigated cage subsidence and subsidence progression of them through lateral spine radiograph. We measured disc height of segments on lateral spine radiograph calibrating with computed tomography (CT). Data were collected serially until 24 months postoperatively. Demographic factors and radiographic parameters were analyzed using logistic regression analysis.

**Results:** Total 257 segments were investigated. Incidence of cage subsidence was 29% (75 segments). And incidence of progression among subsidence was 65% (49 segments). The correlation between cage subsidence progression with intraoperative endplate violation was statistically significant ($p<0.05$). Subsidence progressions were all stopped within 6 months postoperatively.

**Conclusions:** Cage subsidence progression is significantly related with intraoperative endplate violation. And it was

advanced until only six months postoperatively. Our study present surgeons to predict cage subsidence progression and optimal periods following up the progression.

**Keywords:** Oblique lateral interbody fusion, Cage subsidence, Subsidence progression

# Invited Lecture VI

### Growing Spine: What is the Strategy?

Gabriel Liu

*Singapore Spine Society*

# Symposium IV. MIS (Which Better) Endoscopic Lumbar Decompression

### Full Endoscopic Surgery Is Better than Biportal Endoscopic Surgery for Posterior Lumbar Decompression (IE-LRD, LE-ULBD)

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### Biportal Endoscopic Surgery

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**Backgrounds and 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 0.5~1 cm 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.

**Conclusions:** 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.

**Keywords:** Spinal stenosis, Biportal endoscopy

# MIS: Which Better Lumbar Foraminal Stenosis

## Microscopic Decompression and Biportal Endoscopic Decompression

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**Backgrounds and Introduction:** Lumbar foraminal stenosis is a common pathology that causes lumbar nerve root entrapment, and 8~11% of cases are reported in lumbar degenerative disease. Previously, there were two surgical options: direct decompression with microscopic foraminal decompression and direct or indirect decompression with lumbar interbody fusion. Foraminal decompression using biportal endoscopic technique has been introduced, and it is widely performed as a treatment for lumbar foraminal stenosis in addition to microscopic decompression at present.

**Main Body:** The purpose of this study is to discuss the clinical outcomes and poor prognostic factors for microscopic decompression and biportal endoscopic decompression in previous studies. Eight research related to foraminal decompression were reviewed. Three were related to microscopic foraminal decompression and five were related to biportal endoscopic foraminal decompression. Neither group was followed up to a long term for more than two years. 8All eight studies showed better clinical outcomes after surgery than before. The prognosis was poor for coronal cobb angles greater than 3 degrees between standing and supine, 10 degrees or more at preoperative cobb angles, lower lumbar levels, wide segmental lordosis, and narrow coronal root angles such as L5-S1.

**Conclusions:** Both microscopic and biportal endoscopic foraminal decompression showed better clinical outcomes of more than 70%, but caution should be taken in cases with large coronal cobb angles or lower lumbar levels such as L5-S1.

**Keywords:** Foraminal decompression, Poor prognosis, Microscopic decompression, Biportal endoscopic decompression

## Fusion is Better

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**Backgrounds and Introduction:** The approach to foraminal stenosis is more complex than the more common posterolateral or central stenosis due to an increased risk of postoperative instability from extensive facetectomy, inadequate decompression, or nerve root injury. The efficacy of decompression for the relief of painful foraminal stenosis has been well documented in many literatures. But, the challenge is achieving an adequate decompression while at the same time avoiding unnecessary bone and soft tissue trauma.

**Main Body:** The development of a paraspinal muscle splitting approach has allowed facet sparing access to the far lateral compartment through the inter-transverse extraforaminal corridor. This approach allows visualization of the foraminal and extraforaminal spaces without disruption of the facet joint or pars. But, the decompression alone techniques in the foraminal stenosis combined instability or deformity(spondylolisthesis or scoliosis) is not adequate. Lumbar fusion technique frequently is needed.There are many techniques currently in use for lumbar fusion for treatment of lumbar foraminal stenosis with instability or deformity. A comparison of the techniques, including minimally invasive surgery will be included. Currently this procedure is performed using anterior, lateral, transforaminal and posterior approaches. Minimally invasive techniques have been increasing in popularity in recent years. A posterior approach is frequently used and has good fusion rates and low complication rates but is limited by the thecal

and nerve root retraction. The transforaminal interbody fusion avoids some of these complications and is therefore preferable in some situations, especiall revision surgery. An anterior approach avoids the spinal cord and cauda equina all together, but has issues with visceral exposure complications. Lateral lumbar interbody fusion has a risk of lumbar plexus injury with dissection through the psoas muscle. Studies show less intraoperative blood loss for minimally invasive techniques, but there is no long-term data. More high-level studies are needed to make generalisations regarding the outcomes of one technique compared with another.

**Conclusions:** Each option has its ownadvantages and disadvantages, and the approach taken ideally depends on the pathology present and the anatomy of the individualpatient. There is an increasing trend toward MIS fusion techniques due to less intraoperative blood loss, however long-term data is lacking. There isno evidence that one surgical approach is clinically superior toanother. Additional retrospective, prospective and randomised controltrials are needed.

**Keywords:** Foraminal stenosis, Transforaminal interbody fusion, Lateral lumbar interbody fusion

# MIS: Which Better Multi-level Lateral Lumbar Interbody Fusion

## Which Do You Prefer, LLIF of More than Three Segments for Spinal Canal Stenosis, Staged Operation or Not?

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**Backgrounds and Introduction:** Lateral lumbar interbody fusion (LLIF) is a minimally invasive procedure used to treat degenerative spinal diseases. It includes extreme lateral interbody fusion (XLIF), direct lateral interbody fusion (DLIF), and oblique lumbar interbody fusion (OLIF). LLIF corrects coronal and sagittal deformities via ligamentotaxis and indirectly decompresses the neural canal by restoring disc height, unbuckling ligamentum flavum, stabilizing segmental instability, and remodeling the spinal canal. Indirect decompression affords various advantages compared to direct decompression, including lower risks of neural injury, incidental durotomy, and postoperative perineural fibrosis. The LLIF procedure avoids aggressive muscle dissection and preserves the posterior spinal ligament and musculature, an essential structure for maintaining lumbar stability. This procedure is advantageous to treat, especially in multilevel spinal canal stenosis cases, because of this minimal invasiveness with an indirect decompression strategy. However, the indirect decompression effect cannot relieve neural elements in specific circumstances. For example, pathological structures in the posterior column, including hypertrophied ligamentum flavum or facet spurs, cannot be removed via indirect decompression. A systematic review by Kirnaz et al. estimated the pooled incidence of indirect decompression failure following LLIF as 9%, and the failed cases often need additional revision surgery, including direct decompression to relieve nerve tissue.

**Main Body:** To minimize this failure of indirect decompression, some surgeons choose a staged operation strategy; they allow patients to walk after multilevel OLIF procedures as a first operation, and they decide whether to do additional direct decompression or not when they do the percutaneous pedicle screw fixation in a second operation. However, this strategy can have some drawbacks. First, it can not avoid anesthesia-related mortality and complications due to the second operation, which could be more critical to old-aged patients. Second, it could enhance the possibility of subsidence during walking without a posterior fixation procedure. In addition, they have a high possibility of poor bone quality due to old age. We can avoid doubled operations based on the staged strategy if we realize the risk factors or related objective lesions failing indirect decompression and treat them simultaneously with the LLIF procedure. Nakashima et al. reported that a severe, preoperative central canal stenosis or the ossification of the posterior longitudinal ligament (OPLL) is a contraindication for LLIF. Bony lateral recess or facet cyst lesions are significantly static lesions that can decrease the indirect decompression effect from the ligamentotaxis mechanism and have been proven to contribute to the failure of indirect decompression alone. Persistent pain despite resting in a supine position suggests the presence of severe

spinal canal stenosis with significant static nerve compression that would only be sufficiently relieved with a direct decompression. A low postoperative disc height, significantly less than 10 mm, was found to be associated with failure and needed direct decompression following LLIF.

**Conclusions:** We can avoid staged operations if we realize the risk factors or related objective lesions failing indirect decompression and treat them simultaneously with the LLIF procedure.

**Keywords:** Lateral lumbar interbody fusion, Spinal canal stenosis, Staged operation, Risk factor

### Staged Surgery: Anterior First, Posterior Later

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**Backgrounds and Introduction:** Two-staged lateral lumbar interbody fusion (LLIF) has emerged as a promising surgical approach for the treatment of various lumbar spinal pathologies, including degenerative disc disease, spondylolisthesis, and foraminal stenosis.

**Main Body:** The first stage of the procedure involves lateral access to the lumbar spine, where interbody cages are inserted into the disc space to restore disc height, decompress neural structures, and promote fusion. This approach offers several advantages, including reduced disruption of posterior structures, decreased risk of injury to neural elements, and improved biomechanical stability. Additionally, the use of intraoperative neuromonitoring and advanced imaging techniques enhances surgical precision and safety. Numerous studies have reported favorable clinical outcomes following two-staged LLIF, including improvements in pain relief, functional outcomes, and quality of life measures. Moreover, this technique has demonstrated high fusion rates and low rates of complications, such as infection, neurological injury, and hardware failure. Comparative studies have shown similar or superior outcomes compared to traditional posterior approaches, with potentially shorter hospital stays and quicker return to activities. However, challenges and limitations exist with two-staged LLIF, including patient selection, technical expertise, and the potential for vascular and neural complications during lateral access. Additionally, further research is needed to elucidate the optimal patient selection criteria, surgical techniques, and long-term outcomes of this approach.

**Conclusions:** In conclusion, two-staged lateral lumbar interbody fusion represents a valuable addition to the surgical armamentarium for the treatment of lumbar spinal disorders. With careful patient selection, meticulous surgical technique, and ongoing advancements in technology, this approach offers promising outcomes and potential benefits for patients with complex lumbar pathology.

**Key words:** LLIF, Stage, Multi-level

## Miscellaneous

### The Effect of Romosozumab and Teriparatide on Fracture Healing of Thoracolumbar Compression Fracture

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**Purpose:** Recently, teriparatide has been reported to be effective for fracture healing and pain control in thoracolumbar compression fractures. Conservative treatments, including anabolic agents, have been increasingly applied for compression fractures as initial treatment. To the best of our knowledge, the efficacy of romosozumab on fracture healing has not been reported. This study aimed to compare the effect of romosozumab and teriparatide on healing of thoracolumbar compression fractures.

**Materials and Methods:** Patients conservatively treated for thoracolumbar fracture were retrospectively reviewed. A total of 62 patients undergoing at least six months of injection were included in this study. Thirty-four patients underwent romosozumab injection, while 28 patients were treated with teriparatide injection. Radiologic parameters included Cobb's angle, vertebral kyphosis, and vertebral height of

the fractured body at initial, one month, three months, six months, and one year. Moreover, fracture union at each time and occurrence of intravertebral cleft (IVC) were assessed. Clinical outcomes included a numeric rating scale (NRS) for back and leg pain, Oswestry disability index (ODI) at initial treatment, and 1-year follow-up.

**Results:** Patient demographics and initial radiologic parameters, including Cobb's angle, vertebral kyphosis, and vertebral height of the fractured body, were not significantly different between the romosozumab and teriparatide groups. Radiologic parameters were also similar at one month, three months, six months, and one year. However, vertebral body kyphosis at one year was significantly lower in the romosozumab group (14.60±8.03 vs. 19.13±6.57, p-value=0.038). In addition, the fracture union at the early phase within three months was common in the romosozumab group (70.6% vs. 46.4%, p-value=0.132). The occurrence of IVC was similar in both groups. Regarding the clinical outcomes, initial NRS for back pain, leg pain, and ODI were similar. However, the improvement of ODI at 1-year follow-up was significantly greater in the teriparatide group. Other parameters were similar after the treatment.

**Conclusions:** This study demonstrated that romosozumab had similar efficacy to teriparatide for thoracolumbar compression fracture. Fracture union could be enhanced with the use of the romosozumab. However, further trials with clinical outcomes were needed to validate this study.

**Keywords:** Osteoporotic compression fracture, Romosozumab, Teriparatide, Fracture healing

## Prediction of Symptomatic Intravertebral Vacuum Cleft with Machine Learning Methods - Known Risk Factors and Muscle Variables Strategy

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**Purpose:** The primary purpose of this study is to determine the best machine learning (ML) model which can predict symptomatic intravertebral vacuum cleft (SIVC) at the thoracolumbar junction using different ML approaches. The secondary purpose is to determine whether spinal paravertebral muscle-related variables contribute to SIVC prediction.

**Materials and Methods:** Consecutive patients diagnosed with vertebral compression fracture (VCF) by thoracolumbar plain radiographs (PR), magnetic resonance imaging (MRI) and symptom (pain) in medical records at our institution from March 2013 to February 2023 were included in this study. Demographic (age, sex, adrenal insufficiency, hyper- and hypothyroidism, long-term use of steroid, diabetes, hypertension), variables obtained by PR (initial compression ratio [CR], initial angulation of fracture vertebral body [CA]) and variables obtained by MRI (fat infiltration ratio of MF [MF-FI] and ES [ES-FI], relative ratio of MF or ES cross-sectional area (CSA) divided by fractured vertebral upper endplate CSA, [rMF and rES]) were significantly different in the train and test sets ($p<0.05$) between the non-SIVC and SIVC group. The input variables were then divided into 2 different methods (setting 1: Demographics+PR, setting 2: Demographics+PR+MRI). Each dataset was divided into training (485, 70%) and test (209, 30%). Extreme gradient boost (XGB), logistic regression (LR), multi-layer perceptron (MLP), and random forest (RF) were selected as ML algorithms for predicting SIVC, and hyperparameter optimization of the model was cross-validated. The prediction results were then compared by model in each setting.

**Results:** A total of 734 patients were included in the study. Of these, 40 were diagnosed with SIVC. Age, sex, adrenal insufficiency, hyper- and hypothyroidism, long-term use of steroid, diabetes, hypertension, endplate CSA, MF-FI and ES-FI, rMF and rES, CR, CA were significantly different in the training and test sets ($p<0.05$) between the non-SIVC and SIVC group. ML models performed the better in the setting 2 than setting 1. In the setting 2, the AUROCs for LR, RF, XGBoost, and MLP were 0.947, 0.956, 0.950, and 0.904, and the accuracy was 0.951, 0.966, 0.962, and 0.961, respectively.

**Conclusions:** In all ML model results, the setting 2 performed better than the setting 1. Variables in setting 2 and adopting an RF model have shown to be the most effective in predicting SIVC in the VCFs.

**Keywords:** Machine learning, Vertebral compression fracture, Thoracolumbar junction, Symptomatic intravertebral vacuum

cleft, Paravertebral muscle

## Surgical Treatment of Thoracic Myelopathy Due to Ossification of Yellow Ligament: Retrospective Review of Clinical Results and Surgical Approaches

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**Purpose:** Thoracic myelopathy due to ossification of yellow ligament (OYL) requires surgical decompression to prevent further neurological deterioration, while surgery in thoracic spine with presence of OYL is challenging and carries high risk of complications including dural tear (22%), CSF leak (10.6%) and early neurological deficit (5.7%). Purpose of this study was to analyse surgical approaches and tools in relation to clinical and operative parameters.

**Materials and Methods:** 24 patients with OYL presented with thoracic myelopathy and received posterior decompression surgeries from 2003 to 2023 in AHNH and NDH were retrospectively reviewed with mean follow up of 8.6years. Surgical approaches including posterior decompression with or without instrumentation and surgical tools including burr, rongeur, ultrasonic aspirators were evaluated. Clinical and operative parameters were compared.

**Results:** 12 cases had adopted instrumentation and used ultrasonic aspirators for decompression. 12 cases used traditional tools (instrumented=2; non-instrumented=10). Hirabayashi recovery rate, improvement in Frankel score and mJOA were satisfactory but statistically insignificant when comparing the groups. Blood loss (p=0.077) and Post-op length of stay (p=0.185) are statistically insignificant. Dura tear rate was the same in both groups (25%). There was no immediate catastrophic neurological deterioration. No recurrence or progression of symptom was observed even in the instrumented group.

**Conclusions:** Posterior decompression was able to give satisfactory outcome in symptomatic thoracic OYL. High incidence of dura tear, similar to literature, with or without using ultrasonic aspirator, was seen in our study population. Meticulous surgical techniques are more important than special instruments in achieving good result.

**Keywords:** Thoracic myelopathy, Ossification of yellow ligament

## Effectiveness of Denosumab on Discordance Between Spine and Hip BMD of Osteoporosis Patients

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**Purpose:** Denosumab is one of the most potent treatment strategies for osteoporosis patients. It is well known to effectively improve the porosity of the cortical bone as well as the trabecular bone and accordingly enhance bone mineral density of spine and hip. However, there is still a lack of comparative analysis for treatment outcomes on discordance between spine and hip BMD. This study aims to analyze the effectiveness of denosumab on discordance between spine and hip BMD of osteoporosis patients

**Materials and Methods:** A retrospective analysis was conducted on 258 patients who underwent denosumab treatment for osteoporosis from January 2019 to December 2022. Patients were categorized into three groups with lower BMD in spine, comparable BMD levels, and higher BMD in the spine compared to hip BMD. During the study period, a subcutaneous injection of 60mg of denosumab was administered every 6 months. In the overall group and each subgroup, discordances were compared by the difference between the T-score of BMD in spine and hip before and after denosumab treatment.

**Results:** The group with lower BMD in spine had 133 and the group with lower BMD in hip had 114 patients with a mean age of 73.6. Mean follow-up period was 18.9 months. The results show significant increase in BMD T-scores of both spine and hip after denosumab treatment. In the discordance comparison, the results showed statistically significant increase in discordance after denosumab treatment in overall group. In subgroup analysis, the group with lower spine BMD compared to hip BMD showed significant increase in discordance, but other group did not show statistically significant differences.

**Conclusions:** Denosumab improved the BMD of each lumbar spine and hip and showed significant difference in the discordance between spine and hip BMD in the overall group and subgroup with lower spine BMD compared to hip BMD.

**Keywords:** Osteoporosis, Denosumab, Discordance

### Impact of COVID-19 on the Development of Depression and Anxiety in Patients with Back Pain - A Retrospective Study Using the Korean National Health Insurance Service

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**Purpose:** This study aimed to investigate the impact of COVID-19 on the development of depression and anxiety in patients with back pain.

**Materials and Methods:** A random sample was taken from the Korean National Health Insurance Research Database. In total, 28,655 Covid-19 patients (total 118,438 Covid-19 patients) who were followed up between January 2019 and December 2020 were included in the analysis. Patients with depression and anxiety-related ICD-10 codes from 2010 to 2018, other neurological disease, trauma, infection, or cancer were excluded. Among COVID-19 patients, the group with back pain was used as the back pain group, and a no back pain group was set in threefold by matching variables including basic characteristics, comorbidities, and socioeconomic status. The Cox proportional hazards regression model was used to investigate the risk of COVID-19 developing depression or anxiety in patients with low back pain, adjusting for basic characteristics, comorbidities, and socioeconomic status. Patients were followed up 1 year after COVID-19 until development of depression or anxiety.

**Results:** Compared to the back pain group, the crude hazard ratio (HR) of depression (HR, 0.533; 95% confidence interval, 0.331 to 0.858 p=0.01) and anxiety (HR, 0.332; 95% confidence interval, 0.200 to 0.551 p<0.001) were lower in the no back pain group. Also, no back pain group had lower adjusted hazard ratio of depression (HR, 0.566; 95% confidence interval, 0.349 to 0.916 p=0.02) and anxiety(HR, 0.357; 95% confidence interval, 0.213 to 0.599 p<0.001) than back pain group.

**Conclusions:** COVID-19 has a higher risk of developing depression and anxiety in patients with back pain compared to patients without back pain.

**Keywords:** COVID-19, Back pain, Depression, Anxiety

## Free Paper: Trauma

### Factors Associated with Non-contiguous Spine Fracture in Patients with Traumatic Cervical Spine Injury: A 12-Year Retrospective Study

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**Purpose:** Multilevel non-contiguous spine fractures are defined as a lesion separated by at least one normal vertebra. Multilevel non-contiguous spinal fractures in traumatic cervical spine injury patients often miss diagnosis of secondary injuries due to neurological symptoms and extraspinal injuries. Missed secondary injuries with unstable type has been reported as 21% of non-contiguous cervical spine injuries. Purpose is to identify factors associated with non-contiguous spine fracture in patients with traumatic cervical spine injury.

**Materials and Methods:** The 12-year retrospective observational study included 588 patients with traumatic cervical spine injury who be admitted at Maharaj Nakorn Chiang Mai Hospital between January 2011 to December 2022. Patients were categorized into two groups: those with non-contiguous spine fractures and those without non-contiguous spine fractures. Outcomes were analyzed using multivariable logistic regression. Results are presented as odd ratio (OR) and 95% confidence interval (95% CI).

**Results:** Among 588 patients, the incidence of non-contiguous spine fractures was 17.01% (100 of 588 patients). Independent factors associated with non-contiguous spine fracture were motor weakness (OR 1.89, 95% CI (1.19-3.01), p=0.007), intracranial injuries (OR 2.61, 95% CI (1.61-4.23), p=0.000), intrathoracic injuries diagnosed by E-FAST and chest radiograph (OR 2.88, 95% CI (1.77-4.69), p=0.040),

and intraabdominal injuries diagnosed by FAST (OR 1.91, 95% CI (1.03-3.55), p=0.000).

**Conclusions:** The risk of non-contiguous spine fracture in patients with a traumatic cervical spine injury will increase if patients have motor weakness, intracranial injuries, intrathoracic injuries and intraabdominal injuries. Whole spine CT or MRI imaging is beneficial in these patients to avoid missing the remote spinal injury.

**Keywords:** Non-contiguous spine fractures, Cervical spine trauma, Factors.

## Risk Factors for Wound-related Problems after Lumbopelvic Fixation

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**Purpose:** Spinopelvic dissociation is a very rare injury and is traditionally treated through open lumbopelvic fixation. Wound-related problems often occur after surgery, but there are few studies on the risk factors. The purpose of this study was to identify factors related to wound-related problems that occur after surgery in patients with spinopelvic dissociation.

**Materials and Methods:** We retrospectively reviewed the patients with traumatic spinopelvic dissociation who were operated on using open lumbopelvic fixation at the Level 1 trauma center from July 2013 to December 2023. We analyzed demographics, injury factors, and surgical factors by dividing them into groups with (group I) and without postoperative wound-related problems (group II).

**Results:** A total of 69 patients (36 male and 33 female) with an average age 38.6 ± 16.3 years were included. Group I was 26 (37.7%), of which bacteria were identified at the surgical site in 16 patients. Among the identified bacteria, E-coli was the most common, followed by MRSA. Group I had a larger mean body mass index (BMI) and injury severity score (ISS) than Group II, and there were no other differences.

**Conclusions:** High BMI and ISS were identified as risk factors for wound-related problems that occur after spinopelvic dissociation surgery. Blocking surgical site invasion from fecal elements could reduce the incidence of wound-related problems.

**Keywords:** Spinopelvic dissociation, Infection, BMI, ISS, Risk factor

## Spinal Injuries Presenting to a Tertiary Care Center in Chitwan, Nepal: A Five-Year Experience

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**Purpose:** Spinal injuries may cause severe morbidity after trauma having impact on life expectancy, quality of life and psychological status of the patient, which in turn has impact on the family as well. The epidemiology of traumatic spinal injury may be different in our country when compared to that of developed nations. The aim of this study is to describe the patterns of spinal injuries in the patients presenting to a tertiary care center in central Nepal.

**Materials and Methods:** This is a descriptive cross-sectional study which includes all the patients with traumatic spinal injuries who presented to the Department of Orthopedics at Chitwan Medical College-Teaching Hospital from 1 Jan 2016 to 31 December 2020. The data was retrieved from the medical record section, orthopedic ward records and operation theater records. Demographic data, mechanism of injury, delay in presentation, neurological status according to the American Spinal Injury Association (ASIA) score, level of injury, management done and hospital stay were recorded. Data entry and analysis was done using SPSS version 16.

**Results:** Among the 239 patients studied, 62.8% were males and 37.2% females with the mean age of 43.8±17.3 years (range 14-87 years). The most common mechanism of injury was fall (69.9%) followed by road traffic accidents (25.9%). Thoracolumbar region (T11-L2) was involved in 51.1% cases with L1 being the most commonly fractured vertebra (16.7%). Neurology was intact in 58.6% patients whereas 13.4% had ASIA A neurology. Surgery was required in 59.8% patients. The median injury to hospital arrival time was 12 hours (IQR: 6-48 hours) and median hospital stay was 6 days (IQR: 3-9 days).

**Conclusions:** Fall remains the most common cause of injury

in our part of the world with males being more vulnerable for such spinal injuries and majority being in the productive age group (31-45 years). Public awareness about the traumatic spinal injuries and early transfer to health care facility may help reduce the morbidity caused by such injuries.

**Keywords:** Epidemiology, Spinal injury, Trauma

## Transpedicular Intravertebral Cage Augmentation Using Expandable Cage in Kummell Disease: Technical Note and Case Series

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**Purpose:** To demonstrate the surgical techniques for transpedicular intravertebral cage augmentation (TPICA) using an expandable cage for Kummell disease, which requires posterior surgical stabilization, and provide the preliminary surgical outcomes.

**Materials and Methods:** Six consecutive patients undergoing TPICA surgery using an expandable cage with a minimum 6-month follow-up were evaluated. Radiographic analysis to evaluate the local kyphosis angle (LKA), anterior vertebral height restoration ratio (RAVH) of the index vertebra, and clinical outcomes including the Oswestry Disability Index (ODI), EuroQol 5-dimension instrument (EQ-5D), and visual analog scale (VAS) for back and leg pain, were compared between the preoperative and final follow-ups.

**Results:** All patients showed improvements in all clinical outcomes and were able to walk independently without support at the last follow-up. In radiographic evaluation, the mean preoperative RAVH was 41.2±15.6, which increased postoperatively to 70.3±20.5 (1.70 times) and 62.4±20.0 at the last follow-up (1.51 times). The mean preoperative LKA was 10.5±14.8 and was corrected to 6.0±10.0 at the last follow-up. A slight loss of correction was observed between the postoperative period and the last follow-up; however, there was no clinical significance.

**Conclusions:** Expandable cages in TPICA may allow easier surgical manipulation for cage insertion around the pedicle entrance, minimizing damage to the fractured vertebral body's endplates while achieving satisfactory height restoration compared to static cages, and may also provide wider indications for TPICA surgery.

**Keywords:** Kummell disaese, Trans-pedicular interbody cage augmentation, osteoporotic compression fracture

## Expansion Duroplasty for Spinal Cord Injury Decompression: A Systematic Review and Meta-Analysis Study

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**Purpose:** Spinal cord injury (SCI) necessitates timely and adequate decompression for enhanced neurological recovery. Expansion duraplasty (ED) is gaining attention as a surgical approach. This study's main objective is to provide an overview of the existing evidence regarding the effectiveness of ED for SCI decompression.

**Materials and Methods:** This study was conducted using the PRISMA Guidelines. Patient demographics, intraspinal pressure (ISP), neurologic outcome, and sequelae were examined. Eligibility criteria ensured the inclusion of peer-reviewed studies on patients with SCI undergoing ED. This study searched Medline (PubMed) without date constraints and analyzed studies using Cochrane Risk of Bias tool for RCTs and the Newcastle-Ottawa Scale (NOS) for observational studies. The data was presented in summary tables and forest plots with diagnostic test Q-statistics and I2 for heterogeneity.

**Results:** Ten out of 14 studies met the criteria, and four were eligible for meta-analysis. These studies examined 35 SCI patients who underwent ED. Control and duraplasty groups were compared. Journals reporting experimental outcomes without comparing to control used proportional meta-analysis. The study found; The Zhu et al. (2019) study found the shortest operation duration for ED (ES=87.33, 95% CI=110.626 to 199.374). Zhu et al. (2019) and Phang et al. (2015) studies generated effect size of 15.3 and 1.42

for duraplasty and control groups, respectively, with both indicating big differences in the ISP values. The overall effect size across all the studies was 11.19, Q=0.140 , $I^2$= 0%, p>0.05 in favor of ED having smaller ISP values versus control. Zhu et al. (2019) and Aarabi et al. (2022) found the most improved cases, with odds ratios OR=2.72 (95% CI = 1.13 to 6.57, Q=0.22, p=0.03) and 2.72 (95% CI=1.00 to 7.39, Q=0.22, p=0.05), respectively. Telemacque et al. (2018) found a larger impact size for stable cases.

**Conclusions:** Laminectomy alone is insufficient since the dura is inelastic, restricting CSF and blood flow. This meta-analysis showed the efficacy of ED in managing SCI. The data demonstrated a significant decrease in ISP favoring ED. Most studies reported an improvement in neurological outcomes. Several variables, including initial MRI characteristics, level of injury, and initial ASIA grade, could account for the lack of improvement in some patients. Complications, like CSF leaks, were documented but were addressed with appropriate measures.

**Keywords:** Spinal cord injury, Expansion duraplasty, Intraspinal pressure

# Video Session-Cervical

### Fusion Techniques in O-C1-C2 Surgery

Jin Sup Yeom

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### How to do Cervical BESS: From A to Z

Seung Deok Sun

*Department of Orthopaedic Surgery, Sun's Orhtop Aedics Seoul, Korea*

# Video Session-Lumbar

### Single Position Approach Lateral and Prone of Lateral Lumbar Interbody Fusion

Sang-Bum Kim

*Department of Orthopaedic Surgery, Chungnam National University Sejong Hospital, Sejong, Korea*

### Endoscopic Decompression of Thoracic Myelopathy with Ossification of Yellow Ligament

Seung-Hyun Choi

*Department of Orthopaedic Surgery, Busan Korea Hospital, Busan, Korea*

# Video Session-MIS

### Biportal Endoscopic Decompression in Degenerative Spine Disease

Hyun-Jin Park, Sub-Ri Park*

*Department of Orthopaedic Surgery, Kangnam Sacred Heart Hospital, Seoul, Korea*
**Department of Orthopaedic Surgery, Yonsei University College of Medicine, Seoul, Korea*

### Lateral Lumbar Interbody Fusion Mini-open ACR & OLIF L5-S1

Jin-Sung Park

*Department of Orthopaedic Surgery, Samsung Medicine Ceter, Seoul, Korea*

# Video Session-Deformity

### Minimally invasive Scoliosis Surgery

Seung Woo Suh

*Department of Orthopaedic Surgery, Korea University Guro Hospital, Seoul, Korea*

### Pedicle Subtraction Osteotomy

Jung-Hee Lee

*Department of Orthopaedic Surgery, Hyunghee University Hospital, Seoul, Korea*

# Video Session-Tumor

### En-bloc Spondylectomy

Se-Jun Park

*Department of Orthopaedic Surgery, Spine Center, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea*

### Separation Surgery

Jae-Hwan Cho

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# E-Poster

## E01

### Traumatic Dural Tear in Thoracolumbar Spinal Fractures

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**Purpose:** This study is to determine the prevalence, implication, and complications of traumatic dural tear in patients with thoracolumbar fracture in Malaysia and to determine clinical and radiographic factors that associated with traumatic dural tears.

**Materials and Methods:** This is a retrospective study involving all patients with thoracic and lumbar fractures aged 18 to 85 who underwent posterior instrumentation and decompression surgery in four tertiary hospital in the Malaysia Northern region from January 2018 until December 2020. The data collection including demographic data, radiological assessment and measurements, CT imaging, and intraoperative findings. Pre-operative and post-operative neurological assessment based on ASIA impairment scale, blood loss volume, duration of the surgery, and post-surgery complication were collected. All imaging parameters including interpedicular distance, ratio of central canal diameter, laminar fracture gap, and pedicle fractures were identified and measured.

**Results:** This study included 93 patients with thoracic and lumbar fractures who underwent surgery. The mean age of the patients was 38 years old. 74 (79.6%) patients were male and 19 (20.4%) were female. 68 (73.1%) were Malay, 13 (14.0%) were Chinese, and 7 (7.5%) were Indian. 57 (61.3%) had MVA and 36 (38.7%) had fall from height. The number of patients with traumatic dural tears was 20 (21.5%). There is association between presence of dural tear and preoperative neurological deficit ($p<0.001$). Wider mean interpedicular distance ($p=0.004$), increase central canal diameter ratio ($p<0.001$), and displaced laminar fracture

($p<0.001$) were significantly higher in patients with traumatic dural tear. Multiple logistic regression analysis showed both incomplete ($p=0.002$) and complete ($p=0.037$) preoperative neurological deficit, increase of central diameter ratio of encroachment ($p=0.011$), and presence of >2 mm laminar fracture gap ($p=0.015$) had significant association with a traumatic dural tear. Patients with traumatic dural tears had longer surgical times and statistically larger mean blood loss volumes when compared to patients without dural tears ($p=0.001$). There is no significant association between the complications following the surgery and the presence of a dural tear ($p>0.05$).

**Conclusions:** This study showed that preoperative neurological deficit, wider interpedicular distance, severe canal encroachment, and wide separation of laminar fracture is the predictive factors for traumatic dural tear in thoracolumbar fracture. Patient with traumatic dural tear has longer operation duration and intraoperatively more blood loss compared to patient without dural tear.

**Keywords:** Dural tear, Thoracolumbar, Fracture

## E02

### Measurement of Spinal Muscle Function with Spinal Motion Angle in Normal Korean Young Adults using POM Checker

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**Purpose:** As an alternative to directly measuring spinal muscle strength, the spinal angle of motion in normal Korean young adults were measured using a machine called POM checker. By presenting normal values for normal young adults and comparing them with indicators of pathological conditions, it can be used as an indicator of recovery after surgery and is expected to provide a standard for leading to good clinical results.

**Materials and Methods:** The spine motion angle was measured using a POM checker machine for normal 30 adult men and women in their 20s and 30s, from May 2023 to October 2023. POM checker is a markerless motion capture system. This is a machine that measures the angle when the patient is in the maximum possible flexion, extension, and side bending posture.

**Results:** The overall average bending angle was 70.2 degrees, men 69.9 degrees, women 72.8 degrees. The overall average extension angle was 31.6 degrees for men, 32.5 degrees for women, 22.3 degrees. Left lateral bending angle overall average 33.1 degrees, men 33.1 degrees, women 33.3 degrees The overall average right lateral bending angle was measured at 34.5 degrees for men, 34.7 degrees, and 32.6 degrees for women.

**Conclusions:** Through this study, by presenting the normal values of spinal motion angle according to gender/age, it is possible to check in advance the risk of the patient's surgery before surgery by comparing it with the patient's values, and the extent of the patient's recovery by comparing it with the normal values after surgery. Its significance is that it not only allows you to know, but also allows you to perform appropriate post-surgical rehabilitation treatment or obtain information about the degree of future recovery.

**Keywords:** Spinal alignment, Spinal muscle strength, Spinal angle of motion, POM Checker, Recovery after surgery

## E03

### Intradural Lumbar Disc Herniation at the L3-L4 Level: A Case Report and Literature Review

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**Purpose:** Intradural disc herniation (IDH), which is defined as the displacement of the nucleus pulposus of the intervertebral disc in an intradural site, is a rare pathology that comprises 0.26% of all disc herniations. Difficult diagnosis and high misdiagnosis rate may be related to other spinal abnormalities such as arachnoid cysts, infection, intradural tumors, or metastatic disease because of IDH's low incidence and lack of typical imaging features in radiological evaluation.

**Materials and Methods:** We present the case of a 44-year-old man who complained continuous, aggressive pain in his waist and back, and a radiation mainly in the back of his right hip, thigh, and calf for 1 week. His symptoms appeared after he lifted a heavy stuff. The patient had no disease or

surgery before. Right lower limb motor power according to the Medical Research Council scale: Grade 3 in the knee extensors; grade 0 in the ankle dorsiflexion and ankle plantar flexor. The right knee reflex and Achilles tendon reflex were absent. Bladder and bowel function was preserved. Magnetic resonance imaging (MRI) revealed a mass fragment having isointense to normal disc (size 6×7×8 mm) and filling almost the entire spinal canal at the L3-L4 level, causing cauda equina compression. This individual had several specific MRI imaging characteristics of IDH: rim enhancement and "hawk-beak sign". A herniated lumbar disc could be confirmed, and the transforaminal lumbar interbody fusion surgery of the L3-L4 was scheduled. After laminectomy procedure, there was no sign of any extradural disc herniation. We made a microscopically assisted midline incision of dura mater and arachnoid membrane, then detected the disc fragments and a ventral dura defect. The fragments were carefully dissected from the surrounding nerve roots and the ventral dura and then totally removed. The defect on the ventral dura was sutured to prevent cerebrospinal fluid leakage after surgery.

**Results:** Pathologic examination confirmed that the mass was degenerated intervertebral disc. There was no postoperative complication. He presented complete recovery of the radiculopathy and significant improvement of muscle strength at 6 months follow-up.

**Conclusions:** The diagnosis of intradural disc herniation is very challenging and every spine surgeon must be aware. The best treatment for this pathology is surgical intervention.

**Keywords:** Intradural disc herniation, Lumbar herniated disc, Crumble disc sign, Spinal surgery, Case report

## E04

### Primary Osteosarcoma of the Sternum

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**Purpose:** Osteosarcoma is the most common primary malignant tumour of the long bones. However, primary osteosarcoma of the sternum is extremely rare. We report a 62-year-old female presenting with a progressively hard, fixed, anterior chest wall swelling which turns out to be primary osteosarcoma from the sternal bone complicated with lung metastasis.

**Materials and Methods:** This is a retrospective case study. The patient presented to the emergency department(ED) due to increasing anterior chest swelling associated with pain and chest discomfort. A battery of tests were done at the ED including ECG which were normal. We subjected her to a CT scan of the thorax and set a date for a core biopsy under local anaesthesia.

**Results:** CT contrast was performed the following day and we found that the swelling was originating from the sternal bone. The swelling size is about (6.3×7.3) CM with a mass effect on the heart. The homogeneity of the swelling is the same as the sternal bone. We confirmed the findings by detecting the Hounsfield Unit (HU). Otherwise, there is no central necrosis or calcification detected. Unfortunately, we also found multiple suspicious right lung nodules which may represent malignancy. We performed a core biopsy of the lesion and the histopathological result came out to be osteosarcoma of the bone. We broke the news to the patient and referred her to the oncology department for further treatment.

**Conclusions:** Primary osteosarcoma of the sternum is extremely rare. This subset of tumour is usually aggressive, has poor prognosis and is commonly involved with a distant metastasis. Primary osteosarcoma of the sternum usually constitutes about 10% of all primary chest wall tumours with a median age of 42 years at the time of the diagnosis. The tumour usually presents as a hard, rapidly increasing in size with a mass effect on the surrounding structures. Diagnosis is mainly via imaging and biopsy. CT, PET and MRI usually give a good picture of the tumour while a core biopsy will complete the diagnosis. Despite having a poor prognosis, there are effective treatments for this type of tumour. If a local disease, preoperative chemo with wide local excision can be done. In our case, with distant metastasis, the oncology team subjected her to systemic chemotherapy and we proceeded with metastasectomy. In unresectable tumours, chemotherapy with external beam radiotherapy is given. Despite the existing treatment, the five-year overall survival rate is as low as 17%.

**Keywords:** Primar,Osteosarcoma,sternum,bone,tumors

## E05

### Traumatic Pubic Diastasis-A Calamitous Gap

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**Purpose:** Pubic diastasis is defined when the gap between the pubic bone is more than 10 mm in length. Pubic bodies are united by a strong amphiarthrodial cartilaginous joint which is made of Type 2 cartilage. It is a very stable joint and strong forces are needed to break it. It occurs after a road traffic accident, crushing injury or fall from height. 3 main types of mechanisms cause this condition, anterior posterior compression, lateral compression vertical shear, or combinations of these.

**Materials and Methods:** We reported about a teenager who was brought into our ED and we diagnosed a pelvic diastasis. He claimed that he was riding a motorbike before he was hit by a car and was thrown off about 100 metres away. However, post-trauma he can still walk but is having severe bilateral buttocks pain. During the primary survey, we noted that the patient was hypotensive with a systolic of less than 90 mmhg and MAP of < 60 mmhg. We resuscitated him with 2 litres of crystalloid but we could not sustain his blood pressure. Otherwise, there were no indications of any torrential bleeding from anywhere. A pelvic x-ray was performed and we noticed the patient had a significant pelvic diastasis. We applied him a pelvic binder. We also transfused him with safe-O blood and started him on low-dose inotrope. He started to respond and the BP picked up for the orthopaedic team to go in to fix the pelvis.

**Results:** He was operated using ORIF, open reduction and internal fixation. A titanium plate was fixed to unite both pubic symphyses. We performed a CT scan once he was stable to rule out any intra-abdominal injuries. CT showed that he sustained a grade 1 liver injury and a grade 2 right kidney injury. He was managed conservatively in surgical HDU.

**Conclusions:** Pubic diastasis is an insidious condition as it causes torrential pelvic bleeding without any apparent clinical signs. Thus, the attending clinicians should be vigilant in detecting this condition as it can be fatal.

**Keywords:** Pubic, Bone, Diastasis, Trauma, Bleeding

## E06

### A Comparison of Surgical Outcome in Anterior Lumbar Interbody Fusion and Transforaminal Lumbar Interbody Fusion as an Adjunct to Posterior Instrumented Correction of Lumbar Degenerative

I Made Artana

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**Purpose:** To evaluate surgical outcome between ALIF and TLIF.

**Materials and Methods:** A cohort retrospective was performed on 77 patients (38 ALIF; 39 TLIF). X-ray radiographs obtained pre-operatively, prior to discharge were utilized for radiographic assessment. Measurement of VAS and ODI Score also performed pre-operatively and prior to discharge.

**Results:** The mean visual analog scale (VAS) scores decreased, respectively, from 6.55 to 2.53 in the ALIF group and from 6.56 to 3.23 in the TLIF group. The mean Oswestry disability index (ODI) scores improved from 49% to 22.7% in the ALIF group and from 48.5% to 23.8% in the TLIF group. In both groups, the VAS and ODI scores significantly changed preoperatively to postoperatively ($p<0.05$). Statistical analysis showed significant difference in VAS/ODI scores between ALIF and TLIF. In both groups, changes in the disc height and foraminal height between the preoperative and postoperative periods were significant in both group. The amount of change between preoperative and postoperative disc height and foraminal height demonstrated significant intergroup difference ($p<0.05$)

**Conclusions:** ALIF demonstrated a superior method of increasing disc and foraminal height. ALIF also have better VAS and ODI score changes, suggesting ALIF as first of choice to treat Lumbar Degenerative case.

**Keywords:** Spine, Anterior lumbar interbody fusion (ALIF), Transforaminal lumbar interbody fusion (TLIF), Lumbar interbody fusion, Minimally invasive spine surgery

## E07

### Anterior Cervical Discectomy and Fusion Utilizing Contiguous Two Metal Plates in Multilevel Degenerative Cervical Spinal Disease: A Case Report

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**Purpose:** Multilevel degenerative cervical disease, particularly cervical spondylotic myelopathy and or radiculpathy, poses a complex challenge with symptoms stemming from disc and bone changes in the cervical spine. Surgical intervention often necessitates the use of Anterior Cervical Discectomy and Fusion (ACDF). This case report details a surgical approach employing contiguous two anterior metal plates in the context of ACDF for multilevel degenerative cervical disease.

**Materials and Methods:** A 50-year-old male presented to our hospital with progressive tingling sensation and bilateral upper extremity clumsiness. Additionally, he exhibited symptoms of gait disturbance and motor weakness (wrist extension, finger abduction, etc.). Imaging studies revealed severe central canal stenosis from C4 to C7 and foraminal stenosis from C7 to T1 on the right side. A 4-level ACDF from C4 to T1 with cage and plate was planned. Following discectomy and interbody fusion using cages, two short plates were utilized for C4-6 and C6-T1.

**Results:** The patient experienced successful fusion, and improvement of his preoperative neurological symptoms and signs.

**Conclusions:** This case report highlights the successful execution of ACDF with contiguous two anterior plating for management of multilevel cervical myelo-radiculopathy. Our positive outcomes, accompanied by a thorough literature review, contribute valuable insights for surgeons encountering similar complexities in ACDF procedures. This shared experience aims to enhance the understanding of optimal surgical techniques and foster improved outcomes in challenging cases.

**Keywords:** Multilevel degenerative cervical disease, Anterior cervical discectomy and fusion ,Two metal plate

## E08

### Spontaneous Spinal Epidural Abscess in an Adolescent Patient: A Case Report and Literature Review

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**Purpose:** A spontaneous Spinal epidural abscess (SSEA), defined as a Spinal epidural abscess (SEA) without identifiable predisposing factors, is extremely rare in children and adolescents, with only a few cases reported in the literature. Therefore, we present a case of SSEA in an adolescent to assist physicians in identifying and successfully diagnosing this rare condition.

**Materials and Methods:** This paper presents a case of a 16-year-old boy with progressive back pain, uncontrolled fever, and paresthesia in the right lower extremity. Despite the absence of common risk factors, SEA was diagnosed at the L4-L5 level. Laboratory results revealed leukocytosis and elevated levels of inflammatory markers. Magnetic resonance imaging (MRI) confirmed the diagnosis of SEA.

**Results:** The patient underwent urgent laminectomy and abscess drainage, which yielded Group A streptococci in the intraoperative pus. We treated the patient with intravenous cefazolin for six weeks after surgery. He showed significant improvement in the signs of infection, such as fever and neuropathic pain in the right lower extremity, and was discharged to a local rehabilitation clinic. After three consecutive CRP levels were normalized, the patient was discharged. At the six-month follow-up, the patient had regained normal sensation and motor strength without back pain or signs of infection.

**Conclusions:** We present a rare case of SEA in an adolescent, underscoring the diagnostic challenges inherent in this population owing to the rarity of the condition. This emphasizes the need for physicians to maintain high suspicion of SEA in adolescents with spinal symptoms, even in the absence of common risk factors.

**Keywords:** Spontaneous spinal epidural abscess, Adolescent, Spinal intervention

## E09

### Spinopelvic Fracture Fixation

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**Purpose:** To outline the relevant steps in planning and carrying out fixation and stabilization for unstable lumbopelvic injuries.

**Materials and Methods:** The author presents a case-based approach to evaluation, planning, imaging, and carrying out management of lumbopelvic injuries.

**Results:** The author presents a case-based approach to the approach and relevant steps in managing lumbar spino-pelvic injuries. This includes indications, pre-op planning and sequence, intra-op imaging, and surgical tips and tricks.

**Conclusions:** Lumbar spino-pelvic injuries are rare but potentially catastrophic injuries. Approach requires a combination of proper application of spine and orthopedic trauma principles. Proper evaluation, planning, intraop imaging and sequence allows improved results of treatment

**Keywords:** Lumbopelvic fractures

## E10

### Burden of Traumatic Spine Fractures in Myanmar

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**Purpose:** To review demographic characteristics, etiology, level and severity of injury, complications and mortality.

**Materials and Methods:** We reviewed the hospital records of Orthopedics Trauma Unit of Yangon General Hospital, over the period from 1st January 2023 to 31st December 2024.

**Results:** Within one year period, 430 patients were admitted to spine trauma unit. Males: female ratio was 4.5: 1 and young adults (20-50 years) patients were most affected and the youngest age was 11 years old boy. The most common cause of injury was a fall from height, second most was road traffic accident, and third was occupational accident. The mean interval for presentation in the emergency department (from injury) was 12 hours. The earliest presentation in the emergency department was within 1 hour and latest presentation was 2 months. 178 patients were treated for a cervical spine injury, 20 patients for upper thoracic injury, 210 patients for thoracolumbar spine injury, 20 patients for lower lumbar spine injury and 2 patients for sacral fracture. 168 patients had complete spinal cord injury (SCI) (American Spinal Cord Injury Association [ASIA] grade A, 130 had an incomplete injury (ASIA B–D), and 132 were ASIA E. Total 178 patients of the cervical spine injury were admitted. Among them, 11 patients for upper cervical injuries and 49 patients for SCIWORA and 118 patients for subaxial spine injuries. 6 patients of upper cervical spine injuries and 20 patients of sub-axial cervical spine injury were operated. With the limited Intensive Care Unit (ICU) services and unfit for surgery, most of the cervical spine injury patients were treated by conservative management such as skull traction with Crutchfield Cervical Traction and then Philadelphia collar and physiotherapy. Total 252 patients were thoracic and lumbar spine injuries. Of these, 130 patients were operated for thoraco-lumbar spine injuries, 20 patients were operated for upper thoracic spine injury, 16 patients for lower lumbar spine injuries and 2 for sacral fracture. Total 56 patients of Thoracolumbar fracture dislocation AO-Type C were admitted and is common. The most common surgical approach was posterior pedicle screw fixation. Follow-up was available in 200 patients and most were coming for 3 time visits such as 1 month, 3 month and 6 month. Total 47 patients with cervical spine injuries died in hospital and one patient with thoraco-lumbar spine injury died due to poly trauma. Mortality risk is influenced by availability of timely referral, quality medical care, transfer method to hospital after injury and time to hospital admission are important factors.

**Conclusions:** This study aims to provide region-specific data that will guide and inform local practices regarding traumatic spine fractures. It will also map out areas that need more research and intervention to prevent the injuries and to decrease incidence and burden of expensive medical and surgical care.

**Keywords:** Traumatic spinal fractures, Myanmar

## E11

### Titanium Cages are Better than PEEK Cages for Fusion

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**Purpose:** This is a review of related literature regarding the advantages and disadvantages of titanium cages as compared to PEEK cages for inducing spine fusion in animal models and in clinical studies.

**Materials and Methods :** Review of literature.

**Results:** Comparative review of literature of titanium and PEEK cages show titanium cages have improved fusion rates allowing ingrowth and ongrowth of bone into the cages. Rate of subsidence has also decreased with the use of alloys as compared to pure titanium cages, and is comparable with subsidence rates of PEEK cages.

**Conclusions:** Titanium cages showed increase fusion rates in animal and clinical studies as compared to PEEK cages, and non-inferior subsidence rates.

**Keywords:** Titanium cage, Peek cage, Fusion

## E12

### Analysis of Risk Factors for Persistent Postoperative Neuropathic Pain after Surgery in Patients with Lumbar Spinal Stenosis

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**Purpose:** Patients with spinal stenosis often experience neuropathic pain (NP), which may persist post-surgery, impacting patient satisfaction and doctor-patient relationships. Limited research exists on the frequency of neuropathic pain in these patients and its post-surgery improvement. In this study, we attempted to analyze risk factors for persistent postoperative neuropathic pain (PPNP) after surgery.

**Materials and Methods:** This study was conducted on patients who underwent surgery for degenerative spinal stenosis at one institution from September 2021 to October 2022. All patients were evaluated for neuropathic pain using the painDETECT. Numerical rating scale (NRS) of back pain and radiating pain and Oswestry distability index (ODI), underlying disease, smoking status, and American Society of Anesthesiologists score (ASA) were examined. In addition, painDETECT scores were evaluated at 3 months and 1 year after surgery to confirm PPNP, and the patients were divided into a group with PPNP and a group without PPNP. The cross-sectional area of the dural sac and and the grade of central and foraminal stenosis were measured through preoperative magnetic resonance imaging (MRI). An analysis of risk factors for PPNP was conducted based on clinical information and radiological evaluation.

**Results:** Among 158 patients undergoing spinal stenosis surgery, 30.1% had preoperative NP, and 40% of them developed persistent postoperative neuropathic pain (PPNP). Multivariate analysis confirmed younger age, higher central and foraminal stenosis grades as NP risk factors. In the PPNP group, preoperative painDETECT scores were higher compared to the noPPNP group. Longer symptom duration and severe foraminal stenosis were associated with PPNP. Multivariate analysis identified preoperative painDETECT score and grade of foraminal stenosis as PPNP risk factors (OR=1.144, p=0.044; OR=3.449, p=0.014).

**Conclusions:** Younger age, and severe stenosis lesion were the risk of preoperative NP. For PPNP, high preoperative painDETECT scores and severe foraminal stenosis were significant risk factors. Early identification of these factors can aid in better patient management and surgical outcomes.

**Keywords:** Spinal stenosis, Foraminal stenosis, Neuropathic pain, PainDETECT

## E13

### Anterior Approach for a Stab Wound with Penetrating Rebar Injury Causing Incomplete Cauda Equina Syndrome in Lumbosacral Spine Lesion: A Case Report and Literature Review

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**Purpose:** To report a unique case of incomplete CES following a rebar penetrating injury in perineal region with retro-pulsed fragment, which was treated with anterior approach and discuss suitable surgical approach.

**Materials and Methods:** Incomplete cauda equina syndrome caused by non-missile penetrating injury is extremely rare. A 26-year-old male patient presented incomplete cauda equina syndrome due to a penetrating rebar wound from his perineal region to the lumbosacral spine. Computed tomography demonstrated a bony fragment broken from S1 body compressing into the spinal canal.

**Results:** By anterior approach, we performed partial corpectomy of L5, decompression by retrieving the bony fragment, and L5-S1 interbody fusion. The patient had a significant recovery, and no clinical complication was found after over 2-year follow up.

**Conclusions:** It is challenging to determine the optimal strategy of surgical treatment for penetrating spinal injuries with retained foreign bodies, here we suggest an anterior approach situation that has the advantage of being able to effectively perform decompression and prevent iatrogenic damages of thecal sac and nerve rootlets.

**Keywords:** Penetrating injury, Lumbosacral spine trauma, Stab wound, Incomplete cauda equina syndrome, Anterior approach

## E14

### Thoracic Spinal Metastasis of Male Breast Cancer Treated by Surgery: A Case Report

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**Purpose:** We present a literature review and a clinical case in which metastatic spinal tumor at 7th thoracic vertebral column of the patient who underwent left modified radical mastectomy.

**Materials and methods:** A 62-year-old man visited our hospital with continuous back and right flank pain as the chief complaints, which began 2 weeks ago. The patient had no neurologic sign and symptoms but had past history of left breast MRM because of male breast cancer. As CT and MRI showed metastases in T7 vertebra, PET/CT and bone scan there is no any other metastasis in whole body of the patient, separation and stabilization. The separation surgery was performed with posterior corpectomy of T7 (enbloc excision) by using expandable cage which was followed by screws and rods fixation T5 to T9. The biopsy results confirmed metastatic carcinoma with neuroendocrine differentiation from the breast.

**Results:** At the 18-month follow-up, the patient did not have any symptom. There was no evidence of metastasis on the result of follow-up bone scan.

**Conclusions:** Male breast cancer is uncommon, with fewer cases of spinal metastases. Among these, patients who underwent separation surgery are rarer. By presenting this case, we show that radical operation can be a option for MBC with spine metastasis.

**Keywords:** Male breast cancer, Spine metastases

## E15

### Clinical Outcome of Foraminal Decompression in Biportal Endoscopic Surgery in Lumbar Degenerative Disease: Meta Analysis Study

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**Purpose:** To evaluate clinical outcome of foraminal lumbal stenosis underwent foraminal decompression using biportal endoscopic surgery technique.

**Materials and Methods:** Meta-analytic approach was used to identify clinical outcome of biportal endoscopic surgery in foraminal lumbal stenosis. PubMed, EMBASE, Web of Science, and Cochrane Library were systematically searched Results : There were three studies included for the analysis after meeting the inclusion dan exclusion criteria. All of them were retrospective studies with 72 total patients and 84 leves of surgeries. Newcastle-Ottawa scale were used to evaluate these studies. Visual analogue scale (VAS) reduced from 5.78 (95% CI: 4.77-6.79, $I^2$=94%, p<0.001) to 2.14 (95% CI: 1.35-2.92, $I^2$=93%, p<0.001) after 3 months, and 1,77 (95% CI: 1.18-2.36, $I^2$=86%, p<0,001)after 12 months. Mean Oswestry Disability Index (ODI) significantly reduced from 63.25 (95% CI: 56.38-70.12, $I^2$=94%; p<0.001)to 28.70 (95% CI: 19.82-37.58, $I^2$=98%, p<0.001) after 3 months and 17.34 (95% CI: 16.95-17.22, $I^2$=0%, p<0.001) after 12 months. Mean surgery duration for single level was 72.43 minutes (95% CI: 25.40-119.4, $I^2$=98%, p<0.001).

**Conclusions:** Biportal endoscopic surgery is a safe and useful procedure for foraminal lumbal stenosis cases.

**Keywords:** Biportal endoscopic, Lumbal stenosis, Bess

## E16

### Genetic Association in the Pathophysiology of Degenerative Cervical Myelopathy: Defining Roles?

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**Purpose:** Background: Degenerative cervical myelopathy (DCM) encompassing cervical spondylotic myelopathy and posterior longitudinal ligament ossification, is now being documented frequently and significantly burdening the healthcare systems. The pathogenesis of DCM remains somewhat obscure and the focus now is on identifying the role of genetic risk factors. Identifying these risk factors is important for formulating future studies in the direction of novel preventive and therapeutic measures.

**Materials and Methods:** In a cohort study, we evaluated the genetic association of two genes involved in the pathophysiology of DCM i.e. COL11A1 (SNP rs1337185) and ADAMTS5 (SNP rs162509).

**Results:** 60 subjects (27 with DCM, 33 without DCM) were included. The major and minor allelic frequency were evaluated and compared between the cohorts. Significant association was found for SNP rs162509of gene ADAMTS5 for DCM (OR: 2.5375, 95% CI: 0.655-9.89, p=0.177)) whereas no conclusive relation was found for SNP rs1337185 COL11A1 gene.

**Conclusions:** Preliminary data from our study identifies a probable association of two candidate genes which play a pivotal role in the matrix synthesis and degradation. The complex etiopathogenesis of DCM may probably be guided by alteration in these genes and mediated through the altered gene products. Further studies are needed to substantiate and validate this.

**Keywords:** Degenerative cervical myelopathy, Genetics, Single nucleotide polymorphism

## E17

### Measuring Surgical Outcomes of Delayed Presented Cauda Equina Syndrome Patients using a new Scoring System (Dhatt & Kumar Scoring System): Analysis of 109 Patients

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**Purpose:** To evaluate the long-term outcomes of cauda equina syndrome patients who presented delayed in their course of disease. To develop a scoring system to evaluate long-term surgical outcomes of cauda equina patients. To determine the predictors of good and poor functional outcomes.

**Materials and Methods:** All patients who completed 2 years after their surgery were called and examined to see motor, sensory and autonomic dysfunction. ODI (Oswestry Disability Index) scores were measured. Patients were divided into 3 groups i.e, Good, Fair and Poor outcome groups at 2-year follow-up based on a new scoring system i.e, Dhatt & Kumar scoring system. This scoring system was compared with ODI score to check its sensitivity and specificity.

**Results:** 109 patients included in this study with mean age of 42.8 yrs (21-66), mean follow-up duration 7.2±2.6 years, and mean delay was 14.50±9.7 days. All patients showed improvement in atleast few parameters. ODI scores in patients with good, fair and poor outcomes were 2.7±1.26, 7.65±3.05 and 16.17±1.17 respectively. Young patients, male sex, positive anal wink at presentation determine good outcome. Diabetic patients are prone to have poor outcomes.

**Conclusions:** Age, past history of sciatica, diabetes, anal wink are the predictors of surgical outcomes. Dhatt & Kumar scoring system is useful in evaluating functional outcomes of cauda equina patients.

**Keywords:** Cauda equina syndrome, Dhatt & Kumar scoring system

## E18

### Pyogenic Osteomyelitis of Odontoid Process, a Rare presentation

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**Purpose:** The purpose was to evaluate the outcome of surgical vs conservative treatment in odontoid osteomyelitis. Therapeutic approach to infection in upper cervical spine is controversial.

**Materials and Methods:** Radiological images of a 76year old male patient were reviewed, showing collection around the odontoid process on magnetic resonance imaging. Intravenous antibiotics were administered for 3weeks. However ,there were no improvement in biochemical markers. Patient was then subjected for debridement and posterior intrumentation of C1C2. Patient was evaluated clinically as well as biochemical markers values post operatively.

**Results:** Post debridement and C1C2 stabilization, targeted antibiotic was initiated based on tissue culture and patient showed improvement clinically as well as in biochemical markers. Neurological deficit improved markedly after 6weeks of intravenous antibiotics. Pain at cervical region reduced markedly after completion of antibiotics.

**Conclusions:** Pyogenic spondylitis of the upper cervical is a rare manifestation. Surgical or conservative management must be carefully decided based on patient's clinical and biochemical markers. Early surgical treatment is warranted for patients not responding to empirical antibiotic. Furthermore, cervical stabilisation is important post debridement in spinal infection.

**Keywords:** Odontoid process, pyogenic infection

## E19

### Augmented Reality Spine Surgery: Game Changer?

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**Purpose:** The use of pedicle screws in spinal stabilization and fusion remains effective to this day. Pedicle screw placement with navigation has been performed with the assistance of 2D intraoperative C-Arm fluoroscopy. Accuracy and speed are the main challenges in pedicle screws placement, prompting the need for 3D navigation assistance developed using Augmented Reality (AR) to address potential problems and complications.

**Materials and Methods:** Surgical data were collected from 10 patients who underwent Minimally Invasive Surgery (MIS) pedicle screw placement using AR (Holo Lens). Assessment was made of duration of surgery, amount of bleeding, length of hospital stay and post-operative Visual Analog Scale (VAS) scores.

**Results:** The average duration of surgery was 4,221,7 hours, with bleeding amount of 180133ml, a hospital stay of 4,51,2 days and a post-operative VAS score of 2.30,6.

**Conclusions:** MIS pedicle screw placement is effective with the assistance of AR navigation. With learning curve and adaptation to this technology can aid surgeon in spine surgery.

**Keywords:** Augmented reality, Spine surgery, Minimally invasive surgery, Holo lens

## E20

### Clinical Results of Posterior Lumbar Inter-Body Fusion Using Corticocancellous Laminectomy Bone Chips in Spondylolisthesis

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**Purpose:** To study the outcomes of bone union of the single-level instrumented posterior lumbar inter-body fusion with stand-alone local corticocancellous laminectomy bone chips in spondylolisthesis.

**Materials and Methods:** Thirty-two patients underwent PLIF (single-level) using the standalone local bone and segmental pedicle screw fixation. Radiological outcomes were assessed with spinopelvic parameters measurements by lateral X-Ray (standing film) on post-operative 5th day. At 3, 6, and 12 months after surgery, CT scans were obtained to evaluate bony union status. Average follow-up period was 12 months at Yangon Orthopedic Hospital from December 2016 to November 2018. Clinical outcome was also evaluated by the Japanese Orthopedic Association clinical score.

**Results:** The bony union found 18.75% in 6th month and 81.25% in 12th month after surgery. Clinically, the average of JOA scores was improved significantly. The clinical improvements were 89.7% (12th month), on average. Spinopelvic anatomy has a direct influence on the clinical outcome of PLIF operation. There were some complications like superficial infection and adjacent diseases.

**Conclusions:** Our study showed that 81.25% bony union was obtained 12 months after PLIF with only local bone. The results showed that clinical viability of local bone as a source of bone graft in PLIF.

**Keywords:** Lumbar fusion, PLIF, Spondylolisthesis, Laminectomy, Bone graft

## E21

### Narrative Review of Minimally Invasive Spinal Decompression Surgery

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**Purpose:** Spinal decompression surgery appears to be beneficial for lumbar spinal stenosis (LSS) patients who have progressive neural dysfunction and severe chronic pain. In recent decades, minimally invasive spinal surgeries (MISS) utilising posterior decompression techniques that preserve the midline have been introduced. Endoscopic spinal surgery (ESS) arose as a means of reducing the surgical footprint and has been achieving results that demonstrate comparable

efficacy to conventional laminectomies. There is a lack of scientific evidence to support the various midline retaining techniques that have been introduced, nor to identify their potential benefits and drawbacks. The provision of evidence-based guidelines for clinical practice is desperately needed. Thus, the medical community would benefit from this thorough, in-depth review article on various MISS techniques.

**Materials and Methods:** According to the Preferred Reporting Items for Systematic Review and Meta-analyses (PRISMA), a systematic literature search was conducted to identify publications from inception to January 2024 on the PubMed and Cochrane academic search engine with the MeSH terms 'minimally invasive spine surgery AND 'spinal decompression' AND 'endoscopy' OR 'endoscopic' OR 'endoscopic spine surgery'. Inclusion criteria were original clinical human studies; English language; subjects who underwent MISS for spinal decompression with reported treatment outcomes. Assessing the Methodological Quality of Systematic Reviews (AMSTAR) was used to guide this systematic review. Main outcome measurements were size of incisions, blood loss, amount of time to return to normal activities, and visualisation. Articles selected were reviewed independently by three authors.

**Results:** 28 studies met the inclusion criteria. Open and MISS techniques were described, with a greater emphasis on ESS. MISS and ESS techniques reduce tissue dissection, operation times, peri- and post-operative complications, blood loss, length of hospital stay, and incision size, which makes spine surgeons and patients more receptive to them. Compared to traditional, open procedures, MISS also enable patients to resume daily activities sooner, reduce health care costs, and improve postoperative outcomes.

**Conclusions:** Patients with LSS may benefit from endoscopic decompression. With less surgical footprint and fewer complications than open surgery, MISS and ESS have proven to produce comparable results. Appropriate patient selection is crucial for achieving the best possible results in robotic and MISS. Artificial intelligence and machine learning will be used in the near future to assist spine surgeons in better preoperative planning, better surgical execution, and patient selection that will lead to better postoperative outcomes and patient satisfaction.

**Keywords:** Minimally invasive spine surgery, Spinal decompression, Endoscopy, Endoscopic, Endoscopic spine surgery

## E22

### Prediction of Progressive Collapse in Osteoporotic Vertebral Fractures Using Conventional Statistics and Machine Learning

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**Purpose:** To determine prognostic factors for the progression of osteoporotic vertebral fracture (OVF) following conservative treatment.

**Materials and Methods:** The study involved the progression of collapse (PC) and non-PC groups based on the compression rate (15%). Clinical data, fracture site, OVF shape, Cobb's angle, and anterior wedge angle of the fractured vertebra were evaluated. The presence of intravertebral cleft and the type of bone marrow signal change were analyzed using magnetic resonance imaging. Multivariate logistic regression analysis was performed to identify prognostic factors. In machine learning methods, decision tree (DT) and random forest (RF) models were used.

**Results:** There were no significant differences in clinical data between the groups. The proportion of fracture shape ($p<0.001$) and bone marrow signal change ($p=0.01$) were significantly different between the groups. Moderate wedge shape was most observed in the non-PC group (31.7%), whereas the normative shape was most observed in the PC group (54.7%). The Cobb's angle and anterior wedge angle at diagnosis of OVFs were higher in the non-PC group (13.2±10.9; $p=0.001$, 14.3±6.6; $p<0.001$) than in the PC group (10.3±11.8, 10.4±5.5). The bone marrow signal change at the superior aspect of the vertebra was more frequently found in the PC group (42.5%) than in the non-PC group (34.9%). Feature importance using machine learning revealed that vertebral shape at initial diagnosis was the main factor of progression of vertebral collapse. Furthermore, the RF model was better at predicting progression (AUC=0.727, multivariate logistic regression=0.724, DT=0.688).

**Conclusions:** The initial shape of the vertebra and bone edema pattern on MRI are useful prognostic predictors for the progression of collapse in OVFs.
**Keywords:** Osteoporosis, Vertebral fracture, Machine learning, Random forest, Decision tree

## E23

### Transient Motor Paresis and Lumbar Radiculopathy in Prevesicular Herpes Zoster: A Case Report

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**Purpose:** This case report highlights the diagnostic challenge and clinical presentation of herpes zoster before the appearance of the classic vesicular rash, focusing on a patient with transient motor paresis and lumbar radiculopathy.
**Materials and Methods:** A 40-year-old male with a past history of chickenpox presented to the emergency department complaining of sudden onset motor weakness and ipsilateral radiating neuralgia to the left thigh. Initial examination, including a reverse Straight Leg Raise test, revealed no skin lesions or signs typically associated with herpes zoster. The diagnosis was pursued through magnetic resonance imaging (MRI), which showed asymmetrical swelling and Gadolinium enhancement of the dorsal root ganglion.
**Results:** The diagnosis of herpes zoster was confirmed six days post-symptom onset when the patient developed a vesicular rash. The patient was treated with a 7-day course of Valacyclovir (1,000 mg t.i.d.). He experienced a full recovery from motor weakness within two weeks and a gradual resolution of mild post-herpetic neuralgia over two months.
**Conclusions:** This case underscores the importance of maintaining a high index of suspicion for herpes zoster radiculitis in patients presenting with dermatomal pain and motor weakness, even in the absence of a vesicular rash. Differentiating herpes zoster radiculitis from compressive radiculopathy, especially in L2–3 dermatomal or myotomal pain without a reverse Straight Leg Raise sign, is crucial for timely and appropriate management.
**Keywords:** Dorsal root ganglion, Herpes zoster, Lumbar, Radiculopathy, Transient paresis

## E24

### Surgical Management for Degenerative Cervical Myelopathy by Anterior Approach

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**Purpose:** This study was conducted to determine the indications, efficacy, and complication rate associated with performing corpectomy to achieve anterior decompression of neural elements or for removing anterior lesions.
**Materials and Methods:** Twenty-six patients with degenerative cervical myelopathy who had surgical treatment and average 30 months (range, 24-52 months) follow up were included. The mean age was 64.9 years (range, 55-74 years) and average period between myelopathic symptoms and surgery was 2.8 years (range, 6 months–5 years). Preoperative evaluation of every patient consisted of anterior–posterior, lateral, bilateral oblique, flexion ,and extension radiographs, computed tomography reconstructions and magnetic resonance imaging of the cervical spine, Degree of pre and postoperative myelopathy was determined according to the scoring systems developed by Nurick and Japanese Orthopedic Association (JOA). Eight patients had a mild balance problem and difficulty while walking but were able to perform their daily activities. Two patients had spastic quadriparesis ambulating on either crutches or with the help of others. Surgical treatment in all patients consisted of anterior corpectomy.
**Results:** Average preoperative Nurick score was 3.5 (range, 2-5) and JOA score was 7 (range, 1-14). Major and statistically significant neurologic recovery was within the first 3 months, and average Nurick and JOA scores at 3 months were 2 (range, 0-3) and 8 (range, 8-17) respectively. Most of the patients had improved neurologic status at final follow up. As confirmed by plain radiographs and some time computed tomography reconstructions, solid fusion was achieved and we had no implant related complication or failure. One patient developed quadriplegia after operation.

1patient (3.8%) postoperative CSF leaking developed improved spontaneously. At final follow up, all patients except one were able to ambulate without support and maintain their daily activities.

**Conclusions:** Anterior decompression provides good neurologic recovery in patients with degenerative cervical myelopathy. Titeneum cage impregnated with cancellous bone provides good structural support, and solid fusion can be achieved with an anterior cervical plate.

**Keywords:** Cervical spine, Cervical myelopathy, Anterior cervical corpectomy, Stabilization

## E25

### Cervical Spine Injury; Is Late Surgery Always a Failure?

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**Purpose:** According to modern literature there is still controversy whether early surgery has any advantage over late surgery in spinal injury. Developing country like Bangladesh has very few chance to operate early and most of the cases usually operated late due to lack of infrastructure and OT facilities. The purpose of the study was to ascertain whether late surgery (more than 7 days after spinal cord injury) can improve the neurologic and functional outcome in patients with traumatic cervical spinal cord injuries (C3-T1, American Spinal Injury Association grades A-D).

**Materials and Methods:** It is a prospective intervensional study done in Our tertiary care center. Study period 2 years. Sample size 15. All cases operated after 7 days of injury were included. Cases were opertated anteriorly; ACDF. Outcome analysis done by ASIA grading, VAS, ODI, Bridwell fusion grading. Minimum follow up period was 6 months.

**Results:** Total sample size was 15. Age range was 21-55 (44.53±12.5). 86.7% male (n=15). Most common mechanism of injury fall from height 46.7% (n=07), most commonly injured level was C 5/6 , 60% (n=9). Average pre operative delay was 19 (±12) days. 66% (n=10) patient had 1 grade ASIA impairment score (AIS) improvement, 20% (n=3) had 2 AIS grade improvement and 13% (n=2) patient had no improvement of post operative ASIA score. Postoperative VAS and Macnab score improved significantly. 80% (n=12) patient achieved grade 1 fusion according to Bridwell fusion grading. 2 Patient had post operative dysphagia 1 patient had neck pain, No patient had any post op neurological deterioration.

**Conclusions:** Surgery in cervical spine injury has good neurological, functional and radiological outcome even done late.

**Keywords:** ASIA- American Spinal Injury Association, CSI- Cervical Spine Injury, ACDF- Anterior Cervical Discectomy and Fusion, AIS- ASIA Imapirment Score

## E26

### Thoracic Ossification of Posterior Longitudinal Ligament with Staged Posterior Circumferential Decompression

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**Purpose:** Thoracic ossification of the posterior longitudinal ligament (OPLL) is characterized by heterotopic ossification of the spinal ligament. It is a rare disease, with literature reporting an incidence of approximately 0.8%, compared to cervical involvement at 3.2%. Thoracic OPLL can cause progressive myelopathy due to spinal cord compression and subsequent severe neurological impairment, highlighting the necessity for surgical intervention. Multiple surgical procedures have been published to treat thoracic OPLL, each with its respective advantages and disadvantages; however, the most optimal surgical approaches still remain controversial

**Materials and Methods:** We present a case series of three patients with thoracic OPLL, with a mean age of 48.6 years, who underwent surgery from January to December 2022, with a follow-up of a minimum of six months. All patients underwent staged posterior circumferential decompression

and segmental instrumentation with fusion, and the mean interval between the two stages of surgery was 11 days. Operation time and blood loss were evaluated for each surgery. The outcome of the surgery was reported based on the improvement of the VAS score, ASIA impairment scale, total JOA score, and mean recovery rate at six months.

**Results:** At 6 months of follow-up, the patient with Grade B had improved by 2 grades to Grade D; the Grade C patient improved to Grade D, while the Grade D patient remained static in terms of the ASIA impairment scale. Both VAS score and JOA score improved from a preoperative score of 5.6 to 1.6 and 10.0 to 13.3, respectively. The mean recovery rate (Hirabayashi's method) at 6 months of follow-up was 40%±7.2. The overall results were good in one patient and fair in the other two. Dural injury occurred in one patient, and no wound infection was encountered

**Conclusions:** Optimal surgical intervention for thoracic OPLL presents a significant challenge and is less favorable compared to cervical OPLL. This is due to both anatomical factors and the pathophysiology of thoracic OPLL, which is associated with a relatively higher rate of complications. Staged posterior circumferential decompression is considered safe, effective, reliable, and technically feasible. It provides satisfactory spinal decompression while avoiding the more complex, and ideally anterior, decompression procedures with a higher incidence of postoperative complications

**Keywords:** Thoracic, Ossified posterior longitudinal ligament, Thoracic myelopathy, Staged, Posterior circumferential decompression

## E27

### Functional Outcome of Delayed Decompression of Complete Cauda Equina Syndrome Secondary to Lumbar Disc Herniation

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**Purpose:** Cauda equina syndrome (CES) is a rare condition arising from severe compression of the cauda equina to cause such symptoms as saddle and/or genital sensory disturbance and/or sexual, bladder and bowel dysfunctions. Around 50%-70% of patients have urinary retention (CES-R), and 30%-50% have an incomplete syndrome. In complete CES there is clear bladder, bowel retention or incontinence. Lumbar disc herniation (LDH) is a common cause of cauda equina syndrome. Urgent surgical decompression is needed to avoid permanent functional loss. But in our country urgent decompression is not possible due to various reasons. The purpose of the study was to assess the impact of delayed decompression on long-term neurological and bladder function recovery in patients with complete cauda equina syndrome (CES) secondary to lumbar disc herniation (LDH).

**Materials and Methods:** The clinical data of 10 patients receiving delayed decompression surgery for CES secondary to LDH were reviewed. The bladder empty function, bowel control, sexual ability and neurological functions of the lower limbs were evaluated after the operation, 6 months and up to 2 years based on the strategy proposed by Epstein and Hood

**Results:** Surgical decompression was performed at 26.2 ±17 days in all patients with complete CES after the onset of symptoms. The patients were followed up to 2 years. In the 10patients with complete CES,1 excellent, 4 good, 4 fair and 1 poor recovery.

**Conclusions:** Patients with LDH-induced CES who missed the chance of early decompression can still expect favorable functional recovery in the long term.

**Keywords:** Cauda equina syndrome, Lumbar disc herniation

## E28

### The Efficacy of Epidural Ropivacaine Plus Morphine as Post-Operative Analgesia in Major Lumbar Spine Surgery: A Randomized Prospective Double-Blind Study

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**Purpose:** Post-operative pain control includes oral or intravenous analgesics with different combination. However, due to its side effects many adjuvants in pain control were studied.

Epidural anesthesia and analgesia have been superior to intravenous analgesia with respect to pain quality and incidence of side effects.

**Materials and Methods:** This study is a modification on previous studies by placing the analgesic as bolus with direct visualization and not using an epidural catheter. Pain control was then observed post operatively after weaning form general anesthesia using Ropivacaine plus normal saline as the control and compared to its efficacy of analgesic control with Ropivacaine plus Morphine as the experimental group. This is a randomized prospective double-blind study.

**Results:** A total of 18 patients (8 control and 10 experimental) there was noted to have significant difference between the 2 groups. The experimental group that received ropivacaine + morphine has a better pain control post op as there is decrease number of rescue medication given and it showed good pain control throughout 24 hours post op. In comparison with the control group (Ropivacaine + normal saline), all 8 patients received the rescue medication of tramadol with a mean post op time of 2 hours and with a greater number of rescue medications for pain control.

**Conclusions:** Epidural route using Ropivacaine and morphine as a bolus with no epidural catheter is a safe alternative. It shows good pain control and efficacy with no reported adverse effects.

**Keywords:** Lumbar spine surgery, Ropivacaine and morphine epidural anesthesia, Post-operative analgesia.

## E29

### Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS TLIF): Limitations and Innovations

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**Purpose:** This study aims to evaluate the effectiveness and safety of Mini-open Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS TLIF) in patients with grade I spondylolisthesis and Prolapsed Lumbar Intervertebral Disc (PLID). Our study population comprised 30 patients, with an average age of 45 years. The primary outcome assessed was clinical and radiological improvement following Mini-open MIS TLIF, especially in scenarios where logistic support for classic MIS TLIF is unavailable.

**Materials and Methods:** We conducted a retrospective analysis of patients who underwent mini-open MIS TLIF between January 1, 2023, and December 31, 2023. Demographic data, preoperative imaging, surgical details, and postoperative follow-up were meticulously collected. Radiographic fusion rates, pain scores, and functional outcomes were rigorously evaluated.

**Results:** Among the study participants, an impressive 90% reported improved pain after undergoing mini-open MIS TLIF. Radiographic fusion rates at 6 months were consistent with previous research findings. Postoperative pain scores demonstrated a specific percentage reduction in visual analog scale (VAS) scores, signifying successful pain management.

**Conclusions:** Mini-open MIS TLIF represents an effective and safe procedure for achieving spinal fusion and alleviating pain in patients with grade I spondylolisthesis and PLID. While acknowledging limitations, further prospective studies are warranted to validate our findings and optimize patient outcomes. Surgeons should adapt to resource constraints and continue exploring innovative approaches to enhance patient care.

**Key words:** MISS, TLIF, VAS, PLID

## E30

### The Role of Chilled Yoghurt in Reducing Dysphagia and Dysphonia Following Anterior Cervical Surgery

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**Purpose:** To investigate whether a chilled, thickened liquid will be beneficial in reducing the incidence of dysphagia and dysphonia and accelerate recovery after anterior cervical spine surgery.

**Materials and Methods:** 54 patients in our institution who underwent anterior cervical spine surgery during the study period were randomized into 2 groups – the intervention and control groups. Patients in the intervention group were given one serving of chilled yogurt 3 meals a day for the first

5 days post-operatively, while patients in the control group were not given any yoghurt or any chilled food for the first 5 days. Patient reported outcome measures of dysphagia Eating Assessment Tool (EAT-10) and dysphonia (Voice Handicap Index) as well as biodemographic data were collected. Paired samples T-test was performed to identify any statistically significant differences between the intervention and control groups. Radiological measurements of anterior cervical soft tissue space were performed.

**Results:** Majority of patients had minimal swallowing or voice dysfunction pre-operatively, and most of them suffered from swallowing and voice dysfunction immediately post-operatively. There was greater improvement in both dysphagia and dysphonia scores in the intervention group at 4 weeks post-operatively (mean improvement of 4 points, $p<0.024$). This reached statistical significance in the case of the dysphonia scores, but not in the case of the dysphagia scores. Radiological soft tissue swelling was significantly lower in the intervention group.

**Conclusions:** Chilled yogurt is a relatively simple and easily implemented intervention to reduce the incidence of and improve the recovery from post-operative dysphagia and dysphonia after anterior cervical spine surgery.

**Keywords:** Yoghurt, Dysphagia, Cervical spine surgery

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