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ISASS AP

2023

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Advancement of Spine Surgery,
Asia-Pacific Section

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ABSTRACT
BOOK



Seok Woo Kim
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AUGUST 17 (Thu)

FREE PAPER 1
Adult Spinal Deformity 1

FP01-1

Adult Spinal Deformity

Surgery Using an Iliac Screw in Patients with Non-ambulatory Neuromuscular Scoliosis Worsens Hip Subluxation by Reducing the Pelvic Tilting Angle. (Relationship between Pelvic Parameters and Hip Subluxation in Surgery Using a Mono-iliac Screw)Sang-Ho Kim¹ and Hak-Sun Kim^{1*}¹ Orthopedic Department, College of Medicine, Yonsei University, Korea

Background context: The medical treatment of muscular dystrophy and spinal muscular atrophy, which cause non-ambulatory neuromuscular scoliosis, is being innovatively developed. Nevertheless, if the disease is quite advanced, surgical treatment is unavoidable. As for the results of such surgical treatment, there are considerable reports on the correction of thoracolumbar deformity, breathing function, and ADL in patients, but the relationship with hip subluxation, one of the three major deformities caused by these diseases, has not been reported so far.

Purpose: In general spinal deformity surgery, changes in the force applied to the acetabulum by changes in the sagittal plane of the pelvis and lumbar spine have been reported in several studies. To investigate whether changes in sacral inclination and PT, which constitute the pelvic incidence, affect hip subluxation in patients with NM scoliosis.

Study design: This study is a retrospective single-center case study.

Patent sample: A study was conducted on 178 patients with non-ambulatory NM scoliosis who had surgery performed by a single surgeon at one institution and 134 patients who could be followed up for more than 2 years.

Outcome measure : Scoliosis angle, lumbar lordosis, pelvic incidence, sacral slope, pelvic tilting, coronal pelvic tilting angle, Reimers' hip migration percentage (RMP) and hip pain (VAS, visual analog scale)

Methods: Whole spine PA and lateral measurements were measured by three doctors in the sitting state before, immediately after surgery, and over 2 years of follow-up, and the average was used as the standard. The radiographic parameters measured were thoracolumbar scoliosis angle, lumbar kyphosis, pelvic incidence, pelvic tilting angle and sacral slope. Hip subluxation was measured on pelvic 3D CT before surgery and at the last follow-up. Hip pain was measured by the VAS recorded in the medical records and the last f/u by phone interview.

Results: 134 who underwent spinal fusion from T2 or T3 to pelvis. The average age was 15.5 years, and the mean of f/u 5.4 years. The Cobb angle was preoperatively 71.3°424.1° and 29.5°413.9° at the last f/u. The mean PI was 34.9°411.7° and 37.4°411.6° at the f/u. The mean SS was 9.6°435.9° and 43.4°412.9° at the f/u. The mean sagittal PT was 25.3°436.7° and -8.4°415.7° at the f/u. Preoperative hip dislocation was 3 cases (2.2%), but in the last f/u, 8 cases (5.9%). The preoperative coronal PT improved from 22.1°421.0° preoperatively to 10.7°48.1° postoperatively. However, right RMP and left RMP deteriorated from 0.25°40.14°, 0.20°40.14° preoperatively to 0.28°40.14°, 0.22°40.13° postoperatively. Hip VAS was 2.542.3 preoperatively and increased to 3.642.6 postoperatively.

Conclusion: Surgery showed improvements in Cobb's angle and coronal PT, but decreased sagittal PT and increased SS, and consequently, no change in PI. However, hip subluxation increased significantly, complete hip dislocation rate increased, and pain around the hip also increased. According to existing papers on artificial joints when sagittal PT is decreased, the pressure on the hip joint increases and hip dislocation increases. Therefore, this increase in hip subluxation and pain might be caused by the fact that scoliosis surgery improved the Cobb's angle or coronal PT angle, but decreased sagittal PT and thereby

FP01-2

Adult Spinal Deformity

Influence of Negative Sagittal Imbalance and Upper Cervical Malalignment on Clinical Outcomes in Patients with Craniovertebral Junction Kyphosis

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Introduction : The effect of negative sagittal imbalance and malalignment on the clinical outcome has not been studied in patients with craniovertebral junction (CVJ) kyphosis. This study aims to identify the possible prognostic factors for the craniocervical realignment procedure for CVJ kyphosis combined with negative sagittal imbalance to determine the critical radiological parameters for predicting good outcomes.

Material/Method: This study underwent a craniocervical realignment procedure in patients with CVJ kyphosis and negative sagittal imbalance between January 2014 and March 2022.

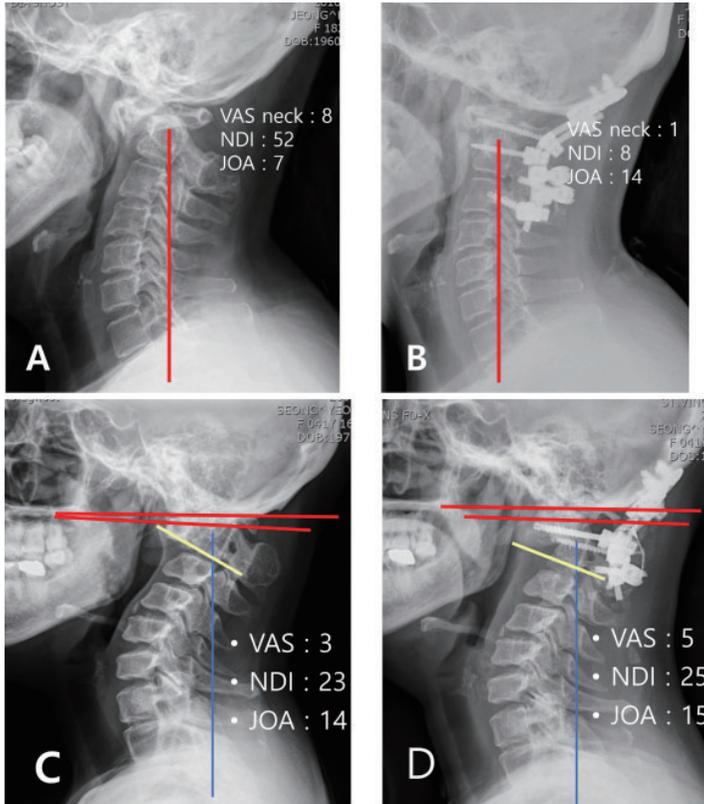
The inclusion criteria were as follows:

1. The C0-C2 angle is less than 0 degree
2. The C2-C7 sagittal vertical axis (SVA) is less than 0mm.
3. Minimum of one-year follow-up after surgery

The C0-C2 angle, C0-2 ROM, C2-C7 angle, C2-7 ROM, the C7 SVA, C2-7 SVA, C2-slope, C7-slope, thoracic kyphosis (TK), pelvic incidence (PI), and lumbar lordosis (LL) were measured before and one year after surgery. The Japanese Orthopaedic Association (JOA) score was used to determine the neurological outcome. Axial symptom severity was quantified by Neck Disability Index (NDI). Patients were divided into two groups according to their neurologic function recovery rate (RR). Patients with RR of >50% and <50% were designated as having good and poor outcomes, respectively. We also divided patients into two groups based on the NDI improvement; good (NDI improvement >10) and poor (NDI improvement <10). The relationship between various prognostic factors and clinical outcomes were assessed by univariate and multivariate analysis.

Results: A total of 25 consecutive patients were enrolled (M/F=13/12, Age = 56.8 ± 17.8 years). The patient age, gender, radiological and clinical parameters were similar between the two groups (P > 0.05). Follow-up data analysis showed significant differences (P < 0.001) in the C02 angle, C27 angle, C2 slope, and C27 SVA, whereas no significant differences in C7 SVA, TK, LL, and PI. Of 25 total patients, eighteen were classified as favorable NDI outcome group (postoperative NDI < 10), while the remaining seven patients achieved unfavorable outcomes (postoperative NDI >10). Patients with favorable NDI outcomes had a significantly higher increase in C0-C2 (p = 0.042) and a higher increase in C2-C7 SVA (p=0.000). Improvements in NDI scores significantly correlated with the correction of CVJ Kyphosis (Δ C0-C2 angle, p=0.002) & negative imbalance (Δ C2-7 SVA, p=0.003). Between the two JOA RR groups, the C02 angle change (12.7 vs 7.5, p=0.042) and the C27 SVA change (18.8 vs. 5.1, p=0.000) had significant differences. JOA RR significantly correlated with the correction of negative sagittal imbalance (Δ C2-7 SVA, p=0.001) after surgery. Multivariate regression analysis showed that C02 angle change was independently associated with NDI improvement (p<0.01). C0-2 angle change significantly correlated with the correction of negative sagittal imbalance (Δ C2-7 SVA, p=0.037) after surgery.

Conclusions: Craniocervical realignment surgery improved the neurological function and quality of life of patients with CVJ kyphosis. The most critical radiological parameter for predicting good outcomes is the postoperative improvement of the C02 angle and C27 SVA. The C02 angle is the most significant independent parameter to predict the improvement of axial neck pain. Our findings suggest that it is essential for clinical recovery to restore CVJ alignment and sagittal balance in CVJ kyphosis patients.



FP01-3

Adult Spinal Deformity

Is There an Association between Psychiatric Disorders and Adolescent Idiopathic Scoliosis? A Large-database Study

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Background: Children with adolescent idiopathic scoliosis (AIS) have reduced quality of life related to poor self-image, perhaps because of cosmetic concerns. However, there has not been a large-database epidemiologic study on the association between psychiatric disorders and scoliosis. Using the Korean National Health Insurance database, we asked: (1) How common are psychiatric disorders among children with AIS? (2) After controlling for gender, age, insurance type, and residential district, are psychiatric disorders more common among children with AIS than among age-matched controls?

Methods: A retrospective analysis was conducted using sample datasets from the Health Insurance Review and Assessment Service from 2012 to 2016, which is a 10% randomly extracted sample of total inpatients and outpatients each year. The mean number of total patients in each dataset was 1,047,603 4 34,534. The mean number of children with AIS was 7409 4 158 for each year. The age criteria was 10 to 19 years for the matching. Mood disorders, anxiety disorders, and behavioral disorders were selected as disorders possibly associated with AIS. We identified children with AIS who had any of the disorders above, and we obtained the prevalence of these disorders based on diagnostic codes. As an exploratory analysis, clinically meaningful variables were selected among the available codes in the dataset, and a univariable logistic regression test was performed for each variable. A multivariable logistic regression test with advanced variables was performed to identify the adjusted odds ratios of psychiatric disorders in children with AIS.

Results: The median prevalence of psychiatric disorders in children with AIS from 2012 to 2016 was 6.9 % (range, 6.0 to 7.1). Compared with children who did not have AIS, and after controlling for gender, age, insurance type, and residential district, children with AIS were more likely to have psychiatric disorders in all 5 years. The adjusted ORs of psychiatric disorders in children with AIS compared with children who did not have AIS ranged from 1.47 to 1.74 (2012: OR 1.60 [95% CI 1.46 to 1.75]; $p < 0.001$; 2013: OR 1.73 [95% CI 1.58 to 1.89]; $p < 0.001$, 2014: OR 1.74 [95% CI 1.59 to 1.91]; $p < 0.001$; 2015: OR 1.71 [95% CI 1.56 to 1.88]; $p < 0.001$; 2016: OR 1.47 [95% CI 1.33 to 1.62]; $p < 0.001$).

Conclusions: Considering the higher prevalence of psychiatric disorders in children with AIS compared with children who did not have AIS, children with AIS and their parents should be counselled about the increased risk of deteriorating mental health of the patients, and surgeons should provide early referral to pediatric psychiatrists. Further studies should investigate the effect of the factors related to AIS, such as curve type, Cobb angle and treatment modality.

FP01-4

Adult Spinal Deformity

Can Intraoperative C2 Slope Predict Postoperative Standing Sagittal Alignment Following Cervical Deformity Correction?

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Background: The importance of cervical sagittal alignment is becoming more stressed since adequate correction can lead to improved postoperative clinical outcomes. However, little is reported of which intraoperative parameters the surgeons could rely on to achieve better outcomes. This study aimed to determine if intraoperative radiographic parameters are maintained postoperatively and whether it could be a reliable parameter to predict sagittal alignment after surgery.

Methods: Patients with cervical deformity who required 3 or more levels of fusion with minimum 2-year follow up were included in the study. Radiographic parameters including C2 slope(C2S), C2-7 sagittal vertical axis (SVA), C2-7 lordosis, and T1 slope were measured pre-, intra-, at postoperative 3 months, and at last follow up. Intraoperative measurements were corrected to compensate for patients' 10° reverse Trendelenburg prone position. Neck and arm pain Visual Analog Scale (VAS), neck disability index (NDI), Japanese Orthopedic Association (JOA) score, and EQ5D were collected as clinical outcome measures. Radiographic parameters over time were compared using repeated measures ANOVA and post hoc analysis was performed. Pre and postoperative clinical outcome were compared using paired t-test. Correlation analysis of radiographic parameters and clinical outcome was performed.

Results: A total of 45 patients (mean age 60.1 years, mean follow up 35.9 months) were included. The C2S was 19.947.2°, 8.846.4°, 11.646.8°, 12.447.1° at pre-, intra-, postoperative 3 months, and at last follow up, with no significant change between the 3 month and last follow up period. The C2-7 SVA did not demonstrate significant change over time. The T1S and C2-7 lordosis correction was lost between the 3 month and last follow up period. The C2S at last follow up demonstrated significant correlation with neck pain, JOA recovery, NDI, and EQ5D.

Conclusions: The results of this study suggest that the C2 slope is maintained over time and therefore can be a reliable intraoperative predictor of sagittal alignment which correlates with clinical outcomes.

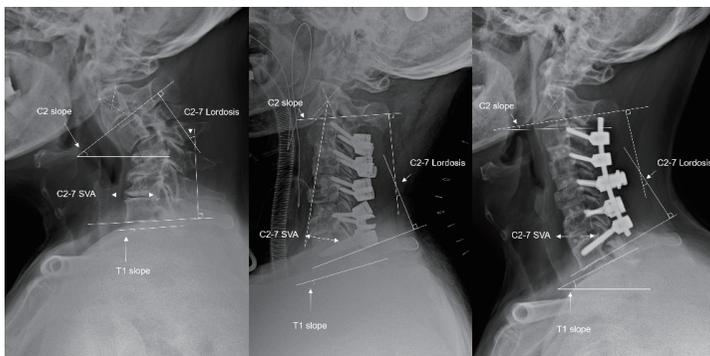


Table 1. Patient demographics overall

Variable	Value
Age (years)	60.1±9.8
Sex	
Male	26(57.8)
Female	19(42.2)
Length of stay (days)	12.4±5.7
Length of follow-up (months)	35.9±15.0
BMI (kg/m ²)	25.7±3.7
Symptom duration (months)	11.0±15.1
ASA classification	
1	8(17.8)
2	18(40.0)
3	19(42.2)
Charlson comorbidity index	2.0±1.3
Smoking	
Non-smoker	34(75.6)
Ex-smoker	4(8.9)
Current smoker	7(15.6)
Alcohol	
Non-drinker	33(73.3)
Ex-drinker	1(2.2)
Current drinker	11(24.4)
Osteoporosis	
Yes	2(4.4)
No	43(95.6)
Surgical details	
Estimated blood loss (mL)	490.0±341.7
Number of levels fused	4.3±0.8
Operation duration (minutes)	250.3±144.0
Surgical approach	
Posterior only	2(4.4)
Anterior + Posterior combined	43(95.6)

Data are expressed as either: Mean±standard deviation or total number (%)

Table 2. Change of clinical outcome parameters

Parameters	Preop	Final follow up	p-value
Neck pain VAS	6.3±2.2	1.1±1.7	<0.001
Arm pain VAS	6.3±1.9	0.6±1.3	<0.001
JOA score	11.6±2.7	15.9±1.8	<0.001
JOA recovery rate(%)		77.6±31.9	
NDI(%)	44.7±16.9	21.6±15.0	<0.001
EQ5D VAS	45.1±9.9	80.6±15.4	<0.001

Data are expressed as mean±standard deviation

Table 3. Radiographic parameters pre, intra, and after surgery

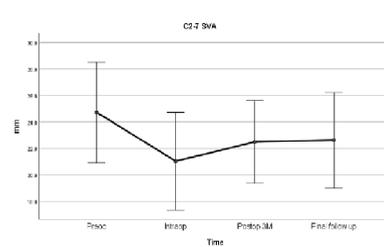
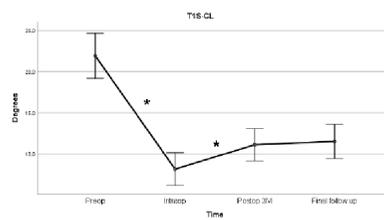
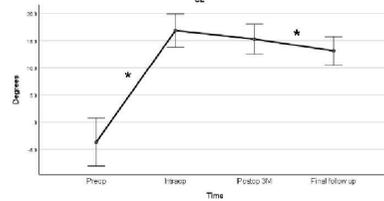
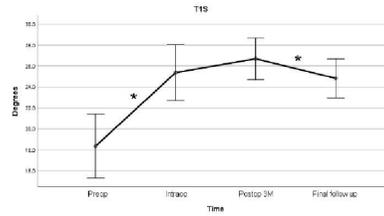
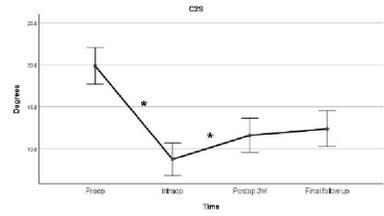
Parameters	Preop	Intraop	Postop 3M	Last follow up
C2 Slope(°)	19.9±7.2	8.8±6.4	11.6±6.8	12.4±7.1
T1 Slope(°)	18.4±10.2	25.4±8.8	26.7±6.6	24.8±6.2
C2-7 Lordosis(°)	-3.6±14.6	16.8±10.1	15.3±9.1	13.1±8.6
T1S minus CL(°)	21.9±9.0	8.2±6.5	11.1±6.5	11.5±6.9
C2-7 SVA(mm)	24.7±12.6	21.0±12.3	22.5±10.3	22.6±12.1

Abbreviations: T1S, T1 slope; CL, C2-7 Lordosis; SVA, Sagittal Vertical Axis

Table 4. Correlation of radiographic parameters and clinical outcome measures at last follow up

Parameters	Neck pain VAS	Arm pain VAS	NDI	JOA	JOA recover y	EQ5D index	EQ5D VAS	IR
C2 Slope	R	0.514	0.135	0.380	-0.301	-0.395	-0.342	-0.338
	P	<0.001	n/s	0.010	0.044	0.007	0.026	0.025
T1 Slope	R	-0.021	0.223	0.113	-0.113	-0.063	-0.105	0.097
	P	n/s	n/s	n/s	n/s	n/s	n/s	n/s
C2-7 Lordosis	R	-0.367	0.053	-0.233	0.170	0.285	0.190	0.345
	P	0.007	n/s	n/s	n/s	n/s	n/s	0.022
T1S minus CL	R	0.479	0.134	0.393	-0.314	-0.414	-0.329	-0.345
	P	0.001	n/s	0.008	0.036	0.005	0.033	0.022
C2-7 SVA	R	0.131	-0.029	0.161	0.025	-0.061	-0.141	-0.177
	P	n/s	n/s	n/s	n/s	n/s	n/s	n/s

Abbreviations: T1S, T1 slope; CL, C2-7 Lordosis; SVA, Sagittal Vertical Axis; VAS, Visual Analogue Scale; NDI, Neck Disability Index; JOA, Japanese Orthopedic Association score; EQ5D, EuroQol -5 Dimension; IR, self-reported Improvement Rate; n/s, not significant



AUGUST 17 (Thu)

FREE PAPER 2

Endoscopic Technologies & Techniques 1

FP02-1

Endoscopic Technologies & Techniques

Biportal Endoscopic Paraspinal Decompressive Foraminotomy for Lumbar Foraminal Stenosis: Clinical Outcomes and Factors Influencing Unsatisfactory OutcomesKi-Han You¹, Min-Seok Kang² and Hyun-Jin Park^{1*}¹ Department of Orthopedic Surgery, Spine Center, Hallym University College of Medicine, Kangnam Sacred Heart Hospital, Seoul, Korea² Department of Orthopedic Surgery, Korea University College of Medicine, Anam Hospital, Seoul, Korea

Background: Lumbar foraminal stenosis (LFS) is an important pathologic entity that cause lumbar radiculopathies, and unrecognized LFS may be associated with surgical failure. However, surgical treatment of LFS is still challenging. So, the purpose of this study was to evaluate clinical outcomes and prognostic factors of decompressive foraminotomy through the biportal endoscopic paraspinal approach for LFS.

Methods: 102 consecutive patients who had single-level unilateral LFS, and underwent biportal endoscopic paraspinal decompressive foraminotomy were included. We evaluated the visual analogue scale (VAS) score and the Oswestry Disability Index (ODI) before and after surgery. Demographic, preoperative data, and radiologic parameters including the coronal root angle (CRA) were investigated. The patients were divided into Group A (satisfaction group) and Group B (unsatisfaction group). Lastly, parameters were assessed between the two groups were evaluated to identify the factors influencing the unsatisfactory outcomes.

Results: In 78.8% of patients, VAS and ODI scores had significantly improved after biportal endoscopic paraspinal decompressive foraminotomy ($p < 0.001$). However, 21.2% of patients were classified into Group B. Group B showed more common distribution in the lower lumbar level ($p = 0.009$), and a significant difference in wide segmental lordosis ($p = 0.021$) and narrow ipsilateral CRA ($p = 0.009$). In logistic regression analysis, lower lumbar level (OR=13.82, 95% CI: 1.33-143.48, $p = 0.028$) and narrow ipsilateral CRA (OR=0.92, 95% CI: 0.86-1.00, $p = 0.047$) were associated with unsatisfactory outcomes.

Conclusions: Significant improvement in clinical outcomes was observed for a year after biportal endoscopic paraspinal decompressive foraminotomy. However, in 21.2% of patients, clinical outcomes were unsatisfactory, and lower lumbar level and narrow ipsilateral CRA were independent risk factors for unsatisfactory outcomes.

FP02-2

Endoscopic Technologies & Techniques

Minimally Invasive Transforaminal Lumbar Interbody Fusion Using the Biportal Endoscopic Techniques Versus Microscopic Tubular Technique**Hyun-Jin Park¹, Ki-Han You¹ and Min-Seok Kang²**¹ Department of Orthopedic Surgery, Hallym university Kangnam Sacred Heart Hospital, Korea² Department of Orthopedic Surgery, Korea University Anam Hospital, Korea

Background: Minimally invasive transforaminal lumbar interbody fusion (MISTLIF) with microscopic tubular technique is an established surgical procedure with several potential advantages, including decreased surgical-related morbidity, reduced length of hospital stay, and accelerated early rehabilitation. A recently introduced biportal endoscopic technique for spine surgery presents familiar surgical anatomy and can be conducted using a conventional approach with a minimal footprint; it is also applicable to TLIF. To compare the clinical and radiological outcomes of biportal endoscopic technique transforaminal lumbar interbody fusion (BE-TLIF) and microscopic tubular technique transforaminal lumbar interbody (MT-TLIF) in patients with single- or two-segment lumbar spinal stenosis with or without spondylolisthesis.

Methods: This is a retrospective cohort study. One hundred two participants with neurogenic intermittent claudication or lumbar radiculopathy with single- or two-level lumbar spinal stenosis with or without spondylolisthesis were enrolled. Clinical outcomes were assessed using the visual analog scale (VAS) score for the back and leg pain, Oswestry Disability Index (ODI), and the Short Form-36 health survey Questionnaire (SF-36). Demographic data, operative data (total operation time, estimated blood loss, amount of surgical drain, postoperative transfusion, and length of hospital stay), and laboratory results (plasma hemoglobin, serum creatine phosphokinase, and C-reactive protein) were also evaluated. The fusion rate was assessed using the Bridwell interbody fusion grading system. Postoperative complications were also noted. Patients were divided into two groups: group A (BE-TLIF) and group B (MT-TLIF). The clinical outcomes, including VAS-Back and VAS-Leg, ODI, and SF-36 scores, were evaluated at 1 month, 6 months, and 1 year after surgery. Differences in demographics, operative data, and the laboratory and radiological results were assessed between the two groups. The fusion rate was assessed using standard standing lumbar radiographs and computed tomography scans conducted 1 year after surgery.

Results: Seventy-nine patients were analyzed in this study, 47 from group A and 32 from group B. Demographic and operative data were comparable for both the groups. The VAS-Back and SF-36 scores were more significantly improved in group A than in group B at 1 month after surgery. However, there were no significant differences between groups for the mean VAS-Back, VAS-Leg, ODI, and SF-36 scores at 1 year after the surgery. Although the total operation time was significantly longer in group A, the estimated blood loss and the amount of surgical drainage was significantly higher in group B ($p < .001$). There were no between-group differences for the fusion rate and postoperative complications.

Conclusions: Both BE-TLIF and MT-TLIF provided equivalent and favorable clinical outcomes and fusion rates. Further large-scale, randomized, controlled trials with long-term followups are warranted.

FP02-3

Endoscopic Technologies & Techniques

Learning Curve and Clinical Outcome of Biportal Endoscopic-assisted Lumbar Interbody FusionKim Ju Eun*Orthopaedic surgery, Baroseomyeon hospital, Korea*

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

FPO2-4

Endoscopic Technologies & Techniques

Anterior Cervical Discectomy and Fusion Versus Cervical Biportal Endoscopic Spine Surgery: A Retrospective Comparison with a Five-year ExperiencesSeok Bong Jung*Spine center, Jinju Bon Hospital, Korea*

Objectives: In patients with cervical disc herniation, there are few surgical options to improve symptoms and signs. The purpose of our study is to compare the outcomes and effectiveness of anterior cervical discectomy and fusion (ACDF) vs. cervical biportal endoscopic spine surgery (C-BESS) during 5 years in a single clinic and single surgeon.

Methods: In our retrospective chart-review we analyzed 249 patients with clinical signs and symptoms with at least 3 months of failed conservative treatment plus MRI or CT scan findings of subarticular cervical disc herniation who underwent ACDF (n=87) and C-BESS (n=162). The data was acquired from January 2018 to December 2022 at a single hospital, department of orthopedic surgery in spinal unit. Patients were divided into 2 groups i.e. who underwent ACDF group and the C-BESS group then we compared the preoperative and postoperative NRS.

Results: Among them, 87 patients (54.1 \pm 10.9 years old, 36 female and 51 male) underwent ACDF with single level and 162 (54.6 \pm 10.5 years old, 49 female and 113 male) patients underwent C-BESS with single level. Symptomatic duration is 21.6 \pm 12.8 in the group with ACDF and 22.8 \pm 14.2 (months, mean \pm SD) in the group with C-BESS, which were not different statistically ($p > .005$). The periodic duration between the preoperative and postoperative NRS was 11.8 \pm 1.1 in ACDF and 12.1 \pm 1.0 (months, mean \pm SD), which were also not different statistically ($p > .005$). The target spinal level was as follows: one in C3-4, sixteen in C4-5, 55 in C5-6, fifteen in C6-7 in the group with ACDF, and six in C3-4, nineteen in C4-5, 65 in C5-6, 65 in C6-7, seven in C7-T1 in the group with C-BESS. The NRS improved significantly postoperatively in both groups ($p < .005$): 7.8 \pm 0.6 to 1.5 \pm 0.8 in the group with ACDF, and 8.1 \pm 0.6 to 1.0 \pm 0.7 in group with C-BESS. The NRS improvement between the two groups has no statistical significance ($p = 0.78$).

Conclusions: The standard surgical treatment of cervical disc herniation has been ACDF but there has been a trend towards minimally invasive procedures. C-BESS is a well-known but developing field, which is increasingly spreading in the last few years. The surgical outcome of C-BESS is about approximately 85% more than 'good' grade. Both methods are equally effective in relieving the relevant symptoms and signs. C-BESS is a safe and effective alternative to conventional ACDF for patients with cervical disc herniation.

Key words: cervical disc herniation; anterior cervical discectomy and fusion; biportal endoscopy; decompression

AUGUST 17 (Thu)

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FREE PAPER 3
MIS 1

FP03-1**MIS****Learning Curve for Biportal Endoscopic Posterior Cervical Foraminotomy Determined Using the Cumulative Summation Test**

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Abstract: Background Learning curves describe the rate of performance improvements corresponding to the surgeon's caseload, followed by a plateau where limited further improvements are observed. This study aimed to determine the learning curve for biportal full-endoscopic posterior cervical foraminotomy (BE-PCF) for the unilateral cervical foraminal disc.

Methods: The learning curve was evaluated using a learning curve cumulative summation test (LC-CUSUM). The goal for the operation time was set to 78 min, which is the mean operation time (mOT) of percutaneous full-endoscopic posterior cervical foraminotomy (PE-PCF) performed by a senior surgeon. Moreover, clinical outcomes and post-operative complications were compared between the early and late learning periods 1 year post-operatively.

Results: This study enrolled the first 50 patients who underwent single-level BE-PCF, performed by a single surgeon. The LC-CUSUM signalled competency for surgery at the 20th operation, indicating that sufficient evidence was obtained to prove that the surgeon was competent. The mOT was 71.29411.69 min in BE-PCF, 71.84412.61 min in the early learning period, and 67.83410.31 min in the late learning period ($p=0.254$). There was no statistical difference in clinical outcomes, visual analogue scale scores, and neck disability index between both periods ($p>0.05$). Four complications were recorded throughout the whole period, with three in the early period and one in the late period ($p=0.285$).

Conclusion: Our study shows that BE-PCF has a learning curve of 20 caseloads to achieve 90% proficiency, and it significantly reduces the operation time based on the performance of a senior surgeon proficient in PE-PCF.

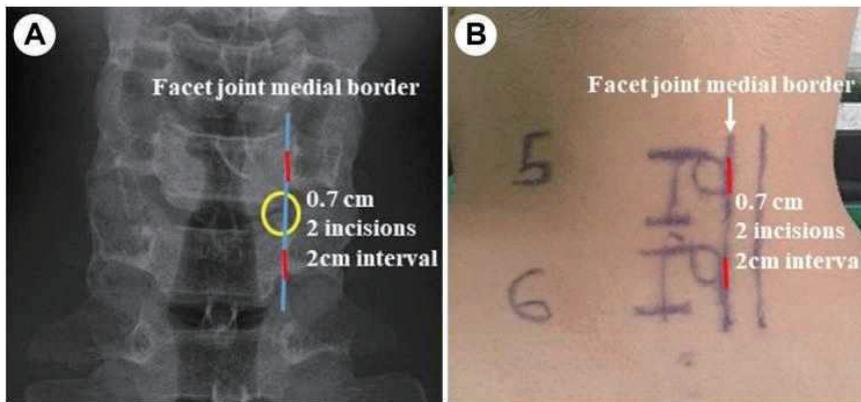


Fig. 1 Skin incisions of biportal full-endoscopic posterior cervical foraminotomy (BE-PCF) (A, B). In BE-PCF, two skin incisions of 0.7 cm are made 2 cm apart around the "V"-point. Blue line, facet joint medial border; red line, incision site; and yellow circle, "V"-point.

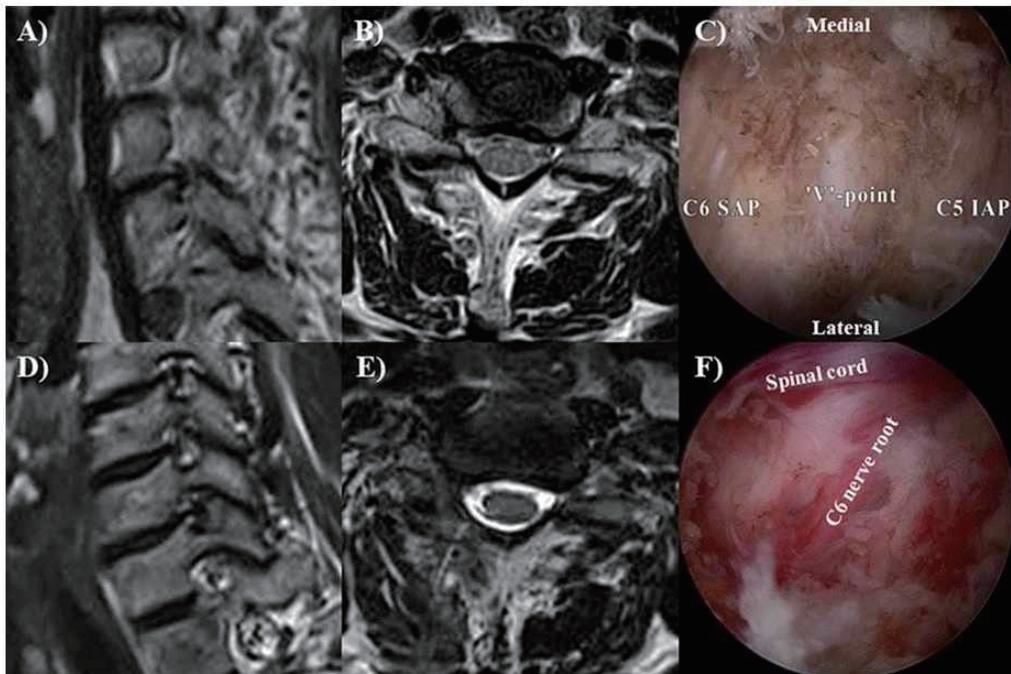


Fig. 2 Biportal full-endoscopic posterior cervical foraminotomy that occurred in a 64-year-old woman. The foraminotomy occurred 2 months previously in the 64-year-old woman who had radiating pain and motor weakness in the right upper extremity. T2-weighted **A** right oblique and **B** axial images of pre-operative magnetic resonance imaging (MRI) demonstrating right C5-6 foraminal stenosis; **C** Intraoperative endoscopic image of the "V"-point; **F** After circumferential foraminotomy is performed from the "V"-point, fully decompressed thecal sac and C6 nerve root are found; **D, E** Post-operative MRI showing well-decompressed nerve root with minimally damaged paraspinal muscles. The patient's symptoms also improved.

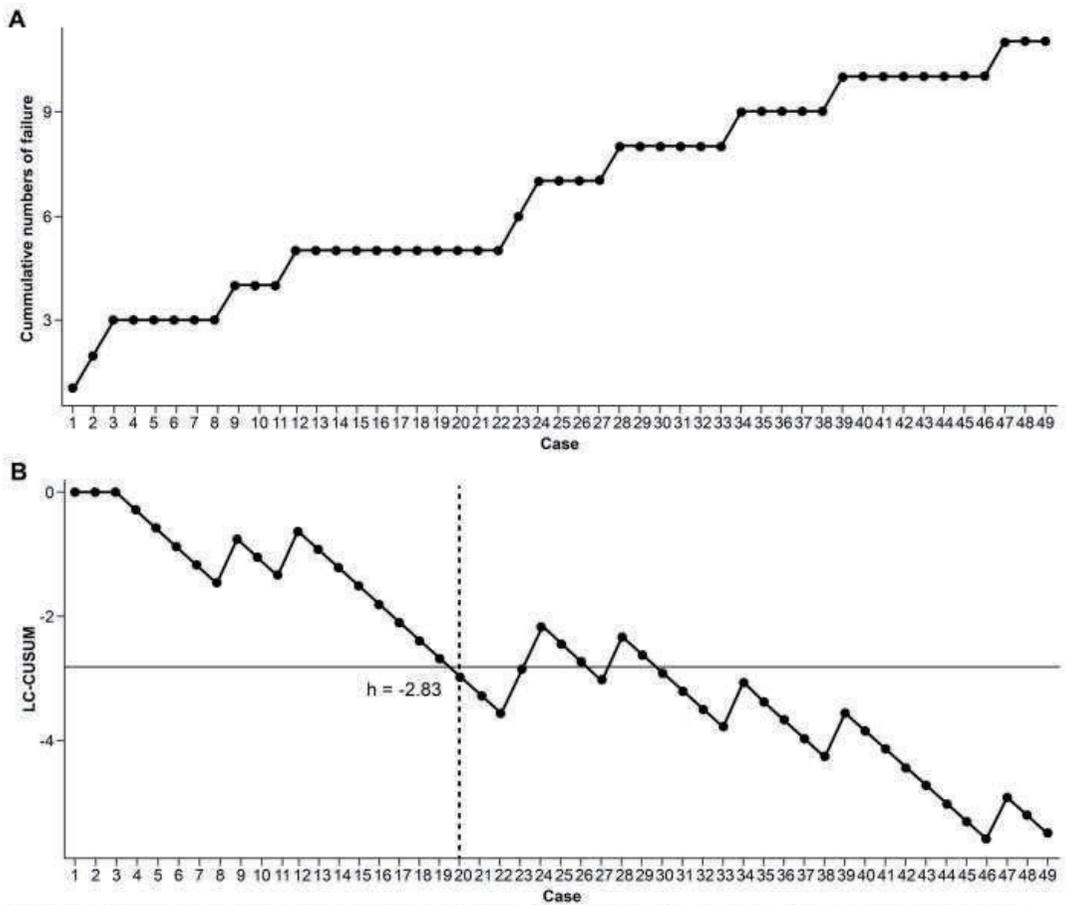


Fig. 3 **A** Cumulative numbers of failure; **B** Cumulative summation test for the learning curve signalled competency for surgery at 20 caseloads. Failure is defined as an operation time > 78.5 min. LC-CUSUM learning curve cumulative summation test.

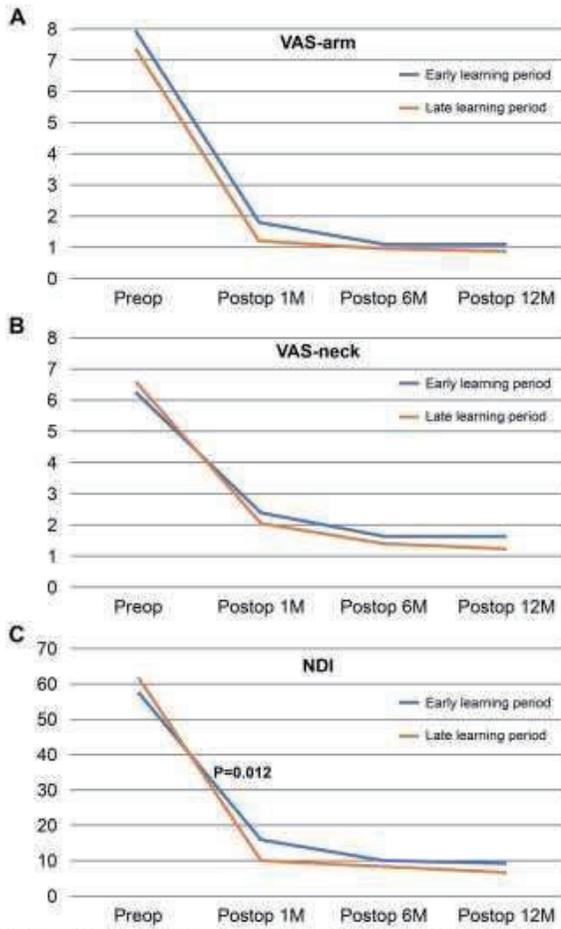


Fig. 4 Clinical outcomes between two learning periods **A** VAS-arm, **B** VAS-neck, and **C** NDI. VAS visual analogue scale; NDI neck disability index

Table 1 Formulas and values involved in plotting the learning curve cumulative summation test

Variable	Value
ρ^0 , unacceptable failure rate	0.4
ρ^1 , acceptable failure rate	0.2
α , probability of the type I error	0.05
β , probability of the type II error	0.2
$P = \ln(\rho^1 / \rho^0)$	-0.6932
$Q = \ln[(1 - \rho^0) / (1 - \rho^1)]$	-0.2877
$S = Q / (P + Q)$	0.2933
1-S	0.7067
$a = \ln[(1 - \beta) / \alpha]$	2.77
$h = a / (P + Q)$, decision limit	-2.83

Descriptive statistics were presented as absolute frequencies for categorical variables and mean with standard deviation (SD) for continuous variables. Dichotomous values were compared using the Chi-squared test, whereas continuous variables were compared between groups using Student's t test. A p value ≤ 0.05 was considered statistically significant. IBM SPSS version 26.0 (SPSS Inc., Chicago, US) was used for data analysis

Table 2 Demographic data and perioperative outcomes

	Early learning period (n = 19)	Late learning period (n = 30)	p value
Sex, Male/Female (Male %)	15:4 (78.9)	21:9 (70.0)	0.719
Age (years)	50.63 \pm 10.76	54.60 \pm 7.78	0.174
Height (cm)	169.63 \pm 7.65	167.17 \pm 8.59	0.301
Weight (kg)	70.11 \pm 8.94	68.63 \pm 10.66	0.605
Body mass index (kg/m ²)	24.32 \pm 2.32	24.52 \pm 3.07	0.8
ASA score 2 (%)	7 (36.8)	29 (96.7)	<0.001
Diagnosis (%)			0.216
Contained foraminal HIVD	11 (57.9)	10 (33.3)	
Uncontained foraminal HIVD	4 (21.1)	7 (23.3)	
Foraminal stenosis	4 (21.1)	13 (43.3)	
Level (%)			0.182
C4-5	3 (15.8)	0 (0.0)	
C5-6	6 (31.6)	9 (30.0)	
C6-7	8 (42.1)	16 (53.3)	
C7-T1	2 (10.5)	5 (16.7)	
Side, Right/Left (Right %)	12:7 (63.2)	15:15 (50.0)	0.544
Operation time (min)	71.84 \pm 12.61	67.83 \pm 10.31	0.254
Length of hospital stay (days)	2.74 \pm 1.52	3.20 \pm 1.99	0.363
Surgical drainage (ml)	55.53 \pm 27.45	40.97 \pm 15.57	0.045
Complication (%)	3 (15.8)	1 (3.3)	0.285
Incomplete neural decompression	2 (10.5)	0 (0.0)	
Epidural hematoma	1 (5.3)	1 (3.3)	
Reoperation (%)	1 (5.3)	0 (0.0)	0.388

Data are presented as mean \pm SD or as number of patients (percentages)

ASA American Society of Anesthesiologist; HIVD herniated intervertebral disc.

FP03-2

MIS

Ten-year Outcomes of Minimally Invasive Versus Open Transforaminal Lumbar Interbody Fusion in Patients with Single-level Lumbar Spondylolisthesis

Young Hyun Yoon¹, Ji-Won Kwon¹, Yung Park^{2*}, Byung Ho Lee¹, Joong-Won Ha², Kyung-Soo Suk¹, Seong-Hwan Moon¹ and Hak-Sun Kim¹

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Background: Few studies have compared 10-year follow-up outcomes between MI-TLIF and open TLIF. This study investigated the clinical and radiological results of minimally invasive (MI) vs. open transforaminal lumbar interbody fusion (TLIF) in patients with single-level lumbar spondylolisthesis over a 10-year period.

Methods: We retrospectively collected the outcome data of patients with single-level lumbar spondylolisthesis who underwent TLIF procedures using an MI (n=108) or open (n=53) approach. Fifty-two (48%) and 31 (58%) patients in the MI-TLIF and open TLIF groups, respectively, completed the 10-year follow-up. Clinical outcomes included the Oswestry Disability Index (ODI) and visual analog scale (VAS) scores for back and leg pain at baseline and at 2, 5, and 10 years postoperatively. The radiographic fusion rate and incidence of secondary surgery due to adjacent segment disease were assessed at 2, 5, and 10 years postoperatively.

Results: Intraoperative blood loss and length of hospitalization were significantly lower in the MI-TLIF group than in the open TLIF group. At 2 years postoperatively, the ODI and VAS scores for back and leg pain were significantly lower in the MI-TLIF group than in the open TLIF group. At 5 years postoperatively, the MI-TLIF group exhibited significantly lower VAS scores for leg pain than the open TLIF group. No significant differences were found in VAS scores for back and leg pain or ODI scores between the two groups at 10 years postoperatively. Radiographic fusion rates and prevalence of secondary surgery for adjacent segment disease were not significantly different between the groups at 10 years postoperatively.

Conclusions: Efficacy of MI-TLIF for patients with degenerative lumbar disease is comparable to that of open TLIF over a 10-year follow-up period. However, MI-TLIF may have superior perioperative recovery and 2-year postoperative functional outcomes than open TLIF.

FP03-3

MIS

Fusion Success in Patients with Degenerative Lumbar Disease without Spondylolisthesis: A Global Study Comparing Anterolateral Versus Posterior MIS Approaches At 2-years Follow-upJiwon Park¹ and Jae-Young Hong^{1*}¹ Department of Orthopedics, Korea University Ansan Hospital, Korea

Background: Several anterolateral and posterior minimally invasive lumbar interbody fusion (MI-LIF) approaches are used to treat patients with degenerative lumbar disease (DLD). However, it is uncertain whether they achieve similar outcomes.

Objective/Aim: To evaluate effectiveness and safety of anterolateral and posterior MI-LIF approaches in DLD patients without spondylolisthesis.

Method: DLD patients without spondylolisthesis (N=109) indicated for either anterolateral or posterior MI-LIF were consecutively enrolled in a 5-year multi-center prospective clinical study (NCT02617563) across Asia, Europe, and Latin America. Surgeons determined the approach for each patient. Demographic and patient reported outcomes (PRO) including disability (ODI), back- and leg-pain (VAS), quality of life (EQ5D), fusion status and serious adverse events (SAE) were collected. Interim analyses at 2-years, used paired t-test and ANCOVA to test for within and between group differences.

Results: Fifty of 109 patients received anterolateral (58% 1-level; 42% 2-level) and 59 patients received posterior (86% 1-level, 14% 2-level) MI-LIF. Stenosis was less common in patients who received anterolateral (60% first level, 52% second level) compared to posterior (78% at first level, 88% at second level) MI-LIF procedures. At 2-years post-surgery, patients reported statistically significant and clinically important improvements on all PROs compared to baseline. Furthermore, there were no significant differences in the amount of improvement between approaches. By 2-years follow-up 90.5% (38/42; anterolateral approach) and 86.0% (37/43; posterior approach) of patients had achieved fusion ($p=.738$). One MI-LIF procedure-related and one device-related SAE in the anterolateral group were reported.

Conclusion: The small differences within the sample that were detected (i.e., number of 2-level fusion and percentage of patients with stenosis) did not result in less favorable outcomes from the fusion surgery by using either a posterior or anterolateral approach. These results suggest that experienced physicians treat DLD patients without spondylolisthesis in an optimized manner by choosing the appropriate approach.

FP03-4

MIS

Mini Open Retropleural Approach Based on Microneurospinal Surgical Anatomy Focusing on Membranes and LayersTakashi Moriwaki¹, Sho Fujiwara¹ and Koichi Iwatsuki¹¹ Department of Neuro Spinal Surgery, Osaka Gyomeikan Hospital, Japan

Background: Thoracic to thoracolumbar junction have anatomical complexity which consist of not only organs, but also membranes and layers. Mini Open Retropleural approach is getting available for adult spinal deformity correction by LIF, OVFs by LIF corpectomy. To purpose is to report Mini Open Retropleural approach based on Microneurospinal Surgical Anatomy focusing on membranes and layers.

Material and Methods: From 2020 to 2022, 17 cases by using Mini Open Retropleural approach with one lung ventilation performed. They consisted of 10 cases; vertebral collapse/LIF corpectomy from T10 to L1, male 4/female 6, mean age 73.1y, blood loss 171.1 cc, op time 278.8cc and 6 cases; cMIS including Thoracic LIF for ASD from T10 to L1, male 2/female 4, mean age 76y, blood loss 108.3cc, op time 346min and 1 case; Thoracic disc herniation of T10, male, 60y, blood loss 50cc, op time 227min. All patients underwent surgery under a microscope, we retrospectively confirmed the Microneurospinal Surgical Anatomy of Mini Open Retropleural approach, and examined the presence or absence of organ damage, nerve damage, and membrane damage during surgery.

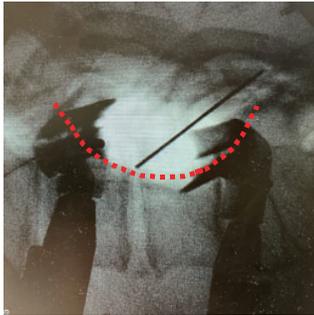
Results: There was no lung or Aorta, vena cava injury. There was 1 case of postoperative transient intercostal neuralgia and 6 cases of partial parietal pleural injury. There were no pneumothorax or organ injuries requiring treatment.

Conclusion: After partial costal bone resection just above the target vertebral body, you can enter the extrapleural compartment between the endothoracic fascia and the parietal pleura, and beyond the intervertebral foramen, using the communicating branch as a landmark, you can return to the subendothoracic compartment and reach the anterior lateral side of the target vertebral body. Mini Open Retropleural approach can safely reach the anterior lateral side of the vertebral body through a layer (extrapleural compartment) that is different from the layer passing the intercostal nerves and intercostal arteries and veins.

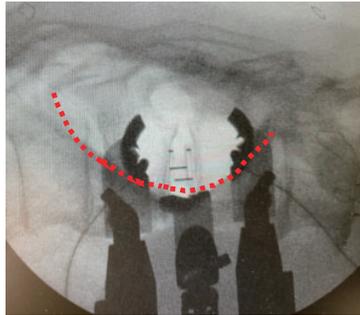
Mini-Open Retropleural Approach with one lung ventilation (under selective lung intubation)



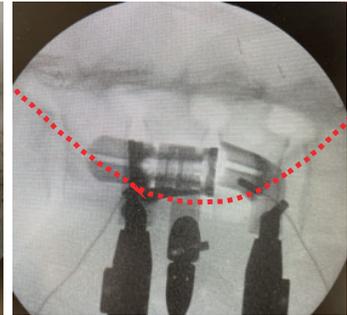
- ✓ Enter the extrapleural compartment between the endothoracic fascia and the parietal pleura.
- ✓ Return to the subendothoracic compartment and reach the anterior lateral side of the target vertebral body.



T10 Thoracic Disc Herniation
; T10/11 intervertebral foramen



LIF T10/11/12/L1
for adult spinal deformity
; T10/11/12/L1 disc



T12 LIF Corpectomy
for OVF
; T12 vertebral body

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Adult Spinal Deformity 2

FP04-1

Adult Spinal Deformity

Decision of Pedicle Subtraction Osteotomy Vertebra in Surgical Correction for Ankylosing Spondylitis with Thoracolumbar KyphosisYong-Chan Kim^{1*}, Sung-Min Kim¹, Kee-Yong Ha¹, Xiongjie Li¹ and JunBum Park¹¹ Orthopaedic Surgery, Kyung Hee University Hospital at Gangdong, Kyung Hee University, Seoul, Korea

Background: Pedicle subtraction osteotomy (PSO) can effectively correct ankylosing spondylitis (AS) patients with thoracolumbar kyphosis, but the choice of location remains controversial. We aimed to create a criterion for selection of the apical vertebra and to determine the ideal site of pedicle subtraction osteotomy in corrective surgery for ankylosing spondylitis with thoracolumbar kyphosis.

Materials and Methods: 235 AS patients with thoracolumbar kyphosis who underwent PSO from May 2009 to August 2021 were retrospectively enrolled in this study. By referring to the Kim's apex vertebra (defined as the farthest vertebra from a line drawn from the center of T10 vertebra body to the midpoint of the S1 upper end plate), 229 patients with apex of T12, L1, or L2 were finally analyzed (excluding L3; 6 patients). We divided all patients into two groups. Group A (n=144) underwent PSO at the Kim's apex vertebra while Group B (n=85) at a different level. Demographic data and radiologic data including sagittal spinopelvic parameters on whole spine of patients were collected and statistically compared using ANOVA between the two groups. An additional analysis was performed within patients with the same Kim's apex vertebra.

Results: The number of patients with T12, L1 or L2 as the apex was 28 (12.2%), 119 (51.9%) and 82 (35.9%), respectively. The correction of C7 sagittal vertical axis (C7 SVA, 101.0448.5mm vs 82.0453.8mm, p=0.041), global kyphosis (GK, 31.6410.0° vs 26.4410.5°, p=0.005), and thoracolumbar kyphosis (TLK, 29.4410.2° vs 24.2412.9°, p=0.012) in group A was significantly greater than in group B, and there was no difference in correction of thoracic kyphosis (TK), lumbar lordosis (LL), and pelvic incidence (PI) between the two groups. According to additional analysis, the correction in TK (26.2413.7° vs 4.5420.1°, p=0.013) of Group A was greater than that of Group B in patients with T12 as the apex. The correction in C7 SVA (101.5444.2mm vs 73.4448.7mm, p=0.020), GK (30.6411.0° vs 26.0410.4°, p=0.041) and TLK (32.647.8° vs 26.749.9°, p=0.012) of Group A were greater than those of Group B in patients with L1 as the apex. And, the correction in TLK (30.046.3° vs 4.3419.5°, p=0.008) of Group A was greater than that of Group B in patients with L2 as the apex. There was no difference in follow-up period (56.5442.7 months vs 42.4439.0 months, p=0.411) and number of fusion levels (5.940.78 vs 5.840.76, p=0.710) between the two groups.

Conclusion: We recommend that Kim's apex should be considered when determining the site of PSO in the surgical correction for AS patients with thoracolumbar kyphosis.

FP04-2

Adult Spinal Deformity

Use of Iliac Screw Associated with more Correction of Lumbar Lordosis than S2-alar-iliac Screw for Adult Spinal DeformityYong-Chan Kim^{1*}, Sung-Min Kim¹, Kee-Yong Ha¹, JunBum Park¹ and Billy Francis Hung¹¹ Orthopaedic Surgery, Kyung Hee University Hospital at Gangdong, Kyung Hee University, Seoul, Korea

Background: To date, there is a paucity of reports clarifying the change of spinopelvic parameters in patients with adult spinal deformity (ASD) who underwent long segment spinal fusion using iliac screw (IS) and S2-alar-iliac screw (S2AI) fixation. The aim of this study was to analyze characteristics of patients with “severe” DSI in adult spinal deformity and establish a criteria for them.

Materials and Methods: A retrospective review of consecutive patients who underwent deformity correction surgery for ASD between 2013 and 2017 was performed. Patients were divided into two groups based on whether IS or S2AI fixation was performed. All radiographic parameters were measured preoperatively, immediately postoperatively, and the last follow-up. Demographics, intraoperative and clinical data were analyzed between the two groups. Additionally, the cohort was subdivided according to the postoperative change in pelvic incidence (PI): subgroup (C) was defined as change in PI $\geq 5^\circ$ and subgroup (NC) with change $< 5^\circ$. In subgroup analyses, the 2 different types of postoperative change of PI were directly compared.

Results: A total of 142 patients met inclusion criteria: 111 who received IS and 31 received S2AI fixation. The IS group (65.6 \pm 4.26°, 39.8 \pm 4.13.8°) showed a significantly higher change in lumbar lordosis (LL) and upper lumbar lordosis (ULL) than the S2AI group (54.4 \pm 4.17.9°, 30.3 \pm 4.9.9°) ($p < 0.05$). In subgroup (C), PI significantly increased from 53° preoperatively to 59° postoperatively at least 50% of IS cohort, with a mean change of 5.8° ($p < 0.05$). The clinical outcomes at the last follow-up were significantly better in IS group than in S2AI group in terms of VAS scores for back and leg. The occurrence of sacroiliac joint pain and pelvic screw fracture were significantly greater in S2AI group than in IS group (25.8% vs 9%, $p < 0.05$) and (16.1% vs 3.6%, $p < 0.05$).

Conclusions: Compared with the S2AI technique, the IS technique usable larger cantilever force demonstrated more correction of lumbar lordosis, and possible increase in pelvic incidence. Further study is warranted to clarify the clinical impaction of these results.

FP04-3

Adult Spinal Deformity

Distal Junctional Failure after Long Fusion Surgery Stopping at L5 in Patients with Adult Spinal DeformityHo Yong Choi¹, Dae Jean Jo¹ and Sungsoo Bae¹¹ Neurosurgery, Kyung Hee University Hospital at Gangdong, Korea

Purpose: To compare the parameters between the distal junctional failure (DJF) group and the non-DJF group, identify risk factors for DJF, and establish radiographic criteria indicating DJF.

Methods: From January 2016 to December 2020, patients with ASD who underwent long fusion surgery (L5 levels) stopping at L5 were analyzed retrospectively. The minimum follow-up period was two years after surgery. DJF was defined as symptomatic adjacent segment pathology at the lumbosacral junction that was considered for revision surgery. The distal junctional angle (DJA) was defined as the angle between the L5 inferior endplate and S1 superior endplate on standing radiographs. Multivariable binary logistic regression analysis was conducted to identify the predictive factors for DJF. Receiver operating characteristic (ROC) curve analysis, including the area under the curve (AUC), was performed to identify the radiographic cut-off value for DJF.

Results: Among 68 patients, 15 (22.1%) experienced DJF. The most common type of DJF was junctional kyphosis with endplate sclerosis or disruption (n = 6), followed by progression of sagittal imbalance (n = 4). Patients with DJF were older (74.0 years vs. 69.9 years), used antidepressants/anxiolytic medication more frequently (40.0% vs. 7.5%), and underwent longer fusions (7.2 vs. 6.2) than those without DJF. The DJF group showed significantly worse preoperative sagittal alignment. Use of antidepressant/anxiolytic medication (OR, 6.38) and preoperative PI-LL mismatch (OR, 1.04) were identified as independent risk factors for DJF. The risk of DJF increased more than seven times (OR, 7.21) when preoperative PI-LL mismatch was greater than 40°. Based on the ROC curve, the AUC for the last DJA and Δ last DJA - post DJA were 0.893 (P < 0.001) and 0.950 (P < 0.001), respectively. Therefore, two radiographic definitions were determined for DJF: A) last DJA > -5° and B) Δ last DJA - post DJA > 5°. When both criteria A and B were met, the sensitivity and specificity of the DJF were 92.9% and 90.6%, respectively.

Conclusions: Use of antidepressant/anxiolytic medication and preoperative PI-LL mismatch are independent risk factors for DJF. DJF can be diagnosed based on postoperative changes in the DJA. If both criteria (last DJA > -5°, Δ last DJA - post DJA > 5°) are met, DJF can be strongly suggested.

FP04-4

Adult Spinal Deformity

Custom Interbody Cage Design and Manufacturing for Correction of Lumbar Spine Deformity**David Edis¹ and Declan Brazil²**¹ *Victorian Orthopaedic Spine Service, Monash University, Australia*² *Signature Orthopaedics, Monash University, Australia*

Background: Spinal deformity correction can be enhanced using anterior or lateral interbody cages and reduce the requirement for 3 column osteotomy. In complex deformity correction, off the shelf interbody cage designs may not provide optimal fit due to end plate irregularity, endplate erosions or use of previous implants. This study aims to demonstrate a process of design and manufacture for custom interbody cages using existing production techniques that utilise CNC machining of PEEK Optima stock material to solve unique problems in lumbar deformity correction.

Methods: CT scan DICOM data was uploaded and converted into CAD design software to allow planning for deformity correction in 4 unique cases of lumbar deformity. Surgical plans for correction were based on correction of segmental sagittal plane and coronal plane deformity using patient's preoperative pelvic and lumbar spine parameters. The primary aim was to restore normal segmental lordosis at L4 to S1 to two thirds of total expected lumbar lordosis based on pelvic incidence. Cage design was optimised to match endplate anatomy and allow correction of deformity, while maintaining structural integrity of the cage. All cages had a generous graft window(s) to allow placement of autograft or allograft bone. Cages were manufactured on a Mazak Variaxis 5 axis machining centre. Follow up CT scans were performed to measure correction and assess bone healing immediately postop and at minimum 12 month follow up

Results: 6 Cages were inserted in four patients using MIS ALIF or OLIF approach to the lumbar spine at L4-5 and L5-S1 levels. All 6 cages were assessed with postoperative CT and demonstrated correction of lordosis to within 1 degree of planned segmental lordosis. Minimum 12 month follow up CT demonstrated bone union across interbody cages at all implanted levels.

Conclusion: This study demonstrates the feasibility of utilising existing CNC machining to manufacture custom shape interbody cages of PEEK optima to solve individual lumbar spine deformity challenges.

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Endoscopic Technologies & Techniques 2

FP05-1

Endoscopic Technologies & Techniques

Clinical Analysis of Biportal Endoscope and Tubular Microscope for Single-level Lumbar Discectomy in Obese Patients: A Multicenter, Retrospective Analysis**Sang-Min Park¹ and Hyun-Jin Park²***¹ Orthopaedic Surgery, Seoul National University Bundang Hospital, Korea² Orthopaedic Surgery, Hallym University Kangnam Sacred Heart Hospital, Korea

Background: When obese patients underwent lumbar discectomy using a microscope, a correlation was found between the operation time and an increase in estimated blood loss according to the increase in body mass index. However, except for minor complications, there was no difference in postoperative outcomes between obese and normal-weight patients. These are the results of microscopic lumbar discectomy in obese patients, but there are no studies on biportal endoscopic lumbar discectomy. The aim of this study was to compare the clinical and radiographic outcomes of microscopic and endoscopic discectomy in obese patients.

Methods: This is a multicenter, retrospective study. Clinical and radiological data were compared and analyzed in 73 obese patients with a body mass index of >30 kg/m² who underwent microscopic and biportal endoscopic lumbar discectomy. Clinical data on the visual analog scale (VAS), Oswestry Disability Index (ODI), and EuroQol-5D (EQ-5D) scores were measured, and radiological data were measured using magnetic resonance imaging (MRI).

Results: In total, 43 patients who underwent microscopic discectomy and 30 who underwent biportal endoscopic discectomy were enrolled in this study. The VAS, ODI, and EQ-5D scores in both groups improved after surgery compared with those before surgery, although there was no difference between the two groups. Although there was a difference in the incidence of recurrent disc herniation confirmed by MRI after surgery, there was no difference in the number of patients requiring surgery between the two groups.

Conclusion: In obese patients with a lumbar disc herniation that was not improved with conservative treatment, there were no significant clinical or radiological differences in outcomes between microscopic and biportal endoscopic surgery methods.

FP05-2

Endoscopic Technologies & Techniques

Single-level Endoscopic TLIF Achieves Similar 1-year Clinical and Radiological Outcomes Compared to Conventional MIS-TLIF With Reduced Surgery Duration, Blood Loss and Length of Hospital Stay**David Shaoen Sim¹, Ayyadarshan Kasivishvanaath¹, Lei Jiang¹ and Zhixing Marcus Ling¹**¹ Department of Orthopaedic Surgery, Singapore General Hospital, Singapore

Background: Endoscopic minimally invasive transforaminal lumbar interbody fusion(E-TLIF) is a novel technique with smaller skin incision and decreased soft tissue disruption compared to conventional minimally invasive transforaminal lumbar interbody fusion(MIS-TLIF). E-TLIF in this study was performed via a uniportal transforaminal approach under general anaesthesia and neuromonitoring with the use of an expandable titanium interbody cage. This study presents a single surgeon experience comparing 1-year outcomes of E-TLIF versus MIS-TLIF in an Asian population.

Methods: Retrospective review was conducted on all consecutive patients who underwent single-level E-TLIF or MIS-TLIF by a single surgeon in a tertiary spine institution from 2018 to 2021 with 1-year follow-up. Inclusion criteria for both procedures were degenerative disc disease with grade I or II spondylolisthesis and mild to moderate central canal stenosis. Choice of technique was dependent on availability of endoscopic technology in later years, surgeon and patient preference. Both techniques were compared based on clinical outcomes including length of stay, blood loss and surgery duration. Patient reported outcomes between both groups were assessed including visual analogue score (VAS) for back pain and lower limb pain, Oswestry Disability Index (ODI) and North American Spine Society (NASS) Neurogenic Symptom Score (NSS). Radiological parameters were also evaluated including segmental lordosis, posterior disc height and amount of listhesis.

Results: 12 E-TLIF and 34 MIS-TLIF patients were included. Both groups were similar in age, BMI, gender and levels at which surgery was performed. E-TLIF had shorter surgery duration (165415 vs 259443 minutes for E-TLIF and MIS-TLIF group, respectively; $p<.001$), reduced blood loss (83475 vs 1814225 mL; $p=.033$) and decreased length of stay (1.840.9 vs 4.742.9 days; $p<.001$) compared to MIS-TLIF. Both E-TLIF and MIS-TLIF patients had significant improvements in all patient report outcomes scores assessed comprising of VAS score for back pain, VAS score for lower limb pain, ODI and NSS. Both E-TLIF and MIS-TLIF patients also had significant improvements in the radiographic parameters assessed comprising of segmental lordosis, posterior disc height and amount of listhesis. Between the E-TLIF and MIS-TLIF group, there was no significant difference in postoperative VAS score for back pain (0.641.5 vs 0.741.8; $p=.777$), VAS score for lower limb pain (0.841.9 vs 0.341.1; $p=.355$), ODI (19.2410.0 vs 15.9413.1; $p=.378$) and NSS (12.1417.4 vs 14.6416.4; $p=.673$). There was no significant difference in the change in segmental lordosis (2.941.9 vs 2.342.6; $p=.444$), posterior disc height (2.741.2 vs 2.041.4; $p=.145$) and listhesis (-4.442.8 vs -3.142.4; $p=.157$) between the E-TLIF and MIS-TLIF groups. No complications were recorded for E-TLIF while MIS-TLIF had a case of dura tear and another case of Meralgia paresthetica. There was no cage subsidence or implant loosening for both groups.

Conclusions: E-TLIF can achieve similar excellent clinical and radiological outcomes compared to MIS-TLIF while reducing surgery duration, blood loss and length of hospital stay. This novel technique offers a safe, effective and less invasive alternative approach to lumbar fusion.

FP05-3

Endoscopic Technologies & Techniques

Comparison of Primary Versus Revision Lumbar Discectomy Using a Biportal Endoscopic Technique

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Study Design: Retrospective study.

Objective: To compare the clinical outcomes of the biportal endoscopic technique for primary lumbar discectomy (BE-LD) and revision lumbar discectomy (BE-RLD).

Methods: Eighty-one consecutive patients who underwent BE-LD or BE-RLD, and could be followed up for at least 12 months were divided into two groups: Group A (BE-LD; n = 59) and Group B (BE-RLD; n = 22). Clinical outcomes included the visual analog scale (VAS), Oswestry Disability Index (ODI), and modified MacNab's criteria. Perioperative results included operation time (OT), length of hospital stay (LOS), amount of surgical drain, and kinetics of serum creatine phosphokinase (CPK) and C-reactive protein (CRP). Clinical and perioperative outcomes were assessed preoperatively and postoperatively at 2 days and at 3, 6, and 12 months. Postoperative complications were noted.

Results: Both groups showed significant improvement in pain (VAS) and disability (ODI) compared to baseline values at postoperative day 2, which lasted until the final follow-up. There were no significant differences in the improvement of the VAS and ODI scores between the groups. According to the modified MacNab's criteria, 88.1 and 90.9% of the patients were excellent or good in groups A and B, respectively. OT, LOS, amount of surgical drain, and kinetics in serum CRP and CPK levels were comparable. Complications in Group A included incidental durotomy (n = 2), epidural hematoma (n = 1), and local recurrence (n = 1) and in Group B incidental durotomy (n = 1) and epidural hematoma (n = 1).

Conclusion: BE-RLD showed favorable clinical outcomes, less postoperative pain, and early laboratory recovery equivalent to BE-LD.

FPO5-4

Endoscopic Technologies & Techniques

Effectiveness of the Two-way Bess Decompression in Central to Extraforaminal Stenosis Patients with Facet Joint Preservation: Minimum 1 Year Short-term Follow UpSub-Ri Park^{1*} and Young-Hyun Yoon¹¹ Orthopedics, Yonsei University College of Medicine, Korea

Purpose: Surgical methods through spinal endoscopy have been developed, and lots of related studies have been reported, but there is still controversy to decompress efficiently at all levels in central to extramarital stenosis patients with unilateral radiculopathy.

Materials and Methods: From March 2021 to March 2022, two-way BESS decompression using extraforaminal and interlaminar approaches was performed on 23 central to extramarital stenosis patients with unilateral radiculopathy. Through follow-up observation for at least 1 year, we checked changes in the cross-sectional area of spinal canal volume and intervertebral foramen areas (CSA-SC, CSA-IVF) before and after surgery, also change of facet joint volume (CSA-FJ) was confirmed. We checked clinical outcomes with change of Back VAS and Leg VAS scores before and after surgery.

Results: The average operation time was 130 minutes, estimated blood loss was 66cc, and the hospitalization period was 3.7 days. The average SCA-SC increased about 183.4%, 261.5% on SCA-IVF, and CSA-FJ remained about 86.6%. The average back VAS scores decreased 4.74 to 1.17 at 12 months after surgery, and the average leg VAS scores decreased 7.52 to 1.96 at 12 months after surgery.

Conclusions: 2 way BESS decompression can be one of the effective treatments in patients with central to extraforaminal stenosis, as it shows better clinical and radiological outcomes with preserving facet joints sufficiently.

AUGUST 17 (Thu)

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FREE PAPER 6
MIS 2

FP06-1

MIS

Slip Reduction in Oblique Lateral Interbody Fusion for Degenerative Spondylolisthesis**Hee-Woong Chung¹, Han-Dong Lee¹, Nam-Su Chung^{1*} and Ki-Hoon Park¹**¹ Orthopaedic surgery, Ajou university hospital, Korea

Background Context: Slip reduction in degenerative spondylolisthesis is generally favored because it may lead to indirect neural decompression and sagittal alignment restoration, although the clinical significance remains controversial. Few studies have investigated slip reduction and associated factors in oblique lateral interbody fusion (OLIF) for degenerative spondylolisthesis.

Purpose: The purpose of this study is to investigate the factors for optimal slip reduction in OLIF.

Study Design/Setting: Retrospective analysis

Patient Sample: A total of 78 operated levels of 72 consecutive patients who underwent OLIF for degenerative spondylolisthesis and had more than 1-year of regular follow-up, were included.

Outcome Measures: The translational/angular slip, anterior/posterior disc height, and spinopelvic parameters measured preoperatively, postoperatively, and at the last follow-up.

Methods: Demographic and surgical parameters were analyzed to determine factors associated with the amount of translational/angular slip reduction.

Results: The mean follow-up duration was 31.6 ± 12.4 months (range, 12 to 61). The cage lordotic angle was 6° in 22 cases and 12° in 45. The mean translational slip reduction was 5.8 ± 2.4 mm (14.1 ± 6.3 %) and the mean angular slip reduction was 8.0 ± 7.1° at the last follow-up. The mean preoperative anterior and posterior disc heights were 7.9 ± 4.6 mm and 4.9 ± 2.0 mm, respectively. The mean postoperative anterior and posterior disc heights were 16.3 ± 2.7 mm and 14.5 ± 3.1 mm, respectively. The amount of slip reduction was greater in female sex, use of 12° cage, cage position from the anterior disc margin of < 7 mm, and cases with posterior decompression.

Conclusions: OLIF showed favorable slip reduction in degenerative spondylolisthesis. To achieve a greater slip reduction, surgeons should consider using a large angle cage, anterior cage placement, and laminectomy.

Keywords: Oblique lateral interbody fusion; slip reduction

FP06-2

MIS

Decompression without Fusion in Degenerative Lumbar Spondylolisthesis : Biportal Endoscopic Spinal SurgeryHo-Jin Lee^{1*}, Jae-Sung Ahn¹ and Sang Bum Kim¹¹ Orthopedic surgery, Chungnam national university college of medicine, Korea

Background: The current study was to access clinical and radiological outcomes after unilateral laminotomy for bilateral decompression (ULBD) procedure using biportal endoscopic spinal surgery (BESS) in lumbar spinal stenosis (LSS) patients with or without stable degenerative spondylolisthesis (DS). For patients of LSS with DS, it has been debatable whether decompression-only surgery is preferable to decompression with instrumented fusion.

Methods: Between January 2015 and April 2020, we conducted a retrospective study on those who have had ULBD using BESS for one level lumbar segment and proceeded the assessment into two groups; LSS with stable DS (Group A) and LSS without DS (Group B). 20 patients in Group A and 49 patients in Group B were enrolled. The length of hospital stay (LOS), follow-up period, operation segment, operative time, complications, and clinical and radiological outcomes were evaluated. Clinical outcomes were measured preoperatively and at the final follow-up time using Visual Analog Scale (VAS) scores, Oswestry Disability Index (ODI) scores, and the modified Macnab criteria. Radiological outcomes were accessed by measuring the sagittal translation of the lateral plain radiogram of DS.

Results: Median follow-up times were 850 days in Group A and 930 days in group B. All the clinical parameters improved significantly after the operation in both groups. At the final follow-up, no clinical parameters differed significantly between the groups, and no complications developed in either group. Radiologically, no significant progression of sagittal translation at the final follow-up time of DS.

Conclusion: We suggest that ULBD using BESS is a practical, alternative, minimally invasive procedure for treating one-segment LSS with stable DS.

FP06-3

MIS

A Morphological Assessment Method for Percutaneous Augmentation in Elderly Osteoporotic Bursting FractureYu-Ching Hsiao¹, Ruey-Mo Lin² and Jing-Jing Fang^{1*}¹ Department of Mechanical Engineering, National Cheng Kung University, Taiwan² Department of Orthopedic Surgery, Tainan Municipal An-Nan Hospital, China Medical University, Taiwan

Background: The newly introduced minimally invasive devices, SpineJack®, which is designed to restore the original vertebral volume through regaining the height of vertebral body and repairing the fractured endplate. With PMMA augmentation can have good and stable results in the management of osteoporotic vertebral fractures without neurological deficits. Although several benefits resulting good clinical outcomes, there was no physical evidences to reveal the target vertebra changes before and after the augmentation.

To develop an automatic and reliable assessment tool to reveal morphological changes of vertebra body after PMMA augmentation in three dimensions. To provide advanced qualitative and quantitative evaluations in correspondence between vertebra fracture and morphological changes of spine.

Methods: Computer tomography were taken for modeling target vertebrae in three dimensions. Geometry features of three-dimensional vertebra body include body heights, length, width, and volume were automatically and uniquely setup and calculated. Angles of local kyphosis on X-Ray imaging in two dimensions were measured by physician for differences assessment before and after augmentation. First of all, we use the principle component analysis method to determine the local coordinate of target vertebra. Therefore, positions of 9 body heights can be evenly distributed automatically as shown in Figure 1. The proposed superimposing method invoke the integrations of the interactive closest points and optimal symmetry plane methods.

Results: The proposed superimposing method was proven in reliable, stable, and efficient to align the three-dimensional digital vertebrae in pre and post procedure (Figure 2). Blue and yellow colors represent the fracture and augmented vertebrae respectively. One case of osteoporotic fracture was retrospectively recruited to test the developing assessment tool. The patient was injected PMMA from the left side only, who had undertaken three times computer tomography in before and after treatment in 5 months and 40 months. Quantitative body heights were collected to record the progressing changes over time.

Conclusions: In Figure 3, we found the PMMA augmentation trend were decreased over time. Augmentation effectiveness initially increase body height at positions of RM, MM, and LP in 5 months, but all the body height positions were decrease after 40 months of augmentation. Recruiting more cases and further investigation of morphological changes are near future work.

Figures

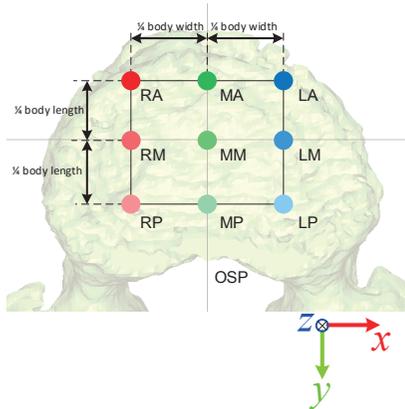


Figure 1. Automatic calculation of 9 positions of body height.

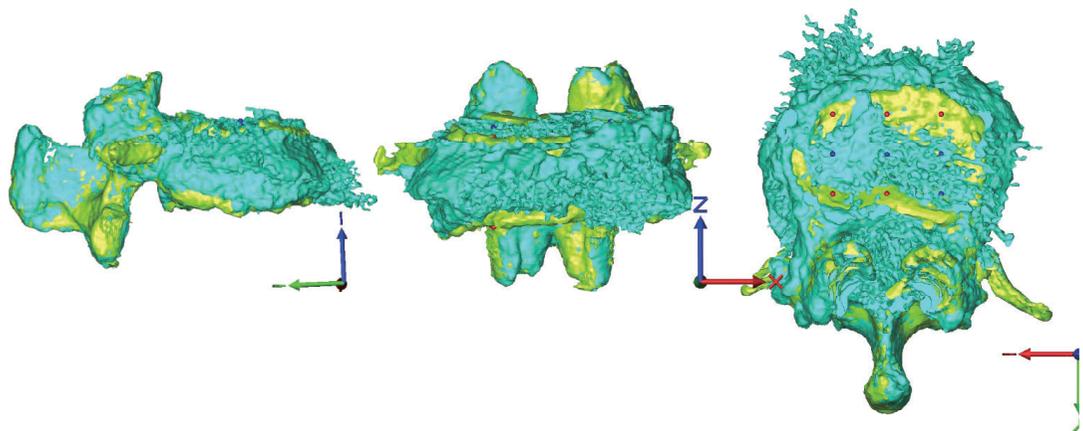


Figure 2. Superimposing the target vertebrae at pre and post 40 months with body height assessing points in three views.

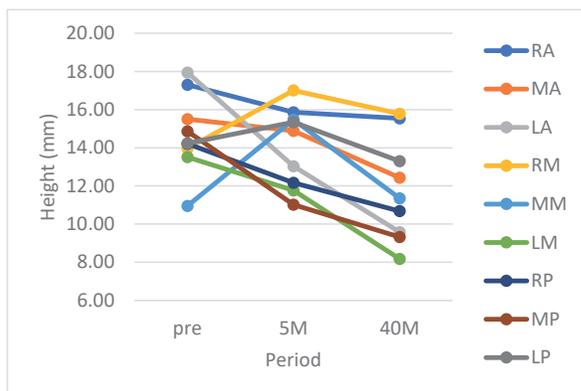


Figure 3. Body heights changes before and after 5M and 40M PMMA injection.

FP06-4**MIS****Cost-utility Analysis of Endoscopic Lumbar Discectomy Following a Uniform Clinical Pathway in the Korean National Health Insurance System****Chi Heon Kim¹, Chun Kee Chung^{1*} and Yunhee Choi²**¹ Neurosurgery, Seoul National University Hospital, Korea² Division of Medical Statistics, Medical Research Collaborating Center, Seoul National University Hospital, Korea

Abstract Introduction: Full-endoscopic lumbar discectomy (FELD) is a type of minimally invasive spinal surgery for lumbar disc herniation (LDH). Sufficient evidence exists to recommend FELD as an alternative to standard open microdiscectomy, and some patients prefer FELD due to its minimally invasive nature. However, in the Republic of Korea, the National Health Insurance System (NHIS) controls the reimbursement and use of supplies for FELD, but FELD is not currently reimbursed by the NHIS. Nonetheless, FELD has been performed upon patients' request, but providing FELD for patients' sake is inherently an unstable arrangement in the absence of a practical reimbursement system. The purpose of this study was to conduct a cost-utility analysis of FELD to suggest appropriate reimbursements.

Method: This study was a subgroup analysis of prospectively collected data including 28 patients who underwent FELD. All patients were NHIS beneficiaries and followed a uniform clinical pathway. Quality-adjusted life years (QALYs) were assessed with a utility score using the EuroQol 5-Dimension (EQ-5D) instrument. The costs included direct medical costs incurred at the hospital for 2 years and the price of the electrode (\$700), although it was not reimbursed. The costs and QALYs gained were used to calculate the cost per QALY gained.

Result: Patients' mean age was 43 years and one-third (32%) were women. L4-5 was the most common surgical level (20/28, 71%) and extrusion was the most common type of LDH (14, 50%). Half of the patients (15, 54%) had jobs with an intermediate level of activity. The preoperative EQ-5D utility score was 0.4840.19. Pain, disability, and the utility score significantly improved starting 1 month postoperatively. The average EQ-5D utility score during 2 years after FELD was estimated as 0.81 (95% CI: 0.78-0.85). For 2 years, the mean direct costs were \$3,459 and the cost per QALY gained was \$5,241.

Conclusion: The cost-utility analysis showed a quite reasonable cost per QALY gained for FELD. A comprehensive range of surgical options should be provided to patients, for which a practical reimbursement system is a prerequisite.

AUGUST 17 (Thu)

SYMPOSIUM 1
Adult Sagittal Imbalance

SY01-1**Adult Sagittal Imbalance****Deformity Surgery in the Elderly****Paul Park***University of Tennessee Health Science Center, USA*

Spinal deformity is prevalent in the elderly and can lead to pain, disability, and/or neurological deficits. Numerous studies have shown that deformity corrective surgery can lead to improved outcomes. However, complications are common and are particularly problematic in the elderly since it has been shown that minor and major complication rates increase significantly with age. This is noteworthy because major complications after deformity corrective surgery have been shown to adversely affect clinical outcomes. Consequently, the decision to offer major deformity corrective surgery in the elderly is not straightforward. Although it has been emphasized that spinopelvic alignment is of primary importance, not all elderly patients require realignment surgery. Surgical decision making should be nuanced. Spinopelvic alignment should be considered but presenting symptoms, advanced imaging, and comorbidities are important factors that determine whether deformity corrective surgery, limited surgery, or no surgery should be recommended.

SY01-2

Adult Sagittal Imbalance

**Selecting Osteotomy Location in Revision Surgery for Adult
Sagittal Imbalance**

Han Jo Kim

Hospital for Special Surgery, USA

SY01-3**Adult Sagittal Imbalance****Patient-Specific Implants to Accurately Attain Desired Spinal Alignment****Jae-Hyuk Yang***Korea University College of Medicine, Korea*

In order of background: Achieving accurate spinal alignment is critical in adult spinal surgery to improve patient outcomes and quality of life. However, patients with varying spinal pathologies, such as spinal instability due to severe intervertebral disc deformity, osteoporosis, arthritic natural fusion of the posterior joint, and spinal deformities accompanied by spinal fractures, present unique challenges in surgical planning and implant selection.

Contents of presentation: This presentation explores the importance of patient-specific implants in attaining desired spinal alignment for individuals with different spinal pathologies. For patients with spinal instability due to severe intervertebral disc deformity, customized implants, such as expandable cages or interbody spacers with variable lordosis angles, are used to address the specific deformities while ensuring adequate stability and motion preservation. Additionally, pedicle screws with varying diameters and lengths are utilized, along with advanced navigation systems, to optimize implant placement accuracy.

In cases of severe osteoporosis, traditional pedicle screw fixation may be compromised due to poor bone quality. To enhance implant fixation, surgeons may employ cement-augmented screws, also known as cement scoliosis screws. These screws are designed with a cannula through which bone cement can be injected after screw placement, providing additional stability and fixation. Alternatively, a combination of pedicle screws and hooks can be used to improve the fixation of the vertebrae, offering a dual-rod construct for enhanced support. Additionally, expandable screws may be used in osteoporotic patients to create more significant purchase within the vertebra, increasing stability.

For patients with arthritic natural fusion of the posterior joint, the surgical approach involves using patient-specific implants that accommodate the fusion pattern while restoring spinal alignment. Polyaxial pedicle screws with a wide range of motion can be utilized to achieve optimal fixation angles, allowing for greater flexibility in adapting to the individual patient's anatomy.

In cases of spinal deformity accompanied by spinal fractures, priority is given to immediate stability and restoration of alignment. For this purpose, specialized surgical instruments such as fracture reduction forceps, fracture distractors, and osteosynthesis material are used. Patient-specific 3D-printed implants may also be employed to precisely match the patient's unique anatomy, facilitating better alignment and reducing postoperative complications.

Conclusion: The symposium will gain insights into the significance of patient-specific implants in achieving desired spinal alignment for various spinal pathologies. Tailoring implant solutions to individual patients' needs based on their specific condition and pathology is essential for improved surgical outcomes, enhanced patient recovery, and reduced postoperative complications. Utilizing a wide range of surgical instruments, including expandable cages, cement-augmented screws, polyaxial pedicle screws, and 3D-printed implants, allows for a personalized approach to adult spinal surgery, leading to better clinical outcomes and patient satisfaction.

Keywords: Spine; Spinal deformity; Patient-specific implants; Sagittal imbalance

SY01-4

Adult Sagittal Imbalance

Cervical Spondylotic Kyphosis with Stenosis: C7/T1 Sparing Anterior Only Multi-Level Correction**Keun Su Kim***Yonsei University College of Medicine, Korea*

Most of spine surgeon prefer anterior and posterior combined surgery for the patient with inverted C-neck and goose neck deformity with radiculopathy and/or myelopathy. For successful decompression of severe multi-level foraminal stenosis and correction of kyphotic deformity, anterior surgery of cervical spine is almost mandatory. In the surgery of anterior multi-level cervical spine surgery, there are several questions which we should consider seriously.

At first, in multi-level anterior cervical spine surgery of C3/4/5/6/7 levels, do we need additional posterior fixation? Secondly, deformed neck can be corrected to acceptable lordotic curve by anterior only surgery? Lastly, how about to preserve the C7/T1 segment motion without screw fixation?

I have done thirty-five cases of C3/4/5/6/7 Anterior cervical discectomy and fusion (ACDF) for the last 3 years. Post-operative C2-7 lordosis was increased about 19 degrees compared to pre-operative angle. Recently whole body balance using gravity line (GL) is hot topic. On EOS images, GL passing center of head (center of auditory meatus, CAM) is located 18mm anterior to center of C7 body according to Dr. Hasegawa's report (2017). Seriously abnormal preoperatively GL was repositioned to anterior to center of C7 body with the range 0-20 mm. There was no post-operative infection, worsen neurological deficit, and instrument failure. All of the patients showed improved neck and arm pain.

In this presentation of anterior only multi-level cervical spine surgery, I will show the surgical techniques of complete resection of hypertrophied uncinated processes and correction of cervical kyphosis. Complete uncinectomy guarantees persistent foraminal decompression and mobile vertebral body for easy deformity correction. Anterior plating technique with long and thick screws is important too. Some surgeons insist C7/T1 fixation to protect the problem of adjacent segment degeneration. However, C7/T1 fixation has many disadvantages.

Various cases of anterior only multi-level cervical spine surgery cases will be presented, and hopefully many delicate points can be discussed.

SY01-5

Adult Sagittal Imbalance

How to Prevent PJK with MIS Techniques for ASD

Neel Anand

Cedars Sinai Medical Center, USA

AUGUST 17 (Thu)

SYMPOSIUM 2

What You Should Know:
How to Maximize the Effects of MIS Fusion

SY02-1

What You Should Know: How to Maximize the Effects of MIS Fusion

Single Position Posterior Instrumentation after Minimally Invasive Lateral Fusion

Worawat Limthongkul

Chulalongkorn University, Thailand

Single lateral position with lateral lumbar interbody fusion (LLIF) is gaining popularity due to lower operation time, length of hospital stays, and blood loss. However, several techniques leading to a successful operation should be addressed. This lecture includes all tips and tricks for a single lateral position LLIF operation. Positioning the patient properly is one of the keys, the patient should be placed closely to the posterior edge of the operating table with proper spinal alignment both coronal and sagittal. Others are also important which will be discussed in the meeting.

SY02-2

What You Should Know: How to Maximize the Effects of MIS Fusion

**Minimizing Radiation Exposure for MIS Spinal Fusion:
Enhancing Safety and Surgical Precision with Technology****Stephen Ryu***Stanford University Medical Center, USA*

Radiation usage is indispensable throughout the care of spine surgery patients, especially minimally invasive approaches. However, this causes a known increase in cancer and other radiation-induced hazards in both patients and surgeons. With more advanced navigation, more common CT imaging, and endoscopic spinal approaches, this radiation exposure is increasing. This presentation will discuss technology designed to minimize radiation exposure in spine surgery. With a focus on patient safety and surgical precision, cutting-edge developments in robotics, navigation systems, artificial intelligence, and novel imaging techniques will be presented that have the potential to revolutionize safe spine care. Low-dose or assistive imaging technologies begin to help achieve a delicate balance between imaging quality and radiation dose. Navigation systems and robotics help surgeons achieve unparalleled accuracy in spinal procedures, reducing the need for frequent intraoperative imaging and thereby minimizing radiation exposure. Non-radiation based imaging can be used to better diagnose fusion targets and inform navigation. The application of computer vision and machine learning algorithms offer real-time surgical guidance and reduce reliance on radiation-based imaging modalities. Artificial intelligence can be used to optimize preoperative planning, intraoperative decision-making, and postoperative care. Through interdisciplinary collaboration and the integration of state-of-the-art technology, we can elevate the standards of care in spine surgery and make a lasting impact on the well-being of our patients and ourselves by mitigating the serious impact of radiation.

SY02-3

What You Should Know: How to Maximize the Effects of MIS Fusion

Improving Lordosis in MIS Fusions - What Strategies Are Available?

Jacob Oh

Tan Tock Seng Hospital, Singapore

SY02-4

What You Should Know: How to Maximize the Effects of MIS Fusion

Expandable Lumbar Interbody Fusion Cages in the Treatment of Spinal Deformity

Charles L. Branch

Wake Forest University School of Medicine, USA

Expandable interbody fusion devices were developed to improve lordosis and sagittal alignment in lateral and posterior approaches to the lumbar spine. Published experience confirms that these can achieve and maintain segmental lordosis. An added value is that expandable devices may achieve coronal balance goals as well. While recent focus has been on the utility in lateral approaches, device development enhances the role for deformity correction in the posterior approach as well.

Recent MIS Deformity correction algorithms (MISDEF 2) suggest that there is a role for expandable cages in MIS approaches as well. We will present clinical cases ranging from two level lumbar degenerative scoliosis, to advanced thoracolumbar scoliosis where selective/segmental use of a novel expandable interbody cage facilitates deformity correction through both open and MIS approaches.

Conclusion - Expandable IF devices are viable options for optimizing or enhancing deformity correction in open and MIS posterior approaches. They are especially useful with posterior MIS approaches as they facilitate single posterior approach deformity correction and stabilization surgery.

SY02-5

What You Should Know: How to Maximize the Effects of MIS Fusion

Use of Various Bone Substitues for MIS Fusion ; Pros and Cons of Each Substitue

Sang-Bum Kim

Chungnam National University College of Medicine, Korea

Over the past decade, there have been significant advancements in minimally invasive surgery (MIS) techniques for spinal procedures, including transforaminal lumbar interbody fusion (TLIF), lateral lumbar interbody fusion, and endoscopic fusion. However, the optimal choice of bone grafts or substitutes for these MIS procedures and the future of spinal arthrodesis still need to be determined.

Bone grafts and substitutes play a crucial role in achieving and maintaining fusion and stability between spinal segments in MIS fusion surgery. Autologous bone grafts have long been considered the gold standard due to their unique micro-architecture and biological properties. They provide a combination of osteoconductive, osteoinductive, and osteogenic potentials. However, the availability of autologous bone grafts is limited in MIS fusion procedures. This demand for alternatives to autologous bone grafts has led to the development of various bone graft substitutes in the industry. Today, spine surgeons have a wide range of options to choose from. It is crucial for surgeons to have a comprehensive understanding of the specific characteristics of these grafts and substitutes, as well as the published clinical and radiological outcomes reported in the contemporary spine literature. This knowledge is essential for the optimal utilization of bone substitutes in spinal surgery.

AUGUST 17 (Thu)

PLENARY LECTURE 1

MIS Surgery for ASD (Adult Spinal Deformity)

PL01-2

MIS Surgery for ASD (Adult Spinal Deformity)

Tailored Modification of Lateral Access Surgery for Minor and Major Spinal Deformities

Jae Chul Lee

Soonchunhyang University College of Medicine, Korea

Adult spinal deformities (ASD) and sagittal plane imbalance have been associated with debilitating back pain, radicular symptoms, and decreased quality of life. Surgical intervention for such deformities has proven to be more cost-effective than non-surgical treatments due to persistent pain and progressive deformity. Traditional open posterior spinal fusion and anterior-posterior spinal fusion, and conventional pedicle subtraction osteotomy (PSO) have been employed to treat these diverse deformities. However, these procedures pose challenges, including extensive soft tissue disruption and significant blood loss, motivating the search for minimally invasive lateral approaches and limited posterior osteotomy techniques.

Traditional posterior corrective surgeries combined with closed wedge osteotomy (Ponte osteotomy, Smith-Peterson osteotomy) and pedicle subtraction osteotomy (PSO) have shown satisfactory correction for adult spinal deformities in the sagittal and coronal planes. Nevertheless, these procedures come with the risk of a significant amount of blood loss and a higher frequency of medical complications leading to prolonged hospital stays. Recently, minimally invasive lateral access surgery and percutaneous pedicle screw fixation have been reported to reduce the occurrence of complications seen in conventional open surgeries. However, these methods are more effective for coronal plane correction but have limitations in correcting sagittal plane deformities. To address this, a novel technique called anterior column realignment, utilizing a minimal approach and employing large cages (typically 20°-30°) or expandable cages after releasing the anterior longitudinal ligament, has been introduced to effectively restore both coronal and sagittal plane corrections. Additionally, the hybrid surgery approach, combining minimally invasive lateral fusion with posterior multilevel wedge osteotomies (Ponte osteotomy, Smith-Peterson osteotomy), is gaining popularity due to its reduced complications and ability to achieve comparable correction angles to the conventional PSO.

In the management of adult spinal deformities, minimally invasive surgery is a promising method. A hybrid approach of minimally invasive lateral interbody fusion and subsequent closed wedge osteotomy in the posterior spine is expected to provide a harmonious improvement in both coronal and sagittal plane deformities while reducing blood loss and complications. This tailored modification of lateral access surgery holds promising potential for achieving superior outcomes in the correction of minor and major spinal deformities.

PL01-2

MIS Surgery for ASD (Adult Spinal Deformity)

Multilevel MIS Lateral Fusion for Adult Spinal Deformity

Neel Anand

Cedars Sinai Medical Center, USA

PL01-4

MIS Surgery for ASD (Adult Spinal Deformity)

Anterior Column Realignment for Adult Spinal Deformity

Juan Uribe

Barrow Neurological Institute, USA

PL01-5

MIS Surgery for ASD (Adult Spinal Deformity)

Comparative Analysis of Clinical and Radiologic Outcome after MIS Correction vs Classic Technique

Jae-Young Hong

Korea University College of Medicine, Korea

Backgrounds and introduction: Oblique lumbar interbody fusion (OLIF) has been proven to be effective in treating lumbar degenerative disorders via indirect decompression. However, its superiority over posterior lumbar interbody fusion remains questionable.

Main body: For surgeons to achieve clinically meaningful treatment of adjacent segment disease, a careful preoperative examination includes an assessment of disk height, vacuum disk phenomenon, and degenerative autofusion in the facet joint. Meticulous intraoperative attention is given to disk space preparation to promote arthrodesis, protection of the cartilaginous endplate to prevent postoperative subsidence, and coronal concavity and osteophyte distribution because these factors can markedly affect disk space access and distraction. Even in ideally selected surgical candidates for LLIF, if the surgeon fails to consider these factors, the likelihood of successful indirect decompression plummets. Failed indirect decompression causes the patient to experience persistent postoperative low back pain from ongoing canal stenosis or radiculopathy because of inadequate lateral recess or neural foramina decompression. It remains unclear which patients experience clinically significant failed indirect decompression.

Conclusion: To determine the appropriate treatment options for adjacent segment lumbar spinal disease, surgeons have to know the indications of single DLIF or OLIF.

PL01-6

MIS Surgery for ASD (Adult Spinal Deformity)

Utilization of Neuromonitoring and Its Clinical Significance in MIS Deformity Surgery

Jae Taek Hong

The Catholic University of Korea College of Medicine, Korea

AUGUST 17 (Thu)

SYMPOSIUM 3

Current Issues of Deformity Surgery

SY03-1**Current Issues of Deformity Surgery****Adult Deformity with OLIF51****Yoshihisa Kotani***Kansai Medical University Medical Center, Japan*

Background: The advantage of oblique lateral interbody fusion at L5/S1 (OLIF51) has been reported as a minimum invasiveness, high fusion rate, superior anterior support and larger segmental lordosis creation. We have started OLIF51 surgery since 2015 and experienced over 200 cases for degenerative and deformity surgeries. In this presentation, we will report the clinical outcome and radiologic alignment of adult spine surgeries with OLIF51 when compared to those with L5/S1 TLIF cases (51TLIF), thereby clarifying the advantages and disadvantages of OLIF51 in deformity surgeries.

Methods: One hundred and fifteen patients received minimally invasive combined anterior and posterior correction surgery with OLIF25 since 2019. The average age at surgery was 76 years old (54-86). Eighty-two cases of 51TLIF received an eighteen-degree lordotic cage and combined percutaneous and mini-open hybrid posterior fusion. The OLIF51 group received circumferential MIS procedure with ten-to-eighteen-degree lordotic cage and all percutaneous screw correction. The evaluated parameters included a total operation time (OT), estimated blood loss (EBL), local and global radiologic alignments of spine and pelvis, JOABPEQ effectiveness rates, VAS and complications.

Results: The average follow-up period was 35 months (17-51). The average fused segment was eight. The average OT was 481 and 430 mins in 51 TLIF and OLIF51 group respectively (NS). The average EBL was 635 and 512 ml in 51 TLIF and OLIF51 group respectively (NS). LL (Pre/Fup) was 7.6/45.4 and 8.9/47.8 degrees respectively (NS). The PILL at follow-up was 6.9 and 0 degrees respectively, which was significantly different at $P=0.01$ level. LLL at follow-up was 28.8 and 34.9 degrees which was significantly different at $P=0.01$ level. The segmental lordosis (Pre/Fup) was 10.5/16 and 11/20.4 ($P<0.01$) and the coronal tilt was 4.3 and 2.3 degrees respectively ($P<0.01$). The JOABPEQ and VAS demonstrated significant improvements in both groups. PJK was reported in 13% and 8% respectively (NS) and implant failures in 5% and 8% respectively (NS).

Discussion: The introduction of OLIF51 in adult deformity surgery led to further improvement of surgical invasiveness and sagittal and coronal alignment correction. The harmonious lumbosacral lordosis was established according to LLL over 70% creation. The OLIF51 serves as a safe and effective modality in terms of minimum invasiveness and three-dimensional deformity correction.

SY03-2

Current Issues of Deformity Surgery

Minimally Invasive Techniques to Reduce Morbidity and Improve Alignment**Sam Yeol Chang***Seoul National University College of Medicine, Korea*

The surgical goal for ASD is to achieve harmonious spinal alignment within acceptable ranges for radiological parameters. However, surgical correction of ASD is associated with high rates of major complications and related reoperations. Therefore, minimally-invasive surgery (MIS) is more than important to reduce surgical morbidity and improve clinical outcomes in ASD patients.

Essential components of MIS techniques for ASD are 1) minimally-invasive lateral lumbar interbody fusion (LLIF) techniques including anterior column realignment (ACR), 2) mini-open posterior osteotomies, and 3) percutaneous pedicle screw fixations (PPF) assisted by the stereotactic navigation and robotics. These surgical techniques can be applied in various combinations depending on the patient's deformities. The circumferential MIS(cMIS) for ASD refers to the combination of LLIF of ACR with PPF. When posterior open surgery, including posterior osteotomies, is performed, it is referred to as a hybrid surgery. In previous studies comparing the clinical and radiological outcomes of cMIS and hybrid surgery, early reoperations and postoperative infections were more common in hybrid surgery, while proximal pseudarthrosis is a concern for patients who underwent cMIS.

Various decision-making systems have been developed to aid spine deformity surgeons decide which surgical techniques should be selected for each ASD patient. The original minimally invasive spinal deformity surgery (MISDEF-2) algorithm divides ASD patients into four classes according to the severity and rigidity of the deformity and suggested different surgical approaches for each group. The minimally-invasive interbody selection algorithm(MIISA) is another system that helps surgeons to decide which interbody fusion technique to be applied on each lumbar level. Novel technologies, such as stereotactic navigations, robotics, and patient-specific rods, can also facilitate MIS for ASD. These techniques are not minimally invasive by themselves, but they can improve the accuracy and consistency of MIS techniques.

The ever-evolving MIS techniques can improve surgical outcomes of ASD patients by reducing morbidity while providing a sufficient radiological correction. Not only the surgical techniques but also the decision-making systems that incorporate these techniques are bringing significant differences in the state-of-the-art management of ASD.

SY03-3

Current Issues of Deformity Surgery

ACR for Treating Deformities

Michael Y. Wang

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SY03-4

Current Issues of Deformity Surgery

MIS (Thoracoscopy) in Pediatric Scoliosis with Tethering

Massimo Balsano

University and Hospital Trust, Italy

Introduction: Vertebral Body Tethering (VBT) is a relatively novel surgical technique used to correct pediatric idiopathic scoliosis through an anterior thoracic approach for mid-thoracic curves and a retroperitoneal lumbar approach for thoracolumbar/lumbar curves. The system employs screws on the convex side of the curve joined with a polyethylene terephthalate (PET) rope. The aim of this study is to determine the degree of three-dimensional curve correction achieved through VBT.

Materials and Methods: We included 39 patients treated with the VBT between 2020 and 2022. Preoperative and at one-month follow-up radiographic parameters were collected. SRS-22 and SF-36 questionnaires were administered.

Results: The analysis revealed an improvement in the coronal plane correction of all curves: PT (-24.67%, $p < 0.01$), MT (-32.97%, $p < 0.01$), TL/L (-43.48%, $p < 0.05$). In addition we also found a derotation in the MT curves measured by the NASH-MOE system (-16.67%, $p < 0.05$). Other statistically significant post-operative improvements were observed in AVT (Apex Vertebral Translation), CL (Clavicle Angle), and trunk height (T1-L1). The questionnaires (SRS-22 and SF-36) also showed a significant improvement at the six-months follow-up.

Conclusions: VBT, by avoiding arthrodesis, can enhance the quality of life of patients with AIS. Our study suggests that this technique directly correct the coronal and axial planes, potentially competing with more established instrumentation techniques.

SY03-5

Current Issues of Deformity Surgery

Optimizing Value in Adult Spinal Deformity Surgery

Han Jo Kim

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AUGUST 17 (Thu)

SYMPOSIUM 4

MIS Fusion: What's New? What's Coming?

SY04-1

MIS Fusion: What's New? What's Coming?

Adjacent Segmental Pathology after Minimally Invasive TLIF - 1, 2, 5 and 10 Years Follow-Up

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Background: To reduce the risk of adjacent segment pathology (ASP) after spine fusion surgery, numerous surgeons worldwide are continuously developing methods to minimize its incidence. One such method is minimally invasive transforaminal interbody fusion (MI-TLIF). Open transforaminal interbody fusion (TLIF) involves significant dissection of the paravertebral musculature and disruption of the posterior tension band effect created by the interspinous and supraspinous ligaments, resulting in increased morbidity and slower recovery times. Comparably, MI-TLIF has been shown to reduce the incidence of adjacent segment disease (ASP) by minimizing surgical invasiveness and damage to muscles and soft tissues, decreasing the instability and load on adjacent segments. Factors such as age, gender, BMI, ASA status, smoking, treatment level, cranial facet violation, preoperative adjacent disc degeneration, and postoperative sagittal alignment are associated with the occurrence of early adjacent segment pathology (ASP) after surgery, and numerous studies have been conducted on this topic. However, there is a need for long-term studies spanning over ten years, and little research has been conducted on which factors influence the development of ASP after MI-TLIF surgery. Considering these factors, we aimed to analyze the incidence of ASP in MI-TLIF compared to open TLIF and investigate the factors that influence the occurrence of ASP after MI-TLIF.

Methods: This retrospective study reviewed the outcomes of patients who underwent transforaminal lumbar interbody fusion through a minimally invasive or open approach. ASP was classified as radiological, clinical, or surgical. Firstly, radiographic ASP (RASP) was evaluated using X-ray imaging to distinguish between degenerative changes, spondylolisthesis, and instability in the adjacent spinal segment. Second, clinical ASP (CASP) was analyzed using a visual analog scale (VAS) score for leg and back pain. Finally, the timing and frequency of reoperation for ASP was analyzed. Patient data were collected 1, 2, 5, and 10 years after surgery.

Results: At the 10-year follow-up, reoperation because of ASP was performed in 14 patients (12.9%) in the MI-TLIF group and 9 (21.4%) in the open TLIF group ($p = 0.072$). The univariate logistic regression analysis revealed that cranial facet violation significantly affected ASP in the MI-TLIF group ($OR=1.375$, $95\% CI=0.343-5.507$). In the open TLIF group, cranial facet violation ($OR=3.444$, $95\% CI=0.47-25.231$) and preoperative adjacent segment disc degeneration ($OR=1.667$, $95\% CI=0.329-8.434$) were further found to influence ASP significantly. However, no significant effects were observed for the other parameters or clinical data.

Conclusions: Overall radiological, clinical, and surgical ASP after surgery was lower after MI-TLIF than open TLIF. Cranial facet violation is a crucial factor that can cause ASP after MI-TLIF.

SY04-2**MIS Fusion: What's New? What's Coming?****Minimally Invasive Lateral Fusion or OLIF...Which Is Best?****Richard Hynes***The B.A.C.K. Center, USA*

Background: MIS Lateral fusion has experienced an ongoing progressive success over past 15-20 years since the introduction by Dr. Luis Pimenta. OLIF, the anterior to psoas (ATP) method was introduced soon after the initial transmuscular approach and over time there has been debate attempting to discern which surgical approach is best. This presentation aims to describe the additive benefits of OLIF in MIS Lateral fusion, implications of elimination of the "flip" as Lateral fusion evolves and opening the opportunity for simultaneous access, hence, simultaneous manipulation of 3 columns of the spine described by Francis Dennis.

Method: Historical benefits of OLIF, relevant publications and long term results of complications and success will be reviewed. A feasibility study will be described with demonstration of the safety and efficacy of modulation of the classic "flip", Single Position Surgeon (SPS) and contrast this method to current methods of Single Position Lateral (SPL) and recently introduction of Single Position Prone (SPP).

Results: OLIF is a safe and reproducible method of approach in MIS Lateral fusion with hundreds of peer reviewed publications. OLIF includes the L5S1 Level, requires no neuromonitoring with patient relaxation of muscle during approach in addition to the excellent benefits of the initial transmuscular approach. OLIF using (SPS) method demonstrates safety and efficacy in initial 462 patients studied with no compromise in surgical options when compared to (SPL) and (SPP).

Conclusion: OLIF and LLIF methods are effective MIS Lateral fusion surgical approaches. The MIS lateral fusion is dramatically enhanced by the established surgical patient positioning methods including (SPL), the evolving, (SPP) with introduction of (SPS). All three methods to improve the classic "flip", save cost and time. All three methods facilitate Simultaneous Access and the opportunity for Simultaneous Manipulation of 3 columns of Spine as described by Francis Dennis.

Keywords: OLIF (Oblique Lumbar Interbody Fusion), LLIF (Lateral Lumbar Interbody Fusion), SPS (Single Position Surgeon), SPL (Single Position Lateral), SPP (Single Position Prone), Simultaneous Access, Simultaneous Manipulation

SY04-3**MIS Fusion: What's New? What's Coming?****Advancement of Intervertebral Cage Technology ; How Did It Impact MIS Fusion?****Tae-Keun Ahn***CHA University School of Medicine, Korea*

The use of intervertebral cages has had a significant impact on MIS fusion procedures. With the advancement of interbody cages, surgeons are able to achieve a more stable fusion with a smaller incision. This results in less tissue damage, reduced blood loss, and a quicker recovery time for the patient. Furthermore, the use of advanced cages has allowed for a more minimally invasive approach to spinal fusion surgery, which has become increasingly popular in recent years.

The earliest interbody fusion cage is hollow, threaded, and cylindrical interbody fusion cage. It has advantage of being easy to implant but has been eliminated due to the disadvantages of having to drill into the intervertebral space, which can seriously damage the endplate and increase the settling rate. Up to now, the shape design of mainstream interbody cage is similar to the shape of the intervertebral space, with larger cancellous bone filling space, larger fusion area, better load carrying capacity and better stability.

In MIS transforaminal interbody fusion (TLIF), regarding cage shape, there have been common designs of cages, such as straight, banana, or bullet-shaped. These types of cages allow for ergonomic placement during minimally invasive approaches. Recently, there has been exploration of expandable cages, which may flatten the learning curve in minimally invasive approaches as they require less formal exposure. Expandable cages have a slim profile that allow for in situ expansion and a more customized fit.

In MIS anterior or lateral interbody fusion, the approach provides wide access to the lateral aspect of the disc, allowing extensive discectomy and the placement of an interbody cage with a large footprint. The early lateral interbody cage with a cylindrical shape was not able to provide as much stability as the intact spine. Cylindrical cages likely provide limited stability since there is limited implant-endplate contact area to resist motion. In contrast, the rectangular lateral interbody spacers provide much greater implant-endplate contact area, which blocks motion and hence gives greater stability. Therefore, rectangular-shaped lateral interbody cages are widely used.

At present, the main components of the most widely used interbody fusion cage are Ploy-ether-ether-ketone and titanium. In order to improve the biomechanical characteristics and fusion rate, cutting-edge technology is applying to interbody cages through modification of material, internal structure with increased porosity and surface coating with osteointegrative materials.

In conclusion, the advancements in intervertebral cage technology have had a significant impact on MIS fusion procedures. The use of advanced cages has increased the success rate of the surgeries and has allowed for a more minimally invasive approach to spinal fusion surgery, resulting in less tissue damage, reduced blood loss, and improved fusion rate for the patients.

SY04-4**MIS Fusion: What's New? What's Coming?****L5/S1 OLIF ; Technical Consideration and Application****Seung Won Park***Chung-ang University College of Medicine, Korea*

Lateral lumbar interbody fusion (LLIF) is a minimally invasive technique (MIS) approaching retroperitoneal space targeting L1-L5 levels. However, transforaminal interbody fusion, posterolateral interbody fusion, and anterior lumbar interbody fusion are the traditional and principal techniques for interbody fusion at L5-S1. Recently, oblique lateral interbody fusion at L5-S1 (OLIF51) was introduced as a new alternative minimally invasive technique.

The approach starts with a skin incision at the left lower abdominal wall in a right lateral decubitus position. After blunt dissection of the three abdominal muscle layers and the retroperitoneal space, expose the L5-S1 disc, the left common iliac vein, and the right common iliac artery. Discectomy and endplate preparation are done with retraction of the vessels, and a proper cage filled with graft material is inserted into the disc space in an oblique direction. Posterior percutaneous fixation is performed for posterior support.

Indications are the same as other types of interbody fusion techniques. Acute infection and previous operation history at the retroperitoneal space are contraindications. Advantages include increased stability using a wide cage, less bleeding, and effective indirect foraminal decompression. The OLIF51 can make a high lordotic angle by using a cage with a high angle, up to 24°. The patient position is the same as in the LLIF for the other lumbar spine levels, making it possible to do a long-level lumbosacral interbody fusion in a single position. There may be intraoperatively bleeding from the common iliac vein, which can be prevented by careful dissection. There was no major complication.

The OLIF51 is a safe MIS procedure providing effective indirect decompression, strong mechanical stability, and a greater lordotic angle at L5-S1.

SY04-5

MIS Fusion: What's New? What's Coming?

Complication Avoidance and Management in MI-TLIF

Weerasak Singhatanadgige

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Despite advances in minimally invasive lumbar interbody fusion (MI TLIF) over the past decade, Complications are still problematic and results in patient morbidity. Common complications include early complications (Such as neurological deficit, dural tear, contralateral radiculopathy, infection and K wire complication Etc.) and delays complications (Such as pseudarthrosis, subsidence and cage migration). Prevention and treatment of these complication is very crucial for patient outcome.

AUGUST 17 (Thu)

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BEST PAPER 1

BP01-01

Pediatric Spine

Can We Control Lateral Shoulder Balance Through Proximal Thoracic Curve Correction in Lenke Type 2 Adolescent Idiopathic Scoliosis?Hyung Rae Lee¹ and Chang Ju Hwang^{2*}¹ Orthopedic surgery, Uijeongbu Eulji Medical Center, Korea² Orthopedic surgery, Seoul Asan Medical Center, Korea

Background: Proximal thoracic curve (PTC) correction has been considered to prevent lateral shoulder imbalance in Lenke Type 1 and 2 AIS patients; however, PSI has been still very common despite these strategies with PTC correction. In this study we investigated the hypothesis that PTC correction would not directly affect postoperative shoulder imbalance (PSI) in the majority of Lenke Type 1 and 2 AIS cases. Furthermore, we attempted to find risk factors for lateral PSI following corrective surgery in patients with Lenke 1 and 2 AIS.

Methods: This is a retrospective study in which we examined the records for AIS patients with Lenke type 1 and 2 who underwent corrective surgery and followed up more than 2 years. Various radiological parameters were collected using whole-spine radiographs. We categorized patients into PSI (-); radiologic shoulder height (RSH) < 15mm and PSI (+); RSH \geq 15mm. Repeated measures ANOVA was performed at preoperatively, postoperatively, 1 month, and final follow up. Predictors of postoperative lateral shoulder imbalance were identified by univariate analysis; multivariate analysis was performed.

Results: One hundred fifty-one patients were reviewed. Twenty nine (19.2%) showed PSI at final follow up. Lateral shoulder balance parameters showed different directionalities between PSI (-) and (+) groups at postoperatively, 1 month, and final follow up ($P < 0.01$ each) (Figure 1). Preoperative PT curve, MT curve, and MT correction showed strong correlations with the RSH ($P = 0.007, 0.027,$ and $0.039,$ respectively). On the other hand, PT correction did not show significant correlation with the RSH (Figure 2). Further, only smaller MT curve and larger MT correction were related to increase RSH after corrective surgery in multivariate analysis (Table 1).

Conclusions: In Lenke type 1 and 2 AIS curves, only MT curve and its correction could affect lateral shoulder imbalance after corrective surgery regardless of PT correction amount. This suggests that it may not be meaningful to adjust excessively for correction of PT curve to achieve lateral shoulder balance. When MT curve is small, surgeons should be careful of MT overcorrection leading to lateral shoulder imbalance.

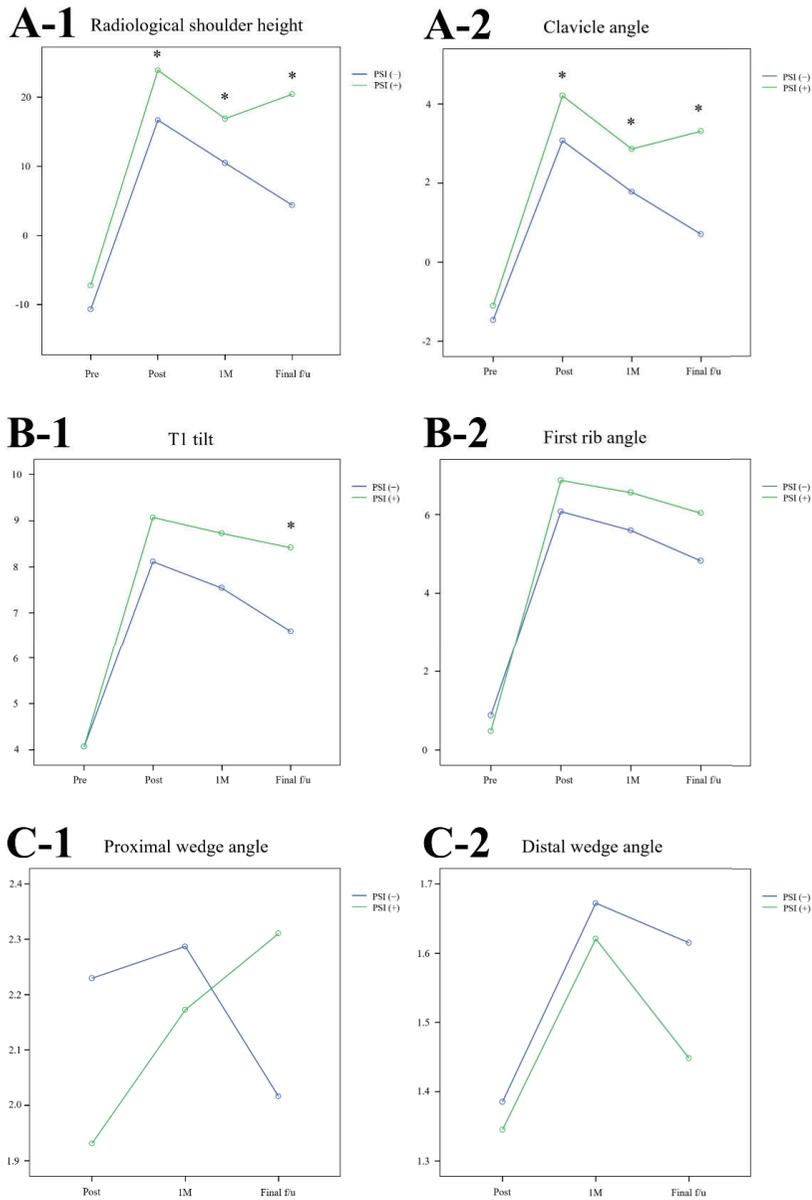


Figure 1. Radiologic parameters over time after correctional surgery in AIS patients with PSI (-) and PSI (+). (A) Radiological shoulder height and clavicle angle, (B) T1 tilt and first rib angle, and (C) Proximal wedge angle and distal wedge angle
 AIS, adolescent idiopathic scoliosis; PSI, postoperative shoulder imbalance
 * Statistically significant difference at each time point. (P < 0.01)

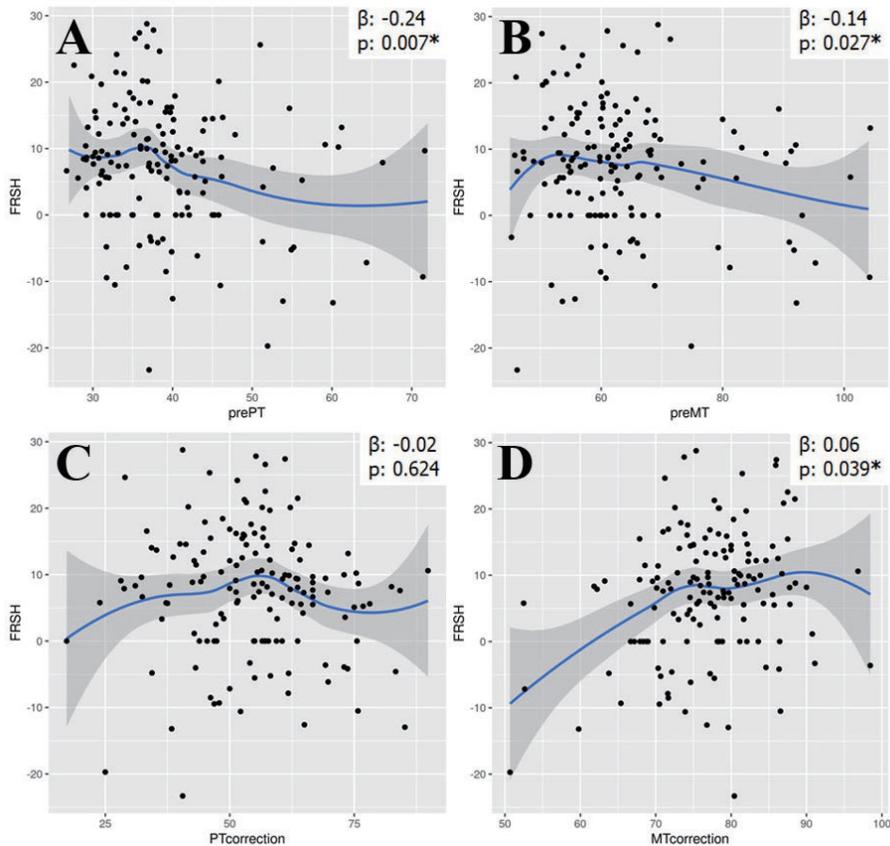


Figure 2. Scatter plots showing the relationship between final RSH and (A) pre PT curve, (B) pre MT curve, (C) PT correction, and (D) MT correction
 RSH, right shoulder height; PT, proximal thoracic; MT, middle thoracic
 * $P < 0.05$.

Table 1. Univariate and multivariate linear regression analysis for right shoulder depression after correctional surgery in patients with AIS lenke type I and II

Variable	Univariable				Multivariable				
	Beta	SE	t	p-value	Beta	SE	t	p-value	
Preoperative PT (proximal thorax curve), °	-0.23818	0.08792	-2.71	0.0075*	45.05853				
Preoperative MT (middle thorax curve), °	-0.13522	0.0605	-2.24	0.0269*	38.65625	-0.14862	0.05844	-2.54	0.012*
Preoperative PT/MT, %	-5.61109	6.93541	-0.81	0.4198	28.61039				
Flexibility (by prone), %	-0.00721	0.1107	-0.07	0.9481	1.94309				
Flexibility (by passive), %	-0.06865	0.082	-0.84	0.4038	1.60798				
Preoperative shoulder balance									
T1 tilt, °	-0.21389	0.15005	-1.43	0.1561	5.30055				
1 st rib angle, °	-0.13029	0.17795	-0.73	0.4652	5.48956				
Clavicle angle (clavicle pre), °	0.32702	0.34131	0.96	0.3395	2.84044				
RSH (preoperative), mm	0.04502	0.06696	0.67	0.5024	2.31867				
Correction									
PT correction: (PT_pre - PT_post)/PT_pre*100, %	-0.02864	0.05824	-0.49	0.6237	21.87404				
MT correction: (MT_pre - MT_post)/MT_pre*100, %	0.06107	0.02941	2.08	0.0396*	15.52155	0.10671	0.02878	3.71	0.0003*
PT correction/MT correction	-11.13	5.66314	-1.97	0.0512	31.97969				

AIS, adolescent idiopathic scoliosis; RSH, radiological shoulder height; PT, proximal thoracic; MT, middle thoracic

* $P < 0.05$.

BP01-02

Pediatric Spine

Rotational Changes Following Use of Direct Vertebral Rotation in Adolescent Idiopathic Scoliosis

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Introduction: Direct vertebral rotation (DVR) using thoracic pedicle screws, a rotational corrective maneuver used in the surgical treatment of adolescent idiopathic scoliosis (AIS), was introduced in 2004. Although DVR is considered to be a main corrective maneuver for vertebral rotation, the long-term rotational changes of vertebra are still unknown in AIS. Therefore, this study is to evaluate long-term rotational changes of vertebra in AIS patients who underwent DVR

Methods: A total of 135 vertebra which underwent DVR using thoracic pedicle screws with minimum 5-year follow-up were retrospectively assessed for vertebral rotation angle. Vertebral rotation of the proximal end vertebra (EV), apical vertebra (AV), and distal EV was evaluated using the Nash-Moe scale, the rotational angle to the sacrum (RASac), and the Aaro and Dahlborn method.

Results: The mean Nash-Moe scale of distal EV showed statistically significant differences between preoperative and postoperative values ($P = 0.034$) and no statistically significant difference between postoperative and last follow-up values ($P = 1.000$), in a Bonferroni post-hoc analysis. The last follow-up RASac of AV did not differ significantly from preoperative RASac of AV ($P = 0.515$). The last follow-up RASac of distal EV significantly lower than preoperative RASac of distal EV ($P = 0.001$). Pearson's correlation analysis showed that the last follow-up RASac of distal EV were correlated with Cobb angle of main curve ($r = 0.459$, $P = 0.004$), loss of correction ($r = 0.541$, $P = 0.001$), and LIV tilt angle ($r = 0.504$, $P = 0.001$)

Conclusions: The rotation regression phenomenon in AV and rotation maintenance in distal EV were observed after DVR for a 10-year follow-up. These findings suggest that the DVR in the surgical treatment of AIS has a positive long-term effect on the stabilization of distal EV in the point of view of axial rotation.

BP01-03

Adult Spinal Deformity

Time-dependent Changes in Stiffness-related Functional Disability (SRFD) after Long Segmental Fusion in Elderly Patients with Adult Spinal Deformity - Minimum 2-year Follow-up Results -

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Background: Stiffness-related functional disability (SRFD) is a frequently encountered problem after long-segmental fusion in patients with adult spinal deformity (ASD). Although several studies were performed to measure SRFD after fusion surgery, the evaluation of SRFD was done at a single point in time. We do not know whether the disability will stay the same, worsen or improve over time. Therefore, the primary aim of this study was to evaluate the time-dependent trend of SRFD after long segmental fusion for ASD. The second aim was to look for any factors affecting the time-dependent change in SRFD.

Methods: In this retrospective observational study, 116 patients with 60 years and older who underwent more than 4-segment fusion from the sacrum for ASD were included. All patients in this study could be followed up more than 2 years and completed Specific Functional Disability Index (SFDI) questionnaire at all designated time points. SFDI consists of 4 categories (sitting on the floor, sanitation activities, lower body activities, and moving activities), each containing three questions, making a total of 12 components of the questionnaire. The SFDI scores taken at 3 months, 1 year, 2 years postoperatively, and at the last follow-up were used for the analysis. The changes in scores for each item, category, and total sum of SFDI were evaluated at these time intervals. Generalizing estimating equation (GEE) analysis was done to identify any factors which affect time-dependent changes in SFDI scores. Pearson's correlation test was done to find any correlation between the time-dependent changes in sagittal parameters and SFDI.

Results: Total sum of SFDI scores significantly improved from 32.8 at 3 months to 29.0 at the last follow-up. Among the four categories of SFDI, sitting on the floor category showed the highest scores followed by lower body activities, sanitation activities and moving activities at all time points of the study. All category except for sitting on the floor showed significant improvement from 3 months until the last visit. Among the 12 items of SFDI, eight showed significant improvements at the last visit when compared to scores at 3 months and this improvement was most pronounced between 3 months and 1 year postoperatively. Patients with lower American Society of Anaesthesiologists (ASA) grades experienced more improvement in moving activities and total sum of SFDI. However, there was no correlation between the changes in radiographic parameters and changes in SFDI.

Conclusion: SRFD was highest at 3 months postoperatively, but it improved over time until the last follow-up except for sitting on the floor category. The improvement was observed greatest between 3 months and 1 year postoperatively. Patients with less ASA grade experienced more improvement in SFDI. However, there was no correlation between the changes in radiographic parameters and those in SFDI.

(A) SITTING ON THE FLOOR



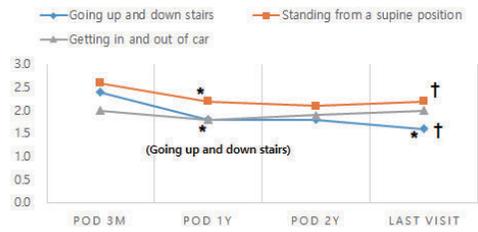
(B) SANITATION ACTIVITIES



(C) LOWER BODY ACTIVITIES



(D) MOVING ACTIVITIES



BP01-04

Adult Spinal Deformity

Selective Thoracolumbar Fusion in Adult Spinal Deformity (ASD) Double Curves with Circumferential Minimally Invasive Surgery (CMIS): 2-year Minimum Follow Up

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Background: CMIS correction for ASD with double curves has typically been reserved for very experienced surgeons or considered for open surgery under recent MISDEF-2 criteria. Further, level selection for adult spinal deformity remains controversial. While selective fusion attempts have been described for fractional curves or adolescent curves, no authors have described selective thoracolumbar fusion performance for ASD with double curves. This study evaluates the performance of selective thoracolumbar fusion for ASD double curves and investigates the compensatory response of the uninstrumented thoracic spine.

Methods: We retrospectively reviewed our adult spinal deformity (Cobb>20, SVA>50mm, (PI-LL)>10) database of 438 patients who underwent CMIS correction between the years 2007 and 2020. Inclusion criteria were ASD double curves (lumbar cobb >35 degrees and thoracic cobb >30 degrees), four or more levels fused, and minimum 2-year follow up. We assessed radiographic data (lumbar cobb, thoracic cobb, coronal balance, lumbar lordosis, thoracic kyphosis) as well as spinopelvic parameters (PI, PT, SS) both pre- and post-operatively. We also assessed pre- and post-intervention clinical data (VAS, ODI, SRS22, and SF36). Complications were recorded.

Results: Twenty-one ASD double curve patients underwent selective thoracolumbar correction with a mean follow up of 91 months (24-174 months, SD 43). A total of 141 levels were fused with a mean of 6.7 levels fused (4-8, SD 1.3). T10 was the most proximal and most common UIV (10/21, 48%). Pelvic fixation was performed in 12 patients (57%). Statistically significant improvements in lumbar cobb, thoracic cobb, coronal balance, lumbar lordosis, thoracic kyphosis, SVA, and PI-LL mismatch were achieved. The uninstrumented thoracic spine had a mean of 14.5 degrees of coronal correction and a mean increase of 9.4 degrees of kyphosis. Statistically significant improvements in VAS and ODI were observed. Four patients required revision surgery, which included the following: (1) a superficial wound infection requiring irrigation and debridement, (2) bilateral L5 pars fractures requiring L5-S1 ALIF and pelvic fixation, (3) adjacent segment degeneration at L5-S1 requiring ALIF and pelvic fixation, and (4) one patient developing proximal junctional kyphosis (PJK) requiring revision fusion to include the entire thoracic curve.

Conclusions: Selective CMIS thoracolumbar fusion for ASD patients with double curves can provide significant clinical improvements. Despite limiting fusion constructs to the lower thoracic and/or lumbar spine, significant correction can be observed in the uninstrumented thoracic curve. Mechanical related complications were low, but inclusion of the lumbosacral junction may limit revision surgery.

Radiographic Data

	Pre-op	Post-op	P Value
Lumbar Cobb Angle	51.5 35-74.7 SD 11.4	19.2 1.3-48.2 SD 12.7	<0.05
Thoracic Cobb Angle	42.7 30-57 SD 10.1	28.2 4-42 SD 11.8	<0.05
Coronal Balance	29.3 12-69.8 SD 16.4	12.5 0-22 SD 7.7	<0.05
Lumbar Lordosis	36.5 9.1-64 SD 15.9	46.6 24-59.1 SD 8.8	<0.05
Thoracic Kyphosis	33.7 9-59 SD 12.9	43.1 29.7-61 SD 8.2	<0.05
SVA	49.3 27.6-114.7 SD 39.2	18.9 5-69.2 SD 17	<0.05
PI-LL Mismatch	19.9 4.3-49.5 13.1	10.8 0.1-47.3 11.5	<0.05
PI	53.8 39.3-74.1 SD 8.9	52.6 40.1-71.3 SD 8.7	>0.05
PT	26.6 13.3-38 SD 8.5	23.8 3.1-39.1 SD 9.7	>0.05
SS	26.8 12-48.6 SD 11	29.9 16.4-42.7 SD 6.6	>0.05

Complications:

Hardware Failure (loosening of the left S1 screw cap is noted)	Was noted on 2m postop, but stable with no change in alignment, nothing was done
Hardware loosening (Bilateral pars fractures, L5)	Was noted on 5yr post op: L5-S1 OLF and L4 to pelvis posterior instrumentation and Placement of bilateral iliac screws
PIK found on 15m	Posterior revision instrumentation and fusion T4-L3
Wound Infection	I&D 2wk postop
Adjacent Segment Degeneration (Facet arthropathy noted at L5-S1)	Note on 12yr postop: a L5-S1 anterior lumbar interbody fusion with L3-pelvis posterior instrumentation and fusion with L3-S removal of hardware was recommended (not done yet)

Clinical Data

	Preop	3m postop	Last FU	P value
VAS	5.4 2-10 SD 2.5	2.4 0-8 SD 2.9	2 0-7 SD 2.7	<0.05
ODI	44.2 13.3-80 SD 19.4	27 0-72 SD 22.7	21.3 0-60 SD 20.2	<0.05
SRS 22	3 2.1-3.7 SD 0.5	3.5 2.2-4.5 SD 0.9	3.9 2.4-4.8 SD 0.8	>0.05
SF 36	42.1 16-98 SD 21.5	48.5 10-96 SD 23.4	49.9 20-70 SD 17	>0.05

BP01-05

MIS

Stable Long-term Regional and Global Alignment in Patients Treated with Minimally Invasive Lateral Retropleural Thoracic Discectomy Without Fixation

Steve Cho¹, S.Harrison Farber¹, James Zhou¹, Nima Alan¹, Laura Snyder¹, Jay Turner¹ and Juan Uribe¹

¹ Neurosurgery, Barrow Neurological Institute, USA

Background and Objective: Thoracic disc herniations are challenging to treat, and open transthoracic or minimally invasive thoracoscopic approaches are associated with significant morbidity, cost, and steep learning curves. The minimally invasive lateral retropleural thoracic discectomy (MIS-LRP-TD) approach is straightforward and is associated with lower perioperative morbidity. With MIS-LRP-TD, the overlying rib, ipsilateral pedicle, ligamentum flavum, posterior longitudinal ligament, and posterior one-third of the adjacent vertebral bodies are resected. Adjunct fixation is typically not performed, eliminating hardware-related complications and costs. This radiographic study investigates long-term global and thoracic spine alignment after MIS-LRP-TD without fixation.

Methods: This study was a single-institution, retrospective evaluation of all patients who underwent MIS-LRP-TD without fixation between 11/7/2017 and 7/19/2022. Preoperative and the most recent postoperative radiographs were used to determine the C7 plumb line to central sacral vertical line (C7PL-CSVL), thoracic Cobb angle (TCA), segmental Cobb angle (SCA), C7 to sagittal vertical axis (C7-SVA), thoracic kyphosis (TK), and segmental kyphosis (SK).

Results: In total, 22 patients with 24 disc herniations underwent MIS-LRP-TD without fixation. The mean (SD) radiographic follow-up was 11.4 (11.7) months. Overall, no significant differences were seen in C7PL-CSVL (P=0.65), C7-SVA (P=0.99), TK (P=0.30), TCA (P=0.28), SK (P=0.27), or SCA (P=0.56) at follow-up. One patient demonstrated a >5° change in TCA but remained asymptomatic.

Conclusion: Despite requiring extensive resection of the middle column and ipsilateral costovertebral joint at the index level, MIS-LRP-TD without adjunct fixation does not lead to significant global, regional, or segmental deformity. Thus, MIS-LRP-TD appears to be a safe, effective treatment approach for challenging thoracic disc herniations.

Table 1. Radiographic data for 22 patients who underwent MIS-LRP-TD*

Parameter	Preoperative	Postoperative	P-value
Sagittal view			
C7-SVA, cm	1.91 (4.84)	1.92 (4.19)	0.99
Thoracic kyphosis, °	40.4 (12.0)	41.5 (11.3)	0.30
Segmental kyphosis, °	9.19 (3.70)	8.00 (6.78)	0.27
Coronal view			
C7PL-CSVL, cm	-0.34 (0.88)	-0.2 (1.2)	0.65
Thoracic Cobb angle, °	1.56 (6.81)	0.7 (6.72)	0.28
Segmental Cobb angle, °	0.81 (1.99)	1.17 (2.74)	0.56

*All values are shown as mean (SD)

Abbreviations: C7-SVA, C7 to sagittal vertical axis; C7PL-CSVL, C7 plumb line to central sacral vertical line; MIS-LRP-TD, minimally invasive lateral retropleural thoracic discectomy; SD, standard deviation.

Figure 1. Case illustration 1: A patient in their late 50s with type 1C herniation of the T11-12 disc. **(A)** Preoperative sagittal and axial magnetic resonance (MR) and computed tomographic (CT) images show a small, calcified paramedian herniation. **(B)** The patient’s preoperative plain radiographs show a thoracic Cobb angle of -0.3° and thoracic kyphosis of 41.2° , with a segmental Cobb angle of -1.8° and segmental kyphosis of 14.7° at the T11-12 operative level. **(C)** The immediate postoperative sagittal and axial MR and CT images of the thoracic spine show the extent of bony resection and cord decompression obtained during the right-sided MIS-LRP-TD at T11-12. **(D)** One-year postoperative plain radiographs show no significant changes to the thoracic or segmental Cobb angles and kyphosis. **(E)** Five-year postoperative plain radiographs show a slight increase in the segmental kyphosis at T11-12 but no significant changes in the thoracic or segmental Cobb angles.



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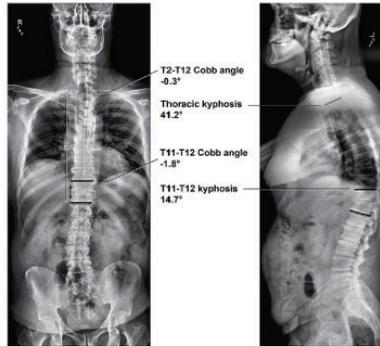


Fig 01B.tif



Fig 01C.tif

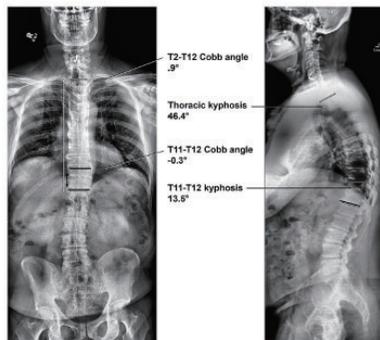


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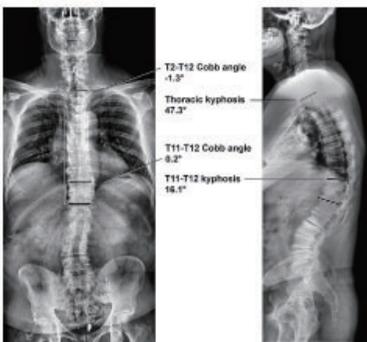


Fig 01e.tif

BP01-06

MIS

Advancements in Cervical Myelopathy Treatment: Exploring Minimally Invasive Laminoplasty through Comparative AnalysisWataru Narita¹, Tomohisa Harada¹ and Kanji Sasaki²¹ Kameoka Municipal Hospital, Director, Spine Center, Japan² Rakuwakai Marutamachi Hospital, Department of Orthopaedic Surgery, Japan

Purpose: Postoperative axial pain and decreased cervical spine function are often problematic after laminoplasty for cervical myelopathy. To address these issues, we perform minimally invasive surgery using a small skin incision. The procedure involves a mid-cervical position with a 3-4 cm skin incision, limited muscle dissection, and use of custom retractors and a titanium spacer. C2 muscle dissection is minimized, and no C7 muscle dissection is performed. We also employ extended reality (XR) as an adjunct. This study aims to evaluate postoperative cervical spine function following minimally invasive surgery.

Materials and Methods: We included 52 patients (30 males, 22 females) who underwent the minimally invasive procedure at our institution. We assessed operation time, intraoperative blood loss, skin incision length, and preoperative, 1-month, and 3-month postoperative JOA scores, neck pain VAS, and JOACMEQ. We also compared these outcomes to a control group of 42 patients (26 males, 16 females) who underwent conventional surgery during the same period.

Results: The minimally invasive procedure showed significant improvement in JOA scores and neck pain VAS postoperatively. Compared to conventional surgery, there were no significant differences in age, sex, or operative level. However, operation time (45.9415.8 min vs. 105.3432.7 min; $p < 0.001$), intraoperative blood loss (12.848.1 ml vs. 51.3440.6 ml; $p < 0.001$), and skin incision length (3.741.2 cm vs. 9.141.6 cm; $p < 0.001$) were significantly lower in the minimally invasive group. Moreover, at 3 months postoperatively, the improvement rate of JOA scores (56.6438.5% vs. 36.5463.2%; $p < 0.05$), cervical spine function on JOACMEQ (10.1425.2 vs. -0.3423.5; $p < 0.05$), and upper limb motor function (7.1418.2 vs. -3.2413.5; $p < 0.01$) were significantly better in the minimally invasive group.

Conclusion: Our study demonstrates that a minimally invasive approach can yield favorable surgical outcomes. The minimally invasive procedure may serve as one of the strategies to address post-laminoplasty axial pain and decreased cervical spine function.



AUGUST 17 (Thu)

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BEST PAPER 2

BP02-01

Adult Spinal Deformity

Proximal Junction Uninstrumented Bone Fusion as a Feasible Additive Procedure to Delay or Prevent Proximal Junctional Kyphosis/failure

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¹ Department of Neurosurgery, Korea University Anam Hospital, Korea

Background: Mechanical failure (MF), especially proximal junctional kyphosis (PJK) and failure (PJF) are significant complications for adult spinal deformity (ASD) corrective surgeries. Uninstrumented bone fusion (UBF) is a potentially powerful procedure with the ability to fuse spine on its own, which we have been implementing at proximal junction for soft landing.

Methods: Patients who underwent ASD corrective surgeries with proximal junction UBF at a single academic center were retrospectively included. Individual 1 to 2 matching for age, gender, osteoporosis, and uppermost instrumented vertebra (UIV) was used to identify ASD patients who had pedicle screw-only construct at UIV. Demographic, operative, and radiographic parameters were analyzed for differences. Complication-free period was analyzed for PJK/F and any MF separately. Multivariable survival analysis was made to find significant factors for mechanical complications.

Results: Twenty-one patients for UBF and 42 patients for No UBF group were identified for matched cohort study. There were no significant differences in demographic, operative, radiographic parameters and patient-reported outcome score. Median time to PJK/F, if any, was 11.0 months for UBF group and 3.5 months for No UBF group ($p=0.037$). Six patients in UBF group had successful bone mass fusion without any MF including PJK/F. Odds ratio of UBF was 0.55 ($p=0.28$) for PJK/F and 0.35 ($p=0.056$) for any MF. By Kaplan-Meier method, UBF group showed significantly longer MF-free period ($p=0.028$), but not for PJK/F ($p=0.16$). By Cox proportional hazard model, male gender was found to be protective, and tethering to be a risk factor for both PJK/F and any MF. Additionally for MF, proximal junction UBF was a significant protective factor (Hazard ratio 0.35, $p=0.017$).

Conclusions: Proximal junction UBF for ASD corrective surgery is a potentially beneficial measure to prevent and delay PJK/F.

BP02-02

Lumbar Degenerative

Comparison of Fusion, Subsidence, and Clinical Results between 3D-Printed Porous Titanium Cage and Polyetheretherketone (PEEK) Cage in Posterior Lumbar Interbody Fusion: A Minimum of 2-years Follow-upSehan Park^{1*} and Jae Jun Yang^{1*}¹ Department of Orthopedic Surgery, Asan Medical Center, University of Ulsan College of Medicine, Korea

Backgrounds: Early osteointegration and reduced modulus of elasticity has been proven with 3D-printed porous titanium (3DP-titanium) cage used for posterior lumbar interbody fusion (PLIF). However, evidence is limited whether 3DP-titanium cage could lead to enhanced fusion rate and minimize risk of subsidence. The present study was conducted to demonstrate fusion rate, subsidence, and clinical outcome of the 3DP-titanium cage in PLIF and to compare its results with those of polyetheretherketone (PEEK) cage.

Methods: A total of 150 patients who underwent 1-2 level PLIF and were followed-up for more than 2 years were retrospectively reviewed. Fusion rates, subsidence, segmental lordosis, back pain visual analogue scale (VAS), leg pain VAS, and Oswestry disability index (ODI) were assessed. Two group comparison of outcome measures between 3DP-titanium group and PEEK group was performed. Logistic regression analysis demonstrated factors associated with fusion assessed on CT and significant subsidence.

Results: Higher 1-year (3DP-titanium, 86.9%; PEEK, 67.7%; $p=0.002$) and 2-years (3DP-titanium, 92.9%; PEEK, 82.3%; $p=0.037$) fusion rate could be achieved with using 3DP-titanium cages for PLIF compared to PEEK cages. Amount of subsidence (3DP-titanium, 1.441.6mm; PEEK, 1.941.8mm; $p=0.092$) and incidence of significant subsidence (3DP-titanium, 17.9%; PEEK, 23.4%; $p=0.389$) was not significantly different between the two materials. Furthermore, back pain/leg pain VAS and ODI also was not significantly different between the two groups. In logistic regression analysis, cage material ($p=0.027$) showed significant association with fusion while number of levels fused ($p=0.012$) was associated with subsidence.

Conclusion: 3DP-titanium cage resulted in higher fusion rate compared to PEEK cage when applied for PLIF. Subsidence rate was not significantly different between the two cage materials. This result suggests that theoretical benefits of porous structure titanium including reduced modulus of elasticity, promoting early osteointegration, and reducing micromotion could manifest its advantages when applied to PLIF.

BP02-03

Cervical Degenerative

Revision Surgery of Upper Cervical Fusion to Correct Atlantoaxial Instability: A Retrospective Study of 19 Cases**Donghun Kim¹, Jaetaek Hong¹ and Jungwoo Hur^{1*}**¹ Department of neurosurgery, Eunpyeong St. Mary's Hospital, Korea

Posterior fixation is the most commonly used surgical approach to treat various atlantoaxial pathologies. However, due to the high mobility of the C1-2 segment, fusion rates are lower than those in the subaxial spine. Atlantoaxial instability is a rare disorder with multiple causes, such as traumatic, inflammatory, idiopathic, and congenital abnormalities. Despite improvements in surgical techniques, there is a lack of data identifying the relevant causes of revision surgery after occipitocervical (OC) or atlantoaxial (AA) fusion. The aim of this retrospective study was to identify the risk factors or complications that contribute to revision surgery in patients undergoing upper cervical fusion.

The study included patients from two institutions, Eunpyeong St. Mary's Hospital and St. Vincent's Hospital, The Catholic University of Korea, who underwent initial surgical fixation of the upper cervical spine at levels C0, C1, or C2. All patients had evidence of instability on flexion and extension studies and underwent posterior C1 lateral mass screw fixation with C2 pedicle or pars screw fixation, with extension to the C0 occiput level if required. The study analyzed medical and radiologic records of patients who underwent revision surgery.

Out of 288 patients evaluated between October 2005 and June 2022, 19 patients required revision surgery. The most common causes of revision were nonunion (6/19), implant failure (4/19), and degenerative junctional failure (3/19). Other causes of revision included occipitocervical erosion, dysphagia, infection, and postoperative hematoma. Six out of the 19 patients had received interlaminar autologous bone graft, and two had received allograft bone graft, while 11 had no graft placed. Autograft placement using iliac bone had a higher incidence of revision surgery (6/8) compared to allograft (2/8). Three out of the 19 patients required long-level fusion extending to T1 and T2 levels.

In conclusion, this study identified nonunion, implant failure, and degenerative junctional failure as the most common causes of revision surgery after upper cervical fusion. Autograft placement using iliac bone had a higher incidence of revision surgery compared to allograft, suggesting the need for further studies on bone graft placement and implant failure.

BP02-04

Emerging Technologies & Techniques

Design and 3D Printing of Novel Titanium Spine Rods with Lower Flexural Modulus & Stiffness Profile with Optimised Imaging Compatibility

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Background: Cancer patients (~10%) develop metastatic spine disease at some point of their lifetime. Titanium (Ti6Al4V) is the current 'gold standard' material for spine implants but it is not optimal for use in metastatic spine tumour surgery (MSTS). Standard solid titanium rods (SSR) have high flexural modulus (110GPa)/stiffness that can lead to stress-shielding and eventual implant loosening/construct failure at implant-bone interface. SSR have improved compatibility with CT/MR imaging compared to stainless steel but generate artefacts, hindering early detection of tumour recurrence, postoperative complications and radiotherapy planning. Newer implant material like polyether-ether-ketone (PEEK) and carbon-fiber reinforced-PEEK (CFR-PEEK) have been explored for use in MSTS due to lower modulus of elasticity (~17 GPa), improved imaging and RT-compatibility. Rods manufactured using PEEK-based materials are not contourable and manufactured with pre-determined curvatures and lengths, limiting their applications. In this study, we aim to manufacture and test novel design titanium spine rods with lower flexural modulus/stiffness vs SSR using 3D-printing technology and to reduce the artefacts generated during CT/MR imaging observed in SSR.

Method: Novel spine rod designs with/without internal cellular structures were created. Dimensions of rods were diameter-5.5mm, shell thickness-0.5mm and length-100mm. Rods were designed via finite element analysis (FEA) and 3D-printed using selective laser melting (SLM). Three-point bending test was performed to assess mechanical performance and French bender was used to assess intraoperative rod contourability and haptic feedback. These rods were tested for compatibility and artefact generation using CT/MR imaging.

Results: Different rod designs generated include shell, voronoi, gyroid, diamond, weaire-phelan, kelvin, and star. Three-point bending tests showed 3D-printed rods had lower flexural modulus ranging from 2-25% compared to SSR. Shell rod exhibited highest flexural modulus of 25% (~77.4GPa) and star rod exhibited lowest reduction in flexural modulus of 2% (100.8GPa). Gyroid rod exhibited increase in flexural modulus by 8% (~111.8GPa). 3D-printed rods showed reduction in stiffness ranging from 40-59%. Shell rod displayed highest reduction in stiffness of 59% (179.9N/mm) and gyroid had least reduction 40% (~259.2N/mm). Haptic feedback test showed that shell, voronoi, and diamond rods demonstrated easier bending compared to other rods, however, gyroid exhibited bending difficulty similar to SSR. All 3D-printed rods demonstrated improved CT/MR imaging compatibility with reduced artefacts.

Conclusion: Through a novel design approach, we generated a spine rod design portfolio with lower flexural modulus/stiffness profile and CT/MR imaging properties for potential use in MSTS and osteoporosis.

BP02-05

Lumbar Degenerative

The Corrective Criteria to Avoid Adjacent Segment Degeneration Following Surgical Correction for Lumbar SpondylolisthesisYong-Chan Kim^{1*}, Sung-Min Kim¹, Kee-Yong Ha¹, Xiongjie Li¹ and JunBum Park¹¹ Orthopaedic Surgery, Kyung Hee University Hospital at Gangdong, Kyung Hee University, Seoul, Korea

Background: Previous articles have reported surgical strategies to prevent the development of adjacent segment degeneration (ASD), but the relationship between surgical correction for lumbar spondylolisthesis and ASD development is unclear. The aim of this study was to determine the correction criteria to prevent adjacent segment degeneration (ASD) following surgical treatment for degenerative spondylolisthesis (DS).

Materials and Methods: This study included consecutive 633 patients who underwent posterior lumbar interbody fusion (PLIF) for L4-L5 DS between 2011 and 2017 in a single institution with a minimum of 5-years follow-up. Patients with adult spinal deformity defined as sagittal imbalance (C7 sagittal vertical axis, C7 SVA > + 5cm) or coronal imbalance or with conditions known to be risk factors for ASD in previous studies, such as the preexisting spinal stenosis at cranial adjacent segment, were excluded. We used the following three radiologic parameters to present correction criteria: sagittal translation (ST), sagittal rotation (SR) and disc height (DH). Demographic data and radiologic data including sagittal spinopelvic parameters on whole spine of patients were collected and analyzed to identify the risk factors for ASD. Like a previous study of Moreau et al., ASD was defined by the presence of 1 or more of the following 3 radiographic criteria in the level immediately above the fusion, comparing immediate postoperative and 3-year follow-up radiographs: onset of U 10° segmental kyphosis, and/or U 50% loss of disc height, and/or U 3mm anteroposterior translation. Logistic regression analysis was used to identify the risk factors for ASD. The receiver operating characteristic (ROC) curves were plotted to evaluate the cut-off value for changes of SR and restoration of DH.

Results: A total of 117 patients (37 were male and 80 were female) met the inclusion criteria. ASD developed in 19 patients (16%). The non-ASD group showed a lower probability of partial ST than the ASD group (8/98: 8.1% vs 5/19: 26.3%, P=0.021). The non-ASD group also showed significantly greater changes in SR (7.55° vs 4.92°, P< 0.001) and DH (4.91mm vs 3.54mm, P= 0.034) compared to the ASD group at immediate postoperative. On logistic regression analysis for potential risk factors of ASD, change of SR (P< 0.001) and restoration of DH (P= 0.041) were associated with postoperative development of ASD. The cut-off value was 5.01° (95%CI, P=0.012) and 4.08mm (95%CI, P=0.034) in changes of SR and restoration of DH respectively.

Conclusion: We suggest the three corrective criteria should be satisfied to prevent ASD following surgical correction for DS; complete ST, the change in SR of more than 5.01°, and restoration in DH of more than 4.08mm.

BPO2-06

Regenerative Medicine

Efficacy of a Newly Designed Helical-shaped 3d-printed Titanium Cage for Cervical Vertebral Defect Healing in Rabbits

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² Department of Regenerative Medicine, Institute of Tissue Regeneration, Soonchunhyang University, Cheonan, Korea

Background: Three-dimensional (3D) printed titanium implants made of Ti-6Al-4V alloy are widely used for spinal fusion and other orthopedic applications. However, the structural design and shape of the implants are a major determinant of the optimal clinical outcome. The purpose of the study was to design and fabricate a newly designed helical-shaped 3D-printed titanium cage (HTC) with a flexible body, and to compare it with a 3D-printed traditional titanium cage (TTC) for healing and bone fusion effect in cervical vertebral defects after corpectomy in a rabbit model.

Methods: For the cervical corpectomy and implantation of HTC and TTC, fourteen male New Zealand white (NZW) rabbits were used and divided equally into both groups. The radiological examinations were performed at 1 and 16 weeks after TTC and HTC implantation. The bone fusion effect and osseointegration of TTC and HTC were assessed using micro-computed tomography (micro-CT) and histological staining of tissue sections at 16 weeks after operation. The height of the operated vertebral segment was also evaluated at post operation and before extraction to investigate cage subsidence risk.

Results: The scanning electron microscopy of the HTC and TTC showed that both cages surface was rough which could be effective for cellular proliferation and differentiation. The radiographic data were measured and found that the average vertebral segment height of the TTC was 23.342.1 mm 1 week after implantation surgery and 21.641.8 mm at 16 weeks. The average vertebral segment height of the HTC at 1 and 16 weeks after the operation were 22.841.4 and 21.94 1.1 mm, respectively. The mean reductions of segmental height in the TTC and HTC groups were 1.840.4 and 0.9140.3 mm, respectively ($P < 0.001$). Therefore, these data showed that the HTC-implanted group had better restoration of vertebral height than the TTC group, indicating a lower risk of cage subsidence. In micro-CT reconstructed images, it was observed that both HTC and TTC were well integrated and stable between the material and host bone. But the bone volume fraction (BV/TV) was significantly higher in the HTC than TTC group (25.6741.78 vs. 17.6541.67, respectively, $P < 0.01$), indicating the better bone formation ability of HTC in vivo system. The histological observations using hematoxylin & eosin (H & E) and Goldner's trichrome staining showed that HTC promoted bone regeneration and osseointegration more effectively than TTC. Histomorphometry further revealed significant new bone formation in the HTC group compared to the TTC group ($P < 0.05$).

Conclusion: These findings demonstrate that HTC has better healing and bone fusion effects than TTC in cervical vertebral defects in rabbits, indicating its potential clinical value as a cervical cage.

Table 1. Radiological outcomes

Parameters	TTC group	HTC group	P-value
Mean segmental height after the operation, mm	23.3±2.1	22.8±1.4	0.4595
Mean segmental height after the final follow-up, mm	21.6±1.8	21.9±1.1	0.6025
Mean reduction in height (subsidence), mm	1.8±0.4	0.91±0.3	0.0001
Cage migration	1	0	
Screw pull-out	1	0	
Screw loosening	0	1	
Screw breakage	0	0	

Values are number or mean ± standard deviation (SD). TTC, traditional titanium cage; HTC, helical-shaped titanium cage.

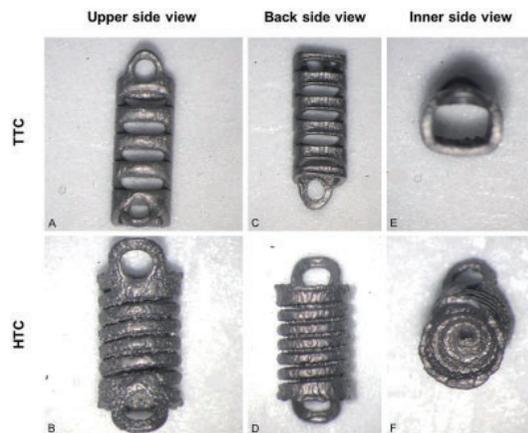


Figure 1. Digital photographs of a traditional titanium cage (TTC) and helical-shaped titanium cage (HTC) showing their gross morphology and design. Top and rear views showed that TTC (A, C) had a conventional structure with a larger gap between horizontal layers, while HTC (B, D) had a helical shape. Internal views of the TTC (E) and HTC (F) showed that TTC had an inner cavity, whereas HTC had a more complex structure.

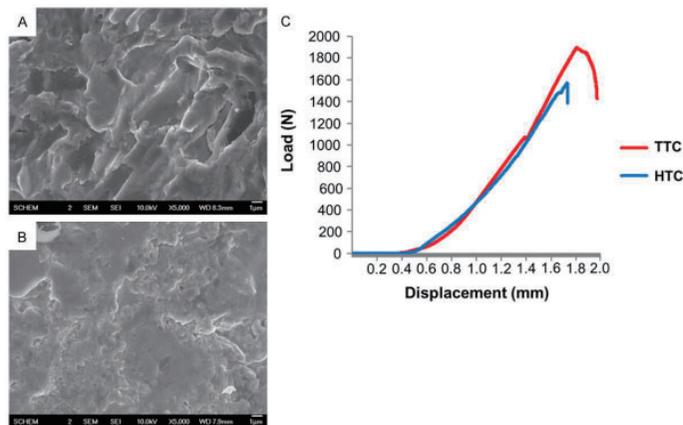


Figure 2. Scanning electron microscopy (SEM) imaging and load-displacement curves of the traditional titanium cage (TTC) and helical-shaped titanium cage (HTC). SEM analysis of the TTC (A) and HTC (B) showed the rough surfaces of both samples. (C) Load-displacement curves of the TTC and HTC revealed the status of the compressive strength of TTC and HTC.

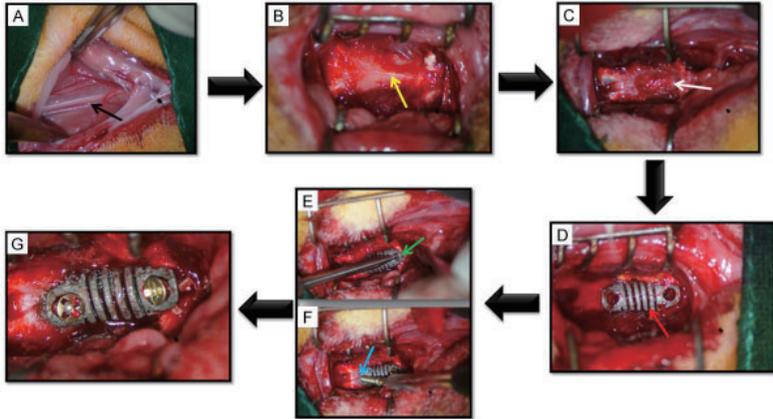


Figure 3. Implantation procedure. A. Skin incision and dissection of the muscles; the black arrow indicates the carotid artery. B. The spine and vertebral body (yellow arrow) were exposed by careful dissection. C. A defect (white arrow) was made in the C3/C4 vertebral body with an electric drill. D. The titanium cage was implanted in the defect indicated by the red arrow. E. Two holes were made with a drill to attach the screws (green arrow). F. The screws were then attached at the point shown by the blue arrow. G. Final view of the implanted cage.

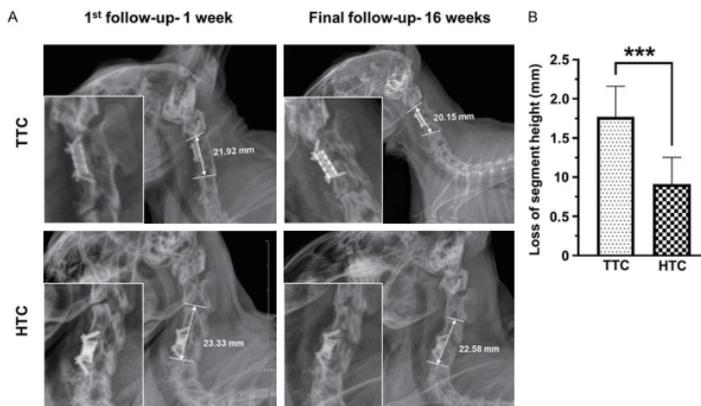


Figure 4. Radiographic analysis. A. Radiographs and vertebral segment height of the traditional titanium cage (TTC) and helical-shaped titanium cage (HTC)-implanted rabbits 1 and 16 weeks after surgery; the images showed the proper implantation and stabilization of the cages in the defect. B. Comparison of the loss of segment height after implantation with the TTC and HTC; similar lateral radiographs were used to compare the segment height between 1 and 16 weeks after implantation. The segment height was significantly reduced in the TTC compared to the HTC, so the TTC was associated with a significantly greater risk of cage subsidence during the postoperative period. All data are expressed as the mean \pm standard deviation (SD). *** $P < 0.001$.

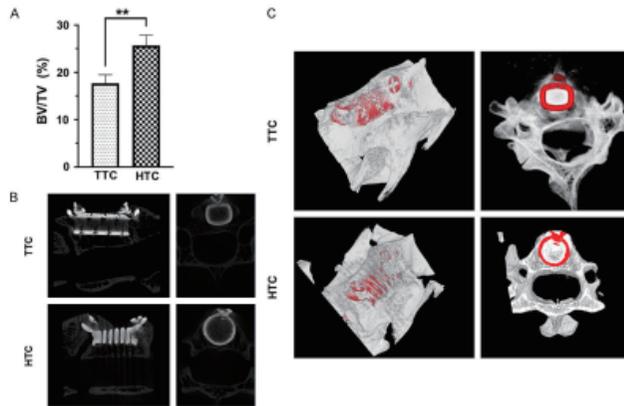


Figure 5. Micro-computed tomography (micro-CT) analysis. A. Analysis of the bone volume fraction (BV/TV) 16 weeks after implantation revealed significantly more bone formation in the helical-shaped titanium cage (HTC) group compared to the traditional titanium cage (TTC) group. B. Two-dimensional micro-CT images of the TTC and HTC 16 weeks after implantation. C. Three-dimensional (3D) micro-CT reconstructed images of the TTC and HTC, where the cage is in red and the bone is grayish-white. All data are expressed as the mean \pm standard deviation (SD). ** $P < 0.01$.

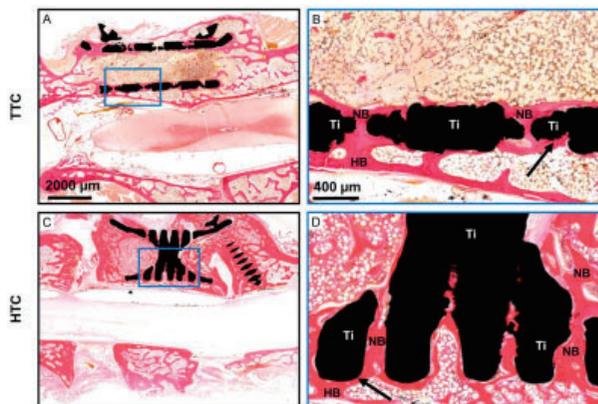


Figure 6. Hematoxylin and eosin (H & E) stained histological sections of the traditional titanium cage (TTC) and helical-shaped titanium cage (HTC)-implanted rabbit cervical vertebral defects at 16 weeks. A. TTC-implanted stained tissue sections at lower magnification. B. Higher magnified area of tissue section of TTC shows the integration between the implant and host bone. C. HTC-implanted histological tissue section at lower magnification. D. HTC-implanted tissue section at higher magnification shows bone ingrowth in HTC and excellent osseointegration in the defect. The formation of new bone (in pink) was greater in the HTC group. The black arrows indicate the contact between the implant and host bone. Ti, cage material; NB, new bone; HB, host bone.

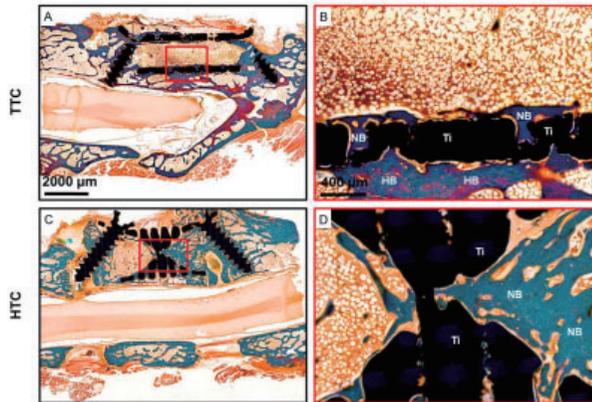


Figure 7. Goldner's trichrome staining of the traditional titanium cage (TTC) and helical-shaped titanium cage (HTC) 16 weeks after implantation in the cervical vertebral defects. A. Stained tissue section with TTC at lower magnification. B. TTC at higher magnification shows bone formation in the TTC. C. HTC-implanted stained tissue section at lower magnification. D. HTC-implanted tissue section at higher magnification. Increased bone ingrowth and more mineralized bone were observed in the HTC compared to TTC. Ti, cage material; NB, new bone; HB, host bone.

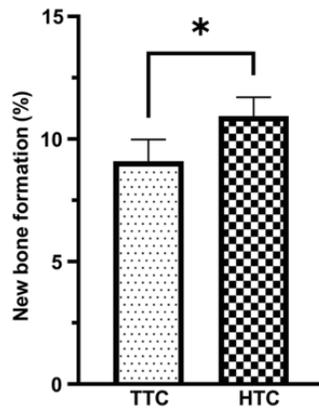


Figure 8. Histomorphometric analysis of the traditional titanium cage (TTC) and helical-shaped titanium cage (HTC) in the cervical vertebral defects. Significant new bone formation was associated with the HTC group 16 weeks after implantation, compared to the TTC group. * $P < 0.05$.

AUGUST 17 (Thu)

FREE PAPER 7

Miscellaneous 1

(Emerging Technologies & Techniques/ Regenerative Medicine
/ Material Science)

FP07-1

Emerging Technologies & Techniques

Machine Learning-Based Measurement of the Regional and Global Spinal Parameters Using the Concept of Incidence Angle of Inflection Points**Sung Hoon Choi¹ and Chang-Nam Kang^{1*}**¹ Orthopedic surgery, Hanyang University Hospital, Seoul, Korea

Introduction: The convolutional neural network (CNN), a subtype of machine learning, is widely used to extract features of image data and a few studies have reported the application to a spinal sagittal analysis recently. For intuitive interpretation of the spinal alignment, incidence angles of the inflection points (IAIPs) had been introduced as useful parameters representing the geometrical relationships between the pelvis and the spine. Therefore, IAIPs were measured using the CNN and the accuracy of thoracolumbar angular parameters derived through geometric relationships was evaluated.

Materials and Methods: For whole spine standing radiographs for parameters measurement, 563 whole spine lateral radiography sheets among 595 high-quality images were analyzed. Endpoints and center of sacrum, L1, T1, and C2 vertebra, and center of femur heads were detected by CNN-based machine learning by 3 layers of the region of interest. And validation of angular parameters was performed on 63 patients of the validation set. The ratio of the training set and the validation set was set at 9:1. The IAIPs, defined as the angle between the extension of pelvic tilt vector line and the perpendicular vector of the upper endplate of each vertebra, represent the geometric summation from the pelvis to each vertebra. And the six test parameters of LL, TK, C27L, L1S, T1S, and C2S were calculated from the proposed equations.

Results: To evaluate the performance of the proposed method, the success rates of parameters, which is the ratio having the mean absolute error of measured results smaller than the error threshold, were high in pelvic incidence and C2 incidence and low in sacral slope and L1 incidence. The proposed method shows efficiency in measuring PI, PT, T1I, C2I, LL, C2-7L, L1S, T1S, and C2S with the detection rate for these angles reaching 80 percentages with an error threshold of 3.5° (Fig. 1). The test results of the method were visualized via Bland-Altman plots for all angles of the entire sagittal parameters, which includes the horizontal lines of mean difference and mean difference ± 1.96 standard deviations (Fig. 2). The mean time required to perform the entire measurement procedure was less than 1 s. And the differences between the value calculated by the proposed formula and the value directly measured by the CNN model were very low as 0.005 as the mean absolute difference value and showed a coefficient of determination value of 1.000 ($p < 0.01$).

Conclusion: The CNN-based deep learning algorithm and the concept of IAIPs were able to accurately measure the spinal sagittal parameters. Based on the three pelvic parameters and three incidence angles, the six additional parameters could be estimated accurately. The advantages of machine learning and the concept of IAIPs will be useful tools for large-scale data accumulation of sagittal spinal alignment.

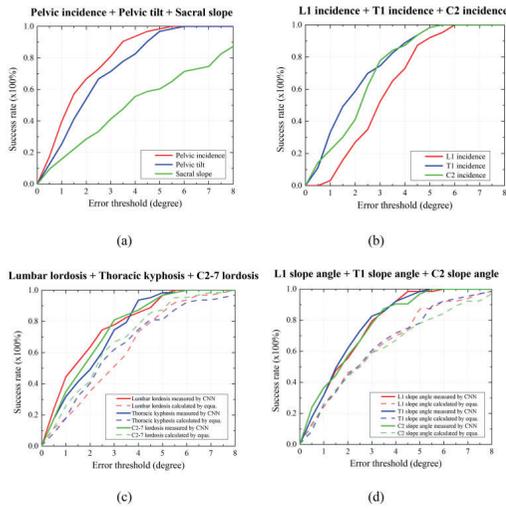


Figure 1: Successful rate for 12 parameters by error threshold. (a) PI, PT, SS measured by CNN; (b) L1I, T1I, C2I measured by CNN; (c) LL, TK, C2-7 measured by CNN and calculated from equations; (d) L1S, T1S, C2S measured by CNN and calculated from equations.

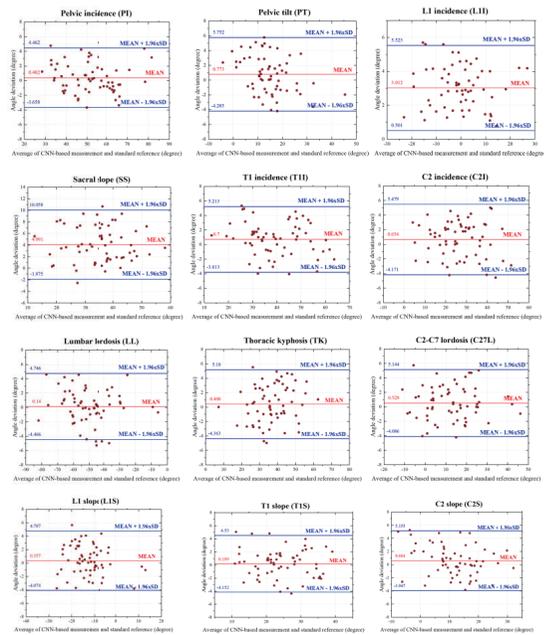


Figure 2: Bland-Altman plots comparing the values of radiographic parameters.

FP07-2

Regenerative Medicine

Injectable Nanomaterial-based Peptide Hydrogel: A Novel Therapeutic Approach For Intervertebral Disc RegenerationInbo Han*Neurosurgery, CHA Univ. School of Medicine, Korea*

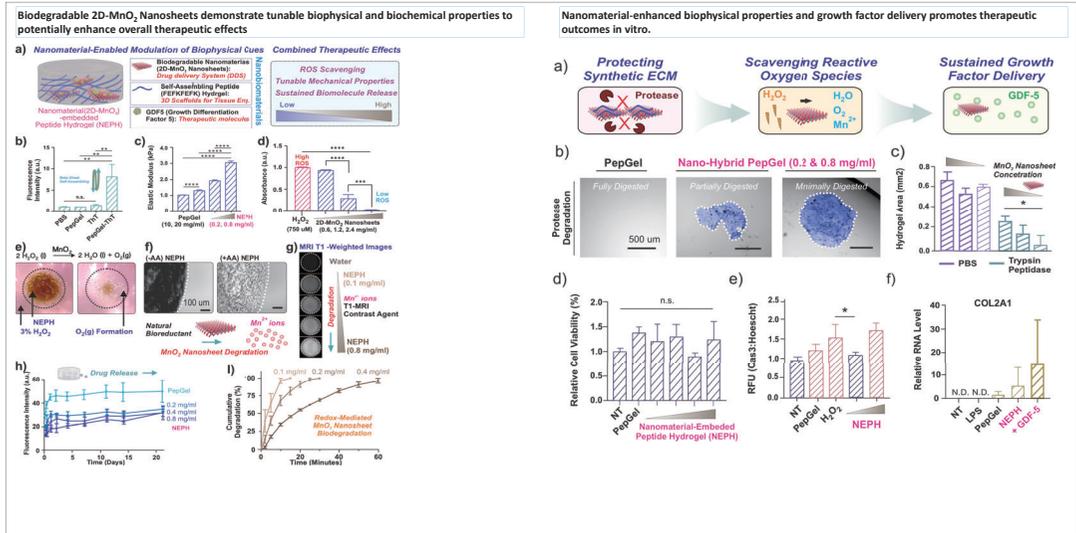
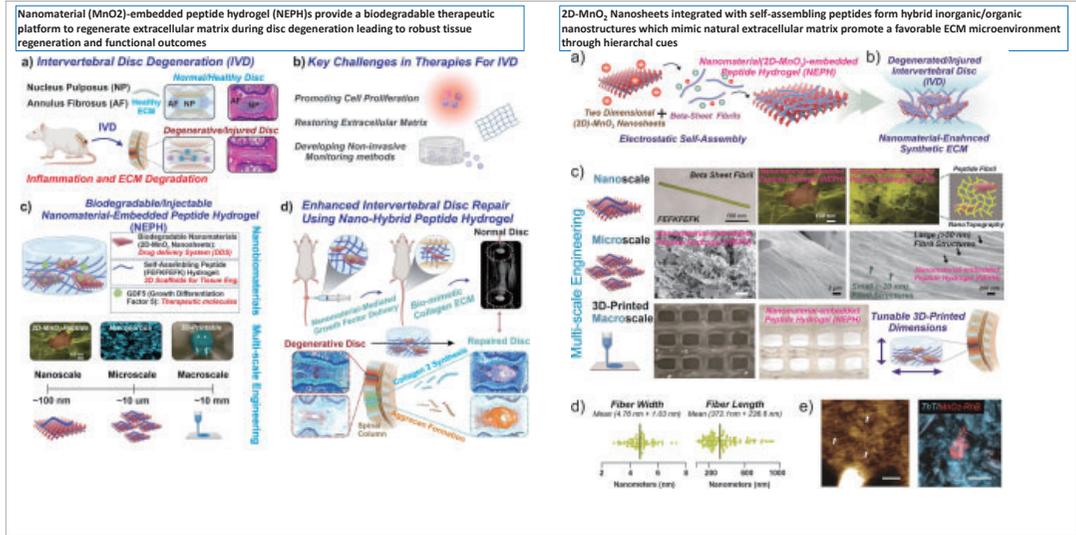
In spite of substantial research on potential therapies for degenerative intervertebral disc (IVD) conditions, the capacity for regeneration remains limited due to the prevalence of pro-inflammatory agents and the intricacy of the extracellular matrix (ECM) microenvironment in degenerated IVD. To address these challenges, we have developed an innovative nanomaterial-based injectable peptide hydrogel, constructed through the hierarchical self-assembly of two-dimensional nanosheets and one-dimensional peptide fibrils. This nano-hybrid peptide hydrogel is capable of delivering pro-regenerative cytokines, inhibiting inflammatory factors, and constructing a regenerative ECM microenvironment subsequent to IVD degeneration induction. When transplanted into a nucleotomy model, the therapeutic hydrogel mitigated inflammation, increased cartilaginous ECM protein expression, promoted nucleus pulposus cell differentiation, expedited tissue regeneration, and alleviated pain resulting from IVD degeneration. The newly synthesized nanomaterial-based hydrogel exhibits superior biocompatibility, complete biodegradability, and injectability, offering promising potential in advancing novel therapeutic strategies for treating IVD degeneration and other degenerative fibrocartilaginous tissue diseases and injuries.

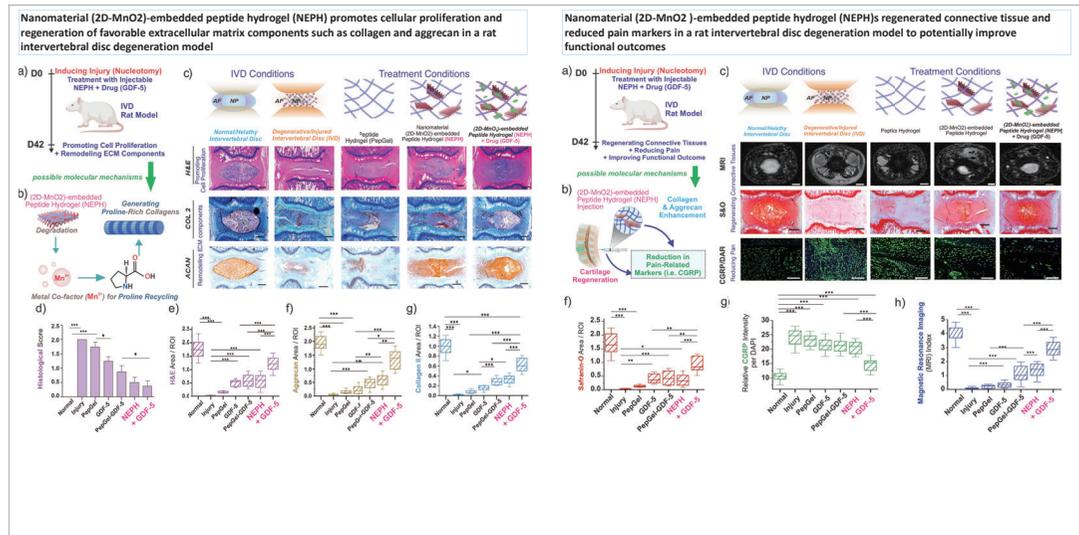
Enhanced Intervertebral Disc Repair and Regeneration Using a Nano-Hybrid Peptide Hydrogel

Inbo Han

Department of Neurosurgery, CHA University School of Medicine

There are no financial conflicts of interest to disclose





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FP07-3

Material Science

Applying Bioglue® after Durotomy in Intradural Spinal Cord Tumor Causing Neurologic DeteriorationSun Woo Jang¹ and Jin Hoon Park^{1*}¹ Department of Neurosurgery, Asan Medical Center, Korea

Objective: To identify that BioGlue® frequently used in off-label applications in neurosurgical procedure to minimize the risk of CSF leakage after dural closure could potentially cause spinal cord compression and neurologic deterioration.

Methods: The data were obtained from a cohort of 250 patients who underwent intradural spinal cord tumor surgery at a solitary center under the care of a single surgeon, from March 2018 to September 2022. The exclusion criteria encompassed revision surgery, operation without durotomy or artificial duroplasty, resulting in a remaining cohort of 174 cases. Dural closure was executed using prolene 5-0 and 6-0 sutures, accompanied by the application of adjunctive materials such as Bioglue, Taccocomb, Tisseel, and Greenplast. Among the remaining cases, Bioglue was employed in 101 cases, whereas in 73 cases, Bioglue was not employed. The postoperative MR images were subjected to analysis, and the cases were subsequently classified based on the Epidural Spinal Cord Compression (ESCC) grading system. Cases exhibiting ESCC grade 2 or higher were deemed indicative of substantial cord compression. Furthermore, a separate multivariate analysis was performed for each factor, encompassing Bioglue, Taccocomb, Tisseel, and Greenplast, in order to identify significant factors.

Results: A significant difference was identified among cases presenting ESCC grade 2 or higher. Specifically, within the studied cases, 34 belonged to the Bioglue group, while a mere 2 cases were classified in the non-Bioglue group. This discrepancy yielded a statistically significant result (p -value < 0.05). The multivariate analysis additionally demonstrated a significant association between the utilization of Bioglue and ESCC grade. Furthermore, within the Bioglue group, there were four cases of infection, two cases of cerebrospinal fluid (CSF) leakage, and two cases of mass effect observed among the revision cases. Conversely, in the non-Bioglue group, only one case of CSF leakage was noted among the revision cases.

Conclusion: Considering the potential risk of mass effect, the application of Bioglue in cases related to spinal epidural conditions to prevent cerebrospinal fluid (CSF) leakage is considered to be potentially precarious.

FP07-4

Material Science

Monolithic 3D-Printed Silicon Nitride-peek Composite Cervical Cages Demonstrate Antimicrobial Effects in Vitro

Ryan Bock^{1*}, Paul DeSantis^{1*}, Tabitha Derr^{1*}, Cemile Basgul², Douglas Hoxworth², B. Sonny Bal², Noreen Hickok¹ and Steven Kurtz¹

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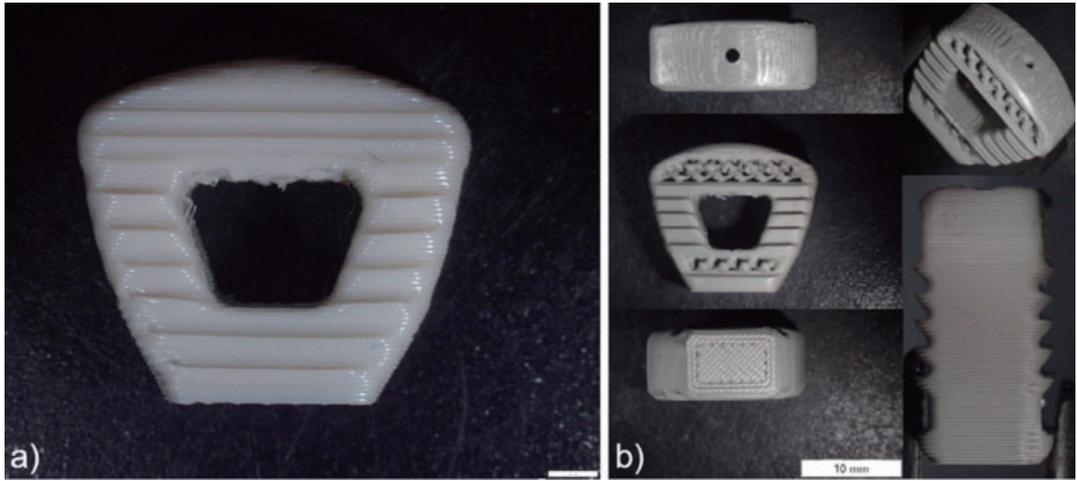
Background: PEEK is widely used for cervical spinal cages. PEEK composites have the potential to combine the favorable mechanical properties and 3d printability of PEEK with the bioactive properties of other materials. One such material is silicon nitride (SiN), a ceramic which has demonstrated its ability to support bone growth and resist bacterial infection in vivo. The goal of this work to test whether composite SiN/PEEK may be suitable for 3D-printed (3DP) cervical cages. We aimed to determine: (1) will 3DP SiN/PEEK cervical cages have the strength of conventional cages and (2) will 3DP SiN/PEEK composites exhibit antimicrobial properties?

Methods: Monolithic PEEK and 15 vol% SiN/PEEK composite filament were 3DP into generic cage designs, including a solid cage and a design with 500 micron endplate porosity for bone ingrowth, based on the literature using a medical PEEK printer. The porosity was formed with a diamond TPMS topology. Five cages of each design were tested in compression and shear per ASTM F2077 (Fig 1). For antibacterial testing, monolithic and composite filament samples were placed in sextuplicate in a 48-well plate with media containing 10% human serum, 1X PBS, and 7 mg/mL dextrose. Samples were inoculated with *S. epidermidis* (ATCC 14990) at a concentration of 10⁴ CFU/mL per well. The plate was then incubated at 37°C and 95 rpm for 24 hours. Samples were aseptically removed, rinsed 3X in PBS, and placed in 10% Trypsin. Serial dilutions were plated on Petrifilms to quantify adherent bacteria. The antimicrobial experiment was performed with 3 replicates. Statistical significance for antibacterial testing was determined using a Kruskal-Wallis test.

Results: The 3DP monolithic PEEK and composite SiN/PEEK cages exhibited gradual yielding behavior for both designs. There was no brittle fracture or load drop for any of the tests. Since there was no clear failure on the force/displacement curves, we tested the individual cervical cages up to benchmark loads per Peck et al (2017). The mean strength of the generic 3DP cage designs exceeded the 75% percentile benchmarks reported by Peck (2017): 14.7kN in compression and 6.9kN in compression-shear. SiN/PEEK was found to have 93.9% lower levels of bacterial adhesion than the Control PEEK ($p < 0.01$), corresponding to a 1.21 log reduction.

Conclusions: Infection is a serious cause of spinal implant failure, demonstrating the need for biomedical materials with strong antimicrobial properties in addition to their strong mechanical properties. A composite material of SiN/PEEK would allow for custom 3D-printed spinal implants that reduce the risk of infection when compared to traditional implant materials such as titanium alloy and unfilled PEEK. We observed antimicrobial properties at the lower end of expected 1-1.5 log reduction for a candidate antimicrobial. This suggests that the presence of Si₃N₄ was able to impart some of its antimicrobial properties to the PEEK matrix. Increasing the concentration of Si₃N₄ to increase antimicrobial benefits must be balanced with the composite material's ability to be 3D printed.

Reference: Peck JH et al. Mechanical performance of cervical intervertebral body fusion devices. *J Biomech* 54: 26, 2017



AUGUST 17 (Thu)

FREE PAPER 8

Miscellaneous 2

(Lumbar Degenerative / Sacroiliac Joint)

FP08-1

Lumbar Degenerative

Does Posterior Lumbar Interbody Fusion Using 16 Degree Rectangular Shape 3-D Cage with Modified Smith-peterson Osteotomy Provides Proper Segmental Lordosis?**Sung Bum Kim^{1*} and Man-Kyu Choi¹**¹ Neurosurgery, Kyung-Hee university medical center, Korea

Introduction: Interbody fusion cage has been widely used to treat degenerative spine and restore the lordosis.. Many techniques have been developed to decompress and restore sagittal alignment. Many authors have emphasized the importance of adequately restoring sagittal alignment and anterior approach and lateral approach have been widely used to restore the sagittal balance. We tried to estimate changes of lordosis after posterior lumbar interbody fusion using 16 degree rectangular shape 3-D cage with modified smith-peterson osteotomy, preliminarily.

Material & Method: 40 cases of PLIF using 16 degree rectangular shape 3-D cage with modified smith-peterson osteotomy and 40 cases of PLIF 8 degree rectangular shape with modified smith-peterson osteotomy were included in this study. Demographic, pre- and postoperative radiologic, and cage-related factors were included. Statistical analyses were designed to compare pre and post operative changes of lordosis according to degree of cage on lower lumbar level.

Results: Surgical level is similar between two groups. Three level PLIF was 2 cases and 2 level was 5 cases and rest of them was single level fusion, in each group. Cage inserted level on L4-5 are mostly involved(17 cases). Average postoperative increase lordosis were measured as 7.84 degree in 16 degree 3-D cages which is larger degree than that of 8 degree cages.

Conclusions: PLIF using 16 degree rectangular shape 3-D cage with modified smith-peterson osteotomy showed increase the segmental lordosis and sagittal balance. Due to preliminary reports, lack of long term outcome results including subsidence and fusion rate might be shortage of this reports.

FP08-2

Lumbar Degenerative

Comparative Analysis of the Occurrence Factors for Adjacent Segment Disease -with Patients Followed more than 10 Years after Lumbar Spinal Fusion-Jaewan Soh^{1*}, Chung-Su Hyun^{1*} and Taejong Jeong¹¹ Orthopaedic Surgery, Sahmyook Seoul Medical Center, Korea

Introduction: There are many concerns about ASD after lumbar spinal fusion using pedicle screws. There are many studies about the causes that is natural degenerative change or risk factors. It was to analyze risk factors for adjacent segment disease(ASD), by comparing patients occurred ASD with patients followed more than 10 years after lumbar spinal fusion with pedicle screw fixation for degenerative lumbar spinal disease.

Materials and Methods: From August 1988 to December 2005, 581 patients underwent lumbar spinal fusion of 3 and less segment to treat degenerative lumbar disease. Among them, 180 patients underwent revision surgery for ASD or followed more than 10 years were included in this study. Average The mean age at the initial operation was 53.6 years old and the mean follow-up period was 160.6 months. Gender, age, residence, preoperative diagnosis, fusion method, number of fused segments, whether laminectomy of adjacent segments, preoperative degree of disc degeneration of adjacent segments in MRI, whether adjacent segments included L4-5 or L5-S1, and radiological measurements were analyzed. In radiological measurement, pre- & post-operative lumbar lordotic angle(LLA), correction of LLA, post-operative fusion segment lordotic angle(FSLA) per level were estimated. Statistical univariate analysis was performed with the Chi-square test and multivariate logistic regression analysis was done by using SPSS 14.0. ($p < 0.05$)

Results: There were 40 patients with revision surgery due to ASD. Seven patients were operated by decompression or discectomy and 33 patients needed additional fusion. In univariate analysis, the frequency of ASD was significantly high in cases that age was more than 65 years old($p=0.002$), laminectomy of adjacent segment was performed($p=0.002$), preoperative disc degeneration of adjacent segments in MRI was present($p=0.001$) and post-operative FSLA per level was $<16^\circ$ ($p=0.024$). In multivariate logistic regression analysis, the frequency of ASD was significantly high in case that age was more than 65 years old($p=0.015$, odd ratio=3.106), laminectomy of adjacent segment was performed($p=0.012$, odd ratio=5.044) and preoperative disc degeneration of adjacent segments in MRI was present($p=0.022$, odd ratio=3.008).

Conclusions: We analyzed risk factors for ASD, by comparing patients occurred ASD with patients followed more than 10 years after lumbar spinal fusion for degenerative lumbar spinal disease. Development of ASD was affected that age was more than 65 years old at initial operation, laminectomy of adjacent segment was performed and preoperative disc degeneration of adjacent segments in MRI was present. In case of old age and patients existed preoperative degenerative change of adjacent segment, careful decision should be considered to carry out lumbar spinal fusion.

FP08-3

Lumbar Degenerative

Short-term Outcomes of B-DYN Dynamic Fixation System in Treatment of Lumbar Degenerative Diseases**Ngoc Quyen Nguyen^{1*}** and **Hong Van Vu¹**¹ Polyclinic and Premier Healthcare Center, 108 Military Central Hospital, Hanoi City, Viet Nam

The dynamic fixation system has been applied in the treatment of lumbar degenerative diseases with the aim of preserving spinal movement and preventing adjacent segment disease. The aim of our study was to evaluate the short-term therapeutic efficacy of the B-Dyn dynamic internal fixation system for the management of lumbar degenerative diseases.

Materials and Methods: A total of 28 patients with lumbar degenerative diseases who underwent posterior lumbar decompression and single-segment B-Dyn dynamic internal fixation between January 2020 and June 2021 at our hospital were retrospectively analyzed. Preoperative, as well as one month, three months, and twelve months postoperative visual analog scale (VAS) pain scores and Oswestry Disability Index (ODI) scores were documented to evaluate the clinical therapeutic effect. The lumbar range of motion (ROM) was measured preoperatively and at the last follow-up to assess the preservation of movement function in the dynamically stabilized segment.

Results: All the patients underwent the procedure successfully without any complications during hospitalization and were followed up for an average of 17 months. The preoperative VAS scores for low back pain and leg pain were 6.1 ± 0.9, and the postoperative and last follow-up scores were 6.7 ± 0.8, 2.3 ± 0.9, and 1.4 ± 0.7, respectively, which were statistically significant ($p < 0.05$). The preoperative ODI score was 44.6 ± 3.2, which decreased to 13.8 ± 2.1, and the difference was statistically significant ($p < 0.05$). The preoperative lumbar ROM was 3.5 ± 1.9, and the ROM at the last follow-up was 3.1 ± 1.5, but the difference was not statistically significant ($P = 0.057$).

Conclusions: The use of the B-Dyn dynamic internal fixation system in the management of lumbar degenerative disc diseases can effectively relieve pain, improve quality of life, and preserve the lumbar ROM of the stabilized segment, in the short-term.

FP08-4

Sacroiliac Joint

Sacroiliac Joint Injection for Management Sacroiliac Joint Pain after Lumbosacral Spinal Fusion Surgery: A Retrospective Study at One Center in VietnamVo Thanh Nghia¹ and Tuan Pham Anh^{1*}¹ Neurosurgery Department, Neurosurgery, Viet Nam

Background: Sacroiliac joint (SIJ) pain after lumbar spinal fusion surgery is a common problem. This study aims to evaluate the response to intra-articular SIJ injection.

Subjects and methods: This prospective study includes 56 patients who had lumbar or lumbosacral fusion from February 2018 to June 2022 and developed postoperative SIJ pain that was not responding to conservative treatment. These patients underwent intra-articular SIJ injection and were followed up for three months after injection. Patients were assessed with the visual analog scale (VAS), the Oswestry Disability Index (ODI).

Results: Of the total 56 patients, 12 (21.4%) were male and 44 (78.6%) were female. Lumbar spinal stenosis was a common cause of prior surgery (78.6%). Up to 57.1% of patients had 2-level fusion surgery and 71.4% received fusion to S1. The mean age was 58.54±10.7. Low back pain and low back pain radiating to the legs accounted for 64.3% and 37.5% respectively. Thirty-three patients (58.9%) had positive provocative tests and 27 patients (48.2%) had severe pre-injection pain with equal pre-injection VAS and ODI scores. There was a significant improvement in post-injection VAS and ODI scores ($p < 0.05$).

Conclusions: SIJ pain is common following spinal fusion surgery. Good to the excellent improvement of disability and pain could be achieved within 3 months after intra-articular injection. SIJ injection could be an effective option to improve the outcomes in patients who failed conservative medical management.

Keywords: sacroiliac joint pain; spinal fusion surgery; intra-articular injection.

AUGUST 17 (Thu)

FREE PAPER 9

Trauma, Tumor & Infection 1

FP09-1

Trauma, Tumor & Infection

Prognostic Factors in Spinal Intradural Hemangioblastoma: An Analysis of Surgical Outcomes and Tumor Characteristics

Hyun Jun Jang¹, Bong Ju Moon¹, Jeong Yoon Park¹, Dong Kyu Chin¹, Keun Su Kim¹ and Yong Eun Cho¹

¹ Department of Neurosurgery, Gangnam Severance Hospital, Korea

Purpose: Spinal intradural hemangioblastoma is a rare and highly vascularized benign tumor. The characteristics of the tumor, its corresponding location, and the surgical outcomes of surgery are still unknown.

Methods: A comprehensive retrospective analysis was undertaken to evaluate patients who underwent surgical intervention for intradural hemangioblastoma at our esteemed institution during the period spanning from 1993 to 2022. Patients with at least one year of follow-up data were included. Analysis covered patient demographics, pre- and post-operative Modified McCormick Scale (MMCS), tumor location and size.

Results: The study included 31 cases, 25 of whom had intramedullary, and 6 with intradural extramedullary (IDEM). Five cases were ventrally located intramedullary cases, and twenty cases were dorsally located intramedullary cases. One-year after surgery, neurological deterioration was observed in 5 cases (16.1%) and neurological improvement in 9 cases (29.0%). Ten patients (32.3%) were diagnosed with von Hippel-Lindau syndrome (VHL). Three of ventral intramedullary hemangioblastomas were confirmed supply by the anterior spinal artery and were larger in size than posterior location tumors, resulting in poorer follow-up MMCS. In the case of dorsal intramedullary, there was no neurologic deterioration, while in the case of IDEM, one case showed neurologic deterioration due to root symptoms.

Conclusion: In intramedullary spinal cord hemangioblastomas, cases located ventrally had a higher incidence of neurological deterioration following surgery than those located dorsally or in intradural extramedullary cases. Ventrally located hemangioblastomas were larger than those in other locations, and they were supplied by the anterior spinal artery in VHL patients.

FP09-2

Trauma, Tumor & Infection

Trends in Survival and Surgical Methods in Patients Surgically Treated for Metastatic Spinal Tumors: 25-year Experience in a Single InstitutionJin-Sung Park^{1*}, Se-Jun Park¹, Choong-Won Jung¹, Hyun-Jun Kim¹, Han-Seok Yang¹ and Jong-hin Lee¹¹ Department of Orthopedics, Samsung Medical Center, Sungkyunkwan University School of Medicine, Korea

Background: Recent advances in targeted systemic medication, surgical management, and adjuvant therapy have resulted in improved survival results for cancer patients. And, with the development of radiotherapy, the role of surgical treatment for tumor control in spinal metastasis has changed. However, there have been very few studies focusing on survival trends and the type of surgical management employed in patients with spinal metastases over a long period. The purpose of this study was to look at trends in postoperative survival and surgical procedures in patients treated surgically for metastatic spinal tumor during a 25-year period.

Methods: We performed a retrospective study of patients who underwent surgical treatment for metastatic spinal tumors between 1996 and 2020. For trend analysis, the study cohort was divided into three groups according to the year of surgery: 1996–2004, 2005–2012, and 2013–2020. A Kaplan-Meier survival analysis was performed to examine survival, and the log-rank test was used to compare the survival of the top six common cancers among the periods. The surgical methods were grouped and examined as follows: fixation only, palliative decompression and fixation, gross total removal and fixation, and total en bloc spondylectomy.

Results: This study included a total of 608 patients. There were 78 patients in 1996–2004, 236 in 2005–2012, and 294 in 2013–2020. Regarding the overall survival trend, the group 2013–2020 had a significantly improved survival as compared to the other two groups ($p < 0.001$). According to specific cancer sites, significant survival improvement was observed in patients with lung, kidney, and breast cancers ($p < 0.001$, $p < 0.001$, and $p = 0.022$, respectively). There were no significant changes in the primary sites of the liver, colorectum, or prostate. Regarding surgical methods, the proportion of gross total tumor removal declined, whereas the proportion of palliative decompression and fixation and fixation only procedures increased.

Conclusions: During the past 25 years, significant survival improvement was observed in patients with lung, kidney, and breast cancers. There was no improvement in survival in patients with liver, colorectum, and prostate cancers. Therefore, primary tumors were an important predictor of survival in patients with metastatic spinal tumors. It was also noted that there was an increasing trend towards palliative decompression with fixation and minimally invasive fixation as compared to gross total tumor removal and total en bloc spondylectomy, thus favoring less radical and invasive surgeries in the management of metastatic spinal tumors.

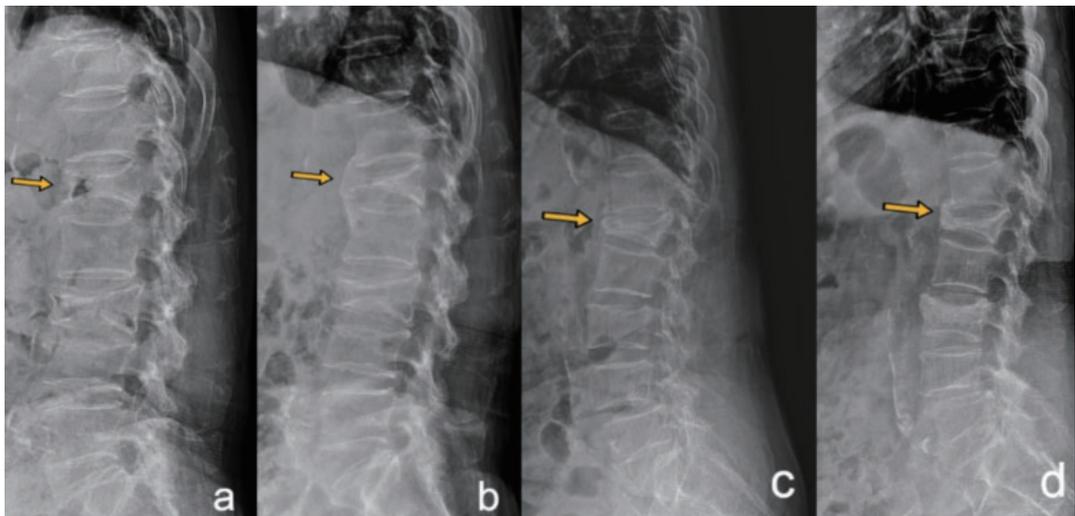
FP09-3

Trauma, Tumor & Infection

Bone Bridge Effect for the Treatment of Acute Osteoporosis Vertebral Compression Fractures: Multistrategic Approach Using Anabolic Versus Anti-resorptive AgentsJa-Yeong Yoon², Seong-Hwan Moon¹, Hak-Sun Kim¹, Kyung-Soo Suk¹, Si-Young Park¹, Ji-Won Kwon¹, Junhan Kwon¹ and Byung-Ho Lee^{1*}¹ Orthopedics, Yonsei University, Korea² Orthopedics, Sun general hospital, Korea

Bone bridge effect (BBE) means the fusion of adjacent vertebrae via bone formation at the anterior margin of the fractured level. This study compared BBE and other results of each medication strategy for osteoporosis vertebral compression fractures (OVCFs). The 264 patients of OVCFs were followed up for 12 months and were divided 4 groups. 1) Denosumab (DMAB) monotherapy (n=84), 2) Combination with teriparatide (TPTD) and DMAB (n=56), 3) sequential treatment administered DMAB after romosozumab (RM) (n=48), 4) bisphosphonate (BP) monotherapy (n=76)

The incidence of BBE in a year was the highest in the RM sequential (RMSq) (56.3%; 27/48) and TPTD combination (TPCo) (51.8%; 29/56) groups, followed by the DMAB (28.6%; 84/24) and BP (21%; 76/16) groups. There is no statistical difference between TPCo and RMSq, but the incidence of BBE is statistically significantly higher than that of the other two groups. The annual increase in bone mineral density (BMD) was significantly higher in the TPCo (1.04) group than in the RM (0.63), DMAB (0.55), and BP (0.35) groups. VAS was also significantly reduced in the anabolic agent group up to 3 months, and a significant decrease was observed in the BBE group at 3 months. In conclusion, the anabolic agent generates BBE more, and at the same time, it has higher BMD gains and rapidly reduces VAS. Therefore, anabolic agent strategies like RMSq or TPCo could be important as a means of treatment in OVCFs.



FP09-4

Trauma, Tumor & Infection

Clinical Outcomes of Surgical Debridement only in Pyogenic SpondylitisOhsang Kwon¹, Sang-Min Park^{1*}, Ho-Joong Kim¹ and Jin S. Yeom¹¹ Orthopaedic Surgery, Seoul National University Bundang Hospital, Korea

Study Design: Retrospective case series**Objectives:** The purpose of this study is to analyze the clinical usefulness of surgical decompression and debridement in pyogenic spondylitis.**Summary of Literature Review:** The surgical treatment of choice in pyogenic spondylitis is fusion in many cases. When only simple decompression and debridement surgery is performed, clinical results are not yet established.**Materials and Methods:** Patients who underwent surgical treatment for infectious spondylitis from March 2017 to December 2021 were analyzed. We analyzed 57 patients who underwent surgery due to pyogenic spondylitis, excluding tuberculous spondylitis, surgical site infection, and intrathecal infection.**Results:** Among 57 patients, we analyzed 54 patients, excluding 3 patients who underwent debridement and fusion surgery at first. The mean number of debridement was 1.35, and there were 41 cases where debridement was performed only once. The mean period for hsCRP recovery to normal was 70 days, and antibiotics were used for a mean of 7.6 weeks. There were 11 cases in which hsCRP did not recover until the last follow-up day. During follow-up, 29 patients (53.7%) had bone defects due to infection, and the height of the intervertebral disc decreased by a mean of 4.7 mm at the final follow-up. During the follow-up period, there were 4 patients who underwent additional fusion surgery, due to bone destruction and neurological injury in 2 patients, and severe radiating pain in 2 patients.**Conclusions:** This study evaluated the clinical and radiographic results of patients who underwent decompression and debridement surgery in pyogenic spondylitis. In most patients, infection improved without fusion surgery, and clinical results were also improved. Therefore, if there is no neurological damage due to pathologic fractures in pyogenic spondylitis, decompression and debridement can be considered a surgery of choice at first.

AUGUST 17 (Thu)

FREE PAPER 10
Biomechanics

FP10-1

Biomechanics

Determining the Instantaneous Center of Rotation of the Cervical Spine via Computer-assisted Radiographic AnalysisJae Hyuk Shin^{1*} and Shaobai Wang¹¹ Department of Orthopedic Surgery, St. Vincent's Hospital, The Catholic University of Korea, Korea

Background: In vivo cervical spine motion combines rotation and translation, resulting in mobile or instantaneous center of rotation (ICR). The ICR is defined as the intersection point of perpendicular bisecting lines from two or more corresponding points between sagittal radiographs during flexion-extension. We present computed motion analysis for semiautomatic two-dimensional cervical ICR acquisition, validated using a dual orthogonal fluoroscopy imaging system (DOFIS) and radiostereometric analysis. Segmental ICR locations were analyzed using a standardized cervical coordinate system.

Methods: We reviewed the flexion-extension lateral cervical radiographs of 51 radiographically unremarkable individuals (age, 31.744.4 years; male:female ratio, 35:16), and landmarked each corner of the vertebral body using a custom program written in MATLAB. The program automatically registered the inferior adjacent vertebral body and calculated the optimized ICR locations of the upper vertebrae, with minimum overall distances to the perpendicular bisecting lines connecting multiple corresponding points. The ICR locations were standardized as a percentage of the height and depth of each vertebral body. The ICRs of each subject were fitted to a two-dimensional Gaussian distribution model using an expectation-maximization algorithm. Five sawbone cervical spines were used for validation; four metal beads were placed on each vertebra, and the ICR locations were calculated and compared with those previously validated using a DOFIS.

Results: The overall accuracy of computer-assisted ICR determination was approximately 2 mm; thus, landmarks and ICRs could be determined via digital analysis. The ICRs of each cervical segment demonstrated level-dependent distribution. During cervical flexion-extension, the ICRs were in the inferior adjacent vertebral bodies; thus, the ICRs were located relatively posterior (C3: 61.49%418.72%, C4: 57.25%417.03%, C5: 43.09%415.85%, C6: 31.78%415.11%), and superior (C3: -108.73%430.47%, C4: -82.81%436.48%, C5: -50.84%425.10%, C6: -40.44%424.81%) to the vertebral width and height, respectively.

Conclusions: The present computer-assisted system efficiently calculated the ICR; thus, probabilistic distribution may help to distinguish abnormal motion. The ICRs of the cervical spine were in the inferior adjacent vertebral body with level-dependent distribution, shifting from anterior-inferior to posterior-superior for C3-6.

FP10-2

Biomechanics

Biomechanical Comparison of Posterior Fixation Combinations with an Allograft Spacer between the Lateral Mass and Pedicle Screws

Soo-Bin Lee¹, Byung Ho Lee^{2*}, Sahyun Sung³, Ji-Won Kwon², Seong-Hwan Moon², Hak-Sun Kim², Si-Young Park² and Kyung-Soo Suk²

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² Orthopaedic Surgery, Yonsei University College of Medicine, Korea

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Background: There are a few biomechanical studies that describe posterior fixation methods with pedicle screws (PS) and lateral mass screws (LMS); the combination of both screw types and their effect on an allograft spacer in a surgically treated cervical segment is unknown.

Methods: Finite element model (FEM) analyses were used to investigate the effects of a hybrid technique using posterior PS and LMS. Stress distribution and subsidence risk from a combination of screws under hybrid motion control conditions, including flexion, extension, axial rotation, and lateral bending, were investigated to evaluate the biomechanical characteristics of different six-screw combinations.

Results: The load sharing on the allograft spacer in flexion mode was highest in the LMS model (74.6%) and lowest in the PS model (35.1%). The likelihood of subsidence of allograft spacer on C6 was highest in the screws from the distal LMS (type 5) model during flexion and extension (4.902 MPa, 30.1% and 2.189 MPa, 13.4%). In lateral bending, the left unilateral LMS (type 4) model screws on C5 (3.726 MPa, 22.9%) and C6 (2.994 MPa, 18.4%) yielded the greatest subsidence risks, because the lateral bending forces were supported by the LMS. In counterclockwise axial rotation, the left unilateral LMS (type 4) model screws on C5 (3.092 MPa, 19.0%) and C6 (3.076 MPa, 18.9%) demonstrated the highest subsidence risks.

Conclusions: The asymmetrical ipsilateral use of LMS and posterior PS in lateral bending and axial rotation demonstrated the lowest stability and greatest subsidence risk. We recommend bilateral symmetrical insertion of LMS or posterior PS and posterior

FP10-3

Biomechanics

Exploring the Correlation between MRI Degenerative Stages of Intervertebral Discs, Chemical Composition, and Biomechanical Properties of the Nucleus Pulposus

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Background: Intervertebral disc degeneration (IDD) is closely related to changes in the intervertebral disc (IVD) composition and the resulting viscoelastic properties. IDD is a severe condition because it decreases the disc's ability to resist mechanical loads. Our research aims to understand IDD at the cellular level, specifically the changes in the viscoelastic properties of the nucleus pulposus (NP), which are poorly understood. The purpose of this study was to investigate the relationship between alterations in the viscoelastic properties and chemical composition of the nucleus pulposus (NP) and the degenerative stage of the intervertebral disc as measured by magnetic resonance imaging (MRI).

Methods: This study employed a system integrating nanoindentation with Raman spectrometry to correlate biomechanics with subtle changes in the biochemical composition of the NP. The characterization was, in turn, correlated with the degenerative severity of IVD as assessed using magnetic resonance imaging (MRI) of different patients with spinal stenosis, degenerative spondylolisthesis, and degenerative scoliosis.

Results: It is shown that there is an increase in the crosslinking ratio in collagen, a reduction in proteoglycan, and a build-up of minerals upon the rise in the severity level of the disc damage in the NP. Assessment of mechanical characteristics reveals that the increasing disc degeneration makes the NP lose its elasticity, becoming more viscous. This shows that the tissue undergoes abnormalities in weight-bearing ability, which contributes to spinal instability. The correlation of the individual discs shows that grades III and IV have similarities in the changes of Amide I and III toward the storage modulus. In contrast, grades IV and V correlate with mineralization toward the storage modulus. Reduction of proteoglycan has the highest impact on the changes of the storage modulus in all grades of IDD.

Conclusion: Connecting compositional alterations to IVD micromechanics at various degrees of degeneration expands our understanding of tissue behavior and provides critical insight into clinical diagnostics, treatment, and tissue engineering.

FP10-4

Biomechanics

The Effect of a New Tethering Device on the Biomechanics of Short-segment Fusion of the Lumbar Spine: A Finite Element Analysis

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Background: Adjacent segment disease (ASD) is a common disease that caused by biomechanical changes following a spinal fusion surgery, resulting in an increase in intradiscal pressure (IDP) and greater range of motion (ROM) in both cranial and caudal adjacent levels. Since the posterior tension band of the spine is frequently lost during a fusion surgery, it could potentially lead to ASD and subsequent operation that affects the quality of life of the patient. In this study, we developed a new tethering device in order to restore the posterior tension band function that could be utilized in lumbar fusion surgery. Our aim is to analyze the effect of this novel tethering device on biomechanics of short-segment fusion of the lumbar spine.

Method: Biomechanical analysis using finite element modeling (FEM) was performed. The tethering device is designed to be implanted at the L3-L4 segment following a fusion surgery at this level. Two types of lumbar fusion including posterior lumbar interbody fusion (PLIF) and posterolateral fusion (PLF) were studied in this work. A 7.5 N-m pure moment flexion was applied on the superior surface of L1, while the inferior surface of L5 was fixed. The IDP, ROM, and facet joint force (FJF) were measured and analyzed. A total of 9 lumbar fusion models without (intact and conventional fusion) and with tethering device (split, one-way, and two-way designs) were compared.

Result: In comparison with conventional posterior lumbar interbody fusion (PLIF) model, the PLIF IDP, ROM, and FJF of L2-L3 were reduced by 71%, 76%, and 81%, respectively, in the case of PLIF utilizing one-way tethering device. Considering posterolateral lumbar fusion (PLF) model, the IDP, ROM, and FJF of L2-L3 with one-way tethering device were reduced by 71%, 77%, and 46%, respectively, as compared to that without tethering device. Comparing between two-way and one-way design of new tethering device, the results showed that there is no significant effect to IDP, ROM, and FJF in both PLF and PLIF models at the L1-L2 and L4-L5 segments. The effects of tethering device on IDP, ROM, and FJF are more prominence at the L2- L3 segment.

Conclusion: Finite element analysis results show the possibility to reduce the chance of ASD in fusion surgery in the lumbar spine by decreasing intradiscal pressure, range of motion, and facet joint force in posterior lumbar interbody fusion and posterolateral lumbar fusion. This novel tethering device could assist the PLIF and PLF by limiting the lumbar motion after the surgery. Further biomechanical tests and clinical research shall be considered to confirm the potential usage of this novel tethering device.

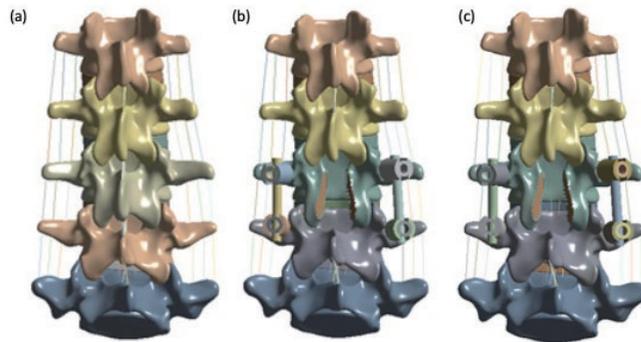


Fig.1 Finite element models of (a) intact lumbar spine, (b) conventional PLIF surgery, and (c) conventional PLF surgery

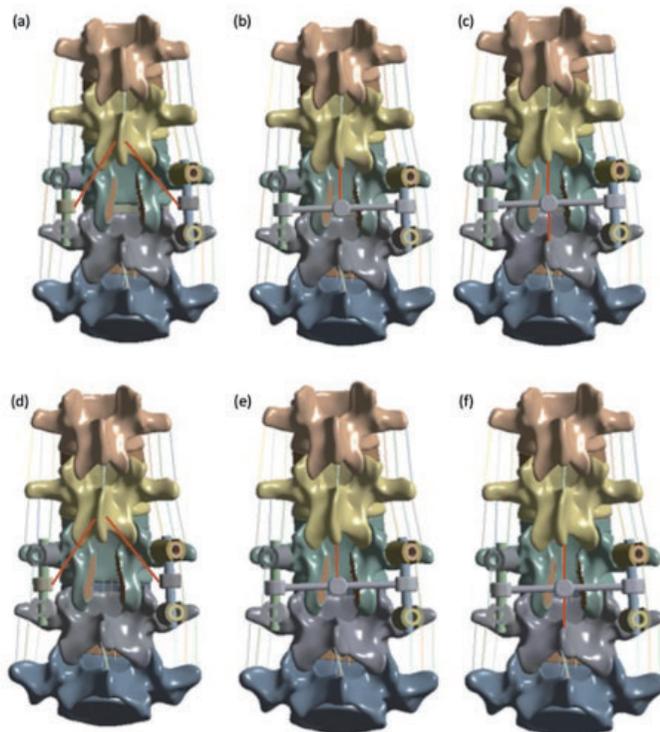


Fig.2 Finite element models of lumbar fusion utilizing various designs of tethering device: (a) PLIF with split tethering, (b) PLIF with one-way tethering, (c) PLIF with two-way tethering, (d) PLF with split tethering, (e) PLF with one-way tethering, (f) PLIF with two-way tethering

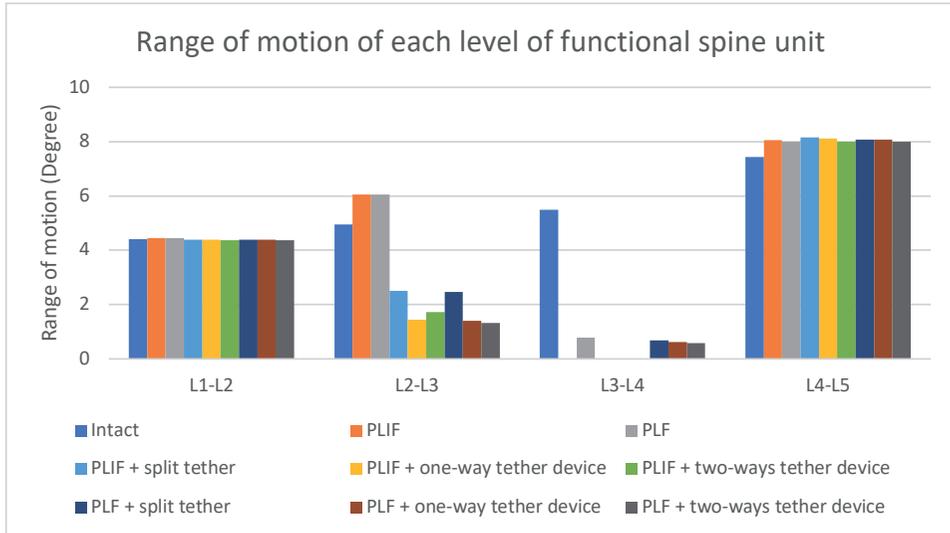


Fig.3 Range of motion of each functional spine unit level

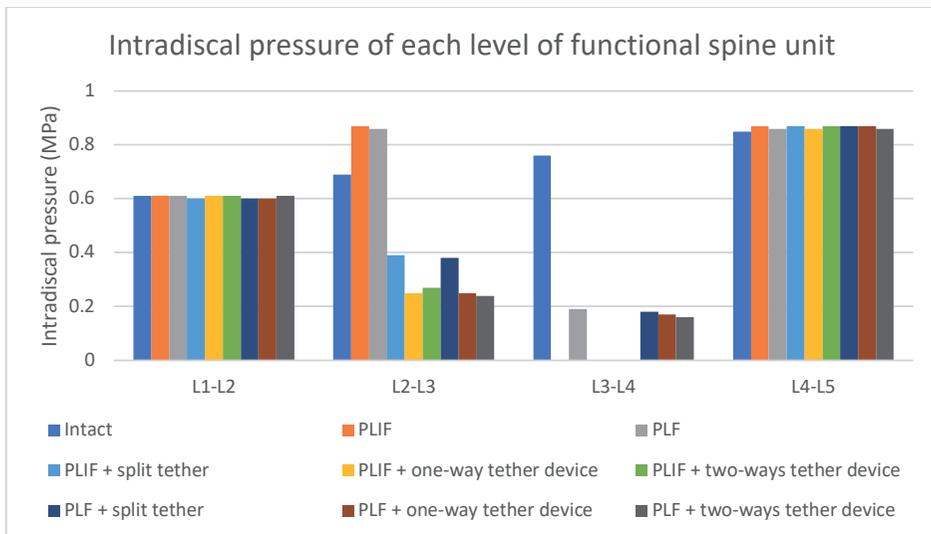


Fig.4 Intradiscal pressure of each functional spine unit level

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FREE PAPER 11
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FP11-1

Spinal Arthroplasty

Lumbar Arthroplasty for Treatment of Primary or Recurrent Lumbar Disc HerniationJoseph Maalouly^{1*}, John Choi^{1*}, Vincent Rossi¹, and Juan Amaya¹¹ orthopedic spine surgery, spine ortho clinic, Australia

Background: Microdiscectomy is the current gold-standard surgical treatment for primary lumbar disc herniations that fail non-surgical measures. Herniated nucleus pulposus is the manifestation of underlying discopathy that remains unaddressed with microdiscectomy. Therefore, risk remains of recurrent disc herniation, progression of the degenerative cascade, and on-going discogenic pain. Lumbar arthroplasty allows for complete discectomy, complete direct and indirect decompression of neural elements, restoration of alignment, restoration of foraminal height, and preservation of motion. In addition, arthroplasty avoids disruption of posterior elements and musculoligamentous stabilizers.

Aims/Objectives: This study aims to describe our experience with lumbar arthroplasty for the treatment of primary or recurrent disc herniation in the lumbar spine.

Methods: All patients that underwent lumbar arthroplasty by a single surgeon at a single institution from 2015 to 2020 were reviewed. All patients with radiculopathy and preoperative imaging demonstrating disc herniation that received lumbar arthroplasty were included in the study. In general, these patients were those with large disc herniations, advanced degenerative disc disease, and a clinical component of axial back pain. Patient reported outcomes of VAS back, VAS leg, and ODI preoperatively, at 3-month, 1 year, and at last follow-up were collected. Reoperation rate, patient satisfaction, and return to work were documented at last follow-up.

Results: Twenty-four patients underwent lumbar arthroplasty during the study period. Twenty-two (91.6%) patients underwent lumbar total disc replacement (LTDR) for a primary disc herniation. Two patients (8.3%) underwent LTDR for a recurrent disc herniation after prior microdiscectomy. The mean age was 40 years. The mean preoperative VAS leg and back pain were 9.2 and 8.9 respectively. The mean preoperative ODI was 22.3. Mean VAS back and leg pain was 1.2 and 0.5 at 3-months postoperative. The mean VAS back and leg pain was 1.3 and 0.6 at 1-year post-operative. The mean ODI was 3.0 at 1-year postoperative. One patient (4.2%) underwent reoperation for migrated arthroplasty device which required repositioning. At last follow-up 92% of patients were satisfied with their outcome and would undergo the same treatment again. The mean time for return-to-work was 4.8 weeks. After returning to work, 89% of patients required no further leave of absence for recurrent back or leg pain at last follow-up. Forty-four percent of patients were pain free at last follow-up.

Conclusion: Microdiscectomy has limitations in the treatment of disc herniation due to the inability to address underlying discopathy and approach related morbidity. Lumbar arthroplasty accomplishes decompression of neural elements while avoiding the long-term morbidity of microdiscectomy. We demonstrate lumbar arthroplasty to be an effective, safe, and durable treatment for primary and recurrent disc herniations in properly selected patients.

FP11-2

Cervical Degenerative

The Result of Treating Myelopathy due to Cervical Disc Herniation with Anterior Cervical Discectomy and Fusion SurgeryTuan Pham Anh^{1*}, Duy Nguyen Nhat^{*} and Hoang Bui Thanh¹¹ Neurosurgery, University of Medicine and Pharmacy at Ho Chi Minh City, Viet Nam

Background and Objectives: Cervical disc herniation is a common condition that can cause cervical myelopathy. Anterior discectomy and interbody fusion surgery has been widely applied. We conducted a study to evaluate the result of treating myelopathy due to cervical disc herniation with anterior cervical discectomy and fusion surgery.

Methods: This is a retrospective case series study with a sample population of patients diagnosed with myelopathy due to cervical disc herniation involving one to three levels who underwent anterior cervical discectomy and fusion surgery.

Results: From 01/2019 to 9/2021, there were 74 cases that met the inclusion criteria at the Department of Neurosurgery - Nguyen Tri Phuong Hospital. The mean age was 52.62 ± 6.81 years old. The mJOA score improved at the 6-month and 12-month follow-up. The rate of good to excellent recovery was 86.5% at 12 months. The average fusion rate after surgery was 91.4%. No severe complications were reported.

Conclusion: anterior cervical discectomy and fusion surgery is an effective and safe treatment method for myelopathy due to cervical disc herniation.

Keywords: Cervical disc herniation, cervical myelopathy, and anterior cervical discectomy and fusion

FP11-3

Cervical Degenerative

Unconstrained Cervical Total Disc Replacement Not One Design Suits Every Patient. Case ReportJuan Amaya*Orthopedics - Spinal Surgery, Spine Ortho Clinic, Australia*

Introduction: Degenerative disc disease is one of the main causes of cervical radiculopathy and myelopathy. It has been treated traditionally with anterior cervical discectomy and fusion (ACDF)¹. However, this procedure was not immune from different types of complications, one of the most frequent is adjacent segment disease (ASD). As a result, new techniques such as total disc replacement (TDR) have emerged as an alternative to preserve motion and decrease the risk of ASD². The purpose of this case report is to demonstrate that not all unconstrained devices are suitable for all patients. Therefore, there are different factors that must be considered to avoid failure^{1,2,4}.

Case: Our patient is a forty-year-old male, who works as a fabricator and has a smoking history. He presented to the clinic with neck pain radiated to the right hand at the level of thumb with pins and needles. At the time, his physical examination presented with decreased right C6 power. Imaging diagnostic studies such as, Magnetic resonance imaging (MRI) showed right lateral recess stenosis at the level of C4/5, C5/6. As initial course of treatment, he underwent epidural injection without relief of symptoms. Hence, surgical treatment was performed with Cervical TDR at C5/6 with Mobi-C (Zimvie) device in March 2018. At four weeks post op review, the patient had relief of his symptoms and had returned to work earlier than advised, raising concerns about device integration were made. Five years post - op, the patient complained of neck pain and right arm pain, a cervical X-ray was done showing hyperextension of the construct and 6 mm anterior translation of the inferior endplate, leading to revision surgery with Simplify (Nuvasive) device. Significant metallosis was found intraoperatively as well as breakage of the device. In the immediate post - op period, the patient experienced relief of symptoms, along with restoration of radiological alignment- on x - ray.

Discussion: There are many factors that must be taken into consideration when assessing the success of TDR. The prothesis design can influence different anatomic components that conjointly resist shear forces and loads¹³. The implanted segment could undergo greater shear forces depending on the sagittal alignment of the cervical spine and the orientation of the affected segment^{7,13}. Several studies have shown that unconstrained multipiece devices such as Mobi - C (Zimvie), rely on axial loading and limited range of motion of the disc segment to preserve integrity¹²⁻¹⁴. However, it is likely that these types of unconstrained implants are at greater risk of migration when distraction is combined with flex extension.

Conclusion: Motion preservation devices are a new tool in the treatment of degenerative disc disease. In order to achieve success and avoid complications as much as possible, it is paramount to consider some key aspects such as sagittal alignment, stability of the cervical spine and the characteristics of the intended device^{10,13,14}; so that, unconstrained 3 - piece devices have a higher risk of migrating in patients that perform high grade activities or involve head mounted gear in every patient before surgery¹⁰⁻¹⁴.



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FREE PAPER 12

Trauma, Tumor & Infection 2

FP12-1

Trauma, Tumor & Infection

Effect of Preoperative Acupuncture and Epidural Steroid Injection on Postoperative Infection after Lumbar Spinal Surgery

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Background: Acupuncture is one of the most commonly used alternative medicines for patients with degenerative lumbar disease. According to data from the Health Insurance Review and Assessment Service, more than 3 million cases of acupuncture for lower back pain are performed annually, and this number is increasing. There are several studies on the effect of preoperative epidural steroid injection (ESI) on postoperative infection after spinal surgery. However, there are no studies on the relationship between acupuncture and postoperative infection. The purpose of this study is to identify preoperative acupuncture and ESI as risk factor of postoperative infection after elective lumbar fusion surgery.

Methods: Patients over 50 years of age who underwent spinal fusion or fixation owing to degenerative lumbar disease from 2010 to 2017 were identified by diagnostic and procedural codes using a nationwide database. The incidence of spinal infection within 3 months of surgery was identified. Patients who underwent acupuncture or epidural steroid injection (ESI) within 3 months prior to spinal surgery were identified using procedural codes. The infection rate was analyzed by grouping patients into four as follows: 1) patients who did not undergo both acupuncture and ESI (unexposed group), 2) patients who underwent acupuncture only (acupuncture group), 3) patients who underwent ESI only, and 4) patients who underwent both acupuncture and ESI (both groups). Cox regression analysis was performed to identify risk factors for postoperative spinal infections.

Results: A total of 165,523 patients were included in this study. The postoperative infection rate in all patients was 4.15%. The infection rate in the unexposed, acupuncture, and ESI groups and in both groups were 4.03% (3,487 of 86,489 patients), 3.89% (258 of 6,634 patients), 4.33% (2,803 of 64,729 patients), and 4.17% (320 of 7,671 patients), respectively. Old age, male sex, high Charlson Comorbidity Index Score, and ESI were confirmed as risk factors for postoperative spinal infection. Preoperative acupuncture was not associated with postoperative spinal infection.

Conclusions: Preoperative epidural steroid injection was identified as a risk factor for postoperative spinal infection, whereas acupuncture did not increase the risk of infection after spinal surgery. as sagittal alignment, stability of the cervical spine and the characteristics of the intended device^{10,13,14}; so that, unconstrained 3 - piece devices have a higher risk of migrating in patients that perform high grade activities or involve head mounted gear in every patient before surgery.

FP12-2

Trauma, Tumor & Infection

Pharmacokinetic Interpretation of Applying Local Drug Delivery System for the Treatment of Deep Surgical Site Infection in the Spine**Ahmad Khalid Madadi² and Moon-Jun Sohn^{1*}**¹ Neurosurgery, Inje University, Ilsan Paik Hospital, Korea² Convergence Medicine, Graduate School, Inje University, Korea

Background: Surgical site infections (SSIs) of the spine are a serious complication after spinal surgery. Poor penetration of antibiotics in surgical dead space and biofilm on implants is the main cause of treatment failure. To improve drug delivery, polymethylmethacrylate (PMMA), as a biocompatible local drug delivery carrier, has been widely used in the treatment of bone infections. Herein, the authors are to present the overall results of 22 cases with postoperative deep wound infections following spinal surgery, treated with antibiotic-loaded PMMA in terms of pharmacokinetic perspective.

Method: From 2006 to 2018, a total of 22 consecutive surgical cases were retrospectively analyzed in the treatment of postoperative site infections. The primary diseases were 9 degenerative diseases (ASA II), 6 traumatic spine injuries (ASA I-II), 3 spinal tumors (ASA IV), 3 OPLL (ASA II-III), and 1 spinal epidural hematoma (ASA IV). Most patients had multi-level fixation, four had single-level instrumentation, and two had simple decompression. The most common pathogen was 10 MR-CoNS followed by 6 MRSA, 3 unknown pathogens, and each of *S. epidermidis*, *Enterococcus*, and *Pseudomonas*.

Result: All patients were cured of infection without any mechanical failure or recurrence of infection during an average follow-up of 75 + 52.6 months. Depending on the pathogen, various antibiotics were impregnated into PMMA, and most of them were 2g of vancomycin alone, 3 cases in combination with 1 to 2g of ceftriaxone, and a case of *Pseudomonas* infection used 2g of ceftazidime. The average number and size of PMMA beads were about 20 to 40 or more, 1 to 1.5 cm in diameter for prolonged drug release with the use of concomitant systemic IV injection. A patient with low GFR (ASA IV) was administered only short-term IV vancomycin (9 days), but deep wound infections were successfully eliminated without antibiotic-related complications. In terms of drug release kinetics, the MIC of vancomycin for MRSA was 8 ×g/mL, and the initial release was calculated as 13.8-40 ×g/mL at each bead of PMMA with 1g vancomycin on the first day and followed by a sustained release for up to 6 weeks.

Conclusion: This study provides clinical and pharmacokinetic evidence for effective local drug delivery with antibiotic-load PMMA vehicles in the treatment of deep wound infections following spinal instrumentation. It helps minimize the side effects associated with systemic antibiotic exposure and ensures a sufficient drug concentration for an appropriate duration. Additional research is necessary to regulate the release rate or kinetic of antibiotics, optimize the duration of release, and prevent initial or burst release that could lead to tissue toxicity.

Keywords: Surgical site infections, drug delivery system, biocompatible polymer, drug release pharmacokinetics, sustainable release

FP12-3

Trauma, Tumor & Infection

Which Factors Are Associated with the Risk of Re-operation after Percutaneous Vertebroplasty or Kyphoplasty for Thoracolumbar Vertebral Fracture? Analysis of the National Health Insurance Service Claims Data in Korea (2006-2017)Jae sin Lee¹, Sub-Ri Park¹, Byung Ho Lee¹, Kyung-Soo Suk¹, Si-Young Park¹, Yung Park², Joong-Won Ha², Seong-Hwan Moon¹, Hak-Sun Kim¹, Ji-Won Kwon^{1*} and Sung-ryul Choi¹¹ Department of Orthopedic Surgery, Yonsei University College of Medicine, Seoul, Korea² Department of Orthopedic Surgery, National Health Insurance Service Ilsan Hospital, Goyang, Korea

Background: There are few reports on the incidence of reoperation after percutaneous vertebroplasty (PVP) or kyphoplasty (PKP). This study aimed to investigate the incidence and factors involved in re-operation for new fractures after PVP or PKP for compression fractures through a population-based study.

Methods: From January 1 to December 31, 2012, patients from the National Health Insurance Service database of South Korea from 2006 to 2017 were recruited using the diagnostic ICD-10th code for vertebral compression fracture and procedure code for PVP or PKP. Patients who received index PVP or PKP due to vertebral compression fracture in 2012 were followed-up for up to 5 years. The incidence and corresponding risk factors of patients who had undergone re-operation due to a subsequent fracture were analyzed using Cox proportional hazard model analysis.

Results: The 5-year cumulative incidence of re-operation in the osteoporosis group and non-osteoporosis group was 12.43% and 10.96%, respectively; there was no significant difference between the two groups ($p=0.8$). Age, female, high Charlson comorbidity index (CCI) scores, low body mass index (BMI), current smoker, and walking >3 days a week had a significant effect on re-operation occurrence (age: 1.05 [1.04-1.06], female: 1.18 [1.00-1.39], CCI scores: 1.06 [1.03-1.10], BMI: 0.93 [0.91-0.96], current smoker: 0.92 [0.70-1.22], walking >3 days a week: 0.78 [0.66-0.92], Crude HR [95% CI]).

Conclusion: No difference in re-operation incidence after percutaneous vertebroplasty (PVP) or kyphoplasty (PKP) for vertebral compression fracture according to anti-osteoporosis medication was observed with 5 years follow-up in a nationwide population-based study. Factors associated with re-operation included female, high age, low body mass index, high Charlson comorbidity index, and irregular exercise.

FP12-4

Trauma, Tumor & Infection

Anatomical Consideration for Anterior Approach of Cervicothoracic Junction: A CT Image AnalysisEugene Park¹ and Woo-Kie Min^{1*}¹ Department of Orthopedic Surgery, Kyungpook National University Hospital, Korea

Background: In the cervicothoracic junction (CTJ), there is limited working space to perform the posterior-only approach. Therefore, a combined anterior approach is required in some cases. However, the great vessels and sternum obstruct the anterior corridor and make the anterior approach difficult. We analyzed relevant anatomical structures encountered during the anterior approach in the CTJ and evaluated the feasibility of previously reported surgical corridors.

Methods: We retrospectively examined 49 patients who underwent neck computed tomography angiography between January 2015 and May 2020. Using the coronal images, we measured the intercarotid artery angle (ICAA), intercarotid artery distance (ICAD), shape of the brachiocephalic trunk (BCT), and position of the BCT base. We then measured the most cranial level requiring manubriotomy for the anterior approach (ML), the most caudal level through the superior corridor (SC), and the most caudal level through the inferior corridor (IC) according to the surgeon's line of sight using the sagittal axis image.

Results: The mean ICAA and ICAD were 50.83 ± 15.23° and 33.38 ± 12.11 mm, respectively. Notably, BCT shape was of the convex type in most cases (42.9%), followed by the straight type (36.7%). In addition, the base of BCT was most commonly located inside the body (49%). Moreover, ICAA and ICAD were significantly greater in males. Although male mostly had the BCT base inside the body (64.3%), female mostly had it on the edge of the body (47.6%). Notably, ML showed the highest frequency (16.3%) in the T1 lower and upper bodies. Furthermore, through SC and IC, it was possible to approach the T4 lower body and T6 mid-body, respectively. SC showed the highest frequency (16.3%) in the T3 lower body, and IC showed the highest frequency (20.4%) in the T5 mid-body.

Conclusion: ICAA and ICAD were larger and higher in males. BCT was convex and located inside the body in most cases. The accessible level of ML, SC, and IC were T1, T3, and T5, respectively. For the anterior approach in the CTJ, preoperative vascular and accessible level analysis of corridors is essential to decide on the appropriate corridor and reduce complications.

Keywords: cervicothoracic junction, anterior approach, brachiocephalic trunk, manubrium

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FREE PAPER 13

Value, Outcomes & Healthcare Economics

FP13-1

Value, Outcomes & Healthcare Economics

The Comprehensive Enhanced Recovery after Surgery (ERAS) Protocol in the Entire Spinal Surgery: A Comparative Analysis of Clinical Outcomes and Medical Costs between Primary Spinal Tumors and Degenerative Spinal DiseasesWoon Tak Yuh¹, Joonhoe Kim², Yunhee Choi³, Chang-Hyun Lee², Chi Heon Kim² and Chun Kee Chung^{2*}¹ Neurosurgery, Hallym University Dongtan Sacred Heart Hospital, Korea² Neurosurgery, Seoul National University Hospital, Korea³ Division of Medical Statistics, Medical Research Collaborating Center, Seoul National University Hospital, Korea

Objective: To evaluate the impact of the comprehensive Enhanced Recovery After Surgery (ERAS) protocol on patients undergoing entire spine surgery and investigate the applicability of the protocol to both primary spine tumors (PST) and degenerative spinal diseases (DSD).

Background: Most studies on the ERAS protocol in spine surgery have focused on DSD, resulting in a lack of evidence for a comprehensive ERAS protocol applicable to both PST and DSD.

Methods: Entire adult spine surgery from 2003 to 2021 in the SNUH Spine Center were retrospectively reviewed, excluding metastatic cancer, infection, and trauma surgeries. Interrupted time series analysis (ITSA) was used to assess the impact of the ERAS protocol on medical costs and clinical outcomes including length of stay (LOS), 30-day readmission, reoperation, and surgical site infection (SSI) rates. Subgroup analyses were conducted on the PST and DSD groups in LOS and medical costs.

Results: The study included 7,143 surgeries, comprising 1,494 PST and 5,340 DSD surgeries. Following ERAS protocol implementation, entire spine surgery showed significant reductions in LOS and medical costs by 22% ($P=0.008$) and 22% ($P<0.001$), respectively. The DSD group demonstrated a 16% ($P<0.001$) reduction in LOS, while the PST group achieved a 28% ($P<0.001$) reduction, with a more pronounced LOS reduction in PST compared to DSD surgeries ($P=0.003$). Medical costs decreased by 23% ($P<0.001$) in the DSD group and 12% ($P=0.054$) in the PST group, with a larger cost reduction in DSD compared to PST surgeries ($P=0.021$). No statistically significant differences were found in 30-day readmission, reoperation, and SSI rates between pre- and post-ERAS implementation ($P=0.65$, 0.59 , and 0.52 , respectively).

Conclusions: The comprehensive ERAS protocol implementation significantly reduced LOS and medical costs in entire spine surgery, while maintaining comparable 30-day readmission, reoperation, and SSI rates. Our findings suggest that the ERAS protocol is equally applicable to surgeries for both PST and DSD, with a more pronounced effect on reducing LOS in the PST group and on reducing medical costs in the DSD group.

FP13-2

Value, Outcomes & Healthcare Economics

Risk of Reoperation and Infection Rate after Spine Osteotomy and Fusion Compare with Spinal Fusion Alone**Jaewon Shin², Joongwon Ha², Haksun Kim², Kyungsoo Suk¹, Sunghwan Moon¹, Byungho Lee¹, Jiwon Kwon¹, Yung Park² and Siyoung Park¹***¹ Orthopaedic surgery, College of Medicine, Yonsei university, Korea² Orthopaedic surgery, National health insurance service, Korea

Introduction: Severe deformity in degenerative spinal disease can greatly affect not only the appearance but also the function of the body by disrupting balance. Therefore, corrective spine surgery through spine osteotomy and fusion is often performed to maintain balance. Adult spinal deformities occur in elderly patients, and spine surgery is often complicated by comorbidities that elderly patients may have. In addition, the occurrence of complications such as device loosening or nonunion is higher in elderly patients due to accompanying osteoporosis. This study aims to compare the reoperation and postoperative infection rates between patients who underwent spinal fusion(SF) alone and those who underwent spine osteotomy and fusion(SOF).

Materials and Methods: In this retrospective, nationwide cohort study, the Korean National Health Insurance database from 1 January 2002 to 31 December 2019 was reviewed. Data were extracted for patients aged over 50 years old who underwent SF or SOF for spine degenerative deformity. The study followed individual patients for a period 6 months using their encrypted unique resident registration number. The primary endpoints were the reoperation and infection rates during the follow-up period. Additionally, other risk and socioeconomic factors associated with reoperation and infection were also assessed.

Results: Among the total of 5,899 patient, 1,091 (18.49%) underwent SOF while 4,808 (81.51%) underwent SF. The reoperation rates were 6.97% for SOF and 7.84% for SF. The infection rates within the first year were 8.52% for SOF and 7.49% for SF. There was no statistically significant difference found in either the reoperation rate or infection rate. However, there was a significant difference in the time to reoperation between the SO group (1.86 years) and SF group (2.82 years). (p=0.002). The risk of infection and reoperation was similar in both group. (hazard ratio 0.974 in infection, 1.099 in reoperation)

Conclusion: Compared with the SF alone, the SOF showed same reoperation and infection rates. But, early reoperation was required in SOF group.

FP13-3

Value, Outcomes & Healthcare Economics

The Modified Frailty Index Can Predict the Postoperative Complications after Lumbar Spine SurgeryJiwon Park¹ and Jae-Young Hong^{1*}¹Orthopaedic Surgery, Korea University Ansan Hospital, Korea

Background: The modified frailty index (mFI) consists of 11 variables and can be applied to stratify the risk after various surgical procedures. The purpose of this study is to evaluate utility of the modified frailty index in predicting postoperative complications among patients undergoing lumbar spine surgery.

Methods: We included 185 consecutive patients over >65 years who underwent lumbar spine surgery between January 1, 2011 and December 31, 2021. Primary outcome measure was rate of major complications based on Clavien-Dindo complication classification. Secondary outcome measure was surgical site infection and overall complication which included pneumonia, sepsis, deep vein thrombosis, pulmonary embolism, central nervous system complications, shock, cardiac arrest, acute renal failure and urinary tract infection.

Results: Total 185 consecutive patients were included in this study (age: 73.14±2.1 year; female: 62%). mFI (mean±SD) was 1.54±1.2 variables. Risk of major complication based on Clavien-Dindo complication classification was increased as mFI increased ($p < 0.05$); and overall complication as well as surgical site infection was also increased as mFI increased ($p < 0.05$ and $p < 0.05$, respectively). Multivariate analysis also showed that increasing mFI was significantly associated with higher complication, reoperation and morbidity rates. ($p < 0.05$).

Conclusion: As frailty was an independently associated with postoperative complications in patients undergoing lumbar spinal surgery, mFI can be utilized to predict surgical outcome and to reduce possible postoperative complications with caution.

FP13-4

Value, Outcomes & Healthcare Economics

Does Epidural Steroid Injection Affect Osteoporosis in Patients with Denosumab Therapy?JunHan Kim¹, JeongMo Koo¹, DongEun Shin¹ and TaeKeun Ahn¹¹ Dept. of Orthopaedic Surgery, CHA Bundang Medical Center, CHA University, Korea

Background: Recent studies have revealed that using steroid increases osteoporosis. In addition, some studies have postulated that the epidural steroid injection also would increase the risk of osteoporosis. Denosumab is a human monoclonal antibody which acts against receptor activator of Nuclear Factor kappa B(NF-kB) and well-used anti-resorptive agent in patients with osteoporosis. Denosumab, with its high anti-resorptive potential, has been studied among patients on glucocorticoid therapy. However, no previous studies analyzed its effect on glucocorticoid as spinal injectate. Therefore, in the current study, we aimed to figure out effect of steroid block therapy from patients who underwent denosumab therapy.

Materials and Methods: Through a retrospective review, among the patients underwent denosumab therapy root block or caudal block for pain relief from January 2018 to April 2022, patients who were able to follow-up for at least 12 months were included. A total 153 patients underwent denosumab therapy with root or caudal block were included. 98 patients were excluded because did not follow up Bone marrow density in any reason. 55 patients in all groups; group 1 (Denosumab user with epidural steroid injection), group 2 (only epidural steroid injection patients), group 3 (Denosumab user without epidural steroid injection) For the analysis the effect on bone marrow density, AVNOVA test was used.

Results: Mean age of the patient group 1 was 70.47(49.61) years-old, group 2 was 70.42(49.20) years-old, group 3 was 71.31(49.20). There were no difference between groups. Interestingly, analyzing degree of change of BMD(Lumbar) value, the change of group 1 was +0.0391, group 2 was -0.0182, group 3 was +0.02(g/cm²). With statistic analyzing, there was statistical difference between group 1 and 2 (p=0.003), there was no significant difference between group 1 and 3 (p=0.507).

Conclusion: Glucocorticoid is well known that it could accelerate osteoporosis. Thus many concern epidural block with glucocorticoid may have negative effect on BMD value. However, comparing with previous study, about 30mg/yr epidural steroid injection on denosumab user did not significantly affect BMD (lumbar) value

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(Adult Spinal Deformity / Pediatric Spine / Value, Outcomes
& Healthcare Economics)

FP14-1

Adult Spinal Deformity

Risk Factors for Radiographic Progression of Proximal Junctional Fracture in Patients Undergoing Surgical Treatment for Adult Spinal Deformity

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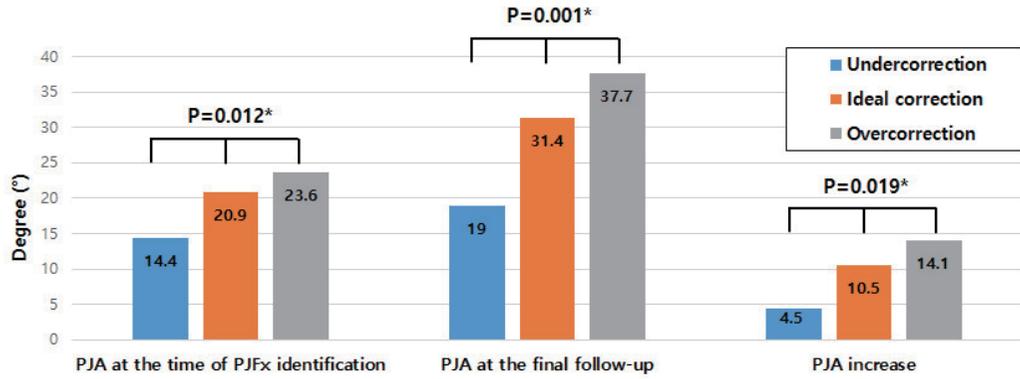
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Background: Proximal junctional fracture (PJFx) at the uppermost instrumented vertebra (UIV) or UIV+1 is the most common mechanism of PJF. Once PJFx develops, we should decide whether to perform revision surgery or to wait and see. There are few studies assessing the radiographic progression after PJFx development. Therefore, this study sought to identify the risk factors for radiographic progression of PJFx in surgical treatment for ASD.

Methods: In this retrospective study, among 317 patients aged > 60 years who underwent U5-level fusion from the sacrum, 76 with PJFx development were included. According to the change in proximal junctional angle (PJA), two groups were created: Group P (change U 10°) and Group NP (change <10°). Patient, surgical, and radiographic variables were compared between the groups to demonstrate risk factors for PJFx progression using uni- and multivariate analysis. The receiver operating characteristic (ROC) curve was used to calculate cutoff values. Clinical outcomes, such as visual analog scale (VAS) scores for back and leg pain, the Oswestry Disability Index (ODI) score, and the Scoliosis Research Society (SRS)-22 score, and revision rate were compared between the two groups.

Results: The mean age at the index surgery was 71.1 years, and there were 67 women enrolled in the study (88.2%). There were 45 patients in Group P and 31 in Group NP. Multivariate analysis revealed that overcorrection relative to the age-adjusted ideal pelvic incidence (PI)-lumbar lordosis (LL) target at the index surgery (odds ratio [OR] = 4.484; P=0.030), PJA at the time of PJFx identification (OR = 1.097; P=0.009), fracture at UIV versus UIV+1 (OR = 3.410; P=0.027) were significant risk factors for PJFx progression. The cutoff value of PJA for PJFx progression was calculated as 21° using the ROC curve. The clinical outcomes were significantly better in Group NP than Group P, including back VAS score, ODI value, and the SRS-22 scores for all items. Revision rate was significantly greater in group P than in group NP (17.8% vs. 51.6%, P = 0.001).

Conclusions: The risk factors for further progression of PJFx were overcorrection relative to age-adjusted PI-LL target at the index surgery, PJA > 21° at initial presentation, and fracture at the UIV level. Close monitoring is warranted for such patients not to miss the timely revision surgery.



FP14-2

Pediatric Spine

Case-based Review of Surgical Treatment for Pediatric Sacrococcygeal Teratomas**Mohammad Mohsen Mosleh¹, Moon Jun Sohn^{1*} and Tae Gil Heo²**

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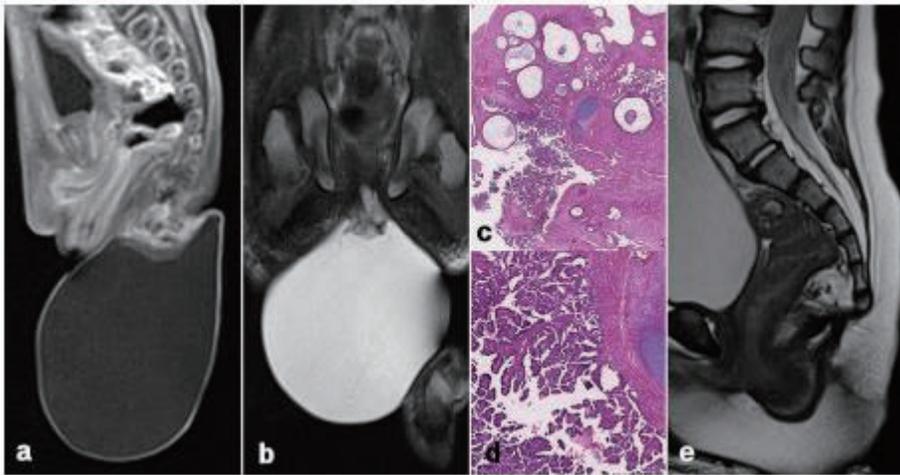
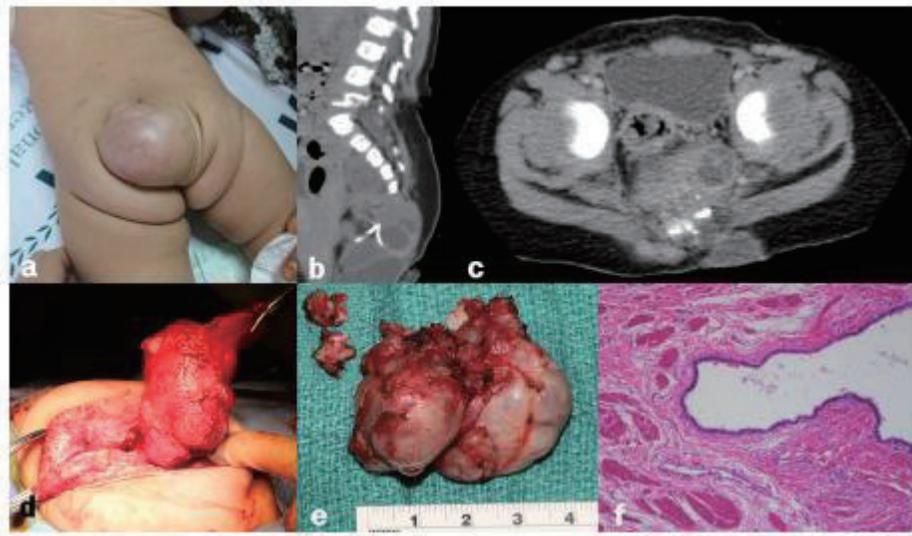
Background: Sacrococcygeal teratoma (SCT) is a rare congenital tumor originating from a variant of extragonadal germ cell neoplasm. Herein, we present three cases of neonatal SCTs undergoing surgical resection and reconstruction. We also review the literature to discuss the importance of proper perinatal management and timely surgical intervention depending on the tumor type and maturity to prevent malignant transformation and recurrence and ensure functional outcomes.

Methods: Three cases of SCT were retrospectively analyzed. Herein, we present three cases of infants undergoing surgery for SCTs and review the literature to highlight the importance and role of a multidisciplinary approach for adequate reconstruction and functional preservation when encountering large-sized tumors with concomitant congenital anomalies. Authors decided the surgical approach according to Altman's classification by the Surgical Section of the American Academy of Pediatrics (AAPSS).

Results: All infants underwent complete surgical resection of the SCT and coccygectomy during their neonatal/infancy period, followed by pelvic floor and buttock reconstruction while minimizing buttock contour deformity and undesirable skin scar. Two of the cases were histopathologically diagnosed as predominantly cystic mature teratomas of Altman types I and IV, and the third was a mature teratoma of Altman type II. There were no complications or tumor recurrence during the average follow-up period of 5.3 years.

Conclusions: This case-based review highlights the role of multidisciplinary team approaches, including prenatal monitoring, oncologic resection, and adequate reconstruction according to the type of tumor and anomaly. Optimal perinatal evaluation allows promising oncologic and functional outcomes in terms of timely intervention to eliminate tumor recurrence and malignant transformation. Complete oncologic surgical resection of SCTs should also include proper functional preservation strategies, such as the reconstruction of the pelvic floor, cosmetic buttock contouring, and preservation of bladder and bowel sphincter function.

Keywords: Functional outcome; Multidisciplinary approach; Reconstruction; Sacrococcygeal teratoma.



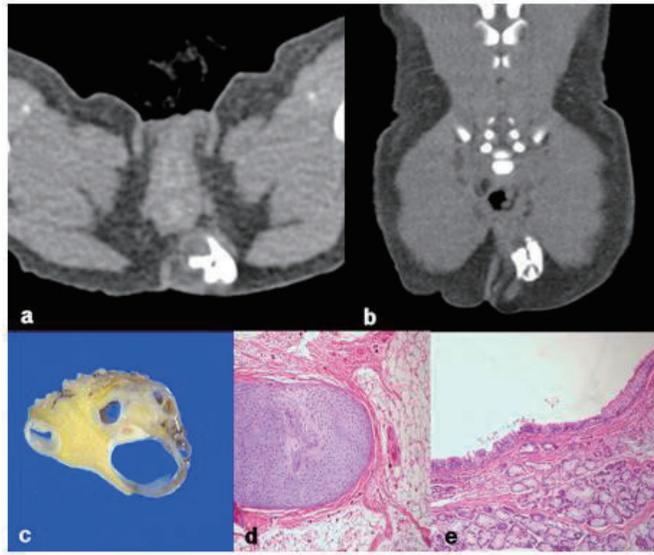


Table 1 A summary of functional disorders, reconstruction, recurrence, and mortality rates were reported in 892 patients with sacrococcygeal teratoma (SCT)

Author	Year	Number of patients	Functional disorder	Reconstruction	Recurrence MT IT MT	Mortality (in %)
Gabra et al.	2006	33	-	-	0, 0, 3, 3/33 (9%)	6
De Backer et al.	2006	70	33%	-	3/5, 2/5, 5/70 (7%)	8.5
Derikx et al.	2006	173	-	-	6, 5, 8, 19 (11.1%)	4.6
Joep et al.	2007	148	(B+U+S) 52 (65.8%)	-	-	8.8
Yoneda et al.	2013	84	-	-	-,-,-, 8.3%	-
Emily et al.	2014	45	U: 33% A: 29%	4 (8.8%)	-,-,-, 5 (11%)	15.5
Yao et al.	2014	107	-	-	-,-,-, 16 (16.4%)	17.8
Wang et al.	2017	105	-	-	-,-,-, 15 (14.4%)	4.7
Hambraeus.	2018	17	U: 29% B: 47%	-	-,-,-,-	-
Hambraeus et al.	2019	49	B: 36% U: 47%	-	-,-,-,-	8
Asahata et al.	2020	29	A: 20.7%, U: 13.8%, LM: 10.3%	3 (10.3%)	-,-,-,-	3.4
O'Shea et al.	2022	32	U: 13% B: 3%	-	-,-,-,-	0

A anorectal dysfunction, B bowel dysfunction, IT immature teratoma, LM lower extremity motion disorder, MT mature teratoma, S unacceptable scar, U urinary tract dysfunction, - no data

FP14-3

Value, Outcomes & Healthcare Economics

Tandem Spinal Stenosis: A Proposed Algorithm Based on Systematic ReviewTodsapon Chanchaoenchai¹, Vit Kotheeranurak^{1*}, Weerasak Singhatanadgige¹ and Worawat Limthongkul¹¹ Spine Unit, Orthopedics department, Faculty of Medicine, Chulalongkorn University, Thailand

Background: The term of tandem spinal stenosis is characterized by stenosis of the spinal canal in more than one noncontiguous region, typically cervical and lumbar spine. Surgical management consisted of simultaneous decompression of all stenosis and staged procedures depending on clinical presentation and severity. To our knowledge, an algorithm for choosing the proper management is still inconclusive.

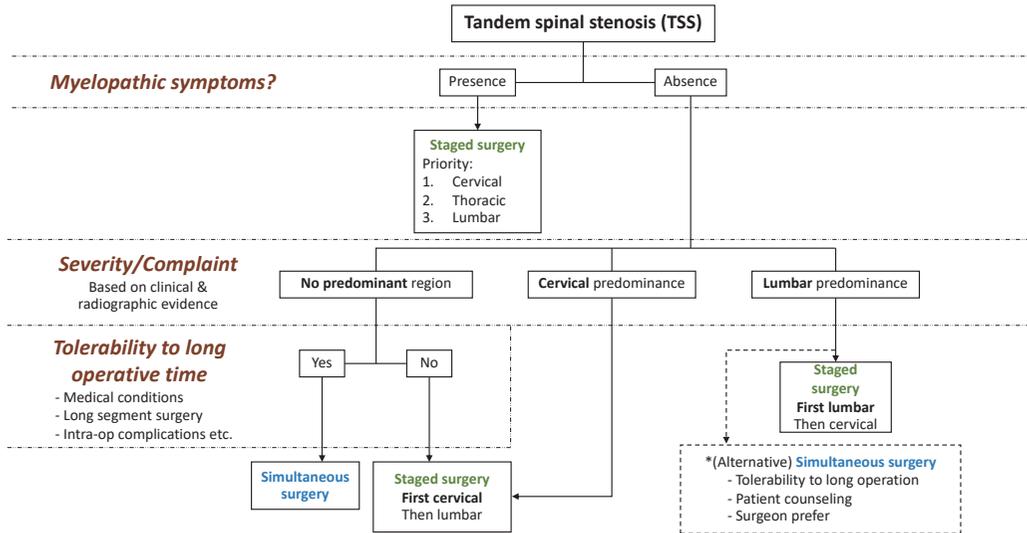
Objective: This study aimed to analyze currently available data and propose a decision making algorithm for treating tandem spinal stenosis to help surgeons choose the most appropriate management between simultaneous surgery of all stenosis or staged surgery.

Study Design: A systematic review of the literature to develop an algorithm formulated by key opinion leaders.

Methods: A systematic review of the literature using PubMed, Scopus and EMBASE databases was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Articles included patients with tandem spinal stenosis reporting outcomes after treatment with simultaneous surgery and staged surgery. Inclusion criteria were interventional research (randomized, non-randomized trials) and observation research (cohort, case-control). Exclusion criteria were 1): studied with subjects lower than 5 patients, 2): Spinal stenosis from infection or neoplasm, 3): systematic reviews, meta-analysis, or case report, 4): articles published in another language except for English. Demographic, perioperative, complications, functional outcome, and neurologic outcome data were collected and reviewed. Then, an algorithm was generated based on these findings with support and reconfirmation from key expert opinions.

Results: In total, 318 articles met the initial screening criteria. The detailed analysis identified the 26 best-matching articles; after applying the inclusion and exclusion criteria, 15 articles remained for this review.

Conclusion: According to the proposed algorithm, if myelopathy is presented, staged surgery is suggested with priority from the cervical, thoracic and lumbar spine respectively. In case of the absence of any myelopathic symptoms, severity and tolerability to long operation are considered. Stage surgery is suggested if 1): the predominant region is presented by performing the predominant region first 2): no predominant region and the patient can't tolerate to long operation due to medical comorbidity or long segment surgery by performing the cervical first. Simultaneous surgery is suggested if no predominant region and can tolerate to long operation.



FP14-4

Value, Outcomes & Healthcare Economics

Feasibility Assessment of an Expandable Lumbar Interbody Cage in Patients with High-risk Factors for Subsidence: Preliminary ReportKwang-Sup Song^{1*}, Jeongik Lee², Dae-Woong Ham¹, Jeuk Lee¹ and Byung-II Yoon¹¹ Department of Orthopedic Surgery, Chung-Ang University Hospital, College of Medicine, Chung-Ang University, Korea² Department of Orthopedic Surgery, Chung-Ang University Gwangmyeong Hospital, College of Medicine, Chung-Ang University, Korea

Introduction: Expandable cages may offer benefits, enhancing the ease of insertion and reducing iatrogenic endplate damage caused by impaction, and its use is increasing. However, exceedingly high stiffness by expansion could be one of the causes of increasing subsidence risk. So, we aimed to demonstrate the clinical feasibility of expandable cages in patients with high risks of subsidence.

Methods: A case series of 14 patients with minimum 6 months follow-up were enrolled and had risk factors, lower BMD (Hip T-score<-3.0, n=4), distal fusion level in multilevel fusion (at least 3 levels, n=6), and spondylolisthesis (more than grade 2, n=4). Bilateral expandable cages, 8 mm in height, maximum expandable to 12 mm, were inserted in PLIF procedures. Clinical outcomes (EuroQol-5-Dimensional questionnaire (EQ-5D), Oswestry Disability Index (ODI), and visual analog scale (VAS) for back and leg pain) and radiographic parameters (restored anterior and posterior disc height and lordotic angle) were evaluated and the threshold of subsidence was defined as > 3mm.

Results: All patients had no cage-related complications and subsidence at postoperative 6 months follow-up and clinical outcomes, including ODI, EQ-5D, and back and leg VAS, improved significantly at 6 months postoperatively. The disc height ratio (pre/last follow-up) at the anterior and posterior ranged from 0.87 to 1.01.

Conclusion: The authors' observations may suggest the feasibility of successfully using expandable cages to achieve and maintain the increased disc height without subsidence in patients with a high risk of subsidence in lumbar interbody fusion, even long-term follow-up needs.

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FREE PAPER 15

Trauma, Tumor & Infection 3

FP15-1

Trauma, Tumor & Infection

Optimal Surgical Methods for Solitary Metastasis of the Thoracolumbar Spine**Chang-Min Ha¹, Se-Jun Park², Sungjoon Lee¹, Sun-Ho Lee¹, Whan Eoh³ and Eun-Sang Kim^{1*}**¹ Department of Neurosurgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Korea² Department of Orthopedic Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Korea³ Department of Neurosurgery, Samsung Changwon Hospital, Sungkyunkwan University School of Medicine, Korea

Background: The aim of this study was to identify optimal surgical methods for extra-compartmental solitary metastasis of the thoracolumbar spine.

Methods: From January 2003 to December 2017, 45 patients who underwent surgical treatment for solitary metastases of the thoracolumbar spine were enrolled. We classified patients into four groups by surgical method: stabilization alone, decompression with stabilization, piecemeal corpectomy, and total en bloc spondylectomy (TES). For the four groups, the patient characteristics and surgical outcomes were analyzed by the Kruskal-Wallis test and Fisher's exact test. The overall survival (OS), local recurrence-free survival (RFS), and distant RFS were calculated by Kaplan-Meier survival curves and compared using log-rank test. Univariate Cox proportional hazards regression models were used to analyze efficiency of surgical methods.

Results: Our study population included 30 men (66.7%) and 15 women (33.3%). The mean age at the time of surgery was 59.1 (range, 33–67) years. There were 8 cases of stabilization alone, 12 cases of decompression with stabilization, 16 cases of piecemeal corpectomy, and 9 cases of TES. Baseline characteristics, including mean age and sex, Tomita surgical classification, and grade of malignancy did not differ between the four groups ($p > 0.05$). The local recurrence rate of the TES group was lower than those of the other three groups, but it did not reach statistical significance. The distant recurrence rate was higher in the piecemeal corpectomy group than in the decompression with stabilization group ($p = 0.006$). Other factors, such as hospital stay and neurological changes, were not significantly different between the four groups ($p > 0.05$). Compared to the stabilization alone group, the piecemeal corpectomy group was significantly associated with a decreased OS (hazard ratio [HR] = 3.86, $p = 0.037$) and a decreased distant RFS (HR = 3.59, $p = 0.026$) in univariate Cox proportional hazards regression model.

Conclusion: Based on our results, no definitive recommendations for surgical methods can be drawn. Thus, surgical methods should be tailored to individual cases to maximize tumor control and reduce recurrence rate and risk of postoperative complications.

FP15-2**Trauma, Tumor & Infection****Some Aspects of Dorsal Stabilization in Odontoid Fractures.**

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² Crimean Federal University named after Vernadsky V.I., anesthetist, Russia

³ Crimean Federal University named after Vernadsky V.I., neurologist, Russia

Objective: The objective was to analyze the modern methods of posterior stabilization of the atlantoaxial complex and development of a method for dorsal stabilization of the spine, which may reduce the incidence of postoperative complications, may reduce radiation exposure of the patient and medical staff, may shorten the time of surgical intervention, and, accordingly, may improve immediate and long-term results in the postoperative period.

Materials and methods: A prospective study of 67 patients with atlantoaxial injuries was investigated (type II odontoid fractures according to Anderson's and D'Alonzo's classification). The combination of C1 and C2 fractures accounted for 21.3% of all atlantoaxial complex injuries. Men dominated in the investigated group - 54 cases or 80.6% (36.1±2.1 years). Women - 13 cases or 19.4% (46.2±4.1 years). The main causes of the injury were road accidents - 94%. Various water incidents compounded 6%. Retrospective monocenter cohort analysis was the design of research. Level of evidence - II.

Results: Dorsal spinal stabilization by hooks was used as a method of surgical treatment of the odontoid fractures of type II in 55 (82.1%) cases. When necessary the odontoid fracture reduction was conducted by Mayfield brace controlled by the C-arm. The occipital spondylodese with the hooks was used at C2-C3 level when odontoid fracture was combined with a C1 fracture (Jefferson fracture). The Philadelphia orthosis was used for 2-3 months to ensure sufficient rotational and axial stability in the postoperative period. The follow-up examination was carried out after 3-6 months. There was no dysfunction of the stabilizing system nor secondary odontoid displacement. Catamnesis for more than one year was followed up in 24 (43.6%) patients. Solid bone fusion of odontoid fracture and absence of atlantoaxial instability were observed in 95.8% cases confirmed by radiography and/or computer tomography.

Conclusion: Dorsal spinal stabilization by hooks is effective method of surgical treatment of odontoid fractures type II for the acute period of atlantoaxial injury. The stabilization by hooks has got the following advantages: there is no risk of injury to the vertebral artery, internal carotid artery, etc.; surgical technique is simplified; the learning curve is shorter; less investigations are required (3D-CT-angiography, postoperative CT-scan, etc.); the radiation load for the doctor and patient is reduced; blood loss and surgery time are reduced; the cost of examination and treatment is less as well.

FP15-3

Trauma, Tumor & Infection

Application of Open Door Laminoplasty Following Intradural Tumor Resection in Cervical, Thoracic, And Lumbar Spine**Andhika Yudistira¹, Ery Satriawan¹ and Syaifullah Asmiragani¹**¹ Orthopaedic & Traumatology - Spine Division, Universitas Brawijaya, Indonesia

Background: Primary intraspinal tumors account for 2-15% of all central nervous system (CNS) tumors. Most intraspinal tumors are benign, and about 40% of them occur intradurally, for which early surgery is the preferred treatment. Laminectomy with pedicle screw fixation is the conventional surgical treatment. However, laminectomy with pedicle screw fixation is likely to reduce the spinal range of motion (ROM), with many other complications, although it can maintain the stability of the spine. The aim of this study is to determine whether laminoplasty as a new surgical approach for cervical, thoracic and lumbar intradural tumors is superior to laminectomy in preserving spinal ROM, maintaining spinal stability and reducing postoperative complications.

Methods: 30 patients (14 men and 16 women) with intradural tumors (3 intramedullary tumors and 17 extramedullary tumors) in the cervical, thoracic, and lumbar spine were included in our study. 8 patients presented with cervical intradural tumors, 13 patients with thoracic, and 9 patients with lumbar intradural tumors. The average age was 53.15 years (range 8 - 77 years). All patients were treated surgically (tumor excision), 19 patients followed by posterior instrumentation and fusion, 4 patients with laminectomy only, and 7 patients followed by open door laminoplasty.

All patients with laminoplasty underwent the same technique : Open door laminoplasty using titanium Arch plate.

Results: Operative exposure was good and permitted complete resection. No complications such as postoperative spinal canal stenosis or kyphosis were observed. Computed tomography(CT) indicated that bony fusion occurred in all cases with laminoplasty following tumor resection.

Conclusion: Compared with the traditional surgery, the laminoplasty procedure following intradural resection surgery can better maintain the stability of the spine, preserve spinal ROM, and reduce postoperative complications. It is a surgical method that can be clinically popularized.

FP15-4

Trauma, Tumor & Infection

Incidence and Treatment Trends of Infectious Spondylodiscitis in South Korea : A Nationwide Population-based Study**Hee Jung Son¹, Chang-Nam Kang^{2*}, Myongwhan Kim¹ and Dong Hong Kim¹**¹ Orthopedic Surgery, Nowon Eulji Medical Center, Eulji University School of Medicine, Seoul, Korea² Orthopedic Surgery, Hanyang University College of Medicine, Seoul, Korea

Background: In recent years, the incidence of infectious spondylodiscitis (IS) has been increasing due to the increased numbers of older patients with chronic diseases, immunocompromised people, steroid use, drug abuse, invasive spinal procedures, and spinal surgeries. However, research on the entire population is lacking. This study aimed to investigate the incidence and treatment trends of IS in South Korea.

Methods: This study used data from the national database of the Korean Health Insurance Review & Assessment Service from 2010 to 2019. The database includes diagnoses classified by International Classification of Diseases, 10th revision, demographic characteristics, prescriptions, inspections, procedures, and operations for almost patients in South Korea. Overall, 169,244 patients (average age, 58.0 years) diagnosed with IS for 10 years were enrolled.

Results: The 10-year incidence of IS in South Korea was 33.4 cases per 100,000 population. The incidence rate per 100,000 population increased 1.5 times from 22.90 cases in 2010 to 35.79 in 2019 ($P < 0.05$). The incidence rate of pyogenic spondylodiscitis has increased from 15.35 per 100,000 population in 2010 to 33.75 in 2019 ($P < 0.05$); those of tuberculous spondylodiscitis has decreased from 7.55 per 100,000 population in 2010 to 2.04 in 2019 ($P < 0.05$). Patients in their 50s accounted for the highest number of 37,132 patients, and 47.6% of all IS (80,578 patients) occurred in elderly patients aged 60 years or older. The incidence rate was higher in women than in men ($P < 0.05$). Conservative treatment has increased from 82.4% in 2010 to 85.8% in 2019; surgical treatment has decreased from 17.6% to 14.2% ($P < 0.05$, respectively). Corpectomy and anterior fusion surgery has decreased significantly, whereas incision and drainage has increased ($P < 0.05$, respectively). There were a lot of comorbidities such as diabetes mellitus (93,199 patients, 55.1%), rheumatoid arthritis (46,146 patients, 27.3%), and end-stage renal disease (21,682 patients, 12.8%). Total healthcare costs increased 2.9 times from \$29,821,391.65 in 2010 to \$86,815,775.81 in 2019. And the share of healthcare costs as a percentage of gross domestic product has increased significantly, thus socio-economic burden of IS has increased rapidly ($P < 0.05$).

Conclusions: The incidence rate of IS has increased in South Korea. The incidence of IS was highest in people in their 50s, and higher in women than in men. As for the treatment trends of IS, conservative treatment tended to increase, and surgical treatment tended to decrease. The socio-economic burden of IS has increased rapidly.

AUGUST 18 (Fri)

FREE PAPER 16

Endoscopic Technologies & Techniques 3

FP16-1

Endoscopic Technologies & Techniques

How to Manage Intraoperative and Postoperative Bleeding in Unilateral Biportal Endoscopic Spine Surgery**Yong Jin Park¹, Sung Kyu Kim² and Hyoung Yeon Seo^{2*}**¹ Orthopaedic Surgery, Suncheon Hana Hospital, Korea² Orthopaedic Surgery, Chonnam National University Hospital, Korea

Background: Bleeding control during endoscopic spine surgery is essential to acquire clear surgical view. Also uncontrolled bleeding may cause symptomatic postoperative epidural hematoma causing revision surgery. We have to recognize the common bleeding focus and know how to control it appropriately.

Method: The subjects of this study were 150 patients who underwent unilateral biportal endoscopic spine surgery from 2021 to 2022. We evaluated common bleeding focus during operation and describe the method how to control effectively without complications.

Results: At initial procedure of unilateral biportal endoscopy (UBE), bleeding is mostly from muscles around working and viewing portal. They can be easily controlled by using radiofrequency device. After approaching space between back muscle and lamina, injury of inferior and superior articular artery branches may cause bleeding interrupting endoscopic view. At this circumstance, radiofrequency device is also effective and powerful tool.

In next step, bone work is proceeded to expose ligamentum flavum. For elderly patients with osteoporosis show considerable bone bleeding during laminotomy procedure. Without controlling this bone bleeding at time becomes more difficult as surgery goes on. Applying bone wax is very useful same as open surgery when we control bone bleeding. However, handling and applying bone wax at right place needs practice. Mostly massive bleeding appears during flavectomy caused by epidural veins. Since dura exposure was done, it is a burden for surgeons controlling bleeding at this stage. Cranial attach site of deep layer of ligament flavum and caudal attach site near traversing root is most frequent bleeding point. Care of using surgical instruments are needed working around this point. Hook type radiofrequency device is also useful with low power setting. In uncontrollable bleeding situation, using gelatin thrombin combined hemostatic agent can be an option. Before finishing operation, we have to check for any remaining bleeding focus and after confirming it insertion of drainage through working portal is important. Depending on postoperative accumulated drainage amount, one to three days is enough for maintaining drainage.

Conclusions: By understanding and predicting the common bleeding focus and knowing how to manage it properly, unilateral biportal endoscopic spine surgery can be safely performed avoiding complications.

FP16-2

Endoscopic Technologies & Techniques

Learning Curve and Clinical Outcome of Biportal Endoscopic Transforaminal Lumbar Interbody Fusion**Sang Bum Kim^{1*}, Byounggu Lee¹, Jae Sung Ahn² and Ho Jin Lee²**¹ Orthopedics, Sejong Cheung Nam University hospital, Korea² Orthopedics, Cheung Nam University hospital, Korea

Minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) is a common surgical technique for diseases of the lumbar spine. Biportal endoscopic(BE)-assisted transforaminal lumbar interbody fusion is a minimally more invasive technique that has a long learning curve. There is currently no consensus on the learning curve and clinical outcome for BE-TLIF. So, we analyzed the learning curve and clinical outcome. A retrospective study of forty patients who underwent BE-TLIF for degenerative lumbar disease by a single surgeon from January 2021 to December 2022 was performed. 38 patients had a single-level fusion, and 2 patients had two level fusion. Total operative time and complications were analyzed. Clinical outcome was measured using the Visual Analog Scale (VAS) score for back and leg pain. The learning curve was evaluated by a nonparametric regression locally weighted scatterplot smoothing curve. Cases before the stable point on the curve were designated as group A, and those after the stable point were designated group B. Operative time decreased as the number of cases increased. A stable point was noticed on the 12th month and the 15th case after the first BE-LIF was performed. All cases showed improved VAS scores at the final follow-up. Time to ambulation was significantly lower in group B compared to group A. VAS scores did not differ between the two groups. BE-LIF is an effective minimally invasive technique for lumbar degenerative disease. In our case series, this technique required approximately 15 cases to reach an adequate performance level.

FP16-3

Endoscopic Technologies & Techniques

What Is the Real Cause of a Postoperative Spinal Epidural Hematoma in Hypertensive Patients?Young Rok Go*Orthopedics, Seoul Sacred Heart General Hospital, Korea*

Purpose: There are studies reporting that hypertension is a causative factor of epidural hematoma after spinal surgery. Some authors suggested that increased blood viscosity in hypertensive patients was the main cause, while other authors suggested that an increase in systolic blood pressure during anesthesia recovery when the endotracheal tube was removed caused massive bleeding and formed a large hematoma that could not be drained said to be the main cause. The present authors attempted to prove the true cause of postoperative spinal epidural hematoma (POSEH) in hypertensive patients.

Method: The patients who underwent a single segment lumbar decompression with a biportal endoscopic spine surgery (BESS) technique between 2018 Aug 1 and 2021 June 30 were reviewed retrospectively. The study subjects were divided into normal group (Group I) and POSEH group (Group II). Their hypertension status, systolic blood pressure before surgery, peak blood pressure at the time of extubation (PS/DBPE), systolic/diastolic blood pressure 1 hour after surgery (S/DBP-PO1), hematologic factors related to blood viscosity, hematologic factors related to blood coagulation, and the use of antiplatelet drugs (APD) affecting hemostasis were compared. Three hundred fifty-two patients were eligible for this study.

Results: Out of the 352 patients, 18 (5.1%) required revision surgery to remove POSEH. Of these patients, 127 did not have hypertension and 227 had been treated for hypertension. In the single variable analysis, the following factors were found to be significant. The peak blood pressure at the time of extubation (PSBPE) was 154.1418.3mmHg in Group I and 163.7415.7 mmHg in Group II (P=0.021). The systolic/diastolic blood pressure 1 hour after surgery (SBP-PO1) was 134.3415.0mmHg in Group I and 143.0415.5mmHg in Group II (P=0.017). The use of antiplatelet drugs (APD) was as follows: non 275/ stop 22/ taking 17 in Group I and non12/ stop 2/ taking 4 in Group II (P=0.002). The fibrinogen level was 443.64151.7mg/dL in Group I and 391.6488.6mg/dL in Group II (P=0.030). For multivariable analysis, PSBPE and SBP-PO1 were converted into categorical variables. The cut-off values for PSBPE and SBP-PO1 were set at 170mmHg and 150mmHg, respectively, based on the widest area under the ROC curve. In the multivariable logistic regression test, the significant factors for POSEH were as follows: PSBPE U 170mmHg (P=0.007, Odds ratio=4.034), SBP-PO1 U 150mmHg (P=0.040, Odds ratio=2.957) and APD medication (P=0.013, Odds ratio=5.048).

Conclusion: The presence of hypertension and preoperative hypertension were not found to be significant risk factors for POSEH. However, PSBPE U 170mmHg and SBP-PO1 U 150mmHg were found to independently increase the risk of POSEH by four times and three times, respectively. Taking APD medication also increased the risk five times independently. To prevent POSEH, it is more important to control systolic blood pressure at the time of extubation and in the few hours after the operation, rather than just before the operation.

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Endoscopic Technologies & Techniques

Comparison of Minimal Invasive Versus Biportal Endoscopic Transforaminal Lumbar Interbody Fusion for Single-level Lumbar DiseaseJu Eun Kim*Orthopaedic surgery, Baroseomyeon hospital, Korea*

Study design: Retrospective study.

Objective: The authors aimed to compare the clinical outcomes of biportal endoscopic transforaminal lumbar interbody fusion (BE-TLIF) with those of minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) using a microscope.

Summary of background data: Lumbar spinal fusion has been widely performed for various lumbar spinal pathologies. Minimally invasive transforaminal interbody fusion using a tubular retractor under a microscope is a method of achieving fusion while reducing soft tissue injury. Recently, several studies have reported minimally invasive techniques for lumbar discectomy, decompression, and interbody fusion using biportal endoscopic spinal surgery.

Materials and methods: This retrospective study included 87 patients who underwent single-level TLIF for degenerative or isthmic spondylolisthesis between 2015 and 2018. Thirty-two and 55 patients underwent BE-TLIF (group A) and MI-TLIF (group B), respectively. Visual Analogue Scale scores of the back and leg and Oswestry Disability Index were collected perioperatively. Further, data regarding perioperative complications, including length of hospital stay, time to ambulation, and fusion rate, were collected.

Results: The Visual Analogue Scale score at 2 weeks and 2 months postoperatively was significantly lower in group A ($P=0.001$). All other clinical scores showed improvement with no significant difference between the 2 groups ($P>0.05$). The difference in the fusion rates between group A (93.7%) and group B (92.7%) were not significant ($P=0.43$).

Conclusions: Because BE-TLIF yielded lesser early postoperative back pain than did MI-TLIF, it may allow early ambulation and a shorter hospitalization period. BE-TLIF may be a viable alternative to MI-TLIF in patients with degenerative or isthmic spondylolisthesis with superior clinical results in the early postoperative period.

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MIS 3

FP17-1**MIS****The Influence on Adjacent Lumbar Segment after Oblique Lumbar Interbody Fusion for Spondylolisthesis****Tae Shin Kim², Chi Heon Kim^{1*}, Tae-Hwan Park² and Chun Kee Chung^{1*}**¹ Neurosurgery, Seoul National Univeristy Hospital, Korea² Neurosurgery, Champodonamu Hospital, Korea

Introduction: Lumbar spondylolisthesis is a common spinal degenerative disease that needs spinal fusion surgery. Sometimes, an adjacent level mild to moderate stenosis is combined, but including the adjacent level during surgery of the index level is controversial. Spondylolisthesis causes anterior slip of vertebra and decrease of segmental angle at the index level, and the adjacent level may compensate the change with hyperextension to maintain spinal balance. Hyperextension may lead to buckling of ligamentum flavum and consequent spinal stenosis. After reduction of spondylolisthesis, the adjacent level may not need the compensation, but it has not been reported. The purpose of this study was to see the radiological change and clinical outcomes of adjacent segment stenosis in patients with lumbar spondylolisthesis.

Method: Consecutive 40 patients (M:F = 12:28, age 67.410 years) who underwent single-level oblique lumbar interbody fusion (OLIF) for L4-5 or L5-S1 spondylolisthesis were retrospectively reviewed. A cranial adjacent segment lumbar central stenosis was combined in 16 patients (Stenosis-group), and it was not in 24 patients (No-stenosis group). Oblique lumbar interbody fusion was performed in one position under the guidance of spinal navigation (OLIF-one) and spondylolisthesis was reduced in all patients. Postoperatively, patients were encouraged to ambulate from the day of surgery and discharged 3-4 days later. Indirect decompression was confirmed with magnetic resonance imaging (MRI). Patient were schedule to visit at 1, 3, 6 and 12 months postoperatively. Clinical parameters (back pain, leg pain, Oswestry disability index) and radiological parameters (pelvic incidence, sacral slope, pelvic tilt, lumbar lordosis, C7-sagittal vertical axis, segmental angle at the index level, segmental angle at adjacent segment, horizontal distance of index level from S1-plumb line, and spinal canal area at index level and adjacent level) were longitudinally compared between groups (Stenosis vs. No-stenosis groups).

Result: All patients were discharged as scheduled. Both groups showed similar significant clinical improvement. Segmental angle at the index was significantly improved in both groups ($p < 0.05$), but segmental angle at the cranial adjacent segment was significantly decreased only in Stenosis-group ($p < 0.05$). Spinal canal area at index level was significantly improved in both groups ($p < 0.05$). Spinal canal area at the adjacent level was significantly improved only in Stenosis group ($p < 0.05$). Lumbar lordosis was significantly increased in both groups ($p < 0.05$). Transient complication occurred in 6 patients of Stenosis-group (37.5%) and 7 patients of No-stenosis group (29%) ($p = 0.59$).

Conclusion: A re-aligned spondylolisthesis may reduce hyperextension of adjacent segment. When a mild lumbar spinal stenosis was combined at adjacent level with spondylolisthesis, it may not be essentially included in surgery.

Keywords: adjacent; lumbar vertebra; spine; spine fusion; spondylolisthesis; stenosis; surgery

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MIS

Does Direct Decompression Necessary for Lateral Lumbar Interbody Fusion (LLIF)?: A Randomized Control Trial**Worawat Limthongkul¹, Pakawas Praisarnti¹, Vit Kotheeranurak¹, Wicharn Yingsakmongkol¹ and Weerasak Singhatanadgige¹**¹ Department of Orthopedics, Faculty of Medicine, Chulalongkorn University and King Chulalongkorn Memorial Hospital, Thailand

Background: Indirect decompression effect after Lateral Lumbar Interbody Fusion (LLIF) in appropriately selected patients has been shown to improve both clinical and radiographic outcomes for the treatment of degenerative lumbar diseases. Re-operation rates following such procedures have been described in the literature as varying and having been reported to be up to 70%. The objective of this study is to compare the clinical and radiographic outcomes between indirect decompression and direct decompression in patients undergoing lateral lumbar interbody fusions.

Methods: A randomized controlled trial of 28 patients undergoing single-level L2-L5 LLIF was conducted. The subjects were divided into two groups (14 in each group): the indirect decompression group and the direct decompression group. Clinical outcomes consisted of the visual analogue scale (VAS) and the Oswestry Disability Index (ODI). Data were collected at preoperative, 1, 3, 6, and 12 months. Radiographic outcomes included cross-sectional thecal sac area (CSA), disc height (DH), foraminal height (FH), and foraminal area (FA). Perioperative outcomes were analyzed based on intraoperative blood loss and operative time.

Results: Demographic characteristics, the preoperative VAS score, the preoperative ODI, and preoperative radiographic parameters did not differ between the two groups. In both groups, there were significant improvements in the clinical outcomes of VAS score and ODI ($p < 0.001$). There were no significant differences in clinical outcomes of VAS back at 6 months between the indirect decompression group and the direct decompression group (0.92 4 0.86 vs 0.93 4 0.83, $p=0.986$), VAS back at 12 months (0.38 4 0.52 vs 0.70 4 0.48, $p=0.182$), VAS leg at 6 months (0.31 4 0.63 vs 0.64 4 0.84, $p=0.256$), VAS leg at 12 months (0.22 4 0.44 vs 0.55 4 1.04, $p=0.395$), ODI at 6 months (7.69 4 7.40 vs 8.72 4 9.87, $p=0.761$), ODI at 12 months (8.88 4 11.22 vs 8.08 4 6.14, $p=0.840$). In terms of radiographic outcomes between CSA, DH, FH, and FA, there was no significant difference between the two groups. LLIF with indirect decompression outperformed LLIF with direct decompression significantly in terms of blood loss (68.13 4 32.06 mL vs. 210.00 4 110.05 mL, $p=0.0029$) and operating time (136.35 4 28.07 mins. vs. 182.18 4 42.67 mins., $p=0.0024$). There was no re-operation in either group.

Conclusions: At 12-month follow-up, there was no difference in the clinical and radiographic outcomes and re-operation rate between the LLIF with indirect decompression and the LLIF with direct decompression. Indirect decompression with appropriate patient selection can provide comparable effectiveness in terms of clinical and radiographic parameters in comparison to direct decompression with less estimated blood loss and a shorter operative time.

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Risk Factors for Predicting “clinical” Indirect Decompression Failure**Kaweekrai Anusart¹, Weerasak Singhatanadgidge^{1*}, Worawat Limthongkul¹, Vit Kotheeranurak¹ and Wicharn Yingsakmongkol¹**¹*Orthopedics, Faculty of Medicine, Chulalongkorn University, Thailand*

Background: Indirect decompression by lateral lumbar interbody fusion (LLIF) has been reported to improve both clinical and radiographic outcomes by indirect decompression of neural structure, while preserving posterior spinal structure and restoration of canal diameter, disc height, foraminal height and sagittal parameters. However, the failure rate previously known as subsidence of cage and revision is rarely reported and doesn't directly reflect patient outcomes. Failure of improvement of Oswestry disability index (ODI) by 20 percent at 1 year had the highest accuracy to identify clinical failure. Our study analyzed the risk factors that could contribute to “clinical” indirect decompression failure (IDF).

Study design: Retrospective cohort study

Objectives: This study aimed to report the incidence and potential risk factors of clinical indirect decompression failure (IDF) following lateral lumbar interbody fusion (LLIF) for lumbar degenerative diseases.

Materials and methods: Fifty-three consecutive patients (91 levels, 8 men and 45 women; mean age, 68.6 years) with symptomatic degenerative spine disease treated with either single- or multi-level LLIF procedure without direct posterior decompression between 2015 and 2021 were included. Patients were divided into clinical success and clinical failure groups. Clinical failure was defined as failure to improve ODI by 20% at 1 year post-operatively. The demographics, clinical characteristics, radiographic measurement were collected. Univariate and multivariate logistic regression analyses were used to assess factors associated with clinical failure.

Results: Of the Fifty-three consecutive patients (91 levels), 42 (79.2%) patients had clinical success while 11(20.7%) patients had clinical indirect decompression failure (IDF). Non-navigation use had the strongest association with IDF (OR = 10.83, p=0.005), Other factors significantly associated with IDF included pre-op VAS (OR=0.61, p=0.035) and having osteoporosis (OR=5.43, p=0.039). The multivariate model including all these factors had the optimum fit. Non-navigation retained the strongest association with IDF (adjusted OR (aOR)=7.77, p=0.024) followed by pre-op VAS (aOR=0.66, p=0.12) and osteoporosis (aOR=3.02, p=0.24) (Figure).

Conclusion: Risk factors for clinical indirect decompression failure included osteoporosis, the lower pre-operative severity by VAS and non-navigation system use.

Keywords: Indirect decompression; Clinical failure; Lateral lumbar interbody fusion (LLIF)

Characteristic	Success (n=42)	Fail (n=11)	P-value
Age (years)	68 (63 - 75)	71 (61 - 76)	0.80
BMI (kg/m ²)	24.95 (22.21 - 29.33)	24.1 (21.48 - 29.7)	0.71
BMD T score	-1.4 (-2.1 to -0.8)	-1.8 (-2.6 to -1.2)	0.05
Pre-operative VAS	8.5 (8 - 10)	8 (6 - 8)	0.03
Diagnosis			0.88
ASD	4 (9.52)	1 (9.09)	
HNP	2 (4.76)	1 (9.09)	
SCS	11 (26.19)	2 (18.18)	
Degenerative scoliosis	8 (19.05)	3 (27.27)	
Spondylolisthesis	17 (40.48)	4 (36.36)	
BMI >25kg/m ²	21 (50)	5 (45.45)	1.00
Osteoporosis classification			0.06
Normal	14 (33.33)	1 (9.09)	
Osteopenia	24 (57.14)	6 (54.55)	
Osteoporosis	4 (9.52)	4 (36.36)	
Smoker	1 (2.38)	0	1.00
O-arm navigation	39 (92.86)	6 (54.55)	0.006
Fixation type			0.62
Percutaneous pedicular screw	39 (92.86)	10 (90.91)	
Pivox plate	1 (2.38)	0	
Stand alone	2 (4.76)	1 (9.09)	
Position			0.71
Single	12 (38.57)	2 (18.18)	
Double	30 (71.43)	9 (81.82)	

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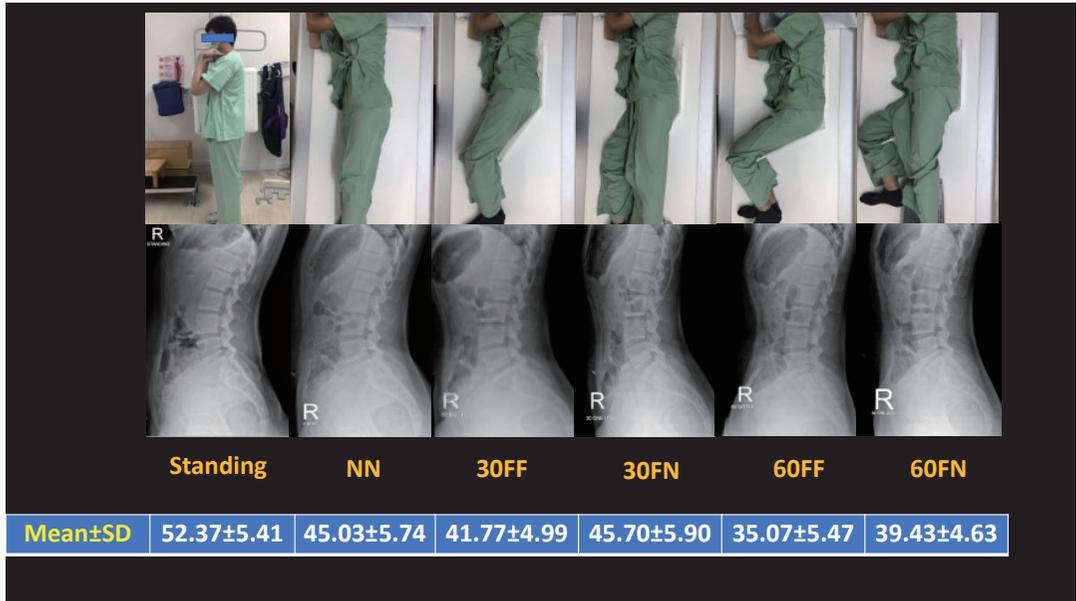
Effect of Difference Hip Positions on Lumbar Lordosis in Single Lateral Position for Lateral Lumbar Interbody Fusion**Natavut Prasertkul¹ and Worawat Limthongkul¹**¹ Orthopaedic, Faculty of Medicine, Chulalongkorn University and King Chulalongkorn Memorial Hospital, Bangkok, Thailand

Background: Single lateral position with lateral lumbar interbody fusion (LLIF) is gaining popularity due to lower operation time, length of hospital stays and blood loss. However, restoration of lumbar lordosis (LL) and pelvic parameters (PPs) in single lateral position may be challenging. Although, difference hip position during spinal fusion has been reported to affect the LL, little information exists concentrating on hips position on lateral decubitus position. Our study focused on effect of 5 difference hips position on LL and PPs in right lateral decubitus position (RLDP).

Methods: Thirty healthy volunteers (15 female and 15 male) without spinal problem were included. Lateral spine radiographs were taken in standing and five difference hip positions, neutral position both hips (NN), 30 degree flexion both hips (30FF), 30 degree flexion left hip and neutral position right hip (30FN), 60 degree flexion both hips (60FF) and 60 degree flexion left hip and neutral position right hip (60FN) in RLDP. LL and PPs including pelvic tilt (PT) and sacral slope (SS) were measured in each position. Statistical analysis was performed to identify a correlation between changes in the LL and PPs in each position.

Results: Mean LL each position was 52.4°± 5.4° in standing position, 45.0°± 5.7° in NN, 41.8°± 5.0° in 30FF, 45.7°± 5.9° in 30FN, 35.1°± 5.5° in 60FF and 39.4°± 4.6° in 60FN. When compared to standing position, significant decreased in LL were found in all hip positions (P<0.05). Mean PT each position was 18.3°± 5.1° in standing position, 17.1°± 6.7° in NN, 17.2°± 5.7° in 30FF, 15.4°± 6.6° in 30FN, 21.1°± 7.4° in 60FF and 17.9°± 5.6° in 60FN. When compared to standing position, significant decreased in PT was found in 30FN (P=0.002) and significant increase in PT was found in 60FF (P=0.011). Mean SS each position was 34.1°± 4.5° in standing position, 35.3°± 6.3° in NN, 35.2°± 5.0° in 30 FF, 37.0°± 5.8° in 30FN, 31.3°± 4.8° in 60FF and 34.5°± 4.6° in 60FN. When compared to standing position, significant decreased in SS was found in 60FF (P=0.011) and significant increase in SS was found in 30FN (P=0.002).

Conclusion: Our study confirmed a significant reduction in LL in RLDP. Surgeon should be aware of positing patient for proper spinal alignment before performing an operation. 30FN position provided the approximate LL to standing position. We recommended flexing lower hip at 30 degree and position upper hip in neutral position for a single lateral position for lumbar interbody fusion surgery.



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Emerging Technologies & Techniques

Multi-pose-based Convolutional Neural Network Model for Diagnosis of Patients with Central Lumbar Spinal Stenosis

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Background: Retrospective radiographic classification using convolutional neural networks.

Objective: The importance of plain radiographs has been gradually declining since development magnetic resonance imaging (MRI). However, plain radiographs reinforced with deep learning have demonstrated a dramatically improved diagnostic ability. Previously, we developed a convolutional neural network (CNN) model using a radiograph for diagnosing lumbar spinal stenosis (LSS).

Objective: To improve and generalize the prediction performance of CNN models using multi-pose radiographs.
Methods: Individuals with severe or no LSS confirmed using MRI were enrolled in this study. Lateral radiographs of three postures were collected consecutively. We used four pre-trained algorithms and developed a multi-pose-based CNN (MP-CNN) model and three single-pose-based CNN (SP-CNN) models using extension, flexion, and neutral postures. The MP-CNN model was validated using additional internal and external datasets to measure its generalization performance.

Results: The performance of the ResNet50-based MP-CNN model achieved the largest area under the receiver operating characteristic curve (AUROC) of 91.4% (95% confidence interval [CI] 90.9%-91.8%). In the extra validation, the AUROC of the MP-CNN model was 91.3% (95% CI 90.7%-91.9%) and 79.5% (95% CI 78.2%-80.8%) for the extra-internal and external validation datasets, respectively. The MP-based heatmap for each patient was validated with a reasonable direction for the decision as an optimized visualization method.

Conclusion: The ResNet50-based MP-CNN model for predicting LSS using the three postures of lumbar radiographs showed high diagnostic accuracy through internal and external validations. This model may use a screening tool for diagnosing LSS with an explainable rationale.

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Frontal Channel EEG-based Biomarkers for Pain Severity Detection: Spectral Analysis, Phase-amplitude Coupling, and Machine Learning IntegrationSeungjun Ryu¹ and Yoon Ha^{2*}¹ Neurosurgery, Daejeon Eulji University Hospital, Korea² Neurosurgery, Yonsei College of Medicine, Korea

There is increasing evidence supporting the use of frontal channel EEG-based signals for pain measurement through spectral analysis and phase-amplitude coupling. In order to identify frontal channel EEG-based biomarkers for pain severity detection, we conducted this study and employed machine learning algorithms to assess the feasibility of feature integration. Our dataset consisted of EEG recordings from 36 patients, both with eyes open and eyes closed. A 21-channel EEG (10-20) system was used to record the brain EEG, and the severity of pain was labeled independently through clinical questionnaires, such as the visual analog scale. We limited feature extraction to the Fp1, Fp2, F3, and F4 channels. Our results indicate that EO asymmetric QEEG has significant implications (Page 3). Additionally, we confirmed that EO asymmetric PAC is also significantly relevant (Page 5). A stepwise linear regression was performed to select the features related to pain scores from all EO features, including those observed in previous results (Page 6). We further conducted regression analyses using multiple models, such as linear regression, 2nd polynomial regression, random forest regression, support vector regression, and robust regression, with the selected features.

Our findings expand upon previous literature by incorporating PAC analysis and providing practical insights through the application of various regression models. By applying the extracted features to a support vector machine, we were able to regress pain intensity within a clinically usable error range. In conclusion, pain intensity monitoring using frontal channel-based EEGs can facilitate early intervention and improve pain management.

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Emerging Technologies & Techniques

Deep Learning Approach for Automatic Point Detection and Sagittal Alignment Analysis in Whole-spine Lateral Radiographs**Sung Hyun Noh¹, Yoon Ha², Pyung Goo Cho¹ and Sang Hyun Kim¹**¹ Neurosurgery, Ajou University Hospital, Korea² Neurosurgery, Yonsei University Hospital, Korea

Introduction: Today, we face an exponential increase in the availability of biomedical data that opens up various challenges and opportunities in medical research. Some of this wealth of data are numerous medical images (CT, MRI, or X-rays) that can be used for a variety of tasks, such as the detection and classification of pathologies, identification of relevant anatomy and points of interest. With respect to imaging of the spine, positioning of landmarks is certainly high from a clinical point of view, as it can characterize the alignment of the spine in terms of angles, distances, and shapes that can help in surgical planning and monitoring deformity progression. The purpose of this study is to evaluate the performance of a novel deep learning tool for fully automated measurements of the sagittal spine parameters from X-ray images

Methods: Between January 2018 and March 2021, 2000 X-rays were used. By taking 30 points per X-ray sheet, 60000 points were taken. The sample was stratified into groups: 1400 cases for training, 600 cases for performance testing. The data were used as input to machine learning algorithms of U-Net. 500 X-rays were used for validation test. Based on this, C0C2 angle, C0C7 angle, C2C7 angle, C7 sagittal vertical axis, pelvic incidence, pelvic tilt, sacral slope, lumbar lordosis, L4S1 lordosis, thoracic kyphosis, and T1 pelvic angle were measured.

Results: The patients' average age was 36.71416.12 years old. The error between the artificial intelligence-measured value and the human-measured value was calculated. The C0C2 angle was 5.820140.0214 and C0C7 angle was 4.452840.4112 and C2C7 angle was 2.721240.2121 and C7 sagittal vertical axis was 5.1240.67mm and pelvic incidence was 2.686840.0124° and pelvic tilt was 0.942940.4012° and sacral slope was 2.432441.3412° and lumbar lordosis was 4.810341.7851° and L4S1 lordosis was 3.232940.9487° and thoracic kyphosis was 5.766541.8781° and T1 pelvic angle was 0.883440.2124°

Conclusions: The proposed automatic alignment analysis system was able to localize spinal anatomic landmarks with high accuracy and to measure various radiographic parameters with favourable correlations with manual measurements.

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Comparative Study of Sagittal and Coronal Plane Balance of the Spine Measured Using a 3D Anthropometric Device and Spine X-ray

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Introduction: With the aging of the population, adult spinal deformity (ASD), caused by degenerative changes in the spine, is becoming increasingly common. Diagnosis and treatment of this condition require accurate measurement of spinal balance. Currently, analysis is mainly performed using x-rays, which have limitations, such as radiation exposure and difficulty reflecting actual daily postures. In contrast, 3D scanning methods for the body surface have been developed due to technological advancements. This study aims to compare the efficacy of 3D body scanner analysis with x-ray methods for measuring ASD.

Methods: This study involved 100 patients with spinal pain who completed clinical questionnaires and underwent 3D body scanning and whole spine x-ray analysis. The 3D scanning device used infrared rays to image the body surface, and automatically recognized coordinates by measuring the inflection points. In the sagittal plane analysis, points A(ear), B(shoulder), C(hip), and D(knee) were recognized automatically, and angles were measured. This was compared with cervical and global sagittal parameters measured on the x-ray. In the coronal plane analysis, the shoulder gradient was measured and compared with coronal parameters measured on x-ray. The modified Oswestry Disability Index (ODI) was used to evaluate the degree of activity interference due to pain.

Results: The sagittal plane analysis on the 3D scanner showed a correlation between the angle between line AB and the plumb line with cervical kyphosis, with a correlation coefficient of 0.37 with the C2-7 SVA and 0.4 with the T1 slope. The angle between line BC and the plumb line was correlated with global sagittal balance, with correlation coefficients of 0.37 with the C7 Tilt value, and 0.42 with the T1SPi value. The angle of ABC was evaluated to be correlated with cervical kyphosis, with a correlation coefficient of 0.35 with the C2-7 SVA. The angle of BCD was related to global sagittal balance, with correlation coefficients of 0.35 with the C7 tilt and 0.38 with the T1SPi. The horizontal distance between points A and B was correlated with cervical kyphosis, with a correlation coefficient of 0.4 with the T1 slope. The horizontal distance between points B and C was related to global sagittal balance, with correlation coefficients of 0.39 with the C7 tilt, and 0.42 with the T1SPi. The shoulder gradient within the coronal plane was correlated with the T1 coronal tilt and the clavicle angle on the x-ray, with correlation coefficients of 0.37 and 0.53, respectively. The clinical symptoms were not significantly related to the data from 3D scanner but related to the data from x-rays like PI-LL mismatch.

Conclusion: The sagittal and coronal balance parameters measured using the 3D scanner showed a statistically significant correlation with x-ray parameters. 3D scanning with no irradiation and physiologic position can be helpful for checking spinal balance. However, the correlation with spinal pain was relatively low, likely due to compensatory motion changing posture.

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Expansion of Application of Unilateral Biportal Endoscopy in Degenerative Thoracic DiseaseHun-chul Kim*Orthopaedic Spine Center, Daechan Hospital, Korea*

Background: Traditional open surgery for degenerative thoracic disorder has a challenging character that can be extremely invasive and accompanied by complication. Recently, Unilateral biportal endoscopy(UBE) is a newly developed technique in the field of spin surgery and is increasing the indication of surgery day by day. In this study, we will introduce three cases for treatment using UBE in different thoracic diseases.

Methods: Male, 50-year-old, bilateral decompression and removal of ossification of yellow ligament(OYL) was done by using an inter-laminar approach for patients who is with both lower extremity tingling sense and right thigh anterior aspect radiating pain. Female, 75-year-old, who had symptoms of gait disturbance and motor weakness due to thoracic myelopathy found in T12-L1, was subjected to canal decompression and discectomy using far-lateral approach. Female, 69-year-old had symptoms of right intercostal pain that occurred after T12 acute compression fracture. Since the patient was unable to perform traditional open surgery due to poor general conditions during chemotherapy for lymphoma, UBE treatment was decided, and nerve decompression was performed using an inter-laminar approach.

Results: In the first case, the tingling sense owing to OYL improved symptoms after 3 months of surgery. In the second case, the right lower extremity radiating pain and gait disturbance showed improvement after surgery, but motor weakness continued until 4 months after surgery. In the third case, intercostal pain showed improvement immediately after surgery.

Conclusion: Although UBE surgery is limited in completely replacing traditional treatments for degenerative thoracic disease, surgery with the advantages of rapid rehabilitation and short hospitalization can be a good surgical treatment option.

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Endoscopic Technologies & Techniques

Posterior Cervical Foraminotomy Using Endoscopic Spine Surgery**Taehwan Chun^{1*} and Daejung Choi²**¹ Orthopedics, Samsung Grand Hospital, Korea² Orthopedics, Himnaera Hospital, Korea

Objective: Biportal Endoscopic Spine Surgery (BESS) comes to spread recently for its feasible application to various surgical indications including cervical foraminal stenosis. Posterior cervical foraminotomy using BESS (BE-PCF) with craniolateral inclination is a new approach concept, showing better accessibility to hypertrophied SAP tip with less resection of facet and lamina, making it possible to preserve facet and lamina integrity in multi-level and bilateral-sided foraminotomy.

Backgrounds: Conventional open posterior cervical foraminotomy showed approach-related injury of deep-and-thick neck muscles and troublesome during inspecting root and disc due to muscle bleeding. Microscopic posterior cervical foraminotomy using tubular retractor under microscope needs relatively larger amount of resection of lamina and facet, showing limitation on multi-level and bilateral foraminal decompression. Even Full-endoscopic or Biportal endoscopic PCF in vertically posterior approach are reported for need of nearly 50% of facet joint resection and making remnant lamina thinner in risk of lamina fracture. The purpose of inclination approach permits accessing to SAP tip with preserving about 75% of facet joint integrity but in need of same amount of lamina resection proximally as the other techniques.

Method: Eight patients (M6:F2, 56-70yr), twelve segments (one-level 4 cases, two-level 4 cases) underwent BE-PCF using craniolateral inclination (CLI) approach for cervical foraminal stenosis and followed up more than 6 months. Portal position for CLI approach should be started from one-level under vertical C-arm view, permitting to access sublaminar space till SAP tip in less-sized opening of the lamina. Lamina-preservation percentage after laminectomy were measured with pre- and post- CT coronal view. Clinical improvement was evaluated using Visual Analogue Scale (VAS) on neck pain and arm, and Neck Disability Index (NDI).

Result: Preoperative lamina height was 14.642.4mm, postoperatively 10.442.4mm, preserving about 70.9% of lamina using CLI approach. Neck-VAS was immediately improved preoperatively 6.040.8 to postoperatively 2.041.1. Arm-VAS, 6.440.7 to 1.440.7. NDI 31.443.4 to 12.143.6. Most radicular pain on the upper arm and hand was improved immediately. One patient showed continuing neck discomfort. There was no root or dural injury, no postoperative infection, and no neurologic aggravation during following up.

Conclusion: CLI approach in BE-PCF could permit sublaminar inspection through 4.2mm laminectomized corridor and preserve about 70.9% of lamina, which is supposed to decrease risks of approach-related complication such as lamina fracture. It could be supposed to permit safety for ipsilateral multilevel foraminotomy.

FP19-3

Endoscopic Technologies & Techniques

Is Surgeon's Uniportal Experience Important for Unilateral Biportal Endoscopic Laminectomy? Comparative Analysis of Learning Curve Beginner and Uniportal ExpertYoung San Ko*Neurosurgery, Keimyung University, Korea*

After introduction of UBE surgery, spine surgeons are able to start endoscopic surgery with familiar anatomical orientation. However, UBE can be still challenging for surgeon with less microsurgical experience. The objective of this study is to show learning curve, clinical outcomes, and feasibility of UBE laminectomy of young spine surgeon. This retrospective cohort study included 58 patient who underwent UBE laminectomy by two surgeons (YS and CH) from spine center at the two tertiary hospital from January 2022 to March 2023. YS(beginner) is proficient in microscopic, without any experience of endoscopic surgery. CH(Expert) is uniportal endoscope expert who had more than 15 years of experience. Learning curve was analyzed with data of surgical time, clinical outcome, and complication.

There was no significant difference for demographic of patients between two groups. Most of surgical level was L4-5(96.3%) for beginner group, and expert group has more diverse surgical level L3-4(23.8%), L4-5(67%), and L5-S1(14.2%). In terms of clinical outcome (visual analog scale score, Oswestry disability index score, hospital stay) there was no significant difference in two groups. The average operation time was 96.4 ± 30.5 min for beginner group and 107.45 ± 27.16 expert group without any statistical significance. Complication rate was 14/54(25.9%) for beginner, and 8/42(19%) for experts. Among complications, dural tear was most frequent complication with significant difference between two groups (beginner 25.9% VS expert 2.4%, $P=0.015$). With scattered chart analysis, minimum number of cases to overcome learning curve was more than 20 cases.

conclusion

Beginner of UBE laminectomy can achieve similar clinical outcome as uniportal experts during learning curve. However, complication rate was higher in beginner with significant cases of dural tear. One must prepare management plan of dural tear before starting UBE laminectomy. Also at least 20 cases are needed to overcome learning curve for UBE laminectomy.

FP19-4

Endoscopic Technologies & Techniques

Percutaneous Endoscopic Lumbar Interbody Fusion by Transkambin or Posterolateral Approach? A Novel Technique-expandable Tunnel for Protection of Exiting Root and Traversing RootYi-Hung Huang*Orthopedics, Chia Yi Christian Hospital, Taiwan*

Introduction: The endoscopic spine surgery(ESS) is rapidly developed in recent three decades and ESS combined with TLIF(endo-TLIF) is the new trend due to the least traumatization. There are two kinds of endo-TLIF. One is transKambin following the principle of transforaminal endoscopic surgery and the other is posterolateral(PL) endoTLIF following the principle of MISTLIF. The safe zone of foramen (Kambin triangle) is so limited for transKambin endoTLIF, therefore implanting a cage into disc space away from the exiting root or dura injury is a major challenge. We developed a novel technique "sentinel pinning with a retractor" to protect the exiting root as application of tunnel protector and to implant a traditional non-expandable cage per segment. We also develop an unique expandable sheath while performing PL endoTLIF for protection of traversing root and dura sac. The complete procedures were well described and effectiveness was surveyed.

Methods: We inserted contralateral percutaneous pedicle screws firstly, and also aspirated bone marrow from vertebral body through a Jamshidi needle for mixing with synthetic crystal bone substitute. In transKambin endoTLIF we inserted the sentinel pin docking at inferolateral border of the cranial vertebral body under the monitor of endoscope and fluoroscope after preliminary foraminoplasty. We performed interbody bone grafting with autogenous bone chips and the synthetic bone substitute mixing with bone marrow and implanted a fixed size cage through the safe quadrangular space created by sentinel pin and lateral retractor. In PL endoTLIF we performed direct decompression by interlaminar endoscopic surgery. As MISTLIF we excised IAP and most SAP. After interbody preparation of disc and endplate we inserted bone graft and cage through a unique expandable sheath. We secured the screws and rods finally. Indications of PL endoTLIF are Schzas D stenosis, advanced facet arthritis, failed reduction of disc space, listhesis and focal scoliosis during operation and L5S1 lesion

Results: To Dec 2021, a total of 89 patients and 119 levels (mean age 63.4 y/o) were evaluated. The rate of TransKambin and PL endoTLIF is around 7:3. The overall mean VAS scores were improved significantly, and mean ODI scores from 50.9 to 3.6 ($P < 0.01$) postoperatively was significantly improved with a mean follow-up of 15 months There was no postoperative permanent exiting root injury, iatrogenic durotomy. Only one case suffered from cage dislodge and needed revision surgery.

Conclusions: Postoperative scores for two kinds of endo-TLIF by this novel technique significantly improved and no disabled complications. The procedure could be considered as a safe and effective TLIF and which needs direct bilateral decompression we prefer PL endoTLIF.

AUGUST 18 (Fri)

FREE PAPER 20
MIS 4

FP20-1

MIS

A Comparative Analysis of Bi-portal Endoscopic Spine Surgery and Unilateral Laminotomy for Bilateral Decompression in Multilevel Lumbar Stenosis PatientsSub-Ri Park*Orthopedics, Yonsei University College of Medicine, Korea*

The clinical and radiological results before and after surgery were compared and analyzed for patients with multilevel lumbar stenosis who underwent bi-portal endoscopic spine surgery (BESS) and microscopic unilateral laminotomy for bilateral decompression (ULBD). We retrospectively identified 47 and 48 patients who underwent BESS and microscopic ULBD, respectively, who were diagnosed with multi-level lumbar stenosis. Clinical outcomes were evaluated using the visual analog scale score for both back and leg pain, and medication (pregabalin) use and Oswestry Disability Index (ODI) scores for overall treatment outcomes were used pre-operatively and at the final follow-up. Radiological outcomes were evaluated as the percentage of dura expansion volume, and percentage preservation of both facets and both lateral recess angles. The follow-up period of patients was about 17.04 months in the BESS group and about 16.90 months in the microscopic ULBD group. The back and leg visual analog scale (VAS) scores and average pregabalin use decreased more significantly in the BESS group than in the microscopic ULBD group (each p-value 0.0443, <0.001, 0.0378). All radiological outcomes were significantly higher in the BESS group than in the ULBD group. The change in ODI in two-level spinal stenosis showed a significantly higher value in the BESS group compared to the microscopic ULBD group (p-value 0.0335). Multilevel decompression with the BESS technique in multiple spinal stenosis is an adequate technique as it shows better clinical and radiological results than microscopic ULBD during a short-term follow-up period.

FP20-2

MIS

An Expanded Surgical Corridor for Oblique Lumbar Interbody Fusion at L4/5: A Magnetic Resonance Imaging Study**Worawat Limthongkul¹, Pakawas Praisarnti¹, Natavut Prasertkul¹, Vit Kotheeranurak¹, Wicharn Yingsakmongkol¹ and Weerasak Singhatanadgige¹**¹ *Department of Orthopedics, Faculty of Medicine, Chulalongkorn University and King Chulalongkorn Memorial Hospital, Thailand*

Background: A surgical corridor for oblique lumbar interbody fusion (OLIF) has previously been defined as an interval between the left psoas muscle and major artery. No surgical corridor was recommended as a contraindication to perform the OLIF surgery. However, studies showed that psoas muscle can be retracted and the artery was mobile during surgery. Those structures can safely be mobilized while approaching to disc space. In contrast, venous structure and lumbar plexus are relatively fixed structures. Our study introduced a new method for preoperative evaluation, an "Expanded surgical corridor" in order to evaluate actual safety corridor, which may expand an indication for OLIF surgery.

Methods: An axial T2-weighted magnetic resonance images at L4-L5 disc level of 511 lumbar degenerative disease patients were evaluated. The distance between the medial edge of the left psoas muscle and the major artery was measured as the conventional surgical corridor (CSc). The distance between the major vein and the lumbar plexus was measured as the "Expanded surgical corridor" (ESc). The surgical corridors were categorized into four types: no corridor, small (M1 cm), moderate (1-2 cm), and large (>2 cm). The differences between surgical and expanded surgical corridor types were analyzed.

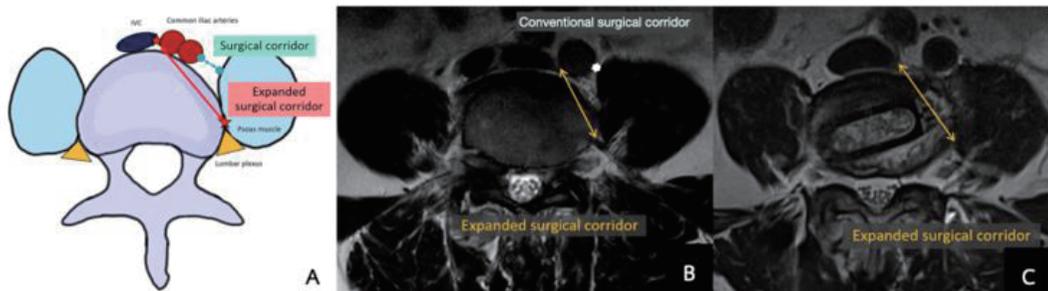
Results: The mean surgical and expanded surgical corridors were 13.9 4 8.2 mm and 37.43410.1mm retrospectively. In comparison between CSc and ESc, no surgical corridor was found in 7.1% (34 patients) for CSc and 1.8% (9 patients) for ESc group, small surgical corridor was found in 27.4% (142 patients) for CSc and 0.6 % (3 Patients) for ESc group, moderate surgical corridor was found in 42.1% (213 patients) for CSc and 1.9 % (11 Patients) for ESc group, and large surgical corridor was found in 23.4% (122 patients) for CSc and 95.7% (488 Patients) for ESc group.

Conclusions: Our study introduced a new method for preoperative evaluation of the OLIF surgical corridor. By using the expanded surgical corridor, 2.4% are categorized as having no or a small surgical corridor, and 97.6% have an approachable corridor. The expanded oblique surgical corridor may represent true accessibility to the disc space for oblique lumbar interbody fusion, particularly at the L4-L5 level.

Figure 1: Illustration of the L4-L5 intervertebral disc level; (A) measurement methods.

(B) Axial magnetic resonance images of the L4-L5 intervertebral disc level showing preoperative small conventional surgical corridor (white dot) versus large expanded surgical corridor (orange arrow). (C) Postoperative image of oblique lumbar interbody fusion L4-L5 in patient with no conventional surgical corridor.

(IVC = inferior vena cava)



FP20-3

MIS

Minimally Invasive Transforaminal Lumbar Interbody Fusion for Spondylolisthesis: 2 Years Results at Vietduc HospitalTien Nguyen Le Bao*Spine Surgery Department, Orthopedic, Spine Surgeon, Viet Nam*

Background: Degenerative spondylolisthesis (DS) is a condition leading to the slippage of one vertebral body over the one below due to degenerative changes resulting in spinal stenosis and producing neurogenic claudication, with or without low back pain. There are many surgical methods to treat DS such as nerve decompression, PLIF or TLIF... At Viet Duc University of Hospital, we did minimally invasive transforaminal lumbar interbody fusion for Degenerative spondylolisthesis from 2010 but there are no reported about this procedure. We reported 2 year follow-up for MIS-TLIF to treat degenerative spondylolisthesis in our hospital.

Subjects and methods: A descriptive study of 51 cases of patients with single level lumbar spondylolisthesis received MIS-TLIF at the Spine Surgery Department, Viet Duc university Hospital from 2019 to 2021.

Results: A total 51 patients were included (11 male, 40 female), mean age was 47,9 ± 12,9 years (from 15 to 72). Long-term outcome after surgery was assessed according to MacNab criteria at 24 months after surgery 44/51 patients re-examined (86,3%): Excellent: 28 (63,6%), good: 14 (31,8%), fair: 2 (4,6%), poor: 0 (0,0%). Evaluation of clinical symptoms improvement after surgery: VAS (Visual Analogue Scale) back pain was improved from 6,22 ± 1,06 to 1,89 ± 1,50, VAS leg pain was improved from 5,90 ± 1,40 to 1,25 ± 1,50, ODI (Oswestry Disability Index) was improved from 49,41 ± 8,00 to 15,18 ± 11,58. Evaluation fusion according to Bridwell: the rate of bone healing was 97,8%. Intraoperative complications: Nerve roots injury in 2 cases (3,9%).

Conclusion: MIS-TLIF is a safe and effective procedure in the treatment of single level lumbar spondylolisthesis.

Keywords: Degenerative spondylolisthesis, minimally invasive spine surgery, transforaminal lumbar interbody fusion, MIS-TLIF.

FP20-4

MIS

A Less Sacrifice of Stabilizing Structure Treatment by Bilateral-contralateral Decompression for Spinal Stenosis in Degenerative Spondylolisthesis Using Unilateral Biportal Endoscopy

Dong Hyun Lee¹, Choon Keun Park¹, Jin Sub Hwang¹, Jae-Won Jang¹ and Dong-Geun Lee^{1*}

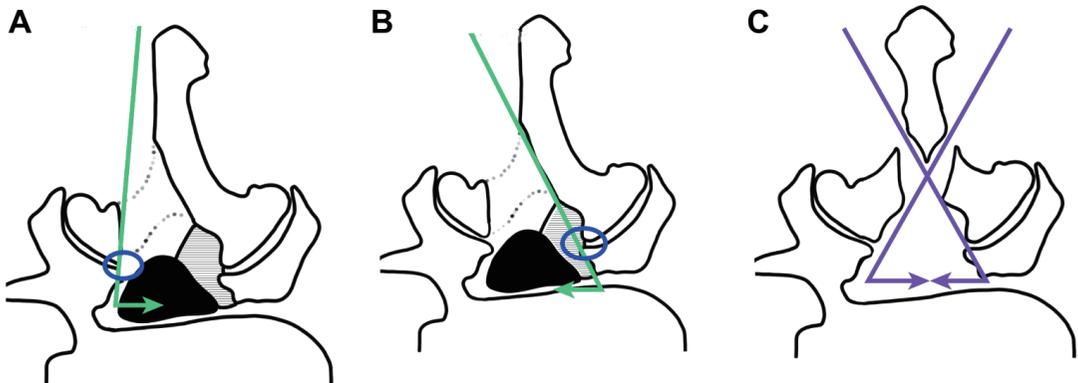
¹ Department of Neurosurgery, Spine Center, The Leon Wiltse Memorial Hospital, Suwon, Gyeonggi-do, Korea

Objective: This study aimed to evaluate the treatment of spinal stenosis with spondylolisthesis using bilateral-contralateral unilateral biportal endoscopic (UBE) decompression to minimize damage to facet joints.

Methods: We retrospectively included 42 patients treated with bilateral-contralateral UBE decompression from July 2018 to September 2019. To identify segmental instability, static and dynamic images from the preoperative and postoperative procedures and final follow-up radiographs were reviewed. The lateral radiograph slippage ratio, sagittal motion, and facet joint preservation were evaluated. Clinical assessments were conducted using the visual analog scale (VAS) score, Oswestry Disability Index (ODI) score, and modified Macnab criteria.

Results: The average final follow-up period was 26.541.3 months. The average preoperative slip percentage was 15.70%45.25%, which worsened to 18.80%45.41% at the final follow-up ($P<0.005$). The facet joint preservation rate was 95.6%44.1% on the contralateral side. Improvements in the VAS scores (leg pain: from 7.942.2 to 3.140.7; $P<0.005$; back pain: from 7.243.0 to 2.841.0; $P<0.005$) were observed at the final follow-up. The mean preoperative ODI was 26.1943.42, which improved to 9.641.0 ($P<0.005$). Based on the modified Macnab criteria, 90.5% of the patients had good or excellent results. Overall, 13 patients had delayed focal segmental instability after decompression. Despite not having any symptoms or relief with conservative treatment, two patients underwent fusion surgery due to instability, two developed a facet synovial cyst, and two had a spinous process fracture.

Conclusion: Bilateral decompression with a contralateral UBE approach could be an effective and alternative treatment method to reduce instability in spinal stenosis with low-grade spondylolisthesis.



AUGUST 18 (Fri)

SYMPOSIUM 5

Long Term Follow Up of ADR
(Artificial Disc Replacement)

SY05-1**Long Term Follow Up of ADR (Artificial Disc Replacement)****Long Term Outcomes in Lumbar Arthroplasty****Jack Zigler***Texas Back Institute, USA*

FDA studies on lumbar arthroplasty required randomized trials comparing disc replacement to fusion for one and two level degenerative disc disease.

These FDA studies and their long-term patient follow-up have provided a data source for evaluation of clinical and radiographic outcomes for both arthroplasty and fusion, with a huge amount of published reports.

VAS and ODI typically demonstrate > 50% reduction from preop status following failure of 6-9 months of failed conservative care. This improvement persists for measured 5 and 7 year data points, and extrapolates to 10 years.

Meta-analyses demonstrate significant superiority of TDR against fusion at 5 year follow-up in ODI, VAS pain, patient satisfaction, and a 50% reduction in reoperations due to device failure.

Six multicenter lumbar trials (5 FDA, 1 European) show significant success of lumbar arthroplasty at 5 years.

Five year radiographic analysis demonstrates statistically significant protection of adjacent level degeneration by arthroplasty compared to fusion.

Shorter term outcomes are predictive of long term outcomes in patients with lumbar disc replacement.

SY05-2

Long Term Follow Up of ADR (Artificial Disc Replacement) **Long-term Result of Cervical Arthroplasty**

Ali Araghi

The Core Institute, USA

SY05-3**Long Term Follow Up of ADR (Artificial Disc Replacement)****CDA vs. Fusion for Multilevel Cervical Pathologies****Byung-Wan Choi***Inje University College of Medicine, Korea*

Anterior cervical discectomy and fusion (ACDF) surgery is commonly performed to treat cervical degenerative disc disease (CDDD). CDA (cervical disc arthroplasty), an alternative to ACDF, is developed to preserve the ROM and reduce ASD. This symposium aims to compare the outcomes between CDA and ACDF.

1. comparing mid to long-term outcomes of CDA with ACDF for the treatment of CDDD.

Prolonged operative duration, better overall success, neurological success, and NDI success rates were found in CDA group in all follow-up periods. Moreover, a lower ASD was found in CDA group during long-term follow-up and overall analysis, with lower reoperation rates in all follow-up periods.

2. Multilevel cervical arthroplasty

multilevel CDA was at least as safe and effective as ACDF, with preservation of cervical motion when compared with ACDF and potentially with fewer reoperations. Multilevel CDAs are clinically effective as single-level surgeries, with good clinical and radiological outcomes. Some studies reported a higher incidence of heterotopic ossification in multilevel CDA.

3. CDA vs ACDF for two contiguous levels CDDD

CDA patients had significant superiorities in mean blood loss, reoperation, adjacent segment degeneration and Neck Disability Index (NDI). The CDA group of sagittal range of motion (ROM) of the operated and adjacent levels, functional segment units and C2-7 is superior to ACDF group by radiographic data

4. Multilevel CDA versus multilevel ACDF

Patients who underwent CDA had similar operative times, blood loss, NDI scores, and VAS scores compared to patients who underwent ACDF. CDA patients had greater overall motion of the cervical spine and the operated levels. CDA patients also had lower rates of ASD. The rate of adverse events was significantly lower in the CDA group.

CDA may be a safe and effective surgical strategy for the treatment of MCDDD.

SY05-4**Long Term Follow Up of ADR (Artificial Disc Replacement)****Long-term Results and Controversies of Cervical TDR****Keun Su Kim***Yonsei University College of Medicine, Korea*

Various kinds of cervical artificial disc replacement for herniated cervical discs have been done from 2005 to 2018. Total number of cases are 97 (male:female=63:34, average age=43). Single level was 86 cases, and two levels were 11 cases. Hybrid cases (C-TDR combined with ACDF) were 18 cases.

Average follow-up period was 44 months. Thirty-five patients (36%) were followed for more than 60 months; average 85 (60-138) months. In a comparative clinical study with ACDF, the results of neck and arm pain showed the same excellent results as ACDF. So far no one was re-operated because of pain or mechanical problem. One patient showed embedding artificial disc with mild segmental kyphosis but no pain. More than 50% of the patients showed HO (heterotopic ossification) grade 3 or 4, but no radicular pain. Despite of high percentage of HO formation rate, they did not complain of neck or radicular pain. Protection of adjacent segmental degeneration (ASD) is still controversial. In this series, compared with ACDF, no one has taken additional surgery on adjacent segment due to adjacent segmental disease. Additionally, author have done 20 revision surgeries of C-TDR, which were not performed by other hospital. The causes of revision were bad indication, poor surgical techniques, breakage of artificial disc, and growing of bony spur with central or foraminal stenosis. There are still controversies in the TDR of severe foraminal stenosis with uncovertebral joint hypertrophy and cervical spondylotic myelopathy.

In conclusion, C-TDR is good surgical choice for cervical soft disc herniation and showed low rate of mechanical problem and low re-operation rate. However, strict surgical indication for C-TDR should be considered in osteoporosis, central stenosis with myelopathy, spondylotic foraminal stenosis or unstable segment.

SY05-5

Long Term Follow Up of ADR (Artificial Disc Replacement)

Nucleus Replacement on an Early Stage Technology

Ali Araghi

The Core Institute, USA

AUGUST 18 (Fri)

SYMPOSIUM 6

Endoscopic Decompression for Complex Spinal Pathologies:
Current State of the Art

SY06-1**Endoscopic Decompression for Complex Spinal Pathologies: Current State of the Art
Endoscopic Cervical Decompression, Is It the Real Deal?****Vit Kotheeranurak***Chulalongkorn University & King Chulalongkorn Memorial Hospital, Thailand*

Minimally invasive techniques for cervical decompression have gained significant attention in recent years, with posterior endoscopic decompression emerging as a potential alternative to microsurgery or traditional open surgical approaches. This topic will walk you through the patient selection, principles and technical aspects, step-by-step, and recent evidence regarding this procedure. Nonetheless, a cautious approach is necessary, and its inclusion in the standard of care should be based on evidence-based research and balanced consideration of its benefits and limitations.

SY06-2

Endoscopic Decompression for Complex Spinal Pathologies: Current State of the Art Biportal Endoscopic ULBD For Thoracic Spinal Stenosis Secondary To Ossified Ligamentum Flavum

Cheol Wung Park

Daejeon Woori Hospital, Korea

Aim: This presentation is aimed to explain about the technique of unilateral biportal endoscopic surgery for a safe and successful removal of thoracic stenosis secondary to severe Ossified Ligamentum Flavum(OLF) by adequate bony decompression,removal of pathologic lesion along with dural layer and preserving the arachinoid.

Summary of Presentation: Video demonstration and discussion of the important surgical steps for a safe biportal endoscopic surgical technique necessary for decompression of moderate to severe symptomatic thoracic stenosis at single or multiple levels with minimal post operative complications under GA.

Result: We have been able to achieve a satisfactory post operative outcome with minimal complications by using UBE technique for severe compressive myelopathies secondary to OLF.

SY06-3**Endoscopic Decompression for Complex Spinal Pathologies: Current State of the Art
Endoscopic Spine Fusion: Short and Long-Term Outcomes****Ju-Eun Kim***Baroseomyeon hospital, Korea*

Background: Biportal endoscopic spine surgery is a minimally invasive technique with the advantages of earlier rehabilitation and shorter hospital stay. Use of biportal endoscopic techniques for transforaminal lumbar interbody fusion (BE-TLIF) has been shown to have similar clinical and fusion outcomes with potentially faster clinical recovery in comparison to tubular TLIF surgery. Subsidence of the interbody, however, could be a potential complication of any minimally invasive TLIF procedures. No study has been compared if difference sizes of static PEEK cages can change the risk of subsidence and clinical outcomes, in particular the endoscopic technique.

Methods: Patients with intractable pain after 3 months of conservative treatment, who underwent 1 or 2 level BE-TLIF for degenerative and isthmic spondylolisthesis between January 2019 and January 2022, were included in this study. A 32 mm × 10 mm cage (Group A) or 40 mm × 15 mm cage (Group B) were utilized in a consecutive series. The Visual Analog Scale (VAS) for back and leg symptoms, and Oswestry Disability Index (ODI) were collected perioperatively. Plain radiographs and computed tomography were routinely performed pre- and postoperatively at three-month intervals. A minimum of 12 month follow was required. Cage subsidence was defined as at least 5 mm of subsidence, and fusion was assessed utilizing the Bridwell fusion grading system.

Results: Of the sixty-nine enrolled patients, 39 Group A patients (51 levels) and 30 Group B patients (32 levels) were compared. The operation time per level was 123.4 ± 15.8 and 138.4 ± 10.5 minutes per fusion level in Group A and B, respectively ($p < 0.05$). The ODI score improved from 64.8 ± 6.2 to 15.7 ± 7.1 in Group A and from 65.3 ± 5.6 to 15.1 ± 6.3 in Group B at final follow-up. The VAS leg and back score improvement did not differ; however, the three-month postoperative VAS back score improvement was significantly higher in Group B. The final fusion rate at final follow-up did not significantly differ both on CT and dynamic radiographs; however, the fusion ratio at 1 year was higher in Group B. Subsidence occurred in 5 cases (9.8%) in Group A and none in Group B.

Conclusion: BE-TLIF using a larger cage can be performed safely with similar clinical patient reported outcome measures with a decreased risk of subsidence. Furthermore, a cage with a larger footprint is assumed to be advantageous in achieving earlier interbody fusion when performing BE-TLIF.

Keyword: Biportal endoscope, TLIF, fusion rate

SY06-4

Endoscopic Decompression for Complex Spinal Pathologies: Current State of the Art Endoscopic Spine Fusion: Inevitable Complications and Deal

Dong Hwa Heo

Champodonamu Hospital, Korea

Biportal endoscopic spine surgery including biportal endoscopic lumbar interbody fusion is gaining popularity in managing degenerative lumbar diseases and has the possibility of complications. The perioperative complications related to the biportal endoscopic approach affect the postoperative outcomes.

For this systematic review, articles on biportal endoscopic lumbar interbody fusion were searched for and reviewed. Additionally, the contraindications of biportal endoscopic fusion surgeries were reviewed.

Complications can be divided into special cases for endoscopic surgery and cases that can occur in general surgery. In most cases, complications can be prevented during biportal endoscopic surgeries.

Perioperative complications are typically minor; major complications include durotomy, epidural hematoma, incomplete decompression, neural injury, and increased epidural pressure.

It is very important to be aware of possible complications during biportal endoscopic fusion surgery.

The purpose of this study is to present the prevention and management of complications related with biportal endoscopic lumbar interbody fusion surgery.

SY06-5**Endoscopic Decompression for Complex Spinal Pathologies: Current State of the Art
Modified Techniques for Full-Endoscopic Decompression
Surgery****Chang-Il Ju***Chosun University College of Medicine, Korea*

Full endoscopic spine surgery first developed with transforaminal discectomy through Kambin's triangle. The advanced foraminaoplasty technique was introduced to successfully perform endoscopic surgery for highly migrated disc herniation and high canal compromised disc herniation which were difficult to operate with early endoscopic surgery. This surgical method has been further developed into decompressing foraminal stenosis.

In addition, in cases where transforaminal access is anatomically difficult, such as the high iliac crest and large transverse process, such as L5-S1 disc herniation, a surgical method through an interlaminar approach was introduced, and this surgery was introduced as a unilateral treatment for spinal stenosis with the spread of drills. Laminotomy bilateral decompression (ULBD) has developed.

Recently, as the transforaminal approach and the interlaminar approach have been independently developed, most of the lateral recess area (proximal), foraminal area (middle), and extraforaminal area (distal) of the exiting nerve root can be decompressed. Endoscopic surgery is expanding its indications for most spinal diseases, except for spinal deformity.

These two foraminoplastic decompression and ULBD techniques have evolved into endoscopic decompressive surgery that can effectively decompress nerve in thoracic and cervical spine.

The thoracic disc herniation and thoracic ossification of yellow ligament were decompressed by , and endoscopic surgery such as posterior foraminotomy with discectomy for cervical disc herniation.

Still today, the standard surgical procedure for lumbar spinal canal stenosis is microsurgery, microscopically assisted decompression. However, as endoscopic surgery develops in the future, it is expected that it will become a standard surgery.

AUGUST 18 (Fri)

PLENARY LECTURE 2

Navigation and Robotics: Present and Future

PL02-1

Navigation and Robotics: Present and Future

Navigated LLIF

Paul Park

University of Tennessee Health Science Center, USA

The lateral lumbar interbody fusion (LLIF) has been shown to be an effective minimally invasive interbody technique. Fluoroscopic guidance is traditionally required to safely perform the procedure. However, 2D fluoroscopic guidance can be difficult to interpret and can lead to complications. In addition, the radiation exposure with fluoroscopy for minimally invasive procedures can be significant. Spinal navigation is an enabling technology that can enhance the capability of a surgeon and can be applied to LLIF. Navigated LLIF, when used properly, is safe, accurate and reliable. Use of 3D navigation can also significantly reduce radiation exposure and can reduce operative time, particularly with multi-level and deformity cases.

PL02-2

Navigation and Robotics: Present and Future

Intraoperative CT Image-Based Navigation-Guided Surgery

Juan Uribe

Barrow Neurological Institute, USA

PL02-3

Navigation and Robotics: Present and Future

Robot-Guided Pedicle Screw Insertion

Sheeraz Qureshi

Weill Cornell Medical College, Cornell University, USA

PL02-4

Navigation and Robotics: Present and Future

Robotic Spine Surgery - "Learning Curve And Experience With 300 Cases"**Luthfi Gatam***Eka Hospital BSD, Indonesia*

Background: Spinal instrumentation in spinal surgery poses challenges to the surgeon especially in the deformity cases. The use of robotic system to aid in spinal surgery has greatly increased over the past decade. Robotic systems must provide a degree of accuracy comparable to that of already-established methods of screw placement, including freehand, fluoroscopically assisted, and computed tomography-assisted screw placement. We aimed to investigate the use of robotic system in spinal surgery especially for the accuracy of screw placement at 1 institution.

Methods: This study was an observation of 300 patients undergoing robotic spine surgeries. By analyzing the factors of demographic characteristic, clinical characteristic, radiological characteristic, and outcomes operation.

Results: In 300 patients identified, more than 3500 screws were attempted, with very high accuracy presentation rate. There were no noted screw-related complications (neurologic or visceral) and no return to the operating room for screw malposition. Other advantages are also seen in robotic spine surgery where reduced blood loss and radiation exposure, besides that the speed of screw installation, especially in cases of deformity is faster.

Conclusion: Combined with other surgical correction modalities, robotic spine surgery is an effective and safe method for spinal surgery. Due to its satisfactory surgical outcomes such as higher accuracy and less trauma, it provides a good alternative for clinical practice.

Keywords: Robotic Spine Surgery, Screw Placement, Deformity, Outcomes.

PL02-5

Navigation and Robotics: Present and Future

The Next Generation Robotic Spine Surgery in Korea and the Future

Seong Yi

Yonsei University College of Medicine, Korea

Introduction: Recent innovation of spine surgery has shown new equipment in the operation room to enhance surgeon's task and successful operation. This topic will present current, global status of development of spine surgery robot, technical demands for spine specialized robot, initial works for developing and design new spine robot system. the 2nd generation of Spine anatomical registration, graphic user interface for spine surgery based on the artificial intelligence will be introduced.

Methods: In the 1st generation of spine surgery robot, Spine surgery robot is under developing by the collaboration of Yonsei University Health System and Curexo Company in Korea, we planned screw paths and performed screw insertion under robot guidance. Using C-arm and CT images, we proved accuracy by comparing the 3D distance of the placed screw head/tip from the planned screw head/tip and 3D angular offset. The analysis of early clinical experience 113 patients (448 screws) was done, the accuracy and clinical outcome will be presented. The development strategy of 2nd generation robot was introduced.

Results: Clinical study using 1st generation of spine surgery robot, the success rate of GRS A or B was 97.6%. the 3D distance accuracy of pedicle screw insertion showed excellent results without neurological complication; entry offset (2.8641.64 mm), target offset (2.4841.73mm), depth offset (1.9942.13mm), angular offset (3.0742.31 degree). The new feature of 2nd generation robot; preoperative planning using 2D CT by 2D-3D image registration, autopanning system by AI and cloud-based image analysis and autopanning platform, and automation in the future.

Conclusion: The Korean 1st spine surgery robot showed good accuracy for the execution of an intended planned trajectory and screw path and can use existing C-arm in early clinical application. The 2nd generation Spine surgery robot in Korea will be introduced in near future and it has the potential to improve patient safety, operator comfort, reducing radiation hazards and procedure efficiency in the field of spinal surgery. The surgery data analysis, neural network could be valuable features in the future.

Keywords: Spine, Robot, development, AI, autopanning

AUGUST 18 (Fri)

SYMPOSIUM 7
Update of Disc Arthroplasty

SY07-2

Update of Disc Arthroplasty

Clinical Evidence on Cervical Disc Arthroplasty (Prospective Multicenter Trial of Cervical Arthroplasty and Long-Term Case Presentation)

Claudius Thomé

Medical University Innsbruck, Germany

Background: Anterior cervical disc arthroplasty (ACDA) is nowadays accepted as a motion-preserving alternative to ACDF for selected patients. In a prospective multicenter study (Fleck et al. 2022), it could be demonstrated that unconstrained cervical disc prostheses with a variable center of rotation aiming physiological motion lead to good clinical and radiographical results after 2-year follow-up. The aim of this study was to evaluate whether this clinical outcome is maintained in the longer term.

Methods: This prospective multicenter study includes 120 patients (72 females and 48 males with a median age of 43.0 years 23-60 yrs who underwent ACDA (108 monosegmental, 12 bisegmental and 6 hybrid procedures; ROTAIO®, SIGNUS Medical, Alzenau, Germany). Clinical outcome was assessed after 3, 12 and 24 months follow-up by VAS, NDI, WL-26, Patient`s Satisfaction Index (PSI), SF-36, Nurick Score, mJOA, Composite Success Rate, complications, patient`s overall satisfaction and analgesics use. 10 cases from a single center were available for a clinical and radiological follow-up of more than 5 years 5-9 yrs.

Results: The multicenter study demonstrated highly significant clinical improvements according to NDI and VAS ($P < .0001$ (arm); $P < .001$ (neck)) at all time points. The composite success rate was 77.5% after 12 months and 76.9% after 24 months. There were no major complications in this series with a spontaneous fusion rate of 2.5% and a revision rate of 1.7% in 2 years. Long-term follow-up revealed continuous clinical success with preserved motion in all cases. Flexion/extension x-rays revealed minimal residual motion in 2 cases and excellent motion ($>10^\circ$) in the remaining 8 cases. Interestingly, the former 2 patients were the oldest in this long-term series (52 and 59 years at implantation).

Conclusion: The ROTAIO® cervical disc prosthesis is a safe and efficient treatment option demonstrating highly significant clinical and radiographic improvement with very low revision rates at 2 years. Physiological facet-guided motion seems to be preserved also at long-term follow-up of up to 9 years, even though some patients may show a decrease of segmental motion over time.

Keywords: cervical disc prosthesis, cervical arthroplasty, outcome, quality of motion, long-term follow-up

SY07-3

Update of Disc Arthroplasty

Revision Cervical Arthroplasty**Scott Blumenthal***Texas Back Institute, USA*

Background: As with any spine surgery, there are failures with cervical total disc replacement (TDR). These may generally be classified as surgeon or technical error (including patient selection), biomechanical failure, biological (osteolysis, allergy, etc.) or other reasons. Surgeons performing TDR should be aware of the failure types leading to subsequent surgery and have a strategy to address these situations. Previously we reviewed our center's experience with cervical TDR removal/revision in a consecutive series of 1,474 patients beginning with first case experience in 2003. There were 20 cases of TDR removal or revision for a rate of 1.36%. Additionally, we have performed removal/revision surgery in patients whose TDRs were implanted at other clinics. The purpose of this study was to describe modes of failure of cervical TDR and related treatment strategies.

Methods: This study included a consecutive series of 42 cervical TDR patients who underwent cervical TDR removal/revision at our center. Chart review was conducted to collect general descriptive data, reasons for TDR removal/revision, duration from index implantation to re-operation, and the subsequent procedure performed.

Results: In the series of 42 TDR patients, 31 underwent TDR removal and ACDF, 10 had TDR removal replaced with another TDR, and in one patient the TDR was repositioned. The most common reason for TDR removal (10 patients) was severe osteolysis, sometimes involving C. acnes. Nine were removed due to symptoms arising from posterior anatomy. Other reasons for removal/revision included device migration, malpositioning, hypermobility/instability, implant size too large, metal allergy, and one case of approach related esophageal tear.

Conclusions: For cases of cervical TDR failure, replacing a TDR with another such implant is feasible in some patients. Factors to consider when deciding if TDR replacement is appropriate include careful assessment of the facet joints and vertebral body endplates, as well as the availability of appropriate TDR size.

Keywords: Total disc replacement; cervical spine; removal/revision surgery

SY07-4

Update of Disc Arthroplasty

Lessons Learned from the Failure of the Partial Disc Replacement

Chan Shik Shim

Wooridul Spine Centre, Healthpoint Hospital, UAE

Contrary to total disc replacement, any device of partial disc placement did not succeed in getting FDA approval, despite of years of development and clinical trials. One of the reason is that it lacks initial stabilizing mechanism inside of the disc space which resulted in extrusion of device. The problem of extrusion of a device is a huge issue to a regulatory body such as FDA, in terms of safety of the device. The other problem identified in the clinical trials of the partial disc replacement were persistent back pain in some group of patients. This was more serious issue to clinical investigators. The persistent back pain was thought to be related to device subsidence and changes of the endplates of the vertebral bodies on the MRI. These, in turn, were thought to be related to the modulus of nucleus implant which was much stiffer than the natural nucleus, though the exact reason of the changes of the vertebral endplate has not been fully understood. Future development for partial disc replacement needs to be directed to develop a device that has initial stabilizing mechanism and, at the same time, has similar modulus to the natural nucleus. However, it seems not easy to develop such a device with current technology. Furthermore, issues such as tissue reactions and immunological responses to materials and their debris, especially reactions of the disc tissues and the vertebral endplate toward the material used in a device should be studied thoroughly before its availability in the market.

SY07-5

Update of Disc Arthroplasty

Osteolysis Related to TDR : Mechanical vs. Biological

Young-Yul Kim

The Catholic University of Korea College of Medicine, Korea

In the first introduction of cervical disc arthroplasty, there were no concerns about osteolysis or related disease. But nowadays, there are many reports published about osteolysis and related disease patterns.

At the Bryan disc, the grading of anterior bone loss of the index level was defined as Grade 0, no remodeling; Grade 1, spur disappearance or mild change in body contour; and Grade 2, apparent bone regression. Some authors reported no symptoms of osteolysis, but the severity increased, and this phenomenon correlated to clinical signs.

The shape of each company's mechanical designs, the position and body of the keel to fix to the bone, etc., are all related to osteolysis. However, in the model compared to fusion, the effect of mechanical strength on the interior and poster was also analyzed as the cause of interior bone loss. Since this occurs in long-term follow-up, it is judged that the association of the biological process cannot be ignored in our body.

AUGUST 18 (Fri)

SYMPOSIUM 8

Future Applications of Endoscopic Spine Surgery:
What We Have and What Lies Ahead

SY08-1**Future Applications of Endoscopic Spine Surgery: What We Have and What Lies Ahead
The Evolution of MIS Techniques for the Treatment of Spine and Brain with Enhanced VISUALIZATION and A.I****Anthony Yeung***DISC (Desert Institute for Spine Care), USA*

Introduction: My 50 year experience in traditional and MIS techniques since retirement are Summarized and reviewed.

Materials and Method: Over 11,000 MIS procedures under local anesthesia and sedation make up the database for this talk using mostly uniportal access, but where needed, biportal endoscopic techniques augment the uniportal approach.

As technology evolved, commercial endoscopic and surgical tools included Radiofrequency, Oratec, Ellman, Elliquence, Laser, aided cauterization and shrinkage of soft tissue and cutting and ablation tools.

Results: Efficacy ranged from 70-90%, with complication rates beginning with 3.5 % to 14 less than 1%

Conclusion: The evolution of MIS techniques for Brain and Spine include technology for enhanced visualization and the application of A.I. for future applications.

SY08-2**Future Applications of Endoscopic Spine Surgery: What We Have and What Lies Ahead
Advances in Lumbar Endoscopic Spine Surgery****Hyun-Jin Park***Hallym University College of Medicine, Korea*

Background: Biportal endoscopic spine surgery (BESS), a type of endoscopic spine surgery that performed through two independent surgical portals, has recently been actively performed worldwide. There are already some studies that the clinical outcome of biportal endoscopic posterior decompression and discectomy is non-inferior to microscopic spine surgery 1,2. Recently, several studies on lumbar interbody fusion using biportal endoscopy reported better clinical outcomes in some aspects than conventional lumbar interbody fusion in the early postoperative period 3-5. BESS not only has the advantages of uniportal endoscopy, but also has the advantages of being able to secure a wider operation field through two independent portals and use surgical instruments freely, similar to open spine surgery. For this reason, BESS is considered to have a wider surgical indication than uniportal endoscopy.

Main body: BESS could be performed through two small incisions within 1cm, so it is expected to have advantages in old age patients with many underlying diseases, because there is less intraoperative and postoperative bleeding, little paraspinal muscle damage, and lower postoperative pain. In addition, it could be more effectively implemented in the following cases. Biportal endoscopic lumbar discectomy could be applied in high-grade migration cases. Complete removal of high-grade migrated disc fragments might require more extensive laminectomy, which lead to facet joint violation as well as extensive removal of the lamina and pars interarticularis. On the other hand, BESS secures a wide surgical field and use surgical instruments with more angulation. Some study has been reported that satisfactory outcomes without prolonging the operation time even in high-grade migration 6. BESS could be effectively performed even in revision surgery 7. Because the operation is performed in a clean and magnified surgical view through biportal endoscopy, so epidural bleeding control is convenient, and the boundary between fibrous scar tissue from previous surgery and normal tissue is well distinguished. In general, it is known that the outcome of spine surgery is poor in obese patients. Meanwhile, BESS is thought to reduce bleeding, muscle damage, and the risk of infection compared to conventional spine surgery in obese patients, as there is no need to forceful retraction of the paraspinal muscle and subcutaneous fat tissue. Biportal endoscopic lumbar discectomy showed similarly good results in obese patients as well as in non-obese patients 8.

Conclusion: BESS is considered a minimally invasive endoscopic spine surgery with more expandability, and it is expected to develop in the future.

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SY08-3**Future Applications of Endoscopic Spine Surgery: What We Have and What Lies Ahead
Advanced in Endoscopy for Lumbar Foraminal Stenosis****Dae-Jung Choi***Himnaera Hospital, Korea*

Lumbar foraminal stenosis (LFS) is one of common causes of radicular pain with about 11% of clinical incidence and 26% of radiographic findings. Its radicular symptoms are related with various anatomic factors. Unilaterally disc height collapse can affect subluxation of superior articular process, and consequently foramen narrowing of concave side in segmental degenerative scoliosis. Far-out syndrome at the L5-S1 level, independently or combined with LFS, come from specific configuration between distoventral spur on the L5 transverse process (TP) and Ala. Incidence of L5-S1 FS is the most common among the other levels but easily neglected. Various foraminal pathologies are scattered, not aligned in one sagittal view of foramen, so that trials of radiographical diagnosis dependent on a cut of MR sagittal view showed lower reliability in correlation with clinical symptom. Anatomical point of view can give reasonable explanation on this mis-matched point because foramen opens about 14-degree anteriorly, but conventional MR sagittal exam cuts the foramen vertically. In surgeons' honest point on L4-5 lateral recess stenosis with combination of L5-S1 foraminal stenosis, L5-S1 foraminal lesion could be frequently neglected and surgeons could show a favor of decompressing L4-5 only rather than L4-5 lateral recess and L5-S1 both-sided foraminal stenosis in need of three different approaches. In another surgeon's choice, decompression with instrumented fusion of L4-5 only to save L5-S1 motion segment under purpose of decreasing stress-shielding to upper level. However, intentional neglected FS for plausible benefits, could bring about persistent spinal pain syndrome (PSPS). Through every endeavor to understand these pathologies, we can choose optimal approach among ipsilateral, contralateral, and paraspinal ones to make an optimal corridor to foraminal pathologies for sufficient decompression with preserving structural integrity. In despite of these trials of decompression, creeping subsidence of foraminal height with endplate fatigue fracture by on-going clinical instability may needs instrumented fusion of the index segment at the final decision.

SY08-4**Future Applications of Endoscopic Spine Surgery: What We Have and What Lies Ahead
Advances in Cervical Endoscopic Spine Surgery****Seok-Bong Jung***Jinju Bon Hospital, Korea*

Background: Biptoral endoscopic spine surgery for cervical disc herniation has been rarely reported. The aim of the article is to describe biportal endoscopic surgery as a posterior approach for CDH and report the preliminary outcomes and complications.

Methods: This single-centered retrospective chart review included 109 consecutive patients who underwent BESS for symptomatic single-level CDH. Working and viewing portals were created in each unilateral paravertebral area at the target disc level. Endoscopic exploration allowed for effective and minimally invasive decompression via safe access to the medial foramen with minimal laminectomy and facetectomy. Clinical outcomes, including the visual analog scale (VAS), neck disability index (NDI), Macnab criteria, and the motor function of the involved arm, were evaluated at 4, 8, 12, and 24 postoperative weeks.

Results: VAS and NDI improved significantly at 24 weeks postoperatively ($p < .01$). According to the Macnab criteria, "excellent," "good," and "fair" results were obtained for 55.9%, 30.3%, and 13.8% of patients, respectively. The post 24-week distribution of the involved upper extremity strength grade was significantly improved compared to the initial value ($p = 0.02$). One patient had a motor weakness with a decreased grade over 4 weeks from excessive irrigation. Complications may be associated with postoperative hematoma, high water pressure and direct injury to the spinal cord.

Conclusion: The posterior approach of biportal endoscopic surgery was efficient and feasible for the treatment of CDH.

Key words: cervical disc herniation; cervical discectomy; biportal endoscopy; decompression

SY08-5**Future Applications of Endoscopic Spine Surgery: What We Have and What Lies Ahead****High Complexity Endoscopic Spine Surgery for Complex Cases****Junseok Bae***Wooridul Spine Hospital, Korea*

Endoscopic spinal surgery has emerged as an innovative and less invasive alternative surgery offering myriad benefits such as less tissue disruption, less blood loss and faster recovery. This lecture discusses the application of endoscopic techniques in the complex area of very complex cases where traditional approaches have formidable obstacles. The highly complex area of spinal surgery requires astute consideration of complex anatomy and the presence of comorbidities. Successful application of endoscopic techniques requires a profound understanding of spinal anatomy, mastery of advanced endoscopic techniques, and implementation of precise imaging modalities. The inherently minimally invasive nature of endoscopy offers the added benefit of reduced soft tissue destruction, ultimately leading to postoperative pain relief and shorter hospital stays. Our direct experience demonstrates the feasibility and effectiveness of highly complex endoscopic spinal surgery in carefully selected cases, with promising results in patients with specific conditions boasting favorable outcomes. Nevertheless, it is essential to be fully aware of the limitations of endoscopic procedures, especially in cases where open surgery may be preferred. Highly complex endoscopic spinal surgery offers a coveted addition to the modern spine surgeon's repertoire and offers a meticulous, minimally invasive approach to carefully selected complex cases, resulting in improved patient outcomes. The ongoing process of improvement in endoscopic technology, together with continued advances in imaging modalities and surgical expertise, will further strengthen the pivotal role of endoscopy in the skillful management of complex spinal pathologies.

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AUGUST 18 (Fri)

SYMPOSIUM 9

Advances in Spinal Tumor:
What's New? What's Coming?

SY09-1

Advances in Spinal Tumor: What's New? What's Coming?

Collaborative Multicenter Studies on Spinal Cord Intramedullary Tumors and AVMs in Japan: Advancing Diagnosis, Treatment, and Understanding

Toshiki Endo

Tohoku Medical and Pharmaceutical University, Japan

Introduction: Both spinal cord intramedullary tumors and arteriovenous malformations (AVMs) are rare conditions in Japan. Their low incidence leads to considerable challenges in accurate diagnosis, treatment planning, and the execution of suitable surgical interventions. The rarity further limits exposure and experience for young neurosurgeons and neurosurgical facilities across the nation.

Objective: The aim of this presentation is to share the collaborative multicenter studies conducted within the Japanese Neurospinal Society. These studies have focused on the collection and detailed analysis of cases involving spinal cord intramedullary tumors and spinal AVMs.

Methods & Findings: Through a comprehensive approach, the study's findings are set to inform best practices in surgical management, enhance patient outcomes, and contribute to a deeper understanding of these complex, rare diseases. The presentation will include intraoperative videos that vividly demonstrate the surgical techniques employed in managing these intricate conditions.

Conclusion: This work symbolizes a crucial step towards a unified approach to dealing with rare spinal conditions. By sharing experiences, techniques, and insights, it hopes to foster a collaborative spirit among professionals in the field. The insights provided in this talk should offer valuable guidance and inspiration for the management of rare spinal conditions, thus promoting improved patient care and scientific advancement.

SY09-2

Advances in Spinal Tumor: What's New? What's Coming?

Surgery on Spine Metastasis over the Last 4 Decades – An Overview of Techniques and Strategy in Cancer Treatment

Christian Mazel

University Paris XIII - Sorbonne-Paris Nord, France

The occurrence of bone metastasis in cancer development is a real milestone in the evolution of the pathology.

The surgical management of spinal metastases began about forty years ago. The surgery initially proposed was based on decompressive laminectomies. The development of spine fixation with pedicle screws was a game changing and allowed the development of this type of surgery avoiding post laminectomy destabilization.

The first years of my experience were spent understanding and developing effective stabilization and decompression techniques. The operating indications had to be refined to prevent surgery from becoming a complication to the patient rather than improving his functional status.

2 types of surgery were developed during this period, palliative surgery and curative surgery.

The respective indications of these operating strategies have been refined gradually over time.

Originally very invasive, surgery has become less and less invasive allowing limited and especially selective procedures. This decrease in operative aggressiveness is the guarantee of greater efficiency and better tolerance for patients whose vital prognosis is unfortunately often engaged in the medium term, sometimes short term.

It is a better understanding of the disease as well as mastering the different operating techniques that improved patient results. It is this evolution of our strategy that I wish to present in this conference.

Nothing is set in stone strategy and technical developments are constantly evolving and have transformed the management of this complex pathology. However, we must remain aware that most often it is the cancerous pathology that will have the last word.

SY09-3**Advances in Spinal Tumor: What's New? What's Coming?****Oligometastasis: Definition and Surgical Strategy****Hyoungmin Kim***Seoul National University College of Medicine, Korea*

Spinal oligometastasis refers to a specific stage of cancer metastasis in which cancer cells have spread from a primary tumor to a limited number of distant sites in the spine, but not extensively to other organs or tissues in the body. However, the term "spinal oligometastasis" remains unclear since no consensus has been reached on the quantitative meaning of "limited number lesions" and "not extensive disease".

The conventional goal of surgery in the treatment of spinal metastasis has been palliation and improvement of patients' quality of life. With the concept of oligometastasis, the local control of the metastatic lesion in the spine has been paid more attention, driven by a plausible but unproved idea that doing so may have potential benefits for the overall prognosis of cancer.

Advancements in surgical techniques, as well as the utilization of therapeutic modalities such as stereotactic body radiation therapy (SBRT) and targeted agents for systemic treatment, have significantly improved the ability to achieve local disease control with reduced morbidity. Optimized overall disease control is believed to have the potential to enhance overall survival.

Primary cancer biology and individual assessment along with each patient's own of the disease course has become very important. When determining the optimal treatment approach, consideration is given to the extent of metastatic disease, both in the spine and in other locations, the stability of the spine whether it is maintained or not, mechanically and neurologically, the patient's own preferences and wished for the treatment. All of these factors play a significant role on the assessment of the suitability of surgical intervention, as well as the combined systemic treatment and radiation therapy.

Spinal oligometastasis management requires a multidisciplinary approach wherein medical oncologists, radiation oncologists, and spine surgeons collaborate to customize the treatment strategy according to the unique needs and objectives of each patient.

SY09-4

Advances in Spinal Tumor: What's New? What's Coming?

The Predictive Value of the Spinal Instability Neoplastic Score (SINS)

Sun Ho Lee

Sungkyunkwan University School of Medicine, Korea

The Spinal Instability Neoplastic Score (SINS) has been widely adopted for assessing spinal instability in patients with malignant spinal tumors. This lecture presents an in-depth analysis of the predictive value of SINS, including its role in anticipating surgical needs, disease progression, and patient survival rates. The accurate prediction of these aspects can significantly impact patient management and treatment planning.

Moreover, the reliability and accuracy of SINS were evaluated across various clinical settings, with the score applied to different types of tumors and stages of disease progression. This evaluation enhanced our understanding of its effective use in diverse situations.

This presentation affirms the significant value of SINS in spine oncology, as it provides a reliable measure of spinal instability and the necessity for surgical intervention. It aids clinicians in their decision-making, thus improving patient outcomes and overall care quality.

Nonetheless, while SINS serves as a powerful tool, it should be viewed as a part of a comprehensive clinical evaluation and not as a substitute. Future research should focus on refining the SINS further and integrating it more efficiently into the clinical workflow.

SY09-5**Advances in Spinal Tumor: What's New? What's Coming?****Surgical Tips and Pearls for Intramedullary Spinal Cord Tumors****Keung-Nyun Kim***Yonsei University College of Medicine, Korea*

The purpose of intramedullary tumor (IMT) surgery is to achieve complete removal of an IMT without causing damage to the spinal cord. The improvement of diagnostic tests, the development of new operative tools, and technical advances in intra-operative electrophysiologic monitoring have largely contributed to the improvement of surgical results. The surgical strategy is determined by analyzing the MRI data in regard to existence of cleavage plane between tumor and normal spinal cord. It is essential to define the limits of the tumor's solid portion, as this will determine the extent of the laminectomy. It is also essential to localize the lesion within the spinal cord with regard to its lateralization and depth. It is essential to look for a cleavage plane. Both the surgeon and the histologist can detect this, and its discovery is crucial. Finding the cleavage plane makes tumor removal possible, and if it is not found, the decision on whether to remove the tumor must be deferred in intramedullary tumor surgery. In this presentation, I'll show the surgical tips and technique for safe resection of each intramedullary tumors (ependymoma, astrocytoma, hemangioblastoma, cavernous angioma).

AUGUST 18 (Fri)

SYMPOSIUM 10

Cutting Edge of Novel Technology in Spine Surgery

SY10-1

Cutting Edge of Novel Technology in Spine Surgery

Transforming Spine Surgery with the Metaverse: Can It be a Game-Changer in Healthcare?**Wataru Narita***Kameoka City Hospital, Japan*

The emergence of the metaverse, a collective virtual shared space blending augmented physical reality with persistent virtual realms, poses transformative potential across myriad industries. Healthcare stands at an intriguing crossroads of this transformation, particularly in the realm of spine surgery, known for its inherent intricacy.

Traditional spine surgery training, utilizing cadavers and real-time patient scenarios, grapples with limitations like repeatability and risk. Enter the metaverse: a realm where surgeons immerse in realistic, three-dimensional simulations of surgical procedures. This not only offers endless repetition without risk but also ensures exposure to a vast array of cases, simulating real-world unpredictability.

Collaborative learning finds a new dimension in the metaverse. Surgeons, irrespective of geography, can engage in real-time shared virtual surgeries. Such borderless collaboration paves the way for rapid, global sharing of innovative techniques and solutions, promising improved patient outcomes.

For patients, this virtual space can demystify their upcoming procedures. By virtually navigating their spinal issues and proposed solutions, they gain unparalleled insights, fostering better understanding and trust in the surgical process.

Yet, while the promises are immense, challenges loom. Data security, fidelity of virtual experiences to real-world scenarios, and integration costs must be meticulously addressed.

In essence, the metaverse's potential in revolutionizing spine surgery is profound. The blend of immersive training, global collaboration, and enhanced patient engagement could very well mark a paradigm shift in healthcare. While obstacles persist, the promise of better surgical outcomes and democratized knowledge makes the metaverse an avenue ripe for exploration.

SY10-2

Cutting Edge of Novel Technology in Spine Surgery

The MAGNAV System: A New Generation of Navigated Steerable Micro-Invasive Decompression Approach for the First Time an Accurate Safe and Effective Micro-Invasive Decompression

Hansen A. Yuan

SUNY Upstate Medical University, USA

The use of navigation has become more prevalent in spine surgery. There is a multitude of available platforms, yet these platforms are based on camera and set of markers attached to the instruments and the patient.

Unlike the current navigation systems, the Epidutech MAGNAV System do not require the line of sight between the camera and the instrument and does not limit the navigated instruments to be rigid and straight.

Epidutech realized that there is a need for flexible instruments / jointed instruments, that will be navigated, and introduce for the first time an innovated navigation system that can track the distal part of the instrument, even with a flexible or jointed instruments.

The MAGNAV system is based on a magnet attached to the distal part of the instrument (the tip) and an array of magnetic sensors attached to the patient. The MAGNAV system is based on a State-Of-The-Art AI machine learning technique, where in every position of the instrument, the MAGNAV sensors provide a unique image, that is interpreted to a specific position of the instrument's tip.

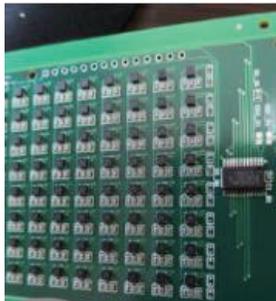
For every position of the instrument in XYZ (Translation) and ABC (Rotation) there is a unique image. Following the collection of millions of images, we have constructed the unique location of each position in an accuracy <1 mm. This AI neural network technique is based on new developments from the last few years which enables methods like the ones used for face recognition is performed in every airport.

The registration process with the patient's CT/MRI is simple and straight forward.

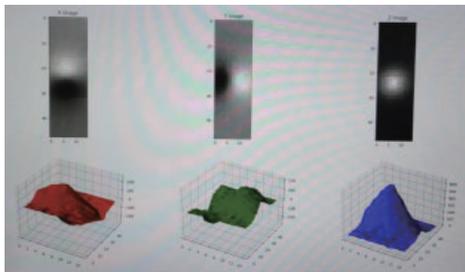
Micro shaver: With the MAGNAV exceptional capabilities, we have developed a unique Micro-Shaver, with a flexible tip that can be steered by the surgeon in order to gain maximum access to any desired location and allow a surgeon to literally visualize in multiple views at the same time all percutaneous and shave bone and capsule or dense flavin all through a tiny port with a tiny navigated magnetic tip.

The combination of the MAGNAV with the Flexible Micro-shaver, attached to an endoscope, we enable a new generation of decompression with a minimum jeopardize of the soft tissues, bones, muscles or any unnecessary collateral damage.

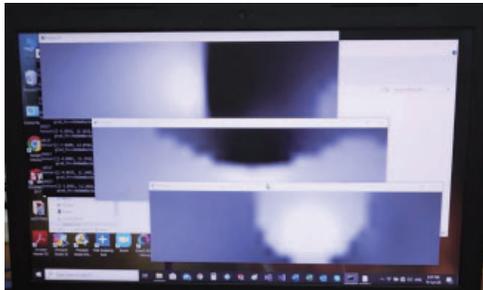
An endoscope can be attached to the Micro-shaver to visualize the field of the decompression, in a micro invasive approach and assure a accurate, safe and effective decompression.



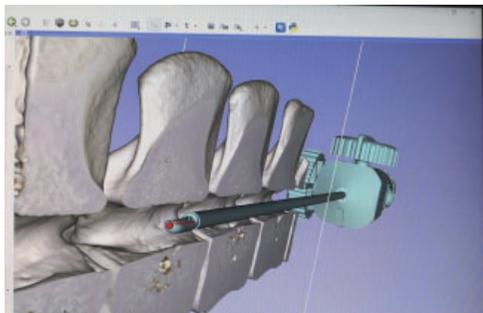
MAGNAV
Array set of magnets



XYZ images, and how they are interpreted in the magnetic field



Magnetic Images of a point in space



The Micro-shaver in the transverse plane



The Micro-shaver with it's unique magnetic tip

SY10-3

Cutting Edge of Novel Technology in Spine Surgery

Machine-Learning Model for Accurately Evaluating Preoperative and Postoperative Condition of Spine Surgery

Gun Woo Lee

Yeungnam University College of Medicine, Korea

Backgrounds: Machine learning (ML), a kind of artificial intelligence (AI), is a computer algorithm that can automatically learn from data without requiring explicit programming. ML can address the limitations of existing techniques and enable breakthroughs in the field of image analysis. Deep learning (DL) is an advanced ML approach which involves the construction of artificial neural networks with structures and functions similar to those of the human brain using a large number of hidden layers. The DL technique can outperform the traditional ML techniques, and learn unstructured and perceptual image data. A convolutional or artificial neural network (CNN or ANN) is a representative DL model that is highly advantageous for imaging recognition and classification.

Main body: The author has some experiences of ML analysis for advancing diagnosis of cervical spine disease. I am not expert for a field of ML analysis, but my trials may be a basis for further studies with ML or DL about spine disease, especially diagnostic aspect of spine disease. In the session, I aimed to share my experiences about DL, (e.g., DL algorithm for predicting cervical myelopathy using lateral radiograph, detecting fusion status after ACDF using cervical spine radiograph, and selecting L5 segment at lumbar lateral radiograph and enumerating spine level accurately).

Conclusion: The evidence from literature and our experiences suggests that ML can be successfully used for advancing the diagnosis in cervical spinal diseases. Therefore, incorporation of ML technique into spine clinical practice may improve clinical decision making.

Keywords: Artificial intelligence, machine learning, spine, evaluation

SY10-4

Cutting Edge of Novel Technology in Spine Surgery

Pearls and Pitfalls of O-arm Navigation Guided Pedicle Screw Placement

Jae Hwan Cho

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O-arm navigation is a useful tool in spinal surgery, but it has both advantages and disadvantages that need to be considered. The O-arm is a full rotational imaging device that acquires imaging data over a 360° arc, providing a greater number of two-dimensional fluoroscopic images for the three-dimensional reconstruction in a shorter period of time. O-arm navigation can be used to register patient anatomy to the CT image, allowing effective spinal navigation. Various studies have shown the superior outcomes of O-arm guided screw insertion, particularly in CT junction surgery, deformity with small pedicles, and anatomical variations such as severe degenerative change or revision surgery. However, there are some pitfalls that need to be considered, including the drift phenomenon, radiation exposure, and cost-effectiveness.

Drift phenomenon refers to the deviation of pedicle screws from the guideline, even with the aid of O-arm navigation. It has been reported in 16.7% of pedicle screws by O-arm navigation and is associated with soft conditions such as cervical spine, pediatric spine, high flexibility, and intraoperative release first before screw placement. Radiation exposure is another concern, with O-arm navigation techniques increasing radiation exposure compared to C-arm use. The effective dose of O-arm related radiation is comparable to diagnostic abdomen and pelvic CT scans, which should be considered in the risk-benefit analysis. Cost-effectiveness is another consideration when using O-arm navigation, as it requires high acquisition and maintenance costs. A study proposed cost savings for centers performing more than 254 cases per year.

Despite these challenges, O-arm navigation has been shown to improve the accuracy of pedicle screw insertion, reduce operation time, and improve outcomes in certain spinal surgeries. Thus, the decision to use O-arm navigation should be made on a case-by-case basis, taking into account the specific patient characteristics and surgical requirements, as well as the potential risks and benefits of the technique.

SY10-5**Cutting Edge of Novel Technology in Spine Surgery****Augmented Reality Assisted Pedicle Screw Fixation****Sang-Min Park***Seoul National University College of Medicine, Korea*

Backgrounds and introduction: Augmented reality (AR) refers to a technology that provides a new real world by linking virtual elements with the real environment. In general, AR means augmenting the real world, wearing a glass-type head mounted device (HMD) that can see the outside, or projecting reality with a mobile phone camera, and showing additional information on it. Recently, it is expressed as an extended reality (XR) as an extended concept, which includes VR, AR, and MR. It is a concept in which the interaction between reality and virtuality is further strengthened.

Main body: XR technology is being used in many fields and is growing in scale. In particular, the medical industry is developing rapidly through the development and utilization of a series of technologies such as XR technology, artificial intelligence, and big data analysis. In the field of orthopedic surgery, research is being conducted to use AR for tumors and spine, etc., and through this, we are trying to improve surgical accuracy.

In the spine field, pedicle screw insertion is the most basic, but one of the techniques that greatly affects the surgical outcome. In order to increase the accuracy of screw insertion surgery, technologies such as navigation and robots have developed and are currently being used. Although AR-based pedicle screw insertion has the same fundamental technology as navigation and robot, it is slightly different in that it uses an HMD instead of a monitor to insert a pedicle screw. AR-assisted pedicle screw insertion using a monitor rather than an HMD has been developed and used by Philips, but the technology using an HMD is still being developed. Although it is currently being developed using it in Korea, it is still being developed in the laboratory stage. The biggest problem during development is that the line of sight and the screen of the HMD do not match well. AR technology using a monitor does not affect accuracy if only the camera position is accurately identified, but HMD has many factors that affect accuracy, such as HMD, eye position, and eye tracking problems.

Conclusion: AR technology is a necessary technology for orthopedic surgery, but it is thought that there is still a long way to go. As described above, improvement of accuracy is the most important task, and for this, hardware performance improvement such as eye tracking and HMD performance improvement is also required. Although the technology is still in its infancy, its potential is thought to be higher than that of other technologies, and a lot of research is needed.

Keywords: Spine, Pedicle screw, Augmented reality

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FP21-1

Non-Operative Care

The Radiographic Assessments of Spino-pelvic Compensation Using lot-based Real-time Ischial Pressure Adjustment**Min-Cheol Seok¹, Moon-Jun Sohn¹ and Haenghwa Lee^{1*}**¹ Department of Neurosurgery, Inje University Ilsan Paik Hospital, College of Medicine, Goyang, Korea

Background: In malalignment syndrome, the spino-pelvic alignment correction with foot orthotics can be applied only to a standing position in the coronal plane. Considering the fact that the average time Koreans spend sitting in a chair is 7.5 hours per day, studies on spino-pelvic correction in sitting position is needed. The purpose of this study is to investigate the pressure changes and radiographic assessment of spino-pelvic alignment using a chair equipped with a height-adjustable seat-plate.

Methods: This study was conducted on 30 participants with spinopelvic malalignment. All participants were subjected to measure buttocks interface pressure while seated using a smart chair in three consecutive steps: 1. on initial seated, 2. on balancing seated, and then 3. on 1 hour balancing seated.

Radiographically, the five spino-pelvic parameters such as shoulder height differences (SHD), iliac crest height differences (ICHHD), leg length discrepancy (LLD), pelvic oblique angle (POA), and coronal imbalance were analyzed to investigate the effect of pelvic imbalance compensation on spino-pelvic alignment. Statistical analysis was performed using ANOVA and paired t test.

Results: The pressure discrepancy improvement between buttocks from 36.4432.3mm on initial seated to 15.7420.3mm on balancing, 12.7410.9mm on 1hr balancing seated (V, P=.008). The radiographic results of pelvic imbalance compensation during seated show a statistical improvement of average SHD (from 0.9 to 0.8mm, P=.005) and average ICHHD (from 9.5 to 2.5mm, P=.037). For a standing posture after use of smart chair, average SHD value (3.0 to 1.0mm, P=.005), ICHHD (from 1.8 to 0.8mm, P=.016), and average LLD value (0.8-0.1mm, P=.033) were statistically significant improved.

Conclusion: Spine-pelvic malalignment can be improved by individually customized pelvic compensation using balanced seat plate height adjustments under the real-time pressure sensing and monitoring on the buttocks while seated. (Abbreviations: BFO = biomechanical foot orthosis, ICHHD = Iliac crest height difference, IOT = Internet of things, LLD = Leg length difference, POA = pelvic oblique angle, SHD = Shoulder height difference.)

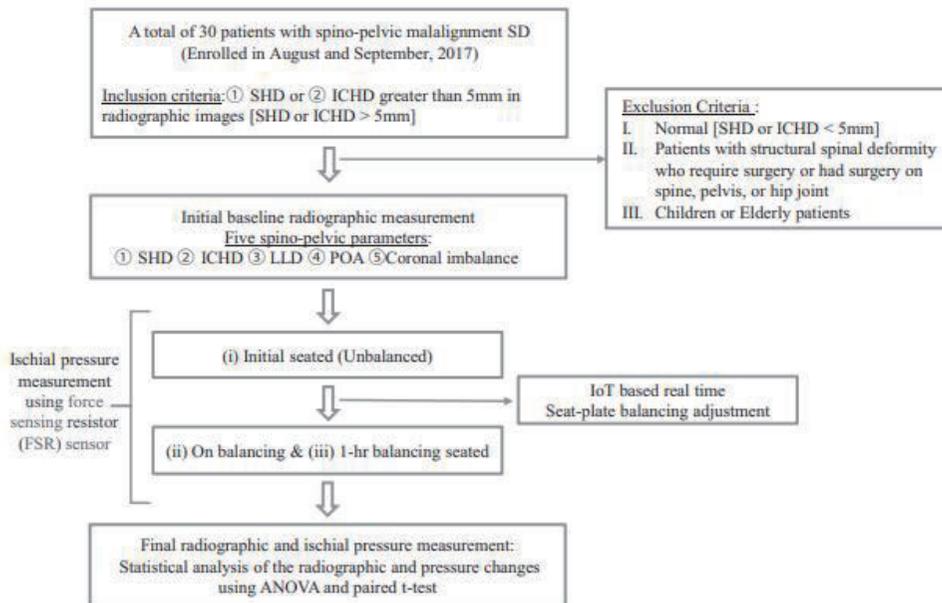


Figure 1. Research flow chart of the study. ICHE=Iliac crest height difference, LLD=Leg length Difference, POA=Pelvic Oblique Angle, SHD=Shoulder height difference.

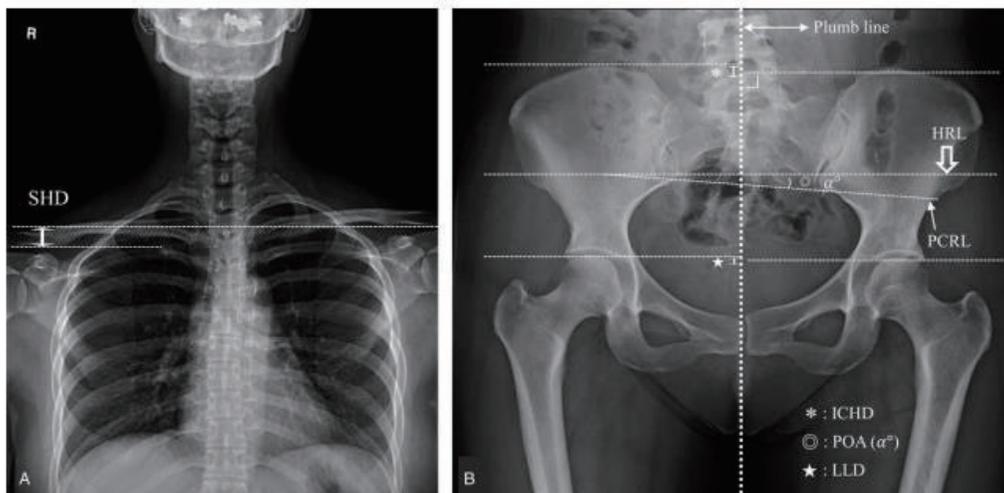


Figure 2. Evaluation of radiographic parameters for spinopelvic imbalance measurement on coronal image. The radiographic parameters included (A) shoulder height differences (SHD, double big arrow), (B) iliac crest height differences (ICHE, asterix), leg length discrepancy (LLD, star), pelvic oblique angle (POA indicates angle (double circle, θ) between horizontal line (HRL, big open arrow) and pelvic coronal reference line (PCRL, narrow arrow).

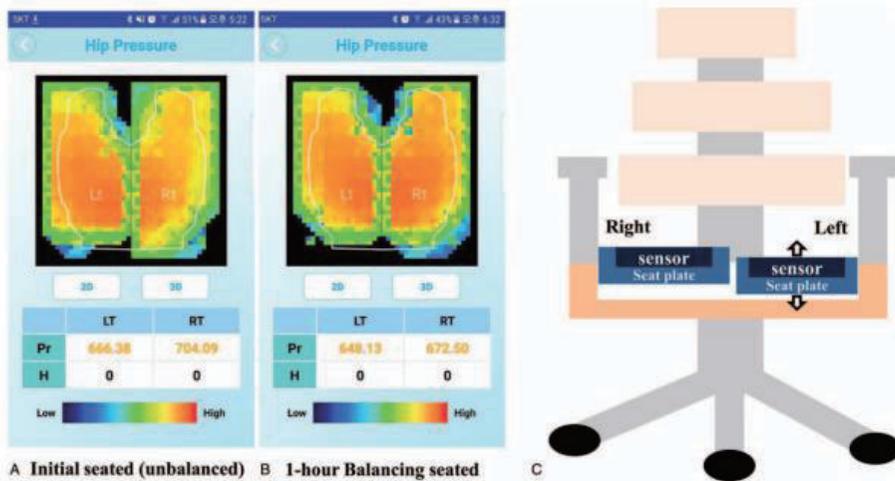
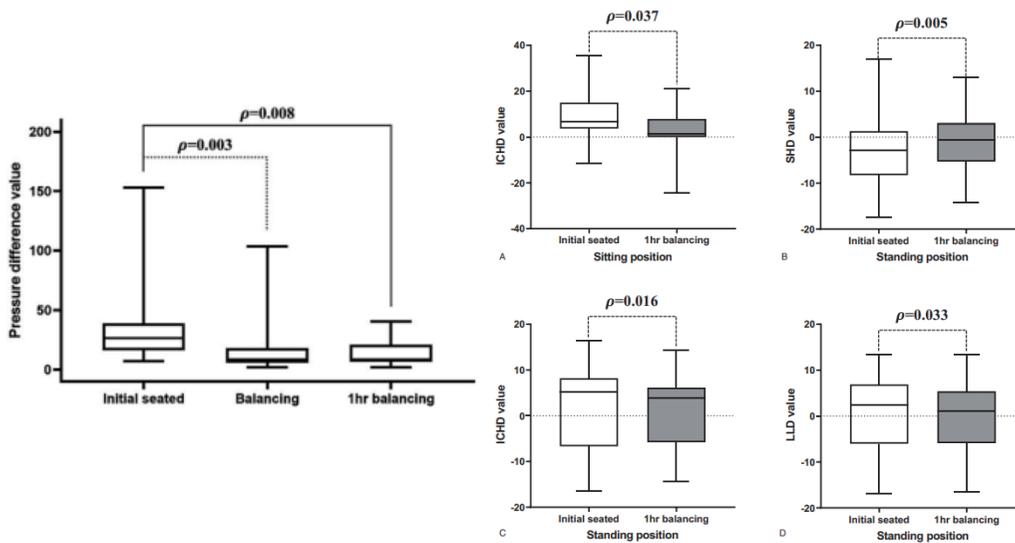


Figure 3. Measurement of ischial pressure using a smart chair. User experience/user interface (UX/UI) display image for ischial pressure measurement (A and B). Initial unbalanced pressure (A) was 666.38 to 704.09, a difference of 37.71, followed by a 1 mm lower left seat plate for balancing, and improved pressure changes (B) during 1-h balanced seating (648.13 vs 672.50, a difference of 24.37). (C) Diagram of the smart chair using adjustable seat plate equipped with pressure sensor. Only left seat plate is adjustable height for balanced pressure distribution.



FP21-2**Non-Operative Care****Spondylitis Treated with Best Effort of Conservative Therapy****Ryoo Fujisawa¹, Takeshi Aoyama¹, Hirokazu Furukawa¹, Naoshi Obara¹ and Takahiro Iida¹**¹ Spine Center, Department of Orthopaedic Surgery, Teine Keijinkai Hospital, Sapporo, Japan

Background: The structure of disease changes in developed countries, as the aging rate rises. Japan is the most advanced super-aging society in the world. By knowing the situation in Japan, it is possible to know the future situation in developed countries that will become an aging society following Japan. The purpose of this study was to analyze the situation of spondylitis in Japan and to know the factors that hinder treatment.

Methods: We retrospectively investigated the cases which were hospitalized from January 2016 to March 2021 and were treated under the diagnosis of spondylitis. Patient background, high morbidity, causative organism, antibiotics used, length of stay, and outcome were evaluated. The standard treatment for spondylitis is conservative treatment with antibiotics for 6-8 weeks. The cases who were able to discharge to home by conservative treatment within this period was the standard therapy group (ST), and the cases who were hospitalized for an extended period of time, were unable to obtain cure by conservative treatment and underwent posterior fusion, or were unable to discharge to home and required to be transferred to other hospital or care house, was defined as a prolonged therapy group (PT). The patient was determined as cured if there was no recurrence for 6 months after the end of treatment.

Results: There were 53 cases, 34 males and 19 females. The age was 71.7 %C2%B1 11.6 (21-91) years. The cases had much comorbidity such as DM and malignancy, and only 11 cases did not have them. The height of spondylitis was 7 lesions in the cervical, 19 lesions in the thoracic, and 44 lesions in the lumbar (there were cases with multiple lesions), and 19 lesions (27.1%) were concentrated in L4 / 5. The most common causative organism was MSSA in 17 cases, followed by alpha-streptococcus in 4 cases, S. epidermidis in 3 cases, and MRSA in 3 cases. In 12 cases, no causative organism was identified in either blood or tissue culture. Ultimately, cure was obtained in 48 cases, excluding 5 cases that died from causes other than spondylitis, but fusion surgery was required in 6 cases. There were 15 cases of ST and 38 cases of PT. The age of ST was 64.6 %C2%B1 14.0 years and that of PT was 74.5 %C2%B1 9.2 years, which were significantly older ($p = 0.02$). Opportunistic infections were identified in 1 case in ST and 12 cases in PT, and tended to be more common in PT ($p = 0.06$).

Conclusions: The average age of patients with spondylitis is high, and it is a disease that increases with aging. The standard treatment is 6-8 weeks of antibiotic treatment, but the older the patient, the more difficult it is to be cured with the standard treatment. Treatment is prolonged if the causative bacteria are opportunistic infectious bacteria such as multidrug-resistant bacteria and intestinal bacteria. Future research is needed to clarify whether early surgical intervention in such cases is useful or not.

FP21-3

Biologics

Comparative Experimental Study on Changes in Serum Bone Turnover Markers and Bone Mineralized Density according to Osteoporosis Drugs after Bony Manipulation in Rabbit Model

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Background: There are no or insignificant animal studies on the degree of bone formation and pull-out strength of internal fixtures due to the effects of each drug on bone formation and osseointegration.

Methods: Twelve rabbits of a 24-week-old, average weight 4 kg, female, were subjected after a one-week acclimatization process. Three were defined as a negative control group, and after a total of 7 weeks of breeding, the lumbar and femur bones were separated and stored in 4% paraformaldehyde solution at room temperature(4°C). Iatrogenic osteoporosis was induced by intramuscular injection of 8 mg/kg of methylprednisolone succinate sodium (Predisole®) once a week for a total of 7 weeks. 2.3mm cancellous screws were inserted into both iliac bones of all rabbits using a hand driver, and this was defined as bony manipulation. Afterwards, 3 were classified into a control group injected with only Predisole, 3 were injected with Predisole+Denosumab (Prolia®), and 3 were treated with Predisole+Denosumab (Prolia®) and Teriparatide (Forsteo®). The lumbar and femur of rabbits administered according to each osteoporotic agent were isolated for 3 weeks and DEXA was performed. Then, through enzyme-linked immunosorbent assay (ELISA), bone turnover markers (N-telopeptide of collagen type 1; NTX, C-telopeptide of collagen type 1; CTX, Procollagen type 1 N-terminal propeptide; PINP, and osteocalcin) were analyzed and compared.

Results: As a result of BMD of ROIs 6, 7, and 8 corresponding to the lumbar spine, BMD compared to control It was confirmed that the level was increased, and the synergistic effect was higher in the group administered with Forsteo and Prolia in combination. (mean BMD at ROI 7: Neg. Control 0.21940.028, Fosteo 0.24340.016, Fosteo+Prolia 0.28040.050) As a result of ELISA, in PINP, the group treated with Prolia was 620 pg/ml at post-manipulation 3weeks, which was 0.9 times higher than the baseline, and 634 pg/ml in the Prolia+Forsteo group, which was 1.4 relative to the baseline.

Conclusions: Through an in vivo study of a rabbit model that induced osteoporosis, it was found that when denosumab and teriparatide were administered in combination, the degree of improvement in the biomechanical properties predicting bone formation was greater.

FP21-4

Non-Operative Care

Could A Simple X-ray be a Screening Tool for Thoracic Ossification of Ligamentum Flavum?Hyunjoo Kwon¹ and Hyunjun Jang¹¹ Neurosurgery, Nowon Eulji Medical Center, Korea

Introduction: Thoracic ossification of the ligamentum flavum (OLF) is one of the major cause of motor and sensory deficit of lower extremity. It's not easy to notify before myelopathy manifest. Unless taking MR images of thoracic spine, it often takes time to get the final diagnosis. The aim of this study is to fine the parameters that could be useful to screen thoracic OLF at primary health care center with simple X-ray images.

Material and Methods: We investigated patients diagnosed Thoracic OLF between 2015 and 2021 in our institution. Total 228 patients were encased. Patients were divided into surgical group and conservative treatment group. Radiologic parameters such as shape and thickness of OLF and occupation ratio of foramen were measured on thoracic lateral X-ray. Patients with thoracic disc herniation or ossification of the posterior longitudinal ligament were excluded. Thickness of OLF (TOLF), Foraminal antero-posterior diameter(FD) - TOLF, OLF free diameter, TOLF / FD were measured. All parameters were measured by two neurosurgeons independently.

Results: One hundred and fourteen patients who underwent surgery for thoracic OLF were enrolled and the same amount of patients (n=114) did not undergo surgery. Beak-type was the most common OLF morphology type, and 88% of patients who underwent surgery had paralysis symptoms. Area of Occupied / Canal had the powerful predictable value among radiologic parameters. The optimal cut-off point was 0.42, 82% Sensitivity, and 83% Specificity.

Conclusion: Area of occupied divided by foramen can predict neurological deterioration. Patients who had TOLF / FD less than 42% showed neurological manifestation such as paralysis or radiculopathy and needed further evaluation. We conclude that even though MRI or CT scan are not prepared, a meticulous reading of simple X-ray could detect thoracic OLF in primary health care centers.

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FP22-1

Cervical Degenerative

Foraminal Decompression Technique during ACDF for Cervical Radiculopathy that Provides a Better Outcome: Total Uncinectomy vs. Partial UncoforaminotomyJooYoung Lee¹, Dong-Ho Lee^{2*} and Sehan Park²¹ Orthopedic Surgery, Dong-A Medical Center, University of Dong-A College of Medicine, Busan, Korea² Orthopedic Surgery, Asan medical center, Korea

Background: Anterior cervical discectomy and fusion (ACDF) provides clinical improvement for cervical radiculopathy, even without direct foraminal decompression, because it stabilizes the mobile segment and provides indirect decompression. Recently, it was determined that foraminal decompression via uncinete process resection could lead to faster and greater improvement of arm pain. Total uncinectomy (TU) and partial uncoforaminotomy (PU) are commonly used for direct foraminal decompression (Fig 1). However, the advantages and pitfalls of the two techniques remain unknown. We aimed to compare the clinical outcomes and complications of TU and PU to determine the most suitable technique for foraminal decompression during ACDF.

Methods: Consecutive patients (n=306) who underwent single-level ACDF for degenerative cervical radiculopathy and who were followed up for >2 years were retrospectively reviewed. The patients were divided into two groups depending on the surgical technique: Group TU and Group PU. Subsidence, fusion, operative time, estimated blood loss (EBL), complications, and patient-reported outcome measures including arm pain visual analogue scale (VAS) score, neck pain VAS score, and neck disability index (NDI) were assessed and compared between the two groups.

Results: Groups TU and PU included 152 (49.7%) and 154 (50.3%) patients, respectively. Group TU had a significantly higher degree of subsidence than Group PU. The 1-year (16 [10.5%] vs 6 [3.9%], p=0.025) and 2-year (11 [7.2%] vs 3 [1.9%], p=0.025) postoperative fusion rates were higher in Group PU than those in Group TU (16 [10.5%] vs 6 [3.9%], p=0.027). Postoperative arm pain VAS score, neck pain VAS score, and NDI scores did not demonstrate significant intergroup differences at all time points. Group TU had a significantly longer operative time (94.21415.74 vs 81.04416.92, p<.001), greater EBL (121.344109.9 vs 71.83485.71, p<.001), higher dysphasia rate (94 (61.8%) vs 75 (48.7%), p=0.021), and more severe retropharyngeal soft tissue swelling (18.2045.02 vs 15.9843.73, p=0.016) than Group PU did. There was one case (0.7%) of cerebral infarction due to vertebral artery injury in Group TU (Table 1).

Conclusion: PU resulted in lesser complications, shorter operative time, and lesser intraoperative bleeding than did TU. While TU guarantees complete foraminal decompression during ACDF, it requires a longer time. Furthermore, excessive lateral exposure and retraction is needed to palpate the lateral margin of the uncinete for TU. This might cause greater postoperative neck swelling and dysphagia. Moreover, the uncinete process was partially preserved in PU as a potential stabilizer, causing lesser subsidence and higher fusion rates. However, the clinical efficacy of PU was comparable to that of TU. Thus, resection of only the posterior part of the uncinete process provides sufficient direct foraminal decompression. Therefore, PU could be an effective and safer alternative to TU for foraminal decompression during ACDF.

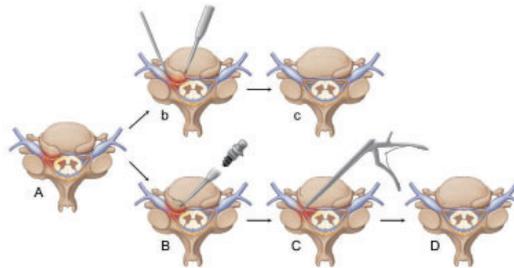


Figure 1. Schematic illustration of the two foraminotomy methods during anterior cervical discectomy and fusion.

A) Right neural foraminal stenosis due to uncinate process (UP) hypertrophy.

Total Uncinectomy (A->b->c): Penfield dissector is inserted lateral to the UP to protect the vertebral artery and nerve root. (b) The UP is removed using a high-speed burr, Kerrison punch, and curette. (c) Completely removed UP and decompressed right neural foramen.

Partial Uncoforaminotomy (A->B->C->D): (B) Using an oblique trajectory with the microscope tilted, a high-speed burr is used to remove the hatched area, leaving a thin outer cortex. (C) The outer cortex and the part adjacent to the nerve are removed by undercutting using a Kerrison punch or a backward micro-curette. (D) Only posterior part of the UP removed and right neural foramen decompressed.

Table 1. Comparison of the clinical outcomes between Groups TU and PU.

Characteristic	Group TU (n=152)	Group PU (n=154)	p-value
Dysphasia score†	13.13±3.51	11.6±2.34	<.001*
Dysphasia††	94 (61.8%)	75 (48.7%)	0.021*
OP time (min)	94.21±15.74	81.04±16.92	<.001*
EBL (ml)	121.34±109.92	71.83±85.71	<.001*
Cage height (mm)	7.63±1.01	6.31±0.61	<.001*
Retro-swelling (mm)			
C2 level	8.10±3.03	6.98±3.51	0.003*
C7 level	18.20±5.02	15.98±3.73	0.016*
(C2+C7)/2	13.65±3.63	11.48±3.06	0.003*
Subsidence (mm)			
POD 1m	0.69±0.71	0.69±0.55	0.95
POD 3m	1.43±0.95	0.95±0.49	<.001*
POD 6m	1.83±0.97	1.32±0.67	<.001*
POD 1y	2.05±1.00	1.45±0.81	<.001*
POD 2y	2.18±1.07	1.52±0.73	<.001*
Nonunion POD 1y	16 (10.5%)	6 (3.9%)	0.025*
Nonunion POD 2y	11 (7.2%)	3 (1.9%)	0.027*
VA injury	1	0	
VAS _{neck}			
POD 1m	4.02±1.81	3.77±3.54	0.45
POD 3m	2.57±1.71	2.35±1.85	0.27
POD 6m	2.44±1.85	2.33±2.23	0.64
POD 1y	2.27±1.55	2.06±1.67	0.26
POD 2y	2.21±1.75	2.10±1.62	0.56
VAS _{arm}			
POD 1m	2.46±1.56	2.59±1.95	0.508
POD 3m	1.97±1.42	2.06±1.73	0.626
POD 6m	1.79±2.42	1.84±2.11	0.859
POD 1y	1.60±1.50	1.59±2.01	0.969
POD 2y	1.13±2.11	1.26±1.72	0.554
NDI			
POD 1m	17.26±10.26	19.59±13.63	0.092
POD 6m	16.74±9.63	16.36±12.56	0.771
POD 1y	16.47±11.50	14.86±12.28	0.236
POD 2y	11.53±11.55	11.96±5.33	0.672

TU, total uncinectomy; PUF, partial uncoforaminotomy; OP, operative; EBL, estimated blood loss; retro-swelling, retropharyngeal soft tissue swelling; VA, vertebral artery; POD, postoperative day; VAS_{neck}, visual analog scale score of neck pain; VAS_{arm}, visual analog scale score of arm pain; NDI, neck instability index.

* P <0.05 calculated using independent samples t-test or chi-square test

† Modified Bazaz dysphagia scoring system.

†† Patient was assessed on the day of operation and on the first, third and fifth post-operative days; the scores were added together. Dysphagia was defined as a cumulative score of ≥ 12.

FP22-2

Cervical Degenerative

Impact of Uniformly Right-side Opening Laminoplasty on Postoperative C5 Palsy in Patients with Degenerative Cervical Myelopathy**Kyung-Chung Kang¹, Se-Han Park¹ and Sang-Gyu Im¹**¹ Orthopedic Department, Kyung Hee University Hospital, Korea

Background: C5 palsy is important complication after unilateral open door laminoplasty (UODL). Many studies had evaluated the risk factors for C5 palsy, but there were few studies about the relationship between lamina opening side and C5 palsy. The aim of this study is to evaluate the impact of uniformly right-side opening laminoplasty on C5 palsy according to preoperative dominant cord compression side and symptom side.

Materials/Methods: Degenerative cervical myeloradiculopathy underwent UODL and followed-up for more than two years were included. UODL was uniformly performed on the right side and hinge was on the left side in all patients. Patients were sub-grouped based on preoperative dominant 3 characteristics: cord compression side, myelopathy symptom side and radiculopathy symptom side (right, symmetric and left). Occurrence of C5 palsy and C5 palsy side were analyzed for each sub-group.

Results: A total of 368 patients were included. C5 palsy incidence was 4.35% (16/368). Four (25%) occurred from the right side and 12 (75%) from the left side. All patients recovered from palsy. According to dominant preoperative cord compression side, C5 palsy rate was not differ in each sub-group. Right and left ratio was respectively 2:2, 2:6 and 0:4. According to dominant preoperative myelopathy symptom side, C5 palsy rate was not differ in each sub-group. Right and left ratio was respectively 1:3, 3:4 and 0:5. According to dominant preoperative radiculopathy symptom side, C5 palsy rate was not differ in each sub-group. Right and left ratio was respectively 1:3, 2:1 and 1:8.

Conclusion: In this study, the occurrence of C5 palsy after uniformly right-side opening laminoplasty was not affected by preoperative dominant cord compression or symptomatic side. Although there was no statistical significance, the patients with preoperatively dominant left-side radiculopathy tend to reveal postoperative left-side C5 palsy and overall occurrence of C5 palsy was higher in the left-side than in the right-side. Further large-scale research is needed in the future.

Table 1. Occurrence of C5 palsy in each sub-group

	Right	Symmetric	Left	p†
Dominant cord compressive side				
Number of patients	71	209	88	
C5 palsy patients (%)	4 (5.63%)	8 (3.83%)	4 (4.54%)	0.808
Dominant myelopathy side				
Number of patients	75	228	65	
C5 palsy patients (%)	4 (5.33%)	7 (3.07%)	5 (7.69%)	0.244
Dominant radiculopathy side				
Number of patients	115	141	112	
C5 palsy patients (%)	4 (3.48%)	3(2.13%)	9 (8.04%)	0.063

† Chi square test

Table 2. Right and left ratio of C5 palsy in each sub-group

	Right	Left	R / L ratio
Total C5 palsy patients (%)	4 (25%)	12 (75%)	0.333
Dominant cord compressive side			
Right	2	2	1.000
Symmetric	2	6	0.333
Left	0	4	0
Dominant myelopathy side			
Right	1	3	0.333
Symmetric	3	4	0.750
Left	0	5	0
Dominant radiculopathy side			
Right	1	3	0.333
Symmetric	2	1	2.000
Left	1	8	0.125

FP22-3

Cervical Degenerative

Shoulder Traction as a Possible Risk Factor for C5 Palsy in Anterior Cervical Surgery: 8 Cadaveric Study

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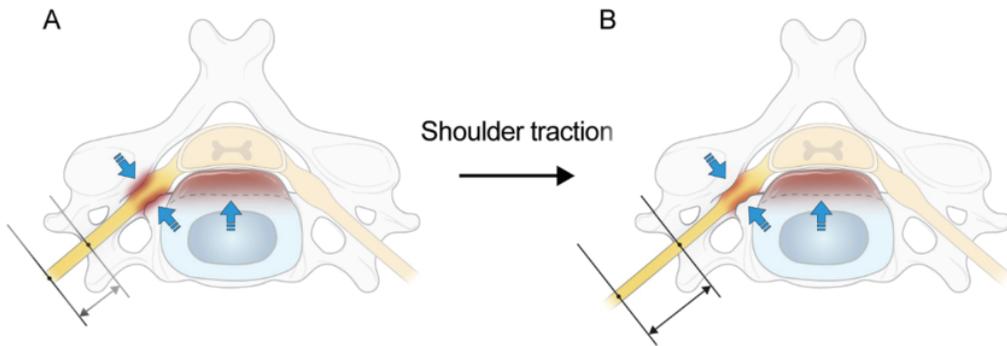
Many risk factors for postoperative C5 palsy (PC5P) have been reported about "cord shift" after a posterior approach. However, there are few reports about shoulder traction as a possible risk factor of anterior cervical surgery. In this study, we observed stretched nerve roots when shoulder traction was applied and to assess the risk factors for PC5P.

8 cadavers were chosen that were available based on age and the presence of foramen stenosis. After dissecting sternocleidomastoid muscle of the cadaver, the shoulder joint was pulled with a force of 2, 5, 8, 10, 15, and 20 kg. Then, stretched length of the fifth nerve root was measured in the extra-foraminal zone.(1st experiment) In addition, the same measurement was performed after cutting of the carotid artery to accurately identify the nerve root origin. (2nd experiment) After additional dissection was performed so that the superior trunk of the brachial plexus could be seen, the stretched length of the 5th and 6th nerve roots was measured again. (3rd experiment)

In the first experiment, the 5th nerve root began to elongate by mean 1.69 mm at 8 kg and increased to mean 4.38 mm. Also, after carotid artery dissection, when 8 kg of traction force was applied, it was elongated by mean 2.13 mm, and increased to mean 7 mm at 20kg. In 3rd experiment, the length of the 5th and 6th nerve roots began to increase from 8 kg, and then increased to mean 5.31 mm and 5.44 mm, respectively.

Although this was a cadaveric experiment, it suggests that shoulder traction could be the risk factors for PC5P after anterior cervical surgery. In addition, for patients with foraminal stenosis and central stenosis, the risk would be higher. Therefore, the surgeon should be aware of this, and the patient will need sufficient explanation.

Experiment	Nerve root	Mean increased length per each traction force (mm)					
		2 kg	5 kg	8 kg	10 kg	15 kg	20 kg
1	C5	0.00	0.25 ± 0.43	1.69 ± 0.43	2.25 ± 0.35	3.44 ± 0.46	4.38 ± 0.48
2	C5	0.00	0.69 ± 0.75	2.13 ± 0.60	2.63 ± 0.48	4.19 ± 1.27	5.00 ± 1.00
3	C5	0.00	0.75 ± 0.66	2.06 ± 0.58	2.63 ± 0.41	3.88 ± 0.74	5.31 ± 1.09
	C6	0.00	0.50 ± 0.50	1.88 ± 0.54	2.81 ± 0.66	3.75 ± 0.71	5.44 ± 0.46
Overall		0.00	0.55 ± 0.43	1.94 ± 0.42	2.58 ± 0.44	3.81 ± 0.44	5.03 ± 0.49



FP22-4

Cervical Degenerative

Lateral Deviation of the Hyoid Bone and Thyroid Cartilage Influences Prevertebral Soft Tissue Swelling and Dysphagia after Anterior Cervical Discectomy and FusionJun-Young Choi¹, Jae Jun Yang^{1*} and Jin-Bog Lee¹¹ Orthopedics, Dongguk University Ilsan Hospital, Korea

Background: Postoperative prevertebral soft tissue swelling (PSTS) is influenced by retraction force during anterior cervical discectomy and fusion (ACDF). The retraction force is mostly determined by the largest hard structures such as the hyoid bone and thyroid cartilage. It was hypothesized that lateral deviation of the hyoid bone and thyroid cartilage may affect PSTS as well as retraction force. The present study aims to elucidate the value of the hyoid bone and thyroid cartilage deviation as a reference for deciding the approach side of ACDF by evaluating correlation with PSTS.

Methods: Two-hundred ninety patients who underwent cervical spine surgery were enrolled in this study. Cervical spine levels, retraction distances to the midline of the vertebral body, and lateral deviation of the hyoid bone (HB), superior cornu (SC) and inferior cornu (IC) of the thyroid cartilage were evaluated using preoperative computed tomography (CT) scan. To assess relationship between the lateral deviation and PSTS, 145 patients who underwent one or two-level ACDF with left-side approach for degenerative cervical spine diseases were enrolled. The difference between preoperative PSTS and postoperative PSTS (dPSTS) was measured using axial CT scan at the middle of each cervical vertebral body. A deviation group (left side deviation >5mm or >10mm) and a non-deviation group (left side deviation <5mm or <10mm) were compared for assessment of correlation with dPSTS and clinical outcomes including dysphagia score and neck disability index.

Results: The means of cervical spine levels of HB, SC, and IC were 3.2, 4.1, and 5.8, respectively. More than 5mm left or right-side deviation of HB, SC, and IC was observed in 31.7%, 31.4%, and 34.5%, respectively. Left-side deviation was more common than right-side deviation in all three structures (Table 1). Linear regression analysis demonstrated significant correlation between degree of the left-side deviation and dPSTS at each level except C7 (Table 2). Compared with the non-deviation group, postoperative steroid was significantly more often used in > 10mm deviation group. Dysphagia was significantly severer in >5mm deviation group (Table 3). The deviation group demonstrated significantly larger dPSTS at C3 and C4 levels based on 5mm deviation, and C3, C4, and C5 levels based on 10mm deviation (Table 4).

Conclusions: More than 5mm lateral deviation of the HB, SC, and IC was observed preoperatively in about 30% of patients and left-side deviation was more common than right-side deviation. The left-side deviation correlates with postoperative PSTS and dysphagia following ACDF with left-side approach. More than 5mm left-side deviation of the hyoid bone and thyroid cartilage may discourage left-side approach for ACDF.

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FP23-1

Cervical Degenerative

Radiographical Pattern Following Multi-level Anterior Cervical Discectomy and Fusion: 'Bony Buttress Formation'**Chang Hwa Ham¹, Woo-Keun Kwon¹, Hong Joo Moon¹, Joo Han Kim¹ and Youn-Kwan Park^{2*}**¹ Department of Neurosurgery, Korea University Guro Hospital, Korea² Department of Neurosurgery, Gachon University Gil Hospital, Korea

Background and Objectives: Anterior cervical discectomy and fusion (ACDF) with anterior plating is a widely performed procedure for cervical disc diseases. Although most reported clinical outcome of multilevel ACDFs are excellent, symptomatic pseudarthrosis remain as a problem and revision surgeries are often necessary. This study aims to present the radiological characteristics of the multi-level ACDF construct, which may be considered during the intraoperative management to avoid pseudarthrosis.

Methods: This is a retrospective cohort study involving patients who underwent multi-level (3 or 4 levels) anterior cervical discectomy and fusion with anterior plating between June 2010 and August 2022. Patients were routinely followed at 4 months, 12 months, and then annually post-operation. Fusion rate and characteristic radiological patterns, such as bony buttress formation underneath the anterior plate were graded and evaluated.

Results: 163 patients were included in the study. Overall fusion rates were 31.29% (37.29% for 3 level and 15.56% for 4 level) at 4 months, 64.62% (69.70% for 3 level and 48.39% for 4 level) at 1 year and 83.48% (83.70% for 3 level and 82.61% for 4 level) at final follow-up. Constructs that caudally end at C7 showed significantly lower fusion rate than other fusion segments. Pseudarthrosis at 1-year post-operation that did not form any bony buttress were vulnerable to remain unfused.

Conclusion: This study underscores the significance of pseudarthrosis following multilevel ACDF. Pseudarthrosis occurs mostly in the caudal most segment of the construct, especially when it ends at C7. Constructs that lack the bony buttress formation in the caudal part of the multilevel ACDF are more likely to develop pseudarthrosis. Tight engagement of the anterior plate to the vertebral body may enhance the fusion rate.

FP23-2

Cervical Degenerative

The Changes in Neck Range of Motion after Laminoplasty according to Cervical Foraminal Stenosis

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Study Design: Retrospective study

Objectives: The purpose of this study is to investigate the relationship between the degree of preoperative cervical foraminal stenosis and postoperative cervical range of motion in patients who underwent cervical laminoplasty due to cervical myelopathy. Summary of Literature Review: Previous studies showed preoperative cervical foraminal stenosis can be a risk factor for cervical kyphosis and neurologic disturbance of upper extremities after cervical laminoplasty,

Materials and Methods: Sixty-three patients who underwent open door cervical laminoplasty below C3 level with C3 laminectomy due to cervical myelopathy at a single institution from January 2007 to September 2021 were included. Study population didn't undergo any level of foraminotomy. Preoperative cervical foraminal stenosis was evaluated by the MRI findings on routinely obtained axial T2-weighted images at cervical disc level and foraminal stenosis was defined as narrowest width of the neural foramen is same or less of the width of the extraforaminal nerve root. The number of foraminal stenosis was counted among 8 foramina(4 levels, left and right) from C3/C4 to C6/C7 and the study population was divided into two groups based on the number of foraminal stenosis. A group with less than 4 foraminal stenosis was defined as group A, and a group with 4 or more was defined as group B. Cervical range of motion was measured by preoperative, postoperative flexion and extension view plain cervical spine lateral radiography using Cobb's method. NDI(Neck Disability Index) and VAS(Visual Analogue Scale) score were used to evaluate axial neck pain, preoperatively, one-year follow-up and three-year follow-up. Statistical analyses were performed using two-sample t test, Chi-square test, and linear mixed model.

Result: Total of 63 cases (44 male; 19 female) were analyzed. When analyzed in two groups (group A : 27; group B : 36), there was a significant difference in average age, NDI after 1 year of surgery, VAS score, flexion ROM, total ROM, flexion ROM preservation, and total ROM preservation after 3 years of surgery. The average age in group A was 59.33 and 66.75 in group B (p=0.019), the NDI score after one year of operation of group A was 18.33 and 19.29 in group B (p=0.027). When comparing the VAS score after 3 years of surgery, group A was 1.55, group B was 3.94 (p=0.043), flexion ROM and total ROM after 3 years of surgery were 24.59 and 36.2, respectively, and group B was 16.04 and 24.98, respectively(p=0.01). Three years after surgery, flexion ROM preservation was 93% for group A and 58% for group B (p=0.01), total ROM preservation was 89% for group A, and 66% for group B.

Conclusions: Cervical ROM after laminoplasty tends to decrease more significantly in the group with four or more preoperative foraminal stenosis than in the group with three or less foraminal stenosis.

Key Words: Cervical spondylotic myelopathy; foraminal stenosis; laminoplasty; range of motion; neck pain

FP23-3

Cervical Degenerative

Comparative Analysis of Surgically Treated Cervical Calcium Pyrophosphate Dihydrate Deposition Versus Cervical Ossification of the Yellow Ligament Presenting with Myelopathy

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Study Design: Retrospective Cohort Study

Objectives: Calcium pyrophosphate dihydrate deposition (CPPD) and ossification of the yellow ligament (OYL) are uncommon causes of myelopathy in the cervical spine. Both manifest as space-occupying lesions, resulting in posterior compression of the spinal cord. Few studies describe them, and those that do are often case reports. This study aimed to compare surgical outcomes of cervical CPPD and OYL.

Methods: 34 patients (17 CPPD, 17 OYL) who underwent posterior decompression surgery from 2015 to 2022 were included. Demographic data and comorbidities were compared. Clinical outcome measures included Visual Analog Scale, Japanese Orthopedic Association (JOA), and Neck Disability Index (NDI). Inflammatory markers included white blood cell (WBC) count, neutrophil count, erythrocyte sedimentation rate (ESR), and C-reactive protein.

Results: Patient age ranged from 62 to 84 years (average 75.13) for CPPD and 49 to 84 years (average 62.86) for OYL. CPPD patients were mostly female (57.14%), whereas OYL patients were predominantly male (72%). The CPPD group had significantly higher ESRs. The OYL group had significantly better pre-operative NDI and JOA scores. Post-operative outcome measures were not significantly different.

Conclusions: Cervical CPPD and OYL present as space-occupying masses in the posterior of the spinal canal, resulting in myelopathy. Inflammatory markers can aid diagnosis, as the resulting compression often leads to inflammation. CPPD may also present with more discomfort and inflammation than OYL. Imaging can uncover morphologic differences: OYL involves growth of lamellar bone in the affected level, whereas "crowned dens" are observed in CPPD.

Keywords: cervical spine; calcium pyrophosphate dihydrate deposition (CPPD); ossification of the yellow ligament (OYL)

FP23-4

Cervical Degenerative

Reciprocal Changes in Radiological Parameters of Patients after Expansive Open-door Laminoplasty: Preoperative Cervical Lordosis Is Inconsequential in K-line Positive CasesByung Wan Choi^{1*}, Junseung Lee¹, Sung soo Kim¹ and Jae Seok Park¹¹ Orthopedic surgery, Inje University Haeundae Paik Hospital, Korea

Introduction: The purpose of cervical laminoplasty is to achieve decompression via posterior migration of the spinal cord. However, it is difficult to predict in advance the spinal cord position after surgery, and the previously reported results are discordant. In this study, we aimed to examine the reciprocal changes that occur in the radiological parameters of patients after cervical laminoplasty.

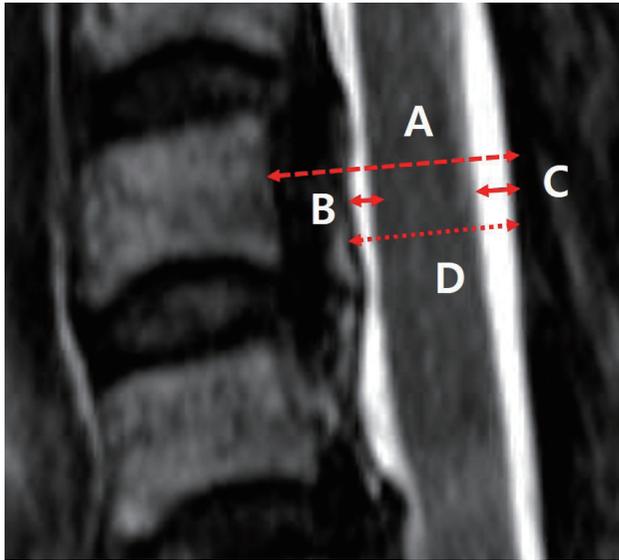
Materials and Methods: We retrospectively assessed 65 patients who underwent open-door laminoplasty for treatment of cervical spondylotic myelopathy. To determine the changes that occurred in the values of radiological parameters after the surgical intervention, magnetic resonance imaging (MRI) was conducted.

The preoperative and postoperative widths of the anterior and the posterior subarachnoid space of the spinal cord and the dural sac diameters were measured at different levels to evaluate the extent of spinal cord decompression.

To identify the factors that affect the postoperative spinal cord position, we evaluated sagittal alignment parameters, including the C2-C7 lordosis angle (LA), the LA of the decompressed area, the C2-C7 spinal cord lordosis angle (SCLA), the SCLA of the decompressed area, C2-7 Sagittal vertical axis (SVA), and the dural sac expansion after the surgery, by measuring the spinal canal diameter and the dural sac diameter at different levels preoperatively and postoperatively. The numbers of operated spinal cord segments and K-line positive and negative cases were also assessed. For the statistical analyses, paired t- test, correlation analysis, and multiple linear regression analysis was performed.

Results: The mean number of operated cord segments was 3.77 (4 0.65). The number of K-line positive cases was 62. After the surgery, the average widths of the anterior subarachnoid space (0.47 mm, $p < 0.001$) and the posterior subarachnoid space (0.89 mm, $p < 0.001$) and the mean dural sac diameter (1.8 mm, $p < 0.001$) increased. The C2-C7 LA decreased by 1.06° , whereas the SVA increased by 1.32 mm after laminoplasty. Moreover, the decrease in the Cobb angle was more than that expected based on the number of operated segments ($p = 0.005$). The LA of the decompressed area decreased by 1.30° ($p = 0.047$), the SCLA decreased by 7.23° ($p < 0.001$), and the SCLA of the decompressed area decreased by 5.93° ($p = 0.001$) after the surgical intervention. Correlation analysis showed a significant relationship between the changes in the values of LA, LA of the decompressed area, SCLA, and SCLA of the decompressed area ($p < 0.001$). Furthermore, a significant relationship was observed between the increase in values of the spinal canal sagittal diameter and the dural sac diameter of each segment of the spinal cord ($p < 0.001$). However, there was no correlation between the sagittal alignment parameters and the dural sac expansion parameters except SVA. Moreover, the number of operated segments was not associated with the dural sac expansion.

Conclusions: After posterior laminoplasty, the spinal cord shifted posteriorly and became upright. The preoperative sagittal parameters and the number of decompressed areas were not associated with the extent of postoperative dural sac expansion in K-line positive patients.



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Lumbar Degenerative

Evaluation of the Efficacy and Safety of 3D Printing Porous Titanium Cage with Non-window Versus Window Type in a Single-level Posterior Lumbar Interbody Fusion: A Prospective, Randomized, Multicenter StudyKwang-Sup Song^{1*}, Dae-Woong Ham¹, Jeongik Lee¹ and Jeuk Lee¹¹ Department of Orthopedic Surgery, Chung-Ang University Hospital, College of Medicine, Chung-Ang University, Korea

Introduction: No studies have compared the clinical outcome and radiographic outcome between window and non-window three-dimensional titanium (3D-Ti) cages. Therefore, well designed a randomized controlled trial (RCT) is needed. This multicenter, prospective randomized clinical trial compare the clinical and radiologic outcomes of window and non-window 3D-Ti cage in lumbar interbody fusion surgery.

Methods: Seventy patients have initially enrolled in the study and undergone a single-level posterior lumbar interbody fusion (PLIF) surgery). Patients were randomly allocated to either a window type 3D-Ti cage (n = 37) or a non-window type 3D-Ti cage (n = 33). Sixty-one of 70 patients completed postoperative 12 months follow-up and analyzed with a drop-out rate of 13%. Blinded radiographic evaluations were performed using computed tomography and assessed by per-protocol analysis in 61 cases that completed 12 months of follow-up postoperatively. Clinical outcomes were evaluated using the EuroQol-5-Dimensional questionnaire (EQ-5D), Oswestry Disability Index (ODI), and visual analog scale (VAS) for back and leg pain.

Results: Fifty-eight of 61 patients achieved interbody fusion with a 95.1% of fusion rate. There was no statistical difference in fusion rate between the non-window and window type 3D-Ti cage (96.6% and 93.8%, respectively). The subsidence rate was higher in the window type 3D-Ti cage group than in the non-window type group, but there were no statistical differences (15.6 % vs. 3.6% and P = 0.262, respectively). Clinical outcomes, including ODI, EQ-5D, and back and leg VAS, improved statistically significantly at 12 months postoperatively in both groups.

Conclusion: The present study demonstrates that the non-window type 3D-Ti cage without void for a bone graft can achieve an adequate interbody fusion rate equivalent to that of a window type 3D-Ti cage with a relatively low subsidence rate.

FP24-2

Lumbar Degenerative

Acute Phase Side Effects of Escherichia Coli-derived Bone Morphogenetic Protein-2 In Lumbar Fusion Surgery

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Background: Recombinant human bone morphogenetic protein-2 (BMP-2) is the growth factor with the most striking osteoinductive performance in the field of dentistry and the spine. However, there have been no studies on the side effects of Escherichia coli-derived BMP-2 (E.BMP-2). The aim of this study was to investigate the types and incidence of acute phase side effects of E.BMP-2 in patients who underwent lumbar fusion surgery.

Methods: A total of 444 patients who received lumbar fusion surgery for degenerative spinal diseases or spinal trauma from September 2013 to October 2021 were included. The enrolled patients were divided into two groups, those receiving autogenous iliac bone grafts (group C, 219 patients) and those receiving E.BMP-2 (group E, 225 patients). Medical records within 3 months after surgery were investigated. Predictive risk factors for postoperative fever among acute phase side effects were evaluated using multivariate logistic regression analysis.

Results: In the group E, acute phase side effects were observed as follows; 47.1% of postoperative fever, 6.7% of atelectasis, 2.7% of ileus, 1.8% of delirium, 2.2% of surgical site infection (SSI) and etc. The incidence of postoperative fever was significantly higher in the group E than group C (47.1% vs. 36.5%, $P = 0.024$). The onset time of postoperative fever showed no significant difference (59.8 hours vs 53.7 hours after surgery, $P = 0.491$). Group E showed higher maximum temperature (38.26 vs 38.05, $P = 0.01$), later fever subsidence (171.9 hours vs 113.7 hours after surgery, $P = 0.007$), and longer duration of fever (112.08 hours vs 60 hours, $p = 0.01$) than group C. E.BMP-2 is one of significant risk factors for postoperative fever with odds ratio of 2.137 ($P = 0.001$).

Conclusions: There were acute phase side effects such as postoperative fever, atelectasis, ileus and etc. The use of E.BMP-2 increased the incidence, maximum temperature and duration of postoperative fever, but it was not associated with SSI.

FP24-3

Lumbar Degenerative

The Evaluation of Feasibility of Psoas, Paraspinal, and Gluteal Muscle Index as a Predictor for Diagnosing Sarcopenia in Patients with Degenerative Lumbar DiseaseKwang-Sup Song^{1*}, Dae-Woong Ham¹, Jeongik Lee¹ and Jeuk Lee¹¹ Department of Orthopedic Surgery, Chung-Ang University Hospital, College of Medicine, Chung-Ang University, Korea

Introduction: Sarcopenia is characterized by a progressive and generalized loss of skeletal muscle mass and strength, resulting in decreased activity and physical function. In 2019, the Asian Working Group for Sarcopenia (AWGS) defined sarcopenia as “age-related loss of muscle mass, plus low muscle strength, and/or low physical performance” and suggested cutoffs for each diagnostic component. To our knowledge, no study has investigated psoas, paraspinal, and gluteal muscle indices as a predictor of diagnosing sarcopenia in patients with degenerative lumbar disease (DLD). Thus, this study aimed to investigate whether three muscle indices measured by computed tomography (CT) can be used to predict diagnosing sarcopenia in patients with DLD.

Materials & Methods: From December 2021 to June 2022, patients who planned to undergo surgery for DLD with documented physical performance test, hand grip strength (HGS), dual-energy X-ray absorptiometry (DEXA), and multi-axial CT scan results were enrolled. Patients' physical performance was evaluated by performing the following two tests, a 6-meter walking test, and a sit-to-stand test. The psoas (PMI), paraspinal (PaMI), and gluteal muscle indices (GMI) were calculated from the CT scan results, and the appendicular skeletal mass (ASM) was measured using DEXA. The diagnosis of sarcopenia was determined according to the 2019 AWGS criteria; low ASM (Male <7.0 kg/m², Female <5.4kg/m²) with low muscle strength (HGS, Male <29 kg, Female <18 kg) or poor physical performance (6-meter walk <1.0 m/s or sit-to-stand test U 12 sec).

Results: A total of 164 patients were enrolled in this study. One hundred and twelve patients (68%) were diagnosed as sarcopenia. And 109 (66%) and 73 (45%) patients were fulfilled the criteria of low ASM with poor physical performance and low ASM with low HGS, respectively. The GMI of the patients diagnosed as sarcopenia was significantly lower than that of the normal patients (66.6 ± 16.0 vs 77.0 ± 16.4, P < 0.001, respectively). In the multivariate logistic regression analysis, the GMI was the only significant parameter for diagnosing sarcopenia among the three muscle indices ($\beta = -0.034$ and P = 0.008).

Conclusions: The present study highlights that GMI, rather than PMI, is a possible predictor for diagnosing sarcopenia among skeletal muscle indices in patients with DLD. In addition, the high prevalence of sarcopenia in this study population might suggest that the AWGS diagnostic criteria for sarcopenia may have been overfitted for the DLD patients, and further investigation is needed.

FP24-4

Lumbar Degenerative

Deep Learning Model for Prediction of OVF Collapse**Sung Bae Park***Department of Neurosurgery, Seoul National University Boramae Medical Center, Korea*

Introduction: Osteoporotic Vertebral Fracture (OVF) is the most typical type of osteoporotic fracture, but there is no gold standard for OVF management. Conservative treatment is usually the primary choice, but some patients require additional treatment such as vertebral augmentation or surgical treatment due to progressive vertebral collapse. If it is possible to predict whether OVF will progress to vertebral collapse, it would be helpful to customize the treatment. Several research were conducted to diagnose OVF based on deep learning, but there have been no studies predicting progressive vertebral collapse to reduce the complication related to the progressed collapse of the vertebral body. In this regard, this study aims to construct a deep-learning model to predict vertebral collapse after OVF with magnetic resonance images.

Methods: The dataset included 98 patients, 82 (Group 1) from Boramae Medical Center and 16 (Group 2) from Suncheonhyang Medical Center and Seoul National University Hospital. Patients were diagnosed with acute OVF between October 2011 and 2020 August and the initial compression ratio was less than 50%. Patients were classified as either 0 or 1 depending on whether the compression ratio was less than 50% (non-collapse) or greater than 50% (vertebral collapse) during the follow-up period of 6 to 12 months. 66 cases of Group 1 were used as a training set. The rest of Group 1 was used for internal validation and cases of Group 2 were used for external validation. MRI T1 and T2 sagittal images of fractured vertebrae were annotated with 6 key points, and bounding boxes were arranged based on these key points to set a range of interest (ROI). Convolutional neural network algorithms, ResNet-18, ResNet-35, and ResNet-50, were used to construct deep learning models. T1 images, T2 images, and both T1 and T2 images were used as input. Metadata of patients including age, gender, and bone mineral density (BMD) were also included in the input data. F1 score, accuracy, specificity, sensitivity, and area under the receiver operating characteristic curve (AUC) were calculated to evaluate the diagnostic performance of each model. The visualization algorithm gradient-weighted class activation mapping (Grad-CAM) was used to interpret the model. Statistical analysis to compare Group 1 and Group 2 was done with two sample t-test, two sample Wilcoxon rank-sum test, Fisher's exact test, and Pearson's chi-square test.

Results: There were no significant differences with respect to age, bone mineral density, gender, and progressive vertebral collapse between Group 1 and Group 2. 41 cases of the training set, 10 cases of the internal validation set, and 8 cases of the external validation set were classified as 0 and the rest were classified as 1. ResNet-18 model with T1 input, ResNet-18 model with T2 input, ResNet-34 model with T1&T2 input, and ResNet-34 model with T1&T2 and metadata input showed the best performance overall with F1 score-accuracy-specificity-sensitivity-AUC of external validation as follows: 0.8889-0.8750-1.0000-0.7500-8750, 0.7692-8125-6250-1.0000-9844, 0.8000-0.8125-0.7500-0.8750-0.9219, 0.8000-0.7500-1.000-0.5000-0.8281. Grad-CAM showed that the model considered the overall vertebral body to predict images as 1 (vertebral collapse), whereas considered part of the endplate or vertebral body wall to predict images

Results

Table 1. Baseline characteristics of patients in the dataset

Variable	Category	Statistics	Group 1 (N=82)	Group 2 (N=16)	Total	P-value
Age (year)		Mean ± SD	73.30 ± 6.87	74.31 ± 8.55	73.47 ± 7.13	0.6078
BMD		Mean ± SD	-3.37 ± 0.85	-3.75 ± 0.77	-3.43 ± 0.84	0.0624
Gender	Female	N(%)	75(91.46)	12(75.00)	87(88.78)	0.0775
	Male	N(%)	7(8.54)	4(25.00)	11(11.22)	
Progressive vertebral collapse	No	N(%)	51(62.20)	8(50.00)	59(60.20)	0.5271
	Yes	N(%)	31(37.80)	8(50.00)	39(39.80)	

Table 2. Distribution of the dataset

	FU compression ratio < 50% (Class 0)	FU compression ratio > 50% (Class 1)	Total
Training	41	25	66
Internal validation	10	6	16
External validation	8	8	16

Results

Table 3. Performance of ResNet-18 model

	F1 score	Accuracy	Specificity	Sensitivity	AUC	
T1	Internal	0.6667	0.7500	0.6667	0.8000	0.6167
	External	0.8889	0.8750	1.0000	0.7500	0.8750
T1 + meta data	Internal	0.6667	0.7500	0.6667	0.8000	0.7000
	External	0.5714	0.6250	0.5000	0.7500	0.7188
T2	Internal	0.6000	0.7500	0.5000	0.9000	0.7833
	External	0.7692	0.8125	0.6250	1.0000	0.9844
T2 + meta data	Internal	0.6000	0.7500	0.5000	0.9000	0.7500
	External	0.7368	0.6875	0.8750	0.5000	0.7344
T1&T2	Internal	0.6000	0.7500	0.5000	0.9000	0.7167
	External	0.6667	0.7500	0.5000	1.0000	0.8750
T1&T2 + meta data	Internal	0.5000	0.7500	0.3333	1.0000	0.5000
	External	0.7500	0.7500	0.7500	0.7500	0.8281

Table 4. Performance of ResNet-34 model

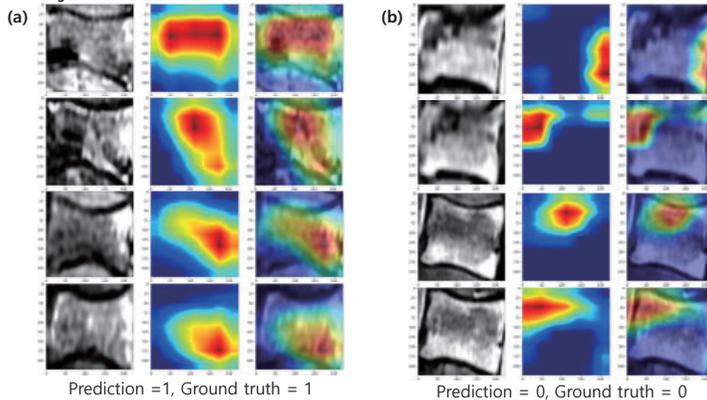
	F1 score	Accuracy	Specificity	Sensitivity	AUC	
T1	Internal	0.6667	0.7500	0.6667	0.8000	0.6667
	External	0.6667	0.6875	0.6250	0.7500	0.7188
T1 + meta data	Internal	0.6667	0.8125	0.5000	1.0000	0.7333
	External	0.0000	0.5000	0.0000	1.0000	0.8125
T2	Internal	0.6667	0.7500	0.6667	0.8000	0.6837
	External	0.6154	0.6875	0.5000	0.8750	0.8281
T2 + meta data	Internal	0.6667	0.8125	0.5000	1.0000	0.9000
	External	0.5455	0.6875	0.3750	1.0000	0.9375
T1&T2	Internal	0.6667	0.7500	0.6667	0.8000	0.7333
	External	0.8000	0.8125	0.7500	0.8750	0.9219
T1&T2 + meta data	Internal	0.6667	0.7500	0.6667	0.8000	0.6333
	External	0.8000	0.7500	1.0000	0.5000	0.8281

Table 5. Performance of ResNet-50 model

	F1 score	Accuracy	Specificity	Sensitivity	AUC	
T1	Internal	0.6667	0.7500	0.6667	0.8000	0.6750
	External	0.7059	0.6875	0.7500	0.6250	0.7969
T1 + meta data	Internal	0.5000	0.7500	0.3333	1.0000	0.7667
	External	0.4000	0.6250	0.2500	1.0000	0.7344
T2	Internal	0.6667	0.7500	0.6667	0.8000	0.7333
	External	0.7143	0.7500	0.6250	0.8750	0.8281
T2 + meta data	Internal	0.8000	0.8125	1.0000	0.7000	0.8500
	External	0.4211	0.3125	0.5000	0.1250	0.4375
T1&T2	Internal	0.6667	0.7500	0.6667	0.8000	0.7000
	External	0.3636	0.5625	0.2500	0.8750	0.7031
T1&T2 + meta data	Internal	0.6000	0.7500	0.5000	0.9000	0.6500
	External	0.2000	0.5000	0.1250	0.8750	0.2812

Results

Figure 1. Grad-CAM of ResNet-34 model



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Lumbar Degenerative 2

FP25-1

Lumbar Degenerative

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 DensityJae-Won Shin¹, Yung Park^{1*} and Sang-Ho Kim¹¹ Department of Orthopedic Surgery, National Health Insurance Service Ilsan Hospital, Korea

Introduction: BMPs are purified from demineralized bone matrix based on their ability to induce new bone in vivo and they represent a large member of the TGF- β superfamily of proteins. BMPs serve as morphogenic signals for mesenchymal stem cell migration, proliferation and subsequently differentiation into cartilage and bone. According to previous studies, BMPs can promote the fusion rate after one-level lumbar fusion surgery. However, with the increase of incidence of osteoporosis and osteopenia recently, It is necessary to evaluate whether BMPs can upregulate the bone fusion rate in patients with low bone density.

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

Material and methods: This retrospective study enrolled 159 patients treated for degenerative disease with one-level trans- foraminal lumbar interbody fusion from February 2012 to December 2018, and who had both pre- and post-operative CTs. 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. Fusion of vertebral body and bone graft was evaluated on two criteria, absence of peri-graft radiolucency and trabecular bone bridging on post-operative CTs taken annually.

Results: In both groups, Time-to-fusion took significantly longer in the osteoporosis group in both fusion criteria. And the difference of time-to-fusion between the two groups was statistically significant, especially for patients with osteoporosis. ($p=0.001$) In non-usage group, median time-to-fusion were 0.5 years in normal, 2 years in osteopenia, 3 years in osteoporosis for absence of peri-graft radiolucency ($p = 0.003$), and 3 years, 4 years, 5 years for trabecular bone bridging. ($p = 0.001$). In BMP-usage group, median time-to-fusion were 0.45 year in normal, 1.85 years in osteopenia, 2.5 years in osteoporosis for absence of peri-graft radiolucency ($p = 0.002$), and 2.8 years, 3.5years, 4 years for trabecular bone bridging. ($p=0.001$)

Conclusion: 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.

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Lumbar Degenerative

Mini-open Intercostal Retroperitoneal Approach for Upper Lumbar Spine Lateral Interbody Fusion

Dongwuk Son^{1*}, Suhun Lee¹, Junseok Lee¹ and Geunsung Song¹

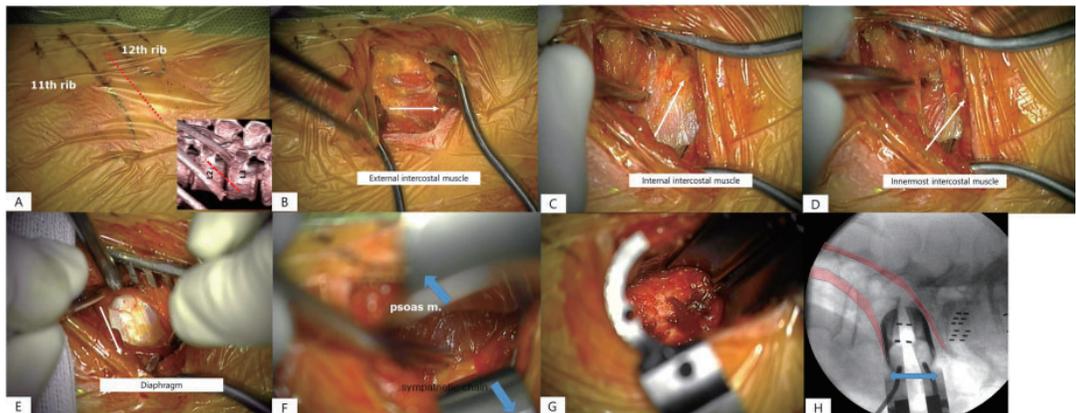
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Background: Conventional oblique lumbar interbody fusion (OLIF) approach is possible from the L2/3 to L4/5 levels. However, obstruction of the lower ribs (10-12th) makes it difficult to maintain disc parallel maneuvers or orthogonal maneuvers. To overcome these limitations, we proposed an intercostal retroperitoneal (ICRP) approach to access the upper lumbar spine. This method does not expose the parietal pleura or require rib resection and employs a small incision.

Methods: We enrolled patients who underwent a lateral interbody procedure on the upper lumbar spine (L1/2/3). We compared the incidence of endplate injury and severe subsidence (>5 mm) between conventional OLIF and ICRP approaches. In addition, by measuring the rib line, the difference in endplate injury according to rib location and approach was analyzed.

Results: A total of 75 patients underwent lateral interbody fusion to the upper lumbar spine (OLIF approach, 63 patients; ICRP approach, 12 patients). Endplate injuries occurred in 35/63 (55.6%) and 1/12 (8.3%) patients during the conventional and ICRP approaches, respectively (p=0.003; odds ratio, 13.75). Severe subsidence occurred in 12.7% (8/63) of the patients in the conventional group but not in those in the ICRP group. When the rib line was located at the L2/3 disc or L3 body level, the endplate injury rate was 92.3% (24/26) for the OLIF approach but only one case (1/9) for the ICRP approach.

Conclusion: The ICRP approach is effective in reducing the incidence of endplate injury in patients with a relatively lower rib line, without pleural exposure or rib resection.



FP25-3

Lumbar Degenerative

Subsidence after L5-S1 Transforaminal Lumbar Interbody Fusion (TLIF) Using 3D-Printed Porous Titanium Interbody Cage; Single Institution Case Series**Jungwoo Hur¹, Jae Taek Hong^{1*} and Donghoon Kim¹**¹ Neurosurgery, Eunpyeong St.Mary's Hospital, The Catholic University of Korea, Korea

Introduction: Cage subsidence is a well-known complication after transforaminal lumbar interbody fusion (TLIF). 3D-printed porous titanium cage (3D-PTC) has a modulus of elasticity similar to human cancellous bone, which reduces stress at bone-cage interface, lowering risk of unwanted subsidence. The purpose of this study is to evaluate the rate of subsidence and reoperation rate of patients who underwent TLIF at L5-S1 level using 3D-PTC.

Material and Methods: This study is a retrospective case series of consecutive adult patients who underwent TLIF at L5-S1 using 3D-PTC from 2019 to 2020. Demographic and operative characteristics including age, sex, bone mineral density (BMD), smoking status, diabetes, number of fusion levels, type of posterior instrumentation and graft profile were collected. The Marchi subsidence grade was assessed at the time of last follow-up using X-ray and 3D-CT. Primary outcome measures were subsidence and rate of reoperation. Uni- and multivariate logistic regression analysis was performed to evaluate the association of collected data with the grade of subsidence.

Results: Eighty-nine patients were treated with 3D-PTCs at L5-S1 with a mean follow-up of 25 month. The mean age was 68.7 years, 61.8% of patients were female and 29.2% of patients were osteoporotic. Patients most commonly underwent single level TLIF (49.4%) and 38 patients (42.7%) had supplement percutaneous pedicle screw fixation (PPF). The subsidence grade distribution was as follows; 68 (76.4%) grade 0, 13 (14.6%) grade I, 6 (6.7%) grade II, and 2 (2.2%) grade III. Intraoperative end plate damage and osteoporosis were significantly associated with presence of overall cage subsidence. Moreover, cage length and final cage position were significantly associated with severe subsidence. 3 (3.4%) patients underwent reoperation for symptomatic subsidence.

Conclusion: In our case series, subsidence occurred 23.5% after L5-S1 TLIF, 8.9% of which were severe subsidence grade. 3.4% of patients required reoperation for symptomatic subsidence. These results are similar to polyetheretherketone cage and greater than theoretically expected. Further studies with larger samples and prospective design is required to evaluate the impact of new cage material on subsidence after TLIF.

FP25-4

Lumbar Degenerative

The Influence of Rheumatoid Arthritis on Higher Reoperation Rates over Time Following Lumbar Spinal Fusion: A Nationwide Cohort Study

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Background: Rheumatoid arthritis (RA) is an autoimmune disease that affects the synovial joints, most commonly the cervical spine. However, there have been few studies concentrating on the influence on the lumbar spine. A few studies have indicated that patients with RA undergoing lumbar spinal surgery have higher rates of complications. All of these studies have used small patient cohorts and were restricted to a single institution. Therefore, this study aimed to analyze the rates of reoperation in RA patients undergoing first lumbar spinal fusion compared to patients without RA using Korean Health Insurance Review and Assessment (HIRA) data.

Methods: We identified the RA group as 2239 patients who underwent their first lumbar fusion with RA and the control group as 11,195 patients without RA between 2012 and 2013. This reflects a ratio of 1:5, and the participants were matched by sex, age, and index surgery date. Reoperation rates were analyzed for three-time intervals (0-90 postoperative days, 91-365 days, and 366 days to 7 years). The multivariate Cox proportional hazards model was used to calculate the hazard ratio (HR) and 95% confidence interval (CI) for reoperation for the RA group compared with the control group.

Results: When comparing the rate of patients undergoing reoperation, the adjusted HR was 1.31 (95% CI: 1.10-1.6) in the RA group ($p = 0.002$). In terms of the three time intervals, the values in the time frames of < 3 months and 3 months-1 year were not statistically significant. However, at 1 year post-surgery, there was a higher risk of reoperation in the RA group, as demonstrated by the Kaplan-Meier cumulative event analysis. This higher risk of reoperation continued to increase throughout 5 years of follow-up, after which it was stable until the last follow-up at 7 years.

Conclusions: This population-based cohort study showed that the RA patients had a 1.31 times higher risk of reoperation following lumbar fusion than did the controls. This difference was more pronounced at 1 year post-surgery.

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Cervical Degenerative

The Effect of Posterior Cervical Laminoplasty with Dome Laminotomy on Cervical Alignment and Disability in Patients with Cervical Spondylotic Myelopathy Patients**Sung Hoon Choi¹, Chang-Nam Kang¹ and Dong-Ho Lee¹**¹ Orthopedic surgery, Hanyang University Hospital, Seoul, Korea

Introduction: Posterior cervical laminoplasty is an effective procedure that can induce multi-level decompression through posterior cord shifting. However, complications such as cord kinking, C5 palsy, and loss of sagittal alignment have also been reported after laminoplasty. To prevent static or dynamic kinking of the spinal cord, dome laminotomy at the upper and/or lower segments can be performed, however, the clinical and radiological results have not been reported yet.

Materials and methods: For 155 patients who underwent posterior laminoplasty, the clinical and radiological parameters were analyzed. Open-door type laminoplasty was performed in all patients. The decision on the opening side of laminoplasty and whether dome laminotomy was needed was decided by the surgeon's decision in consideration of the degree of cord compression and the patient's symptoms.

Results: Among 155 patients, the proportion of men who underwent laminoplasty (72.8%) was significantly higher than women (M: F= 113: 42, $p<0.05$). Compared to the preoperative period, at 6 weeks follow-up after laminoplasty, C2-C7 lordosis (C2-7L, -13.5° vs. -8.9°) and T1 slope (T1S, 31.4° vs. 29.2°) decreased and C2-7 sagittal vertical axis (C2-7SVA, 25.6 mm vs. 29.3 mm) was increased significantly ($p<0.01$). However, there was no statistical difference between all parameters from 6 weeks to 1 year (C2-7L: -8.9° vs. -8.2° , T1S: 29.2° vs. 29.2° , and C2-7 SVA: 29.3mm vs. 29.4mm). Neck pain did not differ between pre- and postoperative 6 weeks (2.4 vs. 2.1), however, decreased significantly at 1-year postoperative follow-up (2.4 vs. 2.0, $p<0.05$). The neck disability index decreased steadily from preoperatively to 6 weeks and 1-year postoperatively (15.7 vs. 10.2 vs. 8.4, $p<0.01$). Arm pain was significantly decreased at postoperative 6 weeks compared to preoperatively (4.7 vs. 2.9, $p<0.01$), and was maintained until postoperative 1-year (2.9 vs. 2.8, Table 1). Patients who underwent C2 dome laminotomy showed longer decompression levels than those without dome laminotomy (5.0 vs 3.7, $p<0.01$) and increased preoperative C2-7 SVA (30.5 mm vs. 21.1 mm, $p< 0.01$). However, C2-7 SVA did not differ at 1-year postoperatively (32.4mm vs. 30.6mm vs. 28.4mm vs. 25.7 mm, $p=0.16$) whether laminotomy was performed. Patients who underwent C7 dome laminotomy showed longer decompression levels than those without dome laminotomy (4.8 vs. 3.7, $p<0.01$), but there was no difference in preoperative C2-7 SVA and C6-7 segmental motion. However, in patients who underwent C7 laminotomy, C6-7 segmental motion significantly decreased at 6-weeks and 1-year after surgery (6 weeks: 8.9° vs. 11.4° ; 1 year: 10.0° vs. 12.0° , $p<0.05$).

Conclusion: After laminoplasty, C2-7L and T1S decreased, and C2-7 SVA increased, however, clinical symptoms improved steadily. C2-7L, T1S, and C2-7SVA at 6-weeks postoperatively can be early parameters for predicting the cervical alignment at 1-year follow-up. Even though patients requiring C2 or C7 dome laminotomy showed longer decompression levels and an increased preoperative C27SVA, however, there was no additional C2-7 SVA loss. Therefore, laminoplasty with dome laminotomy could be an effective procedure for inducing spinal cord decompression without additional loss of cervical sagittal alignment if being careful when performing C7 dome laminotomy for the further loss of segmental motion.

Table 1. Comparison of radiological and clinical outcomes between preoperative and postoperative 6 weeks and 1 year.

Parameters	Preoperative	Postop 6wks	p-value	Preoperative	Postop 1yr	p-value	Postop 6wks	Postop 1yr	p-value
C2-7SVA (mm)	25.6	29.3	0.000	25.6	29.4	0.000	29.3	29.4	0.954
T1 slope (°)	31.4	29.2	0.000	31.4	29.2	0.000	29.2	29.2	0.942
C5-6 ROM (°)	15.4	9.9	0.000	15.4	9.8	0.000	9.9	9.8	0.888
C6-7 ROM (°)	14.5	10.3	0.000	14.5	11.4	0.000	10.3	11.4	0.077
NDI	15.9	10.2	0.000	15.9	8.4	0.000	10.2	8.4	0.001
NP	2.4	2.1	0.187	2.4	2.0	0.077	2.1	2.0	0.645
AP	4.7	2.9	0.000	4.7	2.8	0.000	2.9	2.8	0.695

C2-7L represents C2-C7 lordosis; SVA, sagittal vertical axis; ROM, range of motion; NDI, neck disability index; NP, neck pain; AP, arm pain.

dome laminotomy

Parameters	C3 total laminectomy (N=54)	C2 dome laminotomy (N=26)	C3 dome laminotomy (N=41)	No laminotomy (N=28)	p-value
Age	64.6	62.8	61.4	60.3	.394
No. of levels	4.3	5.0	4.5	3.7	<.01
Preop C2-7L (°)	-13.6	-12.7	-14.5	-11.3	.564
Postop C2-7L (6wks, °)	-7.6	-10.7	-10.1	-6.3	.238
Postop C2-7L (1yr, °)	-8.2	-5.4	-9.4	-7.8	.431
Preop C2-7 SVA (mm)	28.5	30.5	23.7	21.1	<.01
Postop C2-7 SVA (6wks, mm)	33.9	31.7	26.2	24.6	<.01
Postop C2-7 SVA (1yr, mm)	32.4	30.6	28.4	25.7	.164
Preop T1 slope (°)	32.4	32.7	32.0	27.7	<.05
Postop T1 slope (6wks, °)	29.5	32.0	29.0	26.7	.098
Postop T1 slope (1yr, °)	30.5	29.2	29.6	26.5	.253
Preop NP	2.6	3.0	2.3	2.1	.549
Postop NP (6wks)	2.4	1.7	2.5	1.7	.284
Postop NP (1yr)	2.1	2.0	1.7	2.1	.850
Preop NDI	14.8	16.3	16.7	15.9	.661
Postop NDI (6wks)	10.3	10.2	10.2	9.7	.990
Postop NDI (1yr)	8.9	9.5	8.5	5.8	.360
Preop AP	4.2	5.1	5.1	4.9	.267
Postop AP (6wks)	3.0	2.3	2.9	3.4	.484
Postop AP (1yr)	2.8	3.1	2.8	2.6	.939

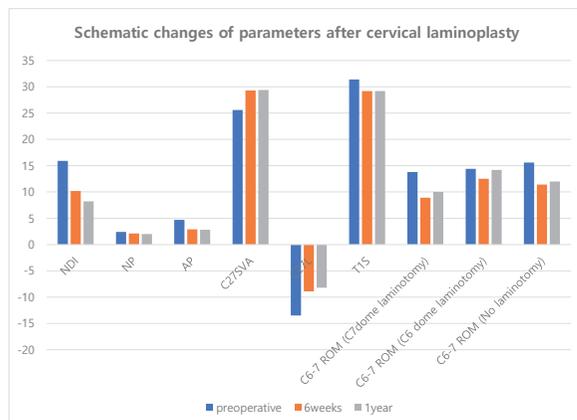
C2-7L represents C2-C7 lordosis; SVA, sagittal vertical axis; ROM, range of motion; NDI, neck disability index; NP, neck pain; AP, arm pain.

dome laminotomy

Parameters	C6 dome laminotomy (N=27)	C7 dome laminotomy (N=80)	No laminotomy (N=41)	p-value
Age	66.0	60.7	63.3	0.118
No. of levels	4.3	4.8	3.7	<.001
Preop C2-7L (°)	-13.2	-13.3	-14.0	.932
Postop C2-7L (6wks, °)	-10.6	-9.0	-7.7	.517
Postop C2-7L (1yr, °)	-7.8	-8.9	-7.5	.727
Preop C6-7 ROM (°)	14.4	13.8	15.6	.407
Postop C6-7 ROM (6wks, °)	12.5	8.9	11.4	<.05
Postop C6-7 ROM (1yr, °)	14.2	10.0	12.0	<.05
Preop C2-7 SVA (mm)	23.5	25.6	25.8	.668
Postop C2-7 SVA (6wks, mm)	25.4	28.5	32.6	.083
Postop C2-7 SVA (1yr, mm)	28.0	29.0	31.0	.616
Preop T1 slope (°)	29.6	31.6	31.5	.474
Postop T1 slope (6wks, °)	28.9	28.9	29.9	.781
Postop T1 slope (1yr, °)	29.1	29.4	29.0	.955
Preop NP	2.5	2.4	2.3	.952
Postop NP (6wks)	1.6	2.1	2.3	.401
Postop NP (1yr)	1.7	2.3	1.7	.245
Preop NDI	16.5	15.6	14.9	.676
Postop NDI (6wks)	10.8	9.7	9.8	.800
Postop NDI (1yr)	8.3	8.1	8.0	.988
Preop AP	4.8	4.7	4.5	.842
Postop AP (6wks)	3.1	2.8	3.1	.786
Postop AP (1yr)	2.9	2.9	2.8	.949

C2-7L represents C2-C7 lordosis; SVA, sagittal vertical axis; ROM, range of motion; NDI, neck disability index; NP, neck pain; AP, arm pain.

Figure 1. Schematic changes of parameters after cervical laminoplasty and/or with additional laminotomy



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Cervical Degenerative

Preliminary RCT Results Comparing Allograft and Novomax Cage in Anterior Cervical Discectomy and FusionYanting Liu¹ and Jin-Sung Kim^{1*}

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Introduction: The quest for better materials in Anterior Cervical Discectomy and Fusion (ACDF) has led to the use of various graft materials including autografts, allografts, and synthetic grafts. The Novomax cage, composed of bioactive BGS-7 (CaO-SiO₂-P₂O₅-B₂O₃), has shown promise due to its superior bioactivity and ability to directly bind with bone, eliminating the need for additional bone supplementation. We conducted a randomized controlled trial (RCT) to compare the long-term clinical and radiological outcomes of the Cornerstone allograft and the Novomax cage.

Methods: From 2017 to 2023, 45 consecutive patients requiring ACDF were randomly assigned to receive either the Cornerstone allograft (n = 21) or the Novomax cage (n = 24). The patient cohort consisted of 21 females with an average age of 55.0449.49 years. The most common level of fusion was at C5-C6. Clinical outcomes were evaluated using patient satisfaction rates, recovery rates, postoperative neck and shoulder pain, and the Neck Disability Index (NDI). Radiological evaluations considered changes in cervical lordosis, T1 slope, and disc height.

Results: The mean follow-up period was 22.31419.51 months. Patient satisfaction and recovery rates were similar in both groups with 87.72 ± 14.73 and 90.91 ± 9.71 for the Cornerstone and Novomax groups respectively. Postoperative neck and shoulder pain showed no statistical difference between the two groups. However, there was a significant difference in postoperative NDI, with the Novomax group showing lower NDI scores with a 4.76 difference compared to the Cornerstone group. Radiological data, including cervical lordosis, T1 slope, and disc height changes pre and postoperatively, showed no significant difference between the two groups.

Conclusions: Preliminary results from our ongoing RCT study suggest that both the Cornerstone allograft and Novomax cage can achieve satisfactory outcomes in ACDF. However, the Novomax cage shows a significant advantage in improving postoperative NDI scores, suggesting better neck disability recovery. Both materials showed similar radiological outcomes, reaffirming the reliability of the Novomax cage as a viable alternative to traditional allografts. Future research with a larger cohort and longer follow-up is required to confirm these preliminary findings.

FP26-3

Cervical Degenerative

Effectiveness of Nasotracheal Intubation in Anterior Cervical Surgery Including C3 Lesions

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Objective: Anterior approach cervical surgery is widely used for accessing C3 lesions. When operating with an anterior approach, the surgical field is obstructed by mandible. Neck extension is popular method to secure better surgical field but risk devastating neurological damage. To overcome this limited surgical field without neck extension, we adopted nasotracheal intubation and evaluated its efficiency.

Methods: We retrospectively analyzed 16 patients who underwent anterior cervical discectomy or corpectomy of C3 lesions via nasotracheal intubation. We enrolled an additional 29 patients who underwent anterior cervical discectomy or corpectomy of C3 lesions via orotracheal intubation as a control group. All patients had been diagnosed with cervical spondylotic myelopathy or ossification of the posterior longitudinal ligament. We measured the mandibular-cervical angle, which is the angle between the lower mandibular line and anterior vertebral line.

Results: The mandibular-cervical angle was increased by 7.3 with nasotracheal intubation compared to orotracheal intubation.

Conclusions: Nasotracheal intubation is an effective surgical option for securing the surgical field without neck extension in anterior cervical surgery including C3 lesions.

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Cervical Degenerative

Comparison of Basic Characteristics and Postoperative Outcomes of Patients with Cervical Myelopathy at an Early Age (<45 Years Old); How Is It Different from Conventional Myelopathy?

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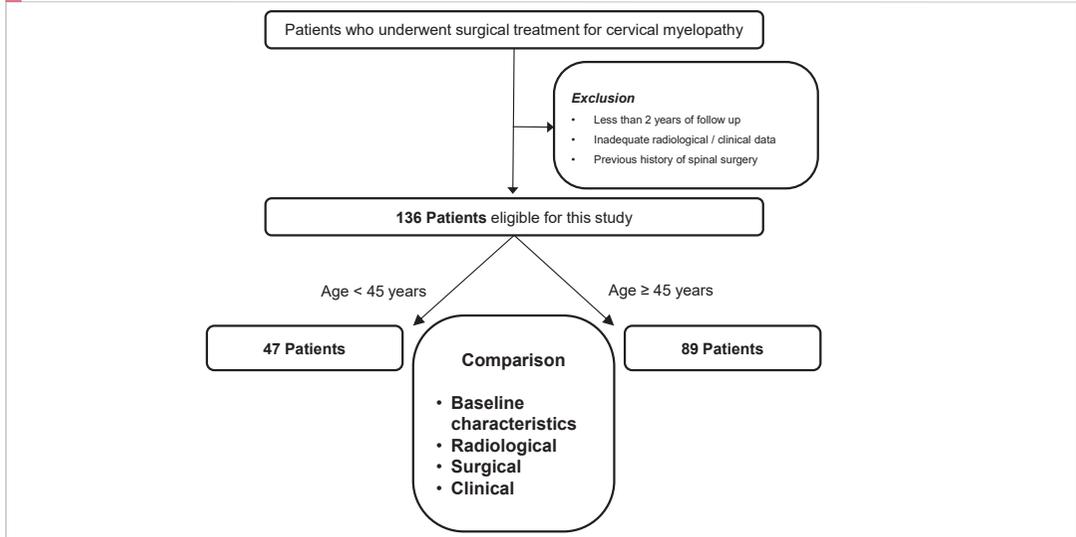
Purpose: To compare the characteristics and clinical outcomes of young aged cervical myelopathy patients with older patients.

Materials and methods: A total of 136 adult patients who underwent surgical treatment for cervical myelopathy with 2 or more years of follow up were included in this study. Patients were grouped according to their age of 45 years. Patient factors, radiological factors, and clinical factors were compared. Patient factors included sex, BMI, smoking, diabetes, number underlying diseases, etiology, chief complaint, symptom duration, and number of positive myelopathy pathologic signs. Radiological factors were presence of ossification of posterior longitudinal ligaments (OPLL) and ossification of yellow ligaments (OYL), cord signal change on MRI, and sagittal alignment parameters including spinopelvic parameters. Clinical factors included type of performed surgical treatment, operated levels, operation time, blood loss, and pre- and postoperative modified Japanese Orthopedic Association (mJOA) scores. Statistical analysis was performed using Independent Samples t-test for continuous variables and chi-square test for categorical variables.

Results: There were 47 patients with < 45 years of age (mean 37.845.3) and 89 patients with U 45 years of age (mean 58.8410.9). Patient factors excluding number of underlying diseases and number of positive pathologic signs were similar between the two groups. Degeneration was the most common etiology in both groups, however, pure OPLL was more common in the young age group. Radiological factors were similar except for T1 slope, C2-7 Cobb's angle, C2-7 range of motion, T1 pelvic angle, and C2-7 sagittal vertical axis, all of which were greater in the older age group. Clinical factors such as pre- and postoperative mJOA score and recovery rate did not demonstrate significant difference. However, operated levels and type of performed surgical treatment were different between the two groups.

Conclusion: Baseline characteristics and surgical outcome were comparable in both age groups. Therefore, similar approach can be taken when treating cervical myelopathy patients regardless of their age.

Methods



Results – Baseline characteristics



	Age < 45	Age ≥ 45	P value
Sex			n/s
Female	16(34.0)	26(34)	
Male	31(66.0)	63(66)	
BMI	25.3	25.0	n/s
Smoking			n/s
No	38(80.9)	72(80.9)	
Yes	9(19.1)	17(19.1)	
Diabetes			0.001
No	46(97.9)	70(78.7)	
Yes	1(2.1)	19(21.3)	
No. of underlying diseases	0.2	1.1	<0.001
Etiology			0.034
Degeneration	27(57.4)	46(51.7)	
OPLL	17(36.2)	22(24.7)	
Mixed	3(6.4)	21(23.6)	
Chief complaint			n/s
Upper motor	16(34.0)	16(18.0)	
Lower motor	4(8.5)	13(14.6)	
Sensory	27(57.4)	60(67.4)	
Sphincter	0(0.0)	0(0.0)	
Symptom duration(months)	22.4	27.6	n/s
No. of positive pathologic signs	3.3	2.7	0.008

Results – Radiological factors



	Age < 45	Age ≥ 45	P value
Presence of OPLL			n/s
No	27(57.4)	46(51.7)	
Yes	20(42.6)	43(48.3)	
Presence of OYL			n/s
No	44(93.6)	78(87.6)	
Yes	3(6.4)	11(12.4)	
Cord signal change on MRI			n/s
No	26(55.3)	47(52.8)	
Yes	21(44.7)	42(47.2)	
C2 slope(°)	13.1	13.7	n/s
T1 slope(°)	17.4	21.7	0.001
C2-7 Cobb's angle			
Neutral(°)	7.6	10.3	0.032
Flexion(°)	-19.2	-13.9	0.008
Extension(°)	23.6	21.6	n/s
C2-7 ROM(°)	42.8	35.2	0.005
C0-2 Cobb's angle(°)	12.0	11.2	n/s
TPA(°)	8.5	10.7	0.031
CTPA(°)	2.0	2.8	0.014
C2-7 SVA(mm)	15.6	20.1	0.017
SVA(mm)	-7.9	12.7	0.001
Thoracic kyphosis(°)	25.0	29.6	0.016
Pelvic Incidence(°)	48.5	50.8	n/s
Lumbar lordosis(°)	45.7	44.6	n/s
Sacral Slope(°)	33.7	35.4	n/s
Pelvic tilt(°)	14.5	15.4	n/s

Results – Surgical factors



	Age <45	Age ≥45	P value
Type of performed surgery			0.003
Anterior fusion	28(59.6)	27(30.3)	
Anterior disc replacement	1(2.1)	0(0)	
Posterior laminoplasty	18(38.3)	52(58.4)	
Posterior fusion	0(0)	7(7.9)	
Combined	0	3(3.4)	
Operated levels	2.2	2.8	0.003
Operation duration(minutes)	198.5	204.1	n/s
Estimated blood loss(cc)	442.6	539.3	n/s

Results – Clinical factors



	Age <45	Age ≥45	P value
Preoperative mJOA score	14.4	14.2	n/s
Postoperative mJOA score	17.2	17.1	n/s
mJOA recovery rate(%)	79.3	79.1	n/s

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Emerging Technologies & Techniques

Transpedicular Intravertebral Augmentation Using Expandable Cage in Kummell Disease: A Novel Anterior Column Support Technical Note**Kwang-Sup Song^{1*}, Jeongik Lee², Dae-Woong Ham¹ and Jeuk Lee¹**¹ Department of Orthopedic Surgery, Chung-Ang University Hospital, College of Medicine, Chung-Ang University, Korea² Department of Orthopedic Surgery, Chung-Ang University Gwangmyeong Hospital, College of Medicine, Chung-Ang University, Korea

Introduction: Most patients with Kummell disease with intractable back pain or neurologic deficits require firm stabilization surgery. However, there are difficulties to support anterior and posterior support simultaneously in most patients with severe osteoporosis and medical comorbidity in the old age population. We aimed to introduce the novel technical note, transpedicular intravertebral cage augmentation (TPICA) using an expandable cage combined with posterior stabilization in a single posterior approach, less invasive anterior and posterior column supports in severe osteoporotic frail patients.

Methods: Four consecutive frail patients underwent the surgical procedures, the average age was 83.7 years old, unable to walk for over 1 month due to intractable back pain, and with severe frailty. All patients underwent TPICA procedures at the index vertebra in a single posterior approach and pedicle screw instrumentation one-level above and below the vertebra, which augmented with cement. The average follow-up period was > 6 months and analyzed the radiologic outcomes, including the restored ratio of anterior vertebral height (RAVH) and local kyphosis angle (LKA), and the patient's demographic characteristics and surgical data, including operation time and external blood loss, were also collected.

Results: All expandable cages were expanded to 4 mm after insertion in the index vertebra. All patients were able to walk independently (n=3) and with a cane (n=1) at postoperative 2 weeks and much improved back pain and ambulatory capacity were sustained at 6 months. The mean operation time was 156 (149-160) min, and the mean external blood loss was 100 (50-150) cc. The postoperative RAVH was 0.64, 1.64 times higher than the preoperative RAVH of 0.39, and LKA was corrected postoperatively from 15.7° to 6.5°. Some losses of corrected angles were observed at 6 months compared to immediate postoperative periods, however, there was no related clinical symptom.

Conclusions: The introduced technique might be a valuable minimal invasive anterior column support technique in patients with severely collapsed Kummel disease, especially, expandable cage in TPICA seems to have the advantages of minimizing the destruction of pedicle structures and effectively recovering the collapsed endplates.

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Emerging Technologies & Techniques

Surgical Complications and Incomplete Canal Widening of the Vertebral Body Sliding Osteotomy to Treat Cervical Myelopathy**Sung Tan Cho¹, Dong-Ho Lee^{2*}, Chang Ju Hwang², Jae Hwan Cho² and Jin Hwan Kim¹**¹ Orthopedic Surgery, Ilsan Paik Hospital, Inje University, Korea² Orthopedic Surgery, Asan Medical Center, University of Ulsan College of Medicine, Korea

Background: Vertebral body sliding osteotomy (VBSO) is a surgical technique that anteriorly translates the vertebral body with compressive lesions and achieves cord decompression through canal widening. However, data on the surgical complications of VBSO is lacking. Furthermore, it has not been known whether VBSO could be a viable alternative in the treatment of cervical myelopathy even when the preoperative canal occupying ratio (COR) is large, which seems to frequently result in incomplete canal widening. This study aims to describe the incidence of VBSO-associated surgical complications and evaluate the incidence and risk factors of incomplete canal widening.

Methods: A total of 109 patients who underwent VBSO to treat cervical myelopathy were retrospectively reviewed. Neck pain visual analog scale, neck disability index, Japanese Orthopedic Association (JOA) scores, and surgical complications were evaluated. For radiological evaluation, C2-7 lordosis, C2-7 sagittal vertical axis, and COR were measured. Patients with a preoperative COR <50% (n = 60) and a COR ≥50% (n = 49) were compared and logistic regression analysis was performed to identify factors associated with incomplete canal widening.

Results: The most frequent complication in the patients was mild dysphagia (7.3%). Dural tears were observed during posterior longitudinal ligament resection (n = 1) and foraminotomy (n = 1). Two patients underwent reoperation due to radiculopathy from adjacent segment disease. Incomplete canal narrowing occurred in 49 patients. According to logistic regression analysis, high preoperative COR was the only factor associated with incomplete canal widening. The amount of canal widening and JOA recovery rate in the COR ≥50% group were significantly higher than in the COR <50% group.

Conclusion: Mild dysphagia was the most common complication following VBSO. Although VBSO aims to decrease the complication rate of corpectomy, it was not free of dural tears. Special care would be required during the posterior longitudinal ligament resection. Incomplete canal widening occurred in 45.0% of patients, and high preoperative COR was the only risk factor for incomplete canal widening. However, high preoperative COR would not be a contraindication for VBSO as favorable clinical outcomes could be presented in the COR ≥50% group.

FP27-3

Emerging Technologies & Techniques

Early-stage Chronic Venous Disorder as a Cause of Leg Pain Overlooked for Lumbar Spinal DiseaseDongHoon Yang*Neurosurgery, Pohang Stroke and Spine Hospital, Korea*

Purpose: Leg pain can be caused by both lumbar spinal disease and chronic venous disorder (CVD) of leg veins, but their clinical differences have not been thoroughly investigated. This study aimed to determine the prevalence of CVD among patients visiting a spine center for leg pain.

Methods: A total of 196 cases underwent ultrasound examination. CVD-diagnosed cases were divided into two groups based on the presence and severity of lumbar spinal disease. The Clinical grades, areas, and types of symptom manifestations were compared, and the differences in symptom improvements with vasoactive medication were assessed.

Results: Varicose and other prominent cutaneous changes were absent in 154 cases. Venous reflux confined only to tributaries and perforators was observed in 70 cases. Moderate and severe lumbar spinal disease was presented in 123 cases. The most common symptom area was calf then the foot in CVD, while calf then thigh in lumbar spinal disease. Tingling-paresthesia was the most common symptom type for both, with pain and cramping similarly common in CVD and pain more common than cramping in lumbar spinal disease. Symptom improvement comparison proved the presence of venous pain in early-stage CVD, which was not influenced by pain and neuropathic medication, pain block, and lumbar surgery.

Conclusion: CVD symptoms have distinguishing features from lumbar spinal disease. Early-stage venous reflux is a symptomatic disease and a possible cause of leg pain and other symptoms. It should be included as a diagnostic option when assessing the lumbar spine for the cause of leg pain.

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Emerging Technologies & Techniques

Diagnosis of Traumatic Thoracolumbar Fracture Using Deep Learning Model with CT

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Background: In patients with severe trauma, CT scans have recently been widely used as the first choice for detecting spinal fractures. Although CT scans have high diagnostic accuracy, they can be time-consuming to interpret, and occasionally, fractures may be missed. Recently, deep learning has been utilized in various medical imaging fields; however, there is very limited research on using it to detect traumatic spinal fractures with CT scans.

Purpose: The aim of this study is to investigate the utility of using a deep learning model for diagnosing traumatic thoracolumbar fractures in CT images.

Methods: The CT images of 327 patients (2536 vertebrae) who visited level one trauma center and had thoracolumbar fractures were enrolled and analyzed retrospectively. The diagnostic results of these images were confirmed by two experienced musculoskeletal radiologists and one experienced spine surgeon with MRI. Fractures were classified and labeled as vertebral body fracture, transverse process fracture, and posterior element fracture and all fracture lines were manually segmented. Deep learning networks were used for diagnosis (272 cases for training and 55 cases for testing). The area under the curve (AUC) was calculated for investigating diagnostic accuracy.

Results: The deep learning model's AUC for spinal fracture was 0.9011. The diagnostic accuracy was highest for transverse process fractures, with AUC values of 0.9801 (left) and 0.9800 (right). Next, the accuracy for posterior element fractures was also high, with AUC values of 0.9267. though the diagnostic accuracy for vertebral body fractures was relatively lower, it still demonstrated high diagnostic accuracy with an AUC of over 0.9. (AUC=0.9065).

Conclusions: In this study, we were able to confirm that the deep learning model demonstrated high accuracy in diagnosing traumatic thoracolumbar fractures. In the current model, the diagnostic accuracy using CT scans was highest for transverse process fractures, followed by posterior element fractures, and then vertebral body fractures. This can potentially aid spine specialists, radiologists, and severe trauma experts. Further validation is needed to determine its effectiveness in actual clinical settings.

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Cervical Degenerative

Cervical Foraminal Stenosis as a Risk Factor for Cervical Kyphosis Following Cervical Laminoplasty

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Background Context: Cervical laminoplasty (CLP) is an effective spinal cord decompression method for patients with cervical myelopathy. However, cervical kyphosis after CLP may cause insufficient decompression of the spinal cord. Thus, prevention of cervical kyphosis after CLP and identification of its risk factors are essential.

Purpose: This study aimed to investigate the relationship between preoperative cervical foraminal stenosis and kyphotic changes after CLP.

Study Design: A retrospective study.

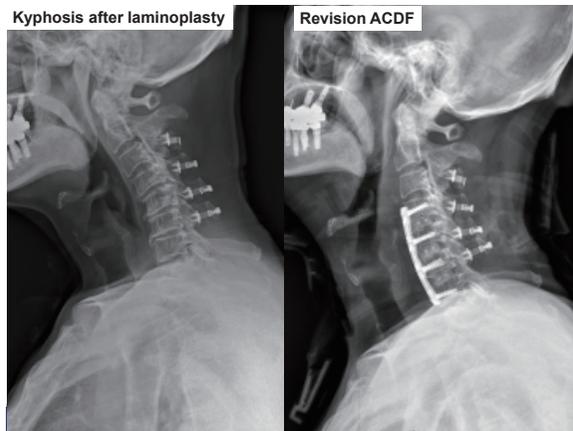
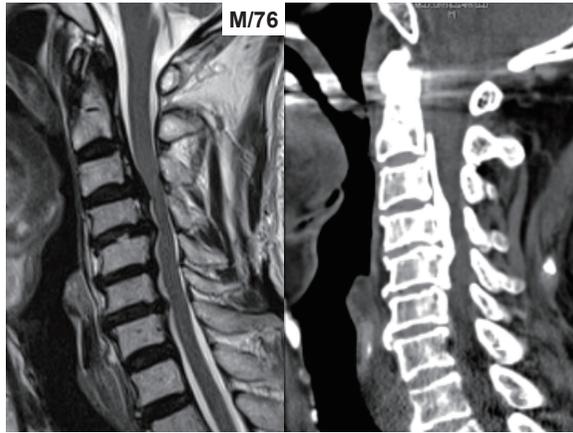
Patient Sample: We reviewed 108 patients who underwent CLP for cervical myelopathy between May 2014 and May 2019 and who were followed up for at least 24 months.

Outcome Measures: For clinical assessments, neck pain, arm pain, neck disability index, Japanese Orthopedic Association scores, EuroQol 5-Dimension, and subjective improvement rate reported by the patients were evaluated. For radiologic parameters, C2-7 Cobb lordotic angle (CLA), C2-7 sagittal vertical axis, T1 slope (TS), TS minus CLA (TS-CLA), and cervical range of motion were assessed preoperatively and postoperatively for 24 months. Cervical foraminal stenosis was evaluated by magnetic resonance imaging and computed tomography.

METHODS: The study population was divided into the kyphosis group (n = 25 patients) and the lordosis group (n = 83 patients) according to the CLA at 24 months postoperatively. Preoperative risk factors related to postoperative kyphosis were analyzed. Statistical analyses were performed using independent two-sample t test, Chi-square test, logistic regression analysis, and linear mixed model.

Results: Preoperative foraminal stenosis, CLA, TS, and TS-CLA were significantly different between the kyphosis and lordosis groups. In multivariate logistic regression analysis, foraminal stenosis (odds ratio [OR], 4.471; p = .0242) significantly increased the risk of kyphosis. The probability of developing kyphosis decreased with an increase in the CLA (OR, 0.840; p = .0001), while the probability of developing kyphosis increased with an increase in the TS-CLA (OR, 1.104; p = .0044).

Conclusions: Preoperative cervical foraminal stenosis is an independent risk factor for cervical kyphosis following CLP. Thus, CLP may not be a suitable surgical option for cervical myelopathy combined with foraminal stenosis.



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Cervical Degenerative

Bladder and Bowel Dysfunction in Patients with Spinal Compressive MyelopathyByung Wan Choi^{1*}, Jea Seok Park¹, Sung soo Kim¹ and Junseung Lee¹¹ Orthopedic surgery, Inje University Haeundae Paik Hospital, Korea

Introduction: Spinal compressive myelopathy is often associated with bladder and bowel disturbance (BBD). However, few studies have investigated the relationship between neurological evaluation and BBD findings. The purpose of this study is to examine the prevalence and characteristics of BBD in spinal compressive myelopathy.

Materials and Methods: We evaluated 483 spinal compressive myelopathy patients. Cervical myelopathy was 383 cases and thoracic myelopathy was 100 cases. Mean age was 60.73 years. Mean duration of symptom was 7.82 months. Clinical characteristics of age, sex, number of involved segments, main symptoms (upper extremity, lower extremity combined), duration of symptoms, and clinical outcomes were evaluated and compared according to BBD group and non-BBD group.

Results: Fifty-six patients presented BBD (11%). Bladder dysfunction was showed in 32 patients; bowel dysfunction was in 5 patients. And 19 patients showed both symptoms. There was no difference of age ($p=0.811$), sex ($p=0.239$), number of involved segment ($p=0.902$) between BBD and non BBD group. Thoracic myelopathy cases showed more BBD (BBD/non BBD=22/78) than cervical cases (34/349) ($p=0.001$). According to main clinical symptoms, lower extremity symptom (20%) and both symptom patients (10%) showed more BBD than upper extremity symptom case (2%) ($p<0.001$).

Conclusions: BBD was more common in thoracic myelopathy and main lower extremity symptom cases. Clinical outcomes were favorable after operative treatment.

Key Words: Cervical myelopathy, Thoracic myelopathy, neurogenic bladder, bowel dysfunction

FP28-3

Cervical Degenerative

Clinical and Radiologic Outcomes of Anterior Sliding Osteotomy and Fusion (ASDF): A Single Center Experience**Donghun Kim¹, Jaetaek Hong^{1*} and Jungwoo Hur¹**¹*Department of neurosurgery, Eunpyeong St. Mary's Hospital, Korea*

Anterior sliding osteotomy and fusion (ASDF), as also known as anterior controllable antedisplacement and fusion (ACAF) or vertebral body sliding osteotomy (VBOSO), is a novel technique to treat cervical myelopathy with ossification of posterior longitudinal ligament (OPLL) presenting K-line negative. It is a fascinating surgical technique in terms of safeness comparable to laminoplasty or anterior cervical discectomy and fusion (ACDF), and preventing kyphosis aggravation and re-growth of ossifying mass after surgery unlike laminoplasty. However, because the surgical outcomes have been analyzed within 4 years in some restricted institutes, clinical data from other diverse institute should be needed to prove practicality of ASDF.

So, we analyzed fifteen ASDF cases underwent between December, 2019 and June, 2022 in our institute. Clinical outcomes between pre-operative and post-operative periods are compared using visual analogue scale (VAS), neck disability index (NDI), and Japanese Orthopaedic Association (JOA) scores. Radiologic results include C0-C2 angle, C2-7 angle, C2-C7 SVA, T1 slope, segmental lordosis, K-line conversion from negative to positive, the most narrow canal diameter, and distance from the most severe stenotic lesion to modified K-line after the surgery. And we also investigated postoperative complications.

The result shows increased T1 slope (23.81 \pm 10.54 $^{\circ}$ vs 27.68 \pm 10.90 $^{\circ}$, $p=0.004$), diameter of the most narrow canal (5.19 \pm 0.69 mm vs 8.69 \pm 1.51 mm, $p=0.000$), and distance from the most severe stenotic lesion to modified K-line (1.45 \pm 2.89 mm vs 6.75 \pm 2.08 mm, $p=0.000$). Rate of K-line conversion from negative to positive is 100 %, and fusion rates after 3months, 6months, and 1 year from the day of surgery are 14.38 %, 85.71 %, 100 %, respectively. And VAS (2.92 \pm 2.25 vs 0.85 \pm 0.80, $p=0.005$), NDI (18.35 \pm 13.00 vs 5.91 \pm 5.66, $p=0.008$) and JOA (12.50 \pm 1.95 vs 15.29 \pm 1.20, $p=0.000$) scores are improved postoperatively. There are complication cases such as 2 cases of graft migration and subsidence, 1 case of reoperation and C5 palsy. However, no dural tear cases have been shown.

We concluded that ASDF is a relatively safe and effective surgical technique because conversion of K-line and canal decompression were achieved successfully without dural tear and other severe complications. And our data showed that posterior augmentation could be necessary for some cases with long level ASDF (> 3 levels) because the fusion rate at 3 months was much lower than generally reported fusion rates of ACDF.

FP28-4

Cervical Degenerative

Restoration of Range of Motion Following Cervical Arthroplasty for Treatment of Severe Cervical Disc Degenerative Diseases: A 1-year Follow-up StudyYi-Syue Tsou*Neurosurgery, Taipei Medical University Hospital, Taiwan*

Background: Clinical outcomes and radiologic results after cervical arthroplasty for degenerative cervical disc disease have been reported in many studies. However, there are no studies about cervical arthroplasty for severe degenerative cervical disc disease have been conducted.

Materials and Methods: Forty patients who underwent cervical arthroplasty (ProDisc-C®) between January 2017 and December 2019. All patient included having single-level treated from C3 to C7 and all of the treated disc are severe degenerated. Range of motion (ROM) and clinical outcomes with Neck Disability Index (NDI) and Visual analogue scale (VAS) for neck and arm were assessed before and after surgery.

Results: Cervical dynamic ROM was increased 3 months after cervical arthroplasty and the increment maintain for at least one year. The increased ROM after cervical arthroplasty mainly come from extension component but not from flexion component. One case of device subsidence but no extrusion was recorded. VAS for neck and arm decreased after surgery from 7.4 and 6.6 to 1.4 and 1.2. The mean NDI scores decreased after surgery from 27.6 to 14.6. The NDI scores, VAS for neck and arm all significantly improved postoperatively.

Conclusion: Cervical arthroplasty is an effective surgical treatment not only to improve clinical outcomes but also to restore ROM in severe cervical disc degeneration patient. The post-operative extension ROM is responsible for the increment of post-operative ROM.

Number	40
Age	58.3±12.6
Gender (female-to-male)	27:13
Level	
C3/4	4
C4/5	6
C5/6	25
C6/7	5

Table 1. Patient Characteristics

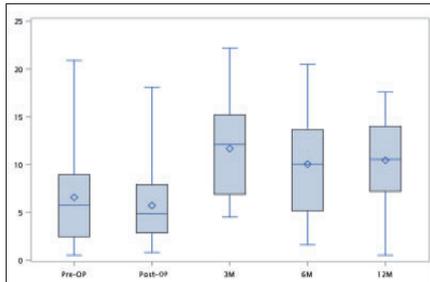


Fig. 1 ROM change of treated segment. The ROM of treated segment was not change immediately after surgery but increase significantly thereafter comparing with preoperative ROM

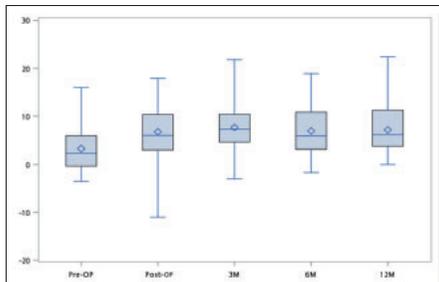


Fig. 2 Extension ROM change of treated segment. The increment of extension ROM begin immediately after operation and maintain for at least one year.

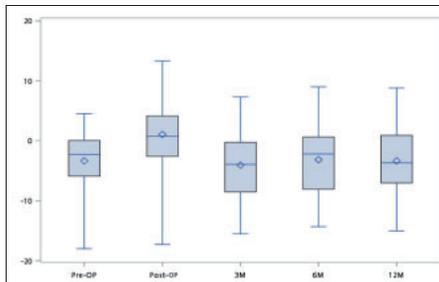


Fig. 3 Flexion ROM change of treated segment. The flexion ROM of the treated segment was reduced immediately postoperatively but restore to preoperative flexion ROM thereafter

	VAS (neck)	VAS (arm)	NDI
Preoperative	7.4	6.6	27.6
Postoperative	1.4	1.2	14.6
p value	<0.001.	<0.001.	<0.001.

Table 2. Clinical Outcome Assessment Using the Neck Disability Index (NDI) and the Visual Analog Scale (VAS) for Neck and Arm Pain

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Advantages of L5 Lamina Hook in Surgical Correction for Adult Spinal Deformity and Its IndicationsYong-Chan Kim^{1*}, Sung-Min Kim¹, Kee-Yong Ha¹, Billy Francis Hung¹ and JunBum Park¹¹ Orthopaedic Surgery, Kyung Hee University Hospital at Gangdong, Kyung Hee University, Seoul, Korea

Background: Although numerous studies report the outcomes of long segmental instrument and fusion, the decision of whether to stop at L5 or the sacrum remains controversial. There is no report on the effect of L5 lamina hook on radiologic sagittal parameters and on the time-dependent fate of the L5-S1 segment following thoracolumbar fusion to L5 in adult spinal deformity patients.

Purpose: We aimed to determine the advantages and indications of L5 lamina hook using on long segmental instrumentation and fusion for surgical correction against adult spinal deformity (ASD) patients.

Materials and Methods: 56 ASD patients who underwent long segmental instrument and fusion from the thoracic spine to L5 at a single institution were retrospectively analyzed according to radiographic spinopelvic sagittal parameters and L5-S1 disc degeneration using radiographic classification system modified from that described by Weiner et al. 32 patients (group I) used L5 lamina hook for surgery and 24 patients (group II) didn't. The receiver operating characteristic (ROC) curves were plotted to evaluate the cut-off value of C7 sagittal vertical axis (C7SVA) and pelvic incidence - lumbar lordosis mismatch (PI-LL). Additional statistical analysis was performed only in group I to verify the indications for use of L5 lamina hook.

Results: The preoperative C7SVA (174.6mm vs 52.9mm, P= 0.011), lumbar lordosis (LL; -11.6° vs -22.8°, P= 0.029) and pelvic incidence - lumbar lordosis mismatch (PI-LL; 44.4° vs 29.1°, P= 0.041) of group I was significantly greater than group II. The group I showed significantly higher changes in C7SVA (136.21mm vs 29.31mm, P= 0.018), LL (40.5° vs 25.4°, P= 0.031), and PI-LL (40.5° vs 24.8°, P< 0.034) compared to the group II at immediate postoperative. By latest follow-up, subsequent advanced L5-S1 disc degeneration developed in 7 of 32 patients (21.9 %) in group I and 18 of 24 patients (75 %) in group II. The cut-off value was 15.8cm (95% CI, P=0.001) and 40.8° (95% CI, P=0.012) in C7SVA and PI-LL respectively. The patients with exacerbated L5-S1 degeneration in group I showed significantly higher body mass index (BMI), preoperative C7SVA, and preoperative PI-LL than others.

Conclusions: L5 lamina hook may provide the greater correction in C7SVA and lumbar lordosis and reduce L5-S1 degeneration. We suggest the following indications for use of L5 lamina hook; low BMI, healthy L5-S1 disc, PI-LL mismatch of less than 40.8°, and C7SVA of less than 15.8cm.

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Emerging Technologies & Techniques

Advantage of Single-position Oblique Lumbar Interbody Fusion with Percutaneous Pedicle Screw Instrumentation**Min-Gu Jang², Eugene Jae Jin Park^{3*} and Sang Bum Kim¹**¹ orthopedics, Sejong Cheung Nam University hospital, Korea² orthopedics, Konyang university hospital, Korea³ orthopedics, Kyungpook university hospital, Korea

Purpose: To evaluate the technical feasibility and advantage of single-position oblique lumbar interbody fusion (OLIF) and the subsequent clinical and radiologic outcomes

Materials and methods: Among the 93 patients that underwent OLIF from January 2017 to January 2019, those that with single-level pathology and followed up for at least a year were enrolled. Deformity, stenosis due to trauma, and patients that underwent additional direct posterior decompression were excluded. Patients were divided into those that underwent the whole surgical procedure on lateral position (Group A) and those that underwent cage insertion on lateral position and subsequent percutaneous pedicle screw fixation after changing the patient to prone position (Group B). Demographics, operative and anesthesia time, clinical outcome, and postoperative complication were compared between the two groups.

Results: Total of 93 patients were enrolled in this study, 36 patients in Group A and 57 patients in Group B. The mean age, and sex ratio, did not differ between the two groups ($p>0.05$). However, the index levels were more in Group A, which showed a significant difference between two groups ($p=0.012$). The preoperative diagnosis included degenerative and isthmic spondylolisthesis, and foraminal stenosis. The mean operative and anesthesia time were 291.1 and 402.6 minutes in Group A, and 232.9 and 297.5 minutes in Group B, respectively. Clinical outcome of VAS back and leg did not show significant difference between the two groups. No complication including pedicle screw malposition occurred in both groups.

Conclusion: Single-position OLIF on lateral position is a feasible procedure that can decrease anesthesia time without complication compared to the conventional position changing method.

Keywords: oblique lumbar interbody fusion, pedicle screw, operative time, anesthesia, postoperative complication

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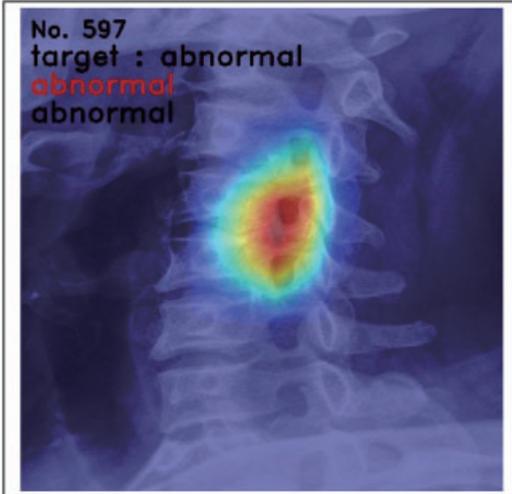
Detection of Cervical Foraminal Stenosis from Oblique Radiograph Using Convolutional Neural Network Algorithm**Sehan Park¹, Ji hie Kim¹ and Jae Jun Yang^{2*}**¹ Department of Orthopedic Surgery, Asan Medical Center, University of Ulsan College of Medicine, Korea² Department of Orthopedic Surgery, Dongguk University Ilsan Hospital, Korea

Backgrounds: Magnetic resonance imaging (MRI) is expensive and inaccessible, although it remains the gold standard for diagnosing cervical neural foraminal stenosis. Cervical oblique radiography is a readily accessible imaging modality that focuses on the cervical neural foramen; however, its diagnostic accuracy for foraminal stenosis is low. Convolutional neural network (CNN) is a specialized deep learning model for image processing. This study was conducted to develop a CNN algorithm that can diagnose cervical foraminal stenosis using oblique radiographs and evaluate its accuracy.

Methods: A total of 997 patients who underwent cervical MRI and cervical oblique radiographs within a 3-month interval were included. Oblique radiographs were labeled as “foraminal stenosis” or “no foraminal stenosis” according to whether foraminal stenosis was present in the C2-T1 levels based on MRI evaluation as ground truth. The CNN model involves data augmentation, image preprocessing, and transfer learning using DenseNet 161. Visualization of the location of the CNN model was performed using gradient-weight class activation mapping (Grad-CAM).

Results: The area under the curve (AUC) of the receiver operating characteristic curve based on DenseNet161 was 0.889 (95% confidence interval, 0.851–0.927). The F1 score, accuracy, precision, and recall were 88.5%, 84.6%, 88.1%, and 88.5%, respectively. The accuracy of the proposed CNN model was significantly higher than that of two orthopedic surgeons (64.0%, $p < 0.001$; 58.0%, $p < 0.001$). Grad-CAM analysis demonstrated that the CNN model most frequently focused on the foramen location for the determination of foraminal stenosis, although disc space was also frequently taken into consideration.

Conclusions: A CNN algorithm that can detect neural foraminal stenosis in cervical oblique radiographs was developed. The AUC, F1 score, and accuracy were 0.889, 88.5%, and 84.6%, respectively. With the current CNN model, cervical oblique radiography could be a more effective screening tool for neural foraminal stenosis.



Ground truth of foraminal stenosis determined by MRI

C3-4	C4-5	C5-6	C6-7	C7-T1
0	1	0	0	0



Ground truth of foraminal stenosis determined by MRI

C3-4	C4-5	C5-6	C6-7	C7-T1
1	0	1	1	0

FP29-4

Emerging Technologies & Techniques

Three-dimensional Quiz-game-based Education for Spine Surgical Workforces

Seon-Jin Yoon¹, Chang Kyu Lee¹, Dong Ah Shin¹, Seong Yi¹, Yoon Ha¹, Sung Uk Kuh¹ and Keung Nyun Kim¹

¹ Neurosurgery, Severance Hospital, Korea

Background: We need to experience the surgical procedures in the operation room to gain dexterity, because the explanation on the textbook does not directly translate to the real setting of a surgical operation. Three-dimensional game system can fill the gap between the surgical manual and the real operation experience by near-zero marginal cost. Here, we introduce an updated version of the training system.

Methods: We used quiz-game creating tools to mimic a spine operation for the enhanced training of an operator (Blender, Unity). We included scoring and polling features in the game to enable comparison among the users through an online server-based backend.

Results: Unlike the Cadaver-based training, students can access the quiz-game-based training system at near-zero marginal cost at any time. Students can compare the score they receive during the training with other students. Students can see the responses of other students in the summary display after they answer the three-dimensional quiz-game.

Conclusions: Surgical game has pros and cons, and it has potential to educate surgical workforces with near-zero marginal cost.

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SYMPOSIUM 11

Osteobiologics for Spine Fusion

SY11-1**Osteobiologics for Spine Fusion****Nanotechnology in Spine Surgery****Muhammad Tariq Sohail***Doctors Hosp. & Medical Ctr., Pakistan*

Nanotechnology, a cutting-edge field of science and engineering, has revolutionized various industries, including medicine and surgery. In the realm of spine surgery, nanotechnology has emerged as a promising avenue for addressing the challenges associated with traditional treatment methods. This abstract explores the advancements and future perspectives of nanotechnology in spine surgery, focusing on its applications in improving surface engineering, enhancing therapeutic strategies, and promoting tissue regeneration.

Conclusion: Nanotechnology holds immense potential in revolutionizing spine surgery by improving diagnostics, enhancing therapeutic strategies, and promoting tissue regeneration. As research continues to progress, nanotechnology is poised to transform the landscape of spine surgery, offering new possibilities for more effective and patient-tailored treatments in the near future.

SY11-2

Osteobiologics for Spine Fusion

Cell Survival in the Nucleus Pulposus and Affecting Factors: Does Physical Loading Plays Key-Role?

Jun-Seok Lee

The Catholic University of Korea College of Medicine, Korea

SY11-3

Osteobiologics for Spine Fusion

An Overview on the Selection of Osteobiologics**Dae-Chul Cho***Kyungpook National University School of Medicine, Korea*

For successful outcomes after spine fusion surgery, especially in the old patients with osteoporosis, solid bone fusion is very essential.

Osteobiologics are engineered materials that enhance bone healing (fusion), and have been increasingly used in spine fusion surgery. Traditionally autologous iliac crest bone grafts have been used in spine field, but donor site morbidity from graft harvesting has led surgeons to seek alternative materials. Allograft bone, biomaterial scaffolds, growth factors, and stem cells have been explored as bone graft substitutes and supplement.

Here characteristics of each osteobiologics are summarized, for the adequate selection of each materials to achieve good surgical results of spine fusion surgery.

SY11-4

Osteobiologics for Spine Fusion

Basic Research for Intervertebral Disc Diseases; Basics and Clinical Application

Joo Han Kim

Korea University College of Medicine, Korea

Intervertebral disc (IVD) degeneration is the main source of intractable lower back pain, and symptomatic IVD degeneration could be due to different degeneration mechanisms. In here, we describe the molecular basis of symptomatic IVD degenerative disc diseases (DDD), emphasizing the role of degeneration, inflammation, angiogenesis, and extracellular matrix (ECM) regulation during this process. In symptomatic DDD, pro-inflammatory mediators modulate catabolic reactions, resulting in changes in ECM homeostasis and, finally, neural/vascular ingrowth-related chronic intractable discogenic pain. In ECM homeostasis, anabolic protein-regulating genes show reduced expression and changes in ECM production, while matrix metalloproteinase gene expression increases and results in aggressive ECM degradation. The resultant loss of normal IVD viscoelasticity and a concomitant change in ECM composition are key mechanisms in DDDs. During inflammation, a macrophage-related cascade is represented by the secretion of high levels of pro-inflammatory cytokines, which induce inflammation. Aberrant angiogenesis is considered a key initiative pathologic step in symptomatic DDD. In reflection of angiogenesis, vascular endothelial growth factor expression is regulated by hypoxia-inducible factor-1 in the hypoxic conditions of IVDs. Furthermore, IVD cells undergoing degeneration potentially enhance neovascularization by secreting large amounts of angiogenic cytokines, which penetrate the IVD from the outer annulus fibrosus, extending deep into the outer part of the nucleus pulposus. Based on current knowledge, a multi-disciplinary approach is needed in all aspects of spinal research, starting from basic research to clinical applications, as this will provide information regarding treatments for DDDs and discogenic pain.

SY11-5**Osteobiologics for Spine Fusion****Bench to Bed: Osteobiologics****Sung Bae Park***Seoul National University College of Medicine, Korea*

Osteobiologics, a rapidly advancing field dedicated to the development and application of biological agents for bone regeneration, has witnessed remarkable progress in recent years. This abstract provides an overview of the translation of osteobiologics from bench to bedside, highlighting key developments, challenges, and future prospects. Osteobiologics encompass a wide range of therapeutic modalities, including growth factors, stem cells, bone graft substitutes, and gene therapy, all aimed at enhancing bone healing and regeneration. Preclinical studies have consistently demonstrated the efficacy of these interventions in promoting bone formation and tissue repair, laying a solid foundation for clinical translation. However, the clinical implementation of osteobiologics is not without challenges. Standardization of production processes, optimization of delivery methods, and compliance with regulatory requirements are significant hurdles that need to be overcome. The production of high-quality and consistent biological agents necessitates stringent manufacturing protocols and quality control measures. Moreover, determining the ideal delivery system and route of administration to achieve optimal therapeutic outcomes remains a subject of ongoing research. Despite these challenges, osteobiologics have shown promising results in various clinical applications, including spinal fusion, fracture repair, and the treatment of bone defects. Clinical trials have demonstrated improved patient outcomes, accelerated healing, and reduced morbidity compared to conventional treatment approaches. The ability to harness the regenerative potential of osteobiologics holds immense promise in revolutionizing bone regeneration strategies and addressing the unmet clinical needs of patients with challenging bone conditions. Looking ahead, ongoing research efforts are focused on further enhancing the safety, efficacy, and cost-effectiveness of osteobiologic therapies. Integration of advanced biomaterials, tissue engineering approaches, and personalized medicine is anticipated to shape the future of osteobiologics. Tailoring treatment strategies to individual patient characteristics, optimizing dosing regimens, and implementing novel delivery systems are key areas of exploration. Additionally, addressing long-term safety concerns, understanding the optimal timing and duration of therapy, and expanding the scope of clinical applications are critical avenues for future investigation.

The translation of osteobiologics from bench to bedside represents a promising frontier in bone regeneration. Collaborative efforts between researchers, clinicians, and regulatory authorities are paramount to expedite the clinical translation of osteobiologics, ensuring their safe and effective utilization in real-world patient care. Through continuous innovation and interdisciplinary collaborations, osteobiologics have the potential to transform bone healing and regeneration, ultimately improving the quality of life for individuals with bone-related conditions.

AUGUST 19 (Sat)

SYMPOSIUM 12

Evolution and Development of Interbody Fusion

SY12-1

Evolution and Development of Interbody Fusion

The Intervertebral Disc - Understanding His Physiology and Challenges in Regeneration or Reconstruction**Christian Mazel***University Paris XIII - Sorbonne-Paris Nord, France*

The first part of this presentation describes the modalities of operation of the intervertebral disc and focus on its viscoelastic and osmolar characterization.

The understanding of the building blocks of this composite structure is mandatory. The intercellular matrix and the cells specific to the anulus and nucleus pulposus are described.

It is essential to understand the role of proteoglycans in the hydration and conservation of this disc shape and function, especially for the nucleus pulposus. It is this element that is responsible for the disc mechanical characteristics.

The disc being the only structure not directly vascularized by the body. The survival of disc cells is directly dependent on a diffusion mechanism of metabolites and catabolites through the osteochondral endplate. Any modification of it will impact cells survival and thus disc physiology.

It is based on the understanding of these physiological elements that it is possible to consider and develop solutions for reconstruction or disc regeneration.

We will study the different options currently available, mechanical option as well as biomedical engineering option.

Challenges and limitations of each technique are described to better understand why no real effective and reliable solution have not been proposed up to now.

Unfortunately, these solutions have not yet proven their usefulness or even effectiveness.

Gene therapy and Micro RNA will perhaps be the future options and solutions.

SY12-2**Evolution and Development of Interbody Fusion****History and Development of Spinal Fusion Techniques****Sung Bum Kim***Kyung Hee University School of Medicine, Korea*

Spinal fusion is a surgical procedure in which two or more vertebrae are fused together to form a single, solid bone. This procedure is used to treat a variety of conditions that cause instability, deformity, or pain in the spine, such as scoliosis, spinal stenosis, and herniated discs. The history and development of spinal fusion techniques can be traced back to ancient times, but significant advances have been made in recent decades that have greatly improved the safety and effectiveness of the procedure.

The earliest known reference to spinal fusion comes from ancient Egypt, where a papyrus dating back to 1550 BCE describes a procedure for treating a spinal injury. The procedure involved packing the wound with linen and applying a splint to immobilize the spine. Similar techniques were used by the Greeks and Romans, who also developed spinal braces and traction devices to treat spinal injuries and deformities.

In the early 20th century, spinal fusion techniques began to evolve rapidly as surgeons developed new methods for stabilizing the spine. In 1911, Albee introduced the use of bone grafts to promote fusion between vertebrae. In the 1930s, Harrington developed the first spinal instrumentation system, which used a rod and hook system to correct scoliosis. In the 1950s and 1960s, the use of pedicle screws and plates became more widespread, allowing for more precise and stable fixation of the spine.

In the 1980s and 1990s, advances in imaging technology and surgical techniques led to further improvements in spinal fusion. The development of the anterior lumbar interbody fusion (ALIF) technique allowed for fusion to be performed through a small incision in the abdomen, reducing the risk of complications and speeding up recovery time. In the 2000s, the use of minimally invasive techniques for spinal fusion became more common, further reducing the risk of complications and improving patient outcomes.

Today, spinal fusion is a widely used and effective treatment for a variety of spinal conditions. While the procedure can still carry risks, advances in surgical techniques and instrumentation have greatly improved its safety and effectiveness. Ongoing research and innovation in the field of spinal surgery are likely to lead to further improvements in the years to come.

SY12-3**Evolution and Development of Interbody Fusion****Spondylolisthesis Interbody Fusion****Shah Alam***Bangladesh Spine and Orthopedic Hospital, Bangladesh*

Spondylolisthesis is a condition where one vertebra slips forward over the vertebra below causing instability and potential compression of spinal nerves. Interbody fusion is a surgical procedure used to treat various spine conditions, including spondylolisthesis. Decompression without fusion was the surgical option choice in spondylolisthesis in early time. Instrumented fusion leads to an 82% fusion rate compared 45% in the non instrumented group. Interbody fusion aims to stabilize the affected segment of the spine and alleviate symptoms caused by the slippage.

During the procedure, the surgeon typically accesses the spine through an incision in the back or abdomen, depending on the approach used. There are several interbody fusion techniques, but the most common ones for treating spondylolisthesis are:

1. Anterior Lumbar Interbody Fusion (ALIF): In this approach, the surgeon accesses the spine from the front (anterior) through the abdominal area. The affected disc is removed, and a bone graft or interbody cage is inserted into the disc space. Over time, the bone graft or cage promotes fusion between the adjacent vertebrae, stabilizing the spine.
2. Posterior Lumbar Interbody Fusion (PLIF): In this approach, the surgeon accesses the spine from the back (posterior) and removes the damaged disc between the affected vertebrae. A bone graft or interbody cage is then placed into the disc space to facilitate fusion.
3. Transforaminal Lumbar Interbody Fusion (TLIF): This approach is similar to PLIF but involves accessing the spine from one side, usually the patient's back. The surgeon removes the disc material and places the bone graft or cage into the intervertebral space.
4. Lateral Lumbar Interbody Fusion (LLIF): In this technique, the surgeon accesses the spine from the patient's side. The disc is removed, and a bone graft or cage is inserted into the disc space, allowing for fusion.

The bone graft used in these procedures may be taken from the patient's own body (autograft) or obtained from a donor (allograft). Additionally, in some cases, the surgeon may use bone graft substitutes or other biologic materials to enhance fusion.

Interbody fusion is often combined with additional spinal instrumentation, such as pedicle screws and rods, to provide additional stability during the fusion process.

Recovery from interbody fusion surgery can take several weeks to months, depending on the individual and the extent of the procedure. Physical therapy and rehabilitation are typically part of the recovery process to help patients regain strength and function.

A prospective study was designed over 817 patients with lumbar spondylolisthesis with severe neurological symptoms. Study time was January 2003-July 2023 in NITOR, DMCH & BSOH, Dhaka. Patients were selected for surgery depending on clinically important & significant pain or neurological symptoms & no sufficient clinical improvement despite conservative care at least for 3 months. Our choice of surgery was PLIF & TLIF.

Evaluation was done comparing their pre & post-operative states including clinical evaluation, X-ray showing gradual fusion, CT scan & MRI. 817 patients (Female- 506 & male-311) with average age of 42 years (09-76 yrs) were studied. Follow up time was 2 months to 2 yrs.

Excellent outcome was seen in 72.4% of cases, good in 14.3%, fair in 28 & poor result in 4.1% cases. The Oswestry Disability Index Scores averages 11.1% (Range 0-62).

Though surgical procedures cannot confirm lifelong recovery of the patients with symptoms, but does ensure a better & comfortable lifestyle with potential improvement of leg symptoms in case of spondylolisthesis. In spite successful fusion is achieved, better outcome will be ensured if any kind of activity that may overload the back is avoided.

SY12-4

Evolution and Development of Interbody Fusion

Current and Future of 3D Printing Cage for Better Interbody Fusion**Jeong-Yoon Park***Yonsei University College of Medicine, Korea*

3D-printed titanium cages have been recently developed for lumbar interbody fusion surgery. Introduced initially as bespoke devices tailored to individual anatomy, they have since evolved into mass-produced cage. The use of these cages capitalizes on the high biocompatibility of titanium and porous structure. The advantages these provide include elevated fusion rates and superior clinical outcomes, significantly outperforming their PEEK cage.

In my recent comparative study involving 40 patients who underwent MIS-TLIF surgery with 3D-printed titanium cages and 43 patients with PEEK cages, there were no notable differences in demographics or clinical outcomes. At 1-year of follow-up, 3D-printed titanium fusion grades were grade I: 77.5%, grade II: 17.5%, and grade III: 5%. The PEEK fusion grades were grade I: 51.2%, grade II: 41.9%, and grade III: 7.0%. For overall fusion rate (grade I + II), there was no difference between the 2 cages (95.0% vs. 93.0%, $p = 0.705$), but grade I was reported at a higher incidence in 3D-printed titanium than PEEK (77.5% vs. 51.2%, $p = 0.013$). There were no significant differences in the overall fusion rate for MIS-TLIF surgery between 3D-printed titanium and PEEK, but the fusion grade was better in 3D-printed titanium than in PEEK.

While these results originate from a relatively short-term study, they indicate a promising future for interbody fusion surgeries utilizing 3D-printed titanium cages. Advancements in 3D printing and imaging technology will likely lead to further improvements in cage design, delivering better compatibility with bone and enhanced surgical outcomes. Potential future enhancements could include the integration of bioresorbable materials instead of titanium, which over time dissolve and are replaced by the patient's bone, thus improving fusion. Incorporating biological fusion material (growth factors et al.) may stimulate bone growth and accelerate fusion, further boosting surgical success rates. It is, however, crucial to validate the long-term safety and efficacy of these cages through comprehensive clinical trials and research. The potential for these cages in revolutionizing spinal surgery and improving patient outcomes is immense.

SY12-5

Evolution and Development of Interbody Fusion

Clinical Application of Expandable Cages in Lumbar Interbody Fusion**Charles L. Branch***Wake Forest University School of Medicine, USA*

The intent of expandable interbody fusion devices is to achieve and maintain sagittal and coronal segmental correction and fusion through anterior, lateral and posterior portals. These devices are the culmination of interbody fusion development from static biconvex or cylindrical devices to static lordotic cages, to the more advanced multidirectional expandable devices. While the lateral approach has gained favor and utility with these devices, the static lordotic device through the anterior approach has been favored at the lumbosacral level to achieve desired segmental lordosis. In part, this has evolved from the fact that static or expandable posterior devices could only achieve 12 to 18o of lordosis. Novel posterior device technology provides lordotic expansion of 22o or greater with delivery through an MIS portal.

We present clinical cases ranging from degenerative disc collapse to Grade 1 and 2 spondylolisthesis at the lumbosacral level treated with a novel expandable interbody fusion device from the posterior MIS or mini open approach. Desired segmental and global lumbar lordosis is achieved and maintained at 18-24 months.

Conclusion – Expandable interbody fusion devices may be safely and effectively employed through the posterior approach for lumbosacral degenerative pathology with correction and fixation through a single incision using both open and MIS approaches.

ISASS AP

2023

2023 Annual Meeting of the International
Society for the Advancement of Spine Surgery
Asia-Pacific Section

| August 16(Wed) - 19(Sat), 2023 | Conrad Seoul Hotel, Seoul, Korea

AUGUST 19 (Sat)

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FP30-1

Lumbar Degenerative

Risk Factors for Adjacent Segment Disease Following L5-Floating Minimally Invasive Oblique Lumbar Interbody Fusion**Dong-Ho Kang¹, Sam Yeol Chang^{1*}, Bong-Soon Chang¹ and Hyoungmin Kim¹**¹ Department of Orthopedic Surgery, Seoul National University College of Medicine and Seoul National University Hospital, Korea

Background: Adjacent segment disease is a common long-term complication after lumbar spinal fusion. Only a few studies have explored the risk factors for adjacent segment disease (ASD) after L5-floating minimally invasive OLIF. This study aimed to identify the potential risk factors associated with radiologic adjacent segment disease (RASD) following L5-floating minimally invasive oblique lumbar interbody fusion (MIS-OLIF).

Materials and methods: A retrospective study of patients who underwent L5-floating MIS-OLIF was conducted. Two groups of patients, those with RASD and those without, were analyzed based on the upper adjacent level and L5-S1 level, and propensity-score matching conducted. Several clinical and radiologic parameters were evaluated, and Cox proportional hazard regression analyses and Kaplan-Meier method were introduced to identify risk factors for RASD.

Results: 108 patients finally included. 41 (38.0%) and 47 (43.5%) developed RASD at the upper adjacent level and L5-S1 level, respectively. In cox regression analysis, osteopenia or osteoporosis (HR [95% CI]: 2.906 [1.111-7.604], p=0.030) and grade 3 facet arthropathy (HR=3.925, [1.246-12.362], p=0.019) were found to be significant predictors for RASD at the upper adjacent level. Similarly, at the L5-S1 level, disc degeneration of Pfirrmann grade IV or V (HR [95% CI]: 2.639 [1.161-6.000], p=0.021), and grade 3 facet arthropathy (HR=8.078, [2.329-28.023], p=0.001) significantly associated with RASD. The survival analysis also showed a significantly lower survival rate in patients with these risk factors.

Conclusion: The study identified osteopenia or osteoporosis, and grade 3 facet arthropathy at the upper adjacent level, along with disc degeneration of Pfirrmann grade IV or V, and grade 3 facet arthropathy at the L5-S1 level as significant predictors for RASD following L5-floating MIS-OLIF. These findings facilitate the prediction of RASD risk, supporting the establishment of comprehensive preoperative assessments and strategic surgical planning, thereby potentially enhancing postoperative outcomes.

FP30-2

Lumbar Degenerative

**Postoperative MRI Analysis of more than 400 Cases of OLIF:
Hidden, But Not to be Overlooked Potential Complications****Suhun Lee¹, Dongwuk Son^{1*}, Junseok Lee¹ and Geunsung Song¹**¹Neurosurgery, Pusan National University Yangsan Hospital, Korea

Background: OLIF has the advantages of minimal invasiveness and indirect decompression, and its proportion in spine surgery increasing recently. It is also in the spotlight as a minimally invasive deformity correction methods. However, OLIF is a new surgical method, and there are still insufficient reports on complications. Especially, complications related to contralateral root injury have recently raised concerns. There may be potential complications that we overlook or unknown. This potential risk is most likely to occur in multi-segmental surgery. We intend to identify potential complications associated with OLIF through postoperative MRI analysis.

Methods: Postoperative MRI (postMR) was routinely performed 1 week after surgery. We measured the position of the cage according to each level through insertion angle and depth. In addition, this location and contra-lateral root injury were analyzed. In addition, the occurrence of approach site and contra-lateral site hematoma was measured. The incidence of specific complications after OLIF surgery, such as residual disc rupture or massive synovial cyst formation, was evaluated.

Results: The 401 patients and 650 level meet the inclusion criteria. OLIF cage was inserted more obliquely at the lower level (L2/3: 4.7144.82°, 3/4: 5.6044.42°, 4/5: 9.8446.29°, 5/1: 18.544.91°). Cage depth was relatively constant (L2/3: 7.0842.68mm, 3/4: 7.3042.52mm, 4/5: 6.8142.67mm, 5/1: 6.5642.99 mm). When the cage depth was less than 5 mm, we categorized it as 'deep cage group', and it occurred in 20.3%, 15.7%, 25.8%, 46.2% of L2/3, 3/4, and 4/5, respectively. In the deep cage group, symptomatic contralateral root damage occurred only at L4/5. Also, in the non-deep cage group, remnant disc rupture occurred in L4/5 5/1 in a central or foraminal type. Approach site hematomas were identified in 65.2%. Among them, significant hematomas larger than 10 cc occurred in 4.9%. Contralateral psoas hematoma occurred in 19.0% and no related symptoms were observed. Massive synovial cyst formation occurred in 4 cases, and foot drop was induced in 1 case. A characteristic of patients with massive synovial cyst formation is that all patients have spondylolisthesis with facet joint subluxation.

Conclusion: The most common postMR finding in the OLIF was an approach site hematoma, but it was a subclinical finding. The contra-lateral psoas hematoma also occurred frequently, but was not related to symptoms. Symptomatic complications such as contralateral root damage and massive synovial cyst formation require additional risk factor analysis.

FP30-3

Lumbar Degenerative

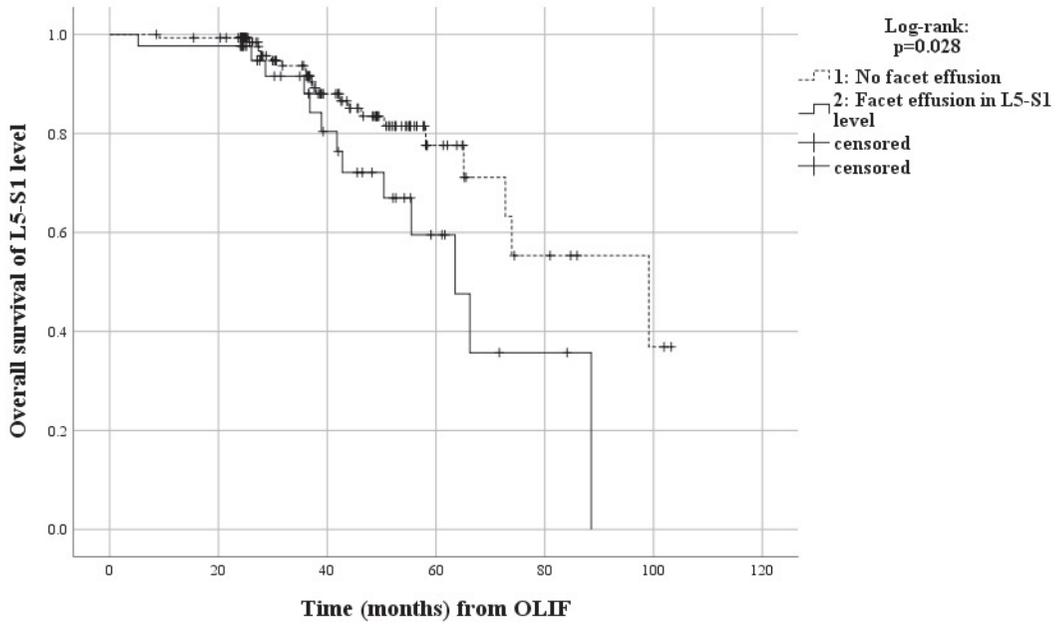
The Fate of Pre-existing L5-S1 Degeneration Following Oblique Lumbar Interbody Fusion of L4-L5 and Above**Sam Yeol Chang^{1*}, Dong-Ho Kang¹, Bong-Soon Chang¹, Hyoungmin Kim¹ and Ji Hwan Kim¹**¹ Department of Orthopedic Surgery, Seoul National University College of Medicine and Seoul National University Hospital, Korea

Background: Adjacent segment degeneration of L5-S1 is not uncommon following lumbar interbody fusion of L4-5 level and above, even after minimally invasive surgical techniques, such as minimally invasive oblique lumbar interbody fusion (MIS-OLIF). The purpose of this study is to identify risk factors for adjacent segment disease (ASD) of L5-S1 level with pre-existing degeneration after MIS-OLIF of L4-L5 level and above.

Methods: We retrospectively reviewed the data of patients who underwent MIS-OLIF of L4-L5 level and above with percutaneous pedicle screw instrumentation with a minimum follow-up period of 2-year. Patients with any central stenosis and Lee grade 2 or 3 foraminal stenosis at L5-S1 level preoperatively were excluded. Patients were divided into two groups, symptomatic ASD group and non-ASD group. Symptomatic ASD group was defined as the patients who experienced new-onset L5 radicular pain uncontrolled by pain medications for more than 3months and required pain intervention, such as ESI during follow-up period. In addition, fusion extension on L5-S1 due to symptomatic ASD was also investigated. Preoperative and operative factors of these two groups were compared and analyzed. Logistic regression models were used to identify risk factors for ASD of L5-S1 level.

Results: A total of 191 patients with a mean age 4 standard deviation of 68.6 4 8.3 years were included in this study. Thirty-four patients (21.7%) received ESI at the L5 root at a mean follow-up period of 19.9 months after MIS-OLIF of L4-L5 level and above. Three (1.6%) patients underwent fusion extension surgery for symptomatic ASD at the L5-S1 level after a mean of 34.2 months after MIS-OLIF of L4-L5 level and above. Symptomatic ASD group showed a significantly higher proportion patients with the presence of facet effusion ($p=0.013$) and severe fatty degeneration of paraspinal muscle in L5-S1 level ($p=0.014$) at time of index surgery. In the multivariate logistic regression analyses, severe disc degeneration of Pfirrmann grade IV and V at L5-S1 disc (Odds ratio (OR) [95% confidence interval]: 2.65, [1.16-6.09]), presence of facet effusion in L5-S1 level (OR=2.55, [1.05-6.23]), and severe paraspinal muscle fatty degeneration of Goutallier grade 3 and 4 (OR=4.47, [1.53-13.05]) at the time of index surgery were significant risk factors for symptomatic ASD.

Conclusions: In this study, the presence of facet effusion, severe disc degeneration, and severe paraspinal muscle fatty degeneration at the time of index surgery were associated with the development of symptomatic ASD at L5-S1 following MIS-OLIF of L4-L5 level and above. For patients with these conditions, surgeons could consider including L5-S1 in the level of fusion when considering OLIF for L4-5 and above.



FP30-4

Lumbar Degenerative

A Comparison between Cortical Bone Trajectory Screws and Traditional Pedicle Screws in Patients with Single-level Lumbar Degenerative Spondylolisthesis: 5 Year Results

Sung-ryul Choi¹, Ji-Won Kwon¹, Yung Park^{2*}, Byung Ho Lee¹, Si Young Park¹, Joong-Won Ha², Seong-Hwan Moon¹, Hak-Sun Kim¹ and Kyung-Soo Suk¹

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Background: Few studies have compared 5-year follow-up outcomes between CBT screws and TP screws in TLIF. This study investigated the clinical and radiological results of using cortical bone trajectory (CBT) screws versus traditional pedicle (TP) screws in transforaminal lumbar interbody fusion(TLIF) during a 5-year follow-up of patients with single-level lumbar degenerative spondylolisthesis.

Methods: We reviewed outcome data of patients with single-level lumbar degenerative spondylolisthesis who underwent TLIF procedures with CBT screws (131 patients) or TP screws (80 patients) between 2011 and 2015. Patient-reported clinical outcome data included Oswestry Disability Index (ODI) scores and visual analog scale (VAS) scores for back and leg pain at baseline, 6 months, and 1 year, 2 years, and 5 years postoperatively. The radiographic fusion rate and prevalence of secondary surgery for adjacent segment disease were also measured.

Results: During the follow-up over 5 years, the CBT group had significantly lower VAS scores for back pain ($p < .0001$, respectively). At 2 years after surgery, the CBT group had significantly higher VAS scores for leg pain ($p = .007$). At 5 years postoperatively, no significant differences existed in the VAS score for leg pain or in the ODI score between the two groups. Radiographic fusion rates (CBT vs. TP: 95.5% vs. 95.9%; $p = 0.881$) and adverse events during the 5 years after surgery were not significantly different. At 2 years postoperatively, the prevalence of secondary surgery to treat adjacent segment disease was significantly different between the two groups (CBT vs. TP: 13.7% vs. 5.0%; $p = 0.044$).

Conclusions: Our results suggest that, during a 5-year follow-up, CBT screws for TLIF were an effective treatment, compared to TP screws, for patients with single-level lumbar degenerative spondylolisthesis. However, when performing CBT screws for TLIF, surgeons should consider a symptomatic adjacent segment disease requiring surgery.

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Endoscopic Technologies & Techniques

Ligamentum Flavum Sparing Unilateral Laminotomy for Bilateral Recess Decompression (ULBRD): Surgical Technique and Clinical Results**Woo-Keun Kwon¹ and Christoph Hofstetter^{2*}**¹ Department of Neurosurgery, Korea University Guro Hospital, Korea University College of Medicine, Seoul, Korea² Department of Neurological Surgery, University of Washington, USA

Background: Interlaminar endoscopic lateral recess decompression (IE-LRD) has been introduced and utilized for lumbar lateral recess decompression. We modified this technique and utilized it for bilateral lateral recess stenoses (LRSs) without significant central stenosis. The unique surgical details and clinical outcome of Ligamentum Flavum (LF) sparing IE-LRD are presented.

Methods: Prospectively collected registry for full-endoscopic surgeries was reviewed retrospectively. 182 consecutive cases from a single center between September 2015 and March 2021 were reviewed and 57 of them whom underwent LF sparing bilateral IE-LRD were enrolled for analysis. Basic patient demographic data, peri-operative details, surgery related complications and clinical outcome were reviewed. The detailed surgical technique is presented as well.

Results: Among the 57 patients enrolled, 37 were males while the other 20 were females. The mean age was 58.53414.51 years, and a bimodal age distribution at the age of mid-fifties and mid-sixties or older was noted. The later age-peak was related to co-existence of degenerative scoliosis. The average operative time per lamina was 70.34420.51 minutes and mean length of stay was 0.5640.85 days. Five peri-operative complications were reported (7.0%) and the overall re-operation rate at the index level within 1-year was 10.5%. The pre-operative back/leg VAS scores and functional outcome scales including EQ5D, ODI presented significant improvement immediately after surgery and were maintained until final follow up.

Conclusion: Our modified bilateral IE-LRD for bilateral LRSs without significant central stenosis presented good clinical outcomes with acceptably low peri-operative complications rates. Sufficient decompression was achieved with the central LF being preserved.

FP31-2

Endoscopic Technologies & Techniques

Outcomes of Patient with Lumbar Disc Herniation Undergoing Unilateral Biportal Endoscopic Surgery

Duong Tran Vu Hoang^{1*}, Linh Pham Quoc^{1*}, Bao Le Tan¹, Vu Huynh Van¹, Lam Chu Van¹, Linh Le Tan¹, Tuan Pham Anh², Duong Luu Binh¹ and Duy Phan¹

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Background: Unilateral biportal endoscopic (UBE) surgery for the treatment of lumbar disc herniation (LDH) has been growing rapidly for a relatively short period of time. This minimally invasive surgical technique has achieved favorable results in developed countries. In the present study, we reported the preliminary outcomes of patients with LDH treated with UBE discectomy in a limited resources institution.

Methods: Clinical and radiographic data of 46 patients of LDH treated between July 2022 and March 2023 using UBE techniques including unilateral interlaminar approach, contralateral sublaminar approach and paraspinous approach, were reviewed. Outcomes were analyzed in view of modified-Macnab criteria, Japanese Orthopedic Association score (JOA), Visual analog scale (VAS) with a mean follow-up of 3.1 months.

Results: At the final follow-up, the mean VAS for low back pain was improved from 4.241.1 to 1.440.3 and VAS for leg pain was improved from 7.941.2 to 2.640.4. The mean JOA score improved from 13.845.2 to 24.444.3. Modified Macnab criteria were excellent in 30 patients (65.3%), good in 14 (30.4%), fair in 2 (4.3%). A total of 57 levels of LDH were done. L4-L5 disc herniation was performed in 30 patients (52.6%), L5-S1 in 20 (35.1%), L2-L3 in 4 (7.0%), and L3-L4 in 3 (5.3%). Unilateral approach technique was performed at 48 patients (84.2%), contralateral sublaminar approach in 7 (12.3%), and paraspinous approach in 2 (3.5%). Complications included 2 patients with dural tears (4.3%), and 1 epidural hematoma (2.2%).

Conclusions: UBE techniques may be performed safely and effectively for the treatment of LDH in limited resources hospitals.

Keywords: Minimally invasive surgery; biportal endoscopic spine surgery; lumbar disc herniation

FP31-3

Endoscopic Technologies & Techniques

In Vivo Comparison of Positive Microbial Culture by Wound Irrigation Methods: Biportal Endoscopic Versus Open Microscopic Transforaminal Lumbar Interbody FusionMinseok Kang^{1*} and Hyunjin Park^{1*}¹Orthopedic Surgery, Anam Hospital, Korea University College of Medicine, Korea

Background: Surgical site infection (SSI) in spinal surgery is a fatal complication. In order to prevent SSI, prophylactic antibiotics, aseptic surgical drape, surgical hand scrub, and intraoperative wound irrigation are emphasized, and these methods reduce intraoperative contamination (IoC). However, there is scanty evidence for the effect of persistence of intraoperative wound irrigation on IoC and SSI. Endoscopic spine surgery is expected to have a lower incidence of IoC and SSI because the entire surgical process is performed under continuous wound irrigation. This study aimed to evaluate the risk factors and prevalence of IoC through the microbial culture of superficial and deep samples obtained during surgery.

Methods: In this in-vivo study, a microbial cultivation was performed on superficial (LF, ligamentum flavum) and deep (NP, nucleus pulposus) surgical specimens to evaluate IoC in patients undergoing single level transforaminal lumbar interbody fusion (TLIF). This study included a total of 132 patients, biportal endoscopic (BE) TLIF was performed under continuous wound irrigation (group A, n=66), whereas open microscopic (OM) TLIF was performed under intermittent wound irrigation (group B, n=66). Specimens of LF and NP were homogenised, gram-stained, and cultured in aerobic and anaerobic media for 14 days. The microbial culture results and occurrence of SSI of the two groups were compared.

Results: A total of 132 patients were analysed, of whom 34 (25.6%) had positive microbial cultures. Among them, except for 3 patients, an incubation period of 72 hours to 2 weeks was required in all patients for positive culture. The overall positive culture was significantly higher in group B than in group A ($p=0.029$). The subgroups of LF and NP positive cultures were 18.18% (n=24) and 12.88% (n=17), respectively; the SSI was 0.76% (n=1). Group A showed a significantly lower subgroup of NP positive culture than group B ($p=0.035$). The OM technique was an independent risk factor influencing overall positive culture. ($p<0.05$). The most common microorganism was *Cutibacterium acnes* (*C. acnes*). Only 1 case in group B was diagnosed with overt SSI by *C. acne*, with the same strains cultured in LF and NP.

Conclusion: BE-TLIF with continuous wound irrigation showed significantly lower the overall and NP positive culture than OM-TLIF with intermittent irrigation. The most common strain of positive culture was *C. acne*.

FP31-4

Endoscopic Technologies & Techniques

End Plate Spur: The Forgotten Pathology in Lumbar Foraminal Stenosis and How We Handle It Using Bess(biportal Endoscopic Spine Surgery)Yilun Huang^{1*}, JH Hwang², MC Kim² and Dae Jung Choi²¹ Orthopaedic Surgery, Seng Kang General Hospital Singapore, Singapore² Orthopaedic Surgery, Himnaera Hospital Busan, Korea

Introduction: Endoscopic decompression has always been a highly favoured method to decompress foraminal stenosis of the lumbar spine. There are many contributory causes to lumbar foraminal stenosis. A common but easily neglected cause is an end plate bony spur. This paper will emphasize the importance of end plate spur excision in decompression of lumbar foraminal stenosis and the technical aspects of how we do it with biportal endoscopic spine surgery.

Methods: We performed biportal endoscopic decompression of lumbar foraminal stenosis in a series of cases with lumbar foraminal stenosis caused by end plate spur. This technical report aims to describe the various approaches of using biportal endoscopic spine surgery to decompress lumbar foraminal stenosis by end plate excision.

Results: We demonstrate adequate clearance of lumbar foraminal stenosis radiologically with post op MRI scans. The favourable results are correlated with the clinical complete resolution of symptoms in the patients post operatively. There are various advantages and disadvantages of ipsilateral posterior (IPA), contralateral posterior (CLA) and transforaminal approach (TFA) using biportal endoscopic spine surgery. TFA provides good access and visibility to the lateral recess, foraminal and extraforaminal portion of the end plate spur, allowing ease of work when excising end plate spur. However, facet instability may arise with sacrificing of the lateral plane of the superior articular facet (SAP) during this approach. IPA is technically challenging and does not allow full vision of the extraforaminal area, thus some decompression work is done blindly and by tactile sense when handling a curette. CLA is the reverse approach of the foramen compared with TFA; the foramen is approach from inside the spinal canal. It allows for good visibility and access as well, similar to TFA, but requires longer surgical time. However, this approach negates the risk of destabilising the facet joints.

Conclusions: We conclude that end plate spur excision in endoscopic foraminal decompression is an important step not to be missed, in order to achieve good outcome in patients post operatively. There are various approaches that can be used with biportal endoscopic spinal surgery. With each approach, there are various advantages and disadvantages, therefore selection of surgical approach needs to be catered to patients individually depending on the profile of their pathology.

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Lumbar Degenerative

Different Pathoanatomy of Central Stenosis in Isthmic Lumbar Spondylolisthesis - Intersegmental Stenosis**Hyuk-joon Sohn¹, Eun-seok Son^{1*} and Min-gyu Lee¹**¹ Department of orthopaedic surgery, Keimyung university Dongsan hospital, Korea

Backgrounds: The pathoanatomy of central stenosis in isthmic spondylolisthesis differ from degenerative spondylolisthesis. We aim to analyze the pathoanatomy of central stenosis in isthmic spondylolisthesis.

Materials & Methods: T2 mid-sagittal magnetic resonance image of 280 cases diagnosed with isthmic spondylolisthesis were evaluated. Quantitative measurement of dural sac anterior-posterior diameter (DSAPD), disc height, anterior translation, pseudo-bulged disc, and ligament hypertrophy was done. Diagnosis and severity assessment of stenosis was done using DSAPD. Relationship of each factors with central stenosis was statistically analyzed. We also assessed common pathoanatomy of central stenosis in cases with isthmic spondylolisthesis.

Results: The mean disc height was lesser in central stenosis group (5.19mm) than non-central stenosis group (7.67mm). (p=0.000) The mean anterior translation was greater in stenosis group (6.92mm) than no stenosis group (4.35mm). (p=0.000) Mean value of pseudo-bulging was larger in central stenosis group (6.25mm) than no stenosis group (5.51mm). (p=0.001) Mean thickness of ligamentum flavum was thicker in central stenosis group (8.03mm) than in no stenosis group (4.16mm). (p=0.000) Regarding the pathoanatomy, central stenosis in IS occurs between pseudo-bulged disc of isthmic vertebra and thickened ligamentum flavum of upper vertebra.

Conclusion: Disc height loss, severe anterior translation, pseudo disc bulging, and thickened ligamentum flavum were correlated with central stenosis in isthmic spondylolisthesis. Pathoanatomy occurring in this study was 'intersegmental stenosis' between buckled and hypertrophied ligamentum flavum of upper vertebra and pseudo-bulging of disc in isthmic vertebra.

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Lumbar Degenerative

Radiographic and Clinical Outcomes after Stand-alone Anterior Lumbar Interbody Fusion for Symptomatic L5-s1 Retrolisthesis**Steve Cho^{1*}, S. Harrison Farber¹, Joseph Didomenico¹, Steve Chang¹, Laura Snyder¹, Zaman Mirzadeh¹, Juan Uribe¹ and Jay Turner¹**¹ Neurosurgery, Barrow Neurological Institute, USA

Background and Objectives: Degenerative lumbar spondylolisthesis is associated with significant pain and disability. There is robust literature on the treatment options and clinical outcomes for lumbar anterolisthesis but very few reports specifically evaluating lumbar retrolisthesis. This study investigated surgical outcomes for symptomatic L5-S1 retrolisthesis treated with stand-alone L5-S1 anterior lumbar interbody fusion (ALIF).

Methods: All patients with symptomatic L5-S1 retrolisthesis treated with stand-alone L5-S1 ALIF at a single institution over a seven-year period were identified. All patients had failed exhaustive nonoperative management. Patients with prior lumbar fusion were excluded. Preoperative and postoperative radiographic images and patient-reported outcome measures were collected and analyzed.

Results: Twenty patients were included. The mean (SD) follow-up was 43.0 (23.7) months (range 12.1 - 102.5 months). Postoperative improvements in L5-S1 retrolisthesis ($P = 0.048$), L5-S1 disc height and angle ($P < 0.001$), L5 foraminal height ($P < 0.001$), L5-S1 lordosis ($P < 0.001$), and lumbar lordosis ($P = 0.01$) were achieved. There were no significant changes in spinopelvic parameters. At most recent follow-up, 55%, 38.5%, and 53.9% of patients achieved minimal clinically important differences in ODI, NRS back, and NRS leg, respectively. All patients demonstrated fusion with no graft subsidence at up to 32 months. No patients experienced intraoperative complications, were readmitted, or required a subsequent posterior decompression or fusion because of refractory symptoms.

Conclusions: Stand-alone L5-S1 ALIF is associated with both radiographic and clinical improvement in patients with symptomatic L5-S1 retrolisthesis.

Table 1. Radiographic data for 22 patients who underwent MIS-LRP-TD*

Parameter	Preoperative	Postoperative	P-value
Sagittal view			
C7-SVA, cm	1.91 (4.84)	1.92 (4.19)	0.99
Thoracic kyphosis, °	40.4 (12.0)	41.5 (11.3)	0.30
Segmental kyphosis, °	9.19 (3.70)	8.00 (6.78)	0.27
Coronal view			
C7PL-CSVL, cm	-0.34 (0.88)	-0.2 (1.2)	0.65
Thoracic Cobb angle, °	1.56 (6.81)	0.7 (6.72)	0.28
Segmental Cobb angle, °	0.81 (1.99)	1.17 (2.74)	0.56

*All values are shown as mean (SD)

Abbreviations: C7-SVA, C7 to sagittal vertical axis; C7PL-CSVL, C7 plumb line to central sacral vertical line; MIS-LRP-TD, minimally invasive lateral retropleural thoracic discectomy; SD, standard deviation.

Figure 1. Case illustration 1: A patient in their late 50s with type 1C herniation of the T11-12 disc. **(A)** Preoperative sagittal and axial magnetic resonance (MR) and computed tomographic (CT) images show a small, calcified paramedian herniation. **(B)** The patient's preoperative plain radiographs show a thoracic Cobb angle of -0.3° and thoracic kyphosis of 41.2° , with a segmental Cobb angle of -1.8° and segmental kyphosis of 14.7° at the T11-12 operative level. **(C)** The immediate postoperative sagittal and axial MR and CT images of the thoracic spine show the extent of bony resection and cord decompression obtained during the right-sided MIS-LRP-TD at T11-12. **(D)** One-year postoperative plain radiographs show no significant changes to the thoracic or segmental Cobb angles and kyphosis. **(E)** Five-year postoperative plain radiographs show a slight increase in the segmental kyphosis at T11-12 but no significant changes in the thoracic or segmental Cobb angles.

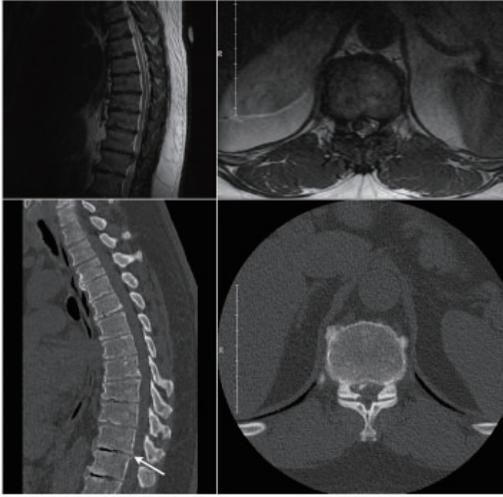


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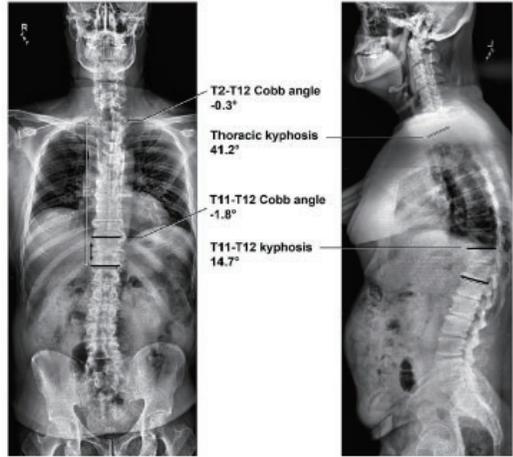


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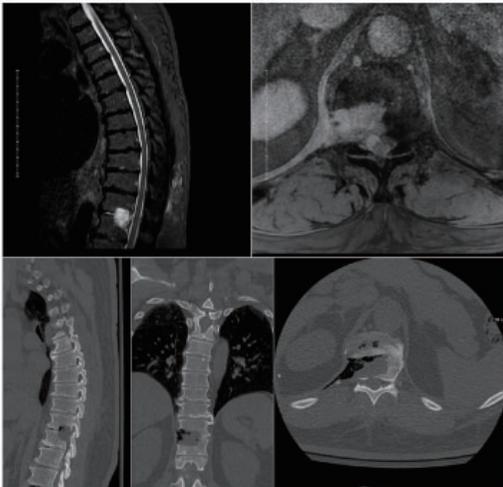


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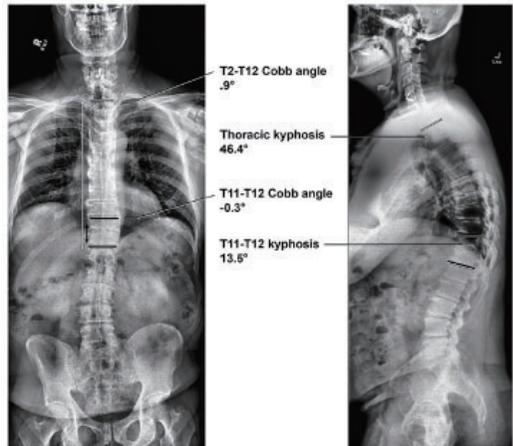


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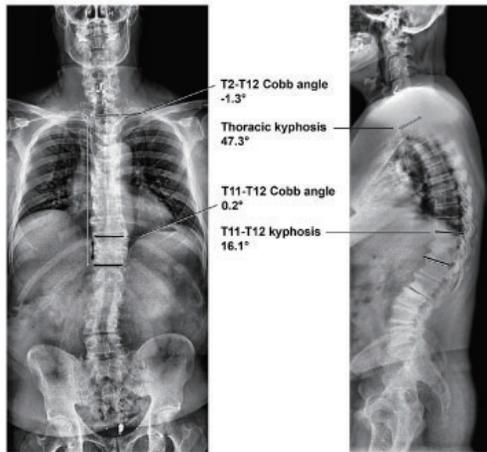


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FP32-3

Lumbar Degenerative

A New Grading System for Endplate Spur in Lumbar Foraminal Stenosis**Sung Cheol Park¹, Dae-Jung Choi^{2*} and Min-Seok Kang³**¹ Department of Orthopaedic Surgery, Spine Endoscopy Center, BumIn Hospital Seoul, Korea² Department of Orthopaedic Surgery, Himnaera Hospital, Korea³ Department of Orthopaedic Surgery, Korea University Anam Hospital, Korea

1. Background: Lumbar foraminal stenosis (LFS) can be caused by foraminal disc extrusion, disc height loss, angulation due to degenerative scoliosis, hypertrophy of ligamentum flavum, and facet arthritis. LFS was anatomically classified into vertical, transverse, and circumferential stenosis in several previous studies. Vertical LFS was defined as nerve root compression caused by the endplate spur, laterally herniated disc, or bulging annulus fibrosus against the superior pedicle. In our experience, clinical manifestations of vertical LFS patients may vary depending on the detailed morphological differences of the endplate spur or disc herniation. Despite previous literature suggesting grading systems of LFS, the endplate spur appears to be somewhat underestimated in previous grading systems or surgical planning. Therefore, we aimed to devise a new grading system focusing on the endplate spur at the foraminal zone with consideration of clinical symptoms.

2. Methods: This study reviewed patients who underwent both lumbar MRI and CT from January 2014 until December 2017 at a single institution. Patients with vertical LFS only at L5-S1 without central and/or subarticular stenosis at any levels or LFS at any other levels were included. We excluded patients with foraminal disc herniation with superior migration, segmental instability at L5-S1, spinal infection, tumor, fracture, deformity, or history of previous spinal surgery to solely evaluate the effect of endplate spur on clinical symptom.

Endplate spur arising at the foraminal zone was classified into a 4-grade system using the sagittal images of MRI and CT: grade 1, absence of endplate spur; grade 2, traction spur not covering entire nerve root; grade 3, traction spur covering entire nerve root; and grade 4, claw spur directly compressing nerve root (Figure 1). Grade 3 was additionally divided into two subgroups: type 3a, without morphologic change of nerve root; and type 3b, with morphologic change. Image analysis was conducted independently by 2 orthopaedic spine surgeons, and reader 1 repeated image evaluation with the interval of 3 months. Clinical symptoms including radicular pain, paresthesia, numbness, weakness of the lower extremity corresponding to L5 root were considered positive clinical manifestations (PCM).

3. Results: A total of 164 foramina with vertical LFS were evaluated. Among the patients evaluated by reader 1, 6 patients (12.8%) of grade 1, 14 (25.0%) of grade 2, 19 (51.4%) of grade 3, and 19 (79.2%) of grade 4 had PCM ($p < 0.001$). Of those assessed by reader 2, 8 patients (19.0%) of grade 1, 14 (22.2%) of grade 2, 16 (50.0%) of grade 3, and 20 (74.1%) of grade 4 had PCM ($p < 0.001$). Among the patients classified as grade 3, patients with subtype 3b had significantly higher rates of PCM than those with subtype 3a. Interobserver and intraobserver agreement were substantial, with kappa values of 0.715 and 0.707, respectively.

4. Conclusions: Our new grading system for the endplate spur at the foraminal zone shows considerable reliability and a notable correlation with clinical manifestations depending on the grades. The authors suggest our grading system to help spine surgeons determine surgical planning for patients with LFS with endplate spur.



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Lumbar Degenerative

Postoperative Urinary Retention after Oblique Lumbar Interbody Fusion Under the Systematic Management ProtocolHangeul Park¹, Chang-Hyun Lee¹, Jun-Hoe Kim¹, Chun Kee Chung¹ and Chi Heon Kim^{1*}¹ Department of Neurosurgery, Seoul National University Hospital, Korea

Background: Oblique lumbar interbody fusion (OLIF) is a minimally invasive lateral lumbar fusion technique and patients are discharged 1-2 days after surgery. Because OLIF utilizes a retroperitoneal approach close to the superior hypogastric plexus, postoperative urinary retention (POUR) may not be an uncommon problem. The purpose of this study was to present the incidence and outcomes of POUR with a systematic care protocol.

Methods: The records of 102 consecutive patients (M:F=34:68; mean age, 68.048.4 years) were retrospectively reviewed. After OLIF, the indwelling urinary catheter was immediately removed, and every patient was encouraged to void within 6 hours. The POUR care protocol, following a clinical pathway, was based on residual urine (RU), which was monitored with an ultrasound bladder scan after each voiding or every 6 hours for 48 hours.

Results: The incidence rate of POUR was 44% (45/102) at 24 hours, 17% (17/102) at 48 hours, and 2% (2/102) at 1 month. Preoperative urological symptoms (odds ratio [OR], 3.6) and violation of the protocol (OR, 28.0) were risk factors at 24 hours. At 48 hours, violation of the protocol was the only risk factor (OR, 10.5).

Conclusions: The incidence of transient POUR after OLIF was high, and POUR could be managed with a systematic care protocol. Identifying risk factors for POUR and applying a preemptive care protocol may reduce the incidence of permanent POUR.

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FP33-1

MIS

Factors Affecting Restoration of the Segmental Lordosis after Lateral Access Spinal Surgery**Hae-Dong Jang¹, Jae Chul Lee^{2*}, Byung-Joon Shin² and Sung-Woo Choi²**¹ Orthopaedic Surgery, Soonchunhyang University Bucheon Hospital, Korea² Orthopaedic Surgery, Soonchunhyang University Seoul Hospital, Korea

Introduction: Lateral access spinal surgery (LASS) is one of the widely performed spinal fusion techniques in recent. An adequate recovery of segmental lordosis (SL) is necessary for successful outcomes. On the other hand, an insufficient restoration of SL leads to a significant problem for patients.

Objectives: To analyze clinical, radiological, and operative factors that are related to the restoration of SL after LASS.

Methods: Patients, who underwent LASS and posterior pedicle screw instrumentation (less than or equal to 4 segments), were analyzed. Multiple radiological factors and clinical outcomes were reviewed at preoperative, immediate postoperative, and 1 year. Radiological evaluation included the presence of anterior osteophyte, spondylolisthesis, facet hypertrophy, facet gap with fluid, cage subsidence, and vacuum change of the intervertebral disc. We also measured SL, lumbar lordosis (LL), dynamic SL (flexion and extension), central disc height, and pelvic incidence-LL mismatch. Clinical factors included age, sex, osteoporosis, and medical comorbidities. Operative factors included the type of operating table during posterior surgery, the addition of posterior column osteotomy, and cage-related factors (type, angle, and location). Univariate and multiple logistic regression analyses were performed using R-EX.

Results: We analyzed 140 patients and 268 segments ranging from L1-S1. The average preoperative SL was 9.3 degrees. The average SL was 11.7 degrees immediately after surgery, and it gradually decreased to 11.0 at postoperative 6 months, and 10.9 at 1 year. In univariate analysis, postoperative SL (at 1 year after surgery) was greater (OR 0.56, $p < 0.001$) when preoperative SL was greater. Likewise, postoperative SL was greater at L4-5 (OR 4.60, $p < 0.001$) and L5-S1 (OR 4.89, $p = 0.013$) than other segments. The patient with a greater PI-LL mismatch showed the greater SL at immediate postoperative (OR 0.05, $p = 0.039$). As age increases, postoperative SL was significantly greater at 6 months (OR 0.07, $p = 0.049$) and 1 year (OR 0.06, $p = 0.044$). The change of SL was significantly smaller (OR -0.44, $p < 0.001$) when preoperative SL was greater. Furthermore, the SL change was significantly greater at L4-5 (OR 5.00, $p < 0.001$) and L5-S1 (OR 4.89, $p = 0.014$) than at other levels. In multiple logistic regression analysis, the change of SL showed an inverse correlation to preoperative SL (OR -0.46, $p < 0.001$). Moreover, the change of SL was significantly greater at L4-5 (OR 4.51, $p < 0.001$) and L5-S1 (OR 4.89, $p = 0.014$) than at other levels.

Conclusions: Preoperative SL was a determinant factor to achieve adequate postoperative SL after LASS. However, the greater preoperative SL could result in a smaller correction of the SL. The change in SL was remarkable at L4-5 and L5-S1 segments, and surgeons should make good use of these characteristics.

FP33-2

When Would One Not Do MIS Surgery in Metastatic Spine Surgery?

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FP33-3

MIS

Comparison of Paraspinal Muscle Degeneration and Clinical Outcome between Posterior Lumbar Interbody Fusion with Supplement Interspinous Process Fixation and Conventional Open Transforaminal Lumbar Interbody Fusion in Low-grade Lumbar SpondylolisthesisJiun-cheng Shiu*Department of Orthopedic Surgery, An-Nan Hospital-China Medical University, Tainan, Taiwan*

Background: Interspinous process device are being developed to aid in the stabilization of the spine. They are being evaluated as alternatives to pedicle screw and rod constructs in combination with interbody fusion.

Objective: The authors present the clinical results obtained in patients who underwent interspinous process device (IPD) implantation with posterior lumbar interbody fusion (PLIF) for lumbar spondylolisthesis. The purpose of this study compares the paraspinal muscle degeneration and clinical outcome of IPD with PLIF and conventional open transforaminal lumbar interbody fusion (TLIF) in the treatment of low-grade lumbar spondylolisthesis

Methods: 20 patients underwent partial laminectomy, PLIF (TM cage) and subsequent IPD (Romeo_2 PAD, or stenofix) implantation (IPD group). 20 patients underwent partial laminectomy, conventional open transforaminal lumbar interbody fusion (TLIF group). Medical records of these patients were retrospectively reviewed to collect relevant data such as blood loss, operative time, length of hospital stay, VAS, SF-32 and ODI score. Radiographs and clinical outcome were evaluated 6 weeks and 12 months after surgery. CT and MRI were collected 12 months after surgery. Measure muscle-fat-index (MFI) change of the paraspinal muscles in T1 MRI

Results: The medical reviews revealed lesser blood loss, lesser operative time and lesser length of hospital stay in IPD group. Better in decreasing ODI and SF-32 was also noted in IPD group. The result of CT revealed that almost the same fusion rate in both group. The result of MRI revealed that lesser MFI change in IPD group.

Conclusion: The interspinous process device appears to achieve adequate posterior fixation and facilitate lumbar fusion in selected patients and decrease soft tissue damage. However, further study is mandatory for novel anatomic and radiological scoring system to identify patients suitable for this treatment modality and prevent postoperative complications.

FP33-4

MIS

Clinical Outcomes of Kyphoplasty in the Treatment of Osteoporotic Vertebral Fractures – Could It Possibly Advance the Priority ?**Ruey-Mo Lin¹, Jiun-Cheng Shiu¹ and Jing-Jing Fang¹**¹ orthopedics, Professor, AnNan Hospital, China Medical University, Taiwan

Introduction: The rapid aging population poses many challenges in disease treatment including the intervention of osteoporotic vertebral fractures (OVF). In this decade, minimally invasive approaches prevailed and thus more controversies encountered. For the OVF without neurological deficits, kyphoplasty or vertebroplasty rapidly increased, however, diverse opinions also raised about the indications, timing, effects etc. In this study, we retrospectively reviewed cases treated with kyphoplasty in five years to evaluate the efficacy and further delineate the indications of the intervention of OVF.

Materials and Methods: We retrospectively reviewed 103 OVF patients treated with percutaneous kyphoplasty (SpineJack and PMMA, uniportal) in 6 years. The posterior 1/3 of vertebral body was left free of cement to avoid the risk of cement leakage and hopefully to expect remodeling of posterior wall. The bone marrow (around 50 cases) was collected for pathology. 96 cases had the plain TL spine X-ray of before intervention, immediately after intervention and follow-up. The regional and global Cobb's angle from lateral X-rays were measured. The Pre-OP and Follow-up VAS scores were also evaluated. We applied AO Spine-DGOU Osteoporotic Fracture (OF) Classification System. Around 20 cases, CT scan was performed before and at follow-up (two years). CT 3D reconstruction using images fusion techniques to delineate morphological changed including the conditions of posterior wall.

Results: There were 103 patients enrolled, included 30 males and 73 females with an average age of 76.29 (49 to 92 yrs). Mean follow-up periods was 47.6 months (range from 13.2 to 87). The duration from trauma episode to kyphoplasty averaged 3.5 months. Based on AO Spine-DGOU Osteoporotic Fracture Classification System, one patient were type 1, 54 patients were type 2, 12 patients were OF type 3, and 26 patients were OF type 4 and 3 patients were type 5. The mean VAS improved from 7.6 to 2.5. The mean regional cobb's angles of preop, immediately postop and follow-up were -11.3, -6.4 and -11.8 degrees, respectively. The mean global cobb's angles of preop, immediately postop and follow-up were 1.29, 5.7 and 2.28 degrees, respectively. The 3D CT image follow-up showed good healing and remodeling of posterior wall of the involved vertebrae. There are 45 cases having the pathological reports of retrieved specimen. The findings included fractures, degeneration, inflammation, fibrosis, necrosis (around 25 %) and malignancy (3 cases). 7 cases of complications occurred including junctional fracture, further collapsing and needs further intervention.

Discussion: The outcomes of percutaneous kyphoplasty for OVF are good, reliable and constant. No significant complications were noted. Extending the indication of kyphoplasty in OVF to OF type 4, even type 5 could be considered. With more clinical experiences, we believe that the indication and timing of intervention for the OVF without neurological deficits will be modified in the near future.

E-POSTERS



ADULT SPINAL DEFORMITY

EP01-01

Adult Spinal Deformity

A Validation Study of 4 Preoperative Surgical Planning Tools in Terms of Proximal Junctional Kyphosis and Clinical Outcome in Adult Spinal Deformity Surgery

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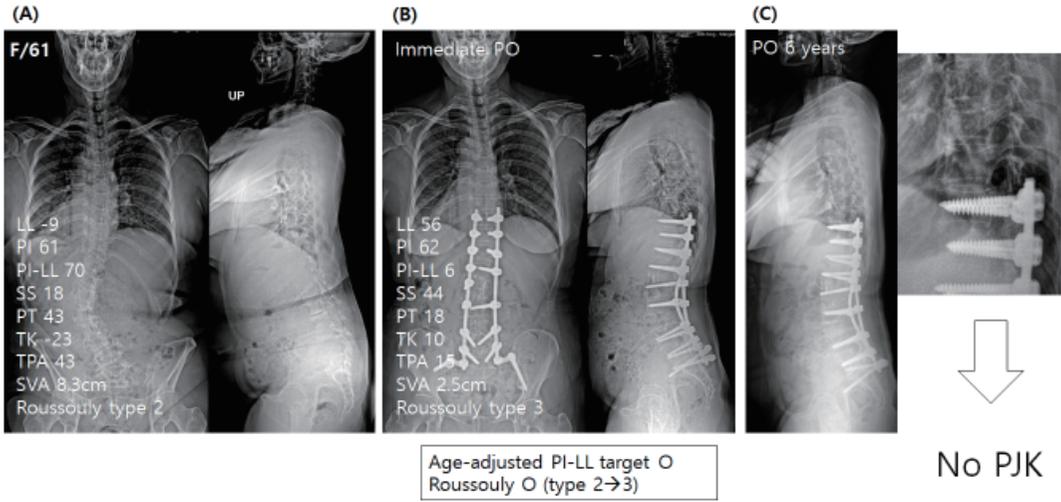
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Background: Optimal correction of a sagittal deformity along with minimizing mechanical failure, such as proximal junctional kyphosis (PJK), is of the utmost importance to achieve good clinical outcomes in adult spinal deformity surgery (ASD). Therefore, any surgical guidelines to suggest the correction target should provide benefits in terms of both clinical outcome improvement and PJK prevention. Four guidelines have been suggested for optimal correction in adult spinal deformity (ASD) surgery: Scoliosis Research Society (SRS)-Schwab classification, age-adjusted sagittal alignment goals, Global Alignment and Proportion (GAP) score, and the Roussouly algorithm. This study aims to validate four preoperative surgical planning tools in terms of both PJK prevention and clinical outcome improvement.

Methods: We retrospectively reviewed patients who underwent U 5-segment fusion including the sacrum for ASD with U 2-year follow-up. PJK development and clinical outcomes were compared among the groups separately using 4 surgical guidelines: SRS-Schwab pelvic incidence (PI)-lumbar lordosis (LL) modifier (Group 0, +, ++), age-adjusted PI-LL goal (undercorrection, matched correction, and overcorrection), GAP score (proportioned, moderately disproportioned, and severely disproportioned groups), and the Roussouly algorithm (restored and non-restored groups).

Results: A total of 189 patients were included in this study. The mean age was 68.3 years, and there were 162 women (85.7%). There were no differences in the rate of PJK development and clinical outcomes among SRS-Schwab PI - LL modifier and GAP score groups. With age-adjusted PI - LL goal, PJK developed significantly less frequently in the matched group compared to the under- and overcorrection groups. Clinical outcomes were significantly better in the matched group compared to the under- and overcorrection groups. With the Roussouly algorithm, PJK developed significantly less frequently in the restored group than in the non-restored group. However, there were no differences in clinical outcomes between the two Roussouly groups.

Conclusion: Correction according to age-adjusted PI-LL goal and the restored Roussouly type was associated with reduced PJK development. However, differences in clinical outcomes were only observed in the age-adjusted PI - LL groups.



EP01-02

Adult Spinal Deformity

Uppermost Instrumented Vertebra-pelvic Tilt Angle: A New Radiographic Parameter for Prediction of Proximal Junctional Failure in Patients Undergoing Thoracolumbar Fusion for Adult Spinal Deformity

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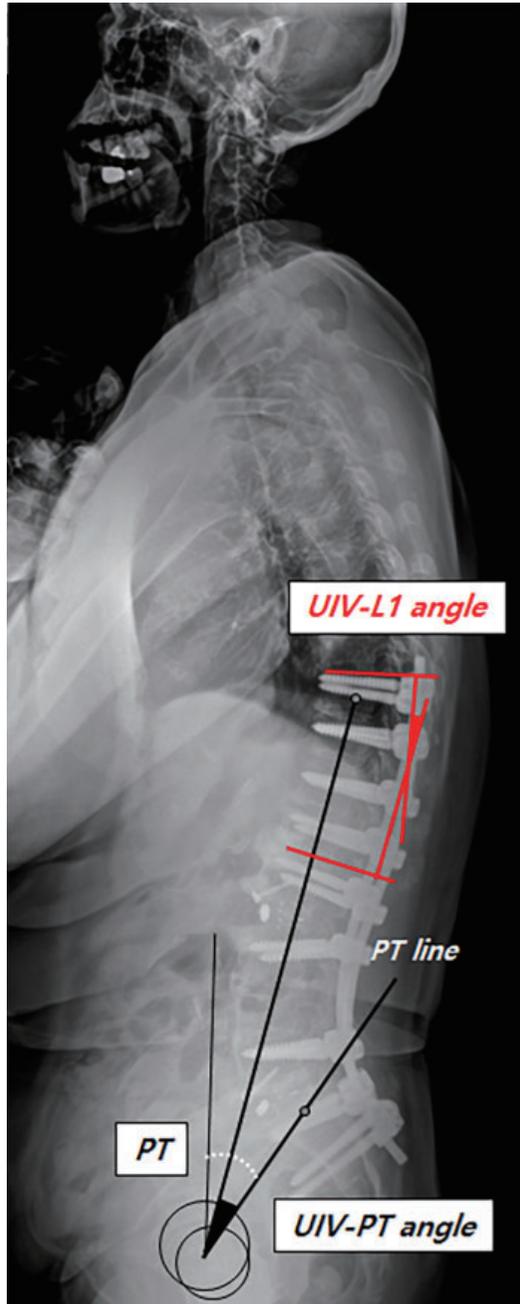
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Background: The optimal sagittal correction relative to age-adjusted ideal target is reported to decrease proximal junctional failure (PJF) in adult spinal deformity (ASD) surgery. However, several aspects have been overlooked such as the shape of lumbar lordosis (LL) or the contour of construct above L1 in case of proximal fixation extending beyond L1. In the present study, a new radiographic parameter, the uppermost instrumented vertebra (UIV)-pelvic tilt (PT) angle was introduced and its effects on the development of PJF in patients undergoing thoracolumbar fixation for ASD were determined.

Methods: The present study included 151 patients who underwent corrective surgery from low thoracic spine (T9-T12) to sacrum for lumbar degenerative kyphosis and were followed up U 2 years. Primary outcome was PJF which was defined as posterior ligament disruption, vertebral fracture at the UIV or UIV+1, pullout of UIV fixation, or the need for revision surgery. Various clinical and radiographic parameters were compared between PJF and non-PJF groups. In addition to conventional sagittal parameters, we measured UIV-PT angle, lumbar distribution index (LDI), and UIV-L1 angle. According to Schwab's PI-LL target and age-adjusted PI-LL target, correction amounts were grouped as undercorrection, ideal correction, and overcorrection. Univariate and multivariate logistic analyses were performed to demonstrate the significant variables for PJF development.

Results: Among 151 patients, PJF developed in 65 patients (43.0%). Univariate analyses showed that UIV level, postoperative PI-LL, correction amount relative to age-adjusted ideal PI-LL target, postoperative UIV-PT angle, and UIV-L1 angle were significant parameters for PJF occurrence. Multivariate analysis showed only smaller postoperative UIV-PT angle and smaller UIV-L1 angle were significant risk factors for PJF development. UIV-PT angle positively correlated with PT, PI, PI-LL, and UIV-L1 angle. Conversely, UIV-PT angle negatively correlated with LL and LDI. Re-analysis of radiographic parameters only for patients who achieved ideal correction relative to age-adjusted PI-LL target also showed UIV-PT and UIV-L1 angles were significant risk factors for PJF.

Conclusion: UIV-PT angle is a new, simple sagittal parameter which collectively contains various existing sagittal parameters. Greater UIV-PT angle combined with optimal correction relative to age-adjusted ideal target is suggested for the prevention of PJF.



EP01-03

Adult Spinal Deformity

“Midline Muscle-sparing” Approach for Circumferential Minimally Invasive Spine Surgery (CMIS) in Adult Spinal Deformity (ASD) Correction

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Background: Numerous incision and exposure strategies exist when attempting posterior instrumentation for adult spinal deformity (ASD). The mainstay approach to ASD is a midline open approach; however, surgeons have sought less traumatic, muscle sparing alternatives to limit complications associated with muscular denervation and detachment. Percutaneous attempts have developed but make rod passage difficult and ultimately limit the ability to perform an adequate posterolateral fusion. Here, we describe a novel “Midline Muscle-Sparing” incision and analyze the soft tissue complications related to its use in ASD.

Methods: We retrospectively reviewed our ASD database of 178 patients underwent cMIS ASD correction between January 2016 and December 2022. Inclusion criteria were ASD (Cobb>20°, SVA>50mm, PI-LL >10°), fusion U4 levels, minimum 6 weeks follow up, and undergoing novel “Midline Muscle-Sparing” incision. The “Midline Muscle-Sparing” incision is defined as a traditional midline incision over spinous processes, subcutaneous dissection to the thoracolumbar fascia with lipocutaneous flaps creation toward the paraspinal muscular interval, and subsequent epi-fascial instrumentation into the paraspinal interval. We reviewed postoperative notes and clinical photographs to evaluate rates of delayed wound healing (>6 weeks), surgical site infections (superficial and deep), antibiotic use related to wound healing, seroma/hematoma rates, and rate of revision surgery for soft tissue associated complications. A sub-analysis of patients with post-operative advanced imaging (MRI or CT) was performed to evaluate for seroma/hematoma formation.

Results: Of the 67 patients who met inclusion criteria, 62 (92.5%) healed uneventfully, without soft tissue complications. The mean follow up was 38 months (2-83, SD 26) with mean levels fused being 7.1 (4-11, SD 1). Four patients (6%) experienced superficial wound dehiscence, delayed wound healing requiring antibiotic treatment and plastic surgeon management. One patient (1.5%) experienced a superficial wound infection requiring operative debridement at 2 weeks. No patients experienced infection deep to the thoracolumbar fascia. Two patients (3%) experienced seromas that resolved by 6 weeks and 3 months without intervention. Sub-analysis of 41 patients with postoperative advanced imaging (MRI or CT) revealed that no subclinical seroma/hematoma present above the thoracolumbar fascia.

Conclusions: The “Midline Muscle Sparing” approach is a novel technique that can be utilized for long-construct, adult spinal deformity correction. The technique yields a midline, cosmetically appealing incision that is muscle sparing. Further, it facilitates smooth rod passage, enhances access for minimally invasive posterolateral fusion, and has a low rate of soft tissue complications.

EP01-04

Adult Spinal Deformity

An Anterior Supplemental Screw Can Prevent Anterior Cage Migration in Oblique Lateral Interbody Fusion at L5-s1Nam-Su Chung^{1*}, Han-Dong Lee¹, Hee-Woong Chung¹ and Ki-Hoon Park¹¹ Orthopaedic surgery, Ajou university hospital, Korea

Background: Anterior cage migration at L5-S1 segment is not a rare complication because of the greater intervertebral disc angle (IDA), the higher shear force on the sacral slope, and the weaker pedicle screw fixation at S1. The effectiveness of anterior supplemental screw fixation for the prevention of anterior cage migration in oblique lateral interbody fusion (OLIF) at L5-S1 has not been studied.

Methods: Seventy-one consecutive patients who underwent OLIF at L5-S1 and had more than 1-year regular follow-up were included. In the first 35 cases, the anterior cage was fixed with pedicle screws only. In the remaining 36 cases, the anterior cage was fixed with an anterior supplemental screw and pedicle screws. IDA, anterior disc height (ADH), posterior disc height (PDH), cage migration, cage subsidence, and fusion rate at L5-S1 were compared.

Results: The mean anterior cage migration was 1.5 4 2.4 mm. Fifteen (21.1%) patients had an anterior cage migration of >2 mm and six (8.4%) patients had an anterior cage migration of >5 mm. All anterior cage migration occurred within postoperative 3 months follow-up. Anterior supplemental screw fixation showed less anterior cage migration (0.8 4 0.9 mm vs. 2.0 4 3.1 mm, $P < 0.001$). The IDA, ADH, PDH, cage subsidence, and fusion rate was similar regardless of anterior supplemental screw fixation (all $P > 0.05$).

Conclusions: An anterior supplemental screw fixation is simple, safe, and effective for the prevention of anterior cage migration in OLIF at L5-S1.

EP01-06

Adult Spinal Deformity

Defining Whole Spine Sagittal Alignment Parameters in Normal 3,666 Population Using Machine Learning

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Introduction: Defining normative values of these clinically relevant sagittal parameters are essential as they provide objective surgical indications when planning treatment and serve as optimal target values for surgical correction. In light of this importance, several studies have presented normative values and ideal surgical targets of sagittal spino-pelvic parameters. Schwab et al employed linear regression models to present threshold values of spino-pelvic parameters associated with Oswestry Disability Index (ODI) scores. The threshold of severe disability (ODI=40) was pelvic tilt (PT) = 22°, sagittal vertical axis (SVA) = 47mm, pelvic incidence minus lumbar lordosis (PI - LL) = 11°. Lafage et al proposed age-specific radiographical threshold values of PT, PI - LL, LL - thoracic kyphosis (TK), SVA, T1 pelvic angle (TPA) for moderate disability (ODI=20) and severe disability (ODI=40). The purpose of this study is to present the normal whole spine sagittal alignment parameters in normal population

Methods: Three thousand six hundred sixty-six patients aged more than 20 years old who had mild disability (MD, ODI of M 20 score) and who met the inclusion criteria were included in this study. Patients were stratified into age cohorts: 20s, 30s, 40s, 50s, 60s, 70s or older. Radiographic evaluation, including COC2 angle, COC7 angle, C27 angle, odontoid hip axis (OH), SVA, TK, LL, L4S1 angle, PT, TPA, PI-LL, sacral slope (SS), spino-sacral angle (SSA) were conducted on the whole spine standing radiographs.

Results: Among 3666 patients, there were 247 people in their 20s, 251 people in their 30s, 454 people in their 40s, 729 people in their 50s, 1075 people in their 60s, and 910 people in their 70s or older. The average COC2 angle, COC7 angle, C2C7 angle, OH, SVA, TK, LL, L4S1 angle, PT, TPA, PI-LL, SS and SSA for 20s were 23.5412.42, 34.72417.41, 14.05412.29, 9.22414.98 degrees, 25.22424.25 mm, 28.31415.07, 54.22417.21, 34.31416.66, 41.49433.58, 26.63439.97, -12.35436.74, 41.0349.75, 132.7149.75 degrees. Those of 30s were 25.1449.61, 36.18411.86, 13.6049.71, 6.42410.57 degrees, 22.01419.16 mm, 26.93411.28, 50.82413.91, 33.62410.93, 47.54421.92, 16.29428.63, -3.06423.42, 39.4547.92, 131.3047.79 degrees. Those of 40s were 24.449.80, 39.40414.06, 16.82411.89, 5.3748.13 degrees, 23.81423.88 mm, 30.58414.35, 48.84412.51, 34.17411.52, 48.66419.65, 14.23422.51, 0.03422.11, 38.6248.39, 129.7748.11 degrees. Those of 50s were 24.8249.40, 40.60412.26, 16.91410.68, 4.7846.84 degrees, 24.95425.23 mm, 30.43411.89, 48.46414.71, 32.86410.02, 50.14418.11, 14.61420.03, 1.66421.76, 37.2148.53, 128.3148.85 degrees. Those of 60s were 24.58410.43, 43.43412.81, 19.68411.51, 4.2945.68 degrees, 30.41428.18 mm, 32.05413.70, 46.56414.83, 31.44410.99, 51.77418.04, 18.64420.15, 5.24421.85, 35.4849.15, 124.8249.95 degrees. Those of 70s or older of were 24.6749.43, 45.13412.47, 21.24411.56, 4.345.36 degrees, 52.91444.01 mm, 31.14415.00, 41.02417.35, 30.62411.60, 53.81418.67, 24.84422.89, 12.77423.89, 34.09410.34, 120.12412.37 degrees. Except for the COC2 angle, changes in variables according to age were statistically significant. (P<0.05)

Conclusions: Through this study, whole spine sagittal alignment parameters according to age in a normal population were presented. COC7 angle, C2C7 angle, SVA, TK, PT, and PI-LL increased statistically significantly with age. OH, LL, L4S1 angle, TPA, SS, and SSA decreased statistically significantly with age. These parameters will be very helpful to doctors and patients performing spinal surgery.

EP01-07

Adult Spinal Deformity

Defining Spino-pelvic Alignment in Adult Population Over 60 Years Old: Prospective Analysis of 214 Volunteers**Sung Hyun Noh¹ and Yoon Ha^{2*}**¹ Neurosurgery, Ajou University Hospital, Korea² Neurosurgery, Yonsei University Hospital, Korea

Introduction: The values of the surgical target angle and ideal sagittal balance that have been published so far are the results of a study targeting patients over 18 years of age. However, most patients in adult spinal deformity surgery are currently in their 60s or older, and it is unreasonable to apply these values to patients in their 60s or older. The purpose of this study is to prospectively analyze adult patients to obtain the ideal sagittal balance value at age 60 or older.

Methods: A total of 214 people over the age of 60 participated in the study. Questionnaires related to HRQOL were administered. Spino-Pelvic parameters were measured by whole spine X-rays. Radiographical evaluation was conducted on the lateral planes and HRQOL questionnaires (Oswestry Disability Index [ODI]) were completed. Multivariate logistic regression analysis was conducted to analyze radiologic parameters related with ODI. Radiographical parameters demonstrating highest correlation with HRQOL values were evaluated to determine thresholds predictive of ODI more than 20.

Results: Two hundred fourteen consecutive patients (mean age, 71.3 yr) were enrolled. There were 131 people with an ODI value of less than 20 (Minimal-ODI group) and 83 people with an ODI value of 20 or more (Moderate-ODI group). Moderate-ODI group had greater pelvic tilt (PT) (28.413.7° vs 19.9413.9°, $P < 0.05$), greater T1 pelvic angle (T1PA) (33.6415° vs 23.7414.6°, $P < 0.05$), and greater pelvic incidence/lumbar lordosis PI/LL mismatch (PI-LL) (45.2430.7 vs 31.7436.1, $P < 0.05$) than Minimal-ODI group. Moderate-ODI group demonstrated greater disability on ODI measures compared with Minimal-ODI (ODI = 25.344.3 vs 11.845.4, $P < 0.05$). Pearson analysis demonstrated that among all parameters, PT, T1PA, and PI-LL correlated most strongly with disability for both Minimal-ODI and Moderate-ODI groups ($P < 0.001$). Logistic regression models demonstrated threshold radiographical spinopelvic parameters for ODI more than 20 to be: PT 15° or more (area under curve (AUC) = 0.820), T1PA 17° or more (AUC = 0.888), PI – LL 16° or more (AUC = 0.842).

Conclusions: As you age, degenerative changes progress. Prospective analysis of consecutively enrolled age 60 or older patients proved that PT, T1PA, and PI-LL can predict patient disability and provide evaluation guides for appropriate treatment decisions. Threshold values for moderate disability (ODI > 20) included: PT 15° or more, T1PA 17° or more, and PI – LL 16° or more.

EP01-08

Adult Spinal Deformity

Surgical Sequence in Anterior Column Realignment with Posterior Osteotomy Is Important for Correction Degree of Adult Spinal DeformityYong-Chan Kim^{1*}, Sung-Min Kim¹, Kee-Yong Ha¹, Xiongjie Li¹ and JunBum Park¹¹ Orthopaedic Surgery, Kyung Hee University Hospital at Gangdong, Kyung Hee University, Seoul, Korea

Background: Greater adult spinal deformity correction has been achieved by ACR with posterior-based osteotomies. However, it is unclear when, if ever, a pre-ACR posterior osteotomy is necessary for adult spinal deformity correction. We aimed to determine if pre-anterior column realignment (ACR) posterior osteotomy allows for greater change of spinopelvic parameters following adult spinal deformity correction and to find what a better indication is.

Materials and Methods: 219 patients (184 women and 35 men) underwent ACR with posterior instrumentation for adult spinal deformity. 41 patients (AP group) underwent an anterior-posterior surgical sequence without a pre-ACR posterior osteotomy, and 178 patients (PAP group) underwent a posterior-anterior-posterior sequence with a pre-ACR posterior osteotomy. Pre- and postoperative free-standing sagittal radiographs were obtained and measured standard spinopelvic sagittal parameters. Comparisons between two groups were analyzed and also investigation within AP group were performed.

Results: The PAP group showed significantly higher changes in C7 sagittal vertical axis (C7SVA; 201.9mm vs 148.1mm, $P < 0.05$), thoracolumbar kyphosis (TLK; 20.4° vs 10.3°, $P < 0.05$), lumbar lordosis (LL; 56.9° vs 39.9°, $P < 0.05$), motion segmental angle (L2-3; 18.4° vs 9.1°, L3-4; 14.8° vs 9.4°, L4-5; 14.8° vs 11.5°, $P < 0.05$), and pelvic tilt (PT; 31.3° vs 20.4°, $P < 0.05$) compared to the AP group. The patients with less correction ($> 10^\circ$ in PI-LL mismatch) in AP group had moderate to severe grading scale of facet joint arthritis, severe osteoporosis, and $< 10^\circ$ of flexibility in more than 80%.

Conclusions: PAP sequence may provide the greater correction of lumbar lordosis due to higher change of motion segmental angle, compared to AP sequence. Especially, we suggest this surgical sequence for severe facet joint arthritis, severe osteoporosis, and rigid lumbar curve.

EP01-09**Adult Spinal Deformity****The Criteria of Severe Dynamic Sagittal Imbalance in Adult Spinal Deformity and Its Importance****Yong-Chan Kim^{1*}, Sung-Min Kim¹, Kee-Yong Ha¹, Xiongjie Li¹ and JunBum Park¹**¹ Orthopaedic Surgery, Kyung Hee University Hospital at Gangdong, Kyung Hee University, Seoul, Korea

Background: There is no study about the evaluation for severity of dynamic sagittal imbalance (DSI) of adult spinal deformity patients. we aimed to analyze characteristics of patients with "severe" DSI in adult spinal deformity and establish a criteria for them.

Materials and Methods: One hundred two ASD patients with sagittal imbalance and 4 cardinal signs of lumbar degenerative kyphosis (LDK) were retrospectively analyzed. All patients undergone spine surgery for deformity correction and were divided into 3 groups according to a diagnostic criteria. The criteria was based on Oswestry Disability Index (ODI) scores and dynamic feature (Timewalk: Time until C7SVA reaches 20cm or more after starting walking) of sagittal imbalance. The quality and quantity of paravertebral back muscles were analyzed and compared by using T2-weighted axial images in the Picture Archiving and Communication System (PACS) viewing software. We performed statistically time-dependent spinopelvic sagittal parameters analysis in the full standing lateral radiographs. The lumbar flexibility of patients was also analyzed based on dynamic (flexion and extension) lateral lumbar radiographs: rigid, less than 10°; not rigid, 10° or more.

Results: Under the diagnostic criteria, 102 patients could be classified into three groups: Mild (Timewalk U 3 min, 35 patients), Moderate (3 min > Timewalk U 30s, 38 patients) and Severe (30s > Timewalk, 29 patients). There was significantly higher signal intensity (533.44237.5, P<0.001) and larger area of fat infiltration (35.245.4, P<0.001) in back muscles of severe group than in those of mild group (223.8467.6/22.9411.9) and moderate group (294.44214.7/21.6410.6). Also, the analysis of lumbar flexibility revealed significantly lower value in severe group than in mild and moderate group. Severe group had significantly larger lumbar kyphosis (LL, 26.1°422.7°, P<0.05), higher pelvic incidence (PI, 60.4°410.7°, P<0.05) and PI-LL (86.5°426.6°, P<0.05) than mild group (5.2°416.3°/52.9413.2°/58.7°418.8°) and moderate group (13.7°428.6°/53.5412.4°/66.6°413.4°). PI-LL was statistically significant with AUC = 0.810 (95% CI, 0.666-0.954) when the baseline was set at 75.3°. Severe group showed more perioperative complications, less immediate postoperative correction of LL, and loss of sagittal balance achieved by immediate postoperative than other groups.

Conclusions: We suggest a criteria of severe dynamic sagittal imbalance in adult spinal deformity. First, C7SVA becomes greater than 20cm within 30 seconds after walking or standing. And second, Rigid lumbar curve less than 10° in dynamic lateral radiographs. And Third, PI-LL mismatch is more than 75.3°.

EP01-10

Adult Spinal Deformity

Surgical Strategy-oriented Classification for the Patients with Severe Dynamic Sagittal ImbalanceYong-Chan Kim^{1*}, Sung-Min Kim¹, Kee-Yong Ha¹, Xiongjie Li¹ and JunBum Park¹¹ Orthopaedic Surgery, Kyung Hee University Hospital at Gangdong, Kyung Hee University, Seoul, Korea

Background: A concept, dynamic sagittal imbalance (DSI) was reported a dynamic feature in patients with degenerative flatback for the first time. There have been several studies on the diagnosis of DSI or its features. However, there have been no studies on surgical strategies for optimal outcomes in patients with severe DSI. Aim. To analyze the characteristics of the patients with severe dynamic sagittal imbalance, develop a comprehensive classification, and raise optimal surgical strategy for each condition.

Methods: Prospectively, 193 patients with a mean age of 65.2 years (62-84 years) from 2017 to 2019 were tracked after surgical treatment for severe dynamic sagittal imbalance that was defined as C7SVA becomes greater than 20cm within 30 seconds after walking or standing in addition to rigid lumbar curve less than 10° in dynamic lateral radiographs and more than 75.3° of PI-LL in previous our study. The characteristic is mainly based on radiographic findings. It is classified according to three criteria: the location of the apex, depending on combined compression fracture and stiffness of apex segment. The receiver operating characteristic (ROC) curves were plotted to evaluate the cut-off value of compression rate (CR) of vertebral body. The patients were categorized into 1 of three groups according to the surgical strategy (anterior column realignment, ACR; posterior spinal fixation, PSF; pedicle subtraction osteotomy, PSO) implemented: ACR+ PSF, ACR+PSO+PSF, PSO+PSF. Time-dependent radiographic analysis with spinopelvic sagittal parameters from each group was assessed and compared with each other using ANOVA.

Results: The patients with severe dynamic sagittal imbalance can be mainly divided into 2 types according to the location of the apex: Type I (thoracolumbar; T12, L1, or L2), Type II (lumbar; L3, L4, or L5), and the following modifiers were identified as potentially influencing the choice of surgical strategy: A; CR M 60% in thoracolumbar or M 30% in lumbar and B; > 60% in thoracolumbar or > 30% in lumbar based on the cut-off value of CR of vertebral body (95% CI, P<0.001) and rigid or fused of apex segment (-, or +). Either Type I or Type II is further divided into four subtypes: Type IA-, Type IA+, Type IB-, Type IB+, Type IIA-, Type IIA+, Type IIB-, and Type IIB+. A surgical strategy was proposed to deal with each situation combining the different patterns and their modifiers by an expert's opinion consensus. At final follow-up, C7SVA (P=0.121), lumbar lordosis (LL) (P=0.665), and pelvic tilt (P=0.096), and PI-LL mismatch (P=0.701) were similar among three groups according to surgical strategy.

Conclusions: This surgical strategy-oriented classification can be used effectively to decide preoperative surgical planning for the patients with severe dynamic sagittal imbalance. Further research may be needed to validate the classification.

EPO1-11

Adult Spinal Deformity

Analysis of the Cement Distribution Pattern and Other Risk Factors That Affect the Incidence of Recompression Fractures of Vertebral Bodies after Vertebroplasty or KyphoplastySiyeon Kim*Department of Orthopaedic Surgery, Gachon University Gil Medical Center, Korea*

Introduction: With the increasing incidence of recompression fractures after vertebroplasty or kyphoplasty, this study analyzed the risk factors that affect the occurrence of recompression vertebral fractures, such as cement distribution, existence of avascular necrosis (Kummell's disease), type of procedures, bone mineral density, sex, and age.

Methods: Two hundred and thirty-eight patients who underwent vertebroplasty or kyphoplasty at the author's clinic from 2005 to 2015 were enrolled in this study. The patients were divided into four groups according to the distribution of injected cement. The patients were classified as type 1 and type 2 when injected cement was contacted only to the upper or lower endplate of the body respectively. They were classified as type 3 when both the upper and lower endplates were contacted by injected cement. When neither the upper nor the lower endplate was contacted, the patients were called type 4. This study statistically evaluated the effects of the risk factors, including the cement distribution on the incidence of recompression vertebral fracture after vertebroplasty or kyphoplasty.

Results: There were 59 cases (24.8%) of recompression fracture after vertebroplasty or kyphoplasty, among the 238 cases. According to the analysis, the recompression of the vertebral body after vertebroplasty or kyphoplasty occurred more often when the compression fracture was accompanied by osteonecrosis at the body ($p < 0.05$). The patients who had injected cement distributed at both upper and lower plate simultaneously (type 3) had a lower incidence of recompression fracture of the vertebral body after vertebroplasty or kyphoplasty ($p = 0.008$). In addition, the kyphoplasty group had a lower incidence of recompression after the procedure than vertebroplasty group ($p = 0.02$).

Conclusions: Careful attention should be given to these patients with osteonecrosis at the compression fracture level through preoperative evaluation. In addition, if the injected cement does not contact both the upper and lower endplates, careful observation is required during the follow-up period based on the high incidence of vertebral recompression fractures proven through this study. Further technical and biomechanical research and efforts will be needed to make the cement contact both endplates.

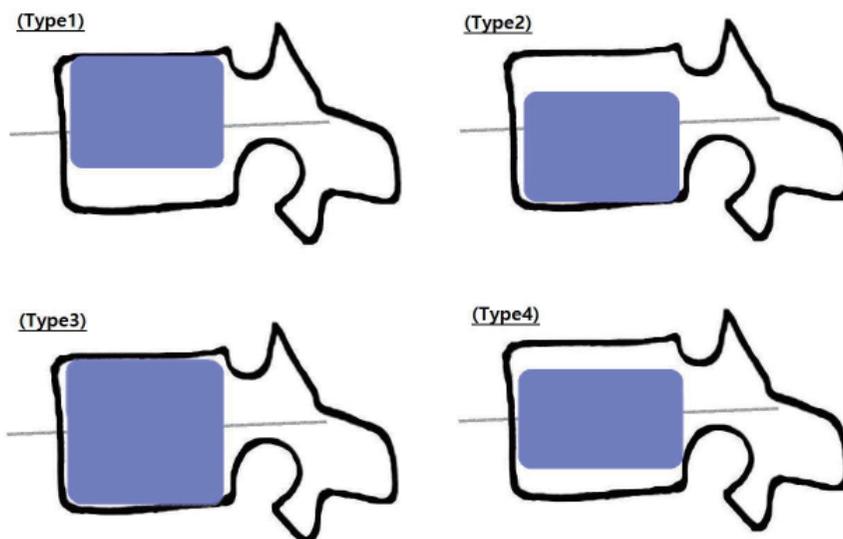


Fig. 1 Schematic drawing image of cement distribution type 1~4. (Type 1 – upper plate contact, Type 2 – lower plate contact, Type 3 – upper & lower plate contact, Type 4 – middle portion of vertebral body.)

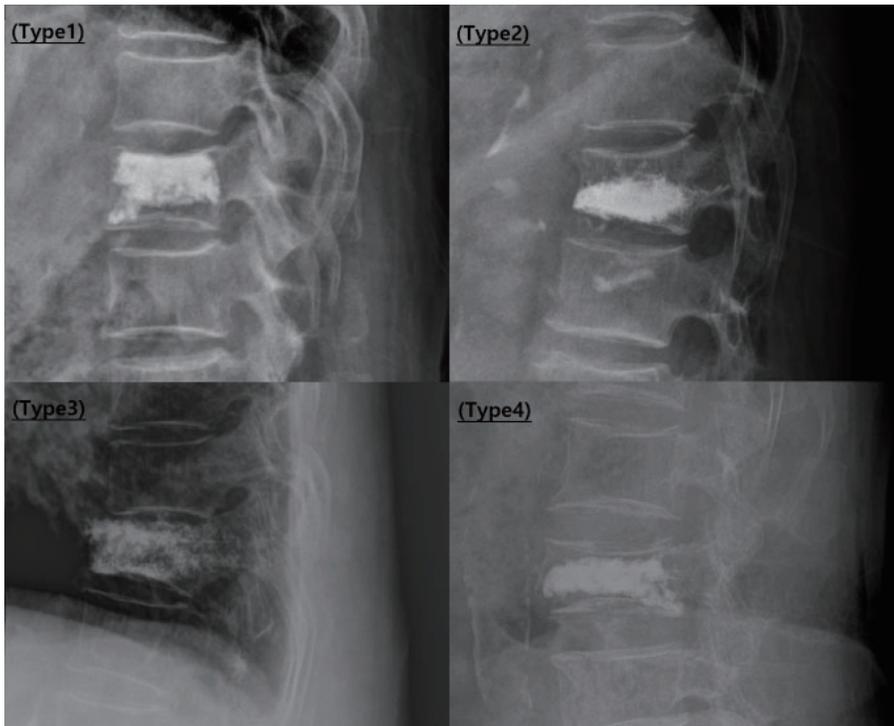


Fig.2 Cement distribution type 1~4 example cases.

	Recomp Fx (X) n=179 (mean ±SD)	Recomp Fx (O) n=59 (mean ±SD)	Total n= 238 (mean ±SD)	p-value
Sex (M/F)	18 / 161	8 / 51	26 / 212	0.454
Age	68.03 ±12.340	72.19 ±9.170	69.1±11.755	0.220
BMD (T-score)	-3.403 ±1.025	-3.334 ±0.9787	-3.386±1.012	0.709
Fracture level (T / TL junction / L)	58 / 62 / 59	16 / 17 / 26	74 / 79 / 85	0.304
Intra-discal cement leakage (X/O)	165 / 14	55 / 4	220 / 18	0.793
Cement volume (cc)	4.949 ±1.630	5.254 ±1.7294	5.025±1.657	0.330
Follow up duration (year)	6.637 ±2.8049	6.254 ±2.8229	6.542±2.8083	0.968
Follow up duration (year)	6.637 ±2.8049	6.254 ±2.8229	6.542±2.8083	0.968

Table 1. Result of the effect evaluation of factors on recompression fracture after VP or KP

(Recomp Fx - Recompression fracture, SD - standard deviation, BMD - Bone marrow density)

	Recomp Fx (X)	Recomp Fx (O)	Total
Kummell's disease (X)	175 (78.8%)	47 (21.2%)	222 (100%)
Kummell's disease (O)	4 (25%)	12 (75%)	16 (100%)
Total	179 (75.2%)	59 (24.8%)	238 (100%)
p-value < 0.001			

Table 2 Correlation between kummell's disease and recompression fracture after VP or KP

	Recomp Fx (X)	Recomp Fx (O)	Total
KP	137 (79.2%)	36 (20.8%)	173 (100%)
VP	42 (64.6%)	23 (35.4%)	65 (100%)
Total	179 (75.2%)	59 (24.8%)	238 (100%)
p-value : 0.020 < 0.05			

Table 3 Incidence of recompression fracture according to procedure type (VP or KP)

(VP - Vertebroplasty, KP - Kyphoplasty)

	Recomp Fx (X)	Recomp Fx (O)	Total
Cement distribution type 1 upper plate touch (X)	142 (77.6%)	41 (22.4%)	183 (100%)
Cement distribution type 1 upper plate touch (O)	37 (67.3%)	18 (32.7%)	55 (100%)
p-value : 0.120 > 0.05			
Cement distribution type 2 lower plate touch (X)	137 (76.5%)	42 (23.5%)	179 (100%)
Cement distribution type 2 lower plate touch (O)	42 (71.2%)	17 (28.8%)	59 (100%)
p-value : 0.409 > 0.05			
Cement distribution type 3 upper&lower plate touch (X)	103 (69.1%)	46 (30.9%)	149 (100%)
Cement distribution type 3 upper&lower plate touch (O)	76 (85.4%)	13 (14.6%)	89 (100%)
p-value : 0.005 < 0.05			
Cement distribution type 4 middle of vertebra body (X)	153 (76.1%)	48 (23.9%)	201 (100%)
Cement distribution type 4 middle of vertebra body (O)	26 (70.3%)	11 (29.7%)	37 (100%)
p-value : 0.449 > 0.05			
Total	179 (75.2%)	59 (24.8%)	238 (100%)

Table 4 The number of occurrence of recompression fracture after VP or KP according to cement distribution type.

EP01-12**Adult Spinal Deformity****Posterior Thoracic Interbody Fusion - When Is It Useful****Lee Min-Gyu***Orthopaedics, Keimyung University Dongsan Hospital, Korea*

Authors and Institution: Eun-Seok Son, Hyuk-Joon Sohn, Min-Gyu Lee

Background: Posterior thoracic interbody fusion (PTIF) technique is not commonly used procedure difficult procedure. 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.

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. 6 patients had disc pathology, 6 had proximal junctional kyphosis. 4 patients had infectious pathology, and 1 patient had OPLL. Excluding short term follow up data, every patients maintain successful bone fusion quality confirmed by follow up X-ray or CT if available. Patients who had neurologic symptoms before surgery, every patients experienced improvement in neurologic status like gait disturbance, motor weakness and tingling paint, etc. The level of operation were T12-L1 in 6 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.

Conclusions: Posterior interbody fusion in thoracic spine can be successful in patients who have thoracic disc herniation, proximal junction kyphosis, infectious thoracic disease and OPLL. Therefore, PTIF can be satisfactory surgical treatments of choice for thoracic decompression and fixation surgery.

EP01-13

Adult Spinal Deformity

Sagittal Parameters of Spine and Pelvis in Young Adults Using the Eos Imaging System: Prospective Study of 92 Asymptomatic Subjects**Min-Gu Jang¹, Sang Bum Kim¹ and Byounggu Lee¹**¹ orthopedics, Konyang university hospital, Korea

Study Design: This study adopted a prospective study design to evaluate the sagittal parameters of the spine and pelvis in young adults using the EOS imaging system.

Purpose: This study was designed to analyze spinopelvic sagittal alignment measurement values obtained using the EOS imaging system in asymptomatic young adults.

Overview of Literature: Sagittal alignment of the spine and pelvis is important in diagnosing and treating spinal diseases. We usually take sagittal images using whole-spine standing lateral radiography. Recently, the EOS imaging system, which uses a low-dose radiation in a weight-bearing state, was developed. So, we studied the sagittal parameters of the spine and pelvis in young adults by using the EOS imaging system.

Methods: We recruited young adults aged 20–30 years and explained the EOS imaging system. They voluntarily participated in the study. We took full-body standing orthogonal anteroposterior and lateral images using the EOS imaging system (EOS imaging, Paris, France). Then, we measured the pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), sagittal vertical axis (SVA), T1/T12 kyphosis, and L1/S1 lordosis. We analyzed each parameter using Student t-test, paired t-test, and Pearson's correlation coefficient.

Results: Ninety-two patients were enrolled in the study. The average PI and SS were 47.18° and 36.03°, respectively. Moreover, PT and SVA were 11.17° and -10.15 mm, respectively. T1/T12 kyphosis was 37.37°, while L1/S1 lordosis was 46.64°. All parameters were enough for normal distribution. Pearson correlation coefficient analysis showed a meaningful correlation between PI and SS and PI and PT ($R > 0.6$, $p < 0.05$).

Conclusions: Measuring spinal and pelvic sagittal values is important. Sagittal parameters could help decide how to operate patients with spinal diseases. We attempted to obtain sagittal values using the EOS imaging system. These parameters could help preoperatively estimate the lumbar lordosis restoration and could also be used as guidelines for spinopelvic sagittal balance.

Keywords: Spine; Pelvis; Whole body imaging; Postural balance

EP01-14**Adult Spinal Deformity****Surgical Treatment of Kimmerle Anomaly: Early Research Results****Mansur Aliev¹, Khulkar Kholmurodova² and Odilbek Kholmurodov²**

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Purpose: to analyze the early results of the effectiveness of surgical treatment of patients with Kimmerle anomaly.
Materials and methods: The results of the examination of 75 patients (58 women - 77.3% and 17 men - 22.67%) with diagnosed Kimmerle anomaly aged 22 to 64 years, for the period from 2021 to 2023, were analyzed. For the analysis, the data of anamnesis, clinical and neurological examination, the results of radiation diagnostics of ultrasound dopplerography and multispinal computed tomography with 3-D reconstruction of the craniovertebral junction in the pre and postoperative period were used.

Results: The following forms of Kimmerle's anomaly were detected on MSCT: not an overgrown ring (n=21; 28%), not overgrown arches (n=31; 41.3%) and not an overgrown bone bridge (n=23; 30.7%). Unilateral anomaly was detected in 58 (77.3%) patients, 29.4% of them on the right side and 70.6% on the left side. Bilateral Kimmerle anomaly was found in 17 (22.7%) patients. As a result of the analysis of anamnesis data and clinical neurological examination, four main symptom complexes associated with Kimmerle's anomaly were identified: paroxysmal circulatory disorders in the vertebral arteries (in 20 patients, 26.67%), cephalgic syndrome (in 25 patients, 33.33%), vertebrobasilar syndrome (dizziness, nausea, tinnitus) (in 22 patients, 29.33%) and radicular syndrome (in 8 patients, 10.67%). The method of surgical treatment of Kimmerle's anomaly included surgical removal of the anomaly and restoration of the anatomical structure of the spinal column. Postoperative data: after surgery, all patients had no complications. The patients were monitored for 2 weeks after surgery, and the results were evaluated based on clinical examinations, anamnesis and additional research methods, such as radiation diagnostics (ultrasound Dopplerography) and multispinal computed tomography (MSCT) with 3-D reconstruction of the craniovertebral junction. In all patients, complete restoration of the anatomical structure of the vertebral column was noted after removal of the Kimmerle anomaly. The symptom complexes associated with Kimmerle's anomaly significantly decreased in the postoperative period, for example: paroxysmal circulatory disorders in the vertebral arteries were observed in 8 patients (10.67%), cephalgic syndrome - 13 (17.33%), vertebrobasilar syndrome - 6 (8%) and radicular syndrome - 3 (4%). In general, the results of surgical treatment of Kimmerle's anomaly in patients who underwent MSCT and subsequent surgery indicate positive results.

Conclusion: Removal of the bone bridge allowed the free flow of blood through the vertebral artery and completely eliminated the symptoms associated with this anomaly. Early detection and surgical treatment of this disease are extremely important to prevent circulatory insufficiency and improve the patient's quality of life.

EP01-15**Adult Spinal Deformity****Risk Factor Analysis of Distal Junctional Failure after Long Level Posterior Cervical Surgery and Instrumentation****Donghun Kim¹, Jaetaek Hong^{1*}, Jungwoo Hur¹ and Wonsur Choi²**¹ Department of neurosurgery, Eunpyeong St. Mary's Hospital, Korea² Department of neurosurgery, Naeun International Hospital, Korea

While risk factors for proximal junctional kyphosis have been well-studied, research on predictive factors for DJF, particularly in the cervical spine, is still lacking. Therefore, understanding these risk factors well before surgery can help in planning the surgery and reducing postoperative risk. Therefore, this study aimed to investigate the radiological outcomes and identify potential risk factors for distal junctional failure (DJF) in patients who underwent long level posterior cervical fusion surgery. A total of 181 patients were included in the study, and the DJF group consisted of 34 patients, while the non-DJF group consisted of 147 patients.

In the demographic data, there were no statistically significant differences between the two groups. However, in the surgical data, the DJF group had a higher mean number of fused levels compared to the non-DJF group (6.15 \pm 1.70 vs 5.50 \pm 1.41, $p=0.0001$). In the radiographic data, the postoperative C2 slope was higher in the DJF group compared to the non-DJF group (18.91 \pm 13.04 vs 15.20 \pm 10.59, $p=0.037$), while the preoperative T1 slope and cervical lordosis were higher in the non-DJF group compared to the DJF group (26.41 \pm 9.89 vs 21.68 \pm 8.92, $p=0.047$; 7.97 \pm 11.81 vs 2.29 \pm 13.98, $p=0.004$, respectively). The difference values between the two groups showed that the DJF group had significantly higher T1 slope (6.20 \pm 8.15 vs -0.11 \pm 8.74, $p=0.0002$) and cervical lordosis (7.23 \pm 10.25 vs 1.86 \pm 11.76, $p=0.0151$) compared to the non-DJF group. Overall, the most frequent LIV level was C7, followed by C6 and C5. In the DJF group, the most frequent levels were C7, T2, and T1, while in the non-DJF group, the most frequent levels were C6, C7, and C5. Regarding disease type, the proportion of patients with deformity and cerebral palsy was higher in the DJF group than in the non-DJF group, with percentages of 26.5% vs 4.8% ($p=0.0001$) and 17.7% vs 6.1% ($p=0.027$), respectively. Hounsfield units showed a weak positive correlation with BMD T-score, and preoperative HU values at LIV and LIV+1 were higher in the non-DJF group than in the DJF group, with values of 223.86 \pm 103.13 vs 217.82 \pm 91.24 ($p=0.006$) and 192.2 \pm 53.82 vs 170.2 \pm 37.62 ($p=0.033$), respectively, which were limited to the axial plane measurement.

The study found that overcorrection of cervical lordosis (CL) and T1 slope may be associated with a higher risk of DJF, while a greater C2 slope may lead to sagittal imbalance. Additionally, the study identified lower Hounsfield unit values of LIV and LIV+1 in the axial plane as a potential risk factor for DJF. However, the study has several limitations due to its retrospective design, lack of consideration of clinical data and patient-reported outcome measures, and limited follow-up period. Nonetheless, these findings can help clinicians plan surgeries and reduce postoperative complications in patients undergoing long level posterior cervical fusion surgery.

E-POSTERS



BIOLOGICS

EPO2-01

Biologics

Which Model Is Advantageous for Observing Apoptosis or Autophagy, Saline Injection, or External Fixator in Intervertebral Disc Degeneration?

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Purpose: 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. 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's disc degeneration.

Methods: Sixteen, nine-week-old male Sprague-Dawley rats were treated with 0.9% saline and EF (two-cross Kirschner wires) for six and twelve weeks. In intervertebral disc degeneration, treated discs were dissected to identify the role of autophagy and apoptosis. H&E staining, Masson's trichrome staining, and immunohistochemistry (IHC) for LC3, beclin-1, and P62, as well as MMP-2, MMP-3, and TIMP-1, were used. Furthermore, we conducted real-time polymerase chain reaction (RT-PCR) to observe autophagy-related gene expression (beclin-1, LC3, and P62) and apoptosis-related gene expression (MMP-2, MMP-3, and TIMP-1).

Results: 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. However, the SI group could not recognize the boundary between NP and AF cells. The EF group showed the highest autophagy-related gene expression, whereas the SI group showed lower expression. In addition, the EF group showed more autophagy-accumulating materials than the SI group, which elevated with increasing compression duration. Furthermore, the SI group induced the highest apoptotic gene expression, but the EF group showed the lowest expression.

Conclusion: The EF model was advantageous for studying autophagy and apoptosis because it enhanced rat tail's disc degeneration after compression, which is actively linked to autophagy and apoptosis. The external fixator elevated the degeneration process by increasing the compression duration, but SI could not distinguish AF and NP cell margins.

E-POSTERS



CERVICAL DEGENERATIVE

EP03-01

Cervical Degenerative

Cervical Kinematic Change after Posterior Full-endoscopic Cervical Foraminotomy for Disc Herniation or Foraminal Stenosis**Chi Heon Kim^{1*}, Seungyoon Paik¹ and YoungRak Kim¹**¹ Neurosurgery, Seoul National Univeristy Hospital, Korea

Objective: Posterior full-endoscopic cervical foraminotomy (PECF) is one of minimally invasive surgical techniques for cervical radiculopathy. Because of minimal disruption of posterior cervical structures, such as facet joint, cervical kinematics was minimally changed. However, a larger resection of facet joint is required for cervical foraminal stenosis (FS) than disc herniation (DH). The objective was to compare the cervical kinematics between patients with FS and DH after PECF.

Methods: Consecutive 52 patients (DH, 34 vs. FS, 18) who underwent PECF for single-level radiculopathy were retrospectively reviewed. Clinical parameters (neck disability index, neck pain and arm pain), and segmental, cervical and global radiological parameters were compared at postoperative 3, 6, and 12 months, and yearly thereafter. A linear mixed-effect model was used to assess interactions between groups and time. Any occurrence of significant pain during follow-up was recorded during a mean follow-up period of 45.5 months (range 24-113 months).

Results: Clinical parameters improved after PECF, with no significant differences between groups. Recurrent pain occurred in 6 patients and surgery (PECF, anterior discectomy and fusion) was performed in 2 patients. Pain-free survival rate was 91% for DH and 83% for FS, with no significant difference between the groups ($P = 0.29$). Radiological changes were not different between groups ($P > 0.05$). Segmental neutral and extension curvature became more lordotic. Cervical curvature became more lordotic on neutral and extension X-rays, and the range of cervical motion increased. The mismatch between T1-slope and cervical curvature decreased. Disc height did not change, but the index level showed degeneration at postoperative 2 years.

Conclusion: Clinical and radiological outcomes after PECF were not different between DH and FS patients and kinematics were significantly improved. These findings may be informative in a shared decision-making process.

EP03-02

Cervical Degenerative

Establishing a Relationship Using CT between Facet Distraction and Clinical Outcomes after ACDF**JooYoung Lee¹, Dong-Ho Lee^{2*} and HyungRae Lee³**¹ Orthopedic Surgery, Dong-A Medical Center, University of Dong-A College of Medicine, Busan, Korea² Orthopedic Surgery, Asan medical center, Korea³ Orthopedic Surgery, Uijeongbu Eulji Medical Center, Korea

Background: Anterior cervical discectomy and fusion (ACDF), the gold standard treatment for radiculopathy and myelopathy, has the potential risk of inducing facet-mediated pain through over-distraction. However, the relationship between the clinical outcomes and facet distraction after ACDF remains unclear. Therefore, this study aimed to measure facet distraction using computed tomography (CT) and compare the results with clinical outcomes.

Methods: This was a retrospective cohort study. Patients (n=144) who underwent a single-level ACDF were included. Each patient underwent plain radiography of the lateral cervical spine preoperatively, immediately and 2years post-surgery. CT was performed preoperatively, and at 3days and 1year post-surgery. The inter-facet distance was measured at each time point, and changes in values from the preoperative distance were noted and used for study. Patient-reported outcome measures were obtained preoperatively and at 2year follow-up. Receiver operating characteristic (ROC) curves were generated to derive the critical facet distraction point.

Results: The neck pain VAS score (VASn) showed a tendency to decrease during the follow-up period, and VASn at 3weeks postoperatively (4.81 4 2.11) was most severe. There was a significant positive correlation between facet distraction measured using CT 3days postoperatively and VASn 3 weeks postoperatively (Fig.1, Spearman's correlation coefficient: 0.703, P<.001). Facet distraction measured using radiography showed less correlation with VASn at all time points than CT. An ROC curve analysis showed that the cut-off value of Δ facet distraction was 1.8 mm for VASn U 4 (AUC = 0.901, sensitivity = 87%, specificity = 81%) (Fig. 2). Based on the cut-off value of Δ facet distraction of 1.8 mm, the patients were divided into Group C (Control group; Δ facet distraction <1.8 mm, n = 69) and Group O (Over-distraction group; Δ facet distraction \geq 1.8 mm, n = 75). Group O showed significant worse clinical outcomes than Group C, including neck and arm pain VAS scores at all time points until the final 2year follow-up (Table 1).

Conclusions: The change value of facet distraction measured using CT rather than plain radiography correlated better with neck pain, and over-distraction contributed to adverse long-term outcomes, including neck and arm pain after ACDF. Additionally, an over-distraction of \geq 1.8 mm may cause radiculopathy of adjacent segments along with facet-mediated axial pain; therefore, cage height should be carefully determined to avoid over-distraction during ACDF.

Table 1. Comparison of clinical outcomes between Groups O and C.

	Group C (Δ facet distraction <1.8 mm)	Group O (Δ facet distraction ≥1.8 mm)	P-value
VASn 3w	2.41 ± 1.14	5.03 ± 2.01	<.001*
VASn 6w	1.29 ± 1.28	3.40 ± 2.01	<.001*
VASn 3m	2.49 ± 2.07	4.69 ± 2.42	<.001*
VASn 6m	1.84 ± 1.49	3.08 ± 1.54	<.001*
VASn 1y	1.00 ± 1.49	2.15 ± 1.59	<.001*
VASn 2y	0.62 ± 0.78	1.01 ± 0.85	.005*
VASa 3w	3.29 ± 1.93	4.23 ± 1.91	.002*
VASa 6w	2.78 ± 1.58	3.52 ± 1.83	.011*
VASa 3m	2.61 ± 1.80	4.11 ± 2.43	<.001*
VASa 6m	2.14 ± 2.11	2.96 ± 2.33	.036*
VASa 1y	1.61 ± 1.59	3.37 ± 2.10	<.001*
VASa 2y	0.91 ± 0.80	1.48 ± 0.87	<.001*

O, Over-distraction; C, control; w, weeks after surgery; m, months after surgery; y, year after surgery; VASn, visual analog scale score of neck pain; VASa, visual analog scale score of arm pain;

*P<0.05, Mann–Whitney U test

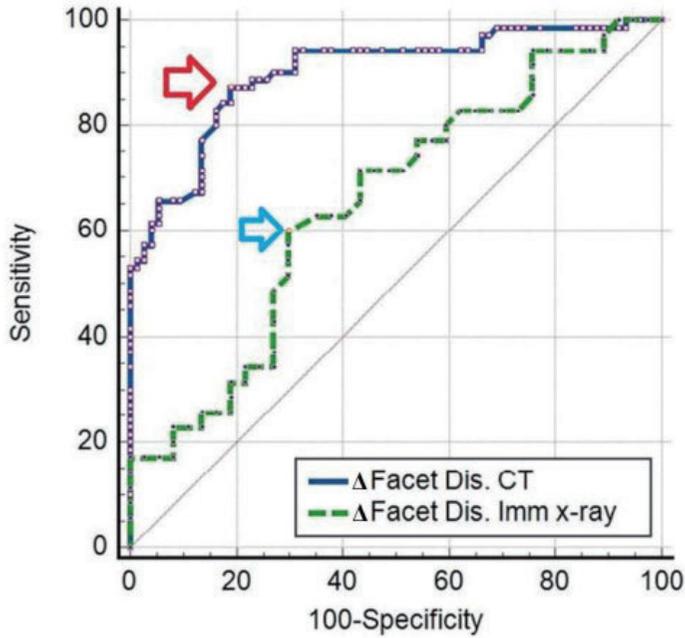
Figure 1. Results of correlation between the neck pain visual analogue scale score and Δ facet distraction measured using CT and radiography after ACDF.

		VASn 3w	VASn 6w	VASn 3m	VASn 6m	VASn 1y	VASn 2y
ΔFacet Dis. 3d CT	Correlation coefficient	0.703	0.586	0.507	0.442	0.322	0.201
	P-value	<.001*	<.001*	<.001*	<.001*	<.001*	0.01*
		VASn 3w	VASn 6w	VASn 3m	VASn 6m	VASn 1y	VASn 2y
ΔFacet Dis. Imm. x-ray	Correlation coefficient	0.275	0.307	0.237	0.141	0.172	0.195
	P-value	<.001*	<.001*	.003*	.110	.054	.029*
		VASn 3w	VASn 6w	VASn 3m	VASn 6m	VASn 1y	VASn 2y
ΔFacet Dis. 3m x-ray	Correlation coefficient	0.225	0.341	0.145	0.131	0.024	0.023
	P-value	.004*	<.001*	.112	.120	.464	.452
		VASn 3w	VASn 6w	VASn 3m	VASn 6m	VASn 1y	VASn 2y
ΔFacet Dis. 6m x-ray	Correlation coefficient	0.257	0.418	0.125	0.140	0.120	0.152
	P-value	.003*	<.001*	.191	.110	.137	.107

Dis., distraction; Imm, immediately after surgery; d, days after surgery; w, weeks after surgery; m, months after surgery; y, year after surgery; VASn, visual analog scale score of neck pain; CT, computed tomography; ACDF, anterior cervical discectomy and fusion.

*P<0.05, Spearman's correlation coefficient rank: green – high, purple – moderate, blue – low, and yellow – low

Figure 2. ROC curve analysis for the cut-off value of Δ facet distraction measured using plain radiography and CT after ACDF for a neck pain VAS score ≥ 4 . The cut-off value (red arrow) for Δ facet distraction measured using CT was 1.8 mm, AUC was 0.901, and the sensitivity and specificity were 87.14 and 81.08, respectively. Additionally, the cut-off value (blue arrow) for Δ facet distraction measured immediately after surgery using plain radiography was 2.56 mm, AUC was 0.654, and the sensitivity and specificity were 60.00 and 70.27, respectively.



Dis., distraction; ROC, receiver operating characteristic; AUC, area under curve; VAS, visual analog scale; Imm, immediately after surgery; CT, computed tomography.

EP03-04

Cervical Degenerative

Does Posterior Cord Compression by Ligamentum Flavum Adversely Affect Clinical Outcome of Anterior Cervical Discectomy and Fusion?Sehan Park¹, Dong-Ho Lee^{1*}, Chang Ju Hwang¹ and Jae Hwan Cho¹¹ Department of Orthopedic Surgery, Asan Medical Center, University of Ulsan College of Medicine, Korea

Backgrounds: Anterior cervical discectomy and fusion (ACDF) achieves cord decompression by removing anterior compressive lesions including disc, bone spurs and ossification of posterior longitudinal ligament. However, combined posterior compressive lesions such as ligamentum flavum buckling or hypertrophy cannot be assessed with anterior approach. While ACDF generally results in favorable outcomes for the treatment of cervical myelopathy, it has not been reported whether posterior cord compression by ligamentum flavum could adversely affect clinical outcomes of ACDF. If remaining posterior compression hinders clinical improvement after ACDF, combined posterior approach or single stage posterior operation should be considered. Therefore, the present study was conducted to demonstrate clinical implications of posterior cord compression by ligamentum flavum in ACDF.

Methods: A total of 195 consecutive patients who underwent ACDF and were followed-up for >2 years were retrospectively reviewed. Ligamentum flavum cord compression (LFC) was graded in 0-2 scale as demonstrated in Figure 1. Patients with LFC grade 2 were classified as LFC group, while patients with LFC grade 0-1 were classified as no-LFC group. Patient characteristics, cervical sagittal parameters, neck pain visual analogue 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-LFC group, while remaining 28 patients (14.4%) were included in the LFC group. Among patients in the LFC group, 14 patients (50.0%) achieved clinical improvement, while other 14 patients (50.0%) did not. Patient baseline characteristics and sagittal parameter did not demonstrate significant difference between the two groups. Spondylolisthesis was significantly more frequently detected in the LFC group ($p=0.001$). JOA score significantly improved in the no-LFC group after the operation ($p<0.001$) while it did not demonstrate improvement in the LFC group ($p=0.642$). JOA score at postoperative 3 months ($p=0.037$) and 2 years ($p=0.001$) were significantly higher in the no-LFC group. Furthermore, JOA recovery rate at postoperative 2 years was significantly higher in the no-LFC group ($p=0.042$) (Table 1). Multiple regression analysis showed that LFC was significantly associated with JOA recovery rate at postoperative 2 years ($p=0.045$) while spondylolisthesis did not demonstrate significant results ($p=0.482$).

Conclusion: Previous case reports have suggested that aggravation of ligamentum flavum buckling after ACDF occasionally requires early posterior revision after ACDF. However, clinical impact of cord compression by ligamentum flavum has not been thoroughly studied. The present study showed that posterior cord compression by ligamentum flavum adversely affects clinical outcome of ACDF. Furthermore, multiple regression analysis confirmed that LFC is associated with JOA recovery rate. While ACDF effectively removes anterior compressive pathologies, amount of canal widening that could be achieved is limited when combined posterior compression exists. Additional posterior decompression with laminoplasty or laminectomy might result in better results which warrants further clarification.

In conclusion, when preoperative MRI shows indentation of spinal cord by ligamentum flavum hypertrophy or buckling, anterior decompression by ACDF only may not bring sufficient decompression and clinical improvement. Therefore, alternative surgical strategies such as anterior-posterior combined approach or posterior approach should be considered.

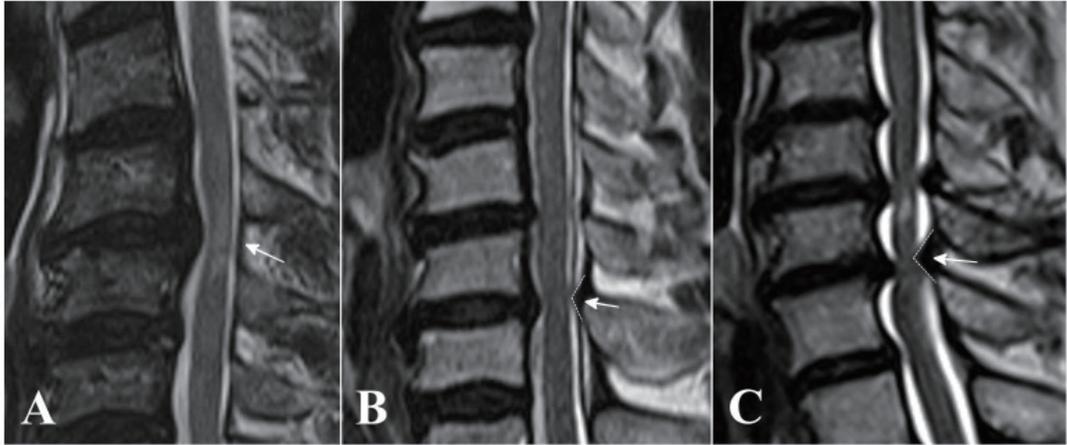


Figure 1. Ligamentum flavum cord compression grade (A) Grade 0, no ligamentum flavum buckling or hypertrophy. Despite cord compression, cerebrospinal fluid (CSF) space can be seen at the posterior aspect of spinal cord. **(B)** Grade 1, mild ligamentum flavum buckling. CSF space posterior to spinal cord is obliterated. However, posterior line of spinal cord can be seen as a smooth line. **(C)** Grade 2, ligamentum flavum buckling and hypertrophy. Spinal cord is compressed by ligamentum flavum and indentation of posterior margin of cord is identified.

EPO3-05

Cervical Degenerative

Posterior Preventive Foraminotomy before Laminectomy Combined with Pedicle Screw Fixation May Decrease the Incidence of C5 Palsy in Complex Cervical Spine Surgery in Patients with Severe MyeloradiculopathyYong-Ho Lee*Orthopedic department, Yonsei University College of Medicine, Korea*

C5 palsy is a frequent sequela of cervical decompression surgeries for cervical myeloradiculopathy. Although many researchers have suggested various risk factors, such as cord shifting and cor-rection of lordotic angles, tethering of the C5 root beneath the narrow foramen is an independent risk factor for C5 palsy. In this study, we tried to investigate different techniques for foramen decompression with posterior cervical fusion and assess the incidence of C5 palsy with each technique depending on the order of foraminal decompression. A combined 540° approach with LMS and uncovertebrectomy was used in group 1. Group 2 combined 540° approach with pedicle screws and posterior foraminotomy, while posterior approach only with pedicle screws and foraminotomy was used in group 3. For groups 2 and 3, prophylactic posterior foraminotomy was performed before laminectomy. Motor manual testing to assess C5 palsy, the Neck Disability Index (NDI) and the Japanese Orthopedic Association (JOA) scores were determined before and after surgery. Simple radiographs, MRI and CT scans, were obtained to assess radiologic parameters preoperatively and postoperatively. A total of 362 patients were enrolled in this study: 208 in group 1, 72 in group 2, and 82 in group 3. The mean age was 63.2, 65.5, and 66.6 years in groups 1-3, respectively. The median for fused levels was 4 for the three groups. There was no significant difference between groups regarding the number of fused levels. Weight, height, comorbidities, and diagnosis were not significantly different between groups. Preoperative JOA scores were similar between groups ($p=0.256$), whereas the preoperative NDI score was significantly higher in group 3 than in group 2 ($p=0.040$). Mean JOA score at 12-month follow-up was 15.541.89, 16.141.48, and 16.141.48 for groups 1-3, respectively; it was higher in group 3 compared with group 1 ($p=0.008$) and in group 2 compared with group 1 ($p=0.024$). NDI score at 12 months was 13, 12, and 13 in groups 1-3, respectively; it was significantly better in group 3 than in group 1 ($p=0.040$), but there were no other significant differences between groups. The incidence of C5 palsy was significantly lower in posterior foraminotomy groups with pedicle screws (groups 2 and 3) than in LMS with uncovertebrectomy (group 1) ($p< 0.001$). Thus, preventive expansive foraminotomy before decompressive laminectomy can significantly decrease the root tethering by stenotic lesion, and resultantly, the incidence of C5 palsy associated with posterior and combined posterior and anterior cervical fusion surgeries. Also, such expansive foraminotomy might appropriate with pedicle screw insertion based on the biomechanical consideration.

EP03-07

Cervical Degenerative

Does Titanium Mesh Cage Location Affect Subsidence after Single-level Anterior Cervical Corpectomy and Fusion? A Minimum 2-year Follow-up Study**Sung Hyun Noh¹, Pyung Goo Cho¹ and Sang Hyun Kim^{1*}**¹ Neurosurgery, Ajou University Hospital, Korea

Background: Subsidence of implants is an important prognostic factor after anterior cervical corpectomy and fusion (ACCF). The purpose of this study was to investigate whether the location of the titanium mesh cage affects the subsidence after ACCF, and to determine whether there is a difference in the clinical outcome based on the subsidence and the location of the titanium mesh cage.

Methods: We reviewed 122 patients who underwent single-level ACCF in titanium mesh cages between January 2007 and December 2021. Groups were divided based on the position of the titanium mesh cage within 2mm of the anterior margin of vertebra body (Anterior group) or within 2mm of the posterior margin of vertebra body (Posterior group). Subsidence was defined as a decrease in partial vertebral body height of 3 mm or more at 1 year compared to 1 week after surgery. Visual analog scale (VAS) and neck disability index (NDI) were evaluated at pre-operation, immediately post-operation, and at last follow-up. Moreover, radiographic studies were reviewed retrospectively. The demographics of age, sex, bone mineral density (BMD), body mass index (BMI), diabetes mellitus (DM), and smoking in the two groups were compared. Radiographic parameters of segmental angle, C2-C7 lordosis, T1 slope, C2-C7 sagittal vertical axis (SVA), the ratio of mesh cage size and normal one level height, the angle of plate and mesh cage in AP x-ray were estimated on plain radiographs at pre-operation, immediately post-operation, and during the follow-up period (median follow-up duration: 36.1 4 2.1 months).

RESULTS: Anterior group was 41 patients and posterior group was 81 patients. The clinical outcomes of VAS and NDI were improved after operation in both groups. C2-C7 lordosis, T1 slope, C2-C7 SVA, the ratio of mesh cage size and normal one level height, the angle of plate and mesh cage in AP x-ray after single-level ACCF were not significantly different between the two groups. Subsidence occurred in 11 cases (27%) in anterior group and 9 cases (11%) in posterior group. The difference between the two groups was statistically significant. (P<0.05)

Conclusion: To minimize risk of subsidence, the titanium mesh cage should be positioned on posterior margin of vertebra body in surgical level

EPO3-08

Cervical Degenerative

Morphologic Change of Corticocancellous Allograft Used for Anterior Cervical Discectomy and Fusion**Jun-Young Choi¹, Jaejun Yang^{1*} and Jin-Bog Lee¹**¹ Orthopedics, Dongguk University Ilsan Hospital, Korea

Background: Although cortico-cancellous allograft is one of the most commonly used interbody spacer for ACDF, clinical implications of allograft resorption or fracture is unclear. The aim of this study was to evaluate the incidence and clinical implications of graft morphologic changes in corti-cocancellous allografts used for anterior cervical discectomy and fusion (ACDF), such as graft resorption or fracture.

Methods: One-hundred and thirty-eight consecutive patients who underwent ACDF for degenerative cervical myelopathy or radiculopathy were retrospectively reviewed. Patients with allograft morphologic changes, including graft resorption and fracture (morphologic change group), were compared with patients without morphologic changes (unchanged group) (Figure 1 and 2). Furthermore, operated segments with morphologic changes were compared with unchanged segments. Patient characteristics, cervical lordosis, segmental lordosis, fusion, subsidence, neck pain visual analogue scale (VAS), arm pain VAS, and neck disability index (NDi) scores were evaluated.

Results: Ninety patients (149 segments) were included in the study (Table 1). Allograft resorption or fracture was detected in 46 (51.1%) patients and 81 (54.3%) segments, respectively. The fusion rate of morphologic change segments was significantly lower than that of the unchanged segments ($P < 0.001$) (Table 2). Furthermore, segments with morphologic changes had significantly higher rates of subsidence compared to unchanged segments ($P = 0.008$). Segmental lordosis at the final follow-up was significantly smaller in the morphologic change segments ($P < 0.001$) (Table 3). Neck pain VAS, arm pain VAS, and NDI scores did not demonstrate significant intergroup differences. (Table 4)

Conclusion: Corticocancellous allograft demonstrated a high rate of graft morphologic change (54.3%). Graft resorption or fracture was associated with increased pseudarthrosis, subsidence, and decreased postoperative segmental lordosis; however, the clinical results were not significantly affected. Caution is needed when choosing to use corticocancellous allografts for ACDF due to the high rate of graft resorption or fracture and the negative implications of these risks.

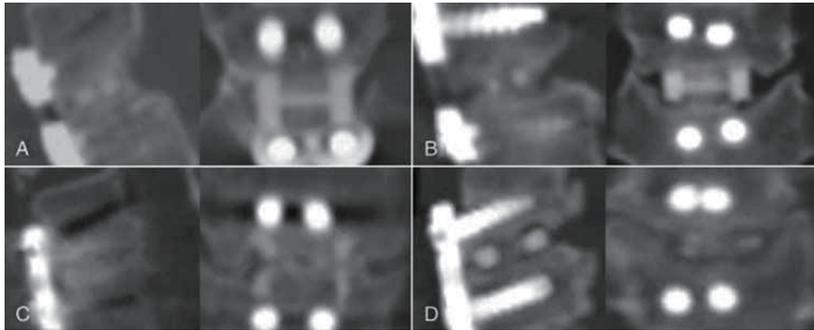


Figure 1. Types of corticocancellous allograft morphologic change. (A) Type 1, no change. (B) Type 2, graft resorption. (C) Type 3, graft fracture. (D) Type 4, graft resorption and fracture.

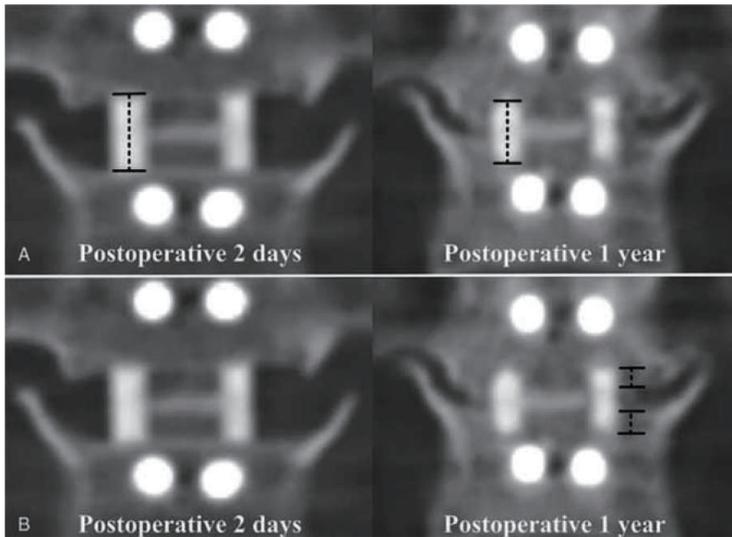


Figure 2. Radiographic assessment. (A) Assessment of graft resorption. Bone graft resorption was assessed by comparing the height of allograft in the CT coronal images taken on the second postoperative day and at the 1-year postoperative mark targeting the anterior 1/3 and posterior 1/3 of the allograft. Height difference >1 mm in either the anterior 1/3 or posterior 1/3 was assessed for bone graft resorption. (B) Assessment of subsidence.

TABLE 1. Patient Characteristics

	Morphologic Change Group	Unchanged Group	P
No.	46	44	
Age	56.5 ± 12.5	56.6 ± 12.5	0.955
Sex			0.051
Male	33 (71.7%)	22 (50.0%)	
Female	13 (28.3%)	22 (50.0%)	
Diagnosis			0.388
Radiculopathy	27 (58.7%)	30 (68.2%)	
Myelopathy	19 (41.3%)	14 (31.8%)	
No. of levels operated	1.8 ± 0.7	1.6 ± 0.6	0.124
Follow-up period	43.3 ± 22.7	49.9 ± 22.3	0.174
Smoking status	12 (26.1%)	10 (22.7%)	0.805
Cumulative nicotine usage (pack-year)	20.8 ± 7.9	20.2 ± 5.1	0.923
BMI, kg/m ²	25.9 ± 4.0	25.6 ± 3.6	0.957
BMD, /cm ²	0.99 ± 0.2	0.98 ± 0.2	0.990
Complications			
Infection	1 (2.2%)	0 (0.0%)	1.000
Dural tear	0 (0.0%)	0 (0.0%)	n/a
Neurologic deterioration	0 (0.0%)	0 (0.0%)	n/a
Reoperation	2 (4.3%)	0 (0.0%)	0.495
Hematoma	0 (0.0%)	0 (0.0%)	n/a

BMD indicates bone mineral density; BMI, body mass index; n/a, not available.
Sex, diagnosis, smoking status, and complications were analyzed using the χ^2 test.
Age, number of levels operated, follow-up period, BMI, and BMD were analyzed using Mann-Whitney U test.
*P < 0.05.

TABLE 2. Comparison of Radiographic Results of Morphologic Change Group and Unchanged Group

		Morphologic Change Group	Unchanged Group	p [‡]
Fusion	CT 1 y	14 (30.4%)	41 (93.2%)	<0.001 [†]
	ISM 1 y	15 (32.6%)	32 (72.7%)	<0.001 [†]
	ISM final	17 (37.0%)	37 (84.1%)	<0.001 [†]
Cervical lordosis (C2–C7)	Preoperative (°)	12.5 ± 9.7	15.2 ± 10.7	0.235
	Postoperative (°)	17.4 ± 8.9	20.0 ± 9.8	0.231
	Difference (pre-post) (°)	4.9 ± 8.5	4.8 ± 5.3	0.735
	P (pre-post) [‡]	<0.001 [†]	<0.001 [†]	
	Final (°)	15.5 ± 7.8	18.7 ± 10.0	0.164
	Difference (pre-final) (°)	3.0 ± 9.1	3.5 ± 5.5	0.608
	Difference (post-final) (°)	-1.9 ± 6.6	-1.4 ± 5.9	0.485
	P (pre-final) [‡]	<0.001 [†]	<0.001 [†]	
	P (post-final) [‡]	0.043 [†]	<0.001 [†]	

CT, computed tomography; ISM, interspinous motion.
Fusion rates were analyzed using a χ^2 test.
*Mann-Whitney U test was used to compare the two groups.
†P < 0.05.
‡Wilcoxon signed rank test were used to compare measurements at each follow-up period.

TABLE 3. Comparison of Radiographic Results of the Morphological Change Segments and Unchanged Segments

		Morphologic Change Segments (n = 81)	Unchanged Segments (n = 68)	P*
Fusion	CT 1 y	50 (61.7%)	60 (88.2%)	<0.001
	ISM 1 y	41 (50.6%)	57 (83.8%)	<0.001
	ISM final	48 (59.3%)	59 (86.8%)	<0.001
Subsidence	Anterior	12 (14.8%)	4 (5.9%)	
	Posterior	15 (18.5%)	7 (10.3%)	
	Both	19 (23.5%)	10 (14.7%)	
	Total	46 (56.8%)	21 (30.9%)	0.008
Segmental	Preoperative (°)	3.3 ± 4.1	2.1 ± 3.9	0.073
Lordosis	Postoperative (°)	6.8 ± 4.0	6.5 ± 4.1	0.619
	Difference (pre-post) (°)	3.6 ± 3.5	4.4 ± 4.1	0.109
	P (pre-post)†	<0.001‡	<0.001‡	
	Final	3.7 ± 3.5	5.6 ± 3.9	0.006*
	Difference (pre-final) (°)	0.4 ± 3.9	3.5 ± 3.9	<0.001*
	Difference (post-final) (°)	-3.1 ± 3.0	-1.0 ± 2.8	<0.001*
	P (pre-final)†	<0.001‡	<0.001‡	
	P (post-final)†	<0.001‡	<0.001‡	

CT indicates computed tomography; ISM, interspinous motion.
 *Mann-Whitney U test was used to compare the two groups.
 †Wilcoxon signed rank test was used to compare measurements at each follow-up period.
 ‡P < 0.05.

TABLE 4. Patient-reported Outcome Measures Results

		Morphologic Change Group	Unchanged Group	P*
Neck pain VAS	Preoperative	7.3 ± 2.2	7.4 ± 2.0	0.928
	Final	2.9 ± 1.5	2.8 ± 0.9	0.879
	Difference	-4.5 ± 2.5	-4.7 ± 1.9	0.744
	P †	<0.001‡	<0.001‡	
Arm pain VAS	Preoperative	7.9 ± 1.6	8.1 ± 1.1	0.879
	Final	1.9 ± 1.3	1.9 ± 1.3	0.989
	Difference	-6.0 ± 2.1	-6.3 ± 1.2	0.495
	P †	<0.001‡	<0.001‡	
NDI	Preoperative	21.5 ± 6.4	20.3 ± 5.5	0.364
	Final	6.6 ± 4.9	6.8 ± 5.8	0.942
	Difference	-14.8 ± 6.8	-13.8 ± 5.3	0.487
	P †	<0.001‡	<0.001‡	

NDI indicates neck disability index; VAS, visual analogue scale.
 *Mann-Whitney U test was used to compare the two groups.
 †Wilcoxon signed rank test was used to compare measurements at each follow-up period.
 ‡P value < 0.05.

EPO3-09

Cervical Degenerative

Which Radiographic Parameter Can Aid in Deciding Optimal Allograft Height for Anterior Cervical Discectomy and Fusion?**Jun-Young Choi¹, Jae Jun Yang^{1*} and Min-Seong Keum¹**¹ Orthopedics, Dongguk University Ilsan Hospital, Korea

Background: Allograft height selection for ACDF depends on intraoperative assessment supported by trials; however, there is currently no radiographic reference parameter that could aid in allograft height selection for improved outcomes. To identify preoperative radiographic parameters that can guide optimal allograft height selection for anterior cervical discectomy and fusion (ACDF).

Methods: A total of 148 patients who underwent ACDF using allografts and were followed up for more than 1 year were retrospectively reviewed. Fusion rates (Figure 1), subsidence, segmental lordosis, and foraminal height were assessed. Segments were divided into 2 groups according to whether the inserted allograft height was within 1 mm from the following 3 reference radiographic parameters: (1) uncinat process height, (2) adjacent disc height, and (3) preoperative disc height +2 mm.

Results: This study included 101 patients with 163 segments. Segments with an allograft-uncinate height difference of M 1mm had a significantly higher fusion rate at 1-year follow-up compared with segments with allograft-uncinate height difference of > 1mm [85/107 (79.4%) vs. 35/56 (62.5%); P = 0.025] (Figure 2, Table 1). Subsidence, segmental lordosis, and foraminal height did not significantly differ between the groups when segments were divided according to uncinat height. Multivariate logistic regression analysis demonstrated that allograft-uncinate height difference of M 1 mm and allograft failure were factors associated with fusion (Table 2).

Conclusions: The uncinat process height can guide optimal allograft height selection for ACDF. Using an allograft with an allograft-uncinate height difference of M 1 mm resulted in a higher fusion rate. Therefore, the uncinat process height should be checked preoperatively and used in conjunction with intraoperative assessment when selecting allograft height.

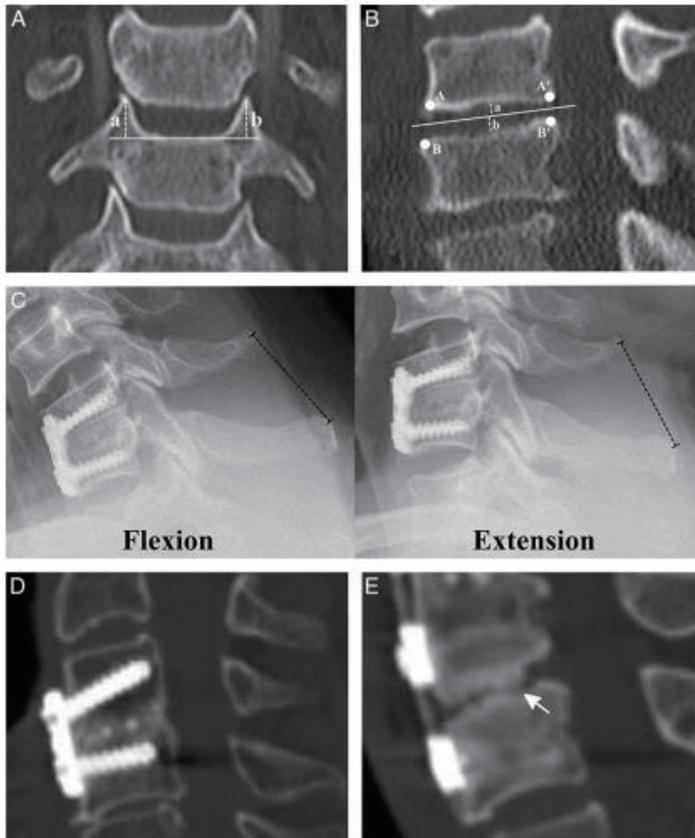


Figure 1. Radiographic assessment. A, Fusion was assessed when interspinous motion in dynamic lateral radiograph with 150% magnification was <1 mm. B, Fusion was also assessed when bone bridge formation (white arrow) was detected in computed tomography (CT) image. C, Uncinate height was defined as the distance (dashed line) between the upper tip of the uncinata and the line passing through the upper endplate of the vertebra (straight line). Mean value of right (a) and left (b) uncinata height was used for evaluation. D, Disc height was measured in sagittal CT image targeting the midline by following method. First, a bisecting line was drawn through the centers of A–B and A'–B'. Sum of the shortest distances from the midpoint of the upper and lower endplates to the bisecting line (a + b) was recorded as disc height. E, Allograft failure was assessed when an allograft fracture, defined as fracture line of an allograft, was detected in 1-year postoperative CT (white arrow) or when an allograft resorption, defined as an allograft height decrement of ≥ 1 mm, was identified by comparing CT images taken 1 year postoperatively and 2 days postoperatively.

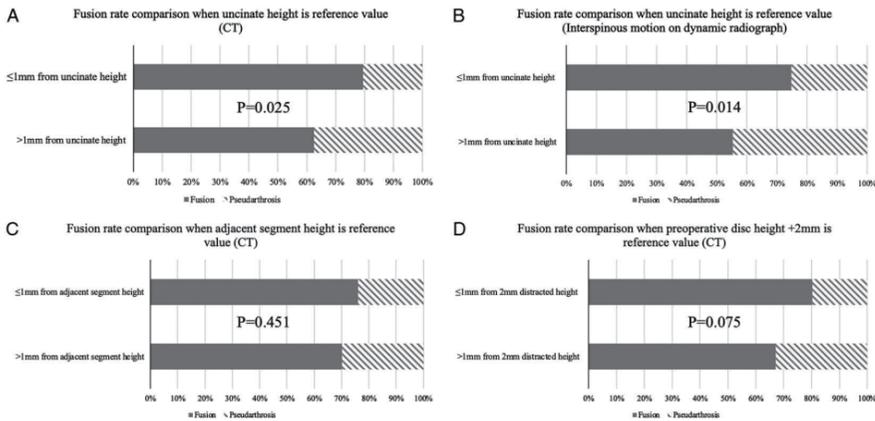


Figure 2. Radiographic results. A, Fusion rate [assessed by computed tomography (CT)] comparison with uncinete height as reference value. B, Fusion rate (assessed by interspinous motion) comparison with uncinete height as reference value. C, Fusion rate (assessed by CT) comparison with adjacent segment height as reference value. D, Fusion rate (assessed by CT) comparison with preoperative disc height + 2 mm as reference value.

	> 1 mm from uncinete height (n = 56)	≤ 1 mm from uncinete height (n = 107)	P
Allograft height (mm)	6.3 ± 0.7	5.9 ± 0.7	0.002*
No. operated levels of the construct which segment is included	1.8 ± 0.7	2.0 ± 0.7	0.237
Uncoforaminotomy, n (%)			
None	13 (23.2)	20 (18.7)	0.961
Unilateral	14 (25.0)	29 (27.1)	
Bilateral	29 (51.8)	58 (54.2)	
PLL resection, n (%)			
No	37 (66.1)	83 (77.6)	0.141
yes	18 (32.1)	24 (22.4)	
Fusion, n (%)			
ISM	31 (55.4)	80 (74.8)	0.014*
CT	35 (62.5)	85 (79.4)	0.025*
Subsidence			
Amount (mm)	1.0 ± 1.2	1.0 ± 1.2	0.999
> 2 mm, n (%)	13 (23.2)	21 (19.6)	0.542
Allograft failure, n (%)	27 (48.2)	37 (34.6)	0.095
Segmental lordosis (deg)			
Preoperative	1.5 ± 4.8	0.8 ± 4.9	0.355
Postoperative 2 d	5.4 ± 4.3	4.9 ± 4.6	0.459
Postoperative 1 y	3.9 ± 4.1	3.0 ± 4.4	0.229
Foraminal height (mm)			
Preoperative	9.2 ± 1.0	9.2 ± 1.0	0.790
Postoperative 2 d	10.2 ± 1.0	10.0 ± 1.4	0.348
Postoperative 1 y	9.4 ± 1.2	9.3 ± 1.4	0.666

Categorical variables were analyzed using a χ^2 test.

Continuous variables were analyzed using student *t* test.

**P* < 0.05.

CT indicates computed tomography; ISM, interspinous motion; n, sample size; PLL, posterior longitudinal ligament.

Table 1. Comparison Between Segments With Allograft Height ≤ 1 mm From Uncinate Height and Segments With Allograft Height > 1 mm From Uncinate Height

Univariate analysis	Odds ratio	95% confidence interval	P
Age	1.008	0.977–1.039	0.629
No. operated levels	1.319	0.784–2.220	0.297
Allograft height	1.428	0.864–2.359	0.165
Uncinate process resection	0.997	0.632–1.574	0.989
PLL resection	1.682	0.801–3.531	0.169
Amount of subsidence	1.540	1.128–2.101	0.007*
Preoperative segmental lordosis	1.081	1.004–1.163	0.038*
Allograft height within 1 mm from uncinat process height	2.318	1.133–4.743	0.021*
Allograft height within 1 mm from adjacent segment height	1.351	0.669–2.726	0.402
Allograft height within 1 mm from 2 mm distracted height	1.994	0.976–4.077	0.058
Allograft failure	0.131	0.059–0.293	< 0.001*
Multivariate analysis			
Preoperative segmental lordosis	1.080	0.999–1.169	0.054
Allograft height within 1 mm from uncinat process height	0.424	0.200–0.895	0.024*
Amount of subsidence	1.569	1.140–2.161	0.006*
Allograft failure	0.151	0.066–0.344	< 0.001*

*P < 0.05.

Factors that demonstrated significant results in the univariate analysis were included in the multivariate analysis.

PLL indicates posterior longitudinal ligament.

Table 2. Results of Logistic Regression Analysis Demonstrating Factors Related to Fusion Assessed by Computed Tomography

EPO3-10

Cervical Degenerative

Surgical Outcomes of Extensive Dome-like Laminoplasty Using En Bloc Resection of C2 Inner Lamina for Patients with Severe Cord Compression Behind C2 BodyKyung-Chung Kang¹, Hong-Sik Park¹, Tae-Soo Jang¹ and Se-Hwan Park¹¹ Orthopedic Department, Kyung Hee University Hospital, Korea

Background: Severe cord compression behind C2 body is rare, but it is a prominent concern for spinal surgeons. Owing to the importance of the paraspinal muscles around the C2 spinous process, laminectomy or laminoplasty of C2 is not preferred. To date, there has been no established solution for severe cord compression behind the C2 body. This study aimed to evaluate the efficacy and safety of a newly developed extensive dome-like laminoplasty using en bloc resection of the C2 inner lamina in patients with severe cord compression behind the C2 body.

METHODS: Patients with severe cord compression behind the C2 body who underwent posterior surgery were reviewed retrospectively. For sufficient decompression, "extensive" dome-like laminoplasty has been developed and performed. To minimize neural tissue damage, en bloc removal of the C2 inner lamina and decompression up to the upper border of the C2 were performed. Pre and postoperative canal diameters behind the C2 and the mean removed area of the C2 inner lamina were measured using MRI and three-dimensional CT scan. With lateral plain radiographs, the pre and postoperative sagittal vertical axis (SVA) at C2-C7 and segmental angle at C2-C3 were checked. Clinical scores, including the neck visual analog scale (VAS), arm VAS, Japanese Orthopaedic Association (JOA) score, and neck disability index (NDI), were also assessed pre and postoperative periods. In addition, perioperative complications were analyzed.

Results: A total of 36 patients had severe cord compression behind the C2 body and underwent extensive dome-like laminoplasty. The patients were diagnosed with ossification of the posterior longitudinal ligament (OPLL) (24, 66.7%) and cervical spondylotic myelopathy (12, 33.3%). In the preoperative midsagittal CT scan, the mean canal diameter behind the C2 increased from 9.85 ± 2.28 (6.59-14.03) mm preoperatively to 19.91 ± 3.93 (12.14-30.65) mm at the last follow-up ($P < 0.001$). Preoperative SVA (23.34 ± 15.16) and C2-C3 angle (0.34 ± 5.27) were significantly different from the postoperative SVA (22.16 ± 14.50) mm and C2-C3 angle (-0.83 ± 5.18) at the last follow-up ($P < 0.05$). Clinically, neck and arm VAS, JOA, and NDI significantly improved at postoperative 1 month ($P < 0.05$), and the scores were maintained until the last follow-up. During the procedures, there were no particular complications, but one patient showed deteriorated spinal cord compression at C1-C2 and underwent additional decompressive surgery.

Conclusions: To date, this study is the largest series regarding the treatment of severe cord compression behind the C2 body without laminectomy or laminoplasty. OPLL is the main pathology in this area, followed by congenital stenosis with spondylosis. After extensive dome-like laminoplasty, surgical outcomes are satisfactory, and complications are rare. Therefore, this technique may be a viable option for patients with severe cord compression behind the C2 body.

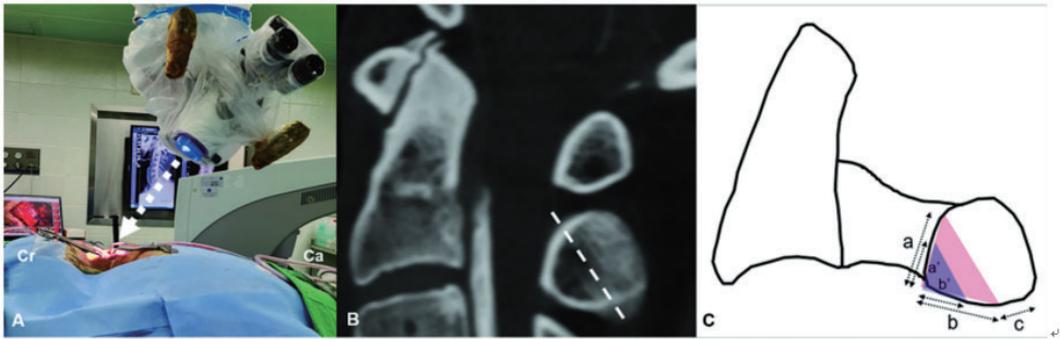


Figure 1. Intraoperative microscope position (A) and preoperative radiography and images (B, C) A. The microscope is tilted to a caudal direction (angle: 40–50°) and used at three times magnification. The right-handed operator stands on the left side of the patient and perform a procedure (Cr: cranial, Ca: caudal). B. The white dotted line indicates the inner part of the C2 lamina to be removed. C. The schematic image shows the comparison between the existing dome-like laminoplasty (triangle area of a–b) and “extensive” dome-like laminoplasty (triangle area of a–b) and remaining C2 lamina (c).

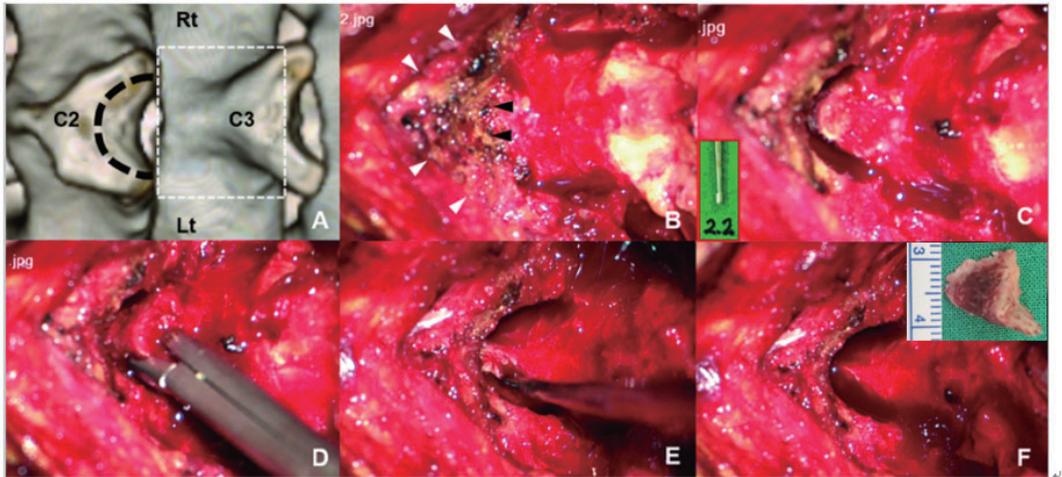


Figure 2. A. Areas scheduled to be removed in preoperative 3D CT scan (black dotted line: inner lamina of C2, white dotted box: total lamina of C3). B. Total exposure of the C2 inner lamina (blackheads) below a low border of the C2 lamina (white arrowheads) without significant muscle damage after C3 total laminectomy. C. A groove is started just below the inner border of the C2 lamina and deepened using a high-speed burr with a 2.2 mm matchstick head. D and E. Cut-off “en bloc” bone is removed, and the remaining border is trimmed. F. Complete decompression behind the C2 body is done (small box: part of the C2 lamina resected by “en bloc”).

EPO3-12

Cervical Degenerative

Bicortical Laminar Screws for Posterior Fixation of Subaxial Cervical Spine: A Radiologic Analysis with Computed Tomography ImagesEugene Park¹ and Woo-Kie Min^{1*}¹ Department of Orthopedic Surgery, Kyungpook National University Hospital, Korea

Study Design: Retrospective radiological analysis.

Objectives: Translaminar screw (TLS) placement is one of the fixation techniques in the subaxial cervical spine. However, it can be difficult to use in small diameter of the lamina. This study proposed a novel bicortical laminar screw (BLS) and analyzed the related parameters using computed tomography (CT).

Methods: Cervical CT images taken at our institution from January 2013 to March 2017 were used for measurement. On the axial images, the maximum screw length (MSL) and trajectory angle (TA) of BLS and TLS were measured, together with the distance from the midline (DM) to the BLS entry point and the lamina width (LW). On the parasagittal images, the height of the lamina (LH) was measured.

Results: MSL of BLS and TLS were 21.00 and 20.97 mm, 19.02 and 20.91 mm, 18.45 and 21.01 mm, and 20.00 and 21.01 mm in C3, C4, C5, and C6, respectively. TA of the BLS and TLS were 21.24 and 34.90, 19.05 and 34.22, 18.65 and 33.61, and 18.30 and 34.51 at C3, C4, C5, and C6, respectively. DM were 6.44, 5.77, 5.68, and 6.03 at C3, C4, C5, and C6, respectively. LW and LH were 3.52 and 12.44 mm, 2.87 and 12.49 mm, 2.76 and 12.42 mm, and 3.18 and 13.30 mm at C3, C4, C5, and C6, respectively.

Conclusion: We suggest that BLS fixation is a feasible alternative option for posterior fixation to the lamina of the subaxial cervical spine. It may be especially useful when pedicle screw, lateral mass screw, and TLS are not appropriate.

Keywords: subaxial cervical spine, bicortical laminar screw, posterior instrumentation

EP03-13

Cervical Degenerative

Identifying Risk Factors for Prevertebral Soft Tissue Swelling after Single-level Anterior Cervical Discectomy and Fusion (ACDF)

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Background: Anterior cervical discectomy and fusion (ACDF) is a common surgical procedure used to treat cervical spinal disorders. One of the complications associated with ACDF is prevertebral soft tissue swelling (PSTS), which can result in airway obstruction, dysphagia, and other adverse outcomes. Although PSTS has been recognized as a potential complication, there is limited research on the risk factors that may predispose patients to this condition. In addition, there is a lack of research that analyzes the correlation between the cervical spine sagittal parameter and PSTS. Therefore, this study aims to investigate the correlation between various cervical sagittal parameters and PSTS after single-level ACDF and identify independent risk factors for PSTS after single-level ACDF.

Methods: A retrospective study conducted at a single institution. The study population included all patients who underwent single-level ACDF between January 2014 and December 2022. Patients with a history of cervical spine surgery or trauma were excluded from the study. The presence and severity of PSTS was assessed by reviewing pre- and postoperative imaging studies. The potential risk factors for PSTS that were examined include patient age, sex, body mass index, tobacco use, comorbidities, serum albumin levels, operative time, implant type, implanted level, and various cervical spine sagittal parameters. Multivariate linear regression analysis was performed to identify the independent risk factors for PSTS.

Results: A total of 62 consecutive patients who underwent single-level ACDF over a 8-year period at a single institution were enrolled in this study. Only preoperative segmental angle showed positive correlation with PSTS among various cervical spine sagittal parameters ($r=0.36$, $p=0.005$). We found that female, lower preoperative serum albumin, and implantation of upper cervical level (above C5) were independent predictors for PSTS after single-level ACDF ($\beta= 1.11$, 95% confidence interval [CI]= 0.15 ~ 2.08, $p= 0.024$, $\beta= -1.40$, 95% CI= -2.77 ~ -0.04, $p= 0.044$, $\beta= 1.59$, 95% CI= 0.50 ~ 2.68, $p= 0.005$, respectively).

Conclusions: Our study revealed that female, lower preoperative serum albumin, and upper surgical level (above C5) are independent predictors for PSTS after single-level ACDF. Our findings may provide valuable information on the risk factors for PSTS after single-level ACDF, which can help surgeons identify high-risk patients and take appropriate measures to minimize the risk of this complication.

Tables

Table 1. Characteristics of patients with single level ACDF

Characteristics	Single level ACDF
Number of patients, n	62
Sex, male, n (%)	34 (54.8)
Age, mean \pm SD, years	73.2 \pm 9.4
BMI, mean \pm SD, kg/m ²	25.2 \pm 4.8
Preoperative albumin, mean \pm SD, mm	2.7 \pm 5.1
Preoperative prevertebral soft tissue thickness, mean \pm SD, mm	9.2 \pm 1.5
Postoperative maximal prevertebral soft tissue thickness, mean \pm SD, mm	14.1 \pm 2.9
Perioperative maximal prevertebral soft tissue swelling, mean \pm SD, mm	5.0 \pm 2.3
Preoperative serum albumin, mean \pm SD, g/dL	4.2 \pm 0.4
Past medical history, n (%)	
Hypertension	25 (40.3)
Diabetes	5 (8.1)
Alcohol	14 (22.6)
Smoking	17 (27.4)
Operative level distribution, n (%)	25.2 \pm 4.8
C3/4	15 (24.2)
C4/5	13 (21.0)
C5/6	19 (30.6)
C6/7	15 (24.2)

SD, standard deviation; BMI, body mass index

Table 2. Changes in radiological parameter values before and after single level anterior cervical discectomy and fusion

Variable	Pre-operation	Post-operation	Difference value (Δ)	p-value
O-C2 angle, mean \pm SD, $^{\circ}$	17.3 \pm 7.8	16.5 \pm 6.8	-0.8 \pm 7.0	0.354
C2-C7 angle, mean \pm SD, $^{\circ}$	13.1 \pm 7.4	13.9 \pm 8.3	0.8 \pm 7.5	0.414
Segmental angle, mean \pm SD, $^{\circ}$	4.0 \pm 4.4	5.7 \pm 4.4	1.7 \pm 5.5	0.019
C2-C7 SVA, mean \pm SD, cm	23.9 \pm 10.4	24.3 \pm 9.7	0.4 \pm 13.7	0.801
T1 slope, mean \pm SD, ($^{\circ}$)	25.1 \pm 7.0	26.9 \pm 6.9	1.7 \pm 7.4	0.069
T1s-CL, mean \pm SD, ($^{\circ}$)	12.0 \pm 8.8	13.0 \pm 7.5	0.9 \pm 9.1	0.414

SD, standard deviation; SVA, sagittal vertical axis; T1s-CL, T1 slope minus cervical lordosis

Table 3. Univariate linear regression analysis of the association between prevertebral soft tissue swelling and various variables in patients undergone single level anterior cervical discectomy and fusion

Variable	Standardized beta	95% CI		p-value
		Lower	Upper	
Sex (Female)	-0.220	-2.120	0.143	0.086
Age	0.352	0.021	0.114	0.005*
BMI	0.098	-0.074	0.167	0.447
Preoperative serum albumin	-0.328	-3.363	-0.497	0.009*
Postoperative serum albumin	-0.261	-3.660	-0.083	0.041*
Past medical history				
Hypertension	0.231	-0.092	2.197	0.071
Diabetes	0.127	-1.064	3.141	0.327
Smoking	0.009	-1.250	1.337	0.947
Alcohol	0.007	-1.341	1.419	0.955
Plate fixation	0.232	-0.092	2.381	0.069
Upper cervical level (above C5)	0.470	1.088	3.135	<0.001*
Operative duration	0.081	-0.021	0.041	0.531
Preoperative segmental angle	0.355	0.058	0.307	0.005*
ΔSegmental angle	-0.266	-0.212	-0.007	0.036*

CI, confidence interval; BMI, Body mass index;

Table 4. Multivariate linear regression analysis of the association between prevertebral soft tissue swelling and various variables in patients undergone single level anterior cervical discectomy and fusion

Variable	Unstandardized coefficients		Standardized coefficients (β)	95% CI		p-value
	B	SE		Lower	Upper	
Sex (Female)	-1.114	0.480	-0.248	-2.078	-0.150	0.024*
Age	0.016	0.026		-0.037	0.068	0.553
Preoperative serum albumin	-1.404	0.679	-0.239	-2.767	-0.042	0.044*
Postoperative serum albumin	-1.087	0.807	-0.152	-2.707	0.533	0.184
Hypertension	0.324	0.558	0.071	-0.796	1.445	0.564
Plate fixation	0.566	0.593	0.115	-0.624	1.757	0.344
Upper cervical level (above C5)	1.591	0.543	0.354	0.503	2.680	0.005*
Preoperative segmental angle	-0.007	0.080	-0.013	-0.167	0.154	0.935
ΔSegmental angle	-0.059	0.057	-0.144	-0.173	0.054	0.300

*Significant (p<0.05); BMI, Body mass index; SE, standard error; CI, confidence interval

EPO3-14

Cervical Degenerative

More Than Three Continuous Segments of Ossification of Posterior Longitudinal Ligament Is Protective Against Postoperative Kyphosis Progression Following Laminoplasty

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Background: Ossification of posterior longitudinal ligament (OPLL) is a potentially catastrophic disease. Among several surgical treatment options, laminoplasty (LP) is the major modality being utilized despite several demerits. Postoperative kyphosis progression is one of such major complications of which various risk factors have been identified and utilized in the surgical decision making. However, most of those studies do not consider the morphological characteristics of OPLL in depth, especially its incremental ability to stabilize spine as the true continuous segment count increases.

Objective: To identify the association between continuous segment count of OPLL and postoperative kyphosis following cervical LP.

Methods: Patients who underwent cervical LP as OPLL treatment with minimum 1 year follow up were retrospectively included. Demographic, operative, and radiographic parameters were analyzed. Valid continuous segment is defined as continuous type OPLL spanning the disc space more than half of adjacent vertebral body height without crack, localized OPLL attached to both upper and lower adjacent vertebral bodies, or obvious interbody autofusion, and is counted from preoperative CT. Subgroup analysis for preoperatively lordotic patients divided into two groups based on postoperative cervical alignment was made to figure out risk factors for kyphosis progression at final follow up. Difference analysis, linear regression analysis for loss of lordosis, and logistic regression analysis for kyphosis progression was made.

Results: Eighty-four patients were identified in total. Among them, 78 patients had lordotic cervical alignment preoperatively, and were divided into two groups who maintained lordotic alignment (n=60), and who progressed to kyphosis at final follow up (n=18) for subgroup analysis. Multiple linear regression analysis showed that continuous segment count ($p < 0.001$) and preoperative C2-7 Cobb angle ($p = 0.007$) had statistically significant positive relationship with loss of lordosis. Multivariate logistic regression analysis showed that postoperative kyphosis progression is significantly related with continuous segment count ($p = 0.020$) and preoperative extension Cobb angle ($p = 0.025$). From receiver operating characteristic curve, the cutoff value of continuous segment count to best predict kyphosis progression was 2.5 (sen 0.283, spe 1.000, AUC 0.629).

Conclusion: For OPLL patients, continuous segment count of more than 3 is identified as a protective factor against kyphosis progression following LP with highly specificity.

E-POSTERS



EMERGING TECHNOLOGIES & TECHNIQUES

EPO4-01

Emerging Technologies & Techniques

Screw Placement for Extremely Small Lumbar Pedicles in Scoliosis**JooYoung Lee¹ and ChangJu Hwang^{2*}**¹ Orthopedic Surgery, Dong-A Medical Center, University of Dong-A College of Medicine, Busan, Korea² Orthopedic Surgery, Asan medical center, Korea

Study Design: case series with technical report.

Background Data: To report our screw placement method in patients with extremely small lumbar pedicles (<2mm) allowing maintenance of screw density and correction power in scoliosis surgery without O-arm navigation system. When the lumbar pedicle is so small that even a probe cannot pass, the corresponding pedicle screw may be skipped or replaced with a hook. In scoliosis surgery, it is necessary to place as many screws as possible, especially in the lumbar curve, because screw density is closely related to correction power. Few studies have provided technical guidelines for screw placement without O-arm navigation system in patients with extremely small lumbar pedicles.

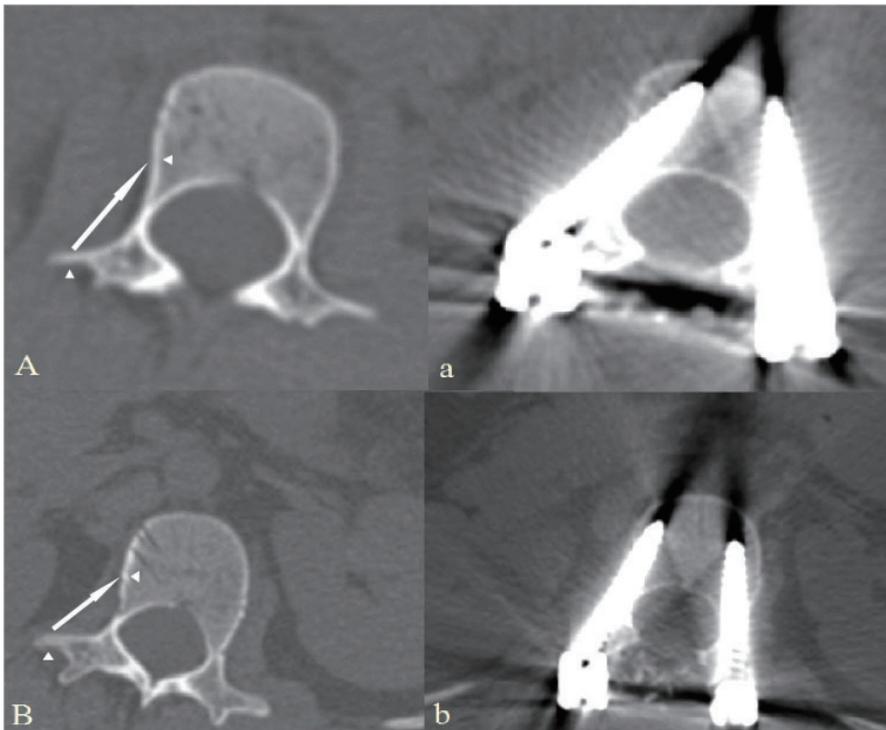
Methods: 19 consecutive patients who underwent scoliosis correction surgery using a novel method of screw placement for extremely small lumbar pedicles were enrolled. Clinical, radiological, and surgical parameters were reviewed. Our technique is evolved from the "medial margin targeting method". After posterior exposure of the spine, the C-arm fluoroscope is gradually rotated until a true poster-anterior view is obtained in which both pedicles are symmetrically visualized. For extremely small pedicles, pedicle shadows appear as long and slender ellipses or lines. An imaginary pedicle outline is presumed with the elliptical or linear shadow. The entry point of a screw is made at 2 (or 10)-o'clock position in the presumed pedicle outline. After adjusting the appropriate convergence of gear-shift, it penetrates both cortices of the transverse process and advances toward lateral wall of vertebral body. If you feel gear-shift tip touching lateral cortex, check it with C-arm fluoroscope. The tip must be located lateral to the pedicular medial margin to avoid penetration into the spinal canal, then, advance the gear shift toward the vertebral body by usually 20 - 25 mm. After creating internal entry point at the lateral body cortex, an extrapedicular screw can be placed into vertebral body with tricortical fixation.

Results: 33 out of 90 lumbar screws from a total of 19 patients were inserted by novel methods, and there was no correction loss without any complications during an average follow-up period of 28.44 months except radiological loosening of one screw.

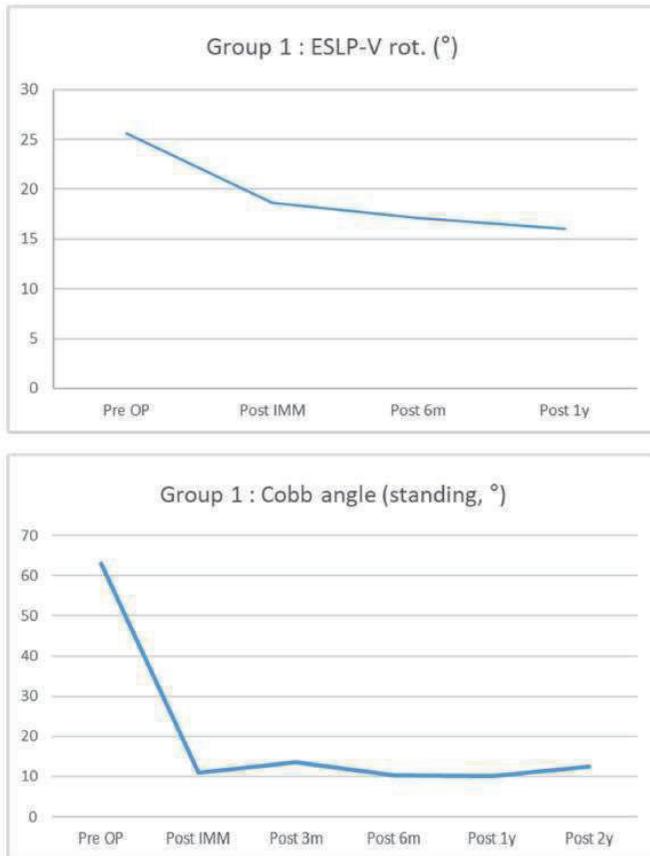
Conclusion: In scoliosis patients with extremely small lumbar pedicles, our new extra-pedicular screw placement method into vertebral body allows easy application with accuracy and safety without O-arm navigation system. Surgeons must try to place an extra-pedicular screw, even if the lumbar pedicle is extremely small, to enhance correction power in scoliosis surgery.



1 A B C
 2 **Figure 1.** Image demonstrating the show extra-pedicular screw placement process under C-arm guidance
 3 in extremely small lumbar pedicles (A->B->C).



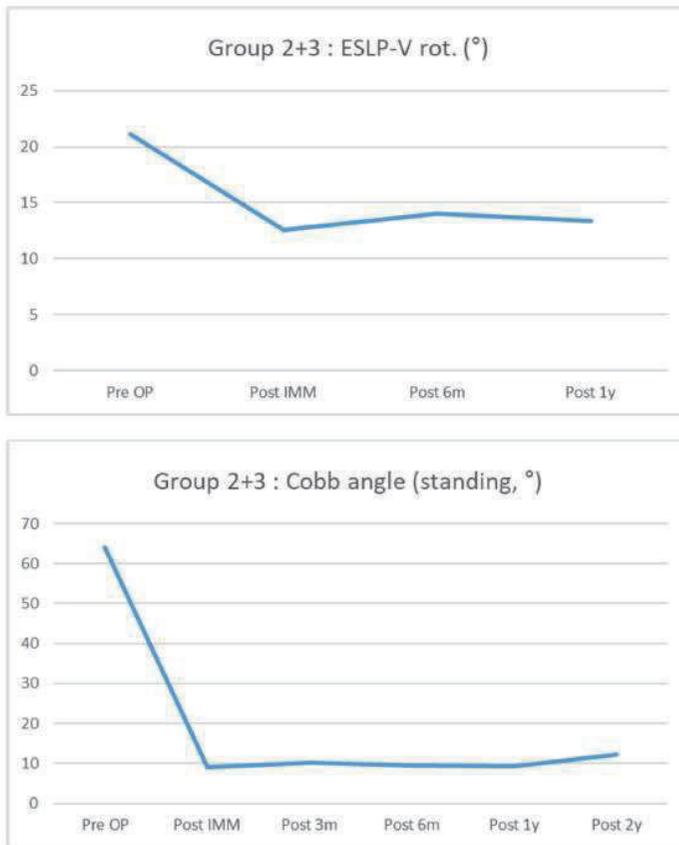
1 A B a b
 2 **Figure 2.** Image demonstrating the comparative CT images before (A,B) and after (a,b) screw insertion
 3 by our new technique in two other patients (A, B). The each angular arrows indicate each cortical bone
 4 entry point, and the long arrows indicate the each screws's trajectory.
 5



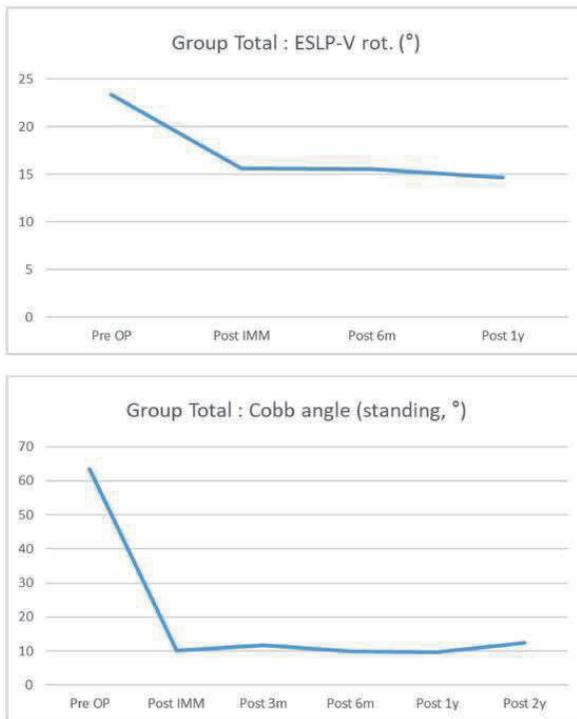
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 2 **Figure 3.** A graph showing the ESLP-V rotation rate measured by CT from before surgery to 1 year after
 3 surgery (top) and a graph showing changes in Cobb angle from before surgery to 2 years after surgery
 4 (bottom) in Group 1.

5 *ESPL, Extremely small lumbar pedicles; V, Vertebra; Rot, Rotation;*

6



1
 2 **Figure 4.** A graph showing the ESLP-V rotation rate measured by CT from before surgery to 1 year after
 3 surgery (top) and a graph showing changes in Cobb angle from before surgery to 2 years after surgery
 4 (bottom) in Group 2.
 5 *ESPL, Extremely small lumbar pedicles; V, Vertebra; Rot, Rotation;*
 6



1
 2 **Figure 5.** A graph showing the ESLP-V rotation rate measured by CT from before surgery to 1 year after
 3 surgery (top) and a graph showing changes in Cobb angle from before surgery to 2 years after surgery
 4 (bottom) in Group of total patients.
 5 *ESPL, Extremely small lumbar pedicles; V, Vertebra; Rot, Rotation;*

EPO4-04

Emerging Technologies & Techniques

3D Printing in Spinal Surgery: Current and FutureSang Bum Kim^{1*}, Eugene Jae Jin Park⁴ and Min-Gu Jang³¹ Orthopedics, Sejong Cheung Nam University hospital, Korea³ Orthopedics, Konyang university hospital, Korea⁴ Orthopedics, Kyungpook university hospital, Korea

Introductions: The Fourth Industrial Revolution is the current and developing environment in which disruptive technologies and trends such as the Internet of Things (IoT), robotics, virtual reality (VR), Three-dimensional (3D) printing and artificial intelligence (AI) are changing the way modern people live and work.

Three-dimensional (3D) printing technique, also known as 'Additive manufacturing technique', is a process of making 3D-printed objects from 3D digital or other electronic data source. It was first used in industry for printing new products, and then introduced into medicine. Nowadays, it is popularized in many aspects of spine surgery

Materials and Methods: In spinal Surgery, application of 3D printing can be categorized three areas, first area is anatomical models for training or pre-operative surgical planning, second is customized implants tailor-made to the surgeon's needs. Last is patient-specific surgical instruments such as pedicle screw drill-guides or jigs. Frequently, intraoperative C-arm X-ray monitor or O-arm monitor or computed tomography (CT) with computer-assisted guide system was used previously. However, the system is expensive, with considerable radiation exposure, is complex to operate, and requires intraoperative bone registration. So the patient-specific navigational template to improve the accuracy of screw placement and decrease the screw misplacement complications in spine surgery. However, the 3D-printed model and patient-specific navigational template is time consuming, and their preparation may require 2 h to 2 days, depending on the volume of models and the machine used. The centralization by platform can be solution.

Conclusions: The 3D printing techniques are applied in areas of research, education, surgical planning, design navigational template, and 3D-printed implant of spine surgery. The initial results of 3D-printed implant are promising, but this technology is still evolving.

EPO4-07

Emerging Technologies & Techniques

Role of Icotec Carbon Fiber Implants for Spine Tumour Disease - A Multicentre Singapore Experience

Naresh Kumar^{1*}, Sean Junn Kit Lee¹, Karthiges Palanichami¹, Tan Yong Hao Joel¹, Laranya Kumar¹ and Dinesh Shree Kumar¹

¹ Department of Orthopaedic Surgery, National University Health System, Singapore

Background Introduction: Spinal metastasis is seen in approximately 10% of cancer patients and contributes to 50% of skeletal metastasis. MSTs is indicated in severe or rapidly progressive neurological deficits, instability or intractable pain. Titanium implants are considered as 'gold standard' in operative fixation in metastatic spine tumour surgery (MSTS), but resulted in artefact generation which compromised post-operative imaging modalities such as CT and MRI, resulting in poor radiotherapy planning, suboptimal tumour surveillance and hence poorer quality of care for patients. Carbon fiber reinforced PEEK (CFR-PEEK) implants (e.g. Icotec) were developed for the specific use in MSTs and primary spine tumour surgery because it generates less artefact in imaging and less backscatter of radiation during radiotherapy. Biomechanically, it has been shown to be comparable to titanium implants. There is also the added benefit of having a modulus of elasticity closer to bone and hence, reduced risk of implant related problems. Several smaller case series have shown acceptable outcomes in patients undergoing surgery with these implants with a few studies showing the potential radiotherapy benefits. In this study, we aim to highlight two-year outcomes of 23 consecutive patients who underwent metastatic spine tumour surgery using Icotec.

Materials and Methods: We report the results of 23 patients from four hospitals who underwent MSTs using Icotec implants from 2020 to 2022. Basic demographics, operative details, clinical outcomes scores and radiological data were collected. Radiotherapy parameters including total artefact volumes, dose calculations and discrepancy between calculated and delivered doses, Clinical Target Volume (CTV) and Gross Tumour Volume, as well as the spinal Cord Visualization were collected and assessed.

Results: All patients in this study reported either a maintenance or improvement in ASIA scores. The median time to radiotherapy was 30 days, and there were no reported delays in oncological treatment. One case alone underwent removal of implants due to L4 screws pull out. There were no major complications in our series.

Conclusion: CFR-PEEK implants display promising outcomes in improved radiotherapy planning, better tumour surveillance and safety.

EPO4-08

Emerging Technologies & Techniques

Deep Learning Model for Grading Metastatic Epidural Spinal Cord Compression on Staging CT

Naresh Kumar^{1*}, James Thomas Patrick Decourcy Hallinan³, Jonathan Jiong Hao Tan¹, A. Vellayappan Balamurugan² and Andrew Makmur¹

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³ Department of Diagnostic Imaging, National University Health System, Singapore

Background Introduction: Metastatic epidural spinal cord compression (MESCC) is a devastating complication of advanced cancer. MRI is the current gold standard imaging test, but it is expensive and unsuitable for screening. Staging CTs are commonly performed for cancer diagnosis and treatment follow-up, allowing for early diagnosis of MESCC. Deep learning (DL) models for automated MESCC classification on staging CT were developed to aid diagnosis.

Materials and Methods: Retrospective collection of staging CTs and corresponding MRI-spine from patients with suspected MESCC was conducted from September 2007 to September 2020. Exclusion criteria were scans with instrumentation, no intravenous contrast, extensive motion artefacts and non-thoracic coverage. The internal CT dataset split was 84% for training/validation; 16% for testing. External CT test set from a different institution was utilised. Internal training and validation sets were labelled by radiologists with spine imaging specialization and used to develop a DL model for MESCC classification on CT. A spine imaging specialist labelled the staging CT test sets (axial portal venous phase images) in conjunction with matched MRI-spine (axial T2-weighted images) to serve as reference. MESCC was classified using modified Bilsky scale; normal/no epidural disease, low-grade (epidural disease with no contact of spinal cord) and high-grade (spinal cord contact or compression). Evaluation of DL model performance using both test sets were independently reviewed by four radiologists; two spine specialists and two body radiologists with experience in oncological CT assessment. Inter-rater agreement (Gwet's kappa) and sensitivity/specificity/AUCs were calculated.

Results: 420 CT scans were evaluated from 225 patients (mean age=60 411.9[SD]); 354 (84%) CTs were used for training/validation and 66 (16%) CTs for internal testing. External test set consisted of 43 CT scans from 32 patients (mean age=60 4 13[SD]). DL model showed near-perfect inter-rater agreement for three-class MESCC grading with kappas of 0.87 ($p<0.001$) and 0.84 ($p<0.001$) on internal and external test sets, respectively. On internal test set, DL model inter-rater agreement (kappa=0.87) was superior to a spine imaging specialist ($\kappa=0.80$) and a body radiologist ($\kappa=0.72$) (both $p<0.001$). The DL model kappa of 0.84 on the external test set was also superior to the body radiologist ($\kappa=0.72$) ($p<0.001$). For detection of high-grade MESCC, DL model showed high kappa/sensitivity/specificity/AUC of 0.94/93.4/95.47/0.94 on the internal test set and 0.95/96.6/96.0/0.96 on the external test set, respectively.

Conclusion: A DL model for detection of MESCC on CT showed comparable or superior inter-rater agreement compared to radiologists on internal and external testing. This model could provide earlier diagnosis and treatment of MESCC, resulting in improved patient outcomes.

EPO4-09

Emerging Technologies & Techniques

Deep Learning Model for Classifying Metastatic Epidural Spinal Cord Compression on MRI

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¹ Department of Orthopaedic Surgery, National University Health System, Singapore

² Department of Radiation Oncology, National University Health System, Singapore

³ Department of Diagnostic Imaging, National University Health System, Singapore

Background Introduction: Metastatic epidural spinal cord compression (MESCC) is a devastating complication of advanced cancer. A deep learning (DL) model for automated MESCC classification on MRI could aid early diagnosis and referral. The aim of this study was to train a DL model for automated Bilsky classification of MESCC using axial T2W-MRI. This could aid early diagnosis of MESCC and identify patients for radiotherapy or surgical decompression.

Materials and Methods: Patients with MESCC diagnosed on MRI between September 2007 and September 2017 were eligible. MRI studies with instrumentation, suboptimal image quality, and non-thoracic regions were excluded. Axial T2-weighted images were utilized and data was obtained using multiple MRI platforms and parameters to prevent overfitting to train a DL model. The internal dataset split was 82% and 18% for training/validation and test sets respectively. External testing was also performed. Internal training/validation data was labelled using the Bilsky MESCC classification by a musculoskeletal radiologist and a neuroradiologist. These labels were used to train a DL model utilizing a prototypical convolutional neural network. Internal and external test sets were labelled by a musculoskeletal radiologist as reference. For assessment of DL model performance and inter-rater agreement, test sets were labelled independently by a neuroradiologist (5-yrs experience), spine oncology surgeon (5-yrs experience), and a radiation oncologist (11-yrs experience). Inter-rater agreement (Gwet's kappa) and sensitivity/specificity were calculated.

Results: 215 MRI spine studies were analysed with 177 (82%) for training/validation; 38 (18%) for internal testing. On internal test set, the DL model showed near-perfect agreement (kappa=0.92, P<0.001) for dichotomous Bilsky MESCC classification (low grade versus high grade), similar to specialists, which included a radiation oncologist (kappa=0.97, P<0.001), a neuroradiologist (kappa=0.96, P<0.001), and a spine oncology surgeon (kappa=0.98, P<0.001). Similar performance was seen on external testing on a set of 32 MRI spines from a different institution with the DL model (kappa=0.94, P<0.001), radiation oncologist (kappa=0.94, P<0.001), neuroradiologist (kappa=0.95, P<0.001), and spine oncology surgeon (kappa=0.94, P<0.001) all showing near-perfect agreement (kappas=0.94-0.95, P<0.001) compared to reference standard. DL model showed high sensitivity/specificity of 97.6/93.6 on the internal set and 89.9/98.1 on external set, respectively.

Conclusion: A DL model showed comparable agreement to a subspecialist radiologist and clinical specialists for the classification of MESCC on MRI. The DL model could be used to triage MRI scans for urgent reporting, augment non-sub-specialized radiologists when they report out of hours and improve the communication and referral pathways between specialties.

EP04-10

Emerging Technologies & Techniques

Is It Necessary to Extend Fusion Segment When We Meet Screw Loosening and Nonunion? The Novel Technique of Short Segment Posterior Pedicle Screw Fixation Using Massive Bone Chip Insertion**Chang Duk Yuk¹ and Jin Hoon Park^{1*}**¹ Department of Neurological surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea

Screw loosening and nonunion that occurs after thoracolumbar posterior fixation is the result of fusion failure and causes anxiety to many spine surgeons. Our goal is to show that firm fixation is working well even though it is a short segment using a bone chip to solve this complications.

In order to promote the success of fusion at our center, short segment fixation has been performed through pedicle screw fixation with the maximum diameter rather than long segment fixation. We apply a massive bone chip to the screw hole to induce firm fixation during screw insertion especially who cannot perform firm screw fixation due to osteoporosis or revision surgery because of fusion failure. Bone chip is mainly used by mixing autologous bone and allogeneic bone, and it is used until the screw hole is full, and sometimes up to 15cc bone chip per one screw hole is used.

A novel technique was created, and this has not been used in any center as far as we know. Since several years ago, the data has been continuously being collected, and the results are also being observed. However, when we observed empirically, the frequency of screw problems or non-union occurrences was relatively small.

We would like to show that the results after surgery by introducing various surgical cases, and through this we would like to clarify that short segment surgery has many advantages in aspect of postoperative complications such as pedicle screw loosening, pullout, and pseudoarthrosis compared with long level extension surgery.

E-POSTERS



ENDOSCOPIC TECHNOLOGIES & TECHNIQUES

EPO5-01

Endoscopic Technologies & Techniques

Full Endoscopic of Interlaminar Approach for Bilateral Decompression in Lumbar Spinal Canal Stenosis : Evaluation of Clinical and Radiographic Outcome 1 Year Follow UpFarid Yudoyono*Neurosurgery, Hasan Sadikin Hospital, Faculty of Medicine, Universitas Padjadjaran, Indonesia*

Objective: To evaluate the outcomes of interlaminar endoscopic unilateral laminectomy and bilateral decompression (PEILD) for lumbar spinal canal stenosis (LSCS).

Methods: This study includes 80 patients diagnosed with LSCS who met the inclusion criteria and underwent surgery for PEILD from April 2021 to January 2022. The mean age of the patients, operation time, hospitalization time, time in bed, and complications were recorded. Patients were followed up for at least 12 months. Visual analog scale (VAS) scores for low-back and lower-limb pain and Oswestry Disability Index (ODI) scores were evaluated preoperatively, before discharge, and at 3, 6, and 12 months postoperatively. To evaluate clinical effectiveness 12 months postoperatively, the modified MacNab criteria were used.

Results: The mean age of the patients was 59.9 years, the mean operation time was 82.1 minutes, the mean hospitalization time was 3.7 days, and the mean time in bed was 20.9 hours. The mean VAS scores of low-back and lower-limb pain improved from 5.9 and 7.2 to 2.0 and 1.6, respectively ($P < 0.05$). The ODI score improved from 56.0 to 16.7 ($P < 0.05$). The overall excellent-good rate of the modified MacNab criteria was 89.7%. Two kinds of complications occurred in 7 patients (10.3%), including 3 patient whose inferior articular process was excessively removed and 4 patients who suffered from postoperative dysesthesia. No other severe complications were noted.

Conclusion: PEILD is a safe, feasible, efficient, and minimally invasive approach to treating LSCS.

Keywords: Endoscopic spinal surgery; Laminectomy; Lumbar spinal stenosis;

EPO5-02

Endoscopic Technologies & Techniques

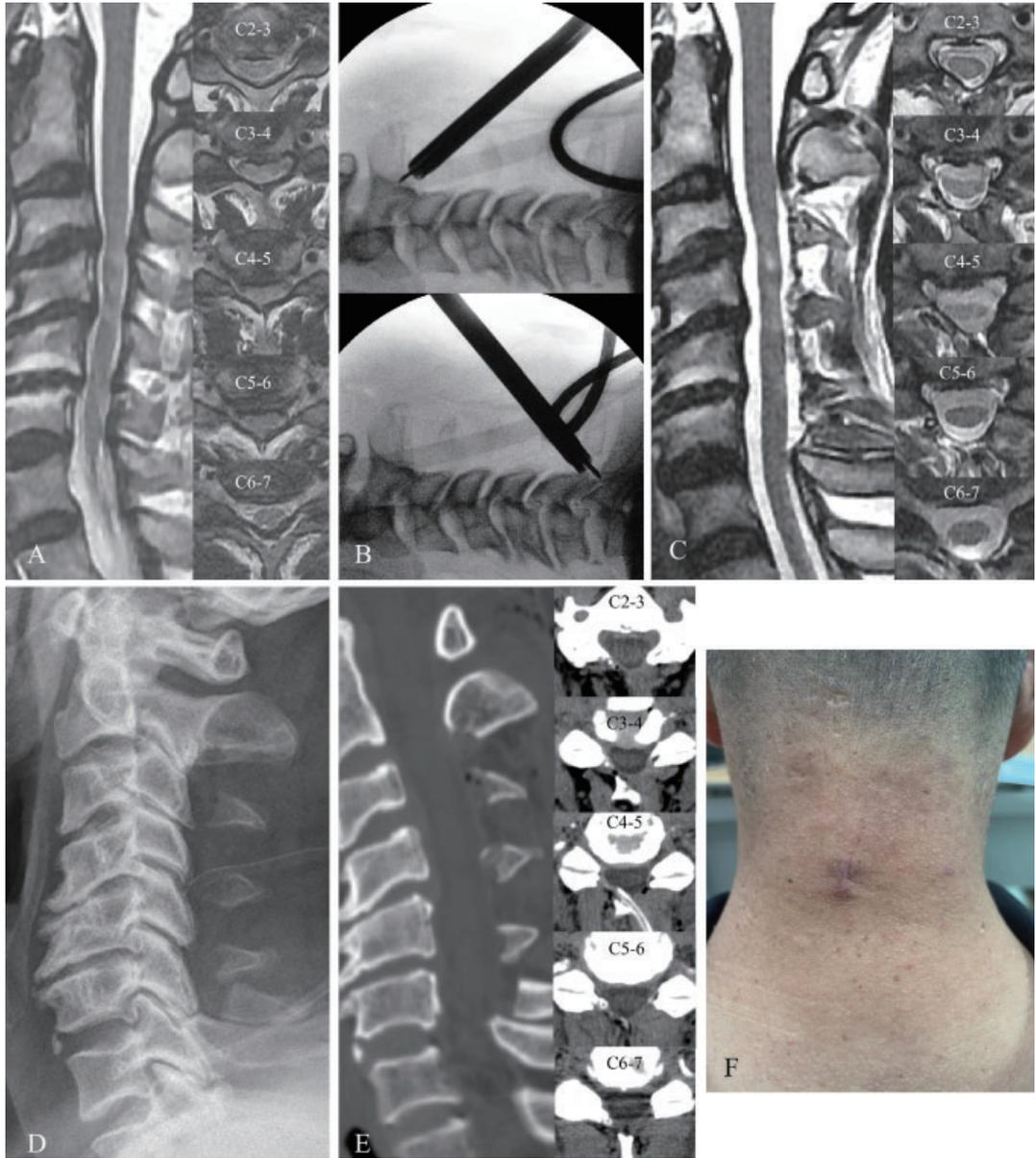
Uniportal Full Endoscopic Spinous Process Preserving Laminectomy for Bilateral Decompression in Cervical Stenotic Myelopathy. (5 Level Endoscopic Decompression, 2 Disease Entity, Csm/opll)Hyun-Jin Ma*Neurosurgery, Daegu Wooridul spine hospital, Korea*

Objective: Endoscopic cervical decompression can be used for cervical stenotic myelopathy. It has various advantages over open conventional surgery like small skin incision, less intraoperative bleeding, preservation of muscle integrity from origin to insertion and non-instrumental surgery. These can make early postoperative recovery and maintaining of cervical spinal angle and range of motion. But sometimes it can be dangerous when doing bilateral decompression, especially during contralateral side decompression. Cervical spine has specific characters that angle of lamina is shallower and thickness of lamina is thinner than lumbar or thoracic lamina. These characters can make chance to compress cord when instruments approach to contralateral side beneath the lamina. This article is to introduce new surgical technique that can overcome these specificities of cervical spine and its efficacy and safety for cervical decompression by uniportal full endoscopic fashion.

Methods: Between 2021 May and 2022 September, 14 patients underwent uniportal full endoscopic spinous process preserving laminectomy (ESP-L) for bilateral decompression to treat multilevel cervical stenotic myelopathy. The radiologic measurements included cervical spine angle (CSA: C2-7 Cobb angle), cervical range of motion (ROM). The clinical outcomes were evaluated using the Japanese Orthopedic Association (JOA) scoring system for cervical myelopathy, numeric rating scale (NRS) about neck and arm pain. Inflammatory factors included WBC (white blood cell), ESR (erythrocyte sedimentation rate), CRP (C-reactive protein) were evaluated. And hospital periods were evaluated.

Results: We analyzed the data for 14 patients. The mean follow-up period was 13.44 months (range 4-17 months). The preoperative CSA and ROM did not change significantly after operation. JOA score showed significantly improved postoperatively. NRS improved significantly after operation. Postoperative inflammatory factors were almost within normal limit. The mean hospital period was postoperative day 2.3.

Conclusions: This new technique, uniportal full endoscopic spinous process preserving laminectomy is safe, effective and most non-invasive surgery but can achieve complete wide decompression for multilevel cervical stenotic myelopathy.



EPO5-03

Endoscopic Technologies & Techniques

Risk Factors Analysis for Inferior Clinical Outcome and Recurrence after Full-endoscopic Interlaminar Discectomy (FEID) for Lumbar Disc Herniation; A Prospective Observational Study**Jungwoo Hur¹, Jae Taek Hong^{1*} and Donghoon Kim¹**¹ Neurosurgery, Eunpyeong St.Mary's Hospital, The Catholic University of Korea, Korea

Background: Full endoscopic interlaminar discectomy (FEID) for lumbar disc herniation (LDH) has become popular in recent years. However, the major concerns for the beginners are inadequate neural decompression and early recurrence. Previous studies have proven the efficacy, but few have discussed the possible risk factors of poor outcome and recurrence. The objective of this study is to determine the possible risk factors for inferior clinical outcome and early recurrence of FEID for LDH in minimum 12 month follow-up.

Methods: This study is a prospective observational study from a single surgeon's experience as a beginner in endoscopic spinal surgery. From May 2019 to July 2020, FEID was performed in consecutive 72 patients for LDH. The operated level was L5-S1 in 41, L4-5 in 29 and L3-4 in 2 patients. Mean operation time was 66.4 minutes and mean hospital stay after the operation was 2.1 days.

Results: The follow-up period was at least 12 month. The visual analog scale (VAS) for back and leg pain, and Oswestry disability index (ODI) showed significant improvement after operation. Excellent or good outcome by the modified MacNab's criteria was observed in 88.8% (64/72) of patients. Disc migration, late surgery, previous spine operation, recurrent herniation and urinary/bowel dysfunction were associated with poor outcome. 8 patients were diagnosed with recurrent disc herniation (11.1%, 8/72) during follow-up period. Recurrence was more common in younger age, higher body mass index (BMI) and early operation. Broad-based (MSU classification 3) discs without calcification or spinal stenosis were also possible risk factors for recurrence.

Small durotomy was occurred in 7 patients and no visible cerebrospinal fluid (CSF) leakage was detected after fibrin sealant patch repair.

Conclusion: FEID is safe and effective alternative to conventional microscopic techniques for LDH even for a beginner in endoscopic spine surgery. We concluded that disc migration, late surgery, previous spine operation, recurrent herniation and urinary/bowel dysfunction were possibly associated with unsatisfactory surgical outcomes. Recurrence was more common in younger age, higher BMI and early operation.

EPO5-05

Endoscopic Technologies & Techniques

Two Cases in Which Fed to the Thoracic Disc Was Performed without Drilling Bones**Ryoo Fujisawa¹, Takeshi Aoyama¹, Hirokazu Furukawa¹, Naoshi Obara¹ and Takahiro Iida¹**¹ Spine Center, Department of Orthopaedic Surgery, Teine Keijinkai Hospital, Sapporo, Japan

Background: Although Full Endoscopic Discectomy (FED) of the lumbar spine is becoming more popular, it is not commonly performed in the thoracic spine. This is because thoracic spine lesions are rare and the head of the rib may obstruct entry into the thoracic discs. We present two cases of thoracic pyogenic spondylitis treated with FED and report the feasibility of FED in the thoracic discs.

Methods: Case report.

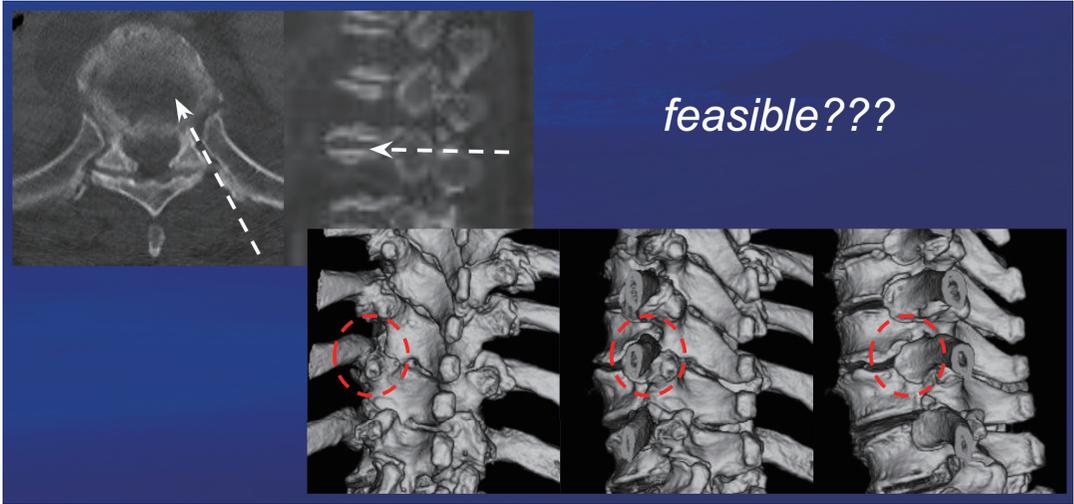
(Case 1) A 72-year-old man presented to our hospital with severe lumbar back pain and mild paraplegia for 10 days. MRI showed pyogenic spondylitis and epidural abscess at the Th7-8 and L4-5 disc level. FED was performed on the Th7-8 disc. Through the transforaminal approach, after the transverse process and superior articular process were identified with the tip of the obturator, the cannula was successfully placed without osteotomy of the head of the rib by using intraoperative imaging. However, the entry space was so narrow that the operator was not able to manipulate the cannula.

(Case 2) 78-year-old woman. Three months after Th9-10 laminectomy and Th8-L1 posterior fusion, pyogenic spondylitis occurred at the Th8-9 disc. The same technique as in case 1 was also able to be applied to the Th8-9 disc.

Results: The infection was controlled promptly after surgery in both cases and there was no recurrence.

Conclusions: FED for thoracic disc herniation was first reported in 2010. In the report, foraminotomy by shaving the superior articular process was applied to insert the cannula. Although there have been reports since then, thoracic herniation accounts for only 0.25-0.75% of all herniations and also the technique takes time to acquire, so it has not been widely favored.

This case report suggests that the head of the ribs are mobile and that it is possible to reach out to the thoracic disc by transforaminal approach without foraminotomy. However, if an intervention to a disc above the middle thoracic level or hand-down manipulation is necessary, as reported in the past, it is assumed that bone removal by drilling may ought to be performed.



EPO5-06

Endoscopic Technologies & Techniques

Oblique Lumbar Interbody Fusion with Selective Biportal Endoscopic Posterior Decompression for Multilevel Lumbar Degenerative Disease**Ki-Han You¹, Woo-Myung Lee¹, Min-Seok Kang² and Hyun-Jin Park^{1*}**¹ Department of Orthopedic Surgery, Spine Center, Hallym University College of Medicine, Kangnam Sacred Heart Hospital, Seoul, Korea² Department of Orthopedic Surgery, Korea University College of Medicine, Anam Hospital, Seoul, Korea

Background: To introduce multilevel lumbar fusion through oblique lumbar interbody fusion and selective direct decompression through biportal endoscopic spinal surgery and discuss the surgical indications, surgical pitfalls, and recommendations for application.

Methods: The patients that multilevel (more than three levels) lumbar spondylosis with lumbosacral radiculopathy received OLIF and biportal endoscopic posterior decompression between February 2019 and April 2021 were collected. Then we collected hospital day, operative time, estimated blood loss, surgical drainage, blood fusion, serum hemoglobin level, and radiographic parameters.

Results: The average hospital day was 12.8 days, average operative time was 379 min, the average estimated blood loss was 470 ml (range, 250–800 ml), and the average surgical drainage volume was 352 ml (range, 249–424 ml). Blood transfusion was performed at an average of 1.2 times 400 ml packed red blood cells. The average serum hemoglobin decreased by 2.0 (12.4 to 10.4). Lumbar lordosis increased from an average of 27.8° preoperatively to an average of 47.9° postoperatively. Accordingly, the pelvic incidence minus lumbar lordosis (PI – LL) mismatch decreased from 20.6° preoperatively to 0.6° postoperatively, and the C7 sagittal vertical axis also decreased from 156.0 mm preoperatively to 53.2 mm postoperatively, resulting in correction of sagittal alignment. There is no major complication.

Conclusions: OLIF with selective biportal endoscopic posterior decompression is a feasible option. In particular, considering three to four levels of lumbar interbody fusion in the elderly, this minimally invasive hybrid technique is expected to restore segmental coronal and sagittal spinal alignment and perform direct neural decompression to the necessary level while reducing the risk of perioperative complications.

EPO5-07

Endoscopic Technologies & Techniques

Removal Technique of Degenerative Epidural Cyst with Biportal Endoscopic SurgeryDongyun Kim*Orthopaedic Surgery, Saeum hospital, Korea*

Background: Intraspinial extradural mass lesions can occur in various tissues such as the disc, facet, and ligamentum flavum with degenerative changes. And can cause clinical symptoms myelopathy and radiculopathy caused by spinal cord and nerve compression. In this case, sufficient removal is possible by biportal endoscopic surgery, and symptomatic recovery can be expected. I would like to report the technical tips and precautions of surgery through a case study

Methods: A 65-year-old male patient with heavy labor visited the hospital because of radiating pain in the right lower extremity and gait disturbance for several years, despite nerve block injections and medical treatment. Spinal stenosis accompanied by an intraspinal extradural mass was diagnosed through MRI, and biportal endoscopic surgery was performed. First, decompression was performed by removing ligamentum flavum and partial laminectomy, and adhesion dissection was performed to remove the mass after confirm the margin of the mass. It was confirmed that the thecal sac was normally expanded, and the operation was completed.

Results: Immediately after the surgery, the radiating pain completely disappeared, and walking was allowed from 5 hours after the operation. On the 2nd day after surgery, MRI was performed and the mass was confirmed to be completely removed, and the patient was discharged. The biopsy result was cystic degeneration with chronic inflammation and hemorrhage. The symptoms remained improved until the 3-month follow-up after surgery.

Conclusions: Intraspinial extradural mass lesions can be removed less invasively and fast recovery is possible through biportal endoscopic surgery. During mass removal, special attention should be paid to the occurrence of dural tears due to adhesions. If the margin of the mass is confirmed through sufficient decompression and adhesion dissection is performed from the edge of the normal dura margin, it can be removed clearly with the help of water flow.

EPO5-09

Endoscopic Technologies & Techniques

Unilateral Biportal Endoscopic Extended Decompression of Extraforaminal Stenosis from the L5 Foramen to The Sacral Ala: Technical Note and Clinical OutcomeHee Chang Kwon*Department of neurosurgery, spine center, Wiltse memorial Hospital, Anyang, Korea*

Objective: The objective of this study was to evaluate the effectiveness and safety of a modified technique for extended decompression of L5-S1 extraforaminal stenosis by using a biportal endoscope. Unlike traditional extraforaminal decompression, this technique involves more vigorous grinding of the sacral ala to release the stenosis while monitoring the downstream pathway of the L5 nerve root.

Method: A total of 15 patients with L5-S1 extraforaminal stenosis or disc herniation underwent biportal endoscopic extended decompression via the modified technique. Pre- and postoperative assessments were conducted using visual analogue scale (VAS) scores for leg and back pain, the Oswestry Disability Index (ODI), and the Macnab criteria.

Results: The mean follow-up period was 6 months. The mean VAS scores for leg and back pain, as well as the ODI, were significantly improved postoperatively ($p < 0.001$). According to the Macnab criteria, 13 patients (87%) reported excellent or good outcomes, while 2 (13%) reported fair or poor outcomes. No major complications occurred during or after the surgery.

Conclusions: The biportal endoscopic extended decompression technique for L5-S1 extraforaminal stenosis is a safe and effective alternative to the traditional technique. This technique allows for better visualization and resolution of the pathology while minimizing the risk of nerve root injury. Further studies with larger samples and longer follow-up periods are warranted to confirm the long-term efficacy and safety of this technique.

EP05-10

Endoscopic Technologies & Techniques

A Preliminary Report of Foraminal Decompression in Adult Isthmic Spondylolisthesis : Pathoanatomy And Endoscopic Posterior ApproachDae-Jung Choi¹, Jin-Ho Hwang¹, Moon-Chan Kim¹ and Tsung-Mu Wu^{2*}¹ Orthopaedic, Himnaer Hospital, Korea² Orthopedic Department, Chi-Mei Medical Center, Taiwan

Background: Adult Isthmic Spondylolisthesis is a common adult spinal condition caused by a defect in the pars interarticularis and neural compression by isthmic spur and/or extruded foraminal disc as ventral prolapse of the vertebral body progresses. It happens very early age of teens and symptom occurs twenties to forties, however surgical intervention using instrumented fusion is recommended lately as much as possible for potential risk of revision surgery for adjacent segment degeneration from relatively early age after fusion surgery. So, patients of early ages with clinical neurologic symptoms should stand on critical point whether immediate fusion with a risk of revision for ASD or delayed fusion with a potential of neurologic sequelae due to longer endurance of root compression. The NASS guideline cannot recommend any of the surgical treatment options toward adult isthmic spondylolisthesis since 2014. The purpose of surgical intervention should not be preventing ventral prolapse or reunion of isthmic defect itself, but decompressing exiting roots with radicular pain by compressive isthmic spur, loose body, hypertrophied granulation tissue with synovitis, and/or extruded foraminal disc.

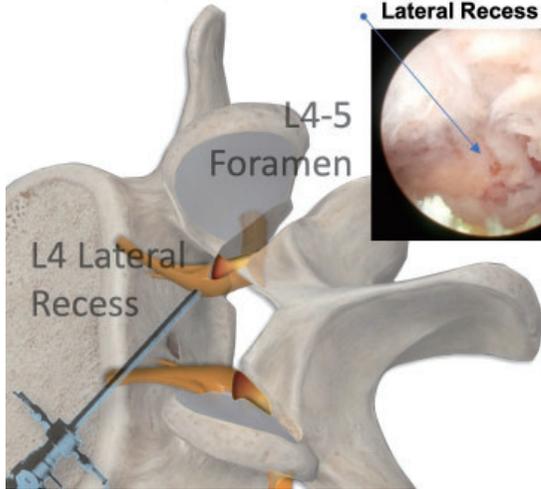
Methods: From January 2022 to June 2022, eleven patients with AIS underwent endoscopic decompression via the endoscopic craniocaudal interlaminar approach and were followed up for at least six months. Visual Analogue Scale, Oswestry Disability Index and MacNab scores were recorded to monitor patients' clinical recovery. All endoscopic procedures were recorded and reviewed to illustrate the pathoanatomy.

Results: In view of surgical pathoanatomy, a nerve root was observed as compressed more in ischemic state at the lateral recess of the upper vertebral level by the hypertrophied spur at isthmic defect of proximal lamina margin, rather than foraminal area. (i.e., in case of L5 isthmic defect, L5 root is compressed at the L4-5 lateral recess by spur on L5 proximal lamina margin more. The root was compressed by a spur from proximal isthmic portion, foraminal area and accessory process.) Conventional transforaminal corridor using microscopic tubular or full-endoscopic approach is supposed to be not feasible to proximal lamina spur on the lateral recess of the upper segment(L4-5). Posterior approach using biportal endoscopic spine surgery(BESS) seems more feasible from the upper segment(L4-5) and decompressing spurs and other pathologic tissues from lateral recess(L4-5), foramen(L5-S1), and till accessory process on the L5 transverse process. It also uses one posterior approach for bilateral foraminal decompression. In clinical point, preoperative VAS and ODI improved significantly in statistics. Satisfaction rate was shown as 90.9% (10/11) in MacNab criteria: Excellent(5) and Good(5), and Fair(1) with revision for hematoma and remnant spur.

Conclusions: The broad spanning spur from isthmic defect, extending from the proximal adjacent lateral recess to accessory process about the foramen, could be the reason why the transforaminal approach yielded less satisfactory results due to the incomplete decompression result from approach-related limited accessibility. Endoscopic decompression, using craniocaudal interlaminar approach from L4-5 interlaminar space to L5-S1 foramen, is supposed to be alternative surgical intervention for decompression-alone in adult isthmic spondylolisthesis, especially relatively younger or senile patients in need of escaping instrumented fusion surgery.

Endoscopic Pathoanatomy

Isthmic Spur



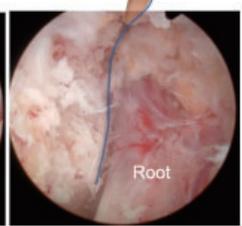
Lateral Recess Spur



Foraminal Spur



Accessory Process



EPO5-11

Endoscopic Technologies & Techniques

Navigation Guided Endo-TLIF in Degeneration Lumbar Lesion and: Tips and TricksYi-Hung Huang*Orthopedics, Chia Yi Christian Hospital, Taiwan*

Background: The endoscopic spine surgery(ESS) is rapidly developed in recent three decades and ESS combined with TLIF(endo-TLIF) is the new trend due to the least traumatization. Recently, Endo-TLIF has been successfully application with successful good clinical results. However, the cons of Endo-TLIF include overdose of radiation, overtime of bony work, and steep learning curves.

Objective: This report aimed to share the experience of navigation aided endo-TLIF and tricks of this novel technique.
Methods: We utilized robotic 3-D fluoroscope to obtain intraoperative tomographic images and transferred these images to the navigation center(Brainlab). We registered not only instruments for insertion of pedicular screws (drill-guide and pointer probe but also instrument for Endo-TLIF(obturator, trephine and cage holder).

Results: The radiation time was significantly lower than non-navigation Endo-TLIF. There was no breach of pedicular screws insertion or malposition of cage implantation.

Conclusions: Perioperative 3D total navigation assisted EndoTLIF has excellent clinical results and provides accurate intraoperative real-time guidance and help spinal surgeons achieve accurate bony works and implantation procedures. The novel Endo-TLIF can reduce radiation exposure and operation time, which improve the operative efficacy and safety.

EPO5-12

Endoscopic Technologies & Techniques

The Effect of Thrombin-containing Local Hemostatics on Postoperative Spinal Epidural Hematoma in Biportal Endoscopic Spinal SurgeryYongho Kim*Orthopedic Surgery Department, Seoul Sacred Heart General Hospital, Korea*

Background: The objectives of this study is to prove the preventive effect of thrombin-containing local hemostatics (TCLH) on postoperative spinal epidural hematoma (POSEH) in biportal endoscopic spinal surgery (BESS) by comparing the incidence of morphometric and symptomatic POSEH between the use of TCLH and the absence of TCLH in BESS.

Methods: The patients with TCLH were assigned to Group A, and those without TCLH were assigned to Group B. We compared POSEH between the two groups in two ways: morphometrically and symptomatically. Patients who experienced a neurological deficit that worsened compared to their preoperative state or those who did not have enough improvement in radiating pain as expected, and those with a postoperative MRI that was compatible with morphometric POSEH (UhG3) underwent a revision surgery for hematoma evacuation. Among the patients who underwent hematoma evacuation, only those who experienced immediate improvement were confirmed as having symptomatic POSEH. Finally, the risk factors for symptomatic and morphometric POSEH in BESS were investigated

Results: The morphometric POSEH was hG1 in 56 (53.8%), hG2 in 31 (29.8%), hG3 in 15 (14.4%), hG4 in 2 (0.2%) cases in Group A, and hG1 in 33 (39.7%), hG2 in 25 (30.1%), hG3 in 22 (26.5%), hG4 in 3 (3.6%) cases in Group B. It was greater in Group B and the difference was significant ($p=0.019$). The incidence of symptomatic POSEH was fewer in Group A, as 4.6% (5/109) compared to 9.5% (9/95) in Group B, but the rate was not significantly different ($p=0.136$). The morphometric POSEH was classified into two groups for the statistical analysis, small (hG1, hG2) versus large (hG3, hG4), and were compared between Group A and B. The difference was significant ($p=0.02$). Non-use of TCLH ($p=0.004$) and preoperative diagnosis of stenosis ($p=0.016$) were the variables found to be significant risk factors of the morphometric POSEH through multivariable logistic regression.

Conclusion: Severe compression of the thecal sac by POSEH occurred more frequently in the group without TCLH. The risk of hematoma formation was higher when bilateral decompression was required and the cut bone surface was more exposed.

EPO5-13**Endoscopic Technologies & Techniques****Endoscopic Correction of Spinal Sagittal Imbalance****Won Joong Kim***Department of Orthopedic surgery, Synergy Orthopedic Clinic, Korea*

Background: Spinal sagittal imbalance has a profound influence on patient function and surgical outcome. However, a correction surgery is at best a challenge with a high risk of peri-/postoperative complications. Accordingly, a large portion of the patients refuse to have a surgical correction. Recently, endoscopy is increasingly employed for lumbar fusion procedures, mitigating the surgical magnitude. This study was carried out to determine the efficacy of endoscopy assisted short level fusion for restoration of the lumbar distal lordosis and its influence in correction of the gross spinal sagittal imbalance in patients who are relatively unsuitable for an extensive full scale correction.

Materials and methods: This is a retrospective review of clinical cases who were subjected to short level endoscopy assisted fusion for symptomatic sagittal imbalance. There were six patients. All were females. The mean age was 70 YO (59-87 YO). Four patients had previous surgeries, three of them had instrumentations. The patients were evaluated pre and postoperatively with whole spine standing radiographs for measurement of sagittal parameters. Distal lumbar lordosis which is relatively constant regardless of PI (pelvic incidence) or age was used as the main parameter for evaluation.

Results: All patients were subjected to one level endoscopy assisted interbody fusion. The level was L4/5 in four and L5/S1 in two patients. Two patients needed removal of the previous instrumentation. One patient had fusion mass osteotomy. Five patients needed PMMA augmentation of the screws and the vertebral body. The operations were under general anesthesia in 5 and spinal anesthesia in 1 patient. The operating time was mean 4.36 hours (2.66-5.75 hours) with a mean transfusion of 1.5 pints (0-2 pints). Distal lumbar lordosis was corrected from mean -6.6 degrees (range: 11 to -17 degrees) to mean -27.3 degrees (range:-18 to -34 degrees). Lumbar lordosis improved from 4.8 degrees to -14.8 degrees on average. Pelvic tilt of mean 36 degrees (31-47 degrees) was improved to mean 28 degrees (22-36 degrees). SVA could not be measured preoperatively in 2 patients because of severe deformity, and could not be numerically analyzed, however, all patients showed improvement in gross balance following the surgery. There were one transient nerve palsy which showed complete recovery, and a pedicle fracture.

Conclusions: Short level endoscopy assisted fusion is quite effective in restoration of distal lumbar lordosis. This may be utilized for correction of sagittal imbalance when the patient is not optimal for an aggressive long level reconstruction.

EPO5-14

Endoscopic Technologies & Techniques

Endoscopic Surgery + Flexible Rod = Awesome Results!Sangyoun Han

Spine center(neurosurgeon), Suwon Leon Wiltse Memorial Hospital, Korea

Introduction: Interbody fusion is the gold standard when there is a foraminal lesion, but fusion may not be possible due to old age, previous history of surgery, and chronic medical disease. In this case, conservative treatment is usually performed, but in the meantime, the patient suffers from extreme pain and complications occur. This problem can be solved by performing surgery with endoscopic surgery through an ipsilateral flexible rod.

Aims/Objectives: The long term outcome of patients who operated using a flexible rod is analyzed and side effects are confirmed.

Methods: Surgery was performed on a total of 57 patients from 2021.05 to 2023.03. In four major categories, surgery was performed using a dynamic screw.

1. Compression fracture root irritation(19 cases)
2. Thoracic HNP or myelopathy(4 cases)
3. L5/S1 paraspinal approach discectomy(22 cases)
4. Facet replacement(discectomy revision - 2 cases)

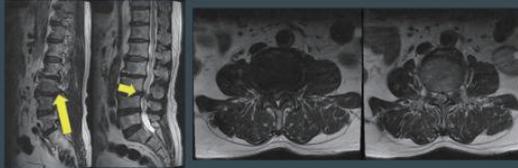
Among them, the cases of compression fracture root irritation and L5/S1 paraspinal approach discectomy were analyzed.

Results: There were a total of 19 patients with compression fracture, with an average follow-up period was 14 months. Pre-operative, immediate post operative, postoperative 1m,3m,6m and last follow up. and it was observed that it decreased from VAS 7.73 4 1.32 to 2.89 4 1.55. The complication also showed good progress, with only acute kidney disease occurring in 1 case after surgery. There were a total of 22 patients with L5/S1 paraspinal approach, and a decrease from VAS 7.90 4 0.75 to 3.09 4 1.87. 2 cases, the pain continued even after surgery, and reoperation was performed through fusion. (Mean VAS score was slightly higher because 2 cases were included)

Conclusions: If surgery is performed using endoscope and flexible rod together, surgery through interbody fusion can be replaced in the presence of foraminal lesions.

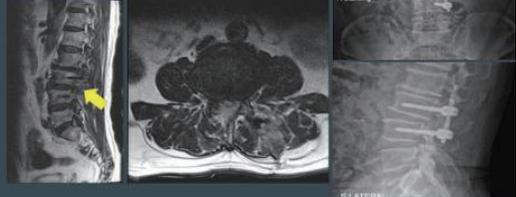
Case 2

M/84 - chronic NIC + acute L3 dermatome radiating pain



Case 2- post op.

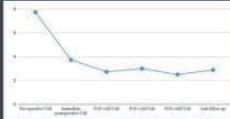
(M/84) - chronic NIC + acute L3 dermatome radiating pain



Compression fx. root irritation Analysis

compression fx. irritation	
No. of patients	18
Sex	
Male	3
Female	14
Age (yr)	70.3 ± 10.65 (44 - 83)
Average follow-up period	2021.11 - 2023.10
Operation time (min)	175.7 ± 42.2
Hospital day (days)	13.1 ± 6.34
Blood loss (ml)	122.1 ± 82.6

Complication : 1 case (AKI)

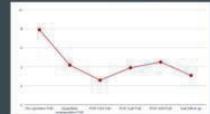


compression fx. irritation	
Pre-operative VAS	7.75 ± 1.32
Immediate postoperative VAS	3.73 ± 0.71
POD #1M VAS	2.73 ± 1.04
POD #3M VAS	3.00 ± 1.24
POD #6M VAS	2.50 ± 1.81
Last follow up	2.80 ± 1.33

L5/S1 stenosis or HNP Analysis

L5/S1	
No. of patients	22
Sex	
Male	10
Female	11
Age (yr)	61.3 ± 10.05 (43 - 86)
Average follow-up period	2021.11 - 2023.04
Operation time (min)	219.3 ± 56.3
Hospital day (days)	9.22 ± 5.49
Blood loss (ml)	97.7 ± 63.2

Complication : 2 case - ALIF revision
TLIF revision



L5/S1	
Pre-operative VAS	7.90 ± 0.75
Immediate postoperative VAS	4.18 ± 0.95
POD #1M VAS	2.59 ± 1.14
POD #3M VAS	3.90 ± 1.66
POD #6M VAS	4.70 ± 0.70
Last follow up	3.08 ± 1.87

EPO5-15

Endoscopic Technologies & Techniques

Percutaneous Endoscopic Thoracic Discectomy ; Case Report of Highly Migrated Thoracolumbar Disc HerniationYoungmin Lee*Neurosurgery, Anyang Wiltse Memorial Hospital, Korea*

Background: Thoracolumbar disc herniation (TLDH) is uncommon, not easy to treat due to clear diagnosis, selection of appropriate treatment methods, and adverse event such as high incidence of complications including recurrence, neurological deterioration, and adjacent segment degeneration. If conservative treatment does not work, surgical procedure may need to be considered. Percutaneous endoscopic discectomy is an increasingly popular method because of several advantages, including rapid patient recovery, less postoperative pain, and minimized iatrogenic injury of soft tissue and muscle. So, PETD is an option that can be considered in this situation.

Methods: A 77-year-old female presented to our hospital with back and Left buttock pain for 5 years. Her symptoms worsened over 3 weeks with rapid progress. She has moderate back tenderness, and restriction of back motion range. The patient's nervous system examination results included muscle force loss of hip flexion, which was more severe on Left side (IV/III). She as well presented sensory changes left anterior thigh. Magnet resonance imaging demonstrated T12-L1 TLDH, with caudally migrated disc fragment with partial calcification. The patient underwent percutaneous endoscopic thoracic discectomy.

Results: The patient's muscle force improved immediately, and the back pain relieved after 5 days post-surgery.

Conclusions: Even though it was highly migrated T12-L1 disc herniation, Percutaneous Endoscopic Thoracic Discectomy for T12-L1 is a safe, effective and comparable to traditional surgery in some situations.

EP05-16

Endoscopic Technologies & Techniques

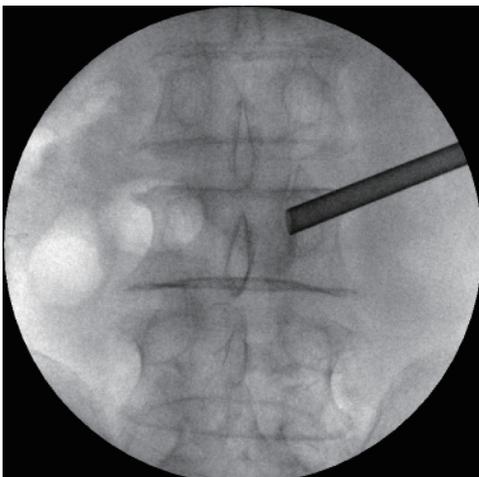
Full Endoscopic Transpedicular Approach for Highly Migrated Ruptured Disc**Yongsoo Choi^{1*}, Junseok Bae¹ and Sang Ho Lee¹**¹ Neurosurgery, Wooridul Spine Hospital, Cheongdam, Korea

Introduction: High-grade migrated lumbar disc herniation (LDH) such as up-migrated and down-migrated discs are challenging pathologies to treat. High-grade migrated discs are usually sequestered and situated adjacent to the medial pedicle wall. This can be easily addressed if the pedicle is used as an access route. The authors present a retrospective case series of high-grade migrated LDH treated using a full endoscopic transforaminal approach.

Materials and Methods: This is a retrospective case series. The clinical outcomes in the patients were evaluated according to improvement in the symptoms as suggested by improvement in Visual Analog Score (VAS) and Oswestry Disability Index (ODI) scores in the immediate postoperative period and at the final follow-up. The radiological outcomes were evaluated using postoperative MRI and CT scans. After the data were collected and tabulated, descriptive statistics were used for continuous variables. The t-test was used to determine the significance of changes in the VAS and ODI scores. Statistical significance was set at $p < 0.05$.

Results: Five patients underwent discectomy using the transpedicular technique, and the mean preoperative VAS scores for the back and leg were 7.240.83 and 8.440.54, respectively. The mean VAS scores at the final follow-up for the back was 0.240.4 and 0 for the leg ($p < 0.05$). The mean preoperative ODI score was 7248.3, which improved to 644.69 at the final follow-up ($p < 0.05$). All patients had a hospital stay of one day.

Conclusion: The full endoscopic transpedicular approach is a good option for treating highly migrated lumbar disc herniations. Surgical planning, including pedicle morphometry and the angle of the approach, should be undertaken preoperatively for the best results.



E-POSTERS



LUMBAR DEGENERATIVE

EPO6-01

Lumbar Degenerative

Cauda Equina Syndrome Due to Huge Lumbar Disc Herniation**Ji Soo Moon¹, Shin Young Lee^{1*}, Sang Ho Lee² and Chan Hong Park³**¹ Neurosurgery, Daegu Wooridul Spine Hospital, Korea² Neurosurgery, Wooridul Spine Hospital, Korea³ Anesthesiology and Pain Medicine, Daegu Wooridul Spine Hospital, Korea

Introduction: Dorsal lateral migration of lumbar disc herniation is usually associated with an acute cauda equina syndrome. The red flags of cauda equine syndrome are bilateral sciatica, bladder and bowel dysfunction, saddle anesthesia, and sexual dysfunction. After immediate surgery, favorable outcomes can be attained.

Objectives: This study is aimed to share a successful case about cauda equina syndrome due to huge lumbar disc herniation.

Methods: A 35-year-old man chiefly complained of right sciatica and weakness of bilateral leg 2 week ago. The pain was 10 in Numeric Rating Scale (NRS) score. He reported fecal incontinence. Bilateral ankle dorsiflexion was grade 1, bilateral ankle plantar flexion was grade 4, bilateral great toe dorsiflexion (GTDF) was grade 0, and bilateral great toe plantar flexion (GTPF) was grade 3 in Muscle Manual Test (MMT). Resting score was grade 2 in The Digital Rectal Examination Scoring System (DRESS). After reviewing Magnetic resonance images (MRI), we found huge disc herniation with dorsal lateral migration and central stenosis at the level of L4-5. Electromyography demonstrated both L5 and S1 radiculopathies. We planned unilateral laminotomy and bilateral decompression at the level of right L4-5 immediately. Clinical outcomes were assessed by using Preoperative and Postoperative NRS score, MMT grade, and DRESS. Postoperative MRI was checked.

Results: Postoperative MRI showed sufficient decompression and no remnant disc herniation. On the first postoperative day, right sciatica was improved in NRS score to 3, bilateral GTDF was improved in MMT grade to 1, and resting score was improved in DRESS to 3. On the third postoperative day, fecal incontinence was improved. On the fifth postoperative day, bilateral GTPF was improved in MMT grade to 4.

Conclusion: Favorable outcomes can be accomplished after immediate surgery for sufficient decompression and herniated disc removal.

EP06-02

Lumbar Degenerative

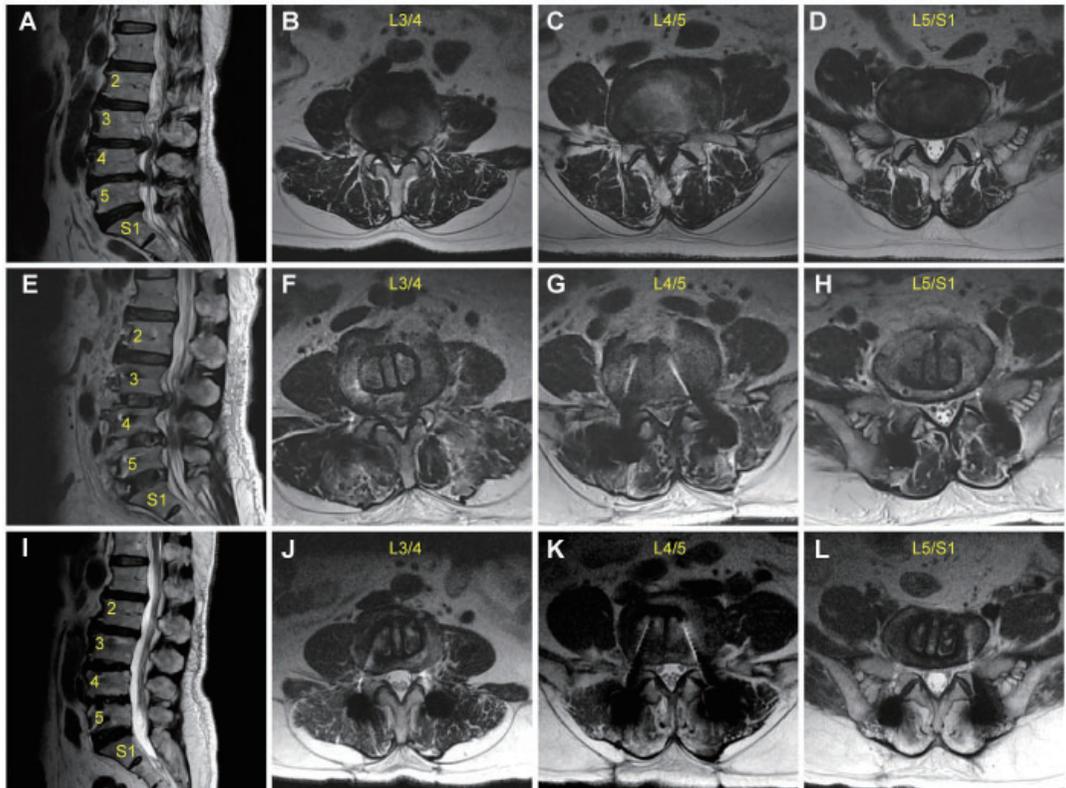
Remodeling of the Spinal Canal after Anterior Lumbar Interbody Fusion(ALIF) in Central Spinal Stenosis: Clinical and Radiological Findings**Dong Hyun Lee¹, Dong-Geun Lee¹, Choon Keun Park^{1*} and Jae-Won Jang¹**¹ *Department of Neurosurgery, Spine Center, The Leon Wiltse Memorial Hospital, Suwon, Gyeonggi-do, Korea*

Objective: Whereas the benefits of indirect decompression after lateral lumbar interbody fusion are well known, the effects of anterior lumbar interbody fusion (ALIF) have not yet been verified. The purpose of this study was to evaluate the clinical and radiological effects of indirect decompression after ALIF for central spinal canal stenosis. In this report, along with the many advantages of the anterior approach, the authors share cases with good outcomes that they have encountered.

Methods: The authors performed a retrospective analysis of 64 consecutive patients who underwent ALIF for central spinal canal stenosis with instability and mixed foraminal stenosis between January 2015 and December 2018 at their hospital. Clinical assessments were performed using the visual analog scale score, the Oswestry Disability Index, and the modified Macnab criteria. The radiographic parameters were determined from pre- and postoperative cross-sectional MRI scans of the spinal canal and were compared to evaluate neural decompression after ALIF. The average follow-up period was 23.3 ± 1.3 months.

Results: All clinical parameters, including the visual analog scale score, Oswestry Disability Index, and modified Macnab criteria, improved significantly. The mean operative duration was 254.8 ± 60.8 minutes, and the intraoperative bleeding volume was 179.8 ± 119.3 ml. In the radiological evaluation, radiological parameters of the cross-sections of the spinal canal showed substantial development. The spinal canal size improved by an average of 43.3% ($p < 0.001$) after surgery. No major complications occurred; however, aspiration guided by ultrasonography was performed in 2 patients because of a pseudocyst and fluid collection.

Conclusions: ALIF can serve as a suitable alternative to extensive posterior approaches. The authors suggest that ALIF can be used for decompression in central spinal canal stenosis as well as restoration of the foraminal dimensions, thus allowing decompression of the nerve roots.



EP06-04

Lumbar Degenerative

Effects of the Severity of Stenosis on Clinical Outcomes of Indirect Decompression Using Minimally Invasive Oblique Lumbar Interbody Fusion

Dong-Ho Kang¹, Sam Yeol Chang¹, Bong-Soon Chang¹, Hyoungmin Kim¹, Seong Hwa Hong¹ and Jonghyuk Baek¹

¹ Department of Orthopedic Surgery, Seoul National University College of Medicine and Seoul National University Hospital, Korea

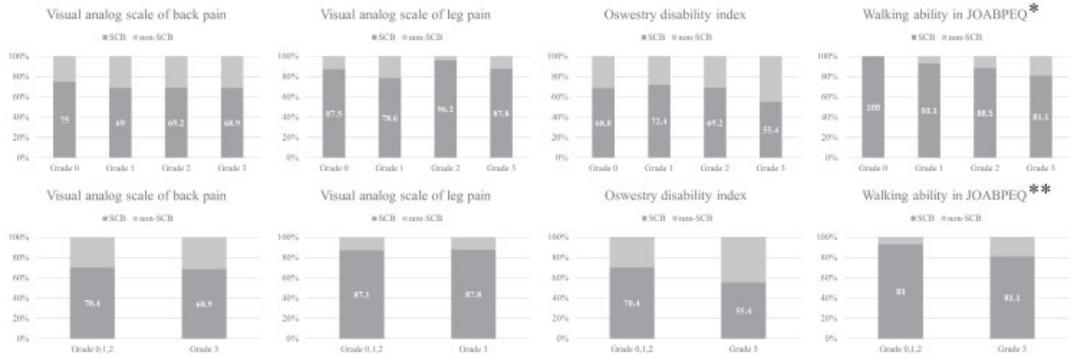
Background: Minimally invasive oblique lumbar interbody fusion (MIS-OLIF) is a safe and effective treatment for lumbar spinal stenosis (LSS). However, indirect decompression may be less effective in patients with endplate osteophytes, foraminal osteophytes, and severe facet arthropathy. Thus, there is no consensus regarding the efficacy of MIS-OLIF in severe spinal stenosis. This study aimed to determine whether the clinical results of indirect decompression through MIS-OLIF differ according to the morphological grading of central stenosis and foraminal stenosis on preoperative magnetic resonance imaging (MRI) in patients with LSS.

Methods: During the study period, MIS-OLIF was selected as the primary surgical option for treating LSS when lumbar fusion surgery was required. We retrospectively reviewed the data of patients with LSS who underwent single- or two- or three-level OLIF and posterior stabilization, with a 1-year follow-up period. Relevant clinical scores obtained preoperatively and at 3, 6, and 12 months postoperatively were collected and analyzed. The severity of central and foraminal stenoses on the initial MRI was assessed using qualitative grading systems. Logistic regression models were used to identify risk factors for inferior clinical outcomes.

Results: A total of 145 patients were included in the study with a mean age 4 standard deviation of 68.93 4 7.72 years. When patients were stratified according to the severity of central stenosis, there was no significant difference in clinical scores and the proportion of patients with substantial clinical benefit (SCB) between the groups. However, the group of patients with severe foraminal stenosis showed significantly lower walking ability scores (72.6 4 34.8 versus 86.4 4 21.3; $P = 0.004$) and a lower proportion of patients achieving SCB (81.1% versus 93.0%; $P = 0.034$) in the JOABPEQ at postoperative 1-year than those without severe foraminal stenosis (Figure 1). In multivariate logistic regression, foraminal osteophyte of superior articular process (SAP) (odds ratio [OR]: 0.22; $P=0.030$) and previous operation history in index surgical level (OR: 0.15; $P=0.001$) were significant risk factors for not achieving substantial clinical benefit (SCB) in walking ability score in JOABPEQ at postoperative 1-year.

Conclusions: In this study, patients with severe central stenosis showed clinical outcomes comparable to those with mild-to-moderate central stenosis. The improvement in walking ability after MIS-OLIF was limited in patients with severe foraminal stenosis, and direct decompression can be considered in patients with the foraminal osteophyte of SAP contributing the foraminal stenosis.

Figure 1. VAS, ODI, JOABPEQ scores at preoperative and postoperative 1-year stratified by the existence of severe foraminal stenosis. The group with severe foraminal stenosis showed significantly lower walking ability score in JOABPEQ than that by the other group ($P = 0.004$). * Error bars showed range of 95-percentile confidence interval.



EPO6-05

Lumbar Degenerative

Risk Factors of New Vertebral Fracture after Vertebroplasty for Osteoporotic Vertebral Compression Fracture**Jong-Hyeok Park¹, Jong Tae Kim¹ and Jae Taek Hong^{1*}**¹ Neurosurgery, Incheon St. Mary's Hospital, The Catholic University of Korea, Korea

Purpose: To determine the natural course of new vertebral fractures after vertebroplasty for osteoporotic vertebral compression fracture and to analyze risk factors for understanding the incidence of adjacent vertebral fracture and remote vertebral fracture.

M & M: The study subjects included 190 patients who received vertebroplasty for osteoporotic vertebral compression fracture. Pathologic and posterior column and multiple fractures were excluded. Patients with Neurologic symptoms and impaired mobility also were excluded. Finally, 152 patients are included. Age, body mass index, bone density, cement leakage, location of fracture, sagittal imbalance, segmental kyphosis were checked to detect risk factor for new vertebral fracture after vertebroplasty. During the follow-up, any new developed vertebral fractures were identified. We analyzed the time of occurrence differed between adjacent vertebral fracture and remote vertebral fracture by calculating survival analysis and each risk factors separately.

Results: New vertebral fractures occurred in 37 patients (24.3%) after vertebroplasty. Adjacent vertebral fracture occurred 16 patients (10.5%), and remote vertebral fracture occurred 21 patients (13.8%). The onset time of adjacent vertebral fracture was about 2.741.6 months after vertebroplasty, showing a significant difference from that of remote vertebral fracture which was 12.149.3 months ($P < 0.001$). In multivariate analysis, risk factors of adjacent vertebral fracture included severe osteoporosis, vertebroplasty in tholacolumbar junction, sagittal imbalance, segmental kyphosis ($P < 0.005$). Risk factors of remote vertebral fracture included osteoporosis, sagittal imbalance ($P < 0.005$).

Conclusion: After vertebroplasty for osteoporotic vertebral compression fracture, a significant difference in the meantime of occurrence between adjacent vertebral fracture and remote vertebral fracture was found. Osteoporosis and sagittal imbalance were important for new vertebral fracture after vertebroplasty, even in both adjacent and remote vertebral fracture.

EP06-06

Lumbar Degenerative

Comparison of Minimally Invasive and Open TLIF Outcomes with more than Seven Years of Follow-upYoonjoong Hwang¹, Jiwon Park¹ and Jae-Young Hong^{1*}¹ Department of Orthopedics, Korea University Ansan Hospital, Korea

Background: Few studies directly comparing minimally invasive (MI) transforaminal lumbar interbody fusion (TLIF) and open TLIF offering long-term follow-up data have been performed to date. Therefore, we sought to compare mid- to long-term outcomes between these two surgical approaches.

Methods: This was a retrospective data analysis of two surgical groups. We analyzed the details of 97 patients with degenerative lumbar disease who were treated with MI TLIF (n = 55) or open TLIF (n = 42) between 2011-2014 and had at least seven years of follow-up data available. Peri- and postoperative outcomes were compared. To evaluate rates of adjacent segment disease (ASD) and revisions, frequencies of radiologic, symptomatic, and operative ASD were analyzed accordingly.

Results: In terms of clinical outcome, the Oswestry Disability Index and visual analog scale scores were significantly reduced, with no difference between the groups. However, data for several peri- and postoperative outcomes, including perioperative blood loss, ambulation day, hospital stay, and operation time, varied in a manner favoring the MI TLIF group (P < 0.05). Rates of radiologic ASD and symptomatic ASD were significantly higher in the open TLIF group beginning at five years of follow-up (P < 0.05), while the rate of operative ASD and the revision rate were similar between the groups. Other long-term outcomes, including fusion rate and complications, remained similar between the two groups at 7 years.

Conclusion: Patients undergoing MI TLIF showed favorable immediate postoperative outcomes and less radiographic ASD. However, the rates of fusion and operative ASD remained similar between the two groups after 7 years of follow-up.

EPO6-07

Lumbar Degenerative

Ankle and Toe Weakness Caused by Ligamentum Flavum Calcified Cyst: A Case Report and Literature ReviewHo-Young Jung¹, Yong-Won Joh¹, Geon-U Kim¹ and Jun-Seok Lee^{1*}¹ Department of Orthopedic Surgery, Eunpyeong St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Korea

Background: The ligamentum flavum cysts are rare cause of spinal stenosis, and they are most common in mobile junctional levels of spine. There are several case reports of ligamentum flavum cyst. However, there is no documented case report of a ligamentum flavum calcified cyst. We report the first case of ligamentum flavum calcified cyst presenting ankle and toe weakness.

Case presentation: A 66-year-old male visited our hospital with complaints of claudication, thigh and calf pain in his left leg that had begun 2 weeks ago. He claimed weakness in the left great toe and ankle. Physical examination revealed motor weakness of the left ankle dorsiflexion and great toe dorsiflexion. Lumbar spinal computed tomography (CT) scans showed spinal stenosis combined with calcified mass at the left side of the L4-5 level. Magnetic resonance imaging (MRI) showed dural sac compression by calcified mass at the left ligamentum flavum of the L4-5 level. We performed decompressive laminectomy and excision of the calcified mass for lumbar spinal stenosis and posterior lumbar interbody fusion at the L4-5 level. Intra-operatively, a firm and nodule like mass originating from ventral surface of ligamentum flavum was found. Pathological examination suggested the calcified cyst with capsular lining. After the operation, the patient's motor weakness of ankle and great toe improved gradually.

Conclusions: The patient's ankle and great toe weakness successfully improved after surgical removal of the calcified cyst.

EPO6-08

Lumbar Degenerative

Recanalization of External Iliac Artery Occlusion in Patient with Spinal Stenosis Using Medications: A Case Report**Geon-U Kim¹, Ho-Young Jung¹, Hyung-Youl Park¹ and Jun-Seok Lee^{1*}**

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Background: Iliac artery occlusion accompanied by spinal canal stenosis is rare. All reported cases were treated with endovascular stenting for iliac artery occlusion. We report the first case of external iliac artery occlusion accompanied by spinal stenosis, which was successfully treated with conservative treatment.

Case presentation: A 66-year-old man with both lower extremity pain and claudication visited the outpatient spine clinic. He complained of a tingling sensation in the L5 dermatome of the right leg and L4 dermatome of the left leg. Magnetic resonance imaging showed central stenosis in L4-5 and L5-S1 levels, and lateral recesses stenosis at the L5-S1 level. The patient's symptoms were ambiguous with mixed neurological claudication and vascular claudication. Computed tomography (CT) of the lower extremity artery showed complete occlusion in the right external iliac artery. Conservative treatment with clopidogrel and beraprost sodium was performed. After treatment, his symptoms gradually improved. Clopidogrel and beraprost sodium were continued for four years. Follow-up CT at four years showed recanalization of the right external iliac artery occlusion.

Conclusion: We describe a rare case of external iliac artery occlusion and spinal stenosis. External iliac artery occlusion may be successfully treated only with conservative treatment using medication.

EP06-09

Lumbar Degenerative

The Impact of Instrumented Lumbar Fusion Surgery on Psychiatric Problems in Elderly Patients with Degenerative Spinal Stenosis

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Background: Patients with chronic spinal disease experience a decrease in the activities of daily living, limitations in physical activity, and loss of quality of life. These patients commonly have comorbid psychiatric problems such as depression, anxiety, and somatoform disorder. Surgery is an effective treatment for reducing pain and disability. However, there have been few studies of the effects of lumbar fusion on aspects of mental health. The purpose of this study was to investigate the effects of instrumented lumbar fusion surgery on psychiatric problems, including anxiety, insomnia, and depression, in patients with degenerative spinal stenosis, as well as on pain and the activities of daily living.

Methods: A total 69 patients who underwent instrumented lumbar fusion for the diagnosis of degenerative spinal stenosis from August 2017 to October 2021 were included prospectively. Beck anxiety inventory (BAI), Insomnia severity index (ISI), Geriatric Depression Scale short form-Korean (GDS-K), visual analogue scale for back pain (VAS-Bp), visual analogue scale for leg pain (VAS-Lp), and Oswestry disability index (ODI) was measured on the day surgery was decided on (T1), the day before surgery (T2), the day before discharge (T3), and 6 months after surgery (T4). Age, gender, marital status, economic level, duration of spinal stenosis, history of psychiatric disease, and religion were investigated.

Results: The patients had mild degrees of anxiety (14.41410.02), insomnia (11.304783), and depression (13.5543.92) at T1, and BAI, ISI, VAS-Bp, VAS-Lp, and ODI improved significantly by T4. In a logistic regression analysis conducted by dividing the patients into two groups according to whether or not GDS-K worsened between T1 and T4, patients with spouses (n=48) were 5.01 times more likely to have an increased level of depression than those who had separated from their spouses (n=21; P=0.021). Comparing the groups with and without postoperative complications, there were no significant differences between the two groups in the difference in VAS-Bp, VAS-Lp, ODI, BAI, ISI, and GDS-K between T1 and T4.

Conclusions: In elderly patients with degenerative spinal stenosis, instrumented lumbar fusion surgery improves not only pain and activities of daily living, but also anxiety and insomnia. However, there was no improvement in depression over the 6-month follow-up period.

EP06-10

Lumbar Degenerative

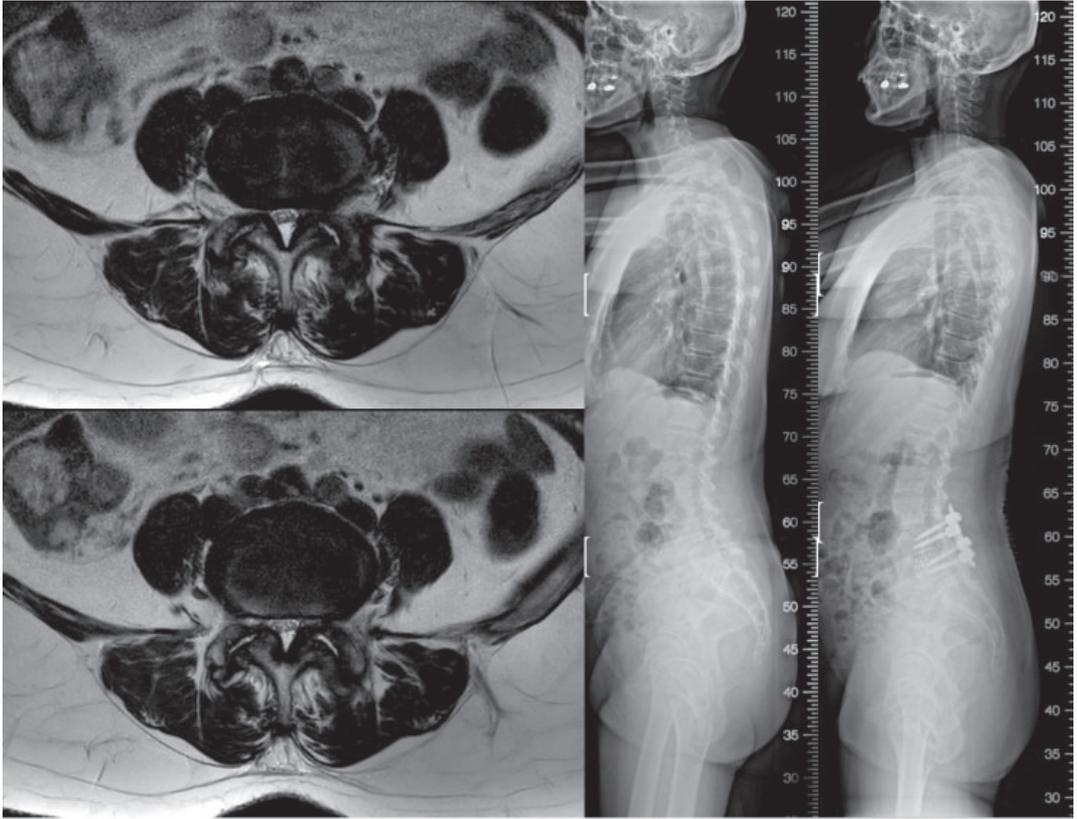
Effect of Short-level Oblique Lumbar Interbody Fusion Correcting Sagittal Imbalance**Dong-Ho Kang¹, Sam Yeol Chang^{1*}, Bong-Soon Chang¹ and Hyoungmin Kim¹**¹ Department of Orthopedic Surgery, Seoul National University College of Medicine and Seoul National University Hospital, Korea

Background: The contributions of revolving stooping posture and the correction of segmental angle (SA) on correcting sagittal imbalance after short-level oblique lumbar interbody fusion (OLIF) remain ambiguous. This study aimed to explore the influence of stooping resolution and segmental correction on sagittal imbalance correction after short-level OLIF and to identify the associated preoperative clinical and radiological factors predicting patients without stooping posture after OLIF.

Methods: A retrospective review was conducted on 148 patients with lumbar spinal stenosis (LSS) who underwent single or two-level OLIF (mean age 4 standard deviation of 71.4 4 8.0 years). Patients were divided into two groups on the basis of the presence or absence of postoperative improvement in stooping posture (S group or NS group, respectively). Preoperative and postoperative clinical and radiological parameters were compared, and a multivariate logistic regression analysis was performed to identify the associated factors for patients without stooping posture.

Results: A total of 96 patients (64.9%) showed improvement of the C7 sagittal vertical axis (SVA) under 50 mm postoperatively. The S group showed a more severe sagittal malalignment preoperatively with a larger preoperative pelvic incidence minus lumbar lordosis (LL) and SVA than the NS group. In the S group, the sum of changes in SA contributed to only 43.8% of the total change of LL, whereas the change of lordosis in remnant lumbar segments that were not fused was 56.2%. Preoperative thoracic kyphosis (TK), SVA, and spondylolytic spondylolisthesis were significant associated factors for predicting patients without stooping posture.

Conclusion: The resolution of stooping posture significantly influences the correction of global sagittal imbalance in patients with LSS undergoing short-level OLIF. A larger TK, a smaller SVA, and the presence of spondylolytic spondylolisthesis are predictors of patients without stooping posture after OLIF.



EPO6-11

Lumbar Degenerative

Analysis of Risk Factors for Early Adjacent Segment Disease Who Underwent Revision Surgery within 5 Years after Lumbar Spinal FusionJaewan Soh^{1*}, Chung-Su Hyun¹ and Taejong Jeong¹¹ Orthopaedic Surgery, Sahmyook Seoul Medical Center, Korea

Introduction: There are many concerns about adjacent segment disease after lumbar spinal fusion using pedicle screws. Of them, we have a question which occurs early adjacent segment disease(EASD) within 5 years. We analyze the risk factors about EASD in patients who underwent revision surgery within 5 years from first operation.

Materials and Methods: From August 1988 to December 2007, 657 patients underwent lumbar spinal fusion of 3 and less segment to treat degenerative lumbar disease. Among them, 137 patients underwent revision surgery within 5 years due to adjacent segment disease or previously followed more than 5 years were included in this study. Gender, age, fusion method, preoperative diagnosis, number of fusion segments and radiological measurements were analyzed. In radiological measurement, pre- & post-operative lumbar lordotic angle(LLA), pre- & post-operative fusion segment lordotic angle(FSLA), pre- & post-operative FSLA per level, correction of LLA, correction of FSLA, and correction of FSLA per level were estimated. Statistical univariate analysis was performed with the Chi-square test and multivariate logistic regression analysis was done by using SPSS 14.0.

Results: There were 13 patients with revision surgery due to EASD. 6 patients were operated by decompression or discectomy and 7 patients needed additional fusion. In univariate analysis, there was little relationship between EASD and gender, age, preoperative diagnosis, number of fusion segments, pre- & post-operative LLA, pre- & post-operative FSLA, pre- & post-operative FSLA per level, correction of FSLA and correction of FSLA per level. However, the frequency of EASD was significantly high in cases where PLIF was more than PLF($P=0.023$), correction of LLA was $>15^\circ$ ($P=0.021$) and correction of FSLA per level was $>5^\circ$ ($P=0.049$). In multivariate logistic regression analysis, the frequency of EASD was significantly high in case where PLIF was more than PLF(odd ratio=17.866) and correction of LLA was $>15^\circ$ (odd ratio=19.282).

Conclusions: There was no statistical significance between EASD and gender, age, preoperative diagnosis, number of fusion segments, pre- & post-operative LLA, pre- & post-operative FSLA, pre- & post-operative FSLA per level, correction of FSLA and correction of FSLA per level. However, PLIF and correction of LLA more than 15 degree increased risk of EASD

EP06-12

Lumbar Degenerative

The Role of the Spine and Pelvic Balance in Determining the Tactics of Surgical Treatment of Lumbar Spondylolisthesis**Akobir Ibragimov¹, Abdurakhmon Norov² and Ravshan Yuldashev^{1*}**¹ *Spinal Surgery, Republican Specialized Scientific and Practical Medical Center of Neurosurgery, Uzbekistan*² *Spinal surgery, Bukhara Regional Multidisciplinary Medical Center, Uzbekistan*

Relevance: Degenerative diseases of the spine are very common among the elderly. Among degenerative diseases of the spine, spondylolisthesis is a common cause of chronic back pain in patients. Depending on the direction of displacement of the vertebra, it is classified as anterolisthesis (anterior displacement) or retrolisthesis (posterior displacement). The physiological curvature of the spinal column is very important, as it absorbs the forces of both physiological and pathological stress, and also serves as a lever, thus protecting the spinal cord and nerve roots. When the normal position of the spine is disturbed, as is seen in spondylolisthesis, compression, traction, or shear injuries can develop. It has been clinically proven that sagittal vertebral-pelvic balance plays an important role in the development and progression of spondylolisthesis. The main parameters of the spinal-pelvic relationship are: pelvic index (Pelvic incidence - PI), which is a constant anatomical and morphological value, pelvic tilt (PT) and sacral slope (SS), which, in turn, depend on the overall balance of the spine and may vary depending on the posture of the patient, as well as due to surgical treatment. The purpose of this study is to choose the tactics of surgical treatment for spondylolisthesis, depending on the indices of the spinal-pelvic balance.

Material and Methods: The work was based on an analysis of the results of examination and surgical treatment of 72 patients with a diagnosis of spondylolisthesis who were hospitalized from 2019 to 2022. The age of the patients varied from 17 to 72 years, the mean age was 44.2 years. There were 24 men and 48 women. All patients underwent an assessment of the spinal-pelvic balance indices before surgery in order to choose the tactics of surgical treatment. When assessing the spinal pelvic index, we measured: the angle of the pelvic tilt (Pelvis Tilt), the slope of the sacrum (Sacral Slope) and the pelvic index (Pelvis index), as well as lumbar lordosis (Lumbar lordosis). Considering the sacral tilt (SS) and Pelvic Tilt (PT) angles, the Pelvic Index (PI) was calculated. $PI=PT+SS$. Depending on the angle of the Pelvic Index and lumbar lordosis, the tactics of surgical treatment was determined. Thus, 12 (16.6%) patients with a pelvic index less than 35 degrees underwent decompressive laminectomy and stabilization with a transpedicular construct with an interbody fusion with a cage. Laminectomy with stabilization without reduction of displaced vertebrae was performed in 42 (58.4%) patients with a pelvic index of 35-50 degrees. A pelvic index of 50-80 degrees was observed in 18 (25%) patients who underwent laminectomy with reduction of the displaced vertebra with stabilization. The results of surgical treatment were assessed using the VAS scale and the Oswestry scale (ODI). A good result with complete neurological regression was achieved in 63 (87.5%) patients, satisfactory in 8 (11.1%) and unsatisfactory in 1 (1.4%).

Conclusion: Assessment of the sagittal balance in spondylolisthesis improved the results of surgical treatment and regression of the pain syndrome, as well as improved the quality of life of patients.

EP06-13

Lumbar Degenerative

Comparison of Radiologic & Clinical Outcome of Posterior Lumbar Interbody Fusion Using Unilateral Cage with Unilateral Facetectomy and Contralateral Facet Fusion Versus Conventional Posterior Lumbar Interbody Fusion Using Bilateral Cages**Suk Hyun Hwang¹, Minjoon Cho², WooSeok Lee³ and Jae Hyup Lee^{4*}**¹ Orthopaedic Surgery, Seoul Red Cross Hospital, Seoul, Korea² Orthopaedic Surgery, Department of Orthopedic Surgery, SMG-SNU Boramae Medical Center, College of Medicine, Seoul National University of Korea, Seoul, Korea³ Orthopaedic Surgery, College of Medicine, Seoul National University of Korea, Seoul, Korea⁴ Orthopaedic Surgery, Department of Orthopedic Surgery, SMG-SNU Boramae Medical Center, College of Medicine, Seoul National University of Korea, Seoul, Korea

Purpose: Transforaminal Lumbar Interbody Fusion (TLIF) is known to show similar clinical results and fusion rate to Posterior Lumbar Interbody Fusion (PLIF) and to have fewer complications than PLIF. There are few studies that performed unilateral facetectomy and contralateral facet joint fusion in PLIF. The purpose of this study was to compare the clinical and radiologic outcomes between conventional posterior lumbar interbody fusion (C-PLIF) and posterior lumbar interbody fusion with unilateral facetectomy and contralateral facet joint fusion (Uni-PLIF).

Materials and Methods: A retrospective analysis was performed on patients who underwent C-PLIF or Uni-PLIF for less than 2 segments lumbar degenerative disease with a follow-up period of more than 1 year From July 2009 to December 2020. Symptom improvement was measured clinically at 1 year after surgery by low back pain VAS, radiating pain VAS, ODI, and FRI, in addition to postoperative complications. An x-ray and CT scan were used to determine the lumbar scoliosis, lordosis angles and the fusion rate. This study was statistically analyzed using the independent sample T-test and chi-square test.

Results: Uni-PLIF 101 cases (165 segments), C-PLIF 89 cases (133 segments), a total of 190 cases (298 segments) were analyzed, and there were no statistical differences in gender, age, diagnosis, and surgical segment. Clinical results were improved in both groups, and no difference in ODI, FRI, and radiating pain VAS score 1 year after surgery. In the 2-segment Uni-PLIF group, the average low back pain VAS score at 1 year after surgery was 1.5541.47, which was lower than that of the C-PLIF group (2.3541.71) ($p=0.021$). In the 1-segment Uni-PLIF group, the lumbar scoliosis angle was improved from 3.6643.45 to 2.7042.67 at 1 year after surgery compared to the C-PLIF group ($P=0.029$), and also in the 2-segment Uni-PLIF group, the lumbar scoliosis angle was improved from 4.0444.53 to 2.3743.04 ($P=0.016$). There were no statistically significant differences in lumbar lordosis angle, fusion rate, and postoperative complications.

Conclusions: Uni-PLIF is similar outcomes in the radiating pain VAS, the lumbar lordosis angle, and the fusion rate compared to C-PLIF. It is considered to be a surgical method that has the advantage of reducing postoperative back pain and the angle of lumbar scoliosis.

Key words: Spinal stenosis; unilateral facetectomy; facet joint fusion; posterior lumbar interbody fusion

EPO6-14

Lumbar Degenerative

Spinal Stenosis Cases of Achondroplasia Patient, Case ReviewSeung Jin Choi*Neurosurgery, Korea University Guro Hospital, Korea*

Background: Achondroplasia is a genetic disorder characterized by a mutation in the fibroblast growth factor receptor 3 (FGFR3) gene, which results in abnormal bone growth and development. Individuals with Achondroplasia typically exhibit short stature, short arms and legs, and other skeletal abnormalities. One of the most common complications associated with Achondroplasia is spinal stenosis, which occurs in up to 75% of affected individuals. Spinal stenosis is a condition that results from the narrowing of the spinal canal, which puts pressure on the spinal cord and nerves. In individuals with Achondroplasia, the characteristic short, round, and differently shaped vertebral column can further exacerbate spinal stenosis, leading to more complex cases and increased risk of complications. To address this issue, decompression surgery has emerged as a potential treatment option for Achondroplasia patients with spinal stenosis. The surgery involves removing bone and other tissue to relieve pressure on the spinal cord and nerves, which can alleviate symptoms and improve function. However, Achondroplasia patients with spinal stenosis face unique challenges due to the characteristic skeletal abnormalities associated with the disorder when it comes to undergoing the surgery.

Method: In this review, we sought to examine the pre- and postoperative progress of Achondroplasia patients who underwent decompression surgery at our hospital. Our study involved three patients who underwent surgery from March 2019 to April 2023.

Result: All three patients exhibited significant improvement in symptoms and function following surgery, with no intra- or post-operative complications observed.

Conclusion: Our findings suggest that decompression surgery is a safe and effective treatment option for Achondroplasia patients with spinal stenosis.

EP06-15

Lumbar Degenerative

Open Midline Decompression (OMD) with Ligament Reconstruction for Multi-level Degenerative Lumbar Spinal Stenosis In Elderly Patients over the Age of 80s**Sang-Ho Lee^{1*}** and **Hyoung-Woo Lho¹**¹ Neurosurgery, Cheongdam Wooridul Spine Hospital, Korea

Background: Multi-level degenerative lumbar spinal stenosis(DLSS) is a common degenerative spinal disease in the elderly patients. The average life expectancy is gradually increasing, and the proportion of geriatric patients is also increasing. The aging adults have complex medical issues such as frailty, sarcopenia, osteoporosis, dementia, stroke, coronary heart disease, arthritis and parkinson's disease. Therefore, from the perspective of geriatric medicine, a multilevel fusion surgery may not be an appropriate treatment for the elderly patients. For elderly patients, midline decompression surgery for DLSS is more considerable with preservation of disc, lamina and facet joint with reconstruction of the posterior tension bands. We describe the technique and clinical results of open midline decompression (OMD) via interspinous window for preservation of facet joints and lamina. And we discuss ligament reconstruction which is soft stabilization using interspinous artificial ligament after microsurgical fenestration to prevent post decompression segmental instability. It can provide alternative stabilization technique for geriatric patients with multiple DLSS.

Methods: This retrospective review was performed on elderly patients aged 80 years or older who were diagnosed with DLSS at three or more levels (with or without spinal instability) and underwent OMD with ligament reconstruction and without any discectomy, facetectomy from January 2012 to December 2021. Pre-, post-operative clinical data, radiologic data were analyzed.

Results: Overall, 67 patients who aged over 80 years underwent OMD with ligament reconstruction between January 2012 and December 2021. Among them, 29 were men and 38 were women. Patients' mean age was 82.39 (4 2.49) years, [Table1] mean preoperative VAS(back pain) was 7.51 (41.16), VAS(leg pain) was 7.75 (41.21) and mean preoperative ODI was 75.6%. The mean preoperative EQ-5D-5L was 20 (42.72). 52 patients underwent 3-level surgeries, 14 patients underwent 4-level surgeries and 1 patient underwent 5-level surgeries. The mean postoperative VAS(back pain) was 2.88 (4 1.09), VAS(leg pain) was 2.64 (41.20) and mean postoperative ODI was 53.3%. The mean postoperative EQ-5D-5L was 13 (43.86). In the Macnab criteria, 16 patients was excellent outcome, 41 patients was good outcome and, 10 patients was fair outcome.[Table2]

Conclusions: OMD and ligament reconstruction are efficient surgeries that can be safely performed in elderly patients with multilevel DLSS. The advantage of sufficient nerve decompression with preservation of facet joints and lamina without discectomy is the strength of the OMD. The soft stabilization of the artificial ligament is a way to simplify and shorten the stabilization procedure in elderly patients with multilevel DLSS. Soft stabilization with artificial ligament represents a viable option for patients who are elderly or who have significant co-morbidities that make a prolonged operation inadvisable.

[Table 1] Baseline Characteristics of the patients

Characteristic	Open midline decompression(OMD) /w Ligament Reconstruction (N=67)
Age – yr	82.39 ± 2.49
Female - no. (%)	38 (57)
Motor deficit – no./total no. (%)	64 / 67 (96)
Walking capacity – min **	4.8 ± 3.9
Body mass index	24.2 ± 3.8
BMD (T-score)	-2.8 ± 1.0
Underlying diseases - no. (%)	
Parkinson dis.	6 (9)
Known osteoporosis	35 (52)
CAD, CVA, A.fib	8 (12)
COPD, Asthma	6 (9)
Depression	2 (3)

** Walking capacity measured the number of minutes a patient could walk without stopping.

[Table 2] Clinical Outcome

	VAS (back pain)		VAS (leg pain)		ODI (%)		EQ-5D-5L	
	Pre op	Post op	Pre op	Post op	Pre op	Post op	Pre op	Post op
OMD /w Ligament reconstruction (N=67)	7.51 ± 1.16	2.88 ± 1.09	7.75 ± 1.21	2.64 ± 1.20	75.6 ± 5.34	53.3 ± 6.13	20 ± 2.72	13 ± 3.86

EPO6-16

Lumbar Degenerative

Impact of Social Distancing on Degenerative Spinal Diseases during the Covid-19 Pandemic Period

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Background: Lumbar spinal stenosis (LSS) and spondylolisthesis (SPL) are common degenerative disease and the primary treatment for is conservative care including exercise. Regarding exercise, physical activity has a different therapeutic meaning for the two diseases; for SPL, it is helpful, whereas, for LSS, it may not be. During the COVID-19 pandemic period, physical activity had been forcibly restricted all people in the world by social distancing policy. We investigated the effect of restrictions of physical activity on LSS and SPL by analyzing changes in hospital visits and medical costs since the implementation of a social distancing.

Method: We included first-visit patients diagnosed exclusively with LSS and SPL in 2017 and followed them up for four years. The common data model was employed to analyze each patient's diagnostic codes, treatments, medications, and procedures. The analysis period for this study was two years before and after the implementation of the social distancing policy in March 2020. Additionally, data from January 2016 to December 2019 were analyzed separately as a control. Hospital visits and medical costs were analyzed by regression discontinuity in time (RDIT) to control for temporal effects on dependent variables.

Result: Among 33,484 patients, 2,615 LSS and 446 SPL were included. A significant decrease in hospital visits was observed in both the LSS (difference, -3.94 times/month*100 patients; $p=0.023$) and SPL (difference, -3.44 times/month*100 patients; $p=0.026$) groups after the social distancing. This change was not observed in the data from 2016-2019. Only the patients with LSS showed a statistically significant decrease in median copayment (difference, -\$45/month*patient; $P<0.001$) after the implementation of social distancing, while a significant change was not observed in the SPL group (difference, -\$19/month*patient; $p=0.160$) after the implementation of social distancing.

Conclusion: Limited physical activity due to social distancing may reduce the medical demand for patients with LSS, with no significant impact on patients with SPL.

EPO6-17

Lumbar Degenerative

5-year Radiological Outcomes Post an Interlaminar Device Insertion for Symptomatic Lumbar Spinal Stenosis

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Background: Lumbar spinal stenosis (LSS) is a common spine condition that is frequently encountered especially with an ageing population. A common treatment strategy employed for symptomatic patients is open decompression and fusion. However, that option poses its own unique set of drawbacks which led to the adjunct use of the interlaminar device (ILD) as an increasingly popular alternative instead. There are varying designs available for interlaminar and interspinous devices, all aiming to serve a common goal of limiting extension at the affected index lumbar segment and allowing for increased foraminal height and reduced disc pressure. This in return may translate into a longer symptom free interval with reduced recurrence or need for further procedures. There is a paucity in the current literature about the radiological parameters that are affected or maintained with the use of an ILD and the implications of those observations. The objective of our paper was to compare and monitor several radiological indices as a surrogate marker to determine the effectiveness of the ILD insertion up to 5-years postoperatively.

Materials and Methods: A retrospective review of prospectively collected data under a single surgeon cohort study, consisting of 116 patients who underwent spinal decompression with and without an ILD insertion between 2007 - 2015 was performed. Patients who met the study criteria were offered the choice of an ILD device insertion. Those who accepted an ILD insertion were placed in the D+ILD group (n=61); while those opting for decompression alone, were placed in the DA group (n=55). Radiological indices consisting of anterior and posterior disc height, foraminal height at the level of decompression, segmental lordosis and sagittal angle were assessed both preoperatively and up to 5-years postoperatively.

Results: The D+ILD group achieved and maintained significant radiological correction at all time points for posterior disc height, foraminal height, sagittal height and L4 to S1 lordosis measured while the DA group did not attain this; implying good lateral recess restoration and neuroforaminal decompression. This in return is translated into better clinical outcome scores in the postoperative period and improvement in radiological parameters.

Conclusion: The use of an interlaminar device in conjunction with spinal decompression in patients with symptomatic LSS has been shown to offer a sustained correction in radiological parameters.

EP06-18

Lumbar Degenerative

A Modified Posterior Lumbar Interbody Fusion Technique Using a Steerable 3D-printed Titanium Cage with Simultaneous Spinous Process Fixation Device: Single-institution Case Series

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Background: This study introduces a technical note on steerable 3D-printed titanium cage implantation for lumbar interbody fusion with simultaneous spinous process fixation. With this method, we can shorten operative time and hospital stay, minimize the extent of surgical dissection, and reduce the risk of adjacent level degeneration.

Methods: The surgical procedure involved in this technique is described in detail. After unilateral partial hemilaminectomy and discectomy, a steerable 3D-printed titanium cage was implanted in the transverse orientation at the anterior portion of the disc space. Concurrent spinous process fixation was achieved using interspinous fixation device. Technical considerations, such as cage design, implantation technique, and fixation device placement, were addressed. Preliminary radiological and clinical results from a small cohort of patients who underwent this procedure were collected and analyzed.

Results: Preliminary results demonstrate the feasibility and potential benefits of the transverse orientation of 3D-printed titanium cage with simultaneous spinous process fixation. Radiological evaluation revealed increased height of intervertebral foramen and restoration of segmental lordotic angle postoperatively. Clinical assessments showed reduced pain scores, early mobilization and shorter hospital stays in select cases. These preliminary findings suggest the potential advantages of this technique in improving segmental lordotic angle and patient recovery.

Conclusions: The technical note on transverse orientation of 3D-printed titanium cage with simultaneous spinous process fixation provides a novel approach to enhance radiological and clinical outcomes in lumbar fusion surgery. Further research and larger-scale studies are warranted to validate these preliminary findings, assess long-term outcomes, and explore the potential impact of this technique on patient quality of life.

EP06-19

Lumbar Degenerative

Long-term Clinical and Radiographic Outcome of Instrumented Facet Fusion of Lumbar Spine

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Background: Surgical treatments for degenerative lumbar spinal disorders involve meticulous neural structure decompression, often with arthrodesis to treat pain associated with continuous motion that remains at the affected unstable disc segment. There are many methods to achieve a firm arthrodesis, each with their pros and cons. Among them instrumented lumbar facet fusion is a surgical technique that is less invasive than posterolateral fusion or other lumbar interbody fusions. 2-year follow-up study of instrumented facet fusion showed beneficial clinical outcome. However, reports on its long-term biomechanical competence and clinical outcomes remain scarce, on which this study aims to report.

Objective: To report the long-term clinical and radiographic outcome of the instrumented facet fusion.

Methods: This study is a single-center retrospective observational case-series. Patients who had undergone single or two-level IFF for degenerative lumbar spinal disorders from January 1996 to January 2021 were included in the study. Patient demographic information and Oswestry Disability Index (ODI) and Visual Analogue Scale (VAS) scores were obtained and radiographic fusion was assessed using either flexion-extension simple radiograph and CT scan. Instrument failures and fusion segment angles were measured.

Results: Total of 494 patients underwent instrumented facet fusion during the studied period. Of those patients, 208 were followed-up for more than 24 months (mean follow-up of 89.96 +/- 55.59 months). Overall fusion rate was 92.05%. Revision surgery due to adjacent segmental disease were done in 11.06% patients. Screw loosening was observed in 6 patients of whom 2 patients underwent revision surgery. Significant improvements in ODI and VAS was observed. A trend of decreasing lordotic curvature in the fusion segment was noticed over follow-up period.

Conclusion: Instrumented facet fusion is a safe and less invasive alternative method of lumbar spinal arthrodesis with comparable fusion rate and clinical outcome. Although, comparative studies are needed, this method show relatively low revision rate.



E-POSTERS



MATERIAL SCIENCE

EP07-01

Material Science

Hydrogel Reservoir as “Self-contained” NP Cell Delivery Vehicle for Immunoregulation to Repair Degenerated Intervertebral Disc

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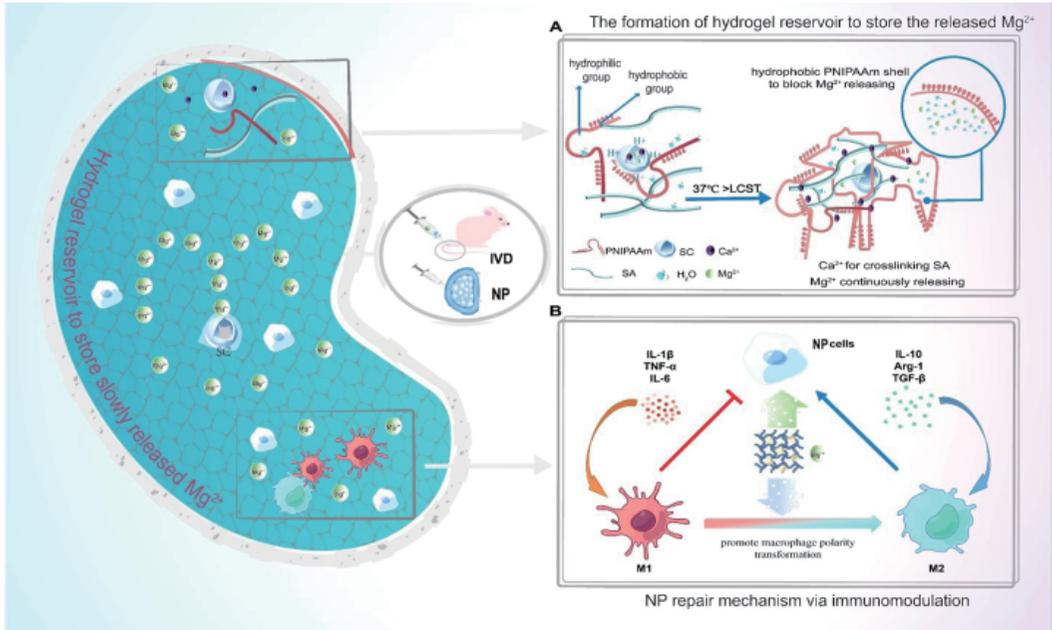
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Background: Intervertebral disc degeneration (IVDD) is a prevalent disorder and there is much interest in the strategies to modulate the local inflammatory microenvironment to inhibit IVDD. In this study, a novel injectable hydrogel as a delivery vehicle capable of inhibiting IVDD via immunoregulation was constructed.

Methods: The precursor solution containing sodium alginate (SA), poly(N-isopropylacrylamide) (PNIPAAm), silicate ceramics (SC), and nucleus pulposus (NP) cells was injected into the NP site. The thermosensitive PNIPAAm instantly gelled under body temperature (~37°C) to keep the precursor solution in place. In vitro and in vivo studies were carried out to evaluate the biological effect of this novel injectable hydrogel.

Results: The release of Ca²⁺ and Mg²⁺ from SC formed an interpenetrating network (IPN) structured hydrogel composed of SA and PNIPAAm. In addition, the released Ca²⁺ participated in the gelation of SA to keep the released Mg²⁺ in storage, and the active Mg²⁺ continuously released from SC into the inner of hydrogel. Innovatively, the instantly formed PNIPAAm shell in contact with NP tissue performed to entrap water and Mg²⁺. The biocompatibility of the hydrogel was assessed in vitro, demonstrating that the Mg²⁺-stored hydrogel presented excellent biocompatibility and higher cell viability, COL II and aggrecan expression than the hydrogel without Mg²⁺. The inflammatory environment was also studied, proving that this Mg²⁺-stored hydrogel could promote the transformation of macrophage polarity from pro-inflammatory M1 to anti-inflammatory M2 phenotype by regulating the inflammatory response of IVDD. The ability to repair IVD was validated in vivo using an animal model, revealing the potential application of the Mg²⁺-stored injectable hydrogel in prohibiting IVDD through immunoregulation.

Conclusions: The novel injectable hydrogel constructed in this study demonstrated excellent biocompatibility and potential application in inhibiting IVDD through immunoregulation.



EP07-02

Material Science

Does I-factor™ Bone Graft Enhances Fusion Rate after Anterior Cervical Discectomy and Fusion?**Jungwoo Hur¹, Jae Teak Hong^{1*} and Donghoon Kim¹**¹ Neurosurgery, Eunpyeong St.Mary's Hospital, The Catholic University of Korea, Korea

Objective: The efficacy and safety of traditional anterior cervical discectomy and fusion (ACDF) surgery has improved with the introduction of new implants and compounds. i-Factor™ bone Graft (Cerapedics Inc, Westminster, Colorado, USA) is a composite bone substitute material consisting of P-15 synthetic collagen fragment adsorbed onto anorganic bone mineral suspended in an inert biocompatible hydrogel carrier. A pivotal, noninferiority, US FDA Investigational Device Exemption study demonstrated the benefits of i-Factor™ compared to local autograft bone in single-level ACDF at 1-yr postoperative. Objective of this study is to compare the fusion rate of single-level anterior cervical discectomy and fusion (ACDF) using i-Factor™ Bone Graft versus conventional demineralized bone matrix (DBM) in minimum 12-month follow-up.

Methods: A retrospective matched cohort study was performed at a single tertiary care hospital. ACDF surgery using stand-alone 3D-printed porous titanium cage filled with i-Factor™ was performed and followed for at least 12 month. Using propensity score matching, a cohort of cases with conventional DBM (DBX, West Chester, PA, USA) was matched 1:1 with study cohort after controlling for patient demographics to reduce bias. The clinical outcomes were evaluated using the Visual analogue scales (VAS) scores for neck and arm pain, neck disability index (NDI) scores. The radiologic results were evaluated with serial plain film and 3D-CT to assess fusion status and device-related complications.

Results: Eighteen patients who underwent single-level ACDF surgery using i-Factor™ were matched paired with control group according to age, sex and operation level. Mean follow-up period was 18.1 month. Mean operation time, fluoroscopic time, intraoperative blood loss, and postoperative surgical drainage were similar between the two groups. Clinical outcome was significantly improved in both groups and well maintained until final follow-up. The fusion rate of DBM group at 3, 6, 12 month postoperatively were 72.7%, 81.8% and 95.4%, respectively. All patients in i-Factor™ group achieved solid fusion at 3 month postoperatively. Subsidence rate were similar in both group and no device related complications were observed in all patients. Furthermore, there were no allergic or adverse reactions associated with i-Factor™.

Conclusion: ACDF surgery using i-Factor™ demonstrated favorable clinical and radiographic outcomes compared to conventional DBM in minimum of 12-month follow-up. The final fusion rate was similar but time to achieve solid fusion might be superior with i-Factor™. However, more long-term follow-up results and more cases should be investigated to prove the superiority.

EP07-03

Material Science

Reliability of the EOS Imaging System for Assessment of the Spinal and Pelvic Alignment in the Sagittal Plane**Sang Bum Kim¹ and Byounggu Lee^{1*}**¹ Orthopedics, Sejong Cheung Nam University hospital, Korea

Background: The sagittal alignment of the spine and pelvis is not only closely related to the overall posture of the body but also to the evaluation and treatment of spine disease. In the last few years, the EOS imaging system, a new low-dose radiation X-ray device, became available for sagittal alignment assessment. However, there has been little research on the reliability of EOS. The purpose of this study was to evaluate the intrarater and interrater reliability of EOS for the sagittal alignment assessment of the spine and pelvis.

Methods: Records of 46 patients were selected from the EOS recording system between November 2016 and April 2017. The exclusion criteria were congenital spinal anomaly and deformity, and previous history of spine and pelvis operation. Sagittal parameters of the spine and pelvis were measured by three examiners three times each using both manual and EOS methods. Means comparison t-test, Pearson bivariate correlation analysis, and reliability analysis by intraclass correlation coefficients (ICCs) for intrarater and interrater reliability were performed using R package "irr."

Results: We found excellent intrarater and interrater reliability of EOS measurements. For intrarater reliability, the ICC ranged from 0.898 to 0.982. For interrater reliability, the ICC ranged from 0.794 to 0.837. We used a paired t-test to compare the values measured by manual and EOS methods: there was no statistically significant difference between the two methods. Correlation analysis also showed a statistically significant positive correlation.

Conclusions: EOS showed excellent reliability for assessment of the sagittal alignment of the spine and pelvis.

Keywords: Pelvis, Whole body imaging, Reproducibility of results, Postural balance

EP07-04

Material Science

Mid-term Efficacy and Safety of Escherichia Coli-derived Rbmp 2/ Hydroxyapatite Carrier in Lumbar Posterolateral Fusion: A Randomized, Multicenter Study

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Purpose: This study aimed to evaluate the mid-term efficacy and safety of Escherichia coli-derived bone morphogenetic protein-2 (E.BMP-2)/hydroxyapatite (HA) in lumbar posterolateral fusion (PLF).

Methods: This multicenter, evaluator-blinded, observational study utilized prospectively collected clinical data. We enrolled 74 patients who underwent lumbar PLF and had previously participated in the BA06-CP01 clinical study, which compared the short-term outcomes of E.BMP-2 with an auto-iliac bone graft (AIBG). Radiographs and CT scans were analyzed to evaluate fusion grade at 12, 24, and 36 months. Visual analog scale (VAS), Oswestry disability index (ODI), and Short Form-36 (SF-36) scores were measured preoperatively and at 36 months after surgery. All adverse events in this study were assessed for its relationship with E.BMP-2.

Results: The fusion grade of the E.BMP-2 group (4.9140.41) was superior to that of the AIBG group (4.2541.26) in CT scans at 36 months after surgery ($p=0.007$). Non-union cases were 4.3% in the E.BMP-2 and 16.7% in the AIBG. Both groups showed improvement in pain VAS, ODI, and SF-36 scores when compared to the baseline values, and there were no statistically significant differences between the two groups. No treatment-related serious adverse reactions were observed in either group. No neoplasm-related adverse events occurred in the E.BMP-2 group.

Conclusions: The fusion quality of E.BMP-2/HA was superior to that of AIBG. E.BMP-2/HA showed comparable mid-term outcomes to that of AIBG in terms of efficacy and safety in one-level lumbar PLF surgery.

Keywords: BMP-2 · Bone substitutes · E. coli · Hydroxyapatite · Posterolateral fusion · Iliac bone graft

EP07-05

Material Science

Preliminary Evaluation of a New Vertebroplasty Material in Tibial Defects of Ovariectomized Rat ModelMosharraf Hossain¹, Je Hoon Jeong¹, Tamima Sultana¹ and Soo Bin Im¹¹ Department of Neurosurgery, Soonchunhyang University, Bucheon Hospital, Korea

Background: Osteoporosis characterized by low bone mass, increases the risk of vertebral fractures. Vertebroplasty with Polymethylmethacrylate (PMMA) bone cement has been a promising treatment for osteoporotic vertebral fractures. In spite of benefit of excellent pain control and achieving the stability of fractured spine, this material could inhibit the normal bone growth lastly. The objective of this study modified the PMMA bone cement by incorporating osteoconductive biodegradable biomaterials and elucidated to improve the properties and bone regeneration capacity of composite cements.

Methods: For this study, we made new composition with tricalcium phosphate (TCP), hydroxy apatite (HA) and hydrogel cement. The composition was 25% β -TCP, 50 % HA and 50% hydrogel. For an animal study, twelve female Wister rats (250-300 g, 12 weeks of age) were prepared and divided into four groups including a two non-ovariectomy groups (No-OVX) and two ovariectomy-induced osteoporosis groups (OVX). And we also made two subgroups by with or without PMMA group; No-OVX with new composition group (No-OVX without PMMA), No-OVX with new composition and PMMA group (No-OVX with PMMA), OVX with new composition group (OVX without PMMA), and an OVX with new composition and PMMA (OVX with PMMA). In vivo bone regeneration efficacy was assessed using micro-CT and histological analysis after implantation with the new composition with or without PMMA into tibial defects of osteoporotic rats.

Results: Micro-CT and histological analysis of 4 groups revealed that there is no difference between 4 groups.

Conclusion: This study suggests that made new composition with TCP, HA and hydrogel cement could be a promising osteoinductive bioabsorbable vertebroplasty material for treating osteoporosis-related vertebral fractures.

EP07-06

Material Science

Novel 3D Printable PEEK-HA-Mg₂SiO₄ Composite Material for Spine Implants: Biocompatibility & Imaging Compatibility Assessments

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Background: Polyether ether ketone (PEEK) is an emerging alternate implant material and is highly researched for manufacturing orthopaedic implants. PEEK-based implants have been used to manufacture spine implants such as cages, rods, plates and screws. Standard PEEK implants have Young's modulus(3.6GPa) closer to cortical bone(17-21GPa). However, standard PEEK material is bioinert which leads to poor bone apposition. Furthermore, low tensile strength(90-140MPa) and Young's modulus of PEEK-based materials could affect the biomechanical stability of the load bearing implants. PEEK-based implants are able to resist compression load but are weak against torsional forces which can result in breakage. The torsional resistance can be mitigated by addition of biocompatible compounds, resulting in novel composite material. We hereby propose a novel 3D printable polyether ether ketone (PEEK)-hydroxyapatite (HA)-magnesium orthosilicate (Mg₂SiO₄) composite material with enhanced properties for potential use in tumour, osteoporosis and other spinal conditions. We aim to do a preliminary evaluation of biocompatibility and imaging compatibility of this novel material.

Methods: Materials were prepared in three different compositions, namely, composite A: 75 weight % PEEK, 20 weight % HA, 5 weight % Mg₂SiO₄; composite B: 70 weight% PEEK, 25 weight % HA, 5 weight % Mg₂SiO₄; and composite C: 65 weight % PEEK, 30 weight % HA, 5 weight % Mg₂SiO₄. The materials were processed to obtain 3D printable filament. Biocompatibility of the novel material was evaluated using indirect cytotoxicity test. Cell viability of the novel material was compared to PEEK and PEEK-HA materials. The novel material was used to 3D print a standard spine cage. Furthermore, the CT & MR imaging compatibility of the novel material cage vs PEEK and PEEK-HA cages were evaluated using a phantom setup.

Results: Composite A resulted in optimal material processing to obtain a 3D printable filament, while composite B & C resulted in non-optimal processing. Composite A enhanced cell viability up to ~20% compared to PEEK and PEEK-HA materials. Composite A cage generated minimal/no artefacts on CT & MR imaging and the images were comparable to that of PEEK and PEEK-HA cages.

Conclusion: Composite A demonstrated superior bioactivity vs PEEK and PEEK-HA materials and comparable imaging compatibility vs PEEK and PEEK-HA. Therefore, our material displays an excellent potential to manufacture spine implants with enhanced bioactive property.

E-POSTERS

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MIS

EP08-01**MIS****Biportal Endoscopic Thoracic Decompression****Seung-Hyun Choi***Department of Orthopedic Surgery, Busan Korea Hospital, Busan, Korea*

Backgrounds and introduction: The use of conventional spinal decompression surgery for thoracic ossification of ligament flavum (OLF) and thoracic disc herniation (TDH) can be limited by technical difficulties and a restricted field of vision. Surgical treatment of thoracic OLF and TDH is major challenge for spine surgeons because of specific anatomical characteristics of thoracic spine.

Main body: Unilateral laminotomy with bilateral decompression using a biportal endoscopy in patients with thoracic OLF was performed.

TDH underwent biportal endoscopic thoracic discectomy with or without fusion. In decompression cases, unilateral laminotomy with bilateral decompression and discectomy via interspinous approach was done. And, in decompression and fusion cases, foraminoplasty, partial pediculotomy, corpectomy, diskectomy and fusion via using posterolateral approach were used. Indications of fusion consist of revision case and wide pediculotomy (> 50%).

Conclusion: From a surgical point of view, biportal endoscopy is very similar to microscopic spinal surgery, permitting good and magnified visualization of the contralateral sublaminar areas. The authors suggest that biportal endoscopy, which is a minimally invasive procedure, is an alternative treatment option for thoracic OLF and TDH.

EPO8-02

MIS

Factors Affecting Segmental Lordotic Angle in Oblique Lateral Interbody Fusion at L5-S1**Nam-Su Chung¹, Han-Dong Lee¹, Hee-Woong Chung^{1*} and Ki-Hoon Park¹**¹ Orthopaedic surgery, Ajou university hospital, Korea

Background Context: Anterior L5-S1 approach is beneficial in spinal reconstruction and fusion. Recent studies with oblique lateral interbody fusion (OLIF) at L5-S1 reported favorable radiological outcomes. However, factors associated with greater segmental lordotic angle (SLA) with OLIF at L5-S1 have not been studied.

Purpose: The purpose of this study was to identify factors that help achieve greater DA in the L5-S1 OLIF.

Study Design/Setting: Retrospective analysis

Patient Sample: This study involved 68 consecutive patients who underwent OLIF at L5-S1, and had more than 1-year regular follow-up. Patients with incomplete data or posterior column osteotomy at L5-S1 were excluded.

Outcome Measures: Using the postoperative lateral radiograph, patients were grouped as having $\geq 20^\circ$ of SLA at the L5-S1 (Group A), having between 12° and 20° of SLA at the L5-S1 (group B), or having $< 12^\circ$ SLA at the L5-S1 (group C). The associations between demographics and/or surgical and/or radiological factors and the L5-S1 SLA were analyzed using multiple regression analysis.

Methods: The patients' medical records were reviewed for age, sex, body mass index, bone mineral density, diagnosis, current smoking status, cage parameters (cage angle and height), laminectomy performed/not performed, estimated blood loss, operative time, configuration of the left common iliac vein (LCIV), and occurrence of LCIV injury during OLIF at L5-S1.

Results: In all, the mean preoperative SLA at L5-S1 was $5.3 \pm 5.1^\circ$, which increased to $19.1 \pm 5.7^\circ$ postoperatively ($P < 0.001$) and was maintained as $17.7 \pm 6.0^\circ$ at the last follow-up ($P < 0.001$). There was no difference in sex, body mass index, bone mineral density, diagnosis, current smoking status, estimated blood loss, operative time, configuration of the LCIV, and occurrence of LCIV injury among the three groups (all $P > 0.05$). There was a stepwise increase in age, cage lordotic angle, and laminectomy cases towards the group A.

Conclusions: OLIF at L5-S1 showed favorable SLA restoration. To achieve a greater SLA, surgeons should consider using a larger lordotic cage, laminectomy, and preventing cage subsidence.

Keywords: Oblique lateral interbody fusion; L5-S1 level; segmental lordotic angle

EPO8-03**MIS****Clinical and Radiological Outcomes of Minimally Invasive Oblique Lumbar Interbody Fusion at L5-S1****Hae-Dong Jang¹, Jae Chul Lee², Sung-Woo Choi² and Byung-Joon Shin^{2*}**¹ Orthopaedic Surgery, Soonchunhyang University Bucheon Hospital, Korea² Orthopaedic Surgery, Soonchunhyang University Seoul Hospital, Korea

Introduction: Minimally invasive oblique lumbar interbody fusion (MI-OLIF) at L5-S1 has advantages of concomitant multilevel lateral lumbar fusion and less soft tissue injury. The purpose of this study was to evaluate the clinical and radiological outcomes of MI-OLIF L5-S1.

Materials & Methods: Patients who underwent MI-OLIF L5-S1 for degenerative spinal disease were included. We reviewed medical records and radiographs of patients who completed the minimum 3-month follow-up. We evaluated the surgical, radiological, and clinical results.

Results: A total of 113 patients were enrolled (17 male and 96 female, mean age; 67.0 years old). The intervertebral disc height (IVDH) significantly increased from an average of 9.6 mm at the initial to 14.5 mm at the 3-month follow-up ($p < 0.001$), and slightly decreased to 13.5 mm at the final follow-up. The mean segmental lordosis (SL) also showed significant restoration postoperatively (10.2° at the initial, 21.2° at the 3-month follow-up, and 19.3° at the final follow-up). We used various types of the cage with an angle of 8° , 12° , 18° , and 24° . Cage with higher angle showed significantly greater restoration of SL (postoperative 3 months vs. the initial) (8° cage; 7.3° , 12° cage; 10.4° , 18° cage; 13° , and 24° cage; 14.2°) ($p = 0.040$). Cage with higher angle also showed greater restoration of IVDH (8° cage; 4.4 mm, 12° cage; 4.7 mm, 18° cage; 5.8 mm, and 24° cage; 6.4 mm), however, there was no significance ($p = 0.332$). Visual analogue scale (VAS) for leg pain and Oswestry Disability Index (ODI) scores (%) significantly decreased from an average of 4.2 at the initial to 0.5 at the 1-year follow-up and 53.8% to 29.9%, respectively ($p < 0.001$ and $p < 0.001$). At the final follow-up, 109 patients (96.4%) had mild leg pain (VAS < 4) and 85 patients (75.2%) had no leg pain. During the surgery, we used a central corridor in 85 patients and a lateral corridor in 28 patients (24.8%). There were 8 vascular injuries during MI-OLIF L5-S1 in patients using a central corridor, and four of them required surgical repair by a vascular surgeon. There has been no vessel injury in patients using the lateral corridor, however, half of them (14/28) required branch vein ligation to retract the LCIV medially. There were 3 vascular injuries during combined MI-OLIF L4-5.

Conclusions: MI-OLIF at L5-S1 was an effective surgical option for lumbosacral interbody fusion with advantages of satisfactory clinical and radiological outcomes in the treatment of degenerative lumbar spinal disease.

EPO8-04

MIS

Proximity of Endplate on Uiv Using Cortical Bone Trajectory Screws Can Be a Risk Factor for Early Onset Postoperative Radiologic Adjacent Segment Disease

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Background: cortical bone trajectory(CBT) screw is an alternative and less-invasive technique for lumbar pedicle screw placement. however, the incidence and risk factor of ASD following transforaminal lumbar interbody fusion(TLIF) using the CBT screw (CBT-TLIF) remains unknown. The purpose of this study was to determine whether penetration of endplate on the upper instrumented vertebra(UIV) using cortical bone trajectory(CBT) screw can be a predictive factor for radiologic adjacent segment disease(r-ASD).

Method: Among patients surgically treated with CBT-TLIF in a single institute, 276 consecutive patients (91 males, 185 females) with degenerative lumbar spondylolisthesis (DLS) who were followed up for at least 24 months were exclusively enrolled. Their clinical and radiological features, including the incidence of r-ASD and significantly associated factors for the developing r-ASD, were retrospectively measured. R-ASD was defined by the following adjacent segment criteria: > 3 mm anteroposterior translation, > 10° segmental kyphosis, or > 50% loss of disc height.

Results: R-ASD was observed in 94 (36.1%) cases at 2 years postoperative follow-up. Preoperative Weishaup classification on adjacent segment (> grade 2), long fusion (> 2 levels), and penetration of endplate on UIV were significantly associated with r-ASD in univariate logistic regression. (OR = 3.93, 95% CI [(1.31-11.75] versus OR = 2.67, 95% CI [1.56-4.58] versus OR = 2.00, 95% CI [1.15-3.47]). Among them, proximity of endplate on UIV was significantly found as a risk factor for r-ASD even in multivariate logistic regression. (OR = 2.76, 95% CI [(1.48-5.13])

Conclusion: Proximity of endplate on UIV using cortical bone trajectory screws can be a risk factor for early onset postoperative radiologic adjacent segment disease.

EPO8-05

MIS

Clinical Outcomes of Biportal Endoscopic Interlaminar Decompression with Oblique Lumbar Interbody Fusion (OLIF): Comparative Analysis with TLIFHo-Jin Lee^{1*}, Jae-Sung Ahn¹ and Sang Bum Kim¹¹ Orthopedic surgery, Chungnam national university college of medicine, Korea

Background: Oblique lumbar interbody fusion (OLIF) improves the spinal canal with favorable clinical outcomes. However, it may not be useful for treating concurrent, severe central canal stenosis (SCCS). Therefore, we added biportal endoscopic spinal surgery (BESS) after OLIF evaluated the combined procedure for one-segment fusion with clinical outcomes, and compared it to open conventional TLIF.

Methods: Patients were divided into two groups: Group A underwent BESS with OLIF, and Group B was treated via TLIF. The length of hospital stay (LOS), follow-up period, operative time, estimated blood loss (EBL), fusion segment, complications, and clinical outcomes were evaluated. Clinical outcomes were measured using Visual Analog Scale (VAS) scores, Oswestry Disability Index (ODI) scores, and the modified Macnab criteria.

Results: All the clinical parameters improved significantly after the operation in Group A. The only significant between-group difference was that the EBL was significantly lower in Group A. At the final follow-up, no clinical parameters differed significantly between the groups. No complications developed in either group.

Conclusions: We suggest that our combination technique is a useful, alternative, minimally invasive procedure for the treatment of one-segment lumbar SCCS associated with foraminal stenosis or segmental instability.

EPO8-06

MIS

Radiographic Analysis of Early Changes in Upper Adjacent Segments after Fusion Surgery: OLIF VS PLIFJooYoung Lee¹ and JaeHwan Cho^{2*}¹Orthopedic Surgery, Dong-A Medical Center, University of Dong-A College of Medicine, Busan, Korea²Orthopedic Surgery, Asan medical center, Korea

Introduction: Recently, oblique lumbar interbody fusion (OLIF) is one of the most frequently performed lumbar fusion surgery technique. The purpose of this study was to compare the early radiological changes of upper adjacent segment between OLIF without laminectomy and posterior lumbar interbody fusion (PLIF).

Methods: This was a retrospective comparative study. Between 2013 and 2020, a group P (PLIF, n=131) and a group O (OLIF, n=65) were recruited as matched pairs (Table 1). Each patient underwent plain upright whole spine lateral radiography preoperatively, 3days, 1, 3, 6months, and 1year postoperatively. Radiographic outcomes (lumbar lordosis, upper adjacent segmental lordosis, retrolisthesis, and foraminal height) were measured at each time point, and changes in values from the preoperative value were noted and used for study. Patient-reported outcome measures were obtained preoperatively and 1years follow-up.

Results: Group O was superior to group P with respect its capability to restore lumbar lordosis (O: 4.03°44.38, P: 1.63°45.11, p=.001) and surgical segmental disc height (O: 5.50mm43.39, P: 2.71mm42.18, p<.001) in 1year after surgery (Fig 1). However, group O showed an increase in upper adjacent segmental lordosis at 3days postoperatively (O: 1.8°44.39, P: 0.08°43.35, p=.001) and showed a significant increase in the incidence (O: 76.9%, P: 24.6%, p<.001) and degree of retrolisthesis (O: 1.69mm41.09, P: 0.29mm40.70, p<.001) of the upper adjacent segment, and a decrease in the foraminal height of the upper adjacent segment (O: -1.43mm42.12, P: 0.54mm42.53, p<.001) at 1month postoperatively (Fig 2).

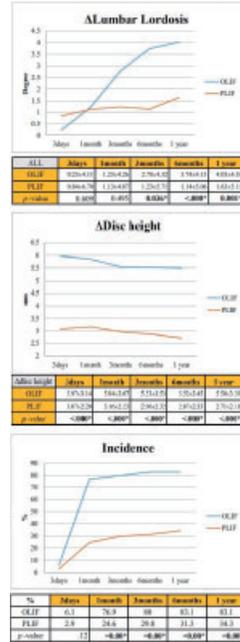
Conclusions: OLIF shows superior ability to PLIF in recovery of lumbar lordosis and surgical segmental disc height. However, it causes radiographic deterioration in retrolisthesis, segmental lordosis, and foraminal height of the upper adjacent segment after surgery. It seems that stress on the upper segment appears to cause several radiological changes in the upper adjacent segment. During fusion surgery, it should be considered that excessive increase in disc height and lumbar lordosis of the surgical segment may cause early degenerative changes due to stress in the upper adjacent segment. Although it was not possible to confirm the clinical difference related to this in short-term follow-up observation, attention should be paid to the difference to be brought about in long-term follow-up observation.

Table 1. Comparison of demographics between Groups O and P

	Group O	Group P	P-value
case	65	136	
Age	65.07±8.22	63.41±7.68	0.133
Sex			0.614
male	16	39	
female	49	97	
Smoking			0.880
Non-smoker	33	65	
smoker	32	71	
Level			0.997
L3-4	10	22	
L4-5	35	74	
L3-4-5	20	40	
Lumbar Lordosis	50.75±8.23	48.35±12.78	0.502
Pelvic incidence	53.47±10.70	51.83±10.64	0.216
Disc height (mm)	7.80±3.16	7.91±2.44	0.487
Upper adjacent Segmental Radiologic Parameters			
Foraminal height (mm)	19.53±2.05	20.1±3.01	0.194
Segmental Lordosis (°)	8.15±3.18	7.75±3.88	0.379
Flexibility (°)	7.64±2.05	7.49±3.88	0.515
Disc degeneration (Pfirrmann Gr.)	2.33±0.62	2.44±0.59	0.267
Facet sagittalization (°)	69.16±9.04	71.19±12.62	0.259
Facet degeneration (Weishaupt Gr.)	2.16±0.69	2.36±0.48	0.085
Patient Outcomes			
ODI (%)	48.71±8.23	45.39±10.39	0.81
Back pain VAS	5.47±2.71	5.98±2.69	0.75
Leg pain VAS	8.51±1.16	7.61±1.94	0.63

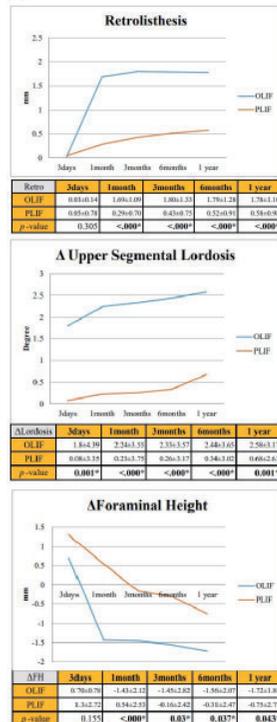
O, OLIF; P, PLIF; VAS, visual analog scale score; ODI, Oswestry Disability index; Gr., grade;

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



Disc height, surgical segmental disc height; Incidence, incidence of upper adjacent segmental retrolisthesis;

Figure 2. Comparison of postoperative radiological outcomes of upper adjacent segment between Groups O and P



EPO8-07

MIS

Clinical and Radiologic Outcomes of Biportal Endoscopic Lumbar Discectomy in Obese Patients: A Retrospective Case control StudyJun-Young Choi¹, Sang-Min Park^{2*} and Hyun-Jin Park³¹ Orthopedics, Dongguk University Ilsan Hospital, Korea² Orthopedics, Seoul National University Bundang Hospital, Korea³ Orthopedics, Hallym University Kangnam Sacred Hospital, Korea

Background: Obese patients have a higher risk of complications during spinal surgery than non-obese patients. To the best of our knowledge, no studies have examined the differences in clinical and radiological outcomes after biportal endoscopic lumbar discectomy (BELD) between obese and non-obese patients. The study evaluated the association between obesity and outcomes after BELD in patients with lumbar disc herniation.

Methods: This was a retrospective case-control study conducted from March 2017 to March 2021 at two hospitals with 360 patients who underwent BELD after showing no improvement with conservative treatment. Clinical and radiologic outcomes were retrospectively analyzed after BELD in the non-obese (body mass index [BMI] < 30 kg/m²) and obese (BMI ≥ 30 kg/m²) groups. Demographic data and surgery-related factors were compared between the two groups. Clinical outcomes were followed up for 12 months after surgery and analyzed for differences.

Results: A total of 211 patients were enrolled in this study, and through case-control matching, the data of 115 patients (29, obese group; 86, non-obese group) were analyzed. The two groups showed no significant differences in Oswestry Disability Index, European Quality of Life-5 Dimensions (EQ-5D), and visual analog scale scores measured immediately after BELD and 12 months after surgery. After surgery, back pain, radiating leg pain, and EQ-5D scores improved. However, there was no significant difference in improvement, residual herniated disc, hematoma, or recurrence between the groups.

Conclusions: Obese patients who underwent BELD for lumbar disc herniation showed no significant difference in clinical and radiologic outcomes compared with non-obese patients.

EPO8-09

MIS

Clinical Outcome of Oblique Lumbar Interbody Fusion with 3D-Printed Titanium CageEugene Park¹ and Woo-Kie Min[†]¹ Department of Orthopedic Surgery, Kyungpook National University Hospital, Korea

Purpose: 3D-printed titanium cage (3DTC) for interbody fusion is recently developed with improved osseointegration compared to other cage materials. We analyzed the radiological outcome of 3DTC used in oblique lumbar interbody fusion (OLIF).

Materials and methods: Patients that underwent OLIF using 3DTC from December 2019 to January 2022 were retrospectively analyzed. Inclusion criteria are (1) single-level, (2) posterior instrumentation with percutaneous pedicle screw fixation, and (3) follow-up period 6 months or longer. Cases of deformity with long level posterior instrumentation, revision, and follow-up period shorter than six months were excluded. All 3DTC were filled with 2.5cc of demineralized bone matrix. We analyzed the perioperative radiological outcomes including anterior (ADH), middle (DH), and posterior disc height (PDH), segmental lordosis (SL), lumbar lordosis (LL), and C7SVA along with complications such as cage subsidence, screw loosening, or other implant failures.

Results: Among a hundred and five patients underwent OLIF using 3DTC during the period and sixty-three cases underwent single-level surgery. After exclusion criteria, forty-four cases were included in this study. Mean age of the cohort was 67 years, and ten patients were male and thirty-four were female. The average follow-up period was 15.9 months. The heights of cage used were 10mm, 12mm, and 14mm in four, twenty-seven, and thirteen patients, respectively. The angles of cage used were 6 and 12 degrees in 3 and 41 patients, respectively. The diagnosis of majority of the patients was degenerative spondylolisthesis (70%, 31/44). SL was significantly improved immediately postoperative by 4.32+/-5.12 ($p<0.001$) degrees, but significantly was decreased of 1.70+/-3.2 degrees on the final follow-up ($p=0.001$). Still, the final SL was significantly improved compared to the preoperative value ($p=0.003$). DH was significantly improved immediately postoperative by 5.20+/-2.53mm ($p<0.001$), but significantly was decreased of 1.02+/-1.62mm on the final follow-up ($p<0.001$). Still, the final DH was significantly improved compared to the preoperative value ($p=0.003$). Overall implant related complication occurred in seven cases, and age was significantly higher in group with complication (65.78 vs 73.143, $p=0.0005$) compared to those without complication. Cage subsidence was the most common complication (13.6%, 6/44), followed by pseudarthrosis (6.8%, 3/44), and screw loosening (2.3%, 1/44)

Conclusion: OLIF using 3DTC significantly improved SL and DH postoperatively which were maintained after a year. However, average of 1-2 degree and 1-2mm of loss of correction is expected during follow up. Patients with older age were at risk of implant complication.

Keywords: oblique lumbar interbody fusion, 3D-printing, segmental lordosis, lumbar lordosis

EP08-10

MIS

A Beginner's Perspective on Biportal Endoscopic Spine Surgery in Single-level Lumbar Decompression: A Comparative Study with a Microscopic SurgeryJeongik Lee², Dae-Woong Ham¹ and Kwang-Sup Song^{1*}¹ Department of Orthopedic Surgery, Chung-Ang University Hospital, College of Medicine, Chung-Ang University, Korea² Department of Orthopedic Surgery, Chung-Ang University Gwangmyeong Hospital, College of Medicine, Chung-Ang University, Korea

Background: The application of biportal endoscopic spinal surgery (BESS) in spine surgery is increasing. However, the clinical results of related studies have been inconsistent. In this study, the perioperative and clinical outcomes of two techniques in single-level lumbar decompression surgery were compared using the perspective of an experienced microscopic spinal surgeon but inexperienced at BESS.

Methods: This is a retrospective study with prospectively collected data. From April 2019, 50 consecutive patients who underwent a single-level lumbar decompression surgery with BESS were evaluated. Additionally, the data of consecutive 150 patients who underwent the same microscopic surgery before April 2019 were collected. We performed 1:1 ratio propensity score matching for these two groups to adjust for baseline variables. The postoperative patient-reported outcome measures (PROMs) included the Oswestry Disability Index (ODI) and numeric rating scale (NRS) for the back and leg preoperatively and at 6 months after surgery. The laboratory data (C-reactive protein [CRP], mg/L) and hemoglobin [Hb], g/dL) were measured preoperatively and three times (1, 2, 3 or 4 days) postoperatively. In these periods, the peak and lowest CRP and Hb concentrations, respectively, were evaluated. The perioperative outcomes, operation time (from skin incision to dressing), length of hospital stay (LOS), drainage (for 24 h after surgery), and surgery-related complications, were also evaluated.

Results: Forty-seven patients (27 male, 20 female) were included in each group. The postoperative 6 months ODI was significantly lower in the BESS group than the microscope group (6.90 \pm 5.98 vs. 11.54 \pm 9.70). The peak CRP concentration (16.63 \pm 19.41 vs. 42.40 \pm 37.73, $p < 0.001$) and CRP increment (peak CRP-preoperative CRP, 14.69 \pm 19.47 vs. 40.71 \pm 37.32, $p < 0.001$) were significantly higher in the microscope group. Operation time (83.72 \pm 35.71 vs. 70.27 \pm 23.24, $p = 0.047$) was significantly longer in the BESS group. Surgery related complications were found in six and three cases in the BESS (three revisions, two dural tears, and one conversion to open surgery) and microscope (two revisions and one hematoma) groups, respectively.

Conclusions: BESS as a new technique resulted in satisfying short-term outcomes. It was a well-tolerated option for surgical treatment of single-level lumbar degenerative disease. The relatively high incidence of recurred disc in index level and incidental dural tear should be considered with surgeons new to BESS; however, these were manageable complications.

EPO8-11

MIS

"Assessment of Adjacent Segment Changes Following Single-level Oblique Lateral Interbody Fusion (OLIF): Insights from Radiographic Assessment"**Kaweekrai Anusart¹, Worawat Limthongkul^{1*}, Weerasak Singhatanadgidge¹, Vit Kotheeranurak¹ and Wicharn Yingsakmongkol¹**¹*Orthopedics, Faculty of Medicine, Chulalongkorn University, Thailand*

Background: Oblique lateral interbody fusion (OLIF) for treating spinal degeneration has been reported to improve both clinical and radiographic outcome by an indirect decompression of neural structure with preserving posterior spinal structure. However, increasing of disc height, foraminal height and area, restoring of sagittal parameters of surgical level can alter biomechanics that may results in radiographic changes of an adjacent level. Our study analyzed radiographic parameters of adjacent level (above and below) after performing OLIF in L4/5 in patient with degenerative spine disease.

Purpose: To investigate the radiographic changes of level above and below after a single level oblique lateral interbody fusion (OLIF) procedure.

Materials and methods: Patients with symptomatic L4/5 degenerative spine disease treated with OLIF procedure with percutaneous pedicle screws fixation without direct posterior decompression were included. After an IRB approved, post-operative plain radiograph and MRI at 6 months were done. Comparison of cross-sectional area (CSA), spinal canal diameter (SCD), foraminal area (FA), left and right foraminal height (FH), ligamentum flavum areas (LFA) and diameter (LFD) on MRI and disc height (DH), segmental lordotic angle, listhesis reduction on plain radiograph of surgical level (L4/5), level above (L3/4) and level below (L5/S1) pre- and postoperatively were done. Correlation of each parameter was analyzed. Degree of facet joint degeneration and disc degeneration were also recorded.

Results: Forty-seven patients with a mean age of 61.247.0 years were included in this study, and the measured spinal parameters are presented in the table. The results revealed a significant decrease in the average foraminal area (FA) and foraminal height (FH) of L5/S1 (mean change -8.92(-13.6- -4.25) p value < 0.001 and -0.89(-1.46- -0.32) p value <0.005, respectively) and a significant increase in the average ligamentum flavum area (LFA) (mean change 10.06 (1.82 - 18.3) p value < 0.005). On the upper level (L3/4), a significant improvement in spondylolisthesis (mean change 1.27 (0.68 - 1.86) p value < 0.001) and an increase in spinal canal anteroposterior (AP) diameter (mean change 0.47 (0.02 - 0.93) p < 0.005) were found. However, other parameters were not significant. After surgery, significant improvements were observed in the anterior and posterior disc height (DH), the cross-sectional area (CSA), the LFA, and the reduction of listhesis at L4/5, with mean changes of 4.27 (3.39 - 5.15), 3.68 (3.01 - 4.36), 64.69 (52.31 - 77.07), -34.03 (-44.72 - -23.35), and -3.03 (-4.04 - -2.03) p-value < 0.001, respectively.

Conclusions: Our study showed a significant decrease in foraminal area and height and an increase in ligamentum flavum area of lower level (L5/S1) in early postoperative period (6 months) after OLIF L4/5. We also found a significant listhesis reduction and an increase of spinal canal diameter on the upper level (L3/4). An increase of spinal neural canal by indirect decompression may affect adjacent level especially the lower level. While treating L4/5 pathology with OLIF procedure, surgeon should be aware of asymptomatic L5/S1 neural compression.

MRI parameters									
N=47	L3/4			L4/5			L5/S1		
	Pre-operative	Post-operative	Mean change (p-value)	Pre-operative	Post-operative	Mean change (p-value)	Pre-operative	Post-operative	Mean change (p-value)
CSA (mm ²)	143.1 (39.97)	145.4 (40.70)	2.3 (0.49)				138.95 (48.50)	138.01 (50.98)	-0.94 (0.79)
SCD (mm)	12.75 (2.89)	13.23 (2.72)	0.47 (0.04)				11.16 (1.72)	11.17 (1.84)	0 (0.97)
FA (mm ²)	91.1 (24.23)	94.23 (25.68)	3.13 (0.27)				94.71 (22.51)	85.79 (22.85)	-8.92 (<0.001*)
FH (mm)	16.48 (2.38)	16.65 (2.29)	-0.7 (0.06)				15.56 (1.94)	14.68 (1.95)	-0.89 (0.003)
LFA (mm ²)	78.16 (30.90)	78.8 (30.74)	0.64 (0.87)				98.49 (35.25)	64.46 (35.09)	-34.03 (<0.001)
Plain radiograph parameters									
DH ant (mm)	13.63 (3.04)	14.02 (2.84)	0.4 (0.06)	11.32 (3.85)	15.59 (2.87)	4.27 (<0.001*)	14.96 (3.62)	14.78 (3.03)	-0.19 (0.63)
DH post (mm)	7.62 (1.89)	7.91 (1.90)	0.3 (0.16)	7.19 (2.31)	10.87 (1.89)	3.68 (<0.001*)	7.5 (2.12)	7.92 (1.91)	0.42 (0.11)
L ₁ isthesis	-2.42 (2.66)	-1.14 (1.81)	1.27 (<0.001*)	5.3 (4.64)	2.26 (2.50)	-3.03 (<0.001*)	0.13 (1.10)	0.12 (1.14)	-0.01 (0.56)

Cross-sectional area (CSA), spinal canal diameter (SCD), foraminal area (FA), foraminal height (FH), ligamentum flavum areas (LFA) on MRI
 Disc height anterior (DH ant), Disc height posterior (DH post), listhesis reduction (L₁isthesis) on plain radiograph
 Data were presented in Mean (SD)**

EP08-12**MIS****Clinical and Radiological Results of Biportal Endoscopic Lumbar Interbody Fusion : More than 2 Year Follow Up**

Dong Geun Lee¹, Choon Keun Park¹, Jae-Won Jang¹ and Jin Seop Hwang¹

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Background: Biportal endoscopic lumbar interbody fusion (BE-fusion) surgery combines the advantages of standard open surgery and endoscopic spinal surgery. However, clinical and radiological evidence in support of biportal endoscopic lumbar interbody fusion remains insufficient. We aimed to verify the clinical and radiological results and expiscate advantages and disadvantages of biportal endoscopic lumbar interbody fusion

Methods: This study included 28 patients who underwent single level transforaminal lumbar interbody fusion or posterior lumbar interbody fusion using two cages for spinal stenosis with degenerative or isthmic spondylolisthesis between January 2019 and August 2022. Operation time, intraoperative blood loss, postoperative blood loss and hospital day was checked. The clinical comparison was performed using Visual Analog Scale (VAS), Oswestry Disability Index (ODI), modified MacNab's criteria. Radiologically, the change of motion and degree of lordosis at operation level, the fusion rate was carried out by plain dynamic X-ray and lumbar CT.

Results: The average follow up was 32.448 months and the average operation time was 211.3412 min. The intra blood loss was 167.345.3 ml and postoperative blood loss was 73.441.2 ml until postoperative 2 days. Hospital stay was 6.641.6 days. The mean leg VAS and ODI improved from each preoperative score 7.940.1 and 34.740.5 to postoperative score 2.940.1 and 12.140.6 after surgery significantly ($P < 0.05$). The mean back VAS was also significantly improved from preoperative score 7.840.1 to postoperative score 3.540.1 after surgery ($P < 0.05$). The average Modified MacNab's criteria was 2.840.1. Complication was postoperative subsidence with leg pain of 2 patients and spinal infection of 1 patient who was performed using 1 Polyetheretherketone (PEEK) cage (length 34mm, width 11mm). There were each 17 patients, 8 patients and 3 patients who underwent surgery using 1 PEEK cage, 2 titanium, 1 expandable cage. The fusion rates was 89.3% and no revision surgery occurred.

Conclusions: More than 2-year clinical and radiological follow up for Biportal endoscopic lumbar interbody fusion were favorable and might be a viable alternative surgery in patients with degenerative or isthmic spondylolisthes. However, choice of one interbody cage with proper width should be cautious, and long-term outcomes should be investigated through prospective, randomized controlled trials in the future.

EP08-13

MIS

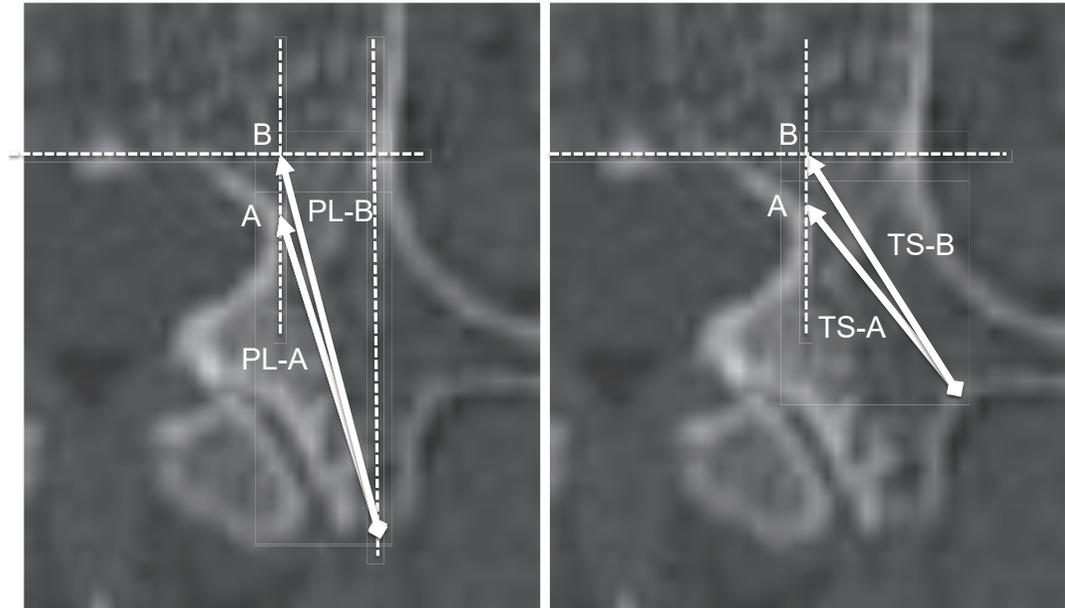
Distance from Screwing Point to Spinal Canal and Vertebral Body in Lumbar Spine – Anatomy for Safe Percutaneous Pedicle Screw Insertion**Takeshi Aoyama¹, Reo Fujisawa¹, Hirokazu Furukawa¹, Naoshi Obara¹ and Takahiro Iida¹**¹ Spine Center Department of Orthopaedic Surgery, Teine Keijinkai Hospital, Sapporo, Japan

Background: Percutaneous pedicle screw(PPS) insertion needs image guidance, different to traditional pedicle screwing. Navigation system is useful, but expensive. So, PPS is mainly inserted with C-arm guide. Needle is inserted with A-P view by observing shape of pedicle in first step. Then depth is checked with lateral view, then it is inserted more deeply. Too angled needle damages spinal canal(SC), and too deep needle damages abdominal vessels. Frequent switching of C-arm is safe but time consuming. The knowledge of length of pedicle is useful to efficient PPS insertion. This study analyses the distance from inserting point to SC and vertebral body(VB).

Materials and methods: 30 cases' lumbar CT was analyzed for measurement of L1-5 pedicle. The methods of PPS insertion are from lateral margin of pedicle in A-P view(PL) or from the angle of transverse and superior articular process(TS). From each starting point, the tangent to the cortex of the SC, i.e., the line through which the screw passes the innermost, was drew. intersection of this line and sagittal line passing through the inner wall of the pedicle(IW) was point A. And the distances from each starting point were determined as PL-A and TS-A. If needle tip reaches less than these distance in A-P view, the needle damages SC. And intersection of IW line and posterior wall line was determined as B, the distances were PL-B and TS-B in same way. This is the longest length to VB, and if needle is inserted this length before the tip reach IW, it is already in VB.

Results: 300 pedicles were analyzed. Each measurement values in L1, L2, L3, L4, L5 and L1-5 all are described as below (mean \pm 4SD, mm). PL-A: L1(16.843.0mm), L2(17.042.7mm), L3(17.442.7mm), L4(17.042.7mm), L5(18.843.4mm), L1-5(17.342.9mm), PL-B: L1(22.143.0mm), L2(21.243.0mm), L3(20.842.9mm), L4(19.242.8mm), L5(19.343.2mm), L1-5(20.543.1mm), TS-A: L1(18.142.6mm), L2(18.242.0mm), L3(18.842.2mm), L4(17.142.1mm), L5(17.742.3mm), L1-5(18.042.3mm), TS-B: L1(21.244.6mm), L2(21.142.1mm), L3(21.042.0mm), L4(18.442.0mm), L5(18.242.2mm), All(20.142.6mm).

Conclusion: Statistically, the probability of being larger than +1SD or less than -1SD is 15.8%, and that of +2SD is 2.3%. PL-A in 84% and 98% cases were less than 20mm and 23mm, respectively. That was, if the needle tip does not reach the IW in these distances, the needle proceeds to VB without violation to SC. Contrary, if the needle reach within 14mm, the needle damages SC in 84% cases. The TS-A were 20mm, 23mm and 16mm, respectively. PL-B in 84% and 98% cases were less than 24mm and 27mm, respectively. The depth of needle must be checked with lateral view when the tip reached these lengths. And TS-B were 23mm and 25mm, respectively. Briefly, the needle should be inserted at an angle that doesn't reach IW when the needle is inserted 23mm, and then checked the depth of needle with lateral view. Results of this study contribute safe and efficient PPS insertion.



EP08-14

MIS

Endoscopic Discectomy for Lumbar Disc Herniation after Decompression Surgery**Ji Soo Moon¹, Eun Soo Park^{1*}, Sang Ho Lee² and Chan Hong Park³**¹ Neurosurgery, Daegu Wooridul Spine Hospital, Korea² Neurosurgery, Wooridul Spine Hospital, Korea³ Anesthesiology and Pain Medicine, Daegu Wooridul Spine Hospital, Korea

Introduction: Potential pitfalls and difficulty exist in reoperation at the previous operation site. If another method can be considered, it may be a good surgical option.

Objectives: This study is aimed to share a successful case about endoscopic discectomy for lumbar disc herniation at the laminectomy site.

Methods: A 51-year-old man chiefly complained of low back pain and right sciatica 2 months ago. The pain was 8 in Numeric Rating Scale (NRS) score. After reviewing Magnetic resonance images (MRI) and Computed tomography (CT) images, we found lumbar central disc herniation at the level of L4-5. 3 years ago, he was treated for multiple stenosis at the level of L3-4, L4-5, and L5-S1 with unilateral laminotomy and bilateral decompression. Symptoms improved after diagnostic block. After percutaneous endoscopic lumbar discectomy (PELD) on right side, clinical outcomes were assessed by using Preoperative and Postoperative NRS score. Postoperative MRI was checked. Preoperative and follow-up dynamic X-ray were checked.

Results: Postoperative MRI showed sufficient decompression and no remnant disc herniation. On the first postoperative day, low back pain and bilateral sciatica was improved in NRS score to 3. At the outpatient department follow-up, improved symptoms remained and instability was not aggravated after checking preoperative and follow-up dynamic X-ray.

Conclusions: PELD is a good surgical option for lumbar disc herniation at the laminectomy site.

EP08-15

MIS

Additional Level Endoscopic Discectomy with One Incision after Diagnostic Selective Nerve Root Block**Ji Soo Moon¹, Eun Soo Park^{1*}, Sang Ho Lee² and Chan Hong Park³**¹ Neurosurgery, Daegu Wooridul Spine Hospital, Korea² Neurosurgery, Wooridul Spine Hospital, Korea³ Anesthesiology and Pain Medicine, Daegu Wooridul Spine Hospital, Korea

Introduction: After reviewing preoperative images, minor lesion correlated with symptoms may be checked. Before endoscopic discectomy, whether additional level discectomy or not should be decided. Diagnostic selective nerve root block may be a good method for deciding additional level discectomy.

Objectives: This study is aimed to share a case about additional level endoscopic discectomy with one incision after diagnostic selective nerve root block.

Methods: A 58-year-old woman chiefly complained of low back pain and left sciatica 6 weeks ago. The pain was 8 in Numeric Rating Scale (NRS) score. After reviewing Magnetic resonance images (MRI) and Computed tomography (CT) images, we found soft type of lumbar central disc herniation at the level of L4-5 and L5-S1. The lesion at the level of L5-S1 is minor, but correlated with symptoms. After performing left S1 root block, the effect was checked. Percutaneous endoscopic lumbar discectomy was performed at the level of L4-5 and L5-S1 with one incision. After endoscopic discectomy, clinical outcomes were assessed by using Preoperative and Postoperative NRS score. Postoperative MRI was checked.

Results: Postoperative MRI showed sufficient decompression. On the first postoperative day, low back pain and left sciatica were improved in NRS score to 3

Conclusions: Diagnostic selective nerve root block is a good method for deciding additional level discectomy.

EP08-16

MIS

Efficacy of the Erector Spinae Plane Block with Sedation for Unilateral Biportal Endoscopic Spine Surgery and Comparison with Other Anesthetic Methods**Tae Hoon Kang¹ and Jae Hyup Lee^{1*}**¹ Department of Orthopedic Surgery, SMG-SNU BRM Medical center, Korea

Background: Erector spinae plane block (ESPB) is a new regional anesthesia. Unilateral biportal endoscopic (UBE) spine surgery, a minimal invasive technique, has been performed under not only general anesthesia (GA) but regional anesthesia including spinal anesthesia (SA). The aims of this study were to evaluate the efficacy of ESPB with sedation for UBE lumbar decompression and compare it with GA and SA.

Method: A retrospective age matched case-control study design was performed. Three groups (20 patients in each group) of patients who underwent UBE lumbar decompressions under each anesthetic method (GA, SA, or ESPB) were formed. The total anesthesia time excluding operation time, postoperative analgesia effects, hospital days and complications related to anesthetic methods were evaluated.

Results: In the ESPB group, all the operations were performed without change of anesthetic methods and without anesthetic complications. But there were no anesthetic effects in the epidural space, which resulted in additional intravenous fentanyl usage. The mean of time from initiation of anesthesia to completion of surgical preparation was 23.344.7 minutes in the ESPB group, which was shorter than 32.3410.8 minutes in the GA (p -value=0.001) or 33.346.7 minutes in the SA group (p <0.001). The proportion of patients requiring first rescue analgesia within 30 minutes was 30% in the ESPB group, which was lower than 85% in the GA (p <0.001) but no significant different with 10% in the SA (p =0.11). The mean of total hospital days in the ESPB was 3.040.8, shorter than 3.741.8 in the GA (p = 0.02) or 3.841.1 in the SA group (p = 0.01). There was no case of postoperative nausea and vomiting in the ESBB even without prophylactic antiemesis.

Conclusion: ESPB with sedation is a viable anesthetic option for UBE lumbar decompression.

Keyword: Erector Spinae Plane Block, Unilateral Biportal Endoscopic Spine Surgery, Regional anesthesia, Minimally invasive spine surgery

EP08-17

MIS

Awake Unilateral Biportal Endoscopic Thoracic Decompression - Technical Note -Tae Hoon Kang*Department of Orthopedic Surgery, SMG-SNU BRM Medical center, Korea*

Study design: Technical note.

Objective: This study aimed to report the results of thoracic myelopathy patients treated with awake unilateral biportal endoscopic decompression and show the possibility of intraoperative neuromonitoring using verbal commands. **Summary of Literature Review:** Surgical decompression is necessary for most thoracic myelopathies. To avoid cord injury, intraoperative neuromonitoring is recommended. If thoracic decompression is possible under local anesthesia, awake surgery with intraoperative neuromonitoring using verbal commands is possible.

Materials and Methods: We retrospectively reviewed three thoracic myelopathy patients treated with awake decompression between March and May 2022. Partial hemilaminectomies with unilateral biportal endoscopy under local anesthesia were performed. The patients were asked to move their legs in response to verbal commands intraoperatively.

Results: The patients' average age was 78.7 years (range, 75-83 years). The average number of levels of surgery was 1.3 (range, 1-2). The average surgical time was 55 minutes. There were no neurological or other complications. Numeric rating scale (NRS) scores during the procedure were lower than 3. The NRS score of back pain improved from 4.6 preoperatively to 2 postoperatively, while that of leg pain improved from 6 to 1.3 at the discharge day. The modified Japanese Orthopaedic Association scores changed from 5.3 preoperatively to 8.6 at postoperative 1 month.

Conclusions: Awake thoracic decompression with unilateral biportal endoscopy can be an alternative for decompression in thoracic myelopathy, avoiding neurological complications.

Key words: Awake spine surgery, Stagnara test, Thoracic myelopathy, Unilateral biportal endoscopic thoracic decompression, Intraoperative neuromonitoring

EP08-18

MIS

Unilateral Biportal Endoscopic Decompression Surgery for Histopathological Diagnosis and Abscess Removal in Spinal Tuberculosis: A Case SeriesYoungsuk Hwang*Neurosurgery, Keimyung University Dongsan Hospital, Korea*

Purpose: Spinal tuberculosis presents challenges in differentiating it from bone metastasis, leading to difficulties in clinical diagnosis and potential delays in appropriate treatment initiation. Computed Tomography-Guided Percutaneous Spine Biopsies have been established as the diagnostic gold standard, particularly for patients who are not suitable for surgical interventions, showing excellent diagnostic value with reported histopathologic accuracy of up to 94% in some studies. However, real-world practice still encounters difficulties in achieving accurate diagnoses, and relying solely on Computed Tomography-Guided Percutaneous Spine Biopsies is limited in addressing underlying issues such as abscesses or cord compression caused by spinal deformity. This paper introduces two cases where Unilateral Biportal Endoscopic Decompression Surgery enabled simultaneous histopathological diagnosis, abscess removal, and nerve decompression in patients with challenging differentiation between multiple bone metastasis and spinal tuberculosis.

Materials and methods: Patient 1, a 42-year-old male previously diagnosed with pulmonary tuberculosis, was admitted to our institution for further evaluation due to cachexic morphology and the presence of multiple bone metastases, including a high uptake lesion in the L2-3 vertebral body observed on a PET-CT scan. The patient complained of back pain and radiating pain in the anterior aspect of the right thigh. Physical examination revealed weakness with mMRC grade 3 hip flexion. An enhanced spine MRI showed findings consistent with an L2 pathologic compression fracture with prominent extraosseous extension, raising suspicion of bone metastasis and indicating the need for histopathological examination and surgical procedure. Patient 2, an 88-year-old female, was admitted to our institution with a diagnosis of L2-3 spondylodiscitis and an epidural abscess. The patient presented with back pain and radiating pain in both anterior aspects of the thighs. The enhanced MRI of the lumbar spine revealed an epidural abscess, requiring differentiation between pyogenic or mycobacterial infection and consideration of surgical debridement for nerve decompression. Due to the severe cachexia in the first patient and the advanced age of the second patient, they were not in a condition to tolerate surgery under general anesthesia with significant bleeding. However, histopathological diagnosis was essential in both cases, and there was a high likelihood of progressing neurological symptoms, necessitating surgical treatment. Therefore, Unilateral Biportal Endoscopic Biopsy with decompressive Surgery was performed on both patients. The tissue samples obtained were subjected to routine gram stain and acid-fast bacilli (AFB) stain, along with culture tests, as appropriate methods for histopathological diagnosis of tuberculosis.

Results: In the first patient, tuberculosis was diagnosed through positive staining of acid-fast bacilli (AFB) in the AFB stain, confirming spinal tuberculosis. In the second patient, the culture analysis of the tissue revealed a positive result for acid-fast bacilli, leading to the diagnosis of tuberculosis.

Conclusion: Various surgical treatment methods, from needle biopsy to laminectomy, are available for diagnosing spinal tuberculosis. For patients who were considered at risk for extensive surgery considering their general condition, minimal invasive spine surgery was considered a favorable option. Among those options, Unilateral Biportal Endoscopic Surgery can be another viable option for decompression and tissue diagnosis.

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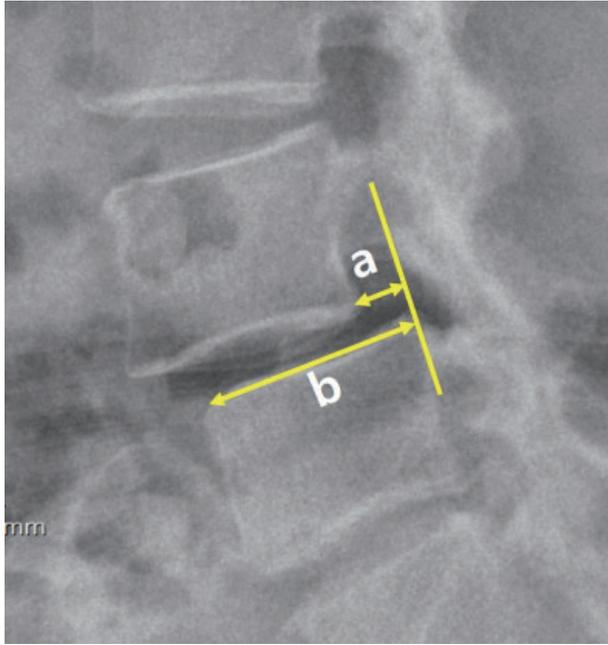
The Sequence of Oblique Lumbar Interbody Fusion: Reduction First or Cage First?Junghoon Han¹, Chi Heon Kim^{2*} and Chang-Min Ha³¹ Neurosurgery, Namkise Hospital, Korea² Neurosurgery, Seoul National University, Korea³ Neurosurgery, Samsung Medical Center, Korea

Background: Oblique lumbar interbody fusion (OLIF) procedures are divided into anterior insertion of interbody cage first in lateral position and insertion of pedicle screw and rod system in a prone position (OLIF-con). The location of the cage is important for restoration of lumbar lordosis and indirect decompression. However, inserting the cage at the desired location is difficult without reduction of spondylolisthesis, and reduction after insertion of interbody cage may limit the amount of reduction. Recent introduction of spinal navigation enabled both surgical procedures in one position (OLIF-one). The objective of this study was to compare the reduction of spondylolisthesis and the placement of cage between OLIF-one and OLIF-con.

Methods: We retrospectively reviewed 72 consecutive patients with spondylolisthesis for this study; 30 patients underwent OLIF-one and 42 underwent OLIF-con. Spinal navigation system was used for OLIF-one. In OLIF-one, the interbody cage was inserted after reducing spondylolisthesis, whereas in OLIF-con, the cage was inserted before reduction. The following parameters were measured on X-rays: pre- and postoperative spondylolisthesis slippage, reduction degree, and the location of the cage in the disc space.

Results: Both groups showed significant improvement in back and leg pains ($p < .05$). Transient motor or sensory changes occurred in three patients after OLIF-con and in two patients after OLIF-one. Pre- and postoperative slips were 26.347.7% and 6.646.2% in OLIF-one, and 23.147.0% and 7.445.8% in OLIF-con. The reduction of slippage was 74.446.3% after OLIF-one and 65.445.7% after OLIF-con, with a significant difference between the two groups ($p = .04$). The cage was located at 34.248.9% after OLIF-one and at 42.8410.3% after OLIF-con, with a significant difference between the two groups ($p = .004$).

Conclusion: Switching the sequence of surgical procedures with OLIF-one facilitated both the reduction of spondylolisthesis and the placement of the cage at the desired location.



EP09-02

Navigation & Robotics

Double Endplates Penetrating Screw Technique and Cross Trajectory Technique Using Robotic Navigation System**Sho Fujiwara¹, Takashi Moriwaki¹ and Koichi Iwatsuki¹**¹ Department of Neurosurgery, Osaka Gyomeikan Hospital, Japan

Background: Although the double endplates penetrating screw (DEPS) technique and the cross trajectory technique have been reported to improve the fixation strength, these techniques under fluoroscopy are difficult. We report cases of the DEPS and the cross trajectory screw insertion using robotic navigation system (ExelsiusGPS®).

Methods: We performed surgery for the following three patients and verified screw insertion accuracy and clinical outcomes.

Case 1: 88-year-old female. She was admitted with the alligator-mouse type L2 vertebral fracture with DISH. She underwent vertebroplasty with Biopex, and PPS fixation was performed for T12, L1, and L4 using the DEPS technique, and for L3 using the conventional technique.

Case 2: 71-year-old woman. She was admitted with T11 vertebral fracture with ossified anterior longitudinal ligament injury with DISH and damage to posterior ligament complex. She underwent vertebroplasty with Biopex, and PPS fixation was performed for T9 and L1 using the DEPS technique, and for T10 and T12 the single endplates penetrating screw technique.

Case 3: 80-year-old woman. She was admitted with L4 burst fracture (AO classification: A4, TL AOSIS: 7 points), and underwent L3-5 laminectomy, vertebroplasty with Biopex, and screw insertion for L3 and L5 using the cross trajectory technique.

Results: No malposition was observed in all screws. All patients improved clinical outcomes (NRS, JOA, FIM, etc.) at 6 months postoperatively and were able to walk.

Conclusion: Robotic navigation systems can improve the accuracy of conventional screw insertion. In addition, this system can safely perform highly difficult screw insertion technique such as the DEPS and cross trajectory technique. Robotic navigation system enables minimally invasive procedures such as reducing the number of fixation levels.

E-POSTERS



NON-OPERATIVE CARE

EP10-01

Non-Operative Care

The Efficacy of Hyaluronidase in Transforaminal Epidural Steroid Injection**Jae Yeun Hwang¹, Min Joon Cho^{2*} and Jae Hyup Lee²**¹ Orthopaedic Surgery, Kangnam Sacred Heart Hospital, Hallym University School of Medicine, Korea² Orthopaedic Surgery, SMG-SNU Boramae Medical Center, Korea

Purpose: We conducted this study in order to evaluate the efficacy of hyaluronidase injections in transforaminal epidural injections. Furthermore, we would like to confirm that the effect varies with the degree of radiological foraminal stenosis.

Materials and methods: Patients selected from September 2019 to April 2022 who underwent transforaminal epidural injections for low back pain and lower extremity pain. We established a follow-up period of at least six months. Magnetic resonance imaging was used to confirm the degree of radiological foraminal stenosis in the patients. Transforaminal epidural injections were used for all procedures. Two groups of patients were compared: those receiving steroid and local anesthetics therapy alone (S) and those receiving additional hyaluronidase (S+H).

Results: A total of 359 patients were analyzed. The S group consisted of 194 patients, while the S+H group consisted of 165 patients. In terms of demographic factors and radiological findings, there were no statistically significant differences between the two groups. At 6 weeks, 36.4% of the S group showed greater than 30% reduction in pain, whereas 54.6% of the S+H group showed greater than 30% reduction in pain. Even at week 12, the response rate was higher in the S+H group. The rate of response that pain was reduced by more than 50%, at 6 weeks was 29.7% in the S group and 39.7% in the S+H group. There was no statistically difference between the use of hyaluronidase and the degree of foraminal stenosis. The effect of injection lasted longer in the S+H group than in the S group, especially in the patient group with severe foraminal stenosis. The S+H group had a lower surgical conversion rate than the S group during the 24-week follow-up period.

Conclusion: At six and twelve weeks following the procedure, hyaluronidase appears to have a greater impact on patients than steroid alone. The effect of hyaluronidase appears to prolong symptomatic improvement, especially in patients with severe radiological foraminal stenosis. However, there was no statistical difference in the degree of radiological foraminal stenosis and the degree of pain reduction caused by the addition of hyaluronidase.

E-POSTERS



PEDIATRIC SPINE

EP11-01

Pediatric Spine

Vertebral Bone Quality Score as a Novel Predictor of Proximal Junctional Kyphosis after Thoracic Adolescent Idiopathic Scoliosis Surgery

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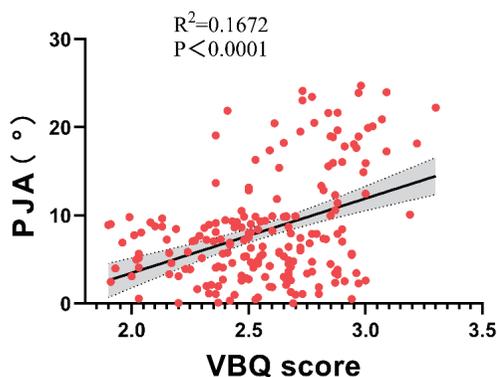
Background: Proximal junctional kyphosis (PJK) is one of the most common complications after thoracic AIS surgery. Previous studies reported that the etiology of PJK was associated with osteopenia and meanwhile the AIS patients were found osteopenia which could persist into adulthood. Recently, an MRI-based vertebral bone quality score (VBQ) was reported to be a promising tool which can assess preoperative bone quality. This study aims to evaluate the utility of VBQ score in predicting PJK after corrective surgery for thoracic AIS (Lenke 1 and 2).

Methods: We conducted a retrospective study to identify the predictive efficiency of VBQ score for PJK in thoracic AIS patients. Demographic, radiographic parameters, and surgical variables were collected. VBQ score was calculated using preoperative T1-weighted MRI. Univariate analysis, linear regression and multivariate logistic regression were performed to determine potential risk factors of PJK and correlation between other parameters and VBQ score. Receiver operating characteristic analysis and area-under-the-curve values were utilized to evaluate the predictive efficiency of VBQ score for PJK.

Results: A total of 198 patients (aged 14.78±1.70 years) were included, of which 47 (23.7%) developed PJK. VBQ scores were significantly different between the PJK and non-PJK groups (2.83±0.22 vs 2.49±0.27, $P < 0.001$). A significant positive correlation was found between VBQ score and PJA ($R^2 = 0.1672$, $P < 0.0001$). On multivariate analysis, VBQ score was the only significant predictor of PJK (odds ratio = 1.723, 95% CI = 1.403-2.116, $P < 0.001$), with a predictive accuracy of 83.1%.

Conclusion: Higher VBQ scores were independently associated with PJK occurrence after corrective surgery for thoracic AIS. Preoperative measurement of VBQ score on MRI may serve as a valuable tool in planning thoracic AIS surgery.

Key words: Adolescent idiopathic scoliosis, Proximal junctional kyphosis, Vertebral bone quality score, MRI



EP11-02

Pediatric Spine

Principles of Preoperative Diagnostics of Split Cord Malformation and Tethered Cord Syndrome in Children**Nodirbek Kadirbekov¹, Makhmud Akhmediev¹ and Tokhir Akhmediev¹**¹ *Republican specialized scientific and practical medical center of neurosurgery, neurosurgeon, Uzbekistan*

Background: The "tethered cord syndrome" in children with various dysplastic pathology of the neural tube is characterized by motor and sensory disorders in the lower extremities, pelvic dysfunction, the identification of which in preschool age is not always an easy task. Although more obvious bone and joint deformities attract attention, they are not always given enough attention and, as a result, there is a late diagnosis of neuronal pathology of the caudal parts of the spinal cord. Tension and restriction of the mobility of the spinal cord caused by its fixation in the lumbosacral spine leads to a violation of oxidative metabolism and electrophysiological activity of neuronal formations. Fixation factors are, as a rule, low-tensile structures, including fibrous, fibrous-fat filaments, tumors, myelomeningocele, lipomyelomeningocele or scar deformation of the filum terminale.

Methods: During the period from 2014 to 2022, 82 children with spina bifida occulta had a "tethered cord syndrome". All of them underwent clinical and instrumental screening with morphometry of the lumbosacral spine.

Results: The etiological factors that caused the atypically low location of the caudal spinal cord were the following: lipoma of the conus and epiconus of the spinal cord (8), lipoma of the filum terminale (9), dermal sinus (13), diastematomyelia (15), deformity of the filum terminale (12), pachymeningitis after spina bifida repair (25). The main method of diagnosing a tethered cord syndrome was magnetic resonance imaging (MRI), electromyography (EMG), MSCT myelography was used less often. The sensitivity and specificity of MRI and MSCT for the verification of pathology (meningomyelocele, spinal hernia, dermal sinus, lipoma of the conus and epiconus) reaches 100%. Morphometry data were analyzed in 62 patients using MRI tomography and measurement of the lumbosacral angle with tethered cord syndrome was performed. The values of the lumbosacral angle ranged from 18° to 64°. When studying the correlation of the value of the lumbosacral angle with the clinical picture, it was revealed that an increase in the angle in children is accompanied by the progression of the disease. Neurophysiological assessment of the functional status of the defect is an important component in preoperative planning and in dynamic control.

Conclusions: The main methods of instrumental diagnosis of tethered cord syndrome are magnetic resonance imaging (MRI) and MSCT myelography, as well as neurophysiological control. In order to determine the progression of the disease and develop indications for surgical treatment, it is advisable to measure the lumbosacral angle, its increase indicates either a relapse or the progression of the disease.

EP11-03

Pediatric Spine

Correction of the Craniospinal Compliance in the Treatment of the Hydrocephalus Combined with the Spinal Hernia**Bakhtiyor Talipov***Neurosurgery, Tashkent pediatric medical institute, Uzbekistan*

Background: The terminology of the craniospinal system elasticity and its capacity are acquainted in the modern literature related with the evaluation of the hydrocephalus and other problems of the increased intracranial problems. We have established the method defining the parameters of the shunting system with fixed pressure for the adequate correction of the hydrocephalus combined with the spinal hernia by the fractional draining of the CSF with the pressure monitoring.

Methods: This method has been used in children with combination of the spinal hernia and hydrocephalus: 33 patients were included in the basic group and 53 in the control group. 23 of 33 pediatric children from the basic group had the risk of the hernial sac rupture. The success of the performed surgery in this category was related with the thoroughly chosen shunting system parameters. It was beneficial both for the regression of the hydrocephalic symptoms as for the improvement condition of the hernial sac walls - skin growing, prevention of the hernia size growth and rupture. During monitoring the initial CSF pressure and its reduction character by the fractional draining were measured. We performed progressive CSF draining until pressure critical drop moment. This pressure indicated about deformity of the CSF cavities and cessation of the implanted shunt functioning. We developed a "CSF dynamic test" computer program to facilitate the registration of the performed researches.

Results: All basic group patients showed the regress of the hydrocephalic syndrome and liquidation of the hernial sac rupture risk. At the same time the hernial size decreased and this condition preserved until the second step procedure - herniectomy. Epithelial regeneration under the thin hernial layers indicated the positive dynamic that facilitated following hernioplasty with the autotissues.

Conclusions: Therefore using the method of fractional liquor draining from the spinal sac for the detection of the CSF production velocity allows increasing the accuracy of defining the parameters of unregulated shunting systems in patients with hydrocephalus combined with the spinal hernia.

EP11-04

Pediatric Spine

Assessment of Lumbosacral Angle in Split Cord Malformation and Tethered Cord Syndrome in ChildrenYugay Igor¹ and Akhmediev Takhir¹¹ Pediatric neurosurgery, Republican Specialized Research and Practical Medical Center for Neurosurgery, Uzbekistan

Objective: Assessment of clinical and radiological signs in patients with split cord malformation and tethered cord syndrome in children

Method: During the period from 2017 to 2023, 82 children with split cord malformation and tethered cord syndrome were treated in the department of pediatric neurosurgery at the Republican center of neurosurgery. All of them underwent clinical and instrumental screening with morphometry of the lumbosacral spine.

Result: The etiological factors that caused the atypically low location of the caudal spinal cord were the following: lipoma of the conus and epiconus of the spinal cord (8), lipoma of the filum terminale (9), dermal sinus (13), diastematomyelia (15), deformity of the filum terminale (12), pachymeningitis after spina bifida repair (25). The main method of diagnosing of tethered cord syndrome was magnetic resonance imaging (MRI), electromyography (EMG), MSCT myelography was used less often. The sensitivity and specificity of MRI and MSCT for the verification of pathology (meningomyelocele, spinal hernia, dermal sinus, lipoma of the conus and epiconus) reaches 100%. Morphometry data were analyzed in 82 patients using MRI tomography and measurement of the lumbosacral angle with split cord malformation and tethered cord syndrome was performed. The values of the lumbosacral angle ranged from 18° to 64°. In according the correlation of the value of the lumbosacral angle with the clinical picture, it was revealed that an increase in the angle in children is accompanied by the progression of the disease. Neurophysiological assessment of the functional status of the defect is an important component in preoperative planning and in dynamic control.

Conclusion: The main methods of instrumental diagnosis of split cord malformation and tethered cord syndrome are magnetic resonance imaging (MRI) and MSCT myelography, as well as neurophysiological control. In order to determine the progression of the disease and develop indications for surgical treatment, it is advisable to measure the lumbosacral angle, its increase indicates either a relapse or the progression of the disease.

EP11-05

Pediatric Spine

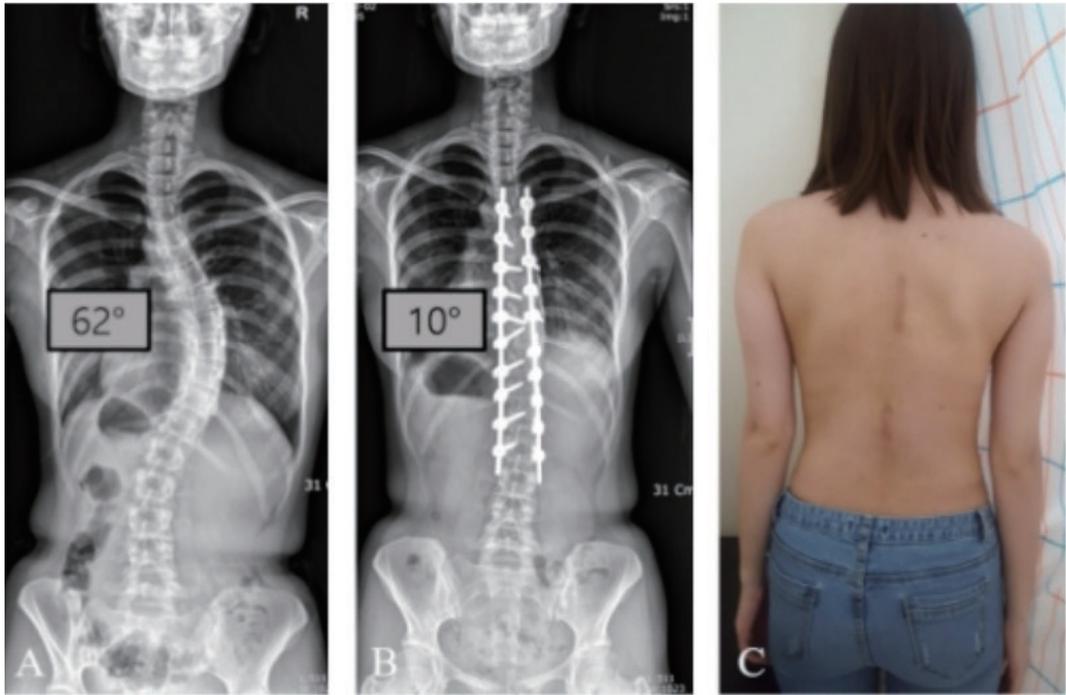
Fusion Rates Based on Type of Bone Graft Substitute Using Minimally Invasive Scoliosis Surgery for Adolescent Idiopathic ScoliosisDong-Gune Chang^{1*}, Hong Jin Kim¹, Ji Su Kim¹, Jae Hyuk Yang² and Seung Woo Suh²¹ Department of Orthopedic Surgery, Inje University Sanggye Paik Hospital, Korea² Department of Orthopedic Surgery, Korea University Anam Hospital, Korea³ Department of Orthopedic Surgery, Korea University Guro Hospital, Korea

Background: Minimally invasive scoliosis surgery (MISS) is currently introduced on novel technique for surgical treatment of adolescent idiopathic scoliosis (AIS). This study is aimed to evaluate the efficacy of facet fusion in MISS compared to posterior fusion in conventional open scoliosis surgery (COSS) and compare facet fusion rates based on three bone graft substitutes in MISS for AIS.

Methods: Eighty six AIS patients who underwent scoliosis surgery were divided into two groups: the COSS group and the MISS group. COSS was performed through posterior fusion with allograft. MISS was applied via facet fusion with three bone graft substitutes. The MISS group was further divided into three subgroups based on graft substitute: Group A (allograft), Group B (demineralized bone matrix [DBM]), and group C (demineralized cancellous bone chips). Fusion rate was measured using conventional radiographs to visualize loss of correction > 10°, presence of lysis around implants, breaks in fusion mass, and abnormal mobility of the fused segment.

Results: The fusion rates showed no significant difference in COSS and MISS groups ($p = 0.070$). In the MISS group, the fusion rates were 85%, 100%, and 100% in groups A, B, and C, respectively, with no significant difference ($p = 0.221$). There were no statistical differences between groups A, B, and C in terms of correction rate, fusion rate, and SRS-22 scores ($p > 0.05$).

Conclusion: The facet fusion in MISS showed comparable to posterior fusion in COSS with regard to radiological and clinical outcomes. Furthermore, the type of graft substitute among allograft, DBM, and demineralized cancellous bone chips did not affect facet fusion rate or clinical outcomes in MISS. Therefore, MISS showed comparable fusion rate (with no influences on the type of graft substitute) and clinical outcomes to those of COSS in the surgical treatment of AIS.



EP11-06**Pediatric Spine****The Role of Rhizotomy in Surgery for Cerebral Palsy in Children****Normurod Zekriyayev¹, Igor Yugay¹ and Ravshan Yuldashev¹**¹ *Spinal surgery, Republican Scientific and Practical Medical Center of Neurosurgery, Uzbekistan*

Introduction: Cerebral palsy (CP) is one of the most common motor disorders in children, affecting 2-3 per 1000 live births. It is characterized by spasticity, muscle weakness, and impaired motor function. While medical management of CP can help to manage symptoms, some patients may require surgical intervention. Rhizotomy is one such surgical intervention that has been used to treat spasticity in CP. This article aims to review the literature on the use of rhizotomy in CP, with a statistical review of outcomes.

Methods: A systematic review of the literature was conducted using PubMed, Embase, and Cochrane Library databases. The inclusion criteria were studies on rhizotomy in CP, published between 2000 and 2021, with a sample size of at least 10 patients. The outcomes of interest were changes in spasticity, function, and quality of life.

Results: Twenty studies were included in the review, comprising a total of 1076 patients. The studies included different types of rhizotomy, including dorsal rhizotomy, selective dorsal rhizotomy (SDR), and percutaneous rhizotomy. The majority of studies reported significant improvements in spasticity, function, and quality of life following rhizotomy. The mean improvement in spasticity was 59.3%, with a range of 20-90%. The mean improvement in function was 57.8%, with a range of 35-95%. The mean improvement in quality of life was 47.9%, with a range of 10-90%. The most common adverse events reported were transient weakness, sensory changes, and wound infection. The overall incidence of adverse events was low, with a mean of 5.1%, and a range of 0-16%.

Discussion: The results of this review suggest that rhizotomy is an effective surgical intervention for spasticity in CP, with significant improvements in spasticity, function, and quality of life. The majority of studies reported good outcomes, with low rates of adverse events. However, it is important to note that the studies included in this review were heterogeneous in terms of patient selection, surgical technique, and outcome measures. Further research is needed to determine the optimal patient selection criteria, surgical technique, and long-term outcomes of rhizotomy in CP.

Conclusion: Rhizotomy is an effective surgical intervention for spasticity in CP, with significant improvements in spasticity, function, and quality of life. The overall incidence of adverse events is low, with transient weakness, sensory changes, and wound infection being the most common adverse events reported. Further research is needed to determine the optimal patient selection criteria, surgical technique, and long-term outcomes of rhizotomy in CP.

E-POSTERS



SPINAL ARTHROPLASTY

EP12-01

Spinal Arthroplasty

Evaluating 5-year Outcomes of between the Use of Coflex Compared to Stenofix Device as an Adjunct to Decompression for Symptomatic Lumbar Spinal Stenosis

Naresh Kumar^{1*}, Kasia Chen Xi Chua¹, Meetrra Seyher Rajoo¹, Andrew Cherian Thomas¹, Sean Junn Kit Lee¹, Shen Liang² and Laranya Kumar¹

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² Biostatistics Unit, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

Background: Literature on benefits of interlaminar devices (ILD) compared to decompression alone for symptomatic lumbar spinal stenosis (LSS) is limited past the 2-year timeframe. Additionally, no radiological parameters for quantifying patients with positive surgical outcomes have been correlated.

Aim: Assess 5-year outcomes following the use of Coflex compared to Stenofix as adjunct to spinal decompression and determine whether improvement in radiological indices correlate with clinical outcomes.

Materials and Methods: A prospective single surgeon cohort study of 116 patients who underwent spinal decompression with or without ILD insertion between 2007 - 2015. Patients with single level symptomatic LSS were offered spinal decompression with either ILD insertion. Exclusion criteria were patients <21 years-age, spondylolysis/lithesis grade-2 or higher, multi-level LSS, previous lumbar surgery and malignancy. Clinical outcomes were assessed preoperatively & up to 5-yrs postoperatively, using the Oswestry disability index(ODI), EuroQoL-5d(Eq5d), VAS and SF-36. Radiological indices were assessed preoperatively and up to 5-yrs postoperatively.

Results: 70 patients were allocated; 21 in Stenofix group and 49 in Coflex group. Stenofix group had a significant reduction of anterior disc height at 5 years from 12.5 to 11.2mm ($p<0.01$) while Coflex group had unsustained improvement postoperatively that reverted to preoperative height at 5-yrs ($p=0.34$). Stenofix group had unsustained increase in posterior disc height and foraminal height postoperatively that reverted to preoperative height at 5-yrs. Coflex group had significant maintained improvement in posterior disc height from 6.9 to 7.9mm ($p=0.01$) and foraminal height of 17 to 20.7mm ($p=0.03$) at 5-yrs. There was significant improvement in posterior disc height favouring Coflex ($p<0.01$). There was no significant difference in sagittal balance, overall lordosis and sagittal angle of the index level. Both groups had significant improvement post-operatively at all time points for all clinical outcomes. Coflex had greater improvement in SF36-MCS than Stenofix ($p<0.01$) from 54.5 to 69.5 compared to 48.2 to 51.8 at 5-year postoperative respectively. Coflex had a greater improvement in VAS than Stenofix ($p=0.03$) from 6.0 to 1.0 compared to 6.2 to 2.3 at 5 years postoperative respectively. There was no significant difference in remaining clinical outcomes between the groups.

Conclusions: ILD with spinal decompression in symptomatic LSS up to grade I spondylolisthesis offers good clinical outcomes compared to decompression alone with sustained radiological correction. Our study highlights that in treatment of symptomatic LSS up to grade I spondylolisthesis, Coflex is superior to Stenofix with greater improvement in posterior disc height and clinical outcomes.

E-POSTERS



TRAUMA, TUMOR & INFECTION

EP13-01

Trauma, Tumor & Infection

Trial and Chronic Lumbosacral Epidural Stimulation to Regain Voluntary Motor Control after Complete Motor Paralysis

Alena Militskova¹, Elvira Mukhametova¹, Artur Biktimirov¹, Vyacheslav Andrianov¹, Elena Yakovleva¹ and Igor Lavrov¹

¹ *Institute of Fundamental Medicine and Biology, Kazan Federal University, Russia*

Background: Electrical epidural stimulation (EES) is well established experimental therapy for reestablishing the functional connectivity in patients with spinal cord injury (SCI). The trial EES could be useful to assess effectiveness of spinal cord neuromodulation for SCI patients with complete motor paralysis before chronic implantation. In this study the effect of trial and chronic EES was compared in patient with a motor complete spinal cord injury (AIS-B).

Methods: EMG was recorded from the following muscles: rectus femoris, vastus lateralis, medial hamstring, tibialis anterior, medial gastrocnemius and soleus muscles bilaterally. EES was first performed with trial two eight-contact leads (Octrode, model 3086; Abbott, Plano, TX, USA) and Multiprogram Trial Stimulator (MTS) (3510, Abbot), and then with chronically implanted 5-6-5 array connected to implantable pulse generator (Medtronic Inc, USA). EES was performed with intensity from 0 to 10 V, pulse width - 250 μ s, and frequency - 20 Hz. Our results suggest that EES applied with both trial and chronic electrodes has immediate effect on voluntary control of movement. Appropriate EMG activation of leg muscles and movements in leg joints was achieved with both trial and chronic EES systems in supine and in side-lying position.

Conclusion: EES with both trial and chronic electrodes also generated a step-like activity in side-lying position with one leg suspended in gravity neutral position. In side-lying position EMG amplitude in muscles of suspended leg was significantly higher. Considering that trial and chronic stimulations demonstrate similar results in regaining the motor functions in participant with motor complete SCI, trial stimulation may have potential prognostic value in evaluation of neuromodulation effect of chronic EES after SCI. This study has been supported by the Kazan Federal University Strategic Academic Leadership Program (PRIORITY-2030).

EP13-03

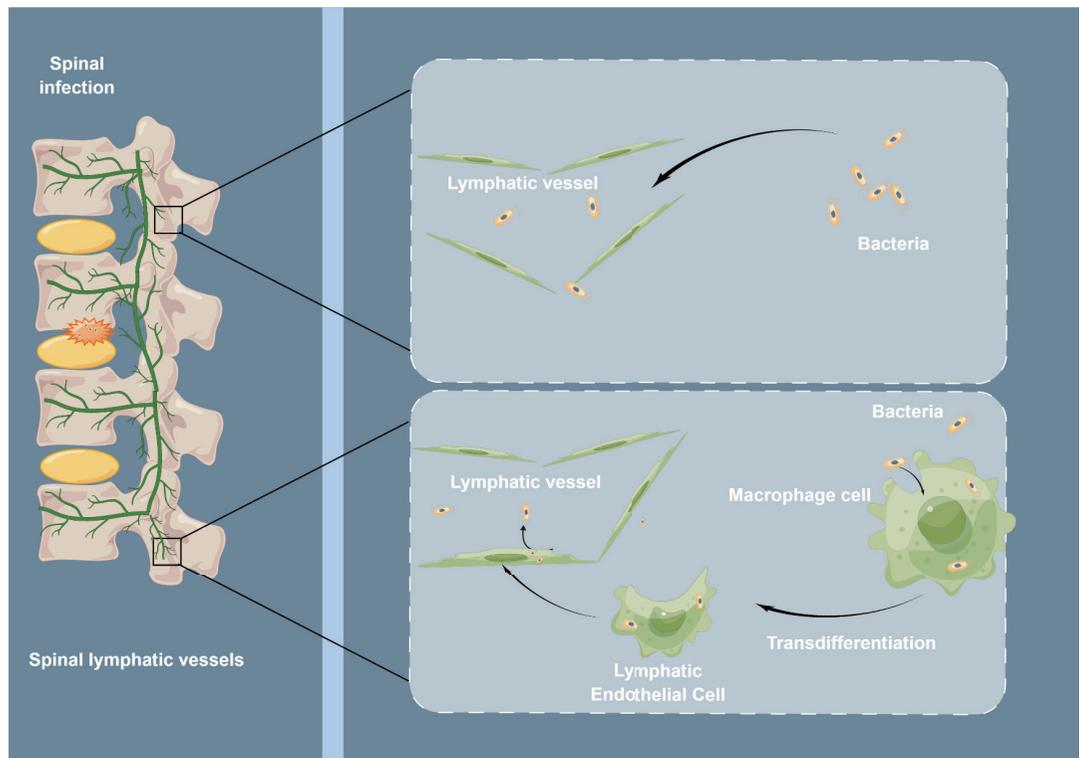
Trauma, Tumor & Infection

Lymphatic Vessels: A Neglected Channel in Spinal Infection

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Spinal infection is a common clinical problem in spinal surgery. It can spread into the spinal canal, involving the dural sac, epidural space, and the paravertebral soft tissue, resulting in the restriction of spinal movement, and even causing neurological and central function damage so that seriously affects the living quality of patients. The formation and role of lymphatic vessels in inflammation have been extensively studied in recent years, suggesting that Inflammatory lymphatic vessels may exert a vital influence on the symptoms and manifestations of inflammation, namely draining lymph fluid, improving tissue blood flow, transporting antigens and antigen-presenting cells to lymph nodes, and activating immune responses. The latest discovery of lymphatic vessels in the spine reminds us that lymphatic vessels may play an important role in the spine and the central nervous system, especially in spinal infections. In view of the special structure of lymphatic vessels and their role in other inflammatory tissues, we hypothesize that: 1. Lymphatic vessels may act as conduits for bacterial infections of the spine. 2. The transdifferentiation of macrophages engulfing bacteria into lymphatic endothelial cells may be a possible way for lymphatic vessels to assist bacterial dissemination. 3. Lymphatic vessels of the vertebral body are also a necessary constitution to maintain and repair the infected spinal tissue. If our hypothesis is proved correct, it could provide a new therapeutic target for controlling spinal infections.



EP13-04

Trauma, Tumor & Infection

Sub-multivariate Logistic Regression for In-hospital Patient Falls (Including Only Primary Surgery Patients)

Han-Bin Jin¹, Kyung-Soo Suk², Seong-Hwan Moon², Si-Young Park², Byungho Lee², Ji-Won Kwon², Yung Park^{1*}, Jae-Won Shin¹, Joong-Won Ha¹ and Hak-Sun Kim²

¹ Department of Orthopedic Surgery, National Health Insurance Service Ilsan Hospital, Korea

² Department of Orthopedic Surgery, Yonsei University College of Medicine, Korea

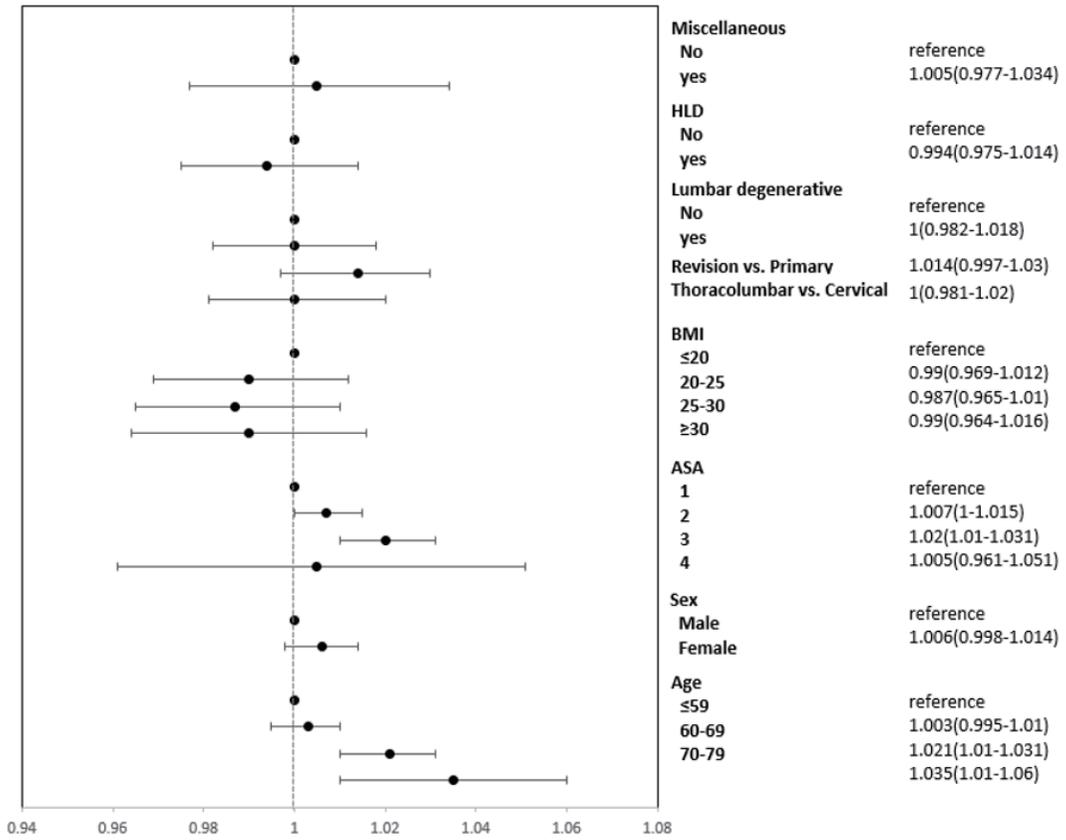
Background: Falls after orthopedic surgeries can cause serious injuries, which lengthen hospital stays and increase medical expenses. This prompted hospitals to implement various fall prevention protocols. To determine the incidence of in-hospital falls after spine surgery, analyze the overall risk factors, discern factors that have a major influence on falls, and evaluate the effectiveness of our implemented fall prevention protocol.

Methods: Retrospective single-center study. Patients from the National Health Insurance Service Ilsan Hospital (NHISIH) who underwent spine surgery from January 2011 to November 2021 were studied. Reported falls in patients who underwent spine surgery were examined. Patient demographics, surgery type and date, fall date and time, and diagnosis were evaluated.

Results: Overall, 5355 spine surgeries were performed, and 128 in-hospital falls were reported (overall incidence: 2.39%). Multivariate analysis indicated that the incidence rate of in-hospital falls increased significantly with older age ($p < 0.05$). Furthermore, the incidence rate differed significantly among different American Society of Anesthesiologists (ASA) classes. No significant difference was noted in sex and body mass index. Most falls occurred 3–7 days postoperatively, demonstrating a bimodal pattern. The late evening time period (6–10 pm) showed the lowest fall rate. Morbidities, including rib, spine, and extremity fractures, were recorded in 12 patients but none underwent reoperation. The NHISIH implemented the comprehensive nursing care service in May 2015 and fall protocol in May 2019, but the annual incidence rate did not improve. The fall rate was higher after thoracolumbar surgeries (2.57%) than after cervical surgeries (1.20%). Moreover, a high fall rate was observed in longer thoracolumbar fusion cases and revision spine surgeries.

Conclusions: Patients with advanced age, higher comorbidities, longer fusion levels, and revision surgeries are more vulnerable to in-hospital falls after spine surgery. Novel strategies that target these risk factors are warranted.

Multivariate logistic regression



EP13-05

Trauma, Tumor & Infection

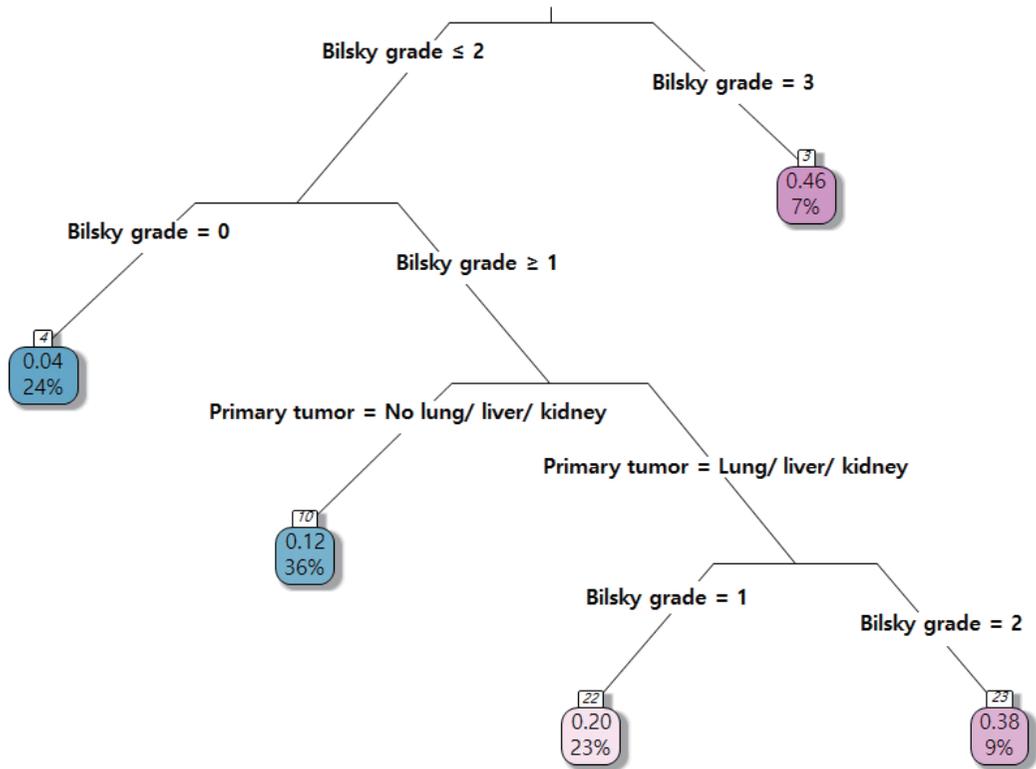
Surgical Intervention Following Radiotherapy in Spinal Metastases with Intermediate Instability: Risk Factor Analysis Using Multicenter Study Cohort**Se-Jun Park¹, Jin-Sung Park¹, Hyun-Jun Kim¹, Jong-Shin Lee¹, Han-Seok Yang¹, Choong-Won Jung¹ and Chong-Suh Lee²**¹ Orthopedic surgery, Samsung medical center, Sungkyunkwan university School of medicine, Korea² Orthopedic surgery, Haeundae BumIn Hospital, Korea

Background: SINS (spinal instability neoplastic score) is based on six items of radiological findings and clinical pain and divides the degree of spinal instability into three categories: 0-6 points, stable; 7-12, potentially unstable; and 13-18, unstable. Clear management guidelines are suggested for stable lesions (non-operative management) and unstable lesions (surgical intervention), but lesions in the potentially unstable category (SINS 7-12) remain a clinical dilemma as no defined recommendation exists regarding that category. This study aims to analyze the risk factors necessitating surgical intervention after radiotherapy (RT) in patients with those lesions.

Methods: A multicenter cohort of 469 patients with spinal metastases who received radiotherapy (RT) between 2019-2021 were retrospectively enrolled. Among them, only patients with intermediate instability (SINS 7-12) who received RT as the first treatment were included in this study. According to the performance of surgical intervention after RT, various clinical and radiographic risk factors were compared between surgery and non-surgery groups. Multivariate logistic regression analysis was performed to identify the risk factors for surgical intervention after RT. Recursive partitioning analysis (RPA) was performed using significant determinants on multivariate analysis.

Results: Mean age at the time of RT was 59.9 years and there were 198 females. During mean follow-up duration of 18.2 months, surgical treatment was required in 79 (17.9%) of patients. Most common surgical method was decompressive laminectomy with stabilization (62.0%). Mean SINS for total cohort was 9.0. Multivariate logistic regression analysis revealed that primary tumor site of lung, liver, and kidney, higher Bilsky grade for epidural spinal cord compression, lytic bone lesion, and higher radiation dose were significant risk factors for surgical intervention after RT. Among them, Bilsky grade and primary tumor type of lung, liver, and kidney were most important determinants for expecting the probability of surgical intervention on RPA.

Conclusions: Surgical intervention was performed in 17.9% of patients with intermediate instability after RT as the initial treatment. Bilsky grade and primary tumor site were most important determinant for expecting the probability of surgical intervention. An optimal treatment strategy needs to be devised by carefully evaluating the risk for surgical intervention.



EP13-06

Trauma, Tumor & Infection

Joystick Reduction and Augmentation with Non-absorbable Sutures for the Treatment of Fracture Dislocation of Sacrococcygeal Joint: A Case Report

Soon Do Wang¹, Chang Hyun Kim¹, Sung Joon Yoon¹, Yong Chan Cho¹ and Chang Hwa Hong¹

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A fracture dislocation of coccygeal vertebra is a rare condition that occurs when the coccyx slips anteriorly or posteriorly. It is commonly caused by acute trauma resulting from falls on the buttocks. Treatment options for this condition vary depending on the severity of the injury. Here, we present a case of an acute, irreducible anteriorly dislocated coccyx that was successfully treated with joystick reduction and augmentation using non-absorbable sutures.

A 66-year-old man presented to our hospital after falling on his coccyx while working on a scissor lift. An X-ray revealed an anterior fracture dislocation of second coccygeal vertebra. Conservative treatment was initially administered, but there was no improvement in the patient's symptoms. Closed reduction was then attempted but proved unsuccessful, and the patient was transferred to our emergency room.

Upon admission, the patient was experiencing severe coccyx pain and was unable to assume a supine position. Surgery was planned, and the patient underwent a closed manual reduction in the prone position under general anesthesia. However, this was also unsuccessful, and an open reduction was performed.

Using a posterior approach on a radiolucent operating table, the ventral and proximal displaced second coccyx was exposed, and a joystick reduction was performed with a freer raspator. The first and second coccygeal vertebra were then fixed together using two non-absorbable polyester sutures. Postoperative radiographs confirmed that reduction had been successful.

Bergkamp et al. have shown that tension band fixation using vicryl sutures is effective for fractures and dislocations of the first coccyx. In this case, double simple sutures were used to achieve stability. While sacrococcygeal fracture dislocations are rare, if conservative treatment fails to improve symptoms, open reduction and internal fixation can be a safe and useful surgical treatment option.

EP13-10

Trauma, Tumor & Infection

The Importance of MR-tractography in the Diagnosis of Spinal Cord Tumors**Mansur Aliev¹, Shohzodbek Abdunazarov² and Kosim Kuvandikov²**¹ *Department of Neurosurgery of Samarkand State Medical University, Head of the Department of Neurosurgery, Uzbekistan*² *Department of Neurosurgery of Samarkand State Medical University, Resident of the Department of Neurosurgery, Uzbekistan*

Relevance: According to WHO statistics, the frequency of detection of spinal cord tumors is 10-15% of tumors of the central nervous system. Spinal cord tumors (SCT) are most often observed in a socially active group of people aged 30-50 years, which determines the great urgency of this problem. With the introduction of modern neuroimaging research methods (MRI, multispinal CT) into neurosurgical practice, the detectability of SCT has increased significantly. However, even now, the problem of timely detection of SCT remains urgent everywhere, which determines the results of surgical interventions.

Thus, the search for new solutions and tactical and technical approaches in the treatment and diagnosis of SCT has not lost its significance and is a subject for discussion by neurosurgical communities.

Purpose: To analyze the results of MR-tractography and to substantiate its informative value in spinal cord tumors.

Materials and methods: To fulfill our tasks, we examined 20 operated patients of the neurosurgical department of the multidisciplinary clinic of SamSMU, diagnosed with a spinal cord tumor, and conducted an MR-tractography study.

Results: MR-tractography as one of the additional functions of magnetic resonance imaging, allows you to visualize the image of the conductive pathways (tracts of white matter), their integrity and transmission of nerve impulses with high accuracy, which is based on a diffuse tensor neuroimaging method, which allows you to identify a violation of the course and structural features of the tracts of white matter and their involvement in oncogenic processes, which is impossible with standard MRI examinations. The study demonstrated that in 10 (50%) patients with spinal cord tumor, with the complication of limb paresis, examined by MR-tractography, destruction, dysfunction of the conductive tracts of the spinal cord, as well as a decrease in the degree of myelination were revealed. In 6 (30%) patients with plegia, thinning and compression of the nerve pathways were observed. Compression and displacement of nerve tracts were revealed in 4 (20%) patients with limb hypalgesia.

Conclusions: This study makes it possible to determine the tactics of surgical treatment, predict possible complications in this pathology and the postoperative results of the patient, which determines the effectiveness of using this method of examination for neoplasms.

EP13-11**Trauma, Tumor & Infection****Psuedogout of the Spine Mimicking Infection: A Case Report**

Jessica Thor^{1*}, Terry Teo^{1*}, Dinesh Kumar¹ and Zhihong Chew¹

¹Orthopaedic Surgery, Changi General Hospital, Singapore

Introduction: Pseudogout in the spine is an uncommon presentation of the crystalline deposition disease. To date, there are increasing reports of gout and pseudogout in the spine available in literature mostly in the form of case reports. In addition, there have been various reports of pseudogout mimicking other diseases such as tumours or infection. This adds on to the difficulty and complexity in the initial diagnosis. There are currently no guidelines available for the treatment of pseudogout in the spine. Here, we present a unique case report of pseudogout in the spine mimicking an infective aetiology.

Case Presentation: A 65-year-old Chinese gentleman initially presented with lower back pain for one week duration following strenuous activity which involved heavy lifting. He also experienced radicular symptoms down his bilateral lower limbs. He had a history of hypertension, hyperlipidaemia, diabetes mellitus and benign prostatic hyperplasia. His physical examination was otherwise unremarkable and laboratory investigations were normal, save for a slightly elevated erythrocyte sedimentation rate. MRI scans of his lumbar spine revealed a L3/4 rim-enhancing lesion resulting in severe spinal stenosis and compression of the cauda equina. He underwent a L4 laminectomy and L4/5 discectomy and recovered well. Intraoperative cultures did not show any bacterial growth and histology revealed features consistent with pseudogout.

Discussion: Laboratory investigations such as serum uric acid levels does not help to identify crystal arthropathy as a normal serum uric acid level does not indicate the absence of crystal deposition diseases. MRI imaging is generally not considered to be the investigation of choice when dealing with CPPD due to the lack of sensitivity and specificity. CPPD can appear hypointense on T1 and T2 weighted images. CT imaging can be helpful in the diagnosis of CPPD, especially in the cervical spine, as it has a high sensitivity and specificity in detecting calcium deposits however at the risk of radiation. The use of a galodinium contrasted scan is not routine but can be helpful if there is a large lesion effacing spinal canal and with high clinical suspicion of a tumour, to further distinguish it from CPPD. CT guided biopsies can also be considered, either to obtain histological specimens or for aspiration of the facet joints to facilitate the diagnostic procedure.

Conclusion: CPPD of the spine must be considered as a differential diagnosis in patients with back pain, radicular or myelopathic symptoms. It can mimic spinal infections or tumours. CT imaging and CT guided biopsies should be considered in conjunction with the commonplace MRI imaging. Treatment of patients with acute development of neurological deficits should be surgical, rather than conservative.

Figure 1: Initial plain radiographs of the lumbar spine



Figure 2: Contrasted MRI lumbar spine images showing the rim enhancing lesion seen at the L3/4 level in sagittal and axial views

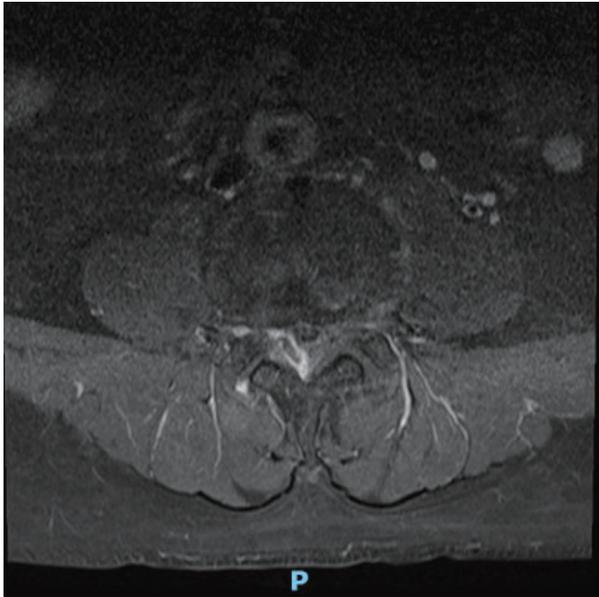
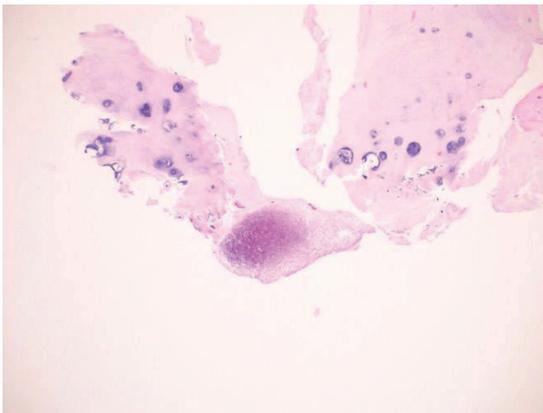
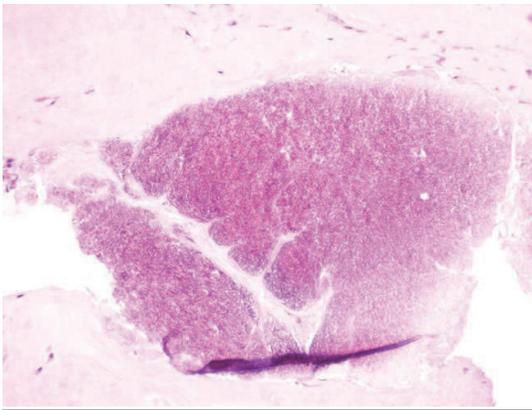
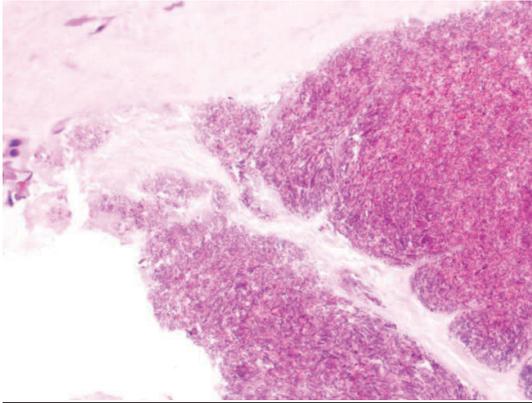


Figure 3: Haematoxylin and eosin staining with evidence of inflammation and focal deposition of calcified debris with rhabdoid crystals noted under polarised light microscopy was present in fibrocartilage and ligamentum flavum



EP13-12

Trauma, Tumor & Infection

Unipedicular-screw Index Vertebra Manipulation Technique for Minimally Invasive Short-segment Thoracolumbar Fracture Fixation

Naresh Kumar¹, Brian Zhaojie Chin¹, Kasia Chen Xi Chua¹, Karthiges Palanichami¹, Pradnya Nishant Mohite¹, Shen Liang², Arnaldo Songcayaon Favila, Jr¹ and Jonathan Jiong Hao Tan¹

¹ Department of Orthopaedic Surgery, National University Health System, Singapore

² Biostatistics Unit, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

Background: MIS spine surgery has revolutionized fixation of thoracolumbar fractures with burst elements. Recent studies have proven that percutaneous pedicle screw instrumentation is as effective as open instrumentation, with reduction in intraoperative blood loss and operative duration. Techniques such as short-segment pedicle screw fixation including the fractured vertebra has shown satisfactory radiological correction and functional outcomes, avoiding the need for extensile posterior constructs. We describe our technique utilizing unipedicular index vertebra fixation and manipulation in minimally invasive surgery (MIS) for thoracolumbar fractures with burst elements. We aim to highlight the two-year radiological & functional outcomes of 20 consecutive patients who underwent this technique.

Material and Methods: A retrospective review of prospectively collected data was conducted on 20 patients with thoracolumbar fractures with burst elements who underwent fixation using our technique. Baseline characteristics and injury profiles of included patients were collected. Radiological parameters - vertebral wedge angle, regional kyphosis angle, coronal Cobb angle, anterior and posterior vertebral body heights were recorded at preoperative, intraoperative, postoperative, and up to 2-year follow-up. Clinical outcome scores of VAS and ODI were also recorded at similar time-points.

Results: Radiological outcomes reflect significant lordotic corrections of the vertebral wedge angles up to 2-year follow-up when compared to preoperative values (intraoperative:p=0.06; postoperative:p=0.001; 3-month:p=0.002; 6-month:p=0.004; 1-year:p=0.011; 2-year:p=0.016). Additionally, significant lordotic corrections of regional kyphosis angles (intraoperative:p=0.00; postoperative:p=0.00; 3-month:p=0.031; 6-month:p=0.039) and increases in anterior vertebral body heights (postoperative:p=0.001; 3-month:p=0.010; 6-month:p=0.020) up to 6-month follow-up was found. Significant improvements in functional outcomes VAS and ODI scores compared to preoperative data were found, with mean scores of 11.5 and 9.9 respectively at 2-year follow-up.

Conclusion: Our approach in treating thoracolumbar fractures with burst elements using MIS short-segment fixation and unipedicular screw manipulation technique shows satisfactory radiological correction & high rates of fracture union, whilst reducing approach-related morbidity & improving functional outcomes.

EP13-14**Trauma, Tumor & Infection****Selection Criteria for Vertebral Augmentation****Sho Fujiwara^{1*}, Takashi Moriwaki¹ and Koichi Iwatsuki¹**¹ *Department of Neurosurgery, Osaka Gyomeikan Hospital, Japan*

Background: In recent years, vertebral augmentation such as balloon kyphoplasty (BKP), vertebral body stenting (VBS), and calcium phosphate bone cement (CPC) has been performed for vertebral fractures. However, the criteria for the choice of surgical technique and the use of posterior fixation has not been clarified. In this study, we combined the AO classification, which evaluates vertebral fracture morphology, and the load sharing classification (LSC), which evaluates vertebral body damage, and examined the criteria for surgical selection based on the presence of postoperative kyphosis progression.

Methods: 66 patients (14 males and 52 females) with thoracolumbar junction vertebral body fracture of one vertebra without neurological deficit who underwent vertebral augmentation at our hospital from April 2021 to October 2022 were retrospectively evaluated for AO classification, LSC, surgical technique, and kyphosis progression (local kyphosis angle change $\geq 5^\circ$).

Results: AO classification A1 was found in 29 cases, A2 in 1 case, A3 in 22 cases, A4 in 11 cases, and B1 in 3 cases. AO classification A1 (29 cases) and A2 (1 case) were all in the BKP alone or VBS alone group, and there was no significant difference in LSC and Kyphosis progression. 6 cases were in the CPC alone group (A3: 3 cases, A4: 3 cases) and 9 cases were in the BKP alone group (all A3 cases). Kyphosis progression was observed in 1 case (16.7%) and 7 cases (77.8%) respectively, with the CPC alone group being significantly lower ($p < 0.05$). The CPC+PPS group had 14 cases (A3: 6 cases, A4: 6 cases, B1: 2 cases), and the BKP+PPS group had 7 cases (A3: 4 cases, A4: 2 cases, B1: 1 case), with kyphosis progression in 7.1% and 57.1% of the cases, respectively ($p < 0.05$). All 4 patients in the CPC+PPS group with LSC ≥ 7 points showed no kyphosis progression, while 1 patient in the BKP+PPS group with LSC ≥ 7 points showed kyphosis progression.

Conclusion: BKP and VBS are suitable for AO classification A1 and A2, while CPC is useful for A3 and A4. CPC with posterior fixation is recommended for severe damage cases with LSC ≥ 7 points.

EP13-15

Trauma, Tumor & Infection

Joystick Reduction and Augmentation with Non-absorbable Sutures for the Treatment of Fracture Dislocation of the Sacrococcygeal Joint: A Case Report

Soon Do Wang¹, Chang Hwa Hong^{1*}, Sung Joon Yoon¹ and Yong Chan Cho¹

¹ Department of Orthopaedic Surgery, Soonchunhyang University Hospital Cheonan, Korea

A fracture dislocation of coccygeal vertebra is a rare condition that occurs when the coccyx slips anteriorly or posteriorly. It is commonly caused by acute trauma resulting from falls on the buttocks. Treatment options for this condition vary depending on the severity of the injury. Here, we present a case of an acute, irreducible anteriorly dislocated coccyx that was successfully treated with joystick reduction and augmentation using non-absorbable sutures.

A 66-year-old man presented to our hospital after falling on his coccyx while working on a scissor lift. An X-ray revealed an anterior fracture dislocation of second coccygeal vertebra. Conservative treatment was initially administered, but there was no improvement in the patient's symptoms. Closed reduction was then attempted but proved unsuccessful, and the patient was transferred to our emergency room.

Upon admission, the patient was experiencing severe coccyx pain and was unable to assume a supine position. Surgery was planned, and the patient underwent a closed manual reduction in the prone position under general anesthesia. However, this was also unsuccessful, and an open reduction was performed.

Using a posterior approach on a radiolucent operating table, the ventral and proximal displaced second coccyx was exposed, and a joystick reduction was performed with a freer raspator. The first and second coccygeal vertebra were then fixed together using two non-absorbable polyester sutures. Postoperative radiographs confirmed that reduction had been successful.

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E-POSTERS



VALUE, OUTCOMES &
HEALTHCARE ECONOMICS

EP14-01

Value, Outcomes & Healthcare Economics

Significance of Body Mass Index on Thoracic Ossification of the Ligamentum Flavum in a Chinese PopulationJialiang Lin¹ and Weishi Li[†]¹ Department of Orthopaedics, Peking University Third Hospital, China

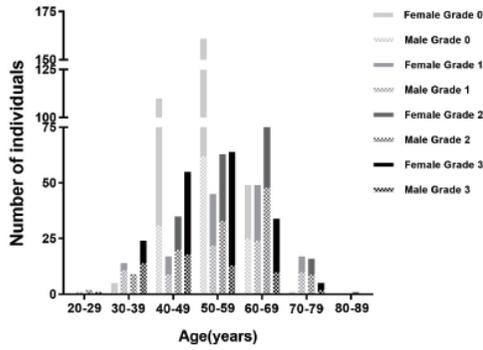
Introduction: The incidence of myelopathy caused by thoracic spinal stenosis (TSS) is much lower than that of cervical spinal stenosis or lumbar spinal stenosis. However, the outcome of thoracic myelopathy is less than desirable. Thoracic ossification of the ligamentum flavum (TOLF) has been reported as the most common causative factor for TSS. It is noteworthy that TOLF has an insidious onset and most patients have no apparent symptoms in the early stages of the disease. However, once the ossified mass compresses the spinal cord or nerve roots without timely decompression, it may lead to serious consequences. Therefore, it is particularly valuable to identify risk factors for the progression of TOLF in order to make an early diagnosis and appropriate treatment. The purpose of this study is to identify independent risk factors for TOLF, specifically the association between BMI and TOLF.

Methods: A total of 856 individuals consisting of 326 controls without ossification of spinal ligaments and 530 TOLF inpatients who underwent thoracic spine decompression surgery at our hospital between January 2013 and September 2020 were included. All subjects were classified into 4 grades: Grade 0) control; Grade 1) single-segment TOLF; Grade 2) multi-segment TOLF; Grade 3) TOLF combined thoracic ossification of the posterior longitudinal ligament (T-OPLL). Logistic regression analysis was performed to identify the risk factors for TOLF. The TOLF index was calculated to assess the severity of TOLF and its relationship with BMI was investigated by correlation analysis.

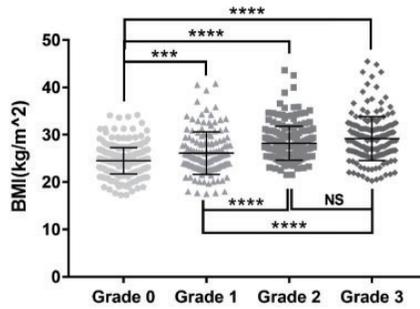
Results: Overall, TOLF patients are most numerous in the 50-59 age group. Age and gender were considered as independent risk factors for Grade 1 and 2. BMI was identified as an independent risk factor for TOLF. Furthermore, BMI was significantly higher in Grade 1 (26.1 VS 24.5 kg/m², P = 0.0001), Grade 2 (28.2 VS 24.5 kg/m², P < 0.0001), and Grade 3 (29.1 VS 24.5 kg/m², P < 0.0001) than Grade 0. Notably, in TOLF patients without combined T-OPLL, BMI was positively correlated with TOLF index; while BMI was negatively correlated with age in younger individuals.

Conclusion: BMI is a crucial risk factor for TOLF. It highlights the necessity of close follow-up of asymptomatic TOLF patients with high BMI to detect and treat their TOLF progression promptly.

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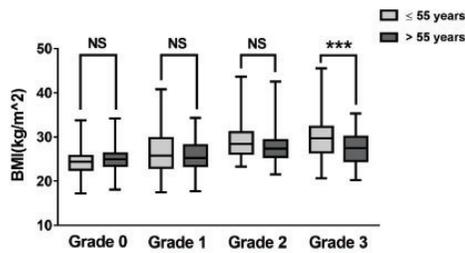


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4 Figure 1. The age distribution and gender ratio of subjects in different grades.
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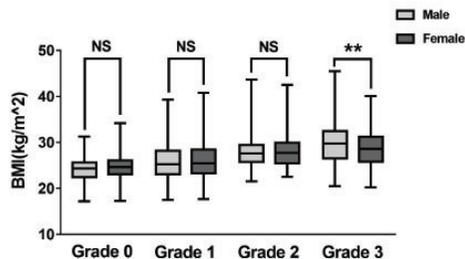


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7 Figure 2. Comparison of BMI in individuals of different grades. ****: $P < 0.001$; ****:
8 $P < 0.0001$; NS: not statistically significant. BMI, body mass index.
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10 A

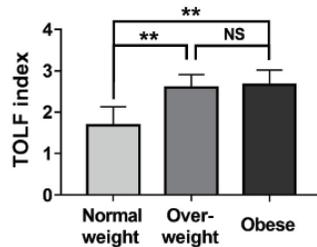


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12 B



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14 Figure 3. Comparison of BMI after stratification by age (A) and gender (B) within
15 different grades. **: $P < 0.01$; ***: $P < 0.001$; NS: not statistically significant. BMI,
16 body mass index.

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20 Figure 4. Comparison of TOLF indices between different BMI levels. **: $P < 0.01$; NS:
 21 not statistically significant. TOLF, thoracic ossification of the ligamentum flavum.

22

23 Table 1. Demographic and clinical characteristics of all subjects

Characteristic	Total (N=856)	Non-TOLF		TOLF		TOLF+T-OPLL (N=183)	P
		Grade 0 (N=326)	Grade 1 (N=143)	Grade 2 (N=204)	Grade 3 (N=183)		
Age (y)	53.9 ± 9.5	52.1 ± 6.9	56.9 ± 11.1	57.3 ± 10.1	51.1 ± 9.9		< 0.0001
Gender							< 0.0001
Male	375 (43.8%)	119 (13.9%)	77 (9.0%)	121 (14.1%)	58 (6.8%)		
Female	481 (56.2%)	207 (24.2%)	66 (7.7%)	83 (9.7%)	125 (14.6%)		
BMI (kg/m ²)	26.7 ± 4.2	24.5 ± 2.8	26.1 ± 4.5	28.2 ± 3.6	29.1 ± 4.7		< 0.0001
Hypertension							0.235
Positive	370 (43.2%)	154 (18.0%)	54 (6.3%)	84 (9.8%)	78 (9.1%)		
Negative	486 (56.8%)	172 (20.1%)	89 (10.4%)	120 (14.0%)	105 (12.3%)		
Diabetes mellitus							0.705
Positive	115 (13.4%)	46 (5.4%)	19 (2.2%)	30 (3.5%)	20 (2.3%)		
Negative	741 (86.6%)	280 (32.7%)	124 (14.5%)	174 (20.3%)	163 (19.0%)		
Smoking							0.298
Positive	124 (14.5%)	49 (5.7%)	25 (2.9%)	31 (3.6%)	19 (2.2%)		
Negative	732 (85.5%)	277 (32.4%)	118 (13.8%)	173 (20.2%)	164 (19.2%)		
Alcohol							0.214
Positive	745 (87.0%)	50 (5.8%)	21 (2.5%)	20 (2.3%)	20 (2.3%)		
Negative	111 (13.0%)	276 (32.2%)	122 (14.3%)	184 (21.5%)	163 (19.0%)		

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25 TOLF, thoracic ossification of the ligamentum flavum; T-OPLL, thoracic ossification
 26 of posterior longitudinal ligament; BMI, body mass index

27

28 Table 2. Multivariate logistic regression analysis of risk factors for TOLF compared to
 29 the subjects without spinal ligament ossification

Groups	Variable	OR	95 % CI	P
Grade 1	Age	1.076	1.05-1.10	<0.0001
	Gender (Male)	2.006	1.32-3.04	0.001
	BMI	1.212	1.13-1.29	<0.0001
Grade 2	Age	1.099	1.07-1.12	<0.0001
	Gender (Male)	2.660	1.77-3.99	<0.0001
	BMI	1.441	1.35-1.53	<0.0001
Grade 3	Age	1.022	0.99-1.04	0.073
	Gender (Male)	0.714	0.46-1.10	0.128
	BMI	1.437	1.34-1.53	<0.0001

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OR, odds ratio; CI, confidence interval; BMI, body mass index

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32 Table 3. Spearman's correlation analysis of factors associated with BMI in TOLF
 33 patients without combined T-OPLL

Parameter	BMI (kg/m ²)			
	≤ 55 years old (N=129)		> 55 years old (N=218)	
	Spearman Coefficients	P	Spearman Coefficients	P
TOLF index	0.203	0.021	0.243	<0.0001
Age	-0.296	0.001	-0.105	0.124

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TOLF, thoracic ossification of the ligamentum flavum; BMI: body mass index

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EP14-02

Value, Outcomes & Healthcare Economics

Risk Factors for the Occurrence and Severity of Vertebral Fractures in Inflammatory Bowel Disease Patients: A Nationwide Population-based Cohort StudyGeon-U Kim¹, Hyung-Youl Park¹, Ho-Young Jung¹, Yong-Won Joh¹ and Jun-Seok Lee^{1*}¹ Department of Orthopedic Surgery, Eunpyeong St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Korea

Background: The risk of vertebral fractures is increased in inflammatory bowel disease (IBD) patients. However, whether the severity of vertebral fractures differs between IBD patients and the general population, or between patients with Crohn's disease (CD) and ulcerative colitis (UC), is unknown.

Methods: We investigated risk factors associated with the occurrence and severity of vertebral fractures in IBD patients using The National Healthcare Insurance Service (NHIS) database. We defined the patients who underwent vertebroplasty or kyphoplasty after being diagnosed with a vertebral fracture as having a severe vertebral fracture than those with only diagnosis codes.

Results: From 2008 to 2018, there were 33,778 patients with IBD (24,370 UC patients and 9408 CD patients) and 101,265 patients in the reference population. The incidence rate ratio of vertebral fractures in the IBD patients was 1.27 per 1000 person-years [95% confidence interval (CI) 1.26 to 1.27]. The risk of vertebral fracture was higher in CD and UC patients than in the matched reference group [hazard ratio (HR) 1.59, 95% CI 1.31-1.92, $P < 0.001$ and HR 1.26, 95% CI 1.14-1.41, $P < 0.001$, respectively]. In a multivariate analysis, the occurrence of vertebral fracture was associated with CD (HR 1.31, 95% CI 1.08-1.59, $P = 0.006$), older age (CD: HR 1.09, 95% CI 1.08-1.09, $P < 0.001$ and UC: HR 1.09, 95% CI 1.08-1.09, $P < 0.001$), female sex (CD: HR 1.81, 95% CI 1.63-2.01, $P < 0.001$ and UC: HR 2.02, 95% CI 1.83-2.22, $P < 0.001$), high Charlson Comorbidity Index (CCI) score (CD: HR 1.42, 95% CI 1.23-1.63, $P < 0.001$ and UC: HR 1.46, 95% CI 1.29-1.65, $P < 0.001$), and long-term steroid use (CD: HR 3.71, 95% CI 2.84-3.37, $P < 0.001$ and UC: HR 3.88, 95% CI 3.07-4.91, $P < 0.001$). The severity of vertebral fractures was associated with IBD (CD: HR 1.82, 95% CI 1.17-2.83, $P = 0.008$ and UC: HR 1.49, 95% CI 1.17-1.89, $P < 0.001$) and older age (HR 1.06, 95% CI 1.05-1.07, $P < 0.001$).

Conclusion: Vertebral fractures occur frequently and more severely in IBD patients, particularly those with CD. Therefore, we suggest monitoring bone density, regular vitamin D supply, and reducing the use of corticosteroids to prevent vertebral fractures in IBD patients who are older, female, or have comorbidities.

EP14-03

Value, Outcomes & Healthcare Economics

The Effect of Psychological Factors on Post-surgical Outcomes in Spinal Surgery Patients**Hak Sun Kim², Sung-Hwan Moon², Si-Young Park², Byung-Ho Lee³, Ji-Won Kwon³, Kyung-Soo Seok³, Yung Park^{1*}, Jae won Shin¹, Joong-Won Ha¹ and Koo yeon Lee¹**¹ Department of Orthopedic Surgery, National Health Insurance Service Ilsan Hospital, Korea² Department of Orthopedic Surgery, Severance hospital College of Medicine, Yonsei university, Korea³ Department of Orthopedic Surgery, Gang Nam Severance hospital College of Medicine, Yonsei university, Korea

Background: Spinal surgery may not always relieve pain, and psychological factors like anxiety and depression may affect outcomes. However, little research has examined the influence of pre-surgical anxiety and depression on post-surgical pain.

Methods: 100 patients scheduled for spinal surgery were assessed for anxiety and depression pre-surgery, and post-surgical pain, disability, and quality of life were measured at 6 weeks, 3 months, and 6 months after surgery. Tramadol and pethidine use were also recorded.

Results: Patients with pre-existing anxiety or depression had worse outcomes after surgery, with higher disability and lower quality of life scores compared to controls. However, there was no significant difference in post-surgical pain or opioid use between groups.

Conclusion: Evaluating and managing anxiety and depression pre-surgery could improve postoperative quality of life and functional recovery for patients undergoing spinal surgery

EP14-04

Value, Outcomes & Healthcare Economics

Intraoperative Real-time Stress in Degenerative Lumbar Spine Surgery: Simultaneous Analysis of Electroencephalography Signals and Heart Rate Variability: A Pilot Study**Ji-Won Kwon¹, Sahyun Sung¹, Soo-Bin Lee³, Hwan-Mo Lee⁴, Kyung-Soo Suk¹, seong-Hwan Moon¹, Si-Young Park¹, Hak-Sun Kim¹ and Byung Ho Lee¹**¹ Department of Orthopedic Surgery, Yonsei University College of Medicine, Seoul, Korea³ Department of Orthopedic Surgery, Ewha Womans University College of Medicine, Seoul, Korea⁴ Department of Orthopedic Surgery, Catholic-Kwandong University, Incheon, Korea

Background: Interest in intraoperative stress has increased due to its potentially detrimental impact on surgical performance and burnout among spine surgeons. The purpose of this study was to analyze intraoperative stress in real time in terms of electroencephalography (EEG) signals and heart rate variability (HRV) using a wearable device during spine surgery.

Methods: From June 2018 to November 2018, 179 consecutive records of intraoperative stress measures, including intraoperative EEG signals and HRV, comprising beats per minute (BPM) and low frequency (LF)/high frequency (HF) ratio, for the orthopedic spine surgeons were prospectively gathered, compared, and analyzed. Five orthopedic spine surgeons with experience ranging from 1 to 30 years were included. The outcome measures included stress levels among the spine surgeons and differences in stress parameters between novice and expert surgeons and between assistants and operators.

Results: Among all measures, sensory-motor rhythm (SMR) waves, gamma waves, and BPM differed significantly during surgery (analysis of variance; $p=0.040, 0.013, 0.002$, respectively). Surgery duration and intraoperative bleeding were positively correlated with stress parameters, including gamma waves and tension. For operators, surgeon experience was negatively correlated with concentration, tension, and SMR, gamma, M-beta, and H-beta waves (Pearson correlation, $p<0.05$). However, for assistants, surgeon experience was positively correlated with concentration, tension, BPM, and SMR, M-beta, H-beta, and gamma waves. Bleeding amounts were correlated positively with gamma waves and tension for both operators and assistants (Pearson correlation, $p<0.05$). Stress among operators was higher than that among assistants in terms of LF/HF ratio.

Conclusions: Operators and surgeons with low experience exhibited higher stress levels during surgery, which should be addressed when scheduling elective surgery to ensure optimal conditions among spine surgeons.

EP14-05

Value, Outcomes & Healthcare Economics

Environmental and Lifestyle Factors in Idiopathic Scoliosis - An Integrated Study Using Korea Children and Youth Panel Survey

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Background: The etiology of idiopathic scoliosis has not yet been clarified. Although the genetic factor is known as the main cause, relationship with hormone factors, environmental factors and lifestyle factors has been suggested. The National Youth Policy Institute in Korea has been building an archive through a panel survey targeting children and adolescents since 2010. The results of this survey include data on life patterns and growth development by age of children and adolescents. The purpose of this study is to identify the environmental factors that affect the development of idiopathic scoliosis by integrating scoliosis research using our previous study on the incidence of idiopathic scoliosis and data archives for children and adolescents.

Methods: In the Korean Child and Youth Panel Survey 2010 (KCYPs 2010), a total of 4,693 students in the first grade of elementary school (7 years-old) and first grade of middle school (13 years-old) were followed up for 7 years from 2010 to 2016. Survey students were divided into urban and rural groups according to their residence. Differences between the two groups in time for bed, total sleep time, indoor activity time and outdoor activity time were compared by age. Pearson correlation analysis and Spearman correlation analysis were performed To confirm the similarity between scoliosis incidence data and archive data.

Results: Time for bed was 10 minutes later in the urban group than in the rural group (22:33 vs. 22:23, $p<0.0001$), and there was no significant difference in total sleep time (urban vs. rural, 8hours 50minutes vs. 8hours 51minutes, $p=0.4379$). After-school learning time was 19 minutes longer in the urban group than the Rural group (244 minutes vs. 225 minutes, $p<0.0001$), and this difference increased with age. Indoor activities such as reading, video games, and watching television were 11 minutes shorter in the urban group than in the rural group (153 minutes vs. 164 minutes, $p<0.0001$), and there was no significant difference in outdoor activity time ($p=0.7566$). The scoliosis incidence graph was related to the bedtime and sleep time graphs (Spearman correlation analysis, $p<0.05$), and in particular, the period when the change in sleep pattern was large and the period when the incidence of scoliosis peaked were similar.

Conclusions: Children and adolescents living in urban areas had a later bedtime and a short total sleep time children and adolescents living in rural areas. There were no regional differences in physical development. The possibility that these environmental and lifestyle factors influenced the difference in the incidence of idiopathic scoliosis can be considered.

EP14-06

Value, Outcomes & Healthcare Economics

Assessment of the Reliability and Validity of the Korean Oswestry Disability Index for Lumbar Spine Surgery Patients**Sung Joon Yoon¹, Yong Chan Cho¹, Soon Do Wang¹ and Chang Hwa Hong¹**¹ Orthopaedic Surgery, Soonchunhyang University Cheonan Hospital, Korea

Background: The Oswestry Disability Index (ODI) is a survey consisting of 10 categories used to evaluate the extent to which back pain affects a patient's daily life. While there have been studies that have utilized the ODI to assess patients who have undergone degenerative lumbar spine surgery in other countries, no validation trials of the ODI in relation to such surgeries have been conducted in Korea.

Methods: A retrospective chart review of 50 patients who underwent lumbar spinal surgery at a university hospital was conducted. The Korean version of the Oswestry Disability Index (KODI) surveys were administered to patients before and after outpatient care by an orthopedic spine specialist. The internal consistency, test-retest reliability, and the influence of extrinsic factors on KODI scores were analyzed.

Results: The KODI demonstrated satisfactory internal consistency, with a Cronbach's alpha coefficient of 0.94 and high test-retest reliability, with an intraclass correlation coefficient of 0.96. After outpatient care, 16 (32%) patients reported decreased KODI scores, while 15 (30%) patients reported unchanged scores, and 18 (36%) patients reported increased scores. No significant differences were found in the KODI scores with respect to sex, age, level of surgery, or whether fusion was performed ($p > 0.05$).

Conclusions: The KODI is a reliable and valid measurement tool for assessing low back pain-related disabilities, particularly in patients who have undergone lumbar spine surgery. Therefore, we recommend the widespread use of the KODI in clinical practice for patients undergoing spine surgery in Korea

EP14-07

Value, Outcomes & Healthcare Economics

Factor Analysis Affecting Degree of Depression in Family Caregivers of Patients with Spinal Cord Injury: A Cross-sectional Pilot StudyKyoung-Tae Kim*Neurosurgery, School of Medicine, Kyungpook National University, Korea*

This study was conducted to determine the degree of depression in family caregivers of spinal-cord-injury patients and to identify factors influencing family caregivers' depression. The final study subjects were 30 (family caregivers: 6 males and 24 females). The CES-D of family caregivers; general characteristics of spinal-cord-injury patients and family caregivers; and information on physical health, household income, leisure, social activity, family relationship, and life-in-general status of family caregiver were collected. A frequency analysis, normality test, Mann-Whitney test, Kruskal-Wallis test, Spearman Correlation analysis, hierarchical regression analysis, and spider network through a path model analysis were performed. As for the general characteristics, when the patient was economically active, the caregiver's depression was mean 4 SD; 2.04 4 0.71; otherwise, it was mean 4 SD 2.86 4 0.74, indicating that the caregiver of the non-economic activity patient was more depressed ($p = 0.013$). In Model 1 of the multiple regression analysis to understand the effect on the depression of the caregiver, it was confirmed that the depression of the caregiver decreased as the family caregiver had more leisure and social activities ($B = -0.718$, $p = 0.001$). In Model 2, it was found that the depression of caregivers increased when the patient did not engage in economic activity ($B = 0.438$, $p = 0.016$). In the spider-web form through the path model analysis, as the family's economic level increased, physical health increased by $B = 0.755$ ($p < 0.001$), and the increase in physical health ($B = 0.424$, $p = 0.042$) was, in turn, a factor in the increase of engagement in leisure and social activities. Various policies will be needed for the successful return to society of spinal-cord-injury patients by ensuring that their leisure and social activities and establishing measures to support their economical income.

EP14-08

Value, Outcomes & Healthcare Economics

Nationwide Sample Data Analysis of Additional Surgery Rate after Anterior or Posterior Cervical Spinal Surgery**Woon Tak Yuh¹, Yunhee Choi⁵, Junhoe Kim^{1,2}, Chang-Hyun Lee^{1,2}, Chun Kee Chung² and Chi Heon Kim^{1*}**¹ Neurosurgery, Hallym University Dongtan Sacred Heart Hospital, Korea² Neurosurgery, Seoul National University Hospital, Korea⁵ Division of Medical Statistics, Medical Research Collaborating Center, Seoul National University Hospital, Korea

Background: Surgical outcomes of degenerative cervical spinal disease are dependent on the selection of surgical techniques. Although a standardized decision cannot be made in an actual clinical setting, continued education is provided to standardize the medical practice among surgeons. Therefore, it is necessary to supervise and regularly update overall surgical outcomes. This study aimed to compare the rate of additional surgery between anterior and posterior surgeries for degenerative cervical spinal disease using the National Health Insurance Service-National Sample Cohort (NHIS-NSC) nationwide patient database.

Methods: The NHIS-NSC is a population-based cohort with about a million participants. This retrospective cohort study included 741 adult patients (> 18 years) who underwent their first cervical spinal surgery for degenerative cervical spinal disease. The median follow-up period was 7.3 years. An event was defined as the registration of any type of cervical spinal surgery during the follow-up period. Event-free survival analysis was used for outcome analysis, and the following factors were used as covariates for adjustment: location of disease, sex, age, type of insurance, disability, type of hospital, Charles comorbidity Index, and osteoporosis.

Results: Anterior cervical surgery was selected for 75.0% of the patients, and posterior cervical surgery for the remaining 25.0%. Cervical radiculopathy due to foraminal stenosis, hard disc, or soft disc was the primary diagnosis in 78.0% of the patients, and central spinal stenosis was the primary diagnosis in 22.0% of them. Additional surgery was performed for 5.0% of the patients after anterior cervical surgery and 6.5% of the patients after posterior cervical surgery (adjusted subhazard ratio, 0.83; 95% confidence interval, 0.40-1.74).

Conclusions: The rates of additional surgery were not different between anterior and posterior cervical surgeries. The results would be helpful in evaluating current practice as a whole and adjusting the health insurance policy.

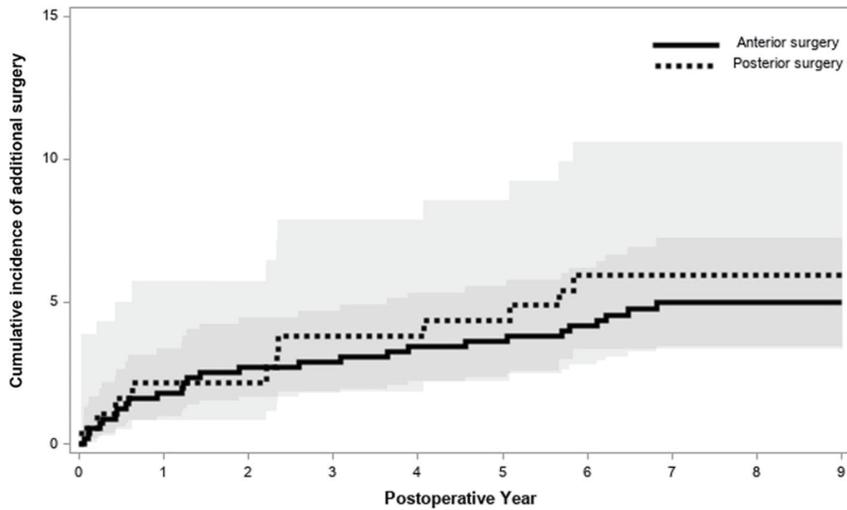


Figure 2. Cumulative incidence of additional surgery. The solid lines represent anterior cervical surgery and the dotted line represents posterior cervical surgery. Shaded region indicates a 95% confidence interval (CI). During the follow-up period for a median of 7.3 years, additional surgery was performed for 5.0% of patients after anterior cervical surgery and 6.5% of patients after posterior cervical surgery. The adjusted additional surgery rate after anterior cervical surgery was not significantly lower than that for posterior cervical surgery (adjusted subhazard ratio, 0.83; 95% CI 0.40–1.74).

EP14-09

Value, Outcomes & Healthcare Economics

Mortality Risk after the First Occurrence of Osteoporotic Vertebral Compression Fractures in the General Population: A Nationwide Cohort StudyJin-Sung Park^{1*}, Se-Jun Park¹, Choong-Won Jung¹, Hyun-Jun Kim¹, Han-Seok Yang¹ and Jong-hin Lee¹¹ Department of Orthopedics, Samsung Medical Center, Sungkyunkwan University School of Medicine, Korea

Background: Osteoporotic vertebral compression fractures (OVCF) can cause severe pain, changes in balance, gait velocity, muscle fatigue, risk of falls, and subsequent fractures. Thus, OVCF significantly lowers the individual's health-related quality of life. Additionally, OVCF may increase patient mortality rates. However, studies on post-OVCF mortality are limited. This study aimed to evaluate mortality risk after OVCF in the general population using a nationwide dataset from the Korean National Health Insurance System.

Methods: We identified 291,203 newly diagnosed patients with OVCF and 873,609 patients without OVCF at a ratio of 1:3 matched by sex, age, and index date between 2010 and 2012. We investigated the latent characteristics of patients' demographic information and chronic comorbidities that could affect mortality when diagnosed with OVCF. By comparing the cohort data, the hazard ratio for subsequent mortality in patients with OVCF was calculated and adjusted based on several risk factors.

Results: Despite adjusting for demographic characteristics and chronic comorbidities, the risk of mortality was 1.22 times higher in the OVCF cohort than in the control group. Multivariate analysis showed that male sex, old age, low-income status, and high Charlson Comorbidity Index were associated with a higher risk of mortality. In addition, the presence of chronic comorbidities, including diabetes mellitus, ischemic heart disease, stroke, chronic obstructive pulmonary disease, cancer, and end-stage renal disease, was shown to increase the risk of mortality.

Conclusions: This population-based cohort study showed that newly diagnosed OVCF significantly increased the subsequent risk of mortality. Moreover, post-OVCF mortality is influenced by demographic characteristics and chronic comorbidities.

EP14-10

Value, Outcomes & Healthcare Economics

Does Patient Blood Management Affect Outcomes in Metastatic Spine Tumour Surgery? A Review of Current Concepts**Naresh Kumar^{1*}, Si Jian Hui¹, Karthiges Palanichami¹, Eunice Xin Yi Lee¹, Ashokka Balakrishnan¹ and Jonathan Jiong Hao Tan¹**¹*Department of Orthopaedic Surgery, National University Health System, Singapore*

Background: The spine is the most common site of metastases, associated with decreased quality of life. Increase in metastatic spine tumour surgery (MSTS) has caused us to focus on the management of blood, as blood loss is a significant morbidity in these patients. However, blood transfusion in MSTS patients with extensive blood loss is also not without its own risks, and hence this led to blood conservation strategies and implementation of a concept of patient blood management (PBM) in clinical practise focusing on these patients.

Methods: A narrative review was conducted and all studies that were related to blood management in metastatic spine disease as well as PBM surrounding this condition were included.

Discussion: A total of 64 studies were included in this review. We discussed a new concept of patient blood management in patients undergoing MSTS, with stratification to pre-operative and intra-operative factors, as well as anaesthesia and surgical considerations. Our team has described the spinal metastasis invasiveness index (SMII), comprised of surgical factors, tumour vascularity and embolisation status, which significantly predicts operative time and intraoperative blood loss. This novel predictive system is of use to both surgeon and anaesthetist to predict expective blood loss and need for PBM measures pre-operatively. Subsequently, we also established three important pillars of PBM measures in MSTS, namely the detection and management of anaemia, minimising blood loss, as well as optimisation of physiological tolerance to anaemia. The studies in current literature also show that PBM and reduction in blood transfusion allows for reduced readmission rates, lower risks associated with blood transfusion, and lower morbidity for patients undergoing MSTS.

Conclusion: Through this paper, we highlight various pre-operative and intra-operative methods in the surgical and anaesthesia domains that can help with PBM. It is an important concept with the significant amount of blood loss expected from MSTS, and it is important for both anaesthetists and surgeons to work hand in hand to tackle blood loss in MSTS patients with adequate pre-operative, intra-operative and post-operative measures.



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