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Aims & Scope

Asian Spine Journal (Asian Spine J), the official journal of the Asia Pacific Spine Society (APSS), Middle East Spine Society (MESS), Association of Spine Surgeons of India (ASSI), Taiwan Spine Society (TWSS), Chinese Spine Society of Medicine Education (CSSME), and Korean Society of Spine Surgery (KSSS), is an international peer-reviewed journal which publishes articles related to basic and clinical researches of all spine fields bimonthly in end of February, April, June, August, October, and December. *Asian Spine Journal* was founded in 2007.

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ABSTRACTS
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Asia Pacific Spine Society (APSS) 2018 Annual Meeting in Taiwan

High Throughput Sequencing of Differential Regulation of miRNA Sreveals Dynamic miRNAs Expression in Glucocorticoid-Induced Osteoporosis Program Patients

Ren Hui[1], Yu Xiang[2], Shen Geng-yang[2], Zhang Zhi-da[2], Huang Jin-jing[2], Zhao Wen-hua[2], Tang Jing-jing[2], Shang Qi[2], Liang De[1], Jiang Xiao-bing[1],

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Background: To find out differential miRNA expression in Glucocorticoid-induced osteoporosis program (GIOP) vertebrae and identify its machanism.
Methods: All of the 26 patients undergoing spinal surgery from Spine Orthopedic of the First Affiliated Hospital of Guangzhou University of Chinese Medicine between 2016 and 2017 were included. Three GIOP patients and three control patients were included in the first discovery stage, while 26 patients (13 in GIOP group, 13 in control group) were included in second verified stage. The total RNAs were extracted from the vertebrae for miRNA screened by high-throughput sequencing. Bioinformatics for clustering analysis of differential miRNAs and predictingits target genes were for gene ontology analysis, pathway analysis and prediction of new miRNAs. Reverse transcription-quantitative polymerase chain reaction (RT-qPCR) validated differential miRNAs by high-throughput sequencing screening, while pathway-related target genes were predicted by bioinformatics.
Results: Eighteen miRNAs of differential expression were screened out by high-throughput sequencing, of which two miRNAs were up-regulated and 16 miRNAs were down-regulated. By predicting target genes of differentially expressed miRNA in miRanda, miRBase, and TargetScan databases, 488 common target genes of up-regulated miRNAs and 475 common target genes of down-regulated miRNAs were found. In addition, three new miRNAs were found on chromosome 1, 11, and 12, respectively. RT-qPCR validated differential miRNAs by high-throughput sequencing screening. According to the sequencing results and the original data standardized tag reads, 25 miRNAs were validated. hsa-miR-186-5p, hsa-miR-21-5p, and hsa-miR-214-5p, hsa-miR-10b-5p, and hsa-miR-451a were significantly up-regulated, and hsa-let-7f-5p, hsa-let-7a-5p, hsa-miR-27a-3p were down-regulated significantly ($p<0.05$), of which the let-7f expression had the most significant difference.
Conclusions: miR-186-5p, miR-21-5p, miR-214-5p, miR-10b-5p, and miR-451a were up-regulated while let-7f-5p, let-7a-5p, and miR-27a-3p were down-reglulated in GIOP patients, which might play important regulatory roles in the pathogenesis of GIOP.
Keywords: Glucocorticoid-induced osteoporosis; miRNA; High throughput sequencing

New Insight into Cervical Myelopathic Hand Sign: A Pilot Study

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Background: The myelopathy hand was first described by Ono et al. on the analysis of finger motion impairment caused by cervical myelopathy. The clumsiness associated with intrinsic finger weakness decreases the number of grip-and-release cycles a patient can perform within 10 seconds. However, this quantitative analysis only provides

a crude representation. The purpose of this study is to perform electromyographic (EMG) analysis of this myelopathic hand sign in pre- and postoperative patients.

Methods: Patients diagnosed with cervical myelopathy and planned for surgical decompression were recruited into the study. Clinical examination including the presence of myelopathy hand and modified Japanese Orthopaedic Association (mJOA) scores, and EMGs during the grip-and-release tests were performed pre- and postoperatively.

Results: Ten patients were recruited into the the pilot study. Five patients had improvement of mJOA score by 2 points or more postoperatively, whereas the remaining Five had similar scores. For patients who had improved mJOA scores, there was a statistical significance in improvement in low frequency EMG amplitudes compared with preoperative during the 10 second grip-and-release tests, whereas there was no difference in high frequency amplitudes. For those who had no change in mJOA scores, EMG amplitudes did not change pre- and postoperatively in high or low frequencies.

Conclusions: Improvement in low frequency EMG amplitudes may represent a sensitive method in detecting improvement in hand function post surgical decompression of cervical myelopathy. Further studies are required to determine if this will allow objective documentation and prognostication of surgical outcomes.

Keywords: Cervical myelopathy; Hand signs; Electromyography

Increased Osteoblastic Activity Suppressed Proliferation of Multiple Myeloma Plasma Cells

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Background: Multiple myeloma (MM) is one of representative hematologic disorders causing the skeletal related events. Increased osteoclastogenesis and decreased osteoblastgenesis have been known as a key pathomechanism. However, few studies regarding the impact of osteoblasts on the proliferation of MM plasma cells have been reported. Moreover, for decreased proliferation of MM is noted at fractured site regardless the systemic disease activity in the clinical situations. Therefore, this study was planned to investigate the impact of microenvironment condition with increased osteoblastic activity on the proliferation of MM plasma cells.

Methods: We investigated the effect of increased osteoblastic activity on survival and proliferation of MM plasma cells with the co-culture under various conditions. MM plasma cells (cell line: IM-9 from Korean cell line bank) were co-cultured with human mesenchymal stem cells (hMSCs, SS16-P2 from Catholic institute of cell therapy), osteoblasts induced from hMSCs and bone morphogenic protein-2 (BMP-2). Proliferation of MM plasma cells was assessed by expression of stat-3, caspase, and Ig immunoglobulin G (IgG).

Results: Whereas hMSCs showed anti-apoptotic effects (increased stat-3 and decreased caspase-3 expression), induced osteoblasts inhibited proliferation of MM plasma cells (decreased cholecystokinin octapeptide and igG production), and resulted in increased apoptosis of the MM cells (decreased stat-3 and increased caspase-3) during 3 days co-culture. Application of BMP-2 during culture, similar to osteoblast, resulted in reduced proliferation of MM plasma cells and increased apoptosis.

Conclusions: Trials of enhancing osteoblastic activities present suppression effects on the proliferation of MM plasma cells. These findings could support the clinical findings that changes in bone microenvironment may induce the suppression of local proliferation of MM plasma cells. Further studies investigating the mechanism of this phenomenon and other trials enhancing osteoblastic activity are required.

Keywords: Myeloma; Osteoblasts; Mesenchymal stem cells; Bone morphogenic protein

Autophagy in the Extruded Disc Compared to the Remaining Disc of Lumbar Disc Herniation in the Same Patient

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Background: To investigate the autophagy in extruded disc and the remained disc from the lumbar disc herniation in the same patient.
Methods: Twelve patients (four female, eight male) with extruded type of lumbar disc herniation (LDH) were surgically treated. The mean age is 54.3±15.8 years (range, 29–78 years). The mean period from occurrence of symptom to the operation is 9.8±9.4 weeks. (Range 2–24 weeks) The extruded discs were excised and then the remained disc material was removed to prevent recurrence of herniation. Immediately after specimen collection, all tissues were stored in liquid nitrogen, at -70°C until the experiments were performed. Autophagy was assessed by immunohistochemical analyses and Western blot analyses. Autophagy gene (Atg) 5, Atg 7, Atg 12, Atg 12 L1, and Beclin-1 were analyzed.
Results: The expressions of autophagic markers are significantly increased in the extruded discs than in the remained discs in the same patients. The mean of expression of Atg 5, Atg 7, Atg 12, and Beclin-1 in extruded disc were statistically significantly higher than the mean of those in remained disc (p<0.01, p<0.001, p<0.01, and p<0.001, respectively).
Conclusions: Autophagic pathway is more activated in the extruded disc material than the remained disc material in the same patient. That may be a clue of spontaneous resorption in the extruded disc in lumbar disc herniation.
Keywords: Autophagy; Lumbar; Disc

Comparison of Transforming Growth Factor-β1 and Lovastatin on Differentiating Mesenchymal Stem Cells toward Nucleus Pulposus-like Phenotype

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Background: Uncommitted mesenchymal stem cells (MSCs) have garnered special attention in tissue-engineering therapy for degeneration of intervertebral disc (IVD). Statins have been shown to stimulate bone morphogenic protein-2 (BMP-2) expression and promote the expression of chondrogenic phenotype in rat chondrocytes and IVD cells. This study aimed to investigate the effects of transforming growth factor (TGF)-β1 and lovastatin on differentiation of MSCs toward nucleus pulposus-like phenotype.
Methods: Commercially available human MSCs (Poietics; Lonza, Basel, Switzerland) were used in this study. Quantitative reverse transcription-polymerase chain reaction: one of four treatments was given to MSCs. Group T: 10 ng/mL TGF-β1; Group L: 5 μM lovastatin; Group T+L: simultaneous treatment with TGF-β1 and lovastatin; Group T/L: sequential treatment with TGF-β1 then lovastatin. The expression of aggrecan (AGC), collagen type (COL)1, COL2, SOX9, metalloproteinase-13, and BMP-2 were examined. Hematoxylin and eosin staining for examination of microscopic morphology and immunohistochemical staining for AGC, COL2, or S-100 protein were used.
Results: Simultaneous or sequential treatments of TGF-β1 and lovastatin could further enhance BMP-2 overexpressions. However, expression levels of AGC and COL2 were not compatible with the levels of BMP-2 expressions. The immunohistochemical studies showed AGC, COL2, and S-100 protein productions were compatible in all three groups treated with lovastatin. The cells in groups treated with lovastatin were less populated than in the group treated with only TGF-β1. Higher cell density before lovastatin treatment or shorter time of lovastatin stimulation may be necessary.
Conclusions: Simultaneous or sequential treatments of TGF-β1 and lovastatin could further enhance BMP-2 overexpressions. Expression levels of AGC and COL2 were not compatible with that of BMP-2 expressions. The

immunohistochemical studies showed AGC, COL2, and S-100 protein productions were compatible in all three groups treated with lovastatin. The cells in groups treated with lovastatin were less populated than in those treated with only TGF-β1. Higher cell density before lovastatin treatment or shorter time of lovastatin stimulation may be necessary.

Keywords: Lovastatin; Mesenchymal stem cell; Nucleus pulposus

The Effect of Paravertebral Muscle on the Maintenance of Upright Posture in Patients with Adult Spinal Deformity

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Background: Although the importance of back muscles for the development of spinal kyphosis was well described, the influence on maintaining the sagittal balance was unclear. Therefore we investigated the relationship between cross-sectional area (CSA) of paravertebral muscle and trunk tilt at standing and walking in adult spinal deformity (ASD) surgery.

Methods: Forty-five female patients (mean age, 68.8 years) with ASD were studied. We measured sagittal vertical axis (SVA), pelvic tilt (PT), and pelvic incidence-lumbar lordosis (PI-LL) by lateral spine X-ray. For the assessment of trunk tilt standing-trunk tilt angle (STA) by lateral standing X-ray, gait-trunk tilt angle (GTA) by lateral gait images, and the increasing trunk tilt angle (ITA) by subtracting the STA from the GTA were calculated. Using L1/2 and L4/5 axial magnetic resonance imaging (MRI), the CSA of bilateral multifidus muscles (MF) and elector spinae (ES) removed fat by Image J software were calculated. We examined the correlation between trunk tilt angle (STA, GTA and ITA) and spinopelvic parameters (SVA, PT, and PI minus LL) and also the correlation among muscle CSA, trunk tilt angle (STA, GTA, and ITA) and Oswestry Disability Index (ODI).

Results: The mean STA, GTA, and ITA were 4.2°, 13.0°, and 8.8°, respectively. The CSA of back muscles were 278 mm^2 at L1/2 MF, 1,687 mm^2 at L1/2 ES, 636 mm^2 at L4/5 MF, and 1,355 mm^2 at L4/5 ES, respectively. Trunk tilt angle had significant relations with spinopelvic parameters. Concerning about muscle CSA, significant correlations were observed between STA and L4/5 MF (r=-0.517), GTA and L1/2 ES (r=-0.461), L4/5 MF (r=-0.476), and ITA and L1/2 ES (r=-0.429). ODI showed significant correlation with STA and GTA.

Conclusions: Paravertebral muscles were crucial to keep upright posture during walking as well as standing.

Keywords: Adult spinal deformity; Paravertebral muscle; Sagittal alignment; Cross sectional area; Gait posture

Is There a Difference Between Patients' and Parents' Perception of the Physical Appearance in Adolescent Idiopathic Scoliosis?

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Background: The physical appearances in adolescent idiopathic scoliosis (AIS) can affect a patient's self-image. However, few studies have looked into the differences between patients and parents' perception of their appearance.

Methods: This study was carried out between June and December 2016. AIS patients and their parents were recruited. Their perception of six common physical attributes were evaluated: waist asymmetry (WA), rib hump (RH), shoulder imbalance (ShI), neck tilt (NT), breast asymmetry (BrA), and anterior rib cage prominence (ARP). These physical attributes were ranked and an aggregate physical attribute (Agg-PA) score for the six types was derived from a score assigned to the attribute (6 for the most important and 1 for the least important). Patients also completed the revised Scoliosis Research Society-22 (SRS-22r) Patient Questionnaire.

Results: One hundred and seventy patient-parents were recruited. Fifty eight point two percent (99) of cases had thoracic major curves whereas 41.8% (71) had lumbar major curves. WA ranked first among 54% (31.8) patients and 50 (29.4%) parents and RH ranked first among 50 (29.4%) patients and 38 (22.4%) parents. BrA was ranked first in only seven (4.1%) patients and four (2.4%) par-

ents. The overall Agg-PA scores when comparing patient-parents' perception was similar (p>0.05). However, for thoracic curves >40°, a significant difference was noted between the Agg-PA scores of patients and parents for ShI (3.5±1.6 vs. 4.2±1.6, p=0.041) and BrA (3.0±1.6 vs. 2.2±1.3, p=0.006). For thoracic <40°, a significant difference was found between the Agg-PA scores of patients and parents for WA (3.7±1.6 vs. 4.4±1.5, p=0.050). BrA showed negative correlation to total SRS-22r Questionnaire score.

Conclusions: There was no significant difference in patient-parents' ranking on the most important physical attributes. However, for thoracic curves >40°, there was a significant difference in the Agg-PA for ShI and BrA. Patient-parents' perception of the six physical attributes did not correlate significantly with SRS-22r Questionnaire score.

Keywords: Physical appearance; Patients; Perception

Comparative Analysis of Perioperative Blood Loss in Posterior Thoracolumbar Spine Surgery in Patients Taking Aspirin and Clopidogrel–A Prospective Matched Cohort Study

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Background: Evidence based recommendations are available regarding continuation of aspirin and clopidogrel in patients listed for surgery who have had percutaneous transluminal coronary angioplasty (PTCA) for ischemic heart disease. However, for non-stented patients, conflicting reports are available in literature regarding the outcome of thoracolumbar surgery on continuation of aspirin and clopidogrel in perioperative period. The objective of this study is to assess whether continuation of these antiplatelet drugs in patients without PTCA are associated with increased perioperative blood loss, need for blood transfusion and perioperative complications, or not.

Methods: In this study, 88 patients were selected with single and multilevel posterior thoracolumbar surgery and was classified into three groups: A group, aspirin only (A=22); B group, clopidogrel only (B=22); and C group, control (C=44). These groups were matched with respect to age, sex, and comorbidity status. The estimated blood loss (EBL), postoperative drain collection (PDC), differential hematocrit (DH) (preoperative PCV–postoperative day 1 PCV) and transfusion related data were collected. This was then statistically analyzed.

Results: There is no significant difference regarding EBL in single level surgery in patients taking aspirin or clopidogrel with Control (A vs. C, p=0.1 and B vs. C, p=0.06) and in multilevel surgery (A vs. C, p=0.38 and B vs. C, p=0.5). No difference has been found in PDC in three groups: single level surgery (A vs. C, p=0.06 and B vs. C, p=0.06) and multilevel surgery (A vs. C, p=0.31 and B vs. C, p=0.22). Regarding differential hematocrit, no significant difference was found in these groups; single level [p=0.48 (A vs. C) and p=0.21 (B vs. C)] and multilevel surgery [p=0.46 (A vs. C) and p=0.33 (B vs. C)].

Conclusions: Continuation of antiplatelet therapy is not associated with increased perioperative blood loss and no significant change in hematocrit occurs. It is not associated with increase in transfusion need and enhanced morbidity.

Keywords: Perioperative blood loss; Posterior thoracolumbar spine surgery; Aspirin and clopidogrel

Postoperative Cervical Kyphosis in Adult Spinal Deformity with Sagittal Imbalance: Is it Permanent when Seen after Surgical Correction of Sagittal Malalignment?

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Background: Several studies have been published with regard to postoperative cervical kyphosis resulting from an effort to achieve an optimal sagittal balance. Therefore, our purpose was to evaluate postoperative cervical kyphosis according to the amount of postoperative lumbar lordosis (LL) correction compared to the pelvic incidence (PI), and to the postoperative and last follow-up sagittal balance.

Methods: Degenerative lumbar kyphosis (n=122) who underwent surgical correction with a minimum of 2-year follow-up were analyzed. Four related studies were performed by comparing spinopelvic parameters

evaluated by categorizing the patients into three different ways (postoperative PI–LL, postoperative C7 plumb line (C7PL), and last follow-up C7PL) and performing a Pearson's correlative study between spinopelvic parameters of the postoperative and last follow-up to assess the relationship of each spinopelvic parameters.

Results: There were significant differences or direct relationship in assessing cervical lordosis and T1 slope with regard to postoperative C7PL (negative: n=29, <50 mm; n=60, >50 mm; n=33), but not with postoperative PI-LL (<-10; n=50, 10<±10; n=43, >10; n=29). There were no significant correlation between postoperative thoracic kyphosis and postoperative cervical lordosis, which showed significant correlation of those of the last follow up. However, cervical kyphotic change with postoperative SVA (C7PL <0 or <50 mm) was restored to cervical lordosis at last follow-up.

Conclusions: Therefore, postoperative cervical kyphosis or hypolordosis is temporary during the adjusting period of thoracic kyphosis restoration, after postoperative negative sagittal malalignment. However, the degree of cervical lordosis may differ from the postoperative or last sagittal balance status.

Keywords: Postoperative cervical kyphosis; Adult spinal deformity

3-cm Minimally Invasive Surgery MIS Cervical Laminoplasty Is Easy and Safe!

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Background: Priority of cervical laminoplasty (LP) is how to spread, and to minimize surgery is not discussed much. Thus, we forget the complication of nape pain after surgery, caused by invasion. We devised minimally invasive surgery (MIS)-LP with 3-cm skin incision. This study aimed to analyze the usefulness and result of this procedure.

Methods: Three hundred and sixteen cases with MIS-LP (213 male and 103 female; average 65 years old) were investigated, retrospectively. This procedure is combination of Shiraishi's and Hirabayashi's method, and needs only right angled Gelpi's retractors. First, we split spinous process above lamina preserves muscles damage like Shiraishi's procedure. After reveal lamina without spinous process, we undergo open-door LP from C4 to C6 and dome LP for C3 and C7. For comparative cases, 44 cases were undergone conventional LP (open-door: hydroxyapatite brocks, more than 10-cm skin incision). Japanese Orthopaedic Association score (JOA score) and Hirabayashi's recovery rate at first outpatient day after operation, operative time, amount of bleeding, and complications (including C5 palsy) were investigated. Postoperative pain was evaluated by numerical rating scale (NRS).

Results: There were no cases of worsened neurological deficit and the neurological scores (JOA) were not significantly different. We had two reoperation case of hematoma. Surgical time of MIS-LP (average 79 minutes) was significantly superior to conventional procedure (103 minutes). Amount of bleeding during MIS procedure (average 28 g) was less than conventional (122 g). Nape pain of the minimum-open (NRS=2.3) was significantly less than conventional one (3.0). No C5 palsy occurred.

Conclusions: MIS-LP resulted better than conventional one. From the measurement, gutter width of MIS-LP is shorter and it effected well for bleeding and C5 palsy. This is one of the best options and this procedure is necessary for coming ages.

Keywords: Laminoplasty; Minimally invasive surgery

Is a Higher Dose Range of Tranexamic Acid More Superior in Reducing Blood Loss in Scoliosis Surgery?

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Background: Scoliosis surgery is often associated with long operative times and extensive blood loss. Published studies consistently demonstrate the efficacy of tranexamic acid (TXA) to reduce intraoperative blood loss compared to placebo. However, the optimal dose to maximize its anti-fibrinolytic properties without increasing thrombotic complications remains elusive. This study compares the efficacy of two different dose range of TXA in reducing intraoperative blood loss in posterior spinal fusion (PSF) surgery.

Methods: One hundred and seventy-three patients diag-

nosed with adolescent idiopathic scoliosis (AIS) who underwent PSF in 2015 and 2016 were retrospectively studied. All patients received 1 g bolus of intravenous TXA at the start without maintenance infusion. They were divided into two groups: Group A, high dose TXA (>20 mg/kg, n=115) and Group B, low dose TXA (<20 mg/kg, n=58). Cell salvage technique was employed in all patients.

Results: Mean age, weight, blood volume, Cobb's angle, and number of levels fused were 15.4 years, 41.8 kg, 2,914.8 mL, 66.4°, 11.2 levels in Group A and 18.2 years, 57.5 kg, 3,652.8 mL, 65.7°, 10.8 levels in Group B, respectively. In terms of mean absolute intraoperative blood loss (827.8 vs. 909.4 mL; p=0.26) and percentage of blood volume loss (28.5% vs. 24.9%; p=0.11), the differences between the high and low dose groups did not achieve statistical significance. Total blood loss per segment (72.2 vs. 81.1 mL; p=0.08) and per screw (56.8 vs. 63.8 mL; p=0.14) also did not differ significantly between the groups and so did duration of hospital stay (3.4 days vs. 3.4 days, p=0.96). No patients received allogenic blood transfusion and none developed thrombotic complications.

Conclusions: A higher dose TXA (>20 mg/kg) failed to demonstrate superiority in reducing blood loss compared to a lower dose TXA (<20 mg/kg) when given in PSF surgery for AIS. Prospective studies to investigate the optimal dose range and regimen of TXA are needed.

Keywords: Scoliosis; Tranexamic acid; Blood loss

Predictability of Coronal Curve Flexibility in Postoperative Curve Correction in Adolescent Idiopathic Scoliosis: The Effect of the Sagittal Profile

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Background: The fulcrum bending radiograph (FBR) is an accepted measure to assess coronal curve flexibility in adolescent idiopathic scoliosis (AIS) patients and to guide clinical management; however, the postoperative curve correction is not in complete agreement with the preoperative curve flexibility. The main objective of the study was to assess whether the sagittal and coronal profiles of the spine affects the ability of the FBR to predict postoperative curve correction.

Methods: A prospective radiological study was conducted of 107 consecutive thoracic AIS patients with a standard screw-fixation protocol with 2-year follow-up. Radiographic variables were assessed preoperatively, postoperatively and at 2-year follow-up. Curve flexibility was determined based on the FBR and the Fulcrum Bending Flexibility Index (FBCI). Radiographic variables included preoperative Cobb angle, T5–T12 kyphosis, T12–S1 lordosis, sagittal vertical axis, list, T1–T12 length, truncal shift, and radiographic shoulder height. Patients were also categorized as hypo-, normo-, or hyperkyphotic.

Results: Mean age at the time of surgery was 15.2 years (82% female). Based on multivariate modelling, increased FBR Cobb angle and thoracic kyphosis were significantly associated with an increase in FBCI (increased mismatch between the FBR and postoperative Cobb angles) at 2-year follow-up (p<0.001). In patients with hyperkyphosis, a longer instrumented length existed despite similar curve size and shorter curve length than the hypo- and normokyphotic groups. Based on these findings, we developed a new predictive postoperative curve correction index, known as the Multi-profile Flexibility Index.

Conclusions: Our results show that an increase in preoperative thoracic kyphosis is associated with an increased difference between the preoperative coronal curve flexibility and the postoperative coronal curve correction. Our findings broaden the understanding of curve flexibility and indicate that selection of fusion levels may need to take into consideration the sagittal profile to improve clinical decision-making and optimize outcomes.

Keywords: Adolescent idiopathic scoliosis; Flexibility; Sagittal; Coronal; Fulcrum bending

Rigorous Lumber Lordosis Correction Is Necessary to Achieve Optimal Surgical Outcome Even in Elderly Spinal Deformity

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Background: Age-dependent target alignment during corrective fusion surgery in elderly patients remains con-

troversial. Age-related target spinal alignment should be examined based on the outcomes data of patients with a fused, non-physiological spine. The objective was to determine the effect of spino-pelvic correction on clinical outcomes and discuss the approach to target alignment in elderly spinal deformity patients.

Methods: This study was retrospective analysis of consecutive case series. Consecutive adult spinal deformity patients aged 45 years or older who underwent thoracolumbar corrective fusion of at least five levels were included. Spinopelvic radiographic parameters, health related quality of life (Oswestry Disability Index [ODI]) were investigated before and after the operation. The patients were stratified into three groups according to age as follows: middle-age, 45–64 years; elderly, 65–74 years; and extremely elderly, ≥75 years. We also stratified the patients into three groups according to the lumber lordosis (LL) as follows: ideal (within ±5° of ideal LL), moderate (between −5° to −20° of ideal LL), and under (under ideal LL by −20°).

Results: A total of 149 patients (middle-age, 38; elderly, 68; and extremely elderly, 43) were included in this study. No significant difference was observed in the radiographic parameters in each age group. The mean ODI of the ideal correction group at 2 years after surgery were 25.9 and significantly better than those of the under correction group (50.1) across all ages. A significant correlation was observed only in terms of the sagittal vertical axis (SVA, r=0.367) in the middle-age group. On the other hand, LL, SVA, and pelvic incidence–LL, were significantly correlated with ODI in the Elderly (r=-0.351, 0.342, and 0.278, respectively) and extremely elderly groups (r=-0.373, 0.412, and 0.412, respectively).

Conclusions: This result indicates that rigorous realignment is necessary to achieve optimal clinical outcomes, especially in extremely elderly patients.

Keywords: Adult spinal deformity; Surgical outcome; Elderly patient

The Natural History of Patients with Cervical Radiculopathy Treated Conservatively: Clinical and Magnetic Resonance Imaging Features after a Mean Follow-up of 3 Years

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Background: The clinical response of cervical disc herniation presenting with radiculopathy, treated conservatively is known to be favorable. However, few published studies are there regarding the radiological outcome. The present study attempts to evaluate the clinical and radiological natural history of such patients.

Methods: Prospective longitudinal study of 30 patients of acute cervical radiculopathy with single level disc herniation presenting to Park Clinic in India from Jan 2012 to April 2015 were included in the study with mean follow-up period of 37 months (range, 18 to 58 months). All patients presented with unilateral brachialgia corresponding to magnetic resonance imaging (MRI) findings. Functional assessment tools used were Neck Disability Index (NDI) and Visual Analogue Scale (VAS) of neck and arm pain. The index and follow-up MRI were graded for disc degeneration (using Miyazaki Score) and neuroforaminal stenosis (NFS) (using Kim's Score) by three independent observers. Patients with myelopathy were strictly excluded. All patients were managed with analgesics, pregabalin, and physical therapy.

Results: Thirty patients with mean age of 45.26 years (range, 31 to 68 years), with mean initial VAS score of neck and arm of 6 and 8, improved to 2 and 1.3, respectively at follow-up (p<0.001). NDI score improved from 53.73 (range, 22.2–90) to 20.19 (range, 0–42.2) (p<0.001). NFS grade for involved side decreased from average of 1.52 to 1.08 (p<0.05). Miyazaki scores changed from 3.20 to 3.35 (p=0.823). Inter-observer reliability for NFS scoring was good (k=0.60–0.66). Miyazaki scoring showed poor inter-observer reliability (k=0.20–0.35). Average protruded disc volume changed from 222 to 125 mm^3 (p<0.05). We did not find any correlation between improvement of NDI scores and improvement of NFS or protruded disc volume.

Conclusions: Clinical improvement and significant regression of neuroforaminal stenosis on follow-up MRI were

seen in cervical radiculopathy patients. However, correlation between the two could not be proved.

Keywords: Cervical disc; Natural history; Magnetic Resonance imaging

The Cut-off Value and Negative Factors of Neck Disability Index among Japanese Volunteers

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Background: Neck Disability Index (NDI) is frequently used to evaluate cervical spine disease. However, few reports have defined the cut-off values of NDI. Moreover, factors with a negative influence on NDI were still unclear. The purpose of this study was to investigate the cut-off values of and factors with a negative influence on NDI.

Methods: A total of 487 volunteers who participated in the health screening study were divided into three groups: no disability (group N, the pain and function item were 0 point); mild disability (group M, the pain item over 1 point); and disability (group D, the pain item over 1 point and function item over 3 points). The cut-off values of NDI were determined using receiver-operating characteristic curves. These groups were divided into male and female groups and age adjustment was done.

Results: Groups N, M, and D contained 207, 186, and 94 volunteers, respectively. The cut-off values of NDI in each group were 0%–5%, 6%–17%, and ≥18%. After age adjusting, there were 65, 56, and 23 males in groups N, M, and D (mean age, 77 years), respectively and 92, 103, and 56 females in groups N, M, and D (mean age, 75 years), respectively. In multiple logistic regression analysis, the factors with a negative impact on NDI in males were manual work (odds ratio [OR], 1.924), higher basal metabolism (OR, 1.004), higher T1 slope minus cervical lordosis (OR 1.043), and higher C2–7 sagittal vertical axis (OR, 1.029; $p<0.05$). The factors in females were reduced hand grip strength (OR, 0.936), body fat percentage (OR, 0.942), and sports activity (OR, 0.456, $p<0.05$).

Conclusions: Deteriorated NDI score is related to cervical spinal malalignment on whole-spine radiographs and manual labor in males and a lack of sports activity and sarcopenia in females.

Keywords: Neck disability index; Cut-off value; Risk factors

A New Surgical Technique Effectively Avoiding Cerebrospinal Fluid Leakage in the Anterior Approach Treating Cervical Ossification of the Posterior Longitudinal Ligament with Dural Ossification: Anterior Controllable Antedisplacement Fusion

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Background: Cerebrospinal fluid (CSF) leakage is a common complication encountered when using anterior approach to treat cervical ossification of the posterior longitudinal ligament (OPLL) with dural ossification (DO) and often brings about lots of adverse effect. The object of this study is to introduce a new method avoiding CSF leakage and demonstrate its effect.

Methods: Anterior controllable antedisplacement fusion (ACAF), a new technique making the vertebrae and ossified mass moving forward in a hoisting manner, was performed on 28 patients with myelopathy due to cervical OPLL with DO. All patients were performed cervical plain films, computed tomography (CT), and magnetic resonance imaging (MRI). The double-layer sign was observed on axial bone window of CT images. The operation duration, blood loss, and hospital stay was estimated. Radiologic assessment included occupying rate, type and extent of OPLL, decompression width, postoperative area of the spinal canal, and anteroposterior (AP) diameter of the spinal cord. The Japanese Orthopedic Association (JOA) scoring system was used to evaluate neurological status. Surgery-related complications such as CSF leakage was recorded. The ACAF group and a control group of 31 anterior corpectomy and fusion (ACCF) patients were compared.

Results: There was no significant difference in operative duration and blood loss between two groups, but hospital

stay was significantly longer in ACCF group. On cross-sectional CT, decompression width and postoperative spinal canal area were both significantly larger in ACAF group than in ACCF group. The AP diameter of the spinal cord on cross-sectional MRI was significantly greater in the ACAF group than in the ACCF group. Mean JOA score was significantly better in the ACAF group. In ACCF group, there were six patients (19.4%) had CSF leakage, but no patient presented with CSF leakage in ACAF group. The difference was significant.

Conclusions: ACAF, which can avoid CSF leakage and gain good neurologic recovery, is a good option to treat cervical OPLL with DO via anterior approach.

Keywords: Ossification of the posterior longitudinal ligament; Anterior controllable antedisplacement fusion; Anterior corpectomy and fusion; Cerebrospinal fluid leakage; Dural ossification

Efficacy of Posterior Decompression with Instrumented Fusion for K-line (-)-type Cervical Ossification of the Posterior Longitudinal Ligament: Minimum 5-Year Follow-up

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Background: We have reported a concept of K-line for making decisions regarding the surgical approach for cervical ossification of the posterior longitudinal ligament (OPLL). The purpose of this study was to assess mid-term outcomes after posterior decompression with instrumented fusion (PDF) in patients with K-line (-)-type cervical OPLL.

Methods: Seventeen cervical OPLL patients of K-line (-)-type who underwent PDF between 2004 and 2011 in our institute were retrospectively reviewed. We divided into two groups which are long fusion group (L group) and short fusion group (S group). We evaluated their neurological status and radiographic findings retrospectively.

Results: There were nine cases whose range of fixation was from C2 to C7 (Th1) (L group) and eight cases whose range of fixation was below C3 to lower (S group). The average recovery rate was 40% in the L group and 39% in the S group at a year follow-up, and was 24% in the L group and 35% in the S group at final follow-up. The data of the C2–7 angle and center of the gravity of the head to C7 sagittal vertical axis showed slightly increase of kyphosis in the S group, whereas no progression of kyphosis was seen in the L group at the final follow-up. The range of motion at the maximal spinal cord compression level controlled during the follow-up period in both groups.

Conclusions: Relatively good surgical outcome could be obtained by posterior decompression with instrumented fusion for patients with K-line (-)-type cervical OPLL. The addition of posterior instrumented fusion eliminated the dynamic factor and preserved local stabilization in both two groups. Instrumented fusion from C2 to C7 (Th1) with C2 pedicle screw fixation preserved the cervical sagittal balance and prevented the progression of cervical kyphosis in L group.

Keywords: Cervical ossification of the posterior longitudinal ligament; Posterior decompression with instrumented fusion; K-line

Surgical Treatment of Patient with Tandem Spinal Stenosis

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Background: Tandem spinal stenosis means a concurrent cervical and lumbar spinal stenosis. Its complex clinical presentation comprises both upper and lower limb symptoms and signs, such as cervical radiculaopathy, myelopathy, neurogenic claudication, and progressive gait abnormality. Surgical strategies differ from simultaneous to staged surgery, which is often chosen for lower risk. However, the priority of surgical decompression is controversial.

Methods: With institutional review board approved, we retrospectively reviewed 47 cases with tandem spinal stenosis undergoing surgical spinal cord decompression procedures from January 1, 2010 to December 30, 2015. We categorized the patient with different surgical priority (A: lumbar-lesion-first, B: cervical-lesion-first) and

the decision to second stage surgery depends on patient's presentation, discussion and mutual agreement of the patient, family and the surgeon. We collected the clinical, functional, and radiographic evaluation data done at preoperative period, postoperative 3, 6, and 12 months, 1 year, and 2 years. The functional outcome included the modified Japanese Orthopedic Association (JOA) score and Nurick's myelopathy grade. The radiographic evaluation included the central stenosis grading on magnetic resonance imaging.

Results: The mean age, gender, follow-up duration, and radiographic stenosis grading of both lesion of group A (n=36), and group B (n=11) were all comparable. The preoperative and 1-year postoperative modified JOA score and Nurick's grade improved statistically significant, but there's no significant group difference. The percentage of second stage surgery differed significantly (33% vs. 91%, p=0.001) in a mean duration of 6.6 and 7.9 months. The complication rate and other reason for operation room reentry were comparable between groups.

Conclusions: Surgical decompression with cervical-lesion-first strategy results a significantly lower rate of operation room reentry for the unoperated stenosis when managing patients with tandem spinal stenosis, while the functional score remained comparable between groups. Upon accurate diagnosis, clinical specialist could choose to decompress the cervical lesion first.

Keywords: Tandem spinal stenosis; Staged operation

Cervical Myelopathy with Tandem Stenosis-Mystery Unravelled! Single Stage Double Team -The New Gold Standard

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Background: The object of this study is to evaluate clinical outcome and safety and efficacy of single staged double team combined surgery in cervical and lumbar tandem spinal stenosis (TSS). TSS is commonly missed degenerative spinal ailment. Single stage vs. staged decompression procedures have been under debate. Literature evaluating efficacy and safety of single-staged double team combined surgery is scarce.

Methods: Comprehensive evaluation was done to ascertain clinicoradiological diagnosis. Demography (age, gender, presentation, American Society of Anesthesiologists [ASA] grade), clinical-neurological (pain-Visual Analogue Scale [VAS], Nurick's grade, modified Japanese Orthopedic Association [mJOA], Oswestry Disability Index [ODI]), perioperative (blood loss, surgical time, length of hospital stay) and radiological parameters (instability, myelomalacia) were documented and analysed.

Results: Eighty-eight patients (38 males, 50 females; mean age, 66.3 years [range, 47–89 years]; mean follow-up, 27 months [range, 24–46 months]) were included. Simultaneous double team single staged surgery (C3–6 cervical laminectomy [n=88], lumbar decompression [L4–5=49, L5–S1=28, L4–S1=11], and fusion [n=16]) was done. Mean blood loss was 300 mL (range, 200–600 mL), mean operating time 135 minutes (range, 80–250 minutes), and mean hospital stay 9 days (range, 6–17 days). Significant improvement noted (p<0.05): VAS (preoperative [Preop], 6.7; postoperative [Postop], 3.4), ODI score (Preop, 72; Postop, 26), mJOA (Preop, 7.9; Postop, 13.7), and Nurick's grade (Preop, 3.5; Postop, 1.5) at final follow-up. Average HRR was 54.73 with high satisfaction rates (80% Odoms criteria). Reversible C5 palsy (n=2), neurological worsening (n=1), dural tear (n=1) and superficial infection (n=1), and persistent cerebrospinal fluid leak requiring epidural drain (n=1) were documented. Two patients died due to unrelated reasons. Comparatively younger age cohort (<60 years) and ambulatory status shorter duration of symptoms had better outcome. Longer operative time, higher blood loss, and ASA grade had no correlation to outcome.

Conclusions: TSS is common and often missed diagnosis with delayed presentation. Single stage double team lumbar+cervical surgery (same anaesthesia) is safe and efficacious modality with minimal morbidity and optimal results. Increasing age and prolonged duration of symptoms were associated with poor outcome. Preoperative ASA grades, Myelomalacia blood loss, or long operative time has no correlation to outcome.

Keywords: Tandem spinal stenosis; Cervical myelopathy; Single staged

Comparative Analysis between Anterior Cervical Discectomy Fusion and Cervical Disc Replacement Procedure in Single Level Degenerative Disc Disease with 2-Year Follow-up

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Background: Critical analysis was needed between anterior cervical discectomy fusion (ACDF) and cervical disc replacement (CDR) procedures, to proclaim which is significant. We evaluated the two procedures with a follow-up of 2 years.

Methods: We retrospectively evaluated patients with single level cervical degenerative disc disease who had undergone ACDF (group A) and CDR (group B) in the period between 2013 to 2015 with 2-year follow-up. There were 24 in group A and 14 in group B. Patients were assessed with preoperative Anteroposterior, Lateral radiographs, Visual Analog Scale (VAS), neck disability index score (NDI), modified Japanese Orthopedic Association score (MJOA), Nurick grading, cervical sagittal angle, cervical segmental angle, and with all the above parameters along with radiographs, Odom's criteria at 2 years of follow-up.

Results: Mean blood loss during surgery was more in group A patients; however, mean duration of surgery and mean inpatient stay in hospital were less in group A patients. Mean VAS was improved from 6.83 to 1.96 (p=0.0022)in group A and from 6.33 to 1.75 in group B (p=0.0019). Mean NDI, MJOA, and Nurick grading were reduced in both groups. Mean cervical sagittal angle and mean cervical segmental angle were improved from 14.97°, 2.38° to 15.42°, 2.47°, respectively in group A patients. In group B patients they changed from 15.21°, 2.99° to 15.33°, 2.35°, respectively. The changes in both these angles in both the groups were statistically significant p<0.05. Mean percentage change from baseline in VAS, NDI, Nurick grading, MJOA, cervical sagittal angle, cervical segmental angle, and Odom's criteria were 71.84, 67.85, 70.54, 49.47, 0.0291, 0.0364, and 3.21 percentage, respectively in group A patients. In group B they were 72.35, 73.58, 65.16, 62.79, 0.0078, 0.272, and 3.4 percentage, respectively. Mean percentage change in all the above parameters between the two groups were not statistically significant.

Conclusions: Mean surgical time and mean inpatient stay were less with ACDF (group A) patients. Both groups showed improved clinical, functional outcome and there was not much difference in the outcome among the groups at 2 years of follow-up.

Keywords: Anterior cervical discectomy and fusion; Anterior cervical procedure; Cervical segmental angle; Cervical sagittal angle; Cervial disc replacement procedure

Differences of Clinical Outcome after Uncoforaminotomy in Anterior Cervical Discectomy and Fusion

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Background: Anterior cervical discectomy and fusion (ACDF) is the basic procedure for relief of neck pain and upper extremity radiating pain in cervical disc herniation and cervical spondylosis. However, the controversy continues as to whether uncoforaminotomy is necessary for ACDF. We would like to compare the results of patients with or without uncoforaminotomy.

Methods: A retrospective study was performed on 59 patients who underwent single level ACDF in our hospital. The average follow-up period was 27 months. There were 35 patients with ACDF alone and 24 patients with ACDF and unilateral uncoforaminotomy (ACDF-U). Fusion material was used in all patients with plate and tricortical iliac auto-bone graft. Dermographic data, Visual Analog Scale (VAS), Japanese Orthopedic Association (JOA) score, and patient satisfaction were compared between ACDF only and ACDF-U group. Moreover, on the lateral plain radiograph, the length of the center of the upper and lower end plate of fusion cervical vertebra were compared with the immediate postoperative and last follow-up for determining the degree of subsidence. The fusion rates were compared between the two groups.

Results: Clinical results showed statistically significant improvement of pain in ACDF-U group at final follow-up in VAS score better than ACDF only group (ACDF only, 2.25±1.06; ACDF-U, 1.73±0.80; p<0.05). There was no statistically significant difference in JOA score and patient satisfaction between two groups. In both groups, almost

solid fusion was achieved (ACDF only, 34/35; ACDF-U, 23/24). Fusion rates and the degree of subsidence were no statistically significant difference between the two groups. No complications were observed between the two groups, except hoarseness was found in ACDF-U group.

Conclusions: Uncoforaminotomy in ACDF showed no significant difference in clinical outcome and fusion rate, except for the VAS score at final follow-up. We should pay more attention to the need for uncoforamitomy in ACDF.

Keywords: Uncoforaminotomy; Anterior cervical discectomy and fusion

Reoperation Rate of Microscope-Assisted and Non-Microscope Anterior Cervical Discectomy and Fusion for Treatment of Degenerative Cervical Myeloradiculopathy

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Background: It has been known that microscope-assisted anterior cervical discectomy and fusion (ACDF) provides various advantages, such as better magnification and superior illumination through its coaxial light source for safer, faster, and more extensive decompression. However, using routine microscope-assisted surgery takes longer operative time, higher costs, and more technically demanding. There are no former studies that compare the reoperation rate between non-microscope and microscope-assisted surgery. Purpose is to demonstrate whether microscope-assisted ACDF can decrease reoperation rate, increase postoperative fusion rate, and decrease complications.

Methods: It was retrospective descriptive study. We collected the patients with cervical spondylotic radiculopathy and/or myelopathy whom underwent ACDF with anterior cervical plating in our institution since 2006–2016 by single experienced spine surgeon. In microscope-assisted group, it had been brought into the operative field during meticulous decompression of the neural elements, endplate preparation, fusion, and instrumentation. Demographic data, radiographic study, and clinical outcome were reviewed.

Results: Twenty-three of 1,082 ACDF cases (2.12%) were reoperated; 20 non-microscope ACDF (86.96%), and 3 microscope ACDF (13.04%). Mean time-to-reoperation was 33.04 months (standard deviation=36.27 months). Most common causes of reoperation in both groups were adjacent segment diseases (52.17% non-microscope group, 8.69% microscope-assisted group), following by residual disc protrusion or remnant of osteophyte in non-microscope ACDF (three cases, 13.04%). Absence of wound complication and similar fusion rate presented in both groups.

Conclusions: Reoperation rate of 2.12% is found in patients who underwent non-microscope ACDF and microscope-assisted ACDF for treatment of degenerative cervical myeloradiculopathy. Adjacent segment disease is the most common cause of reoperation in patients who have previous ACDF surgery in both groups.

Keywords: Degenerative cervical myeloradiculopathy; Anterior cervical discectomy and fusion; Reoperation rate

Esophageal Perforation Following Corrective Cervical Spine Surgery Complicated with Difficult Extubation: A Case Report

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Background: Anterior cervical discectomy and fusion is a commonly performed surgery for the treatment of spondylosis, radiculopathy, myelopathy, and trauma to the cervical spine. Esophagus rupture is rare but serious complication following C-spine surgery with an incidence of 0.02% to 1.52%.

Methods: The 54-year-old female patient we present here complained symptom of right upper extremity numbness and weakness without other underlying disease. Surgery for anterior cervical discectomy and fusion with posterior lateral fusion was performed, then delayed extubation episode and esophagus rupture were developed subsequently. We discuss the possible causes and the appropriate management in such circumstances after a thorough literature review.

Results: As the detailed review of the management of esophageal perforation following cervical spine surgery will provide a deeper understanding for the orthopedic surgeon in regards to appropriate awareness, diagnosis, and management in such circumstances. Leak test before extubation and air accumulation in prevertebral fascia was

done in neck lateral view. Pneumomediastinum, subcutaneous emphysema, mediastinal widening, or a mediastinal air-fluid level may be seen in the chest X-ray. Water-soluble contrast agent initially followed by a barium study was also seen on literatures but remain controversy.

Conclusions: Esophageal perforation following cervical spine surgery is a rare yet serious complication. Greater vigilance is required in the event reintubation is required as perforation of the surgical repair site is of great concern. Early diagnosis and surgical intervention can have better survival rate of the patients complicated with esophageal perforation.

Keywords: Esophageal perforation; Corrective cervical spine surgery

Esophageal Perforation Following Anterior Cervical Spine Surgery: A Retrospective Single-Center Case Series

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Background: Esophageal perforation following anterior cervical spine surgery is a rare but potentially fatal complication. The study aimed to present our experience in the diagnosis and treatment of this complication

Methods: We retrospectively analyzed seven patients with esophageal perforation after anterior cervical spine surgery in our institution between January 1992 and June 2017. All cases were male, with an average age of 54.5 years (range, 42–62 years).The initial surgery was performed due to cervical spine trauma in three patients cervical spondylosis in three patients, and tuberculosis in one patient. Surgical procedures involved the C3–C4 (1 patient), the C3–C5 (2 patients), the C4–C6 (two patients), the C5–C6 (one patient) and the C6-T1 (one patient). The occurrence time, symptom, diagnosis, and treatment of this compliction were analyzed.

Results: In all seven patients, the esophageal perforation was recognized in the early postoperative period (range, postoperative day 2–7). The common clinical symptoms consisted of neck pain, dysphagia, odynophagia, coughing, fever, localized neck tenderness, incision swelling, and food residue leaking from the incision. Diagnosis was confirmed by one or several of the following methods: oral methylene blue, cervical radiographs, contrast swallow study, or endoscopic examination. Nasogastric tube placement, parenteral and enteral nutrition, intravenous antibiotics, and incision drainage were conducted in all seven patients. The wound was debrided in four patients, while two had implant removal and primary suture of the perforation. Six of seven patients were cured after treatment, while one patient died due to severe pneumonia and respiratory failure.

Conclusions: Patients should be highly suspected for esophageal perforation with neck incision swelling and pain, swallowing pain, difficulty swallowing, coughing, unexplained fever, etc. Cervical radiographs, contrast swallow study, endoscopy, and oral methylene blue are particularly helpful to diagnose this complication. Early diagnosis and active intervention can obtain a good clinical outcome.

Keywords: Anterior cervical spine surgery; Esophageal perforation; Complication

Surgical Management of Unilateral Multi-Level Cervical Spondylotic Radiculopathy: A Comparative Study of Clinical and Radiological Outcomes of Posterior Foraminotomy versus Anterior Cervical Discectomy and Fusion

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Background: Anterior cervical discectomy and fusion (ACDF) has been considered the standard surgical treatment for cervical radiculopathy. However, it has many disadvantages such as the loss of motion, adjacent segment disease, and pseudarthrosis. Posterior cervical foraminotomy (PCF) is another surgical option that could avoid those complications. The purpose of this study is to elucidate the efficacy of unilateral multi-level PCF performed for cervical spondylotic radiculopathy patients by comparing its clinical and radiological outcomes with those of ACDF.

Methods: We retrospectively reviewed medical records and radiographic data of 121 consecutive patients who underwent multi-level (≥2 levels) ACDF or PCF with unilateral radiculopathy symptoms occurring from spondylotic neural foraminal stenosis. In this study, PCF was

selected as a more favorable procedure than ACDF in patients without severe neck pain (Visual Analog Scale >4), segmental instability and/or kyphosis, or central cord compression.

Results: There were no baseline group differences in age, gender, or follow-up periods. Arm pain scores were similar in both groups pre- and postoperatively. Mean neck pain score was significantly worse in the ACDF group preoperatively, but it improved to a similar degree as that of the PCF group after surgery. Similarly, there were no significant differences in mean postoperative neck disability index (NDI) score between the two groups. Mean C2–7 range of motion (ROM) was reduced by 9.6° in the ACDF group, but increased by 3.2° in the PCF group. Significant segmental kyphotic change or anterolisthesis were not detected in any patients. Revision surgeries were performed for one patient in the PCF group and for two patients in the ACDF group because of relapsed or persistent radicular symptoms

Conclusions: Our results support that unilateral multilevel PCF would provide satisfactory outcomes in terms of improvements in arm pain, postoperative NDI, and reoperation rates without aggravation of neck pain. Also, it could maintain sagittal ROM, which is markedly reduced after ACDF.

Keywords: Posterior cervical foraminotomy; Unilateral multi-level neural foraminal stenosis

Comparison of Pre-existing Factors Causing Spinal Cord Compression between Patients Suffering from Cervical Spinal Cord Injury with and without Bone Injury

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Background: Previous studies suggested that pre-existing factors causing spinal cord compression such as ossification of posterior longitudinal ligament (OPLL) and bulging of the intervertebral disc can be a risk of cervical spinal cord injury (CSCI) without bone injury. The purpose of this study is to compare the pre-existing factors and clinical characteristics between patients suffering from CSCI with and without bone injury.

Methods: This study included 169 patients with CSCI. The patients were divided into two groups: CSCI with bone injury and CSCI without bone injury. Clinical characteristics such as sex, age, cause of injury, Frankel grade, and level of injury were investigated. Pre-existing factors causing spinal cord compression such as OPLL, posterior spur of the vertebral body, developmental stenosis, disk bulge, calcification of the yellow ligament, and others were evaluated. The clinical characteristics and pre-existing factors were compared between the two groups.

Results: Fifty-four patients were with bone injury, and 115 patients were without bone injury. Age of the patients without bone injury was higher than that with bone injury. In cause of injury, falling on a level ground was more common in patients without bone injury (60%) compared to those with bone injury (15%) (p<0.001). Frankel grade in patients with bone injury were significantly severer than that without bone injury (p=0.005). The level of injury was more common at C5–6 (28%) among patients with bone injury, at C3–4 (33%) among those without bone injury, respectively (p<0.001). The prevalence of the pre-existing factors in patients without bone injury (86%) was significantly higher than those with bone injury (20%) (p<0.001). The most common pre-existing factor was OPLL followed by posterior spur and developmental stenosis in the both groups.

Conclusions: The pre-existing factors such as OPLL, posterior spur, and developmental stenosis can be a risk of CSCI without bone injury caused by low-energy trauma in elder population.

Keywords: Spinal cord injury; Spinal cord compression

Cervical Myelopathy and Osteoporosis: A Cross-Sectional Study

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Background: There are few researches trying to demonstrate the relationship between cervical spine myelopathy (CSM) and osteoporosis. However, the bone quality may have a crucial role in bone healing and alignment main-

taining of the cervical spine when surgical treatment is required. As a result, we conduct this study in order to prove the correlation between cervical spine myelopathy and osteoporosis.

Methods: Cervical myelopathy patients treated at the Department of Spinal Surgery from 2014 to 2017 are screened for osteoporosis by dual energy X-ray absorptiometry method. The spinal canal diameter was measured on plain sagittal X-ray. We analysed the correlation between bone quality (presented by the T-score) and factors such as age, gender, Japanese Orthopedic Association (JOA) score, concomitant disease, time of onset of CSM. $p<0.05$ is considered as statistical significant. Hypothetic risk factors of osteoporosis were defined as old age (>60 years old), female, low JOA score (<12), concomitant disease(s), and late onset of CSM.

Results: There were 84 patients included in our study. The average age of the group was 59 and the male/female ratio was approximately 2:1. The mean T-score was -1.4. There were 33 patients classified as osteoporotic (39%). Mean spinal canal diameter were 12.5 mm for the osteoporotic group and 11.9 mm for the non-osteoporotic group ($p>0.05$). By using the multivariate logistic analysis, we can identify the independent risk factors of osteoporosis with odd ratios (ORs) as follow: low JOA score ((OR, 4.3; $p=0.001$), older than 60 years old (OR, 3.6; $p=0.01$), and female (OR, 2.5; $p=0.004$).

Conclusions: Cervical spine myelopathy can have a negative effect on the bone quality of the patients and this should be accounted for, especially when surgical treatment is required

Keywords: Osteoporosis; Cervical myelopathy

Brown-Sequard Syndrome Caused by Cervical Disc Herniation: Case Report and Review of the Literature

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Background: The Brown-Sequard syndrome (BSS) is frequently seen in patients with spinal trauma. A cervical disc herniation has been rarely considered as a cause of this syndrome. We reported two cases who were diagnosed with BSS caused by a herniated cervical disc in Viet Nam and the results of those in the literature.

Methods: Two females were diagnosed the BSS caused by a cervical disc herniation. Magnetic resonance imaging of the cervical spine showed a large disc herniation on the right side at the level C3/4 in one patient and at the level C4/5 in the other. The anterior microdiscectomy and fusion were performed immediately in both cases. We reviewed the articles involved BSS and herniated cervical disc in the literature.

Results: After surgery, both patients were improved very good. The recovery of the motor and sensory deficits were seen almost completely. Review of the literature showed that the surgical outcome was good in these patients and the anterior microdiscectomy was the most approach.

Conclusions: A cervical disc herniation can be a cause of the Brown-Sequard syndrome. Immediate surgical treatment is necessary to have a good recovery of neurological function.

Keywords: Brown-Sequard syndrome; Cervical disc herniation; Anterior microdiscectomy

Brain Transplantation at Spinal Level: Head Anastomosis Venture Project versus Nerve Root Anastomosis Hypothesis

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Background: Head Anastomosis Venture (HEAVEN) project plans on transplanting a human head by fusing the donor and host at spinal cord level. Its scientific validity and feasibility will be tested and compared with a possible alternative hypothesis which anastomoses the central nervous system at the nerve root level without sectioning the cord.

Methods: A systematic review was performed in the following database: PubMed and Google Scholar.

Results: Glue assisted fusion, polyethylene glycol/other induced healing of cord after trauma, and hand transplantation were selected for analysis which ultimately gave 23, 11, and 16 articles, respectively after reviewing over 18,000 articles. Out of 23 articles 12 were reviews and 11 were experimental studies in the HEAVEN-GEMINIspinal cord fusion protocol. Healing agents used for cord healing were Articles for nerve root anastomosis (NERA) were in-

ternational registries (4.5%), case series/unit experiences (27.3%), case reports (27.3%), systematic reviews (31.8%), multicenter cohort studies (4.5%), and retrospective studies (4.5%).

Conclusions: Only two human studies were done for HEAVEN project to test feasibility rather than the functional outcome of cord regeneration and fusion. No post traumatic cord healing studies analyse healing after cervical cord sectioning. Cord healing in contusion/hemisection is different from complete transection required in a head transplant. Complete cord transection was tested at low thoracic level making all studies unfavourable for HEAVEN project. Hand transplantation is taken for the alternative hypothesis (NERA) as both happen at the peripheral nerve level bypassing unproven reanastomosis of the sectioned cord in a human. Hand transplantation gave 68.2% better functional outcome. Maximum mortality was 6.4%. We conclude that human spinal cord fusion requires further research while anastomosing a brain with the intact spinal cord at the nerve root level is theoretically possible using current technology.

Keywords: Transplantation; Head

The Biomechanical Origins of Modic Changes as Mediated by Disc Stiffness: A Finite-Elemen Analysis

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Background: Modic changes (MCs) are one of the most clinically relevant spinal phenotypes related to low back pain. Its etiology is under constant debate but mechanical factors are highly influential due to altered biomechanics with disc degeneration. With advanced disc degeneration, natural stabilization occurs and the disc becomes stiffer. With loading, increased stress to the adjacent vertebral body may manifest as MCs. Hence, the objective of this study is to determine the patterns of Modic changes that may result from disc stiffness.

Methods: Through a finite-element model of L4/5, a selected portion of the disc was made stiffer to mimic reduced mobility in disc degeneration. Simulation models included variable sizes and position of disc stiffness and variable position of compressive (flexion, axial, extension) loading force. Resultant stress magnitude projected onto the vertebral body was measured along with width and height of the stress area. Further testing was performed with a normal disc and a fused segment under loading.

Results: Formation of stress rings were observed through all disc stiffness models. Larger sized disc stiffness led to increased stress areas. Flexion and extension moments created larger focal stress and areas of involvement corresponding to the anterior and posterior aspects of the vertebral body, respectively. Variable positions of disc stiffness had similar reactive stress patterns given a constant axial loading force. No significant focal stress was produced for the normal and fused disc simulations.

Conclusions: This study, based on a biomechanical simulation, is the first to note that loading across an area of disc stiffness will produce reactive stress patterns to the adjacent endplate and may manifest as MCs. These findings suggest that MCs may develop as a result of altered loading through a disc with stiffer properties. This provides further insight into the relationship between advancing disc degeneration and MCs with respect to loading.

Keywords: Modic; Disc stiffness; Finite-element analysis

Postural Balance: Variants of Norms and Mechanisms for Compensation of Functional Disorders in Patients with Lumbar Osteochondrosis

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Background: Variability of sagittal spinal-pelvic balance parameters results to a change of the postural balance.

Methods: In the groups of asymptomatic volunteers (n=30; age, 20–30 years) and patients with lumbar osteochondrosis (n=42; age, 20–40 years) were investigated parameters of sagittal spinal-pelvic balance, the location of the lower limbs joints relative to the line gravity, the standing type, and the electromyography parameters of muscles flexors and extensors of the trunk and lower extremities.

Results: Ergonomically and biomechanically was determined discordant versions vertical posture. It is shown that the postural balance regulation mechanisms are

aimed at: (1) the preservation of the ideal ratio of "spine balance" to "pelvis balance" at the location of the line of gravity in the area of lumbosacral disc; (2) keeping the ideal position of the hip joints during anterior displacement of the line of gravity. It was established that the frontal plane of vertical posture ergonomics ensured asymmetrical standing with compensatory ipsilateral bend of the trunk and pelvis lateroflexion. Compensation mechanisms postural imbalance with functionally disable units body segments consist in a significant tightening of links of the kinematic chain of the spine–pelvis–hip joints with significant restrictions on their mobility, increasing the interdependence of bioelectrical activity of the muscle groups of the trunk and lower limbs and changing the parameters of functional stability of the vertical posture.

Conclusions: The mismatch of sagittal spinal-pelvic balance parameters creates a biomechanical conditions for the further progression of degenerative lumbar disc diseases.

Keywords: Postural balance; Gravity loads

The Effects of Orientation of Lumbar Facet Joints on the Facet Joint Contact Forces: An *in Vitro* Biomechanical Study

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Background: Biomechanically the bilateral facet joints play a critical role in maintaining stability of the lumbar spine by sharing load. The effect of orientation of lumbar facet joints on the contact forces remains unknown.

Methods: Eight human cadaveric lumbar spine specimens (L2–L3) were tested by applying a pure moment of ±7.5 Nm in three directions of loading (flexion-extension, lateral bending, and axial rotation) with and without a follower preload of 300 N. The orientation of the lumbar facet joints at the L2–L3 was measured on axial computed tomography scans. Bilateral facet contact forces were measured during flexibility tests using thin film electroresistive sensors (Tekscan 6900).

Results: The average total peak facet loads was 66 N in axial rotation, 27 N in extension, and 20 N in lateral bending under a pure moment. Under a pure moment and with a follower preload of 300 N, the average total peak facet loads was 53 N in axial rotation, 43 N in extension, and 24 N in lateral bending. The facet joint forces were correlated positively and significantly with the orientation in all directions with and without a compressive follower preload ($p<0.05$). In addition, the facet joint contact forces at neutral position with a follower preload were correlated positively with the orientation ($rs=0.759$, $p=0.001$).

Conclusions: This study identified that the greater coronal orientation of lumbar facet joints are, the higher the facet joint contact forces are.

Keywords: Lumbar facet joint; Orientation; Facet joint contact forces; Biomechanics

Effects of Pedicle Screw Design and Bone Quality on Screw Fixation Strength: An Experimental Study Using Synthetic Bone

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Background: Robust fixation of pedicle screws remains challenge. Previous studies have demonstrated that numerous factors such as screw types (perforation or expansion) and screw designs (thread, thread pitch, shaft diameter) are related to screw anchoring strength. However, literatures addressing the influence of screw design including outer/inner diameter shape (cylindrical/cylindrical, cylindrical/conical, conical/conical) and thread type (square or V-thread) on the screw fixation strength is lacking. This study aims to explore the mechanical performance of the aforementioned screws in two-fold: (1) effect of bone quality on screw fixation strength; (2) association among pilot-hole size, screw insertion torque and screw fixation strength.

Methods: Two types of synthetic bones (test blocks: 20 pcf and 30 pcf) were used to mimic human vertebrae with different bone qualities. Six kinds of pedicle screws were recruited. These include three different outer/inner diam-

eter shape (conical/conical, cylindrical/conical, and cylindrical/cylindrical) equipped with two different thread types (square or V-thread). Three different sizes of pilot hole (2.7 mm, 3.2 mm, and 3.7 mm in diameter) were prepared. During screw insertion, the insertion torque was measured using a torque gauge. Following specimens preparation, screw pullout tests were then conducted using MTS (material testing machine) testing machine.

Results: (1) Regardless of bone quality, V-shape groups have higher pullout strength as compared to square-shape groups. Additionally, V-type pedicle screws with cylindrical/conical shape exhibited the highest pullout strength among groups ($p<0.05$). (2) No significant difference was found between thread type (V- or square-shape) and insertion torque. (3) Regardless of screw types, a smaller pilot hole let to an increase in insertion torque and pullout strength. (4) Enlargement of pilot hole significantly reduced pullout strength, particularly for screw with a 3.3 mm pilot hole.

Conclusions: V-type pedicle screws with cylindrical/conical shape presented the most robust fixation.

Keywords: Pedicle screw; Screw loosening; Screw pullout test

The Effect of Removing Vertebral Dorsal Bone on Pedicle Screw Pullout Strength

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Background: Various biomechanical studies have examined ways to improve the pullout strength of pedicle screws. One area that has not been extensively examined in the literature is whether removing dorsal cortical bone or performing a complete facetectomy of the vertebra affects screw pullout strength.

Methods: Fresh frozen human cadaveric spines were disarticulated resulting in 21 thoracic and 10 lumbar vertebrae. Dorsal bone from the posterior aspect of the vertebral body was removed unilaterally and compared with the contra-lateral pedicle. The technique of decortication in the thoracic spine was as per the 'funnel' technique. In the lumbar spine a complete facetectomy was performed. All vertebrae had pre- and post-screw insertion radiographs to determine the size of the pedicle to optimize pedicle fill. After the pedicle screws were placed by hand, each individual vertebra was then potted in epoxy resin and placed in a servo-hydraulic test machine. Axial distraction was applied along the axis of the pedicle screw at a rate of 5 mm/min until "failure" occurred as per the American Society for Testing and Materials standards.

Results: There was no significant difference when comparing the decorticated side to the intact side when all screw sizes were combined. A statistically significant difference was identified within the 6.5-mm diameter screw group between the intact and decorticated side. The intact side had significantly greater pullout strength (829.1±198.2 N vs. 582.1±208.7 N, $p=0.003$). There was not a significant difference when comparing the other screw diameters used (5.5, 7.5, and 8.5 mm).

Conclusions: In screw sizes larger than 6.5-mm diameter, decorticating the dorsal bone had no significant effect on the pullout strength. Sub-analysis of the 6.5-mm screw group showed a significant difference in pullout strength between the sides. Limitations of this study included the limited sample size and the cadaveric samples.

Keywords: Pullout; Biomechanics; Facetectomy; Pedicle screw

Radiation Exposure and Accuracy of Lumbar Pedicle Screws Insertion Using Two-Dimensional Computerized Navigation

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Background: Accuracy and radiation exposure are important considerations in modern spinal instrumentation. In this article, we compare these two issues using conventional and two-dimensional (2D) computerized navigation technique.

Methods: In conventional group, pedicle finder was inserted towards the medial side of the pedicle under anteroposterior fluoroscopy. Once reaching the medial pedicle, lateral fluoroscopic view was taken before advancing to appropriate depth. Integrity of the track was checked before tapping and insertion of screw. In navigation group, patient tracker was secured over a spinous process. Good

anteroposterior (AP) and lateral fluoroscopic views were taken and sent to navigation machine. Further procedures were performed using simultaneous AP and lateral views from the machine and using navigated instrument. Radiation emitted from C-arm and the time taken were record after screw insertion. The patients were evaluated for any complications. Further assessments were performed for those with computed tomography (CT) available. Statistical analysis was performed using SPSS.

Results: Navigation technique was employed in 20 patients and 83 screws were inserted. A retrospective cohort of 78 patients using conventional technique was recruited and 202 screws were inserted. For both groups, no immediate surgical complication was found and the mean age was 60 years. Statistically significant differences were found (2D navigation vs. conventional) in the mean radiation exposure time (13.76 seconds vs. 30.45 seconds) and the mean dosage of radiation emitted from C-arm (90.02 cGy cm^2 vs. 280.54 cGy cm^2) for each screw. Forty-four screws in navigation group and 78 screws in the conventional group were assessed by CT using 2-mm classification system. Excellent position (grade A) were observed in 95% of navigation group (n=42) and 93.6% of conventional group (n=73), respectively. The remaining screws were belonged to grade B. No grade C screws were seen in both groups. No significant difference was found in accuracy.

Conclusions: Utilization of computerized navigation in spinal instrumentation was effective and safe.

Keywords: Computerized navigation; Lumbar pedicle screw

Does Neuroregulation Participate in the Abnormal Development of Cartilage in Scoliolis?: New Evidence for the Exist of Nerve in Cartilage

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Background: Abnormal development of cartilage is a cause for scoliosis. And the reason why the cartilage develope abnormally is not totally clear. We hypothesize that neuroregulation participate in the development of cartilage. However, in traditional theories, for the normal mature cartilage, nerve exist in perichondrium rather than the parenchyma of the chondrocytes accumulation area. Previous morphologic studies on nerve fibers and chondrocytes were limited to the histological structure, and there were few reports on their ultrastructure.

Methods: The selected neonatal SD rats were randomly divided into three groups: the 1-day-postnatal (1 day), the 5-day-postnatal (5 day), and the 10-day-postnatal (10 day). Their cartilage tissues were collected, then the samples (paraffin and ultrathin sections) were sectioned after fixed with paraformaldehyde and glutaraldehyde, respectively. The sectioned samples were deparaffinized and stained with hematoxylin and eosin (HE) or immunohistochemical staining, and were then observed under the transmission electron microscope and scanning electron microscope. Enzyme-linked immunosorbent assay (ELISA) was also performed for the cartilage tissue of knee joints at different stages

Results: Nerve fibers increased in the chondrocytes accumulation areas of the knee joint cartilage tissue of the 1-, 5- and 10-day-postnatal SD rats, and formed synaptic contacts with chondrocytes. As time went on, the chondrocytes completed their development with the enhancement of secretion function, the increase in the collagenous fibril and the deposition of extracellular calcium salt, and the gradual degradation of the nerve fibers. The ELISA showed the increased contents of the sensory neuropeptide substance (SP) and the sympathetic neuropeptide substance (NPY) ($p<0.05$). Immunofluorescence results showed the distributions of SP and NPY in the perichondrium, membranous structure of cartilage canals and extracellular matrix of chondrocytes in the chondrocytes accumulation area.

Conclusions: Nerve fibers exist in the cartilage tissue and they form synaptic contacts with chondrocytes at the early stage, and then degrade gradually in the course of chondrocyte maturation.

Keywords: Scoliosis; Neuroregulation; Cartilage

Histopathological Findings of Ligamentum Flavum between Superficial Layer and Deeper Layer in Patients with Spinal Stenosis

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Background: Ligamentum flavum degeneration is common in patients with spinal stenosis, usually occurs in the lumbar spine and lower segment of the thoracic spine. In this study, we tried to elucidate the histopathological findings of the superficial layer and deeper layer of ligamentum flavum in patients with spinal stenosis.
Methods: Tissues were obtained from the patients with lumbar or lower thoracic spinal stenosis (experimental groups) and the young patients with lumbar intervertebral disc herniation (control group), and were then sectioned and stained with hematoxylin and eosin (H&E) Verhoeff-Van Gieson elastin staining kit, alizarin red S or immunohistochemical (IHC) staining with bone morphogenic protein-2 (BMP-2) antibody, etc., respectively.
Results: H&E stain showed that different degree of fibrosis, calcification, or chondroid metaplasia could be observed. Verhoeff stain showed there were more degenerative changes in the superficial layer than deeper layer. In control group, there was more ordered parallel alignment in the deeper layer than in experimental group. Alizarin red S staining showed the superficial layer was strongly positively stained, and the deeper layer was weakly stained. In control group, the margin area of superficial layer still positively stained, and middle area of the superficial layer and deeper layer showed weakly stained; but in experimental group, the middle area of superficial layer would have moderate to strong stained area or spot. IHC staining with BMP-2 antibody also showed the superficial layer with a moderate to strong positively stained, and deeper layer with weak or non- stained. In control group, it was stained weakly.
Conclusions: There are more degenerative changes in the superficial layer of ligamentum flavum of patients with spinal stenosis including the lower content of elastin, and higher calcium deposition, and higher BMP-2 expression. More efforts should be made to elucidate the degeneration of ligamentum flavum.

Keywords: Ligamentum flavum; Spinal stenosis; Histopathological

Pattern of Pathway of Superior Cluneal Nerve

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Background: Posterior Iliac bone graft harvesting may injure the superior cluneal causing the neuropathic pain which will burden patient after surgery and bring severe pain and unsatisfactory results. To avoid this superior cluneal nerve injury is mandatory and understanding of anatomical pathway of this nerve is necessary. The objective of this descriptive study is to determine, measure, and demonstrate the direction and the course of superior cluneal nerve in cadavers in relation to midline and posterior superior iliac spine (PSIS).
Methods: Eighteen cadavers were used and dissected through posterior midline and the superior cluneal nerve were identified and measured the course, direction, and distance between midline and PSIS.
Results: The distance from the medial branch nerve to the midline and PSIS were 70.1±5.0 mm and 53.4±5.6 mm, respectively. These distances, direction, and distance are not related to the body height and the width of pelvis.
Conclusions: We recommend the safe zone for avoiding the superior cluneal nerve should not be 70 mm from the midline and 50 mm from the PSIS.

Keywords: Superior cluneal nerve; Donor site pain

Potential Pathomechanism of Chordoma: Overexpressions of Nerve Growth Factor and Its Tropomyosin-Related Kinase A Receptor on Chordoma Cells

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Background: Chordomas arise from primitive notochordal remnants. Why these notochordal remnants undergo malignant transformation to chordoma remains unknown. The binding of nerve growth factor (NGF) to

the tropomyosin-related kinase A (TrkA) receptor promotes cell survival, while its binding to the p75 receptor triggers apoptosis. If there is simultaneous expression of both receptors, the effect of TrkA supersedes and the cells survive. The purpose of the current study was to investigate the expression levels of NGF and its 2 receptors, TrkA and p75, as well as proliferation potential and apoptosis indexes in chordoma and notochordal cells.

Methods: We examined 10 surgically obtained sacral chordoma tissue samples to determine the expressions of NGF and TrkA and p75 receptors as well as markers of cellular proliferation and apoptosis. As controls, we used notochordal cells of L4–L5 discs obtained from ten 1-month old rats. We quantified the expressions of NGF and TrkA and p75 receptors as well as markers of cellular proliferation and apoptosis for both groups, respectively.

Results: Chordoma and notochordal cells both expressed NGF as well as TrkA and p75 receptors. While the mean percentage of p75 receptor expression was very similar between chordoma and notochordal cells (p=0.394), the mean percentages of TrkA and NGF expressions were significantly higher in chordoma cells than in notochordal cells (both p=0.002). The mean proliferation potential index of chordoma cells was significantly higher than in notochordal cells (p<0.01). Conversely, the mean apoptosis index of chordoma cells was significantly lower compared with that of notochordal cells (p=0.03).

Conclusions: The current results suggest that increased expressions of NGF and TrkA receptor in chordoma cells might be a possible mechanism of malignant transformation of notochordal remnants to chordoma by negating apoptotic signal of p75 receptor.

Keywords: Chordoma; Nerve growth factor; Tropomyosin-related kinase A

Efficacy of Transpedicular Percutaneous Biopsy of Vertebral Body Lesions in Establishing Diagnosis

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Background: The purpose of this retrospective study is to compare the accuracy of the preliminary diagnosis derived from clinical, hematological, and radiological findings with definitive diagnosis obtained from transpedicular biopsy of vertebral body lesion in three major pathology (tuberculosis, pyogenic, and malignancy).

Methods: One hundred and seventeen patients undergone transpedicular biopsy under local anaesthetic with fluoroscopy guidance from C4 to S1 level for histopathological examination (HPE). All patients prior to biopsy were evaluated based on clinical, laboratory investigation and radiology (X-ray and magnetic resonance imaging).

Results: Out of 117 patients, conclusive HPE diagnosis was obtained in 111 (94.9%) of patients. Forty-seven point nine percent of HPE results supports the initial diagnosis; 20.5% of HPE results suggest other diagnosis than the preliminary impression. No pathology found in 26.5% of samples. Patients HPE that back with no pathology, proceeded with open biopsy.

Conclusions: All spine lesion patients need to undergo proper clinical treatment, hematology, radiology, and transpedicular biopsy to establish the diagnosis. Single diagnostic method is inadequate in treating the spine lesion patients.

Keywords: Spine lesion; Transpedicular biopsy

Reducing the Dependence on Allogenic Blood in Metastatic Spine Surgery with Intraoperative Autologous Salvaged Blood: A Prospective Clinical Trial

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Background: The spine is the most common site of skeletal metastases. However, blood loss remains a significant concern, with the mean blood loss per surgery at our institution being 911 mils. Allogenic blood is the mainstay of treatment and this is associated with an increase in perioperative complications. Autologous salvaged blood is not used due to the theoretical risk of tumour seeding in other organs. This is a prospective study to ascertain the safety of intraoperative autologous cell-salvaged blood which has been passed through a leukocyte depletion filter (IOCS-LDF) transfusion in patients undergoing sur-

gery for spinal metastases.

Methods: This is a prospective clinical trial of patients undergoing surgery for spinal metastases who were consented to receive salvaged autologous blood passed through a LDF. These patients were labeled salvaged blood transfusion (SBT) patients and were compared to no blood transfusion (NBT) patients who were recruited for this study but did not require transfusion and allogenic blood transfusion (ABT) patients who were recruited for this study but only received ABT. The primary outcome was progression free survival at 3 months. The secondary outcome was overall survival (OS), postoperative complication rates, and length of hospital stay (LOS).

Results: Seventeen patients received SBT, 18 received ABT, and 18 did not receive any transfusion (NBT). There was a trend towards increased progression free survival, decreased postoperative complication rates, and decreased length of stay in patients who received SBT. This was not statistically significant. There was no difference in survival rate at 3 months. Tumour histology and preoperative Eastern Cooperative Oncology Group score was significantly associated with survival.

Conclusions: IOCS-LDF blood appears safe for transfusion in patients undergoing spinal metastases surgery. There is a need for further prospective longer term, larger cohort studies

Keywords: Spine metastases; Transfusion

The Outcome of Operative Treatment Modalities in Patients with Spinal Metastases

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Background: Cancer is increasingly becoming a major health problem globally. One of the complications of cancer is metastases. It is estimated that two thirds of patients will develop bone metastases. An oncological study revealed that 29% of bone metastases occurred in the spine followed by 28% in the femur, making it one of the commonest complication of cancer. Spinal metastases can be debilitating, causing pain, instability, and neurological injuries such as incontinence and paraplegia. Therefore, diagnosing and treating spinal metastases early is important, as well as ascertaining the prognosis.

Methods: All patients who presented to a single centre from July 2014 to July 2016 with spinal metastases were included. There were 31 men and 20 women with an average age of 55.1 years (range, 23 to 98 years). Each patient was scored using the modified Tokuhashi score, 36-item Short-Form Health Survey (SF-36), and Karnofsky's Performance status upon admission. The patients or their next of kin were then interviewed 1 year from the time of admission or surgery.

Results: Out of the 51 patients enrolled, 10 patients and their next of kin were uncontactable. The highest type of primary malignancy was breast carcinoma with 23.5%. The modified Tokuhashi predicted survival rate of 60.8% for less than 6 months, 29.4% for 6 to 12 months and 9.8% for more than 1 year. A total of 37 patients underwent a surgical procedure, 11 of which were biopsies. Among the procedures done were posterior instrumentation with laminectomy (12, 46.2%) and posterior instrumentation with vertebrectomy (10, 38.5%). The other 14 were treated conservatively. From those who underwent surgical palliation, 69.2% showed improved SF-36 and Karnofsky's performance status, as compared to 27.3% among the biopsied patients and 21.4% from those treated conservatively. Those who underwent surgical palliation but deteriorated, was due to disease progression.

Conclusions: Palliative surgery in patients with spinal metastases was associated with improved quality of life, as opposed to conservative management.

Keywords: Spinal metastases; Outcome; Complications; Operative; Palliative

Clinical Significance of Preoperative Embolization for Non-hypervascular Metastatic Spine Tumors

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Background: The efficacies of preoperative embolization for hypervascular metastatic spine disease (MSD) such as renal cell and thyroid cancers have been reported. However, debate on the efficacy of preoperative embolization for non-hypervascular MSD is still remained. The purpose of this study is to determine whether preoperative embolization for non-hypervascular MSD decreases perioperative blood loss.
Methods: Sixty-nine (29 preoperative embolization and 40 non-embolization) patients with MSD other than renal cell and thyroid cancers were enrolled. The average age was 56.2±13.0 years of 48 men and 21 women. Intraoperative and perioperative estimated blood losses (EBL) and calibrated EBL were recorded. The differences in EBL were also compared along the type of surgery. The incidence of the Adamkiewicz artery and complications were also assessed for investigating the clinical significance of preoperative embolization.
Results: Lung (23), hepatocellular (17), gastrointestinal (11), and others (18) were the primary cancers. There was no significant difference in intraoperative EBL, perioperative EBL, and transfusion amount between preoperative embolization and non-embolization groups. Corpectomy was done in 29 patients, and palliative laminectomy was performed in 40 patients. EBL between two groups was not significantly different along the type of surgery. No complications of embolization were seen in any patients. However, the Adamkiewicz artery was noted in two patients. Disruption of this major feeder artery made significant changes in intraoperative neuromonitoring.
Conclusions: Preoperative embolization for non-hypevascular metastatic spine lesions did not present favorable results in reduction of perioperative blood loss. Meanwhile, the procedure was able to provide invaluable information on the vascularity of the tumor and the spinal cord.
Keywords: Metastatic; Spine; Angiography

Which Material is the Desirable Factor for Lumbar Interbody Fusion?

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Background: The aim of interbody fusion is the fixation of two vertebrae. One of a "true" rapid surgery is fast bone ingrowth in lumbar interbody. On the other hand, many factors (e.g., ages, sex, co-morbidity alignment, bone quality, surgical technique, etc.) are related to bone ingrowth and union, but we can interfere by surgery is not too much. From the view of surgical devices, progress of the material is still now advancing and considers affecting bone union. Now we use polyetheretherketone (PEEK) cage coated by titanium which has the characteristic of the elasticity of PEEK and biocompatibility of titanium. The chief aim of this study is to reveal the factors of rapid bone union.
Methods: This study included 42 cases. All cases are single interbody fusion, and performed by oblique lateral lumbar interbody fusion (OLIF). Twenty-six cases were enrolled to PEEK cage group (group P; mean age, 63.7 years; male:female=11:15), and 16 cases were to PEEK cage coated by titanium (group T; mean age, 68.5 years; male:female=13:3). Three months after the surgery, we evaluated the interbody bone fusion by the sagittal and coronal view of computed tomography. We also evaluated by multivariate analysis the correlation between the fusion rate and the spinal alignment (sagittal vertical axis [SVA], lumbar lordosis, and sacral slope [SS]).
Results: Bone fusion was confirmed in nine cases (35%) of group P, and 13 cases (81%) of group T. Group T has significantly higher fusion rate than group P. Moreover, multivariate analysis revealed that no-coated, higher age, the level of L3/4, larger SVA, and larger SS is a significant risk factor about the bone fusion.
Conclusions: The sagittal mal-alignment and higher age is risk factor of the bone fusion in the lateral access lumbar interbody fusion. The titanium coated PEEK cage is better option for early bone fusion.
Keywords: Polyetheretherketone cage coated by titanium;

Oblique lateral lumbar interbody fusion; Bone union

Weekly Teriparatide Administration and Preoperative Anterior Spondylolisthesis of the Upper Adjacent Vertebra Promote Osseous Union within six Months after Posterior Lumbar Interbody Fusion

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Background: Posterior lumbar interbody fusion (PLIF) is usually performed to treat lumbar degenerative diseases in elderly patients. Some patients exhibit intervertebral pseudo-arthrosis. The purpose of our study is to investigate independent predictors of osseous union after PLIF.
Methods: We analyzed 66 elderly patients with osteoporosis after PLIF from 2011 to 2014 (all females; mean age, 71 years; follow-up period, at least 6 months). Patients were randomly allocated to treatment with weekly teriparatide, starting at 1 week postoperatively; others received no teriparatide. Preoperative lumbar spine radiographs were obtained and examined for the presence of spondylolisthesis (amount of spondylolisthesis >0 mm). Osseous union was assessed by using computed tomography 6 months postoperatively.
Results: Thirty-three patients in the group showed osseous union (50%), whereas the other 33 did not. Teriparatide was administered in 19 (58%) of the patients who showed osseous union and in 9 (27%) of those who did not (p<0.01). Preoperative anterior spondylolisthesis of the upper adjacent vertebra was observed in 19 patients (58%) in the osseous union group and in eight (24%) in the non-osseous union group (p<0.01). The multivariate logistic regression analysis showed that administration of teriparatide (odds ratio [OR], 4.8; 95% confidence interval [CI], 1.546–14.603; p<0.01) and preoperative anterior spondylolisthesis of the upper adjacent vertebra (OR, 3.7; 95% CI, 1.185–11.821; p<0.05) were independently associated with osseous union within 6 months after PLIF. Six months postoperatively, the mean femoral neck bone mineral density had increased by 1.5% in osseous union group and decreased by 2.3% in non-osseous union group.
Conclusions: Weekly administration of teriparatide and preoperative anterior spondylolisthesis of the upper adjacent vertebra were independent predictors of osseous union 6 months after operation. Our findings suggest that PLIF and teriparatide treatment are an effective option for managing lumbar degenerative diseases in elderly patients with osteoporosis.
Keywords: Teriparatide; Posterior lumbar interbody fusion; Osseous union

Cost-utility Analysis of Instrumented Posterior Lumbar Interbody Fusion at 2 Years after Surgery

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Background: Super-aged society in Japan is facing a problem of runaway cost for healthcare. However, there were few Japanese health economic data for surgical intervention. The purpose of this study is to determine the cost/quality-adjusted life year (QALY) gained for single-level instrumented posterior lumbar interbody fusion (PLIF) for degenerative lumbar disorders at 2 years after surgery.
Methods: From 2013 to 2015, 64 patients who treated with a single-level instrumented PLIF were enrolled. As interbody fusion materials, we used two chip-filled carbon polyetheretherketone cages and autologous bone chips and blocks from excised lamina. Clinical outcomes were evaluated by the Japanese Orthopaedic Association score and the SF-6D, a utility index derived from the Short Form 6D 36-item Short-Form Health Survey ver. 2.0, preoperatively and at 1 year and 2 years after surgery. We used the SF-6D to determine QALY. Cost analysis was performed based on actual reimbursement of medical fees

for during a period of hospitalization, and cost per QALY was calculated. For each reimbursement price of surgical procedure and instrumentations (four pedicle screws, two rods, and two interbody cages) which are set up by the Japanese Ministry of Health, Labour and Welfare was 557,200 JPY and 832,600 JPY, respectively.

Results: There were significant improvements in the clinical outcomes both at 1 year and 2 years after surgery. The mean SF-6D healthy utility value gained in each year postoperatively was 0.123, 0.122, for cumulative 0.245 QALY improvement during the 2-year interval. The mean medical cost was 2,278,429 JPY. The resultant cost per QALY gained at 2 years after surgery was 9,284,959 JPY (80,000 USD).

Conclusions: World Health Organization suggested that upper threshold for cost per QALY is 3 times per capita gross domestic product. The cost per QALY of this study was within the acceptable range and decrease with time. This study will contribute to find the way for the sustainability of Japanese universal healthcare system.

Keywords: Cost-utility analysis; Quality-adjusted life year; Posterior lumbar interbody fusion; Short Form 6D; Universal healthcare system

Outcome and Safety of Transforaminal Lumbar Interbody Fusion: A Single Center Experience

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Background: Transforaminal lumbar interbody fusion (TLIF) is an established procedure for patients with degenerative disorders of spine. It enables anterior and posterior 360-degree fusion while utilizing unilateral posterior access, minimising morbidity. This study was conducted to evaluate the outcome of TLIF in terms of symptoms improvement, fusion and complications.

Methods: This descriptive cross-sectional study was performed from January 2012 to January 2017. All patients who underwent TLIF for degenerative disc disease (DDD), spondylolisthesis, or recurrent intervertebral disc herniation were included. Clinical results in terms of Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) scores were measured. Modified Lee criteria was used for radiological evaluation of fusion. Data presented as mean±standard deviation.

Results: A total of 140 patients were included in this study out of which 31 (22.1%) were male while 109 (77.9%) were female. Mean age of the patients was 44.8±10.9 years with minimum of 20 and maximum 74 years. Out of 140 patients, 48 (34.3%) were with degenerative disc disease, 18 (12.9%) with recurrent intervertebral disc herniation, and 74 (52.9%) were with spondylolisthesis. In majority of patients single level surgery was performed 133 (95%). Mean preoperative VAS was 6±1.2 with minimum of 4 and maximum 9. Mean VAS at last follow-up was 2.1±0.6. Mean preoperative ODI was 33.4±11.1 with minimum of 16 and maximum 66, while mean ODI at last follow-up was 13.3±5.8. Mean ody mass index of patients was 31.85±3.6. Majority of our patients were nonsmokers 129 (92.1%) out of 140. Mean follow-up was 32.9±14.8 months with minimum of 6 and maximum 66 months. According to Lee's criteria, 57 (40.7%) had definitive fusion, 72 (51.4%) had probable fusion, and eight (5.7%) had possible pseudoarthrosis, while 3 (2.1%) had definitive pseudoarthrosis. In six patients (4.3%) we had dural tear and four (2.9%) had early postoperative infection, while in six (4.3%) implant related problems occurred.

Conclusions: TLIF is an excellent procedure producing promising clinical and radiological results. Proper patient selection remains the key for desired results.

Keywords: Spondylolisthesis; Transforaminal lumbar interbody fusion; Degenerative disc disease

Postoperative Outcomes of the Patients with Degenerative Lumbar Disease Treated by Mini Open-Anterior Lumbar Interbody Fusion

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Background: We have performed mini open-anterior lumbar interbody fusion (ALIF) in the anterior lumbar spinal fusion for the patients with degenerative lumbar spine disease in our institute. We analyzed and compared the postoperative outcome and total medical cost (TMC) between the young and elder patients and examined the

cost value.

Methods: Since 2006, 96 patients were selected to this study (male 41, female 55). Inclusion criteria were single level fusion, stand alone method, and minimum follow-up of 1 year. Age, body mass index, operative time, intraoperative bleeding, Japanese Orthopaedic Association (JOA) lumbar score at preoperative, postoperative, and final follow-up, JOA improvement rate, length of hospital stay (LHS), and TMC were investigated. Also, the patients were divided two groups: Y group, the patients aged 64 years old or less; O group, the patients aged 65 years old or older. Examination items, the correlation in JOA improvement rate, and TMC in both groups were also investigated and compared.

Results: In all cases, the mean age, operative time, and-intraoperative bleeding were 58 years old, 108 minutes, and 50 mL, respectively. The mean JOA score at preoperative and final follow-up were 17 points and 26 points, respectively. The mean JOA improvement rate was 75%. The average LHS was 19 days, and the mean TMC was $17,704. There were no significant differences in the operative time, intraoperative bleeding, JOA score, and JOA improvement rate between the two groups. The LHS and TMC were significantly lower in the Y group. The correlation of the JOA improvement rate and TMC was low in the two groups.

Conclusions: This study demonstrated mini open-ALIF procedure supplied the similar postoperative outcomes and the cost value in the young and elderly patients. In the young patients, compared to the older patients, the good condition without health history and preoperative activity was thought to have led to early discharge and TMC reduction.

Keywords: Postoperative outcomes; Mini open-anterior lumbar interbody fusion

Cortical Bone Trajectory versus Traditional Pedicle Screw in Transforaminal Lumbar Interbody Fusion

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Background: Transforaminal lumbar interbody fusion and pedicle screw (PS) fixation has been the mainstay technique for the spinal disorders. Meanwhile, Santoni and his colleagues in 2009 also reported a new cortical bone trajectory (CBT) and provided an alternative fixation technique. However, the differences in perioperative clinical outcomes and postoperative fusion rate between TLIF with CBT and TLIF with conventional PS placement remain unknown.

Methods: Twenty-five patients with CBT-TLIF were compared with 25 matched PS-TLIF controls. A short-term follow-up and a statistical analysis of perioperative and short-term clinical outcomes were performed. In the same time, the potential complications were evaluated.

Results: The mean ages of the CBT-TLIF and PS-TLIF cases were 48.3 years (range, 33–69 years) and 47.6 years (range, 32–69 years), respectively. The male/female ratio was 14:11 for both groups. Average follow-up was 12 months for the CBT-TLIF group and 13 months for the PS-TLIF group. Operative duration and blood lost were significantly shorter in the CBT-TLIF group than that in the PS-TLIF group ($p<0.05$). No difference in length of stay and duration to ambulation were found. Significant improvements in the Oswestry Disability Index (ODI) functional scores and Visual Analogue Scale (VAS) were observed at 3-, 6-, and 12-months in both groups, but no significant difference was found between the two groups. Fusion rates were comparable by radiography. One patient aged 67 years happened screw loosing sign postoperative 6 months at PS-TLIF group due to osteopenia morbidity. Another one aged 45 years arise screw breaking the pedical medial wall and nerve root irritation postoperative 1st day at PS-TLIF group and followed by correcting screw position immediately. Subsequently, the signs disappeared.

Conclusions: CBT-TLIF and PS-TLIF had comparable functional benefits, while CBT-TLIF had superiority in blood control, operative time, and temporary interbody stability.

Keywords: Cortical bone trajectory; Pedicle screws; Transforaminal lumbar interbody fusion

An Analysis and Study on the Changes of Lumbar Function Curve after Single Segment Transforaminal Lumbar Interbody Fusion in Patients with Lumbar Degenerative Disease

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Background: Various spinal shapes and positional parameters have been described by radiographic assessment of asymptomatic volunteers to understand human sagittal balance in the standing position. We study the characteristics and regularity of lumbar vertebral function curve classification after single segment transforaminal lumbar interbody fusion (TLIF) in patients with lumbar degenerative disease.

Methods: One hundred and twenty-one patients (63 males and 58 females; mean age, 47.2±9.6 years) underwent TLIF surgery by the same surgeon and complete follow-up were included in. Based on the adjusting Roussouly lumbar spine classification method proposed by Weishi Li were measured parameters such as pelvic incidence (PI), sacral slope, lumbar lordosis (LL), thoracic kyphosis (TK), sagittal vertical axis (SVA), Visual Analog Scale (VAS), and Japanese Orthopaedic Association (JOA) scores. In order to analysis the changes of lumbar vertebral function curve and the parameters of spine pelvic sagittal parameters at different time points before and after the surgery and their relationship.

Results: The VAS and the JOA scores were significantly improved after surgery (p<0.05). There were significant differences in LL, TK, lumbar sacral angle, L1 sagittal spino-pelvic inclination, T9 sagittal spino-pelvic inclination, SVA, VAS, and JOA after the surgery (p<0.05). According to Weishi Li's classification, there were type Ⅰ:22, type Ⅱ:28, type Ⅲ:35, and type Ⅳ:36. Lumbar spine classification of the patients (64%) were changed after the surgery. There was a statistically significant difference in the PI values between the unchanged group and the changed group (p<0.05). We found that no matter what type of lumbar spine is before the surgery, there were no significant difference in the PI values in patients with the same lumbar function curve after the surgery (p>0.05).

Conclusions: Once the PI was in the same range, the type of the lumbar function curve of the patients are same. PI was in the same range, and lumbar function curve classification will be restored to the same lumbar type matched to PI when underwent single segment lumbar TLIF surgery. This will help us use the PI predict the type of the lumbar curve and the formulation of the individualized surgical treatment programs suit for the patients.

Keywords: Lumbar function curve; Lumbar degenerative disease; Lumbar sagittal parameters

Vitamin-D Levels and Low Back Pain in Patients Presenting to a Tertiary Care Hospital

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Background: Chronic lower back pain is one of the most common complains which warrants visits to the outpatient clinic.

Methods: This descriptive study was conducted from 20th March 2016 to 19th March 2017. All patients presenting with low back pain for less than 6 months aged between 15–55 years were included. Patients having disc prolapse, spinal stenosis, and degenerative pathologies of spine or any signs of neurological involvement were left out of the study. Venous blood (5 mL) was withdrawn from each patient and serum vitamin-D levels measured. Results interpreted as follows: if levels were less than 30 ng/dL, they were termed as deficient. Deficiency was further categorized into mild, moderate, and severe for levels between 20–30 ng/dL, 10–19.9 ng/dL, and <10 ng/dL, respectively. If vitamin-D level between 30–100 ng/dL, termed as sufficient. And if >100 ng/dL, labelled as vitamin-D excess.

Results: A total of 600 patients who fulfilled the inclusion criteria were included in the study. Out of the total, 337 (56.17%) were males and 263 (43.83%) females. Mean age of patients included was 44.21±11.92 years. Patients were divided into age groups of 15–25, 25–35, 35–45, and 45–55 years. Patients with low back pain belonged to having deficient vitamin-D levels belonged to the younger age group (range, 15–35 years; 49.7%). Out of the total, 20.67%, 26.17%, and 28.83% had mild, moderate, and severe vitamin-D deficiency, respectively. The most predominant risk factor in patients with low vitamin-D levels was smoking (21.33%).Predominantly patients with severe vitamin-D deficiency presented in winters (October–

February, 17.16%) as compared to other seasons.
Conclusions: Vitamin D plays a crucial role in the musculoskeletal framework of the body. The deficiency is more prevalent in the youth due to sedentary lifestyle and indoor preference. Its low levels contribute to lower back pain by decreasing bone density, promoting micro fractures and other mechanisms which are yet understood.
Keywords: Low back pain; Venous blood; Vitamin-D

Diagnosis and Surgical Outcome of Upper Lumbar Herniated Disc: 47 Cases from 7,491 Patients Review

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Background: Upper lumbar herniated disc is clinically different from those occur at lower lumbar spine. The previous study had reported for a less frequency about 5%. Due to the unique anatomical feature of narrower spinal canal and shorter lamina over upper lumbar, clinical symptoms are more non-specific. The achievement of precise diagnosis and surgical outcome was not well known. In this study, we recorded the diagnosis and the surgical outcome for upper lumbar disc herniation.
Methods: We retrospectively reviewed 47 patients diagnosed of upper lumbar herniation and received surgery in our institution from 2013 to 2017. The herniations level were L1–L2 in 8 patients and L2–L3 in 38 patients. One patient had both L1–L2 and L2–L3 lesions. Clinical symptoms and signs, image characteristics, surgical method, and prognosis were reviewed by chart and investigated.
Results: The average age was 56.1 years. The major symptom in upper lumbar disc herniation was back pain, recorded in 39 patients. Radiating pain to lateral or anterolateral thigh was another symptom that most patient had. One-third patients had neurologic deficit of muscle weakness at related key muscle. In this series, most patients received decompression procedure. Three patients received nerve block only, and the others received fusion surgery. Regarding the prognosis, around 80% patients felt satisfied with improved symptoms after surgical intervention. There was one residual disc, one recurrent disc herniation, and one recurrent sciatica and these patients received 2nd operation for the same level.
Conclusions: The diagnosis of upper lumbar herniation was more difficult than lower lumbar herniation by history or physical examination due to the variation of the symptoms and signs. In this series, most patients had satisfactory outcome after receiving surgical intervention.
Keywords: Upper lumbar; Herniated disc; Surgical outcome

A Case of Lumbar Disc Hernia in Nerve Root Anomaly

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Background: Typical neurological symptom is decided by the level of disc hernia. However, there is discrepancy between symptoms and morbid level in the patients of nerve root anomaly (NRA). And NRA is not rare.
Methods: The case was 67-year-old male. Left leg pain arose on him 8 months ago and lumbar disc hernia in left L4/5 was diagnosed by other hospital. He received conservative treatment in admission and recovered. Recurrence of lumbar and leg pain occur 1 month ago, and he admitted again. His symptom was pain from the buttocks to posterior thigh and posterior/lateral lower leg and sole, atypical L4/5 disc hernia. Coexistence of L3/4 disc hernia was assumed, and conservative therapy was continued. Though the speed of improvement was slow, he hoped to be treated as surgery. Then he was transfered to our hospital. On magnetic resonance imaging, caudally migrated disc fragment compressed the nerve roots in L4/5 level. One of the roots was followed caudally, and it was revealed as S1 root. The NRA was diagnosed, as cranial origin of nerve root.
Results: Disc hernia was planed to be removed between L5 and S1 root. This approach was via axilla of L5 root, so bleeding from venous plexus was predicted. Additionally,

dural tear by S1 root retraction was predicted. Surgical procedure was performed meticulously, and disc hernia was removed as planed. His symptom had improved immediately.

Conclusions: For the surgery of lumbar disc hernia with conjoined nerve root, which is thick and most frequent as NRA, wide bone window is needed. And sometimes facetectomy and pediclectomy is necessary. For the NRA like this patient, type 2a of Kadish classification for NRA, the width of bone window is same for normal. However, excess retraction of nerve root is possibly risky. Diagnosis of neurological and radiological should be performed carefully.

Keywords: Cranial origin root; Lumbar disc hernia; Nerve root anomaly

Back Pain with Degenerative Scoliosis Treated with Triple Modalities Guided Radiofrequency Ablation: Case Series with Preliminary Results

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Background: Balanced degenerative scoliotic patients with back pain with or without focal neurological signs were sometimes treated with large scale deformity correction surgery. However, postoperative morbidity even mortalities were noted. Facet syndrome and sacroiliac syndrome could be found and treated on these patients and lower their backpain to a certain degree. This study is aimed to study the effect of back pain of degenerative scoliotic patients treated with radiofrequency ablation.

Methods: The prospective study of non-randomized case series from a single hospital by a single surgeon (author) from May 2017 to January 2018 was conducted. Patients diagnosed with degenerative scoliosis on plain film with symptoms of low back pain for more than 2 months were enrolled and patients who had focal neurological signs or could not finish the complete follow-up were excluded. Patients were followed up to 6 months (immediate postoperative, postoperative 1, 3, 6 months) and Visual Analog Scale (VAS), 36-item Short-Form Health Survey, Oswestry Disability Index (ODI), and Japanese Orthopaedic Association (JOA) scores were recorded. Radiofrequency ablation was done with fluoroscopic, ultrasound, and sensory-motor stimulation guidance.

Results: Consecutive 10 cases of (male:female=1:9; average age, 82±2 years; Cobb angle=25°±5°) were enrolled. VAS, JOA score, and ODI revealed major improvements comparing preoperatively and postoperatively conditions (Mann-Whitney *U*-test). No severe complications were noted.

Conclusions: Balanced degenerative scoliotic patients with back pain could have relief of partial back pain by treating facet and sacroliliac pain with radiofrequency ablation as an alternative or an analgesics treatment before they underwent large scale deformity correction surgery.

Keywords: Degenerative scoliosis; Radiofrequency ablation; Back pain; Facet syndrome; Sacroiliac syndrome

Bertolotti Syndrome Treated with Tripple Modalities Guidance Radiofrequency Ablation: Case Series and Technical Note

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Background: Bertolotti syndrome as known as transitional vertebrae has a rather high incidence and had been associated with low back pain. Facet syndrome and sacroiliac syndrome could be found and treated on these patients and lower their back pain. This study is aimed to study the effect of back pain of patients with Bertolotti syndrome treated with radiofrequency ablation.

Methods: The prospective study of non-randomized case series from a single hospital by a single surgeon (author) from May 2017 to January 2018 was conducted. Patients diagnosed with Bertolotti's syndrome on plain film with symptoms of extensional low back pain for more than 2 months were enrolled and patients who had focal neurological signs or could not finish the complete follow-up were excluded. Patients were followed up to 6 months (immediate postoperative, postoperative 1, 3, 6 months) and Visual Analog Scale (VAS), 36-item Short-Form Health Survey, EuroQol-5D, Oswestry Disability Index (ODI), and Japanese Orthopaedic Association (JOA) scores were recorded. Radiofrequency ablation was done with fluoroscopic, ultrasound, and sensory-motor stimulation guidance.

Results: Consecutive 10 cases of (Male:female=1:9; average age, 82±2 years; Bertolotti syndrome IB IIB IIA, 25±5) were enrolled. VAS, JOA score, and ODI revealed major improvements comparing preoperatively and postoperatively conditions (Mann-Whitney *U*-test). No severe complications were noted.
Conclusions: Patients with Bertolotti's syndrome and low back pain could have relief partial of back pain by treating facet and sacroliliac pain with radiofrequency ablation as an alternative or an analgesics treatment before they underwent large scale deformity correction surgery.
Keywords: Bertolotti's syndrome (transional vertebrae); Radiofrequency ablation; Back pain; Facet syndrome; Sacroiliac syndrome

The Long-term Clinical Efficacy of Single Segment Lumbar 4–5 Fusion and Its Effect on the Lumbar-Pelvis Sagittal Alignment Parameters

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Background: The effect of lumbar fusion of single segment 4–5 (SL4–5) with lumbar healthy adjacent segments on the lumbar-pelvis sagittal alignment parameter, radiographic adult spinal deformity (rASD), and its clinical efficacy was discussed according to lumbar types (Roussouly type).
Methods: Fifty-one patients with lumbar fusion of SL4–5 (25 males and 26 females, 43.45±9.7 years old). They were categorized to four types according to the types of Roussouly. Compared the Visual Analog Scale (VAS), Oswestry Disability Index (ODI), and Japanese Orthopaedic Association (JOA) scores, pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), lumbar lordosis (LL), UP arc and intervertebral lordosis of lumbar 4–5 (intervertebral angle [IVA] 4–5), C7 plumb line/sacro-femoral distance ratio (C7PL/SFD ratio) of the patients in the preoperative, postoperative, and final follow-up were measured. was adopted to evaluate ASD before the surgery, and the UCLA Grading Scale and intervertebral stability criteria of lumbar degeneration were introduced to evaluate ASD after the operation.
Results: Type I: there were significant improvement (p<0.01) in LL, UP arc, IVA4–5 and SS in postoperative and final follow-up. Type II and III: IVA4–5, LL, and UP arc were significantly improved (p<0.05) in the postoperative and final follow-up, while the SS, PT, and PI showed no significant differences. Type IV: The IVA4–5 (p<0.05) significantly increased comparing to the preoperative, but no significant difference in LL, UP arc, SS, PT, and PI. The ratio of C7PL/SFD was significantly decreased in all types. Postoperative and follow-up of patients had significant improvement over preoperative in VAS, ODI, and JOA scores. The general prevalence of rASD was 17.64% in all patients, and age, follow-up time, PI, IVA4–5 was major factor.
Conclusions: SL4–5 can significantly increase IVA4–5, but have different effects to spine-pelvis sagittal alignment parameters according to types of Roussouly. IVA4-5 is a significant risk factor, and the greater the age, the longer follow-up time, and higher PI values are more prone to rASD. The view of selecting the appropriate intervertebral fusion angle is possible to change the adjacent segment degeneration process, reduce the incidence of rASD, and improve patient prognosis.
Keywords: Lumbar fusion; Lumbar-pelvis sagittal alignment parameters; Adult spinal deformity

Study on the Relationship between the Facet Joint Orientation and Sagittal Parameters of Degenerative Spondylolisthesis

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Background: Degenerative spondylolisthesis (DS) is common and most studies suggest the sagittal orientation of facet joint is an important factor of occurrence and development of DS. We studied the facet joint orientation, sagittal parameters, and compensatory mechanism of DS patients.
Methods: A total of 46 patients (DS group, 16 males and 30 females with the age of 50.1±9.6 years) and 46 DSS patients matching sex and age were enrolled in the study. Measured parameters are as follows: sagittal vertical axis, thoracic kyphosis, lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), sacral slope, PI-LL, degree of spondylolisthesis, bilateral L4–5 facet joint orientation, tro-

pism and degenerative grade of facet joint. DS group was divided into group A and group B according to the facet joint orientation, group A <36.5° and B ≥36.5°. We analyzed the difference of facet joint orientation and sagittal parameters between different group and studied the relationship.

Results: The PI, LL, PT, and PI-LL of DS group were greater than those of DSS group (p<0.05) and the mean value facet joint orientation in DS group (36.5°) was smaller than that in DSS group (43.2°, p=0.04). The degree of spondylolisthesis in DS group was 0.24°±0.15°. PI and facet joint orientation were related to the degree of spondylolisthesis (r=0.561, r=-0.631; p<0.05). The facet joint orientation was correlated with PI, LL, PT, PI-LL, and was strongest correlated with PT and PI (r=-0.642, p<0.01). The degree of spondylolisthesis, PI, PT, and PI-LL, and PT/PI in group A were higher than group B (p<0.05).

Conclusions: DS patients are great PI, seriously sagittal orientation, and high degeneration grade of facet joint. Great PI and sagittal orientation of facet joint may be the common cause of the occurrence and development of DS. The orientation of facet joint was significantly correlated with PI, LL, PT, PI-LL, and PT/PI. The patients with heavily sagittal orientation of facet joint tend to spondylolisthesis severely.

Keywords: Degenerative spondylolisthesis; Facet joint; Sagittal alignment

Does Multilevel Lumbar Stenosis Relate to Poorer Clinical Outcomes?: A Correlation Study of Standing Magnetic Resonance Imaging Findings and Multilevel Stenosis Symptoms

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Background: Lumbar spinal stenosis has shown improved clinical correlation with findings of standing magnetic resonance imaging (MRI). However, the impact of multilevel stenosis was unknown. We assessed the relationship between clinical features, dural sac cross sectional area (DSCA), and multilevel stenosis in this prospective study.

Methods: This is a subanalysis of a clinical correlation study of standing MRI. Sixty-eight patients with neurogenic claudication were included to undergo a 0.25-T MRI exam performed in supine and standing positions. Clinical features including body mass index (BMI), duration, walking distance, leg pain Visual Analog Scale, Chinese Oswestry Disability Index (CODI), and 12-item Short-Form Health Survey were assessed. DSCA of the most constricted and the next stenotic levels were measured and correlated with each feature by correlation coefficients (r). The number of stenosis levels with DSCA ≤75 mm^2 and the presence of spondylolisthesis were studied.

Results: Standing MRI diagnosed 22% more cases of multilevel stenosis than supine MRI. Dynamic narrowing of dural sac on standing happened in multilevel stenosis as in overall spinal stenosis (r=0.88, p<0.0001). DSCA at the most constricted level was smaller on standing MRI than on supine MRI (r=0.79, p<0.0001). This is also true the next stenotic level (r=0.69, p<0.0001). Shorter walking distance correlated with smaller DSCA in either single-level stenosis (r=0.44, p=0.005) or multilevel stenosis (r=0.45, p=0.014). The minimal DSCA associated with BMI (r=-0.44, p=0.018) and duration of symptom (r=-0.41, p=0.027) only in multilevel stenosis patients. Smaller DSCA in the next stenotic level correlated with worse leg pain (r=-0.41, p=0.027). Patients with multilevel stenosis showed less disability (r=-0.27, p=0.025) despite having smaller DSCA than patients with single-level stenosis (p<0.0001).

Conclusions: Standing MRI is efficient to uncover multilevel stenosis with limited walking ability. The significant correlations of BMI, duration, and less functional disability with multilevel stenosis reflect the dural-sac adaptation capability for chronic compression. Since the next stenotic level associated with radicular leg pain, better-defined diagnosis of multilevel stenosis influences surgical decision and outcome.

Keywords: Functional magnetic resonance imaging; Lumbar stenosis; Multilevel; Clinical outcome

Can the Conventional Magnetic Resonance Imaging Substitute for the Three-Dimensional-MRI to Diagnose Lumbar Foraminal Stenosis?

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Background: The diagnosis of lumbar foraminal stenosis (LFS) is still difficult. We have reported the utility of three-dimensional (3D)-magnetic resonance imaging (MRI) by calculating a novel diagnostic parameter, foranimal stenotic ratio (FSR), which indicate the degree of fat obliteration in the neural foramen. However, measurement of FSR is bothersome and taking a few minutes. The purpose of this study was to investigate whether the conventional MRI substitute for the 3D-MRI on evaluation of FSR.

Methods: A total of 46 patients, 92 foramina at L5–S, were investigated in this study. This study included consecutive patients who were performed both 3D-MRI and conventional T1 or T2 sagittal MRI for lumbar degenerative disorders. Patients who underwent surgery at L5–S or implantation at L5 were excluded. FSR were calculated by the reported methods on reconstructed images using 3D-MRI (3D-FSR). FSR were also evaluated by ratio of slices which showed fat-obliteration around nerve root to the slices of neural foramen on parasagittal images using conventional MRI (con-FSR). Difference and correlation between 3D-FSR and con-FSR were evaluated.

Results: The average evaluated slices per a foramen were 20.0 by 3D-FSR and 3.6 by con-FSR. As a whole, the difference absolute value between 3D-FSR and con-FSR was 10.9% and correlation coefficient was strong (0.883, $p<0.001$). In patients with con-FSR <50%, the difference was 4.6% and correlation coefficient was 0.791. In contrast, the difference was 25.2% and correlation coefficient was 0.418 in patients with con-FSR ≥50%. All patients requiring surgery were indicated ≥50% both on 3D-FSR and con-FSR.

Conclusions: The con-FSR were sufficiently reliable for 3D-FSR in patients with <50%. However, the reliability was weak in patients with ≥50%. Patients with 3D-FSR ≥50% were reportedly likely to require surgical treatment. Therefore, in case with suspected LFS on conventional MRI, the additional 3D-MRI evaluation were recommended.

Keywords: Magnetic resonance imaging; Lumbar foraminal stenosis; Three-dimensional Conventional

Radiologically Defining Horizontal Gaze Using EOS Imaging: A Prospective Study Of Healthy Subjects and a Retrospective Audit

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Background: As sagittal alignment of the cervical spine is important for maintaining horizontal gaze, it is important to determine whether the latter has be achieved when evaluating radiographs for cervical alignment. This study aims to establish radiological criteria for horizontal gaze as it currently remains poorly defined.

Methods: A prospective cohort of 67 healthy patients was recruited over a month. Each patient underwent EOS radiographs taken in a directed standing posture. Horizontal gaze was radiographically defined using each of the six parameters tested, as represented by means, 95% confidence interval (CI), and 2 standard deviation (2SD). Subsequently, applying the radiographic criteria, a retrospective audit of such radiographs (prior to the implementation of strict radioimaging standardization) was conducted to determine the incidence of horizontal gaze.

Results: The four parameters with the lowest 95% CI and 2SD were the distance offsets of the midpoint of the hard palate (A), and the base of the sella turcica (B), as well as the horizontal convergents formed by the tangential line to the hard palate (C), and the line joining the centre of the orbital orifice with the internal occipital protuberance (D). In the prospective cohort, good sensitivity (>98%) was attained when two or more parameters were used. Audit using criteria B+D yielded compliance rates of 76.7%–close to that of A+B+C+D (74.8%). Criteria B+D, when applied to EOS radiographs, is most feasible for clinical use, and can be simplified to the "3-6-12 rule" as a form of cursory assessment. Verbal instructions without stringent postural checks only yielded approximately 75% horizontal gaze compliance.

Conclusions: Fulfilment of criteria B+D is sufficient to evaluate for horizontal gaze. A radiological definition of horizontal gaze should be routinely applied for better evaluation of sagittal spinal alignment.
Keywords: Horizontal gaze; EOS; Imaging protocol; Radiological definition

Comparing EOS and X-Ray for Evaluation of Adolescent Idiopathic Scoliosis

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Background: There is increasing use of EOS imaging in place of the conventional 91.44-cm long cassette X-rays for assessing spinal alignment. This study aims to compare EOS® with conventional X-rays to enable cross-interpretation between both imaging modalities.

Methods: A comparative study of prospectively-collected data of 148 adolescent idiopathic scoliosis patients was conducted. Each patient had a set of EOS and X-ray images taken in random order, <1 month apart. Coronal and sagittal parameters based on the Lenke and Scoliosis Research Society–Schwab classifications were measured. Separate analyses of all patients, Lenke 1 patients only, and both Lenke 1 and 2 patients were performed. The McNemar test, Wilcoxon signed-rank test, and paired *t*-test were used to analyze dichotomous, ordinal, and continuous variables, respectively.

Results: All patients demonstrated more rightward truncal shift (p=0.01) as well as larger proximal and main thoracic curves (p=0.03 and p=0.005, respectively) with EOS as compared to conventional X-rays. For the Lenke 1 and 2 subgroups, more caudal stable and touch vertebrae (p=0.005 and p=0.008, respectively) were also found. Variations in radiographic shoulder and hip prominences were observed. EOS showed less negative spinal balance, larger lumbar lordosis, and smaller pelvic tilt than conventional X-rays. Thoracolumbar alignment was more lordotic for the Lenke 1 and 2 subgroups (p=0.03). End and apical vertebrae were not significantly different across imaging modalities, with the exception of the lumbar apical vertebrae (p<0.001). However, this difference was not clinically appreciable as both modalities demonstrated a median apical vertebra at L3.

Conclusions: Discrepancies between EOS and conventional X-rays need to be considered when managing patients with adolescent idiopathic scoliosis.
Keywords: Adolescent idiopathic scoliosis; Coronal alignment; EOS imaging

Fulcrum Bending to Generate Maximum Extension of the Spine and Hip: A New Strategy using EOS Imaging for Patient-Specific Adult Spinal Deformity Surgical Planning

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Background: Lordotic restoration of the lumbar spine, a key strategy to improve patient-reported outcomes in adult spinal deformity surgery, is poorly understood. Recent recognition of the hip as an important contributor to whole body lordosis rather than a compensator for spinal imbalance has improved this understanding. This study aims to compare the fulcrum extension with conventional extension imaging posture in determining hip lordosis and other contributors to body lordosis.

Methods: This was a retrospective, radiographic comparative study conducted in a single, academic institution. Patients >45 years of age with mechanical low back pain due to degenerative spinal conditions were included in the study. They were grouped based on the imaging performed—fulcrum extension or conventional extension. All imaging were performed using the EOS slot scanner, and under standardised verbal instructions supplemented with visual aids. Radiographic parameters including global lordotic angle (GLA), segmental lumbar angles, pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), femoral alignment angle (FAA), hip lordosis, and spino-cranial angle (SCA) were measured and compared.

Results: A total of 100 patients (40 males and 60 females) with a mean age of 63 years underwent fulcrum or conventional extension EOS imaging. Both groups had

comparable baseline radiographic parameters. Fulcrum extension gives a larger GLA (-60.71° vs. -48.53°) and inf-S1 angle (-58.76° vs. -48.77°) than conventional extension. It also gives larger L5/S1 and L4/5 lordosis compared to conventional extension (-22.3° vs. -17.1° and -20.7° vs. -17.7°), respectively. SS, PT, FAS, and hip lordosis were similar between both postures. However, SCA, a parameter reflective of whole body functional lordosis, is significantly larger in fulcrum extension (-36.5° vs. -24.8°).

Conclusions: Fulcrum extension is better than conventional extension, in generating more lordosis in the lower lumbar spine. Both methods are equally effective in the study of patient-specific maximum hip lordosis via assessments of PT and FAA, which will in turn impact on management strategies for patients with adult spinal deformity.

Keywords: Adult spinal deformity; EOS; Extension X-rays; Fulcrum bending; Hip lordosis

Normal Variation in Sagittal Spinal Alignment Parameters in Adult Patients: An EOS Study Using Serial Imaging

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Background: Weight-bearing, lateral whole body X-rays are increasingly performed for evaluation of spinal deformity. This was made possible with the advent of EOS slot scanning technology, which produces true-to-proportion and true-to-dimension images for assessment of whole body alignment. However, the reference ranges for its sagittal parameters have not been established. We aim to describe normal variations in sagittal spinal radiographic parameters over an interval period and establish physiological norms and guidelines for interpretation of these images.

Methods: Data was prospectively collected from a continuous series of adult patients with first-episode mild low back pain presenting to a single institution. The sagittal parameters of two serial radiographic images taken 6-month apart were obtained with the EOS slot scanner. Measured parameters include cervical lordosis (CL), thoracic kyphosis (TK), thoracic lumbar (TL), lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), and end and apical vertebrae. Wilcoxon signed-rank test and chi-square test were used to compare categorical and continuous variables.

Results: Sixty patients with a total of 120 whole-body sagittal X-rays were analysed. Mean age was 52.1 years (standard deviation [SD]=21.2). Mean interval between the first and second X-rays was 126.2 days (SD=47.2). Small variations (<1°) occur for all except PT (1.2°), CL (1.2°), and sagittal vertical axis (SVA, 2.9 cm). PT showed significant difference between two images (p=0.035). Subgroup analysis based on the time interval between X-rays, and between the first and second X-rays, did not show significant differences. Consistent findings were found for end and apical vertebrae of the thoracic and lumbar spine between the first and second X-rays for sagittal curves.

Conclusions: Radiographic sagittal parameters vary between serial images and reflect dynamism in spinal balancing. SVA and PT are predisposed to the widest variation. SVA has the largest variation between individuals of low PT. Therefore, interpretation of these parameters should be patient-specific and rely on trends rather than a one-time assessment.

Keywords: EOS; Low back pain; Radiographic parameters; Sagittal spinal alignment; Serial imaging

Whole Body Sagittal Alignment during Directed versus Natural Standing Postures: An Introduction to the Concepts of Ligamentous-Muscular Counterbalancing

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Background: Radioimaging for adult spinal deformity is conventionally performed in a directed manner to assess the patient's most upright standing posture. However, this method does not reflect an individual's habitual posture—the posture a patient likely reverts to post-operatively, and also the posture likely to explain existing spinal pathology. The objective of this study was to identify radiographic differences between directed and natural standing.

Methods: This was a prospective study which comprised 60 young healthy adults. EOS whole spine radiographs of patients in directed standing and natural standing postures were obtained, and sagittal radiographic parameters were measured. Univariate analysis using Wilcoxon signed-rank test paired *t*-test, and paired chi-square tests were used to compare parameters between postures.

Results: Compared to directed standing, natural standing had a more positive mean sagittal vertical axis (9.6±35.3 vs. -0.3±24.2), less global lumbar angle (-44.8±13.0 vs. -50.6±11.6), larger global thoracic angle (44.4±11.5 vs. 26.1±11.4), larger thoracolumbar kyphosis (12.1±8.7 vs. 2.2±8.0), higher T1-slope (30.1±9.0 vs. 15.2±7.4), and a caudal shift in thoracolumbar inflexion point (L1 vs. T12). More subjects assumed a lower Roussouly type curve in their natural standing postures (p<0.001).

Conclusions: The clear distinction between directed and natural standing postures can be explained by our natural tendency to conserve energy via ligamentous-muscular counterbalancing while staying within the cone of economy. Additionally imaging subjects in their natural standing posture allows better appreciation of pathology and anticipation of postoperative problems. In particular, the radiological findings suggest a need for smaller lumbar lordosis, and concentration of lordosis in the lower lumbar spine.

Keywords: Energy conservation; Femoral extension; Sagittal imbalance; Spinopelvic compensation; Pelvic incidence

Intervertebral Cages for Lordosis or for Optimal Anterior Support?: Recommendations from a Radiographic Study Using Dynamic Stress X-rays Performed in Key Physiological Postures

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Background: The weight-bearing properties of the spine vary with alignment changes across various postures. This study investigates how intervertebral cage positioning can help maintain optimal anterior support for each functional spinal unit based on their weight-bearing properties in commonly assumed flexed, neutral, and extended spinal postures.

Methods: This was a single-centre radiographic comparative study of prospectively collected data. We recruited healthy young patients with non-specific low back pain of less than 3 months duration. Each patient underwent a series of three EOS X-rays taken in the flexed (slump sitting), neutral (standing), and extended (backward bending) positions, plus a lumbar spine magnetic resonance imaging, enabling assessment of the extent of disc degeneration. Radiographic measurements for global/segmental angles and disc heights were compared between postures. Alignment-specific weight-bearing axes of each lumbar intervertebral level were determined from the changes in disc height relative to the neutral standing posture.

Results: Eighty-three healthy young patients with 415 lumbar intervertebral discs were studied. Disc height measurements showed the weight-bearing axis—the ideal location for cage placement—to be more anterior in a flexed spine and more posterior in an extended spine in order to provide optimal anterior column support. To recreate standing lordosis, intervertebral cages should be placed within the mid-zone or slightly posterior along the endplates.

Conclusions: Intervertebral cage placement should be alignment- and level-specific, and this is in turn dependent on the surgical strategy for fusion. The findings of this study show the weight-bearing axes at each lumbar intervertebral level in different postures, and provides surgeons with a level-specific range of cage positions to choose from, depending on the extent of lordosis intended for said level. Awareness of the weight-bearing axes in different extents of lumbar lordosis can help surgeons achieve their desired amount of correction while respecting the need for anterior column support.

Keywords: Cage position; Lumbar spine; Deformity; Functional spinal unit; Weight-bearing

Comparison of Artefacts in Magnetic Resonance Scanning of Polyetheretherketone and Titanium Implants in Both Pig and Human

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Background: Spinal stereotactic body radiotherapy (SBRT) delivers high doses of radiation and it is highly conformally focusing the radiation dose on the metastatic bone while sparing spinal cord. Postoperative SBRT dose planning relies on computed tomography (CT) and magnetic resonance imaging (MRI) imaging. Polyetheretherketone (PEEK) is a new material of radiolucent character. Aim is to compare the artefacts in CT and MRI scans caused by PEEK and titanium rods implanted in pigs and humans.

Methods: In the pig spine specimen three groups of implants were sequentially inserted: two titanium rods; one titanium rod and one PEEK rod; and two PEEK rods. CT and MRI scans were acquired of all groups. A region of interest (ROI) was defined in order to measure the imaging noise caused by the rods. CT Hounsfield units (HU) were measured in ROIs and the image-noise were compared by calculating artefact density standard deviation (SD). The accuracy of spinal cord identification on MRI scans was compared on two patients who underwent spinal stabilisation.

Results: In the CT scans of pig specimen, the image-noise (artefact density standard deviation) was 63.5 HU for the titanium rods and 6.2 HU for the PEEK rods. There was a significant difference in image-noise between the two groups (p<0.01). The artefacts in the CT scans caused by the implanted rods were considerably lower for PEEK than for titanium. For the two patients with respectively implanted PEEK and titanium rods, it was only possible to identify the spinal cord for the patient with PEEK implants.

Conclusions: PEEK rods created significantly less artefacts than Titanium rods in both CT and MRI scans, thus enabling more accurate spinal cord definition before SBRT. By using this new material, patients could benefit from a more precise and secure SBRT treatment with less risk of radiation induced side-effects.

Keywords: Spinal stereotactic body radiotherapy; Polyetheretherketone; Spinal tumor

Analysis of Fracture Patterns in Nuclear Medicine Imaging and Risk Factors of Sacral Insufficiency Fracture: Does the Sacral Fractures in Lumbosacral Fusion Be an Insufficiency Fracture or a Stress Fracture?

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Background: The purpose of this study is to investigate risk factors associated with the development of sacral insufficiency fractures to improve diagnosis in clinical practice.

Methods: Patients who suffered sacral insufficiency fracture between June 2010 and December 2016 underwent consecutive radiological assessments. The study population was divided into lumbosacral fusion group (n=16) and non-fusion groups (n=30). Patient description, physical examination findings, administering drugs, imaging, follow-up, and risk factors were assessed. Patients were grouped by plain radiography with at least one of following diagnostic imaging including. Magnetic resonance imaging, computed tomography, bone scan, single photon emission competed tomography were performed for evidence of sacral insufficiency fractures.

Results: Forty-six patients for treatment of sacral insufficiency fracture were enrolled. The mean age of non-fusion group is 75.8±9.8 years and that of fusion group is 66.6±9.1 years (p=0.003). The mean body mass index of non-fusion group is 21.4±3.8 kg/m^2 and that of fusion group is 24.6±3.34 kg/m^2 (p=0.010). The mean bone mineral density of spine in non-fusion group is 0.788±0.134 g/cm^2 and that of fusion group is 0.996±0.202 g/cm^2 (p=0.001). The mean T-score in non-fusion group

is -2.55±1.23 and that of fusion group is -1.16±1.59 (p=0.007). Twenty-one patients had osteoporosis medication, 11 of 30 non-fusion group (10 bisphosphonate, one raloxifene), and 10 of 16 in fusion group (nine bisphosphonate, 1 raloxifene). The mean dose-length of osteoporosis medication in non-fusion group is 3.45±3.08 years and that of fusion group is 8.1±5.04 years (p=0.024). There is no statistically significant difference between patients' lower segment of fusion to sacral and L5.

Conclusions: Sacral insufficiency fractures develop in younger patients who had lumbosacral fusion. It takes about 10 years from fusion to injury. There is no statistical difference whether patients have been taken osteoporotic medication. The sacral insufficiency fractures develop despite the bone mineral density is statistically higher in lumbosacral fusion patients.

Keywords: Sacral insufficiency fracture; Nuclear medicine imaging; Stress fracture

Spinal Cord Infarct after Transarterial Embolization for Metastatic Spinal Tumor

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Background: Transient decreased muscle power after transarterial embolization (TAE) as a result of spinal infarct has never been reported to our knowledge. We described a case with transient decreased muscle power (as short as 2 hours) after TAE as a consequence of spinal infarct.

Methods: This 30-year-old female patient with pheochromocytoma with bilateral lung and bone metastases. She suffered from back pain around upper third of thoracic area. Magnetic resonance imaging revealed paraspinal and epidural soft tissue lesion at T2–T4 levels with nerve root and spinal cord compression. Operation is indicated and TAE with embozene 400 micrometer was arranged first in order to prevent bleeding during operation. Tumor stain was noted at bilateral T2–T4 paraspinal regions supplied by branches of bilateral subclavian arteries, right T3–T4 segmental artery, left T2 and T3 segmental arteries and thus these arteries were embolized with Embozene 400 microns. The procedure finished at around 14:00 and bed rest with right inguinal compression till 18:00. However, right ankle decreased muscle power (0/5) in dorsiflexion and plantarflexion was noted at 20:30. Right deltoid region tingling pain, left foot sole and left hand palm numbness was also mentioned with right deltoid region numbness. Emergent MRI showed focal spinal cord infarct at right aspect of C5 and left C4 levels.

Results: After performing MRI (about 22:15), muscle power recovered by itself (3/5). Posterior instrumentation, posterior decompression and tumor debulking was performed as scheduled. One week later, she can stand up and walk by her own self.

Conclusions: To our knowledge, there had been no any transient muscle power loss reported after spinal infarct caused by TAE. Our case regained her muscle power immediately without any medication. We luckily found out the symptoms and thus discovered the fact of spine infarct with immediately arrangement of MRI.

Keywords: Spinal cord infarct; Transarterial embolization; Spinal tumor

Lumbar Intervertebral Height Index, Intervertebral Angle and Lumbar Lordosis Angle in Normal Imaging Population

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Background: There is no standard measurement of intervertebral height and lacking of large-scale epidemiological study epically in normal population. This study is aimed at measuring the intervertebral height index (IHI), intervertebral angle (IVA) in every lumbar segment, and lumbar lordosis (LL) in normal imaging population, and analyzing its characteristics.

Methods: Collecting outpatiens who underwent standard lateral X-ray, lumbar magnetic resonance imaging and show no obvious disease and Pfirrmann scale (P-G) were less than or equal to II grade. A total of 303 people (144 male, 159 female) were divided into five groups according to age: young group (range, 20–29 years old; 56 cases); young and middle aged group (range, 30–39 years old; 59 cases); middle aged group (range, 40–49 years old; 83 cases); middle aged and aged group (range, 50–59 years old; 57 cases); and aged group (over 60 years, 48 cases). Measured parameters were as follows: IHI, IVA in every lumbar segment, and LL. The changes were analyzed.

Results: IHI in different lumbar segment was as follows:

L1–2, 22.98°±3.2°; L2–3, 26.32°±3.3°; L3–4, 29.09°±3.2°; L4–5, 32.26°±3.4°; and L5–1, 34.02°±4.7°. The IHI is gradually increased from L1–2 to L5–S1 (p<0.05). Comparing the different in different age, gender, and P-G groups in the same segment, there is difference in IHI, but no statistical significance (p>0.05). IVA in different lumbar segement and LL L1–2, 4.08°±2.4°; L2–3, 5.98°±2.9°; L3–4, 7.49°±3.1°; L4–5, 9.55°±3.8°; L5–1, 13.72°.±4.8°; and LL, 39.42°±14.5°. The IVA is gradually increased from L1–2 to L5–S1 (p<0.05). Comparing the different age groups, there is significant difference (p<0.05) in IVA at L2V3, L3–4, L4V5 segments and LL, but no statistical significance in L1V2, L5VS1 segments (p>0.05).

Conclusions: This study get the normal range of IHI, IVA in every lumbar segments, and LL in normal imaging population. At low grade degeneration disc, the lumbar spine IHI remained unchanged and did not vary with age or gender. The changes of IVA and LL in each segment of the lumbar spine varied with age. After entering the middle-aged group, the angle gradually increased with age.

Keywords: Intervertebral disc height index; Lumbar degeneration; Disc degeneration; Pfirrmann scores

The Relationship between Intervertebral Disc Height Index and Pfirrmann Grading of Lumbar Intervertebral Disc

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Background: The widely used to assess the disc degeneration in magnetic resonance imaging (MRI) is Pfirrmann grading system. But there is no standard measurement to sensitive measure the change of intervertebral height. This study aimed at analyzing the correlation between the lumbar intervertebral height index (IHI) and the Pfirrmann grading system and establish a regression formula to improve the system at lacking of quantitative evaluation in intervertebral disc height.

Methods: A total of 213 patients (110 males and 103 females; age, 49.5±10.3 years old) who underwent lumbar spine surgery in Xijing Hospital were collected. All of them had standard lateral X-ray film and lumbar spine MRI examine. Three experienced physicians measured intervertebral height index (IHI4–5) and L4–5 segment Pfirrmann's grade (P-G) in lateral X-ray film and MRI, respectively. The correlation between the IHI4-5 and the P-G were investigated, and a linear regression fitting formula was analyzed and established in this study.

Results: The intraclass correlation coefficient was greater than 0.85 in the group and between the groups. Pfirrmann grade distribution were as follows: grade I, 15 cases; grade II, 68 cases; grade III, 72 cases; grade IV, 37 cases; and grade V, 21 cases. The different Pfirrmann grade's IHI4–5 were as follows: grade I, 34.04±4.3; grade II, 32.40±3.0; grade III, 28.89±2.9; grade IV, 24.04±2.6; and grade V, 21.68±4.0. IHI4–5 was not statistically significant between grade I and II (p>0.05). From grade II to grade V, the IHI4–5 was gradually decreased, and the difference was statistically significant (p<0.05). IHI4–5 was significantly related to Pfirrmann grade (r=0.77, p<0.01). A preliminary regression formula between IHI4-5 and Pfirrmann was as follows: P-G=7.571-0.159×IHI4–5 (adjusted R^2=0.601, p<0.01).

Conclusions: Lumbar intervertebral disc height index and Pfirrmann classification has certain correlation, regular Pfirrmann grade assessment lack of quantitative standard for disc height, and the regression formula is useful for the clinical work to assessment disc degeneration more accurately.

Keywords: Intervertebral disc height index; Pfirrmann score; Disc degeneration; Lumbar degeneration

Dynamic Change of the Cervical Canal Diameter During Motion: A Case-Control Study with the Help of Kinetic Magnetic Resonance Imaging

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Background: Dynamic compression of the cervical spinal cord is an increasingly popular concept assuming the diameter of the spinal canal will change while the cervical spine is moving.

Methods: Symptomatic patients and healthy volunteers were divided into two groups and had magnetic resonance imaging (MRI) images taken in three different positions of the neck: flexion, neutral, and extension. The space available for cord (SAC) was measured at the disc level from C2–3 to C7–D1 on the mid-sagittal cut of the T2

weighed image.

Results: There were 40 patients and 25 healthy volunteers who participated to our study. The mean age was 50 years for the patient group and 40 years for the control one. The mean SAC when the neck at flexion/neutral/extension positions of the patient group and control group was 10.82/9.84/9.01 mm and 12.2/11.42/10.24 mm, respectively, with statistically significant difference ($p<0.05$). The difference of the SAC between flexion and extension positions was 1.97 mm for the patient group and 1.62 mm for the control group without statistical difference ($p>0.05$). The cutoff point of the SAC was 11 mm with the sensitivity and specificity of 90% and 72%, respectively, which means individual with SAC measured on mid-sagittal plane at neutral position inferior than 11 mm has high risk of dynamic compression of the spinal cord when the neck in full extension.

Conclusions: The change of the SAC of the cervical spine during motion can be observed in both symptomatic patients and healthy individuals with similar degree. The evaluation of the SAC by using kinetic MRI can reveal hidden compression sites possibly overlooked in conventional MRI images and therefore provides additional informations necessary to the diagnosis and decision making.

Keywords: Dynamic compression; Kinetic magnetic resonance imaging

Facet Sagittal Orientation: Possible Role in the Pathology of Degenerative Lumbar Spinal Stenosis

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Background: Many studies have demonstrated the relationship between sagittal facet orientation and degenerative lumbar spondylolisthesis. However, the associations between facet orientation and degenerative lumbar spinal stenosis (DLSS) have rarely been studied.

Methods: Ninety-one age-matched and sex-matched patients with DLSS (LSS group) and 91 control participants were consecutively enrolled. Their lumbar facet angles and the dural sac cross-sectional area at L2–L3, L3–L4, L4–L5, and L5–S1 were measured using axial magnetic resonance imaging (MRI). The intersection angle of the midsagittal line of the vertebra to the facet line represents the orientation of the facet joint.

Results: The facet angles on the left side or right side of the LSS group were significantly smaller than the respective ones of the control group. Outcomes of the groups revealed significantly and consistently increasing facet angles from L2–L3 to L5–S1. The dural sac cross-sectional area of the LSS group had significantly smaller measurements values than that of the control group at L2–L3, L3–L4, L4VL5, and L5VS1.

Conclusions: Sagittalization of lumbar facet joints was considered to be a risk factor for DLSS and may play a role in the pathology of DLSS.

Keywords: Lumbar facet angle; Degenerative lumbar spinal stenosis; Sagittal orientation

Clinical Analysis of the Infectious Spondylitis

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Background: The infectious spondylitis is one of the common spinal disorders. According to the development of the antibiotics, it is reported that good results have been gained by the conservative treatment for this lesion. However, there are quite a few patients who need the surgical treatment because of their indications such as complication of paralysis, continuous severe pain, and intractable fistula and abscess. In this presentation, the clinical analysis of the infectious spondylitis is reported.

Methods: The clinical cases are 88 with infectious spondylitis. There were 55 males and 33 females. The diagnosis is as follows: pyogenic spondylitis 77 cases, tuberculous eight cases, and mycotic three cases. Their average age is 75.2 years old. Evaluation items are as fpllows: yearly change of the cases, age distribution, infected site of the spine, causative bacteria, basic disease, treatment methods, and prognpsis.

Results: According to the age distribution, most patient was popular over 60 years old. Infected site of the spine

was as follows: cervical 10 cases, thoracic 15 cases, thoracolumbar four cases, and lumbar 59 cases. Identification of bacteria throuh operation and biopsy was 57.8%. *Staphylococcus aureus* was the most popular bacteria and methicillin-resistant S. aureus was followed. Fifty-two cases were treated by conservative treament, 11 cases by percutaneous drainage, and 18 cases by operation. Prognosis was as follows: return to social life 64 cases, treatment for repeated recurrence nine, transfer to other insutitute five, and dead due to basic deserase 10.

Conclusions: Recent infections spondylitis is characterized by the increase of the elder patient, compromized host, and the patient unless acute inflammatory signs. Early diagnosis and early begging of the treatment are the most important for the infectious spondylitis. Conservative treatment using the sensitive antibiotics for the causative bacteria is the principle. Surgical treatment is indicated for the cases with the progressive paralysis, prolonged inflammatory sign, intractable fistula and abscess, and spinal deformity.

Keywords: Pyogenic spondylitis; Causative bacteria

The Usefulness of Serum Albumin and Globulin Levels in the Management of Pyogenic Spinal Infection

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Background: C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and white blood cells count (WBC) are regularly used to diagnose spinal infection and monitor the treatment response. The usefulness of serum albumin, globulin, and their ratio is not fully investigated.

Methods: Eighty-two inpatients of pyogenic spinal infection (SPI) diagnosed between 2006 and 2015 were reviewed. The inclusion criteria included typical clinical features with elevation of serum infective markers plus typical radiological features, positive blood culture, or positive biopsy results. All patients had complete set of blood tests from admission to satisfactory infection control. Only cases of single episode of SPI in the study period without recurrence in 2 years were included.

Results: The average age of 82 patients was 66 years old (range, 34–97 years). Thirteen patients were intravenous drug addicts and eight patients were diabetics on regular medication. On admission, all patients had elevation of CRP (average, 12.2 mg/dL; range, 0.81–45.5 mg/dL) and ESR (average, 106 mm/hr; range, 43–140 mm/hr). Only 49 patients (60%) got elevation of WBC. Albumin levels (average, 31 g/L; range, 18–38 g/L) was decreased in 79 patients (96%) and globulin levels (average, 46 g/L; range, 38–62 g/L) was increased in 56 patients (68%). Reversed albumin/globulin ratio occurred in 73 patients (89%). After adequate control of the infection, only 48 patients' albumin levels (59%) and 63 patients' globulin levels (77%) returned to normal. Albumin/globulin ratio of 56 patients was above.

Conclusions: Serum albumin level was decreased in 96% of SPI. Therefore, it is sensitive to support the diagnosis for patients with compatible clinical features. It only returned to normal in 59% of cases after the infection was apparently under control. Aggressive nutritional support may speed up patients' recovery.

Keywords: Pyogenic; Albumin; Globulin; Nutrition

Posterior Instrumentation without Anterior Debridement for Infectious Spondylitis

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Background: The principle of surgical treatment of infectious spondylitis that failed in medical treatment is anterior curettage and debridement to remove infected discs directly. But the purpose of this study was to evaluate the results of only posterior fixation without anterior debridement.

Methods: Sixteen patients who underwent posterior fixation without anterior debridement and fusion in patients with thoracolumbar infectious spondylitis who were suffering from severe pain, here were 10 males and six females, an average age of 68 years. The mean operative segments were 1.6 (range, 1-7), and seven were percutaneous pedicle screw fixation and nine were pedicle screw fixation with posterior decompression simultaneously. The average follow-up period was 12 months. Postoperative laboratory findings (erythrocyte sedimentation rate [ESR]

and C-reactive protein [CRP]), postoperative pain (Visual Analog Scale), and improvement of disability index (Oswestry Disability Index [ODI]) were investigated.

Results: The mean preoperative ESR was 71.6 mm/hr, which was improved to 60.1 mm/hr at 4 weeks, 49.2 mm/hr at 8 weeks, and 38.6 mm/hr at 12 weeks. The mean preoperative CRP was 5.26, which was improved to 4.0 mg/dL at 4 weeks, 1.3 mg/dL at 8 weeks, and 0.9 mg/dL at 12 weeks. The preoperative pain was improved from an average of 10 to an average of 5 in the immediately postoperative. The mean postoperative pain was improved to 4 at 4 weeks, 2 at 8 weeks, and 2 at 12 weeks. The preoperative ODI score improved from an average of 83 to 17 at 12 weeks postoperatively. Infection was totally treated in all 16 cases. Complications were continued in a case about radiculopathy on lower extremity. Anterior debridement and fusion were necessary because of spondylolisthesis in a case.

Conclusions: Depending on the general condition of the patient and the extent of the infection, posterior fixation only, which provides stability to the vertebral segment, may reduce the pain and make the treatment period shorten as increase the effectiveness of antibiotic treatment.

Keywords: Infectious spondylitis; Posterior pedicle screw fixation

Posterior Only Approach for Lumbar Pyogenic Spondylitis with Short Instrumentation and Prolonged Suction Drainage

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Background: Several methods of posterior surgical treatment for pyogenic spondylitis have been reported, and there have been few reports regarding the efficacy of posterior only approach with short instrumentation including even inflamed segment.

Methods: Thirty-three patients with lumbar pyogenic spondylitis who underwent posterior decompression and lumbar interbody fusion with short instrumentation including the inflamed segment and cathter drainage were enrolled. Clinically infection control (erythrocyte sedimentation rate [ESR] and C-reactive protein [CRP] normalization time) and onset of ambulation were reviewed. Also achievement of fusion and changes of sagittal alignment were investigated radiologically.

Results: In all the 33 cases, infection was controlled successfully without any recurrence. There was no breakage of implant. Postoperative interval to normalization of ESR was average 69.4 days and CRP was 25.4 days, respectively. Ambulation was started at average 5.8 postoperative days. Successful interbody fusion was confirmed radiologically in all the cases at a mean of 5.4 months. Sagittal angle of fixed segment was average 6.9° of lordosis before operation, which became more lordotic to 11.5° just after operation, but decreased to 4.7° of lordosis at the final follow-up. Actually final sagittal alignment was almost same as preoperative status (p=0.24).

Conclusions: By achieving favorable clinical and radiological results, short instrumentation and prolonged suction drainage with posterior only approach seemed to be an effective method in managing lumbar pyogenic spondylitis.

Keywords: Posterior only approach; Prolonged suction drainage; Short instrumentation

Analysis of Segmental Kyphosis Angle after Anterior Debridement and Spinal Fusion without Instrumentation for Cervical Pyogenic Spondylitis

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Background: Occurrence of infection in the cervical spine is quite rare in comparison with involvement of the lumbar and thoracic regions. Anterior debridement and spinal fusion without instrumentation is performed as a treatment option for cervical pyogenic spondylitis. However, there is no report about the change of postoperative segmental kyphosis angle. The purpose of this study is to analyze the segmental kyphosis angle after anterior debridement and spinal fusion without instrumentation for cervical pyogenic spondylitis.

Methods: We analyzed five patients (two males and three females) who were performed anterior debridement and spinal fusion without instrumentation (Kokubun's method) of single level for cervical pyogenic spondylitis

between May, 1997 and September, 2010. The mean age at the time of surgery was 63.4 years (range, 58–70 years). The following factors were analyzed: segmental angle of fusion level, C2–7 angle, height of fusion level, bone union, and Frankel classification.

Results: Our results were segmental angle (preoperative, -5.0°; immediate postoperative, -3.8°; postoperative 1 year, -12.2°), C2-7 angle (preoperative, 10.4°; immediate postoperative, 12.0°; postoperative 1 year, 7.6°), and height of fusion level (preoperative, 28.4 mm; immediate postoperative, 29.4 mm; postoperative 1 year, 25.6 mm). Bone union was achieved in all cases. According to Frankel classification, all patients showed improvement or unchanging in clinical symptoms.

Conclusions: In anterior debridement and spinal fusion without instrumentation for cervical pyogenic spondylitis, the progression of segmental kyphosis angle and subsidence of graft bone was observed during postoperative course. This may be caused by weakening of the bone associated with infection.

Keywords: Cervical pyogenic spondylitis; Anterior spinal fusion; Segmental kyphosis

Surgical Strategies for Pyogenic Vertebral Osteomyelitis with Unstable Cervicothoracic Junction

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Background: Pyogenic vertebral osteomyelitis of cervicothoracic junction is a rare condition. It is a quite challenging problem in surgical decision-making when there is an unstable spine with neurological symptoms. Surgical decompression and stabilization are usually inevitable. Many issues, anterior duration of antibiotics therapy, single-staged or two-stage operation, and the timing of instrumentation, remain controversial and open to discussion.

Methods: We reported a 40-year-old male who presented with acute onset of neck pain and tetraplegia after falling down. Pyogenic vertebral osteomyelitis with destruction and subluxation at C7 to T2 levels was diagnosed from the series of images. We performed posterior decompression and fixation from C4 to T5. The pus culture showed MRSA which was susceptible to vancomycin and trimethoprim/sulfamethoxazole (TMP/SMX). After 6 weeks of vancomycin treatment was completed, this patient underwent anterior corpectomy and fusion using an iliac graft from C6 to T3. After 2 stages of operation were done, the vancomycin injection was shifted to oral TMP/SMX. The antibiotic therapy continued until the erythrocyte sedimentation rate level decreased to the normal limit.

Results: After 2 months of treatment, this patient's American Spinal Injury Association Impairment Scale improved from grade B to grade D after 2 months. He can slowly walk with assistance but still presented with weakness in hand grip.

Conclusions: The posterior approach can provide a safe route to obtain bacteria culture and achieve early immobilization. Combine anterior and posterior approach should be considered for unstable cervicothoracic junction, especially multi-level segments lesion or kyphosis deformity. Massive blood loss and prolonged operative time can be avoided by 2-staged operation.

Keywords: Osteomyelitis; Cervicothoracic junction

Selection of Surgical Approach in Spinal Tuberculosis: Experiences of 663 Cases

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Background: Tuberculosis (TB) of the spine is a common form of TB infection for 50% to 60% of osseous TB. Although uncommon, spinal TB still occurs in both developed and developing countries. The diagnosis of spinal TB is difficult and it commonly presents at an advanced stage. Delays in establishing diagnosis and management result in complications such as spinal cord compression and spinal deformity.

Methods: A total of 663 patients with TB of the cervical, thoracic, and lumbar spine with moderate to severe cord compression were studied. Variable degrees of neurological deficit with deformity were treated from January 2003 to July 2017. Thoracotomy along with anterolateral decompression and autogenous strut bone grafting with simultaneous fixation by screws and rods were done in 113

cases. Posterior decompression, posterior interbody, and posterolateral fusion by bone graft with stabilization by transpedicular screws and rods were done in the remaining 550 cases. Appropriate anti TB drugs were given to all patients for 12–18 months. The follow-up period was 3 months to 10 years.

Results: The average age was 47 years (range, 9–85 years). All patients survived surgery. There were eight cases of superficial infections (1.2%), while there were five cases (0.7%) of deep infections. Revision surgery was performed in seven patients (1.0%). Implant failure occurred in five cases (0.7%), while malposition of screws occurred in 14 cases (2.1%). Perioperative bleeding complications were reported for five patients (0.7%). Neurological improvement occurred in all patients except for two cases (0.3%). Preoperatively, the majority of patients (n=245, 37%) were classified with class A on the American Spinal Injury Association neurological impairment scale. This was significantly reduced postoperatively to 0.3%.

Conclusions: For patients with spinal TB anterior debridement, auto graft bone fusion, anterior or posterior fixation appears to be effective in arresting disease, correcting kyphotic deformity, and maintaining correction until solid spinal fusion.

Keywords: Spinal tuberculosis; Debridement; Stabilization

Results of the Treatment of the Spinal Infections: Experiences with 41 Cases

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Background: Spinal infections are rare pathology but are an important clinical problem that often require aggressive medical therapy, and sometimes even surgery. Known risk factors are advanced age, diabetes mellitus, immunosuppression, and previous surgical procedures involving or adjacent to the intervertebral disc space. The most common level of involvement is at the lumbar spine, followed by the thoracic, cervical, and sacral levels: lesions at the thoracic spine tend to lead more frequently to neurological symptoms.

Methods: This study is retrospective review of 41 patients who were diagnosed with spinal infections and were managed medically and surgically from March 2011 to December 2015 at the neurosurgery department, Nguyen Tri Phuong Hospital, Ho Chi Minh city.

Results: Back pain and fever are dominant symptoms 56.1%. There were 32 cases of pyogenic infections and nine cases of tuberculosis. We had carried out operations of seven cases and medical treatments of 34 cases. The most common bacterium isolated was *Staphylococcus aureus*. The first choice of antibiotics were ceftazidim and vancomycin. The mean duration of antibiotic perfusions was 28.7 days.

Conclusions: Antibiotic therapy is required effectivenessly and approriate durations. *S. aureus* is common bacterium isolated. Most cases were managed medically. Some cases were operated with indications of spinal decompression or failed medical treatments.

Keywords: Spinal infection; Pyogenic infection

The Characteristics of Axial Gout among Korean Patients with Peripheral Gouty Arthritis in a Tertiary Spine Center

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Background: The study aimed to describe the prevalence and possible risk factors of axial gout among patients with peripheral gouty arthritis in Korea. We also report the feasibility of using dual-energy computed tomography (DECT) to diagnose axial gout.

Methods: We enrolled 95 Korean patients who visited our spine center from March 2012 to February 2017 and who were previously diagnosed with peripheral gouty arthritis with available CT images of vertebral columns. Seven patients underwent DECT. Axial gout was defined by the presence of erosions or tophi in the vertebral endplate or facet joint. Clinical and laboratory data of these patients were retrieved from medical records.

Results: Fifteen (15.8%) of 95 patients had conventional CT evidence suggestive of axial gout. Of the 15 patients, the lumbar spine was commonly involved (12 patients, 80%). Fifteen patients (17 vertebral lesions) had erosions

in vertebral columns and two patients presented with tophi with erosive changes in facet joints. Of the seven patients subjected to DECT, six demonstrated monosodium urate deposits with erosive foci. There were no correlations of the presence of axial gout with age, duration of peripheral gouty arthritis, laboratory findings, and the presence of hypertension and end-stage renal disease. However, there was a significant correlation of axial gout with the presence of diabetes.

Conclusions: The prevalence of axial gout in Korean patients with peripheral gouty arthritis and spinal symptoms was 15.8%. The lumbar spine was commonly involved. DECT may be useful as an adjunctive tool in the diagnosis of axial gout.

Keywords: Gout; Spine; Computed tomography; Erosion; Tophus

Three-Dimensional Morphological Evaluation of Percutaneous SpineJack Augmentation in Elderly Bursting Fracture

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Background: Although polymethylmethacrylate (PMMA) vertebroplasty and kyphoplasty were suggested as ideal procedures for senile compression fractures, further collapse or adjacent level fractures are inevitable partly due to lacking of endplate support. In bursting fractures, this factor is even more important. The rationale of the design of SpineJack tried to overcome these problems. The purpose of this study is to evaluate the SpineJack effects through three-dimensional (3D) morphological evaluation.

Methods: Only elderly spontaneous bursting fractures treated with one SpineJack through one portal were included in this study. Nearly every case had intolerable back pain during sitting and walking. 3D reconstruction of the lesion vertebrae was performed preoperatively and 6 month postoperatively by 1 mm cut computed tomography (CT). The changes of morphology was evaluated by fusion of preoperative and postoperative images. All the patients were evaluated with Oswestry Disability Index and Visual Analog Scale (VAS) scores. We kept the posterior body free of PMMA cement to facilitate the healing and avoid the leakage of PMMA into canal.

Results: In total, 35 cases (age, 60–88 years; seven males and 28 females) were consecutively collected. There were T11 (1), T12 (13), L1 (12), L2 (5), and L3 (4). The duration of symptoms were from 2 weeks to 10 months. Every case had intolerable back pain during sitting and walking before treatment. The average VAS score improved from 7.5 preoperative to 2.3 postoperative. The score did not become worse in follow-up. The body height increased by 30% to 95% especially in the anterior body height. The posterior wall had good healing without further collapse. No major complications were noted.

Conclusions: The 3D morphological reconstruction of CT and fusion of images are useful in evaluation of augmentation. Our protocol (one SpineJack via one portal; keeping the posterior vertebrae free of PMMA) can have satisfactory results in treating the elderly osteoporotic bursting fractures.

Keywords: SpineJack; Three-dimensional reconstruction; Computed tomography; Vertebral augmentation; Image fusion

Do the Dynamic Mobility Stress Radiographs Predict the Postoperative Vertebral Height Restoration, Kyphosis Correction, and Cement Volume Injected after Vertebroplasty for Osteoporotic Thoracolumbar Vertebral Fractures with Intravertebral Cleft?

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Background: This prospective clinical-radiological study was conducted to determine whether the dynamic mobility stress radiographs can predict the postoperative vertebral height restoration, kyphosis correction, and cement volume injected after vertebroplasty

Methods: Patients included had the diagnosis of significant back pain caused by osteoporotic vertebral compression fracture secondary to trivial injury. All the patients underwent routine preoperative sitting lateral spine

radiograph, supine stress lateral spine radiograph, and supine anteroposterior spine radiograph. The radiological parameters recorded were as follow: anterior vertebral height (AVH), middle vertebral height (MVH), posterior vertebral height (PVH), MVH level below, wedge endplate angle (WEPA), and regional kyphotic angle (RKA). The supine stress vs. sitting difference (SSD) for all the above parameters were calculated

Results: A total of 28 patients (four males and 24 females) with the mean age of 75.6±7.7 years were recruited into this study. The mean cement volume injected was 5.5±1.8 mL. There was no difference between supine stress and postoperative radiographs for AVH (p=0.507), PVH (p=0.913), WEPA (p=0.379), and RKA (p=0.005). The MVH was significantly less in the supine stress radiographs compared to postoperative radiographs (p=0.026). There was significant correlation (p<0.05) between Supine supine stress and postoperative AVH, MVH, PVH, WEPA, and RKA. The sum of squared differences (SSD) for AVH, PVH, WEPA, and RKA did not have significant correlation with the cement volume (p>0.05). Only the SSD-MVH had significant correlation with cement volume but the correlation was weak (r=0.39, p=0.04)

Conclusions: Dynamic mobility stress radiographs can predict the postoperative vertebral height restoration and kyphosis correction after vertebroplasty for thoracolumbar osteoporotic fracture with intravertebral clefts. However, it did not reliably predict the amount of cement volume injected as it was affected by other factors.

Keywords: Osteoporosis; Thoracolumbar; Fracture; Dynamic radiographs; Vertebroplasty

Increased Sagittal Vertical Axis Is Associated with Less Effective Control of Acute Pain Following Vertebroplasty

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Background: Although vertebroplasty is very effective for relieving acute pain from an osteoporotic vertebral compression fracture, not all patients who undergo vertebroplasty receive the same degree of benefit from the procedure. In order to identify the ideal candidate for vertebroplasty, preoperative prognostic demographic or clinico-radiological factors need to be identified. The objective of this study was to identify the preoperative prognostic factors related to the effect of vertebroplasty on acute pain control using a cohort of surgically and non-surgically managed patients.

Methods: Patients with single-level acute osteoporotic vertebral compression fracture at thoracolumbar junction (T10 to L2) were followed. If the patients were not satisfied with acute pain reduction after a 3-week conservative treatment, vertebroplasty was recommended. Pain assessment was carried out at the time of diagnosis, as well as 3, 4, 6, and 12 weeks after the diagnosis. The effect of vertebroplasty, compared with conservative treatment, on back pain (Visual Analog Scale [VAS]) was analysed with the use of analysis of covariance models that adjusted for preoperative VAS scores.

Results: A total of 342 patients finished the 12-week follow-up, and 120 patients underwent vertebroplasty (35.1%). The effect of vertebroplasty over conservative treatment was significant regardless of age, body mass index, medical comorbidity, previous fracture, pain duration, bone mineral density, degree of vertebral body compression, and canal encroachment. However, the effect of vertebroplasty was not significant at all time points in patients with increased sagittal vertical axis.

Conclusions: For single-level acute osteoporotic vertebral compression fractures, the effect of vertebroplasty was less favorable in patients with increased sagittal vertical axis (> 5 cm) possible due to aggravation of kyphotic stress from walking imbalance.

Keywords: Osteoporotic vertebral fracture; Vertebroplasty; Conservative treatment; Pain control; Recurrence

Necessity of Physical Performance Assessment as Potential Risk Factor of Osteoporotic Vertebral Fractures

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Background: Poor physical performance, particularly

slow walking speed and weak handgrip, have increasingly considered as a vital sign in elderly people. Recently, sarcopenia is to be a risk factor for osteoporoticfracture, which is a major health problem. We aimed to investigate the association between sarcopenia criteria, given by the paralumbar muscle mass and physical performance, and osteoporoticvertebral fracture (OVF).

Methods: This cross-sectional study examined 45 patients with OVF (group 1) diagnosed by magnetic resonance imaging (MRI) and 37 patients who did not have an OVF (group 2). The body mass index (BMI), bone mineral density (BMD), and whole spine radiography were examined. In addition, we investigated gait speed test, handgrip strength, paralumbar muscle mass in MRI, and rectus femoris muscle mass in ultrasound for sarcopenia.

Results: The mean BMI and BMD were 21.87 kg/m², -3.32 of T-score in group 1 and 24.20 kg/m², -1.62 of T-score in group 2, respectively. The average of gait speed, handgrip strength, paralumbar muscle mass, and rectus femoris muscle mass was 0.42 m/sec, 12.71 kg, 1,068.78 mm², 292.1 mm² in group 1 and 0.65 m/sec, 18.84 kg, 1,510.02 mm², 305.52 mm² in group 2, respectively. There was significant difference of BMD (p=0.01), gait speed (p=0.01), handgrip strength (p=0.01), and paralumbar muscle mass (p=0.01) between two groups. However, there was no difference of rectus femoris muscle mass (p=0.52), radiographic lumbar lordosis (p=0.09), and sacral slope (p=0.18) between two groups. BMD (r=-0.42, p=0.01), gait speed (r=-0.55, p=0.01), handgrip strength (r=-0.50, p=0.01), paralumbar muscle mass (r=-0.49, p=0.01), and age (r=0.54, p=0.01) were correlated with osteoporotic vertebral fracture.

Conclusions: Potential risk factor of osteoporotic vertebral fracture is associated with loss of the paralumbar muscle mass, slow gait speed, and weak handgrip strength as well as low bone density.

Keywords: Osteoporosis; Vertebral fractures; Sarcopenia

Which is the Exacerbate Factor of Low Back Pain after Osteoporotic Vertebral Fracture: Bone Non-union, Vertebral Deformity, or Spino-Pelvic Malalignment?

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Background: Fracture non-union has been proposed as the primary cause of residual low back pain (LBP) following osteoporotic vertebral fracture (OVF). However, LBP can occur even when union is maintained. Other reported causes of LBP after OVF include vertebral deformities and spino-pelvic malalignment. Objective of this study is to identify independent risk factors for residual LBP following OVF.

Methods: Fifty-nine patients with fresh single-level thoracolumbar OVF who had not received previous osteoporotic treatment were enrolled. Conservative treatment was conducted using soft lumbosacral orthosis plus osteoporosis drugs, either weekly alendronate (back pain) or daily teriparatide. Oswestry Disability Index (ODI) and other pain scores, kyphosis of fractured vertebra, and spino-pelvic parameters were assessed at admission and periodically during treatment. Radiographic union was evaluated independently by three doctors at 24 weeks. Residual LBP was defined as ODI >40% at 24 weeks, and patients were divided accordingly into LBP (n=14) and cured (n=45) groups. Temporal changes and statistical associations among variables were examined and multivariable analysis conducted to identify independent risk factors for residual LBP.

Results: Union rate was significantly higher in the cured group compared to the LBP group (82% vs. 50%, p=0.031). Alternatively, kyphosis was higher in the LBP group (26.3°±2.3° vs. 19.4°±1.3°, p=0.012), as was age (77.1±2.0 vs. 72.4±1.1 years, p=0.046) and malalignment (pelvic incidence minus lumbar lordosis, 27.1°±3.9° vs. 19.2°±2.2°; p=0.084). Past vertebral fracture incidence was lower in the LBP group (11% vs. 36%, p=0.187). Multivariable analysis identified kyphosis (odds ratio [OR], 8.07) and past vertebral fracture (OR, 6.9) as independent risk factors for residual LBP. Non-union correlated with

kyphosis progression (area under the curve=0.908).
Conclusions: Kyphosis is the predominant factor leading to residual LBP after OVF, while non-union is the main driver of kyphosis progression. Spino-pelvic malalignment is not an independent risk factor for LBP after OVF.
Keywords: Residual low back pain; Osteoporotic vertebral fracture; Kyphosis; Non-union; Spino-pelvic alignment

Difference of Clinical Course between Cases with Bone Union and Those with Delayed Union Following Osteoporotic Vertebral Fractures

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Background: Delayed union following osteoporotic vertebral fracture displayed as an intravertebral cleft on plain X-rays, was reported to be a factor for prolonged severe pain. However, the difference of clinical course between bone union and delayed union cases remain still unclear. The purpose of this study was to identify how osteoporotic vertebral fracture (OVF) delayed union following conventional conservative treatment influences the clinical course with a prospective multicenter study.
Methods: A total of 324 OVF patients from 25 institutes in Osaka, Japan were included in the study. At the 6-month follow-up after initial visit to each institute, the patients were classified into bone union and delayed union groups based on plain X-ray findings. The outcome assessments included a Visual Analog Scale (VAS) for back pain, 36-item Short-Form Health Survey (SF-36) for quality of life (QOL), severity of bed-ridden state for activities of daily living (ADL), Mini-Mental State Examination for cognitive functions, and degree of vertebral collapse on plain X-rays.
Results: Overall, 280 patients were included into the union group and 44 into the delayed union group. The VAS score at 6 months was significantly worse in the delayed union group (p=0.01). The scores for the SF-36 scales of physical functioning and bodily pain at 6 months were significantly lower in the delayed union group (p=0.019, p=0.01, respectively). The percentage of nearly or completely bed-ridden patients was significantly higher in the delayed union group. The percentage of newly developed cognitive impairment was significantly higher in the delayed union group (p=0.02). Progression of vertebral collapse during the 6-month follow-up was more pronounced in the delayed union group (p<0.01).
Conclusions: The present results reveal that delayed union following OVF causes prolonged pain, QOL impairment, ADL impairment, cognitive status deterioration, and vertebral collapse progression.
Keywords: Osteoporosis; Vertebral fracture; Clinical course; Delayed union

Effects of Prevalent Vertebral Fractures on Incidental Vertebral Fractures and Low Back Pain during Treatment for Osteoporosis

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Background: Osteoporotic vertebral fractures (VFs) cause low back pain (LBP). We prospectively determined the incidence of LBP and VFs during treatment of postmenopausal osteoporosis with and without already present VFs.
Methods: Altogether, 101 osteoporotic women were randomly stratified into two groups: Ris-group (n=51) treated with risedronate alone (17.5 mg/wk) and the Ris+K2 group (n=50) treated with risedronate and menatetranone (45 mg/day). In all, 29 women in the Ris group and 26 in the Ris+K2 group continued treatment for 1 year and were included in this study. They were divided into two subgroups—with or without VF—and underwent evaluation for incidental VFs by plain radiography and LBP by interview before and after treatment.
Results: VFs were present pretreatment in 12 patients (41%) in the Ris group and 13 (50%) in the Ris+K2 group. LBP was present in 52% in the Ris group and 58% in the Ris+K2 group. After 1 year of treatment, incidences of VF and LBP had decreased to 14% and 28%, respectively, in the Ris group and 27% and 27%, respectively, in the Ris+K2 group. Among the patients who developed VF or LBP during treatment, pretreatment VFs had been present in all four (p=0.01) and in seven of eight patients

(p=0.002), respectively, in the Ris-group and in six of seven (p=0.02) and in four of seven patients, respectively in the Ris+K2 group.

Conclusions: VF incidences were significantly high in participants with pretreatment VFs. Incidence of LBP was significantly high only in participants who had pretreatment VFs and who were treated with Ris monotherapy.

Keywords: Vertebral fracture; Low back pain

Thoracolumbar Osteoporotic Vertebral Fracture with Delayed-Onset Myelopathy: Clinical Presentation and Surgical Outcomes

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Background: Osteoporotic vertebral fractures (OVFs) with neurological compromise have increasingly been reported. We investigated the clinical and radiological characteristics of these complicated OVFs.

Methods: Between January 2008 and December 2014, patients who developed myelopathy during the treatment of an osteoporotic thoracolumbar vertebral fracture were investigated. Twenty-five patients (male:female=7:18) with a mean age of 73.9±7.1 years were enrolled. Patients were grouped according to surgical approach into an anterior decompression group and a posterior decompression group. The height loss and kyphotic angle of the affected vertebral body were measured from consecutive radiographs. Clinical outcomes were assessed using the Visual Analogue Scale and Oswestry Disability Index.

Results: The mean interval from the initial diagnosis of OVF to decompressive surgery was 9.9±10.0 weeks. Delayed myelopathy after OVF usually occurred at the thoracolumbar junction. Intravertebral cleft was identified in 14 out of 25 patients (56%) on preoperative radiographic studies. Six patients (24%) received cement augmentation before the development of neurological impairment; among them, five patients developed nonunion with pericement osteolysis. Two patients (8%) experienced ossification of the yellow ligament around the fractured vertebra. Even after reconstructive surgery, a loss of correction (vertebral height and kyphosis) was inevitable. However, an improvement in terms of the clinical outcomes could be obtained in most patients.

Conclusions: OVF with delayed neurological deficit developed after nonunion, intravertebral cleft with fracture instability, progression of kyphosis, and failure of cement augmentation. If a fracture develops at the thoracolumbar junction in elderly people, the preexisting stenotic lesion should be identified first. The presence of an intravertebral cleft with instability on follow-up radiographic examination should be identified. Preventive reconstructive surgery is recommended for these patients. Appropriate reconstructive surgery considering age and bone quality could be helpful in avoiding debilitating complications.

Keywords: Thoracolumbar; Osteoporosis; Myelopathy

Osteoporotic Burst Fracture Associated with Neurological Deficit–Clinico-Radiological Outcome of Posterior Only (Decompressi on+Instrumentation+Transpedicular Bone Graft) Surgery

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Background: Surgery in neurological deficit due to delayed collapse of non-healing osteoporotic fractures is often met with complication due to associated co-morbidity and potential of instrumentation failure. Management of osteoporotic burst fracture associated with neurological deficit (OFND) is controversial.

Methods: Forty patients with neurological deficit due to delayed osteoporotic vertebral collapse managed by posterior surgery (decompression+instrumentation+transpedicular bone graft) with minimum Demographic data (age, sex, mode of injury, severity of osteoporosis, duration of delay in presentation), clinical parameters (Visual Analog Scale [VAS], Oswestry Disability Index [ODI], Frankel grade), radiological parameters (local kyphosis), and surgical variables (blood loss, surgery duration, intraoperative problems) were recorded. Neurological worsening/improvement, complications, and implant loosening/failures were noted.

Results: Significant improvement was noted in VAS (preoperative, 8.20±0.65; postoperative, 4.1±0.64) and ODI

(preoperative, 76.54±6.96; postoperative, 30.5±6.56). Complete neurological recovery noted in 37 patients (Frankel grade E) and three patients remained non ambulatory (Frankel grade C). Significant improvement was was noted in local kyphosis angle (preoperative, 21.80±2.70; postoperative, 11.40±1.80) with 10% loss of correction (2.5±0.90) at final follow-up. Symptomatic implant failure was noted in two patients and proximal junctional failure in one patient requiring revision.

Conclusions: OFND can be managed with single posterior surgery (decompression+instrumentation+transpedicular bone-graft) with significant improvement in neurology and functional scores of patient. Aggressive kyphosis correction is often not required and significant correction of kyphosis is noticed due to positioning alone. Transpedicular grafting is safe and simple alternative to cement augmentation or anterior surgery for collapsed vertebrae.

Keywords: Osteoporotic burst fracture; Transpedicular bone grafting

Comparison of Clinical Effect between Percutaneous Vertebroplasty and Percutaneous Kyphoplasty for Treatment of Osteoporotic Vertebral Compression Fractures with Intravertebral Vacuum Cleft

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Background: The objective of this study is to compare the clinical efficacy and safety of percutaneous vertebroplasty (PVP) with percutaneous kyphoplasty (PKP) in the treatment for osteoporotic vertebral compression fractures (OVCFs) with intravertebral vacuum cleft (IVC).

Methods: Sixty-eight patients treated for single OVCFs with IVC were reviewed from January 2010 to December 2013, which were 48 in PVP group and 20 in PKP group.

Results: There was no significant difference in cement volume; the cement leakage occurred in nine (18.7%) for PVP group and one (5%) for PKP group; the mean operating time was 32.13±4.61 minutes in PVP group and 43.24±5.02 minutes in PKP group; the mean follow-up time was 2.4 years. The Visual Analog Scale and Oswestry Disability Index scores was significantly reduced at postoperative 1st day, 1 year, and 2 years; however, there was no significant difference between the two groups at each follow-up stage. The incidence of ad vertebral fracture was five out of 48 patients in PVP group and two out of 20 patients in PKP group; bone mineral density (BMD) was significant increased at postoperative 1 year and 2 years with compared to preoperative BMD and no significant difference was found in both groups. The X-ray films showed that vertebral height and kyphotic angle in both groups was significantly restored at immediate postoperative period; however, significant recollapse was observed with the 2-year postoperative follow-up; there was no significant difference in compression rate and kyphotic angle between the two groups at each follow-up stage. Reduction rate, reduction angle, progressive height loss, and progressive angle also showed no significant difference in both groups.

Conclusions: There was similar clinical and radiological efficiency between PVP and PKP treatment for OVCFs with IVC, but PKP could had lower rate of cement leakage. Recollapse could possibly happen after postoperative long-term period and hence. we strongly recommend its strict observation and follow-up.

Keywords: Intravertebral vacuum cleft; Osteoporotic vertebral compression fractures; Percutaneous kyphoplasty

Risk Factors for the Occurrence of Insufficient Cement Distribution in the Fractured Area after Percutaneous Vertebroplasty in Osteoporotic Vertebral Compression Fractures

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Background: Insufficient cement distribution (ICD) in the fractured area has been advocated to be responsible for unsatisfied pain relief after percutaneous vertebroplasty (PVP) for osteoporotic vertebral compression fractures (OVCFs). However, little is known about risk factors for the occurrence of ICD.

Methods: Patients who underwent PVP for single-level OVCF from January 2012 to September 2014 and met this study's inclusion criteria were retrospectively reviewed. Associations of ICD with co-variates (age, gender, bone

mass density with a T-score, amount of injected cement, cement leakage, fracture level, fracture age, fracture severity grade, and location of the fractured area) and the influence of ICD on pain relief were analyzed.

Results: A total of 225 patients were included. ICD was found in 26 patients (11.6%). Fractured area located in the superior portion of the index vertebra was significantly associated with occurrence of ICD. No further significant associations between the studied co-variates and emergence of ICD were seen in the adjusted analysis. In addition, patients with ICD had significantly higher immediate postoperative visual analog scale scores of back pain compared with those with sufficient cement distribution in the fractured area.

Conclusions: The incidence of ICD is higher in patients with the fractured area located in the superior portion of the index vertebra and ICD might be responsible for unsatisfied pain relief after PVP for OVCFs.

Keywords: Percutaneous vertebroplasty; Insufficient cement distribution; Fractured area; Risk factor

Cortical Bone Trajectory: Rationales and Applications

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Background: New trajectory and screw design introduced for difficult spine conditions.

Methods: Literature search.

Results: Cortical bone trajectory and screw are additional tool and technique in osteoporotic vertebrae. With increasing age, the prevalence of osteoporosis is increasing in elderly population and so is the spinal problem secondary to degenerative disorders. Currently, osteoporosis with poor purchase in the pedicle and vertebral bone and the number of patients requiring revision are increasing in number and pose a challenge during surgery. New cortical bone trajectory is new technique and provides better pullout strength and stiffness—even in osteoporotic bone and in revision cases. Screw is also of different design in threads as that have better purchase in both cortical and cancellous bone. Biomechanical studies are very promising. The experience of cortical bone trajectory screws is so far limited but good. So far very few cases of intraoperative fracture of pars or postoperative stress fracture of pars have been reported. In conclusion, cortical bone trajectory offer new techniques in addressing some difficult problems in elderly with poor bone stock.

Conclusions: New screws/trajectory have better purchase in bone with the decreased likelihood of failure.

Keywords: Cortical bone trajectory; Osteoporosis

Preventing Implant Loosening via the Cortical Bone Trajectory Technique

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Background: The adoption of the cortical bone trajectory (CBT) technique while instrumenting the osteoporotic lumbar spine is relevant in elderly spines. We studied the effectiveness of CBT by focusing on the rate of screw loosening.

Methods: From December 2012 till June 2015, 180 adult women underwent lumbar spine decompression and instrumentation. Every other patient was treated using the CBT technique while the alternate patient received classical pedicle screw fixation. All were post-menopausal women with ages ranging from 62 till 92 years old with densitometry T-score readings less than -2.5. Surgery was indicated for lumbar spine stenosis presenting with radiculopathy, from one till three levels. Excluded were acute traumatic lesions, metastatic spine disease, infective spines, and spondylolisthesis greater than grade 1. CBT technique was effected in 86 patients and classical pedicle screw technique in 94. All patients had bilaminar decompression and at least one level of interbody fusion. They were followed up for a minimum of 24 months. Nine patients were lost to follow-up. We monitored with quarterly radiographs in the first year and twice annually in the second, with computed tomography scans at 12 and 24 months. Radiographs were interpreted separately by the author and two radiologists, with statistical adjustment of inter-observer variation.

Results: In the CBT arm, eight patients suffered screw loosening, five of them having it at the sacral level and the remaining, on the cephalad last-instrumented vertebra. Loosening afflicted 17 of those receiving classical pedicle screws. The chronological incidence of loosening ranged

from 3 to 10 months after surgery.

Conclusions: We conclude that compared to classical pedicle screw constructs, cortical bone trajectory has prevents implant loosening by virtue of its good cortical purchase —which outlasts traditional time needed for spine fusion. We suggest the adoption of this technique in the elderly osteoporotic lumbar spine.

Keywords: Osteoporosis; Cortical bone trajectory; Loosening

Different Effect of Tortoise Plastron on Lumbar Vertebral and Tibia of Glucocorticoid-Induced Osteoporosis Rats after Glucocorticoid Cessation

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Background: The objective of this study is to observe different effect of tortoise plastron on lumbar vertebral and tibia of glucocorticoid-induced osteoporosis rats after glucocorticoid cessation.

Methods: Forty-eight 3-month female Sprague-Dawley rats rats were randomly divided into four groups: control group, model group, alendronate group, and tortoise plastron group (n=12). Model group, alendronate group, and tortoise plastron group received hypodermic injection of dexamethasone to establish model for 3 months. Control group was subcutaneously injectly with saline. And then, model group, alendronate group, and tortoise plastron group received saline, alendronate, and tortoise plastron, respectively, and control group the saline for the next 3 months. Bone mineral density (BMD) and bone strength of lumbar vertebral and tibia of all rats were tested at 3rd month (M3), 5th month (M5), and 6th month (M6).

Results: At M3, BMD and bone strength of both lumbar vertebral and tibia in model group, alendronate group, and tortoise plastron group were significantly decreased compared with control group. Tortoise plastron group showed significantly increased BMD of lumbar vertebral at M6, and enhanced compression strength at M5 and M6 compared with model group. At M6, BMD and maximum load of tibia in tortoise plastron group were notably elevated compared with model group. At M6, bone mineral density of lumbar vertebral was 8.08%, and tibia was 8.30%, bone strength of lumbar vertebral was 44.67%, and tibia was 30.58%.

Conclusions: Tortoise plastron could improve BMD and bone strength of both lumbar vertebral and tibia after glucocorticoid cessation with relatively better improvement on the former. Tortoise plastron could elevate bone strength of lumbar vertebral more than that of tibia, while could increase approximate BMD of lumbar vertebral and tibia.

Keywords: Tortoise plastron; Glucocorticoid-induced osteoporosis; Bone mineral density; Bone strength

Regulation of Zuogui Pill on DKK1 in Its Prevention and Treatment for Glucocorticoid-Induced Osteoporosis

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Background: Chinese medicine is effective in prevention and treatment for glucocorticoid-induced osteoporosis (GIOP); however, the underlying mechanism for the effectiveness remains unclear. The objective of this study is to explore the regulation of zuogui pill on DKK1 in its prevention and treatment for GIOP.

Methods: Eighteen 3-month female Sprague-Dawley rats were randomly divided into three groups: control group, model group, and zuogui pill group. Rats in model group received subcutaneous injection of dexamethasone while control group received the same volume of saline subcutaneously, and zuogui pill group were administered with subcutaneous injection of dexamethasone and intragastrical administration of aqueous extract from zuogui pills.

After 1 months, micro-computed tomography scan of lumbar vertebrae was performed to examine bone mass and bone microstructure; compression test on lumbar vertebrae was performed for biomechanic properties; quantitative polymerase chain reaction was implemented for the expression of DKK1, runt-related transcription factor 2 (Runx2), and cathepsin K (CTSK) mRNA in lumbar vertebrae; and serum alkaline phosphatase (AKP) activity was tested.

Results: Compared with control group, volumetric bone mineral density (vBMD), trabecular bone volume ratio (BV/TV), trabecular number (Tb.N), and trabecular thickness in model group were significantly reduced (p<0.05), while trabecular space (Tb.Sp) and structure model index (SMI) were significantly increased; serum AKP activity was attenuated but insignificantly; expression of DKK1 mRNA showed a marked up-regulation (p<0.05), expression of Runx2 mRNA showed a down-regulation trend while expression of CTSK mRNA showed up-regulation trend. Compared with model group, zuogui pill group showed notably enhanced vBMD, BV/TV, and Tb.N (p<0.05), while notably reduced SMI (p<0.05) and reduced Tb.Sp without statistical significance; serum AKP activity was enhanced but insignificantly; and expression of Runx2 mRNA showed a up-regulation trend while expression of CTSK mRNA showed down-regulation trend.

Conclusions: Zuogui pill prevents and treats GIOP possibly through the down-regulation on mRNA expression of DKK1.

Keywords: Zuogui pill; Glucocorticoid-induced osteoporosis; Mechanism

Regulation of Zuogui Pill on mTORC1 in Its Prevention and Treatment for Glucocorticoid-induced Osteoporosis

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Background: The objective of this study is to explore the regulation of zuogui pill on mTORC1 in its prevention and treatment for glucocorticoid-induced osteoporosis (GIOP).

Methods: Eighteen 3-month female Sprague-Dawley rats were randomly divided into three groups: control group, model group, and zuogui pill group. Rats in model group received subcutaneous injection of dexamethasone while control group received the same volume of saline subcutaneously, and zuogui pill group were administered with subcutaneous injection of dexamethasone and intragastrical administration of aqueous extract from zuogui pills. After 1 months, micro-computed tomography scan of lumbar vertebrae was performed to examine bone mass and bone microstructure; compression test on lumbar vertebrae was performed for biomechanic properties; quantitative polymerase chain reaction was implemented for the expression of DKK1, Runx2 (runt-related transcription factor 2), and CTSK (cathepsin K) mRNA in lumbar vertebrae, and serum alkaline phosphatase (AKP) activity was tested.

Results: Compared with model group, bone mineral density, bone mineral content, compressive strength, serum AKP activity, and mTORC1 mRNA expression in the control group and Zuoguiwan group were significantly increased (p<0.05).

Conclusions: zuogui pill prevents and treats GIOP possibly through the down-regulation on mRNA expression of mTORC1.

Keywords: Glucocorticoid-induced osteoporosis; Zuogui pill; mTORC1; Mechanism

Effects of Combined Ovariectomy with Dexamethasone on Rat Lumbar Vertebrae

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Background: This study investigated effects of combined ovariectomy with dexamethasone treatment on rat lumbar vertebrae in comparison with osteoporosis induced via ovariectomy or dexamethasone alone, and analysis of the associated molecular mechanism.

Methods: Sixty-two 3-month female rats were randomly divided into five treatment groups: an untreated baseline (BL) group; a sham operation (SHAM); a dexamethasone

injection alone (DEXA); bilateral ovariectomy (OVX); and both ovariectomy and dexamethasone injection (OVX-DEXA). Animals in the BL group were euthanized at the beginning of the experiment, whereas animals in the remaining groups were euthanized at the end of the 1st month (M1), 2nd month (M2), or 3rd month (M3). bone mineral density (BMD), bone microarchitecture, biomechanical properties, and serum levels of estrogen, PINP (propeptide N-terminal of type 1 procollagen), and bCTX (beta C-terminal cross-linked telopeptide of type 1 collagen) were measured. In addition, we examined biglycan, runt-related transcription factor 2 (Runx2), osteoprotegerin (OPG), low-density lipoprotein receptor-related protein-5 (LRP-5), cathepsin K (CTSK), and sclerostin mRNA expression.

Results: Bone mineral content and BMD were lower in the OVX-DEXA group compared with OVX group. bone surface density, trabecular bone volume ratio, and trabecular number were lower in the OVX-DEXA group compared with the remaining groups, whereas trabecular separation was higher in OVX-DEXA group compared with the remaining groups at M2 or M3. The OVX-DEXA group showed lower compressive strength and lower stiffness compared with the other groups at M2 and M3. Compressive displacement and energy absorption capacity were also markedly lower in the OVX-DEXA group compared with the OVX group at M3. Estradiol levels were lower in the OVX-DEXA group compared with the other groups. Biglycan, Runx2, OPG, and LRP-5 were down in the DEXA, OVX, whereas CTSK and sclerostin were up-regulated in the OVX-DEXA group compared with the DEXA and OVX groups.

Conclusions: Ovariectomy combined with dexamethasone induced more serious osteoporosis in the rat lumbar spine. The combined effect may be due to a combination of suppressed bone formation and increased bone resorption related to an estradiol deficit.

Keywords: Dexamethasone; Lumbar vertebra; Mechanism; Osteoporosis; Ovariectomy

Promotion Effect of Extracts from Plastrum Testudinis on Alendronate against Glucocorticoid-Induced Osteoporosis in Rat Spine

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Background: Alendronate (ALN) is a key therapeutic used to treat glucocorticoid-induced osteoporosis (GIOP), but may induce severe side effects. We showed earlier that plastrum testudinis extracts (PTE) prevented and treated GIOP *in vivo*. However, clinically, PTE is seldom used alone.

Methods: We reveal the synergistic effect of ALN and PTE can treat GIOP of the rat spine and define the mechanism. Sprague-Dawley rats were randomly assigned to four groups: a vehicle group, a GIOP group, an ALN group, and an ALN+PTE group. Each group was further divided into two experimental phases, including dexamethasone (DXM) intervention and withdrawal. Bone mass, microarchitecture, biomechanics, bone-turnover markers, and histomorphology were evaluated. The mRNA and protein expression levels of cathepsin K (CTSK) and runt-related transcription factor 2 (Runx2) were detemined.

Results: We found that ALN+PTE improved bone quantity and quality, bone strength, and bone turnover; and mitigated histological damage during glucocorticoid intervention and withdrawal. The therapeutic effect was better than that afforded by ALN alone. ALN+PTE reduced CTSK protein expression, promoted Runx2 mRNA and protein expression to varying extents, and more strongly inhibited bone resorption than did ALN alone.

Conclusions: The synergistic effect mediated by ALN+PTE reversed GIOP during DXM intervention and withdrawal via affecting CTSK and Runx2 expression at mRNA and protein levels.

Keywords: Plastrum testudinis; Alendronate; Glucocorticoid-induced osteoporosis

The Modulating Effect of miR-34a on Bone Homeostasis: Potential Implication in Osteoporosis

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Background: miR-34a is a non-coding, single-stranded small RNA, which inhibits gene expression at the post-transcriptional level through nucleotide base pairing between complementary sequences of miRNAs and 3'-untranslated regions of messenger RNAs (mRNAs). It has been demonstrated to function as a tumor suppressor by down-regulating the expression of many essential oncogenes and therefore it is often used in the studies of oncology. Recently it has been found to be involved in the regulation of bone homeostasis.

Methods: The CNKI, ChinaInfo, VIP, PubMed, Cochrane library, and EMBASE databases were systematically searched from the inception dates to December 20, 2017, using the keywords miR-34a, bone homeostasis, and osteoporosis to investigate how miR-34 regulates osteoblast and osteoclast differentiation and how it interacts with other signal pathways to modulate bone homeostasis.

Results: Tgif2 has been reported to represses osteoblast proliferation by binding directly to DNA or interacts with transforming growth factor-β-activated Smads. Tgif2 intensifies osteoclastogenesis through a positive feedback loop in which receptor activator of NF-κB ligand-induced transcription factors activate Tgif2 expression, and Tgif2 in turn promotes their activity. MiR-34a facilitates osteogenesis by down-regulating Tgif2 expression and restrains osteoclastogenesis by indirectly suppressing osteoprotegerin (OPG)/receptor activator of NF-κB (RANK)/RANKL signal pathway while down-regulating Tgif2. Meanwhile, miR-34a is a direct transcriptional target of the tumor suppressor p53 that mediates genetic transcription of miR-34a and their form of pre-miRNA. The interaction of miR-34a, Tgif2, and P53 regulates bone homeostasis directly through affecting proliferation and differentiation of osteoblasts and osteoclasts. The action indirectly affects bone homeostasis by involving many factors in the classical signal pathways and by crosslinking with OPG/RANK/RANKL and Wnt/β-catenin signal pathways.

Conclusions: It is meaningful to investigate how miR-34 regulates osteoblast and osteoclast differentiation and how it interacts with other signal pathways to modulate bone homeostasis.

Keywords: miR-34a; Bone homeostasis; Osteoporosis

Variance of Spinal Osteoporosis Induced by Dexamethasone and Methylprednisolone and Its Associated Mechanism

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Background: Glucocorticoid (GC) administration is the most common cause of secondary osteoporosis. Previous studies investigated GCs dose and frequency correlated positively with the side effects of GC on bone health; however, the impaired effect of various types of GCs on bone has not yet been reported.

Methods: Sprague-Dawley rats (N=48) were divided into four groups: baseline group (BL), control group (CON), methylprednisolone group (MP), and dexamethasone group (DEXA). BL rats were euthanized to remain as baseline (M0) in the beginning. CON group were injected daily with vehicle. CON, MP, and DEXA groups were monitored at 4th week (M1), 8th week (M2), and 12th week (M3) after intervention. Bone mineral density (BMD), microarchitecture, biomechanical property of vertebrae and levels of estrogen, PINP (propeptide N-terminal of type 1 procollagen), and β-CTX (β C-terminal cross-linked telopeptide of type 1 collagen) were tested. mRNA expression analysis of biglycan, Col1a1, metalloproteinase-9, cathepsin K, runt-related transcription factor 2 (Runx2), osteoprotegerin (OPG), low-density lipoprotein receptor-related protein-5 (LRP-5), and sclerostin were performed.

Results: BMD was lower in DEXA rats at M3 compared with MP. The relative surface and trabecular number were lower in DEXA than that in MP at M2, while trabecular separation was higher in DEXA than that in MP group. The compressive strength was lower in L4 of DEXA than that in MP rats at M2 and M3. The levels of both PINP and estradiol in DEXA group were lower than MP group at M3. The expression of bone formation marker Runx2 was down-regulated at M3 in DEXA group compared with MP, CON, and BL groups, while Col1a1 was up-

regulated and biglycan, LRP-5, and OPG were down-regulated in GCs intervention groups compared with CON and BL groups.

Conclusions: Dexamethasone, the long-acting glucocorticoid, generates more serious osteoporosis of rat lumbar spine than methylprednisolone. The discrepancy between the two GCs inducing osteoporosis may be mainly caused by a decrease in bone formation. Runx2 and Col1a1 may be the two of critical genes inducing the discrepant impairment.

Keywords: Glucocorticoid-induced osteoporosis; Variance; Dexamethasone; Methylprednisolone

Short-Segment versus Long-Segment Stabilization for Unstable Thoracolumbar Junction Burst Fractures

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Background: The treatment of unstable thoracolumbar junction burst fractures remains a controversial issue. We evaluate the efficacy of short segment (SS) compared with that of long-segment (LS) stabilization in terms of clinical and the radiological outcomes.

Methods: Records of 88 patients with thoracolumbar burst fracture underwent posterior pedicle screw fixation from January 2004 to December 2015, were studied retrospectively. These patients were divided into two groups: SS- and LS-group. Clinical parameters (back pain, disability, and neurological deficit) and radiologic parameters (Cobb angle, sagittal index, the kyphotic deformation of vertebral body, vertebral height, and canal compromise) were measured before surgery, immediately after surgery, and at 3, 6, and 12 months postoperatively. Overall outcomes were evaluated using the modified Mcnab criteria at the last follow-up. Paired t-test and chi-square test were used for statistical analysis using SPSS.

Results: There were 36 and 52 patients in the SS- and LS- group, respectively. The mean age of the patients was 30.6±8.4 and 33.4±8.4 years and the mean follow-up period was 24.5 and 16.8 months in SS- and LS-group, respectively. In the SS group, the fractured vertebral body level was L1, T12, L2, T11, and T10 in 15, 10, six, three, and two cases and in the LS group, the fractured vertebral body level was L1, T12, L2, T11, and T10 in 22, 17, five, five, and three cases, respectively. Both groups achieved satisfactory clinical outcomes according to the modified Mcnab criteria. In the SS group, eight (22.22%), 21 (58.33%), and seven (19.44%) cases were considered to have excellent, good, and fair outcome and in the LS group, 18 (34.61%), 25 (48.08%), six (11.54%), and three (5.77%) cases were considered to have excellent, good, fair, and poor outcome, respectively.

Conclusions: SS pedicle screw fixation including the fractured vertebral body might be as effective as LS pedicle screw fixation for the treatment of unstable thoracolumbar junction burst fracture.

Keywords: Short-segment pedicle screw stabilization; Long-segment pedicle screw stabilization; Unstable; Thoracolumbar junction; Burst fracture

Postoperative Outcomes of Short Segment Percutaneous Pedicular Screw Fixation Compare with Long Segment Fixation in Thoracolumbar Fracture

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Background: Percutaneous pedicular screw fixation becomes an option in thoracolumbar spine fracture whom without neuro deficit. The limitation is the cost of the system especially in a government hospital, so we have applied standard screw with percutaneous technique to treat these patients. But we have not known the result of this technique yet. The purpose of this study is to evaluate the postoperative outcome of percutaneous screw fixation (PSF) using our technique in the treatment of thoracolumbar spine fracture compared with open split-muscle long segment fixation technique (OSF).

Methods: Thirty-six consecutive cases of thoracolumbar spine fracture without neuro deficit include patients that treated in Maharat Nakhonratchasima Hospital during January 2015–June 2017. Demographics data, postoperative Visual Analog Scale (VAS), intraoperative blood loss, and length of stay were collected from medical records. Postoperative radiographic parameters were collected from computed tomography scan.

Results: There were no significant different between two

groups in demographic except age (p=0.01) and intraoperative blood loss which more in OSF group (p<0.001). Mean kyphosis reduction was 10.64°±4.80° in PSF group and 12.00°±4.61° in OSF group. Mean canal reduction was 9.02%±7.16% and 19.48%±14.24%, respectively. Mean VAS reduction was 4.88±1.62 and 4.57±2.04, respectively. There were no significant different between two groups in these 3 parameters (p>0.05). Screw malposition in PSF was found 10 of 78 screws and all of them were Zdichavsky's type 1a that not require revision.

Conclusions: In terms of postoperative outcome, there were no significant different between PSF and OSF groups in both clinical outcomes and radiographic outcomes. Percutaneous screw fixation technique using less invasive options by our technique is one of the options to treat thoracolumbar spine fractures.

Keywords: Percutaneous pedicular screw fixation; Thoracolumbar spine fracture

Epidemiology and Outcome of Operatively Treated Thoracolumbar Spinal Fractures

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Background: Traumatic thoracolumbar spine fractures are a source of significant morbidity in the young. However, there is a paucity of local data regarding the epidemiology of patients requiring surgery for thoracolumbar spine fractures and the early postoperative morbidity and mortality of these patients.

Methods: This is a retrospective cohort study of 164 patients with thoracolumbar fractures treated between January 2007 to January 2016. Patient demographics, fracture mechanism and classification, operative treatment, and postoperative morbidity and mortality data was collected. In total there were 131 males and 33 females; and mean age was 37.0 years (range, 15 to 65 years). The most common injury mechanisms were fall from height 88 (53.7%), 38 (23.2%) from road traffic accident, and 25 (15.2%) from direct trauma. Sixty-nine (42.1%) were workplace-related injuries and 70 (42.7%) were polytrauma patients.

Results: One hundred and twenty-eight fractures (78.1%) occurred at the thoracolumbar junction and 53 (32.3%) had multiple levels of injury. The most common fracture class was AO A3 83 (56.7%) and 131 (79.9%) had Thoracolumbar Injury Classification and Severity score of 4 or more, and 80 (48.8%) had a Gaines score of 6 or more. Preoperatively 21 (12.8%) patients were ASIA A, 14 (8.5%) the American Spine Injury Association (ASIA) B, 19 (11.6%) ASIA C, 60 (36.6%) ASIA D, and 50 (30.5) ASIA E. One hundred and twenty-two (74.4%) underwent open surgery and 42 (25.6%) underwent minimally invasive surgery. Mean number of levels instrumented was 5 (range, 2–13). Seventy patients (61.4%) had an improvement in ASIA score and 88 (53.7%) were ASIA E after surgical treatment. There was no deterioration in ASIA score. Mean hospital stay was 18.8 days (range, 5–90 days). Seven patients (4.36%) developed intra-operative surgical complications requiring repeat surgery within 30 days. Seventy-five patients (45.7%) developed postoperative complications with urinary tract infections 41 (25%), wound complications 19 (11.6%), and psychiatric complications 11 (6.7%). Mortality rate was 2.4%.

Conclusions: Thoracolumbar fractures can be managed surgically with improvement in neurological outcome; however, postoperative complications remain high.

Keywords: Thoracolumbar; Spine; Trauma; Epidemiology; Outcome

Pediculectomy and Reduction of Retropulsed Bone Fragments in Thoracolumbar Burst Fractures

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Background: Unstable burst fractures with retropulsed bone fragments leading to neurological deficits require surgical intervention and decompression of neural structures and stabilization. In this case series we describe the use of pediculectomy with creation of a trough within the vertebral body followed by reduction of retropulsed bone fragments into the vertebral body in combination with posterior instrumentation and fusion.

Methods: This is a retrospective single surgeon study of patients admitted at our institution between 2011–2016 with thoracolumbar burst fractures with canal compro-

mise of more than 50% on axial computed tomography and neurological deficits. These patients underwent a standard bilateral laminectomy and partial facetectomy followed by a pediculectomy followed by the creation of a trough below the posterior wall of the vertebrae and reduction of the retropulsed fragment. After the fusion and reduction of kyphosis, the construct is locked and the operation completed.

Results: This study included a total of 10 patients, eight of whom were male and two of whom were female with a mean age of 35.2 years (range, 24–50 years). Three patients were the American Spine Injury Association (ASIA) A, one was ASIA B, 3 were ASIA C, and 3 were ASIA D preoperatively. Mean operative time was 356.4 minutes (range, 246–750 minutes) and mean blood loss was 542 mL. Preoperatively, the mean canal compromise on the sagittal and axial views was 54.1% and 55.0%, respectively; the mean vertebrae body height was 55% of the original height. Post operatively, the average canal compromise improved to 35.5% and 37.3% on sagittal and axial views, respectively. The average vertebrae body height improved to 80% of its original height. Postoperatively nine out of 10 patients experienced an improvement in ASIA score.

Conclusions: We were able to achieve good clinical and radiological outcomes with a pediculectomy followed by reduction of the retropulsed fragments and posterior instrumentation.

Keywords: Burst fracture; Pediculectomy

Restoration of Spinal Motion in Thoracolumbar Fractures Managed by Nonfusion Technique

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Background: In managing thoracolumbar and lumbar fractures, posterior fusion using transpedicular screw system has been the treatment of choice. However, fusion method results in permanent loss of segmental motion. If both proper stability and motion can be achieved, functional result will be improved considerably.

Methods: Twelve patients with thoracolumbar and lumbar spine fractures under 40 years of age (mean, 28.4 years) were managed by this non-fusion method. Implants were removed at mean 9.2 months after initial fixation of fracture and patients were followed up for more than 10 months. For metal-fixed segments, sagittal alignment such as angle of kyphosis, height of body, recovered motion range in flexion-extension, and right-left bending view were measured radiologically comparing with control group. Clinical aspects such as gross deformity and functional ability were also investigated.

Results: Immediately after injury, sagittal angle was average 17.2° kyphosis, which was changed into 2.8° lordotic angle after fixation of fractures. This angle changed to 1.7° kyphotic angle just before implant removal, 2.4° kyphotic just after implant removal of implants operation, which increased to 9.8° kyphotic at final follow-up. The height of fractured body was maintained till final follow-up. The mean segmental motion was measured 10.5° in sagittal plane and 10.9° in coronal plane. Most patients were satisfied for final gross appearance and functional outcomes. Only one patient showed considerable development of kyphotic angulation but functional outcome was good.

Conclusions: The author's non-fusion method seemed to be effective in achieving stability and sagittal alignment as well as regaining segemental motion of fixed segments. In managing thoracolumbar fractures especially for young active persons, non-fusion method seemed to be one of the effective methods.

Keywords: Thoracolumbar fracture; Non-fusion; Recovery of motion

Minimally Invasive Fracture Reduction Using Percutaneous Monoaxial Pedicle Screws in Thoracolumbar Burst Fracture: A Description of Surgical Technique and Preliminary Report of Radiological Outcome

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Background: Minimally invasive spine surgery has revolutionised the treatment of thoracolumbar fractures with favourable outcomes compared to conventional open surgery in terms of intraoperative blood loss and operative time. However, to date, there is lack of data comparing the efficacy of percutaneous monoaxial screws inserted at

adjacent fracture level for fracture reduction to polyaxial screws method. We described the reduction technique of thoracolumbar burst fracture using percutaneous monoaxial screws and its radiological outcomes compared to polyaxial screws

Methods: This is a retrospective review of prospectively collected data in our institution. All surgeries were performed by minimally invasive technique with percutaneous monoaxial screws inserted at adjacent fracture levels perpendicular to both superior end plates. Fracture reduction is achieved with adequate rod contouring and distraction manoeuvre. Radiological parameters were measured during pre-operation, preoperation, postoperation, and follow-up.

Results: A total of 21 patients were included. Eleven patients were performed with monoaxial pedicle screws and 10 patients performed with polyaxial pedicle screws. Based on AO Thoracolumbar Classification System, 10 patients in monoaxial group had A3N0M0 and one had A4N0M0. In polyaxial group, six patients had A3N0M0 and four patients had A4N0M0. Total correction of anterior vertebral body height ratio was 0.30±0.10 and 0.08±0.07 in monoaxial and polyaxial group, respectively (p<0.001). Total correction of posterior vertebral body height ratio was 0.11±0.05 and 0.02±0.02 in monoaxial and polyaxial group, respectively (p<0.001). Monoaxial group achieved more correction of 13° (62.6%) in local kyphotic angle compared to 8.2° (48.0%) in polyaxial group. Similarly, in regional kyphotic angle, 16.5° (103.1%) in monoaxial group and 8.1° (76.4%) in polyaxial group.

Conclusions: Monoaxial percutaneous pedicle screws inserted at adjacent fracture levels provides significantly better fracture reduction compared to polyaxial screws in thoracolumbar fractures

Keywords: Thoracolumbar; Burst fracture; Minimal invasive spine surgery; Monoaxial pedicle screw; Fracture reduction

A Comparison of Minimally Invasive Surgery and Open Posterior Instrumentation of Unstable Burst Fractures

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Background: Unstable burst fractures may be treated with posterior instrumentation and stabilisation and decompression in the presence of neurological deficits. The role of minimally invasive surgery (MIS) stabilisation of unstable burst fractures is controversial. In this study we compare the results of open versus MIS stabilisation of unstable thoracolumbar burst fractures.

Methods: This is a retrospective cohort study of 49 patients treated at our institution between 2007 to 2016 with unstable thoracolumbar burst fractures treated surgically with either open posterior instrumentation or MIS posterior instrumentation. Pre- and postoperative Cobb angle, percentage of vertebral compromise, intraoperative blood loss, number of levels instrumented, surgical timing, and postoperative morbidity and mortality were recorded.

Results: In total 65 patients 17 were treated with MIS and 48 were treated with open posterior instrumentation. Each patient had a Thoracolumbar Injury Classification and Severity score of more then 4. Among the MIS patients seven were treated with short segment instrumentation (3-levels) while 10 had instrumentation of 4 or more levels. Twelve of the open patients were treated with short segment instrumentation and 36 with instrumentation of 4 or more levels. Mean operative time was 176 minutes in the MIS group and 186 minutes in the open group. There was no significant difference in postoperative correction of Cobb angle, intraoperative blood loss, operative time, and postoperative morbidity (p<0.05).

Conclusions: This study suggests that there is a role for MIS posterior stabilisation of unstable thoracolumbar burst fractures with no significant increase in complications and similar postoperative results

Keywords: Minimally invasive surgery; Burst fracture

The Validity of the Thoracolumbar Injury Classification System in Thoracolumbar Spine Injuries

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Background: Although there were many studies about the application of the Thoracolumbar Injury Classification and Severity (TLICS) score to thoracolumbar spine injuries, large-scale studies of efficacy in treated patients were rarely investigated. This study aimed to assess the efficacy of TLICS score in the selection of treatment methods for patients with thoracolumbar spine injury.

Methods: From 2000 to 2016, we retrospectively studied 330 patients who were treated for thoracolumbar spine injuries. Clinical results and radiological data were studied and analyzed using the American Spine Injury Association scale, Magerl/AO classification, and TLICS score.

Results: Among 330 patients, 139 patients (42.1%) received conservative treatment and 191 patients (57.9%) received surgical treatment. Of the 139 patients who underwent conservative treatment, 128 patients (92.1%) were consistent with the recommended treatment in TLICS. Of the patients who underwent conservative treatment, 10 patients (7.2%) failed conservative treatment and required surgical treatment. On the other hand, out of a total of 191 patients who underwent surgical treatment, 160 patients (83.8%) were consistent with the recommended treatment in TLICS.

Conclusions: The TLICS classification is highly effective in the conservative treatment of thoracolumbar junction injury. In addition, it has relatively good efficacy in surgical treatment.

Keywords: Thoracolumbar spine; Fracture; Thoracolumbar Injury Classification and Severity score; Surgical treatment; Conservative treatment

Epiduroscopic Laser Neural Decompression: Clinical Significance and Complications for 8 Years

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Background: A novel epiduroscopic laser neural decompression (ELND) provides an alternative less-invasive technique for treating lumbar spine pathology. This study report on the outcomes and complications of ELND

Methods: Between October 2008 and September 2015, a total of 219 patients underwent ELND. Indication is central canal stenosis, lumbar disc herniation, chronic lower back pain, and post lumbar surgery syndrome. They are no improvement in back pain or radiating pain despite several conservative treatments for a minimum period of 3 months, where the conservative treatment included medication, physical therapy, and injection treatment. Clinical outcomes were evaluated using the Visual Analog Scale (VAS) at follow-up days. For the postprocedure complication, we reviewed the medical records and called to the patients.

Results: The mean age was 67.1±7.8 years and mean follow-up period was 34±3.1 months. Distribution of disease was as follows: spinal stenosis, 94 patients (64%); lumbar disc herniation, 31 patients (21%); post lumbar surgery syndrome, 21 (14%); chronic low back pain, two patients (1%). In VAS flow for every disease, lumbar disc herniation is more effective pain improvement than other disease. There is no permanent or chronic complication

Conclusions: In back pain or radiating pain for spine pathology, ELND is effective non-surgical treatment. It is more effective for lumbar disc herniation.

Keywords: Epiduroscopic laser neural decompression; Tras-sacral epiduroscopic laser decompression

Unilateral Biportal Endoscopic Decompression by 30º Cndoscopy in Lumbar Spinal Stenosis: Technical Note and 2-Year Results

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Background: Open laminectomy or open laminectomy and lumbar spinal fusion have been regarded as the standard surgical method up to date in degenerative spinal stenosis. The conventional method has been associated with complications such as paraspinal muscle damage, bleeding, and infection. Several surgical techniques including microendoscopic decompression have been introduced to solve these problems. The aim of this study is to introduce a new spinal surgical technique using a 30° endoscopy through unilateral biportal endscopic technique and to report result of patients who have been on follow-up for more than 2 years.

Methods: Fifty-five patients who were suffering from neurologic symptoms by degenerative lumbar spinal stenosis were included even after preoperative conservative treatment. Patients with foraminal stenosis requiring an extraforaminal approach were excluded from the study. Two or three portals were used for each level. One portal was used for viewing, the others, for working of a certain instruments. Unilateral laminotomy was followed by bilateral decompression under 30° endoscopy. Clinical outcomes were analyzed in view of modified-MacNab criteria, Oswestry Disability Index (ODI), Visual Analog Scale (VAS), and postoperative complications were analyzed.

Results: ODI improved from 67.4±11.5 preoperatively to 19.3±12.1 after follow-up for the last 2 years. VAS for leg decreased from 7.7±1.5 to 1.7±1.5 at final follow-up. Eighty-one percent of the patients were improved over a level of good based on the MacNab criteria. There were not infection case.

Conclusions: Full endoscopic decompression using 30° endoscopy allowed satisfactory result clinically at 2 years and reduction of surgical infection. It could be alternative method of microscopic laminectomy.

Keywords: Biportal endoscopic spinal surgery; Unilateral biportal endoscopic decompression; Spinal stenosis; Endoscopy

Result Comparison between Instrumented Fusion and Percutaneous Endoscopic Interlaminar Decompression for Spondylolisthetic Stenosis

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Background: The treatment of symptomatic lumbar spondylolisthetic stenosis refractory to conservative treatment is surgical decompression alone or fusion with or without instrumentation. However, the conventional decompression is still concerned about the iatrogenic instability due to destruction of posterior stabilizers. Therefore, instrumented fusion is favored in most surgeons. The Percutaneous endoscopic lumbar decompression is the least invasive, and there is compatible results with the same microscopic surgery. Ruetten and his colleagues developed a new percutaneous endoscopic interlaminar decompression (PEID) to treat lumbar lateral recess stenosis comparison to microscopic method. There were no differences in Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) in 24-month follow-up. However, PEID decreased VAS of back in 5 days postoperatively.

Methods: We use the one portal endoscopic interlaminar decompression to treat bilateral lateral recess and central stenosis. Under general anesthesia the patient was set in prone on the radiolucent frame. Only the longitudinal 7-mm incision wound was made after checking under fluoroscope and then put the dilator onto the interlaminar space followed by inserting working cannula. As the open laminotomy, firstly we decompressed the ipsilateral lamina and lateral recess by scope burr and Kerrison punch followed by contralateral sublaminar decompression. The other group is instrumented fusion which was performed by posterior lumbar interbody fusion and transforaminal lumbar interbody fusion with pedicle screws and rods fixation.

Results: There were no dura tear or neurological injury during operation. Both groups had significant improvement in 3rd-, 6th-, and 12th-month follow-up postoperatively. The PEID group had not only significant better results at 3rd-month VAS of back and 3rd-, 6th-, and 12th-month ODI than instrumented fusion but also had fewer

admission days and no transfusion need.

Conclusions: There are encouraging results in our experience and no serious complication. We conclude the one portal endoscopic interlaminar decompression is comparable even better than the instrumented fusion in one year.

Keywords: Endoscopic spine surgery; Percutaneous endoscopic lumbar decompression; Percutaneous endoscopic interlaminar decompression

Clinical Efficacy of Biportal Endoscopic Spine Surgery with Modified Approach in Patients with Severe Lumbar Central Canal Stenosis

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Background: The aim of study is to report the clinical efficacy in patients with severe lumbar central canal stenosis (LCCS) treated with biportal endoscopic (arthroscopic) surgery using modified approaching technique.

Methods: The working port was inserted in a near perpendicular direction, and a endoscopic port was inserted into it by about 20°–30°. With this modified approach, effective removal of the tissue is possible by efficient and direct access to the bilateral hypertrophic yellow ligament without significant contralateral laminectomy. We evaluated the efficacy with 15 patients (eight males, seven females; median age, 63 years; median symptom duration, 24 months). All the patients had been diagnosed as severe LCCS through physical examinations and magnetic resonance images. Clinical outcome was analyzed by using numeric rating scale (NRS), MacNab criteria and subjective report of neurogenic claudication, serially assessed before the procedure and at 6, 12, and 18 months post procedure.

Results: The NRS about low back pain fell from 7 to 2 scores at 6 months, to 1.5 at 12 months, and to 2 at 18 months post procedure. The NRS about lower extremity pain fell from 8 to 1 scores at 6 months, to 1 at 12 months, and to 1 at 18 months post procedure (median values in statistics). According to the MacNab criteria, 'excellent' was obtained for eight patients (53.3%), 'good' results for six (40.0%), and 'fair' results for one patient. All patients had been unable to walk more than 400 m with neurogenic claudication before the surgery. However, twelve patients were able to walk for more than 1 hour, two patients had slight pain when walking for 30 minutes, and one patient had less than 400 m of walking pain.

Conclusions: The results show that the biportal endoscopic surgery with modified approach can be an efficient and safe intervention for resection of hypertrophic yellow ligament in patients with severe LCCS.

Keywords: Minimally invasive surgical procedures; Spinal Stenosis; Endoscopic surgical procedure; Arthroscopes

High Anesthetic Risk Patient with Spinal Stenosis Treated with Partial Decompression with Percutaneous Endoscopic Lumbar Decompression Through Interlaminar Approach under Local Anesthesia

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Background: Spinal stenosis treated with decompression obtained good long-term results. However, multiple comorbidity patients and patients fear of general anesthesia underwent open or even microendoscopic (MED) decompression under local anesthesia were not established. Percutaneous endoscopic lumbar decompression (PELD) through interlaminar approach for L5/S1 herniated disc under local anesthesia was proved to be effective. This research is to proposed PELD through interlaminar approach for spinal stenosis treatment of unilateral laminotomy for bilateral decompression.

Methods: The prospective study of non-randomized case series from a single hospital by a single surgeon (author) from May 2017 to January 2018 was conducted. Patients diagnosed with bilateral neurogenic claudication (less than 30 minutes) more than 2 months and central stenosis noted on preoperative magnetic resonance imaging with American Society of Anesthesiologist (ASA) grading III to IV were enrolled and patients who could not finish the complete follow-up were excluded. Patients were followed up to 6 months (immediate postoperative, postoperative 1, 3, and 6 months) and Visual Analog Scale (VAS), 36-item Short-Form Health Survey (SF-36), EuroQol-5D (EQ-

5D), Oswestry Disability Index (ODI), and Japanese Orthopaedic Association (JOA) scores were recorded. PELD through interlaminar approach under local anesthesia (2% xylocaine injected around the incision and around facets) was done without any sedation. Patients were discharged 1 hour after surgery.

Results: Consecutive 10 cases of (three males, seven females; average age, 76±2 years; ASA grading, III=7, IV=3; level, T12/L1=1, L2/3=3, L3/4=1 L4/5=5; Sedimentation sign, C=7, D=3) were enrolled. VAS, JOA, ODI, SF-36, and EQ-5D revealed major improvements comparing preoperatively and postoperatively conditions (Mann-Whitney *U*-test). According to modified MacNab criteria, excellent rate was 30%, good 50%, fair 10%, poor 10%, total efficiency 80%, complication 10%, and recurrence rate 0%. Bleeding (neglectable) and operation time (mean, 135±30 minutes) were noted. Complications of one asymptomatic minimal dural tear, one hyperventilation syndrome, and postoperative hematoma converted to open decompression were noted.

Conclusions: Interlaminar approach of PELD for spinal stenosis maybe an alternative treatment for stable spinal stenosis for patient with multiple comorbidity or patient refuse general anesthesia.

Keywords: Spinal stenosis; Percutaneous endoscopic lumbar decompression; Local anesthesia; High anesthetic risk; Interlaminar approach

Percutaneous Endoscopic Transforaminal Decompression for Degenerative Lumbar Lateral Recess Stenosis: Comparison of Clinical Outcomes in Patients with or without Scoliosis

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Background: Transforaminal approach with the outside-in technique provides a direct access to foramen and lateral recess and the lateral stenotic area can be decompressed comprehensively without disturbing the segmental stability. Decompression surgery is an option for degenerative lumbar stenosis associated with scoliosis, but there remain concerns for postsurgical instability and salvaging fusion surgery.

Methods: Percutaneous endoscopic transforaminal decompression (PETD) was performed in consecutive 59 patients from Jan 2016 to Dec 2017 for lumbar radiculopathy due to single level of degenerative lumbar lateral recess stenosis. Inclusion criteria for patients with associated degenerative scoliosis were Cobb angle less than 30° and without instability. Clinical outcome was evaluated using Oswestry Disability Index (ODI), Visual Analog Scale (VAS) score, and MacNab criteria.

Results: Among 59 patients, associated scoliosis with Cobb angle >10° was presented in 25 patients (group 1) and Cobb angle ≤10° in 34 patients (group 2). Satisfactory rate (excellent and good results) of group 1 was 84.0% and group 2 was 85.3%. Patients with preoperative scoliosis had more improvement in ODI and VAS score after procedure but there were no significant differences in their clinical outcome or reoperation rate. There were no major complications in both groups.

Conclusions: PETD for degenerative lateral recess stenosis produced satisfactory clinical outcomes even in patients with degenerative lumbar scoliosis. Functional improvement is similar in patients with and without scoliosis. This procedure can be an alternative to open laminectomy. Routine fusion may not be indicated in all patients with degenerative lateral recess stenosis and scoliosis.

Keywords: Percutaneous endoscopic transforaminal decompression; Lateral recess stenosis; Degenerative scoliosis

Interspinous Fusion Device Combining Ipsilateral-Unilateral Screw System for Transforaminal Lumbar Interbody Fusion: A Finite Element Study

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Background: Though spinal fusion with bilateral pedicle

screw fixation system (BPS) is considered to be a standard treatment, it has shown to exert various adverse events. To prevent these, interspinous fusion device (IFD) combining ipsilateral-unilateral pedicle or cortical screw system (IUPS/IUCS) had been proposed as a new choice. Hence, the purpose of this study is to compare four different fixation systems for a single level transforaminal lumbar interbody fusion (TLIF) using finite element analysis.

Methods: The study developed three-dimensional geometric models for a normal L1–S1 spine and the implants with computer-aided design software. Then we performed mechanical analysis using finite element analysis software ANSYS Workbench ver. 17.2. The construct was designed to be a L4/L5 TLIF using IUPS, IUPS+IFD, IUCS+IFD, and BPS. Model reference was set as load conditions with 10 Nm bending moment to simulate flexion, extension, torsion, and side bending. We recorded the angular change, intervertebral disc pressure between the surgical segment and its adjacent segments, and the neuroforaminal width of the surgical segment during forward bending. All constructs were compared with a normal spinal model.

Results: A significant decrease in the angular change among in all the three groups compared to normal group was demonstrated. During forward bending, the IUPS+IFD and BPS had similar angular change, intervertebral disc pressure, and contralateral neuroforamen diameter at the surgical segment. Further, IUPS+IFD and IUCS+IFD had higher pressure at L2–3 during torsion and side bending while less pressure at L5–S1 during flexion and extension.

Conclusions: Overall, IUPS+IFD and IUCS+IFD displayed similar patterns of angular motion, neuroforamen maintenance, and intervertebral disc pressure change as BPS in a L4/5 TLIF. Therefore, IUPS+IFD and IUCS+IFD may be used as an alternative to BPS in order to reduce pedicle screw related complications.

Keywords: Interspinous fusion device; Cortical screw; Pedicle screw; Transforaminal interbody fusion

Sagittal Alignment of the Cervical Spine in Directed and Natural Standing Postures: A Comparative Radiographic Study Considering Whole Body Balance

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Background: As the natural standing posture is more commonly assumed than the directed standing posture, it is more likely to reflect pathology, as well as more relevant in determining alignment targets. However, the sagittal profile of the cervical spine in the natural standing posture has yet to be studied, and the "optimal cervical sagittal alignment" for fusion remains unknown. Therefore, this study aims to investigate the differences in cervical alignment between the directed and natural standing postures, in the context of integrated whole body balance.

Methods: This was a prospective study conducted over a 9-month period. Sixty young healthy subjects underwent whole spine EOS radiographs for comparison of both their natural and directed standing postures. Measurements obtained comprised translational parameters, global and regional cervical angles, spinopelvic angles, as well as other whole body sagittal parameters. Paired *t*-tests were used to compare radiographic parameters between postures.

Results: The natural standing posture demonstrated a more positive mean sagittal vertical axis (SVA), a steeper T1-slope, and a larger T1-Inflexion vertebra (Inf) kyphotic angle. This corresponded with a smaller Inf-S1 lordotic angle. C2–7 SVA are similar in both postures. All global (C0–T1 and C2–7) and regional cervical angular parameters (C2–4 and C4–7) showed increase in lordosis with the exception of the C0–2 angle, which became more kyphotic by a mean of 4.43°±7.41° (p<0.001). Equilibration of kyphotic and lordotic angles was observed when using inflexion vertebra for Cobb angle measurements and following consideration of whole body parameters (T1-slope and femoral anatomic axis).

Conclusions: Greater cervical lordosis occurs in natural standing. Isolated increase in C0–2 kyphosis during natural standing is reflective of ligament recruitment, and suggestive of ocular compensation to maintain horizontal gaze. Spinal alignment should always be assessed using

functional anatomy (e.g., inflexion vertebra, horizontal gaze axis), with consideration of whole body parameters, and preferably in the natural standing posture.

Keywords: Natural standing; Cervical spine; Cervical alignment; Whole body balance

Functional Prognosis after Late Decompression Surgery for Cervical Spinal Cord Injury With Severe Cord Compression

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Background: Of the factors that affecting a prognosis following traumatic cervical spinal cord injury (CSCI) without bone injury, pre-existing cord compression is an important issue to consider. The purpose of the current study was to examine the effectiveness of late decompression surgery for CSCI with pre-existing cord compression.

Methods: Seventy-eight patients with traumatic CSCI without bone injury hospitalized in 2012–2015 in our institute for rehabilitation after initial emergency care were divided into four groups according to the compression rate (CR) of the injured level and whether or not decompression surgery was performed. Neurological status was evaluated by American Spinal Injury Association impairment scale (AIS), Barthel index, and Spinal Cord Independence Measure (SCIM).

Results: In the severe compression group (CR ≥40%), more than 2 grade improvement in the AIS was observed in 30% of patients with surgical treatment, although it was not observed in any patient without surgery. The SCIM improvement rate at discharge was 60% in the surgical treatment group and 20% in the non-surgical treatment group. In the minor compression group (CR <40%), more than 2 grade improvement in the AIS was observed in 18% of patients with surgical treatment and in 11% without surgery. The SCIM improvement rate at discharge was 52% in the surgical treatment group and 43% in the non-surgical treatment group.

Conclusions: These results indicate that surgical treatment has an advantage for patients following traumatic CSCI with severe cord compression. In contrast, surgical efficacy is not proved for CSCI patients without severe cord compression.

Keywords: Cervical spinal cord injury without bone and disc injury; Decompression surgery; Spinal cord independence measure

The Evaluation for the Muscle in Cervical Spinal Cord Injury Patients

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Background: Muscle atrophy (MA) is a common complication of patients with cervical spinal cord injury (c-SCI), and induces the diabetes mellitus and stroke. We reported the MA after c-SCI using a Dual-energy X-ray absorptiometry (DEXA), and the results showed the remarkable decrease of muscle mass at 6 months after the injury. However, the DEXA that can evaluate the MA is very expensive, so the method which can evaluate the MA more easily, is needed. In this study, we evaluated the MA using both DEXA and measurement of circumference (upper and lower extremity) at 1 month and 6 months after injury, and reported about the relationship between the DEXA and circumference.

Methods: Fifteen patients with c-SCI were included from February 2015 to February 2017 at our institution (13 males, 2 females; mean age, 65 years). The patients were classified by the American Spine Injury Association score (type A, 4; B, 1; C, 7; D, 3). The muscle mass was evaluated using the DEXA and circumference at the 1 month and 6 months after injury. We compared the muscle mass of upper and lower extremity by DEXA and upper-arm, forearm, thigh, and calf by circumference. The results were analyzed by Spearman's rank correlation coefficient.

Results: The DEXA showed the MA at the 6 months after injury compared with 1 month (upper extremity, 16% decrease; lower extremity, 16% decrease). The circumference also showed the MA (upper-arm, 3.4% decrease; forearm, 2.6% decrease; thigh, 5.1% decrease; calf, 5.5% decrease). There was no statistically significant difference

in upper extremity between DEXA and circumference. However, there was statistically significant difference in lower extremity between DEXA and circumference (thigh: p=0.0037, calf: p=0.0365).

Conclusions: Circumference was a reliable method to evaluate the change of muscle mass of lower extremity in patients with c-SCI. We need to continue this study to report the results more accurately.

Keywords: Muscle atrophy; Dual-energy X-ray absorptiometry; Circumference; Spinal cord injury

Cervical Spine Fracture in Patient with Diffuse Idiopathic Skeletal Hyperostosis: Clinical Characteristics by Fracture Level

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Background: Diffuse idiopathic skeletal hyperostosis (DISH) makes the spine prone to unstable fractures with neurological deterioration. This study was conducted to assess clinical and radiographic features of cervical spine fractures in DISH comparing thoracic and lumbar spine injury.

Methods: A multicenter retrospective study over a 5-year period includes 46 patients (35 males, 11 females) with a mean age of 77.2±9.7 years at the time of injury. Among them, seven were cervical (15.2%), 25 thoracic (54.3%), and 14 lumbar (30.4%). We compared the cause of injury, whether diagnosis was delayed, and neurological status by Frankel grade, ossification and fracture patterns assessed by computed tomography multiplanar reconstruction among the cervical, thoracic, and lumbar groups.

Results: Immediately after the injury, the majority of patients were neurologically intact (cervical 71.0%, thoracic 88.0%, lumbar 78.6%). However, 29.0% of the patients in the cervical spine group could not walk at admission, which was more frequent than the other groups (thoracic 12.0%, lumbar 0.0%; p=0.031). Vertebral-body fractures were observed in 14.3% of the cervical group, which was less frequent than the other groups (thoracic 80.0%, lumbar 50.0%; p=0.004). While, the majority of patients in the cervical group had a disc-level fracture (85.7%), which was more frequent than the other groups (thoracic 20%, lumbar 50%; p=0.004). Posterior-column ankylosis was less observed in the cervical group (14.3%) than the other groups (thoracic 72.0%, lumbar 78.6%; p=0.008).

Conclusions: Fracture patterns in patients with DISH varied distinctly by the level of spinal injury. Intervertebral-disc fractures and severe neurological symptom were frequently observed in the cervical spine than in thoracic and lumbar spine.

Keywords: Diffuse idiopathic skeletal hyperostosis; Cervical spine; Spinal fracture; Treatment

Accuracy of Navigated Cervical Pedicle Screw Insertion: 9-Year Surgical Experience and Technical Pearls

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Background: Despite the advantages of longer bony purchase and better fixation, the technical difficulties associated with insertion and the threat of vertebral artery injury serve as major deterrents for cervical pedicle screw (CPS) insertion. The employment of intra-operative three-dimensional (O-arm) computed tomography (CT)-based navigation in the placement of cervical pedicle screws promises to circumvent these dangers and enhance fixation. This study aims to assess the accuracy of CPS insertion under navigation.

Methods: Seventy-seven patients who underwent CT-guided cervical pedicle screw insertion performed between 2009 and 2017 were retrospectively evaluated. A total of 266 CPSs were evaluated using the Gertzbein clas-

sification based on their post-insertion scans.

Results: two hundred and fourteen screws (80.5%) were placed without any pedicle breach (grade 0). Thirty-nine screws (14.7%) had a breach of less than 2 mm (grade 1), 10 screws (3.8%) had a breach of between 2 mm and 4 mm (grade 2), and three screws (1.1%) had a complete breach of 4 mm or more (grade 3). None of the patients reported clinical symptoms despite the breaches. The reoperation rate is 0%. Of the 52 breaches, 45 (86.5%) were found to perforate laterally, and the remaining seven (13.5%) medially. It was also noted that the C6 cervical level had the highest breach rate of 32.6%.

Conclusions: CT-based navigation provides the surgeon with immediate intra-operative feedback for cervical pedicle screws insertion, thus improving its accuracy. However, there is a learning curve associated with this technological advancement. We will discuss the technical tips to improve safety that we have accrued over our 9-year surgical experience using this CT-based navigated system.

Keywords: Navigation; Cervical spine; Pedicle screw

Application of Ultrasonic Osteotome for Anterior Approach Resection of Cervical Ossification of the Posterior Longitudinal Ligament: A Case Report

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Background: Ossification of the posterior longitudinal ligament (OPLL) is most commonly found in Asian male patients. Management of OPLL includes anterior and posterior approaches.

Methods: We present a case report of 50-year-old male patient with cervical myelopathy symptoms. He was diagnosed with C2–7 stenosis with OPLL and underwent combined anterior and posterior decompression and fusion surgery. We utilized the ultrasonic osteotome for the resection of the OPLL during the anterior approach.

Results: Surgical insult to the neural tissue must not be disregarded. Ultrasonic osteotome utilize back and forth micro-motion rather than rotatory-motion, thus energy from the cutting edges of these devises is preferentially transmitted to hard structures because the dura can bend, vibrate and deform to vibratory micromotion with minimal transmission of energy. However, the pressure of irrigation fluid may injure spinal cord and this should be noticed before utilizing ultrasonic osteotome.

Conclusions: We have shown the feasibility of an ultrasonic osteotome for anterior decompression of C spine OPLL. We hope that surgical difficulties might be overcome by utilizing this technique.

Keywords: Cervical ossification of the posterior longitudinal ligament; Ultrasonic osteotome

Surgical Outcomes of Cervical Myelopathy Due to Ossification of Posterior Longitudinal Ligament: Anterior Decompression and Fusion versus Posterior Laminoplasty

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Background: Both anterior decompression and fusion (ADF) and posterior laminoplasty (LAMP) are frequently used for treatment of cervical myelopathy due to ossification of posterior longitudinal ligament (OPLL), but considerable controversies over surgical options still perplex many spine surgeons. The aim of this study is to compare the surgical outcomes of ADF to that of LAMP in treatment of cervical myelopathy due to OPLL.

Methods: We retrospectively assessed 82 patients who underwent surgery for treatment of cervical myelopathy due to OPLL at our institution. Thirty-two patients who did not meet included criteria were excluded. Finally 50 patients (ADF group, n=17; LAMP group, n=33) were included in our study. Surgical outcomes were assessed by use of the Japanese Orthopaedic Association (JOA) scoring system. The radiologic and clinical data were compared between two groups using IBM SPSS ver. 22.0 software.

Results: There were no significant difference in comparison of age, follow-up time, operation time, blood loss, length of stay, preoperative JOA scores, preoperative occupying ratio of OPLL, and preoperative C2–C7 Cobb angle between ADF and LAMP groups, but the mean surgical segment of ADF group was less than that of LAMP group. Radiologic outcomes indicated that postoperative C2–C7 Cobb angle and the change of C2–C7 Cobb angle before

and after operation were similar between two groups. Final follow-up postoperative JOA score and recovery rate of neurological function were significant higher in ADF group than those in LAMP group, especially in patients with segmental-type OPLL. The major complication after ADF was cerebrospinal fliud leakage, but LAMP was complicated with a high incidence of C5 paralysis and axial pain.

Conclusions: Compared to LAMP, ADF had better improvement rate of neurological function in treatment of cervical myelopathy due to OPLL, especially in patients with segmental-type OPLL.

Keywords: Anterior decompression and fusion; Laminoplasty; Ossification of posterior longitudinal ligament; Cervical myelopathy

The Surgical Management of Cervical Spondylotic Myelopathy by Minimal Invasive Laminoplasty: Tateru Shiraishi Method

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Background: The cervical spinal stenosis (CSS) often occurs in Vietnam due to cervical disc herniation, CSS, ossification of posterior longitudinal ligament, and ossification of the yellow ligament. The golden methods were Kurokawa or Itoh laminoplasty in Japan. The axial discomfort including pain was found in long-term follow-up by Hosono with these techniques due to generous destruction of the posterior cervical stabilizing muscle complex. The new minimal invasive posterior approach with preservation of cervical extensors muscles has been introduced by Tateru Shiraishi since 2002.

Methods: Continuous laminoplasty data of 20 cases operated in Trung Vuong Hospital and Vietnam were analyzed (mean age, 55.2±8.3 years [range, 39–69 years]; mean preoperative JOA, 10.45±2.8 [range, 6–16]; mean preoperative paralytic onset, 71.53±10.88 days).

Results: The outcomes of this study as follows: mean blood loss, 151l±56.8 mL (range, 70–300 mL); mean surgical time, 162±53.2 minutes (range, 90–330 minutes); mean immediate postoperative Japanese Orthopaedic Association (JOA) score, 13.4±1.8 (range, 10–17); mean final follow-up JOA score, 14.95±1.9 (range, 12–17); mean follow-up, 14.95±1.9 months (range, 12–17 months); mean final JOA recovery rate, 71.3±24.8 (range, 33.3–100); no complication, 95%; C5 palsy, one case (5%); recovery, 100% after 3-month follow-up; and axial pain, 5%. The improvement of axial pain in the follow-up looks very good (only 5%) in our patients group (instead of 13%–25% in other series). The final JOA recovery rate was good so far as 71.3±24.8 (range, 33.3–100).

Conclusions: The good results were obtained with Tateru Shiraishi laminoplasty with preservation of the posterior stabilizing cervical muscle complex, especially sternocleidomastoid muscle. It is also a cost-effective technique.

Keywords: Laminoplasty; Preservation; Cervical extensors muscle; Cost-effective

Differential Diagnosis of Paraspinal Muscle Electromyography on Dissociated Motor Loss in the Upper Extremities with Cervical Spondylosis and Brachial Plexus Injury

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Background: The objective of this study is to investigate the differential diagnosis of paraspinal muscle electromyography on dissociated motor loss in the upper extremities with cervical spondylosis and brachial plexus injury.

Methods: We retrospectively analyzed nine cases with dissociated motor loss in the upper extremities with cervical spondylosis clinical data, imaging and electromyography test results from March 2012 to July 2016.

Results: In the nine cases, three cases were difficulty to distinguish with brachial plexus injury. The paraspinal muscle electromyogram (EMG) showed the cervical paraspinal muscle with a lot of positive sharp waves and fibrillation potential and neurogenic damage.

Conclusions: Paraspinal muscle EMG has clinical significance in the differential diagnosis of dissociated motor loss in the upper extremities with cervical spondylosis and brachial plexus injury.

Keywords: Paraspinal muscle electromyography; Cervical spondylosis; Brachial plexus injury

Natural History of Cervical Myelopathy: The Wakayama Spine Study

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Background: The natural course of cervical myelopathy (CM) remains unknown. The purpose of this study is to investigate the occurrence of CM among cervical cord compression (CCC) cases and to reveal the predictors for CM.

Methods: The present study is a population-based magnetic resonance imaging cohort study: the Wakayama Spine Study. Physical performance on 10-s grip and release test (GRT), grip strength, 6-m walking time at a usual and a maximal pace, chair-stand time (CST), and one-leg standing (OLS) time. At the baseline survey, we diagnosed 238 subjects as having CCC. We followed up 211 subjects who had CCC for more than 4 years after excluding 27 participants diagnosed with CM at baseline. Among these subjects, 142 (mean age, 68.9 years) participated in the second survey (follow-up rate, 67.3%). In the second survey, *de novo* CM was defined clinically as having myelopathic signs. Physical performance was evaluated at baseline and at the second survey.

Results: Among the 142 participants, nine (incidence rate, 6.3%) were newly diagnosed as having CM. The CST (p=0.0002), 6-m walking time at a usual (p=0.0032), and at a maximal pace (p=0.0019) significantly decreased in the *de novo* CM participants at baseline, but not grip strength (p=0.29), OLS (p=0.34), and GRT (p=0.41). Multivariate analysis revealed that CST (p=0.019), 6-m walking time at a usual pace (p=0.016), and at a maximal pace (p=0.012) were significant predictive factors of *de novo* CM.

Conclusions: We clarified the incidence rate of CM in subjects with CCC and the predictors of de novo CM. These physical performance measures can be useful diagnostic tools for diagnosing CM. This indicates that CCC influences physical performance, especially of the lower limbs, before other physical signs become clear.

Keywords: Cervical myelopathy; Ervical cord compression; Opulation-based cohort; Atural history; Hysical performance

Cervical Hemilaminoplasty for Cervical Myelopathy

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Background: Cervical laminoplasty is one of the surgical procedures for the cervical spondylotic myelopathy (CSM), cervical ossification of posterior longitudinal ligament (OPLL), and cervical cord tumor, and the good operative result have been reported in the literature. In our hospital, hemilaminoplasty has been applied for the cervical lesions. In this presentation, the operative results, postoperative complication, and the change of cervical space after cervical hemilaminoplasty is reported.

Methods: Forty-five cases were operated in our hospital. They were 34 males and 11 females. Their average age was 72.9 years old. Clinical diagnosis were as follows: CSM 29 cases, cervical OPLL 15 cases, and cervical cord tumor 1 case. Mean follow-up periods were 19.5 months. Evaluation items are as follows: mean recovery rate, mean operating time, mean operative bleeding volume, and postoperative complications such as postoperative C5 root palsy and postoperative axial pain and change of cervical space on the computed tomography (CT) photograph.

Results: Mean recovery rate was 60%. Five cases within seven cases with preoperative gait disabiliy have regained gait ability after surgery. Mean operating time was 2 hours and 18 minutes from 1 hour 50 minutes to 2 hours 45 minutes. Mean bleeding volume was 355 mL. Postoperative C5 root palsy was found in one case and post-operative axial pain were complicated in seven cases. Cervical space on the CT photograph has enlarged to about 2 times at each disc leveis from C3 to C7.

Conclusions: It is concluded that the cervical hemilaminoplasty is one of the useful surgical procdures for the survical compressive lesions such as CSM and cervical OPLL because of the good operative results and less severe complication.

Keywords: Cervical hemilaminoplasty; Cervical myelopathy

Risk of Spring-Back Closure in Skipped-Level Plating for Open-Door Laminoplasty: Insight into Its Cost-Saving Potential

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Background: The open-door laminoplasty technique is a commonly adopted posterior approach to decompression for cervical spondylotic myelopathy (CSM). Spring-back phenomenon is a concern as closure of the lamina can cause recurrence of symptoms. Plating has since reduced the risk of spring-back but is costlier. Hence, the aim of this study is to determine whether alternate level plating can still avoid the risk of spring-back closure while maintaining adequate neurological recovery.

Methods: Patients with CSM treated by open-door laminoplasty with minimum 2-year postoperative follow-up were included. All patients had opening from C3–6 or C3–7 and were divided into skipped-level or all-level plating groups. Japanese Orthopaedic Association (JOA) scores and canal measurements were obtained preoperatively, immediate (within 1 week) postoperatively, and at 2 weeks, 6 weeks, 3, 6, and 12 months postoperatively. Paired *t*-test was used for comparative analysis. Receiver operating characteristic analysis was used to determine the canal expansion cut-off for spring-back closure.

Results: A total of 74 subjects were included with mean age of 66.1±11.3 years at surgery. Of these, 32 underwent skipped-level plating and 42 underwent all-level plating. No significant differences were noted between the two groups at baseline and follow-up. Spring-back closure was observed in up to 50% of the non-plated levels within 3 months postoperatively. The cut-off for developing spring-back closure was 7 mm canal expansion for C3–6. No differences were observed in JOA scores and recovery rates between the two groups. None of the patients with spring-back required reoperation.

Conclusions: There were no significant differences between skipped-level and all-level plating in terms of JOA or recovery rate, and canal diameter differences. This has tremendous impact on saving costs in CSM management as up to two plates per patient undergoing a standard C3–6 laminoplasty may be omitted instead of four plates to every level to achieve similar clinical and radiological outcomes.

Keywords: Cervical spondylotic myelopathy; Spring-back; Skipped-level; Laminoplasty; Plates

Midline Spinous Process Splitting Cervical Laminoplasty Using Trapezoid Shaped Allogeneic Bone Spacers: Comparison of Clinical and Radiographic Outcomes between Cervical Spondylotic Myelopathy and Ossification of Posterior Longitudinal Ligament

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Background: The objective of this study is to examine the clinical and radiological outcomes in patients undergoing spinous process splitting cervical laminoplasty (SPSCL) using allogeneic bone grafts from a hospital-based bone bank and compare the results between patients with cervical spondylotic myelopathy (CSM) and ossification of posterior longitudinal ligament (OPLL).

Methods: We retrospectively reviewed 70 patients who underwent SPSCL with allogeneic bone spacers between September 2006 and December 2015 with minimal 12-month follow-up. These patients were divided into two groups: CSM (60 patients) and OPLL (10 patients). Patients with large cervical kyphosis (>13°), cervical instability, as well as those who underwent prior cervical surgeries were excluded. Patient characteristics including gender, age, alcohol, diabetes mellitus, and smoking histories were obtained. Clinical outcomes were evaluated by the Japanese Orthopedic Association (JOA) scores and Nurick functional grade preoperatively and postoperatively. Simple cervical X-rays were taken preoperatively, immediate postoperatively, 3, 6, and 12 months after operation. Computed tomography (CT) scans were performed 12 months postoperatively. The differences between two diseases were analyzed on cervical lordosis, canal dimension, fusion between lamina, and allogeneic bone spacer and affecting factors of fusion.

Results: All surgeries were performed on 277 levels. There were no significant differences on the changes of lordosis, canal dimension as well as Nurick scores and JOA scores

between CSM and OPLL groups. Overall fusion rate was 55%. Multivariate analysis on the factor for the fusion rates between lamina and spacers showed that lower cervical level and OPLL as significant factor of fusion.

Conclusions: Although graft fusion rate is higher in patients with OPLL, the present study suggests that CSM and OPLL did not show difference of surgical outcome in SPSCL using allogeneic bone spacer. We conclude that allogeneic bone graft from a hospital-based bone bank is a safe and effective choice of spacer to achieve gutter healing in SPSCL surgeries.

Keywords: Allograft; laminoplasty; Ossification of posterior longitudinal ligament; Cervical spondylotic myelopathy

Relationship between Spinal Cord Morphology and Alignment in Patients with Cervical Spondylotic Myelopathy Status Post-spinous Process-Splitting Laminoplasty

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Background: The efficacy of spinous-process splitting laminoplasty and its impact on cervical alignment change and the incidence of postoperative neck pain remain unclear. This study aimed to analyze the parameters of cervical alignment and cord morphology in patients with cervical spondylotic myelopathy (CSM).

Methods: This study comprised 46 CSM patients with a minimum follow-up of 18 months. All patients underwent anteroposterior (AP) and lateral plain film, and either computed tomography or magnetic resonance imaging. The parameters investigated were pre- and postoperative C2–C7 lordosis, the C2–C7 sagittal vertical axis, T1 slope, and cervical spinal cord morphology including the postoperative spinal cord posterior drift and postoperative expansion of the AP dura diameter. Patients were divided into three groups: lordotic, neutral, and kyphotic sagittal alignment. Statistical analysis was performed to determine the significant differences between preoperative and follow-up radiological findings.

Results: Of the patients, 19.5% (n=9) had improvement in their preoperative cervical lordotic alignment and 22.2% (n=10) developed progressive cervical kyphotic alignment aggravation. CL positively correlated with preoperative spinal cord posterior drift. Patients in the lordotic alignment group had the best spinal cord posterior shift, followed by the neutral group, and finally the kyphotic group. Those patients with preoperative progressive kyphotic deformity had significantly different cervical lordosis (CL), cervical sagittal vertical axis (CSVA), and clinical results compared with others. Logistic regression analysis showed that preoperative CSVA was an independent predictor of the change in CL curve, and that gender was an independent predictor of postoperative Japanese Orthopedic Association score.

Conclusions: Patients with kyphotic cervical alignment accompanied with a high CSVA were not suitable candidates for spinous-process splitting laminoplasty. Changes in cervical sagittal parameters after surgical procedures were noted in patients with CSVA >3 cm. Proper CSVA balance is critical in maintaining an efficient, pain-free, and upright posture. Preoperative spinal alignment parameters and cord morphology can be used as predictive factors of postoperative alignment in patients with CSM.

Keywords: Cervical sagittal alignment; Cervical spondylotic myelopathy

Relationship of T1 Slope with Loss of Lordosis and Surgical Outcomes after Laminoplasty for Cervical Ossification of the Posterior Longitudinal Ligament

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Background: T1 slope (T1S) has emerged as a predictor of kyphotic alignment change after laminoplasty. Although it was reported that patients with cervical ossification of the posterior longitudinal ligament (OPLL) and higher T1S had more pronounced lordotic curvature before surgery and higher loss of cervical lordosis after surgery, few studies have attempted to correlate these findings with clinical outcomes. We aimed to investigate the relationship of T1S with loss of cervical lordosis and surgical outcomes after laminoplasty for cervical OPLL.

Methods: Thirty-five consecutive patients (26 men and

nine women) with cervical OPLL who underwent double-door laminoplasty were followed for more than 12 months. Radiological and clinical measurements were performed to analyze the following parameters: pre- and postoperative C2–C7 Cobb lordotic angle (LA), preoperative C2–C7 range of motion, loss of cervical lordosis, percentage of change in postoperative kyphosis, pre- and postoperative C2–C7 sagittal vertical axis (SVA), change in C2–C7 SVA and occupying ratio of the OPLL, Japanese Orthopedic Association (JOA) score recovery rate, and preoperative magnetic resonance imaging (MRI) grade.

Results: Patients were divided into two groups according to preoperative T1S with the cutoff value being the average preoperative T1S. Preoperative C2–C7 Cobb LA (p=0.007) and loss of cervical lordosis (p=0.034) differed between the two groups. Preoperative C2–C7 Cobb LA (r=0.50, p=0.002) and loss of cervical lordosis (r=0.36, p=0.036) were significantly correlated to preoperative T1S. Multivariate linear regression analysis showed that the preoperative T1S was not related to JOA score recovery rate and the preoperative MRI grade (odds ratio, -9.985; p= 0.015) was only related to JOA score recovery rate.

Conclusions: Although the degree of alignment compromise is correlated with the preoperative T1S, clinical outcomes demonstrate overall improvement after cervical laminoplasty with cervical OPLL, regardless of preoperative T1S.

Keywords: Cervical ossification of the posterior longitudinal ligament; T1 slope; Cervical laminoplasty

Adjacent Segment Pathology after Laminoplasty and Short Level Anterior Fusion for Cervical Spine

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Background: Radiographic adjacent segment pathology (RASP) is a common problem after anterior cervical discectomied fusion (ACDF). The pathology often occurred at C5–6 and C6–7 level. ACDF following laminoplasty is a good method to decompress spinal cord and take down short level anterior pathology at the same time. This study is aimed to finding out if RASP increases after ACDF combined with laminoplasty.

Methods: The retrospective study included 40 consecutive patients who underwent laminoplasty and short level for cervical spondylotic myelopathy. The difference in C2–3, C3–4, C4–5, C5–6, and C6–7 Cobb angle between the postoperative and preoperative films was used to evaluate change in cervical alignment. Age, sex, body mass index, smoking history, preoperative C2–7 Cobb angle, C7 slope, and C2–7 sagittal vertical axis were assessed. Data were analyzed using Pearson and Spearman correlation test, and univariate and stepwise multivariate linear regression.

Results: RASP over C6–7 level is more significant than other level. Preoperative cervical sagittal parameters have larger influence on the incidence of RASP.

Conclusions: The extent of preoperative adjacent segment degenerative changes and loss of lordosis have been shown as risk factors for RASP. Further development of CASP may be surveyed.

Keywords: Adjacent segment disease; Laminoplasty

Are Rigid Cervical Collars Necessary for Patients Undergoing Open-Door Laminoplasty and Titanium Arch Plates for Cervical Myelopathy?: A Randomized Clinical Trial

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Background: Cervical collars are used after laminoplasty to protect the hinge opening, reduce risks of hinge fractures, and avoid springback phenomena. However, its use may lead to reduced range of motion, axial neck pain, and increased cost. We aim to investigate the clinical, radiological and functional outcomes of patients undergoing hinge laminoplasty with or without cervical collar immobilization by randomized controlled trial.

Methods: This was a prospective, parallel single-blinded randomized controlled trial. Patients undergoing laminoplasty for cervical myelopathy were randomly allocated into two groups based on the use of collar postoperatively for 3 weeks. Clinical assessments included cervical range of motion, axial pain (Visual Analogue Scale [VAS]), and objective scores (36-item Short-Form Health Survey [SF-36], Neck disability index [NDI], modified Japanese

Orthopaedic Association [mJOA]). Patients' group allocation was blinded to three assessors during radiographic measurements which included cervical alignment, spinal canal diameter, and complications (implant loosening, springback). All assessments were performed preoperatively and at postoperative 1 week, 2 weeks, 3 weeks, 6 weeks, 3 months, 6 months, and 12 months. Comparative analysis was performed via analysis of variance adjusted by the baseline scores, sex, and age as covariates.

Results: Thirty-five patients were recruited and randomized to collar use (n=16) and without collar immobilization (n=19). All patients completed all follow-up assessments without dropout, and had no complications. There were no differences between groups at baseline. Subjects had comparable mJOA scores, SF-36, NDI, and range of motion at postoperative timepoints. Patients without collar use had higher VAS at postoperative 1 week (5.2 vs. 3.3, p=0.025) and 2 weeks (3.5 vs. 1.0, p=0.001) but subsequently was similar with further follow-up.

Conclusions: The use of a rigid collar after laminoplasty leads to less axial neck pain in the first 2 weeks after surgery. However, there is no benefit with using a cervical collar postoperatively with regards to range of motion, disability, quality of life, or risk of complications.

Keywords: Cervical myelopathy; Laminoplasty; Miniplates; Cervical collar; Randomized controlled trial

C1 Laminoplasty Might Have the Possibility to Prevent the Spontaneous Anterior Arch Fracture

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Background: Anterior arch fragility following C1 laminectomy was recently recognized by using a finite element analysis. The purpose of this study was to evaluate the clinical and radiographic results of C1 laminoplasty without fusion.

Methods: Seven patients underwent C1 laminoplasty were included. All patients underwent plain X-ray, computed tomography, and magnetic resonance imaging before and after surgery to assess instability, spontaneous anterior arch fracture, and size of pseudotumor. Clinical results were evaluated using the Japanese Orthopaedic Association (JOA) score and JOA Cervical Myelopathy Evaluation Questionnaire (JOACMEQ). Perioperative and postoperative complications were also investigated.

Results: The mean age of patients was 71 years old. The mean follow-up (FU) period was about 46 months. Retroodontoid pseudotumor was observed in four patients. No patients showed C1/2 segmental instability before and after surgery. The mean pre- and postoperative size of pseudotumor were 8.7 mm and 9.3 mm, respectively. The mean pre- and postoperative JOA scores were 8.6 and 11.7, respectively. The mean recovery rate was 37.3%. The mean points about each domain (cervical spine function, upper extremity function, lower extremity function, bladder function, quality of life) in the JOACMEQ were improved except upper extremity function. No patients had spontaneous anterior arch fracture during FU. One patient needed an additional fusion surgery (Magerl's procedure) due to deterioration caused by increase the pseudotumor at 21 months after C1 laminoplasty.

Conclusions: In this study, no spontaneous anterior arch fracture was observed in mean 46-month FU. Although all cases could not get the fusion between HA (hydroxyapatite) spacer and lamina, C1 laminoplasty could keep the bone loop. C1 laminoplasty might have the possibility to prevent the spontaneous anterior arch fracture. Another merit of C1 laminopasty is the securement of grafting site if an additional salvage fusion is necessary afterward.

Keywords: C1 laminoplasty; Retroodontoid pseudotumor

Results of Occipito-Cervical Fusion in Post-Traumatic Upper Cervical Spinal Instability and Odontoid Fracture

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Background: Surgery for upper cervical instability (e.g.,.

atlanto-occipital & atlanto-axial) and odontoid fracture is always challenging. Our study demonstrates the results of occipito-cervical fusion when there is any of neurologic involvement, failure to conservative treatment, and significant deformity due to post-traumatic injury at the mentioned levels.

Methods: Nine patients (seven males and two females) with the mean age of 23 years (range, 18–37 years) underwent occipito-cervical fusion at National Institute of Traumatology & Orthopaedic Rehabilitation and Bangladesh Spine & Orthopaedic Hospital in between July 2015 and December 2017. Posterior approach was adopted in all keeping them in neutral position with tong traction during surgery. A midline incision extending from the superior nuchal line to below the level involved, was made. Fixation was done by pedicle screw or lateral mass screw or occipito-cervical plate-rod system. Autogenous chunk bone graft taken from iliac crest was given to ensure adequate fusion. Halo immobilization was continued for 6 weeks after surgery to maintain correction and ensure fusion.

Results: All patients survived surgery. No neurological deterioration was there. They were kept at intensive care unit during the postoperative period for a closed monitoring. C1-C2 trans-articular fusion was done along with atlanto-occipital fusion for all. Solid fusion was achieved within 6 months. During follow-up, satisfactory deformity correction & neurological improvement were noticed. Postoperative flexion decrease (average 28°) along with lack of rotation were seen in each patient. No implant failure and wound infection was noted.

Conclusions: Occipito-cervical fusion is a reliable option for upper cervical spinal instability and significant deformity. It provides satisfactory clinical results with important neurologic recovery.

Keywords: Occiopito-cervical fusion; Upper cervical spinal instability; Posterior approach

Influence of Atlantoaxial Fusion on Sagittal Alignment of Adjacent Occipitocervical and Subaxial Spines in Os Odontoideum with Atlantoaxial Instability

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Background: It has been our experience that sagittal malalignment, such as kyphosis or loss of lordosis, occurs at C0–C1 as well as C2–C7 following atlantoaxial fusion. Our hypothesis was that the larger the C1–C2 fusion angle, the more severe sagittal malalignment of C0–C1 and C2–C7.

Methods: We examined 21 patients achieved solid atlantoaxial fusion for reducible atlantoaxial instability secondary to Os odontoideum. The mean age was 42.8 years, and the mean follow-up duration was 4.9 years. Radiographic parameters were measured before operation and at the final follow-up: C0–C1 angle, C1–C2 angle, C2–C7 angle, C0–C1 range of motion (ROM), C1–C2 ROM, and C2–C7 ROM. Patients were divided into two groups depending on C1–C2 fusion angle. In group A (n=11), C1–C2 fusion angle was ≥22°, and in group B (n=10) it was <22°. The differences between two groups in radiographic parameters were evaluated.

Results: At the final follow-up, C1–C2 angle was increased but statistically not significant (18° vs. 22°, p=0.097) while C0–C1 angle (10° vs. 5°, p<0.05) and C2–C7 angle (22° vs. 13°, p<0.05) was significantly decreased. Final C1–C2 angle was negatively correlated to final C0–C1 angle (correlation coefficient -0.547, p<0.05) and final C2–C7 angle (correlation coefficient -0.705, p<0.01). The final C0–C1 angle (3.8° vs. 6.2°) and C2–C7 angle (7.7° vs. 20°) were smaller in group A than in group B (both p<0.05). After atlantoaxial fusion, C0–C1 ROM (17° vs. 9°, p<0.05) and C2–C7 ROM (39° vs. 31°, p<0.05) were significantly decreased.

Conclusions: We found a negative association between C1–C2 fusion angle and sagittal alignments of C0–C1 and C2–C7, along with decreased ROM. We now strive to fuse C1–C2 in <22° in order to decrease the likelihood of sagittal malalignment of C0–C1 and C2–C7.

Keywords: Atlantoaxial fusion; Sagittal alignment; Occipitocervical and subaxial spines; Os odontoideum; Atlantoaxial instability

Determinants of Upper Cervical Spine Sagittal Alignment: Gaze Direction, C2–7 Sagittal Vertical Axis, and T1-Slope

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Background: Normal sagittal alignment of the cervical spine is highly variable and may even be of S- or reverse S-morphologies. Since multiple parameters, including gaze direction, may influence alignment of the upper cervical spine (a lesser studied area), identifying such predictors is crucial in guiding cervical fusion surgery.

Methods: This was a prospective study which analysed whole body standing radiographs of patients with non-ankylosed spines. EOS images were taken with standardized protocol. Averaged measurements from two orthopaedic specialists were recorded. Outcome parameters included the upper cervical angle (UCA—as measured from gaze direction to C2), and the gaze direction-C4 angle. Other parameters measured comprised cervical lordosis, lower cervical alignment, T1-slope, C7 sagittal vertical axis (C7SVA) and C2–7 sagittal vertical axis (C2–7SVA) as well as thoracic kyphosis, thoracolumbar angle (TL), lumbar angle, and spinopelvic parameters. Multivariate analyses with performed to identify predictors for upper cervical alignment.

Results: A total of 103 subjects had a mean age of 37.2 years. Their mean C7SVA was 6.4 mm, pelvic incidence (PI) 49.7°, PI-LL ratio -0.3, and pelvic tilt 15.9°. In terms of cervical alignment parameters, C2–C7SVA was 10.3 mm and C2–7 angle was -0.2°. UCA was more kyphotic and less variable compared to the gaze direction-C4 angle (mean, 17.3° vs. 14.7°; standard deviation, 8.4° vs. 12.4°), suggesting its homogeneity and advantage in defining upper cervical spine alignment. More predictors were identified for UCA than for gaze direction-C4 angle. Specifically, T1-slope <16.2° (odds ratio [OR], 1.923; p=0.037), C2–C7–SVA >10.3 mm (OR, 2.184; p=0.020), and upward gaze direction <0° (OR, 2.268; p=0.049) were found to be predictive of UCA>17.3°.

Conclusions: Highly variable cervical morphology should be studied as three sagittal segments—UCA, C2–4, and C4–7 angles, each of which are likely to have different functions. Predictors of UCA include T1-slope, C2–7SVA and gaze direction, and these should be considered during surgical planning.

Keywords: Upper cervical spine; Cervical spine alignment; Horizontal gaze; Predictors

Multilevel Anterior Cervical Discectomy and Fusion in the Elderly: A Retros-pective Review of Outcomes

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Background: The elderly is a growing demographic that has an increased risk of cervical degenerative disease. This causes motor and sensory dysfunction and a poor quality of life. Anterior cervical discectomy and fusion (ACDF) may be one option for surgical treatment. Surgeries can be multi-level depending on the number of diseased levels; however, surgeons are hesitant to operate from the anterior approach on the elderly, due to a perceived increased risk of complications. Literature on these surgeries are few. The goal of this study is to report the outcomes of these surgeries.

Methods: The authors conducted a retrospective cohort review of patients aged 70 years old and above who underwent multilevel ACDF for degenerative disease. The following were recorded: patients comorbidities, social history, and postoperative complications. The following radiographic parameters, C2–C7 cobbs angle, anterior and posterior inter-body height, and fusion rate were measured. Measurements were done at these intervals: preoperatively, postoperatively, 1- and 2 years postoperatively. Odom's scores and JOA scores were recorded.

Results: Twenty-six elderly patients were included (16 males and 10 females; average age, 72.99 years; range, 70–80 years). Three level surgery was the most common with 17 patients, 4 level surgery had eight patients, and one patient underwent 5 level surgery. Hypertension was the most common co-morbidity. Only two patients had severe complications, one screw back out, and one surgical site infection. Radiographically anterior and posterior intervertebral height were maintained with only 11 levels having a decrease in 2.5 mm. Fusion was seen in 84.61% of patients. JOA scores increased from 11.3 at baseline to

14.5 at 2 years. Fifty percent of patients had an Odom's score of good.

Conclusions: Although multilevel ACDF is an extensive procedure. This procedure is feasible for the elder patients with good clinical outcomes and less complications.

Keywords: Elderly; Anterior cervical discectomy and fusion; Multievel

Anterior Approach Surgical Strategies in Managing Cervical Spinal Cord Compression

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Background: Anterior cervical discectomy and fusion (ACDF) and anterior cervical corpectomy with fusion (ACCF) are the surgical means for managing cervical spinal cord compression. Our study demonstrates the benefits of anterior only approach to decompress cervical spinal cord.

Methods: Total 356 patients (284 males and 72 females) were studied from July 2009 to March 2017. Among them, 258 patients had cervical fracture-dislocation, 88 had degenerative disc disease, and 10 had acute cervical disc herniation with myelopathic change. In 301 patients, ACDF was undertaken. Steps included identification of the affected vertebra, discectomy and denudation of the articular cartilage of the superior/inferior vertebrae followed by insertion of autogenous iliac crest bone graft into the respective disc space, and stabilization by plate and screws. Rest 51 underwent ACCF where cage incorporated with bone graft was inserted following corpectomy of the fractured vertebra and denudation of articular cartilage of superior/inferior vertebrae. ACCF was done in patients with comminuted vertebral fractures. Follow-up period was 6 months to 8 years. Assessment were done clinically, assessing radiology, American Spinal Injury Association (ASIA) impairment scale, and pain assessment through Visual Analog Scale and Oswestry Disability Index scoring.

Results: All patients survived surgery. No improvement in ASIA grading was observed in those having preoperative ASIA impairment scale of A (46 patients). Other 310 patients (about 87%) had significant improvement in ASIA grading with a conversion into ASIA-E and ASIA-D. Postoperative complications included superficial wound infection and dysphagia in a few patients (2.1%) which were resolved conservatively. No patient needed revision surgery.

Conclusions: ACDF was satisfactory in treating patients with degenerative cervical disc disease, acute disc prolapse, and single level cervical fracture-dislocation with varying degree of spinal cord compression while ACCF was done in multilevel or comminuted fractures. Among the procedures, ACDF was found to be superior to ACCF in terms of hospital stay, operation time, blood loss, and incidence of complications.

Keywords: Anterior surgery; Cervical spinal cord compression

Cervical Kyphosis

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Background: Normal cervical alignment in sagittal plane is about 10° in lordosis from C2 to C7 and 30° in lordosis from C0 to C2. The C2–7 sagittal vertical axis is normally from 1.5 to 4.0 cm. Normal cervical alignment can protect neural elements and maintain basic daily function, e.g., horizontal gaze, normal swallowing, etc. The cervical spinal deformity could be primary or secondary to thoracolumbar deformity. While assessing the cervical spinal deformity, the whole spinal alignment should be assessed at the same time. Part of the spinal deformity is combined with neurocompression, which makes the surgical procedure more complicated.

Methods: According the location of deformity, the cervical spinal deformity could be classified in to upper cervical, subaxial, and cervicothoracic junctional deformity. According to the causes, the deformity could be classified into congenital, degenerative, posttraumatic, postsurgical, ankylosing spondylitis, rheumatoid arthritis, tumor, and so on. If there is not cord compression at deformed cervical level, the deformed thoracolumbar level usually needs

to be corrected at first. If the motion segments are flexible, the anterior only or posterior only approach might be enough. If the spine is rigid without fused facet joints, the anterior only approach could be chosen. If the spine is rigid with already fused facet joints, the combined anterior and posterior approaches could be selected. In these rigid spines, the pedicle subtraction osteotomy is also a choice of treatment. I will show some cases with upper cervical and thoracolumbar junctional deformity/stenosis. Also, we collected a series of cases with degenerative cervical kyphosis treated with combined anterior and posterior approaches.

Results: After adequate decompression and restoration of cervical alignment, most of patients got well fusion and functional recovery.

Conclusions: Realignment of cervical spinal deformity is very important in addition to decompression of the squeezed neural elements. After detailed preoperative assessment, selection of suitable surgical strategy for right patient will get the best results.

Keywords: Cervical kyphosis; C2–7 sagittal vertical axis

Can the Adjuvant Saline Neurolysis in Preganglionic Epidural Steroid Injection Promote the Clinical Efficacy?

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Background: Percutaneous epidural neuroplasty (PEN) uses an epidural catheter to enable neurolysis and more effective drug delivery the pathology. PEN is known to have superior clinical outcomes than epidural injection. However, epidural injection through the retro-discal transforaminal (TF) or trans-lateral recess approach also can be accessed the preganglionic epidural space and was known to superior to ganglionic epidural injection through the conventional TF approach. In the preganglionic epidural approach, we sought to evaluate the clinical ability of adjuvant saline neurolysis.

Methods: Between May 2017 and July 2017, the medical records of 78 patients (38 in the adjuvant saline neurolysis group, 40 in the control group) who had lumbar degenerative disc pathology at L4–5 and received preganglionic epidural injection of L4–5 and L5–S1 were reviewed. The group 1 (adjuvant saline neurolysis) performed neurolysis with 10 mL of 0.9% normal saline and followed by solution added to 2 mL of 0.2% ropivacaine, 2 mg of dexamethasone, and 1,500 units of hyaluronidase. Goup 2 (control) received 4 mL of 0.9% normal saline, 2 mL of 0.2% ropivacaine, 2 mg of dexamethasone, and 1,500 units of hyaluronidase. Outcomes on pain reduction were measured using a Visual Analogue Scale and on functional improvement were measured using Oswestry Disability Index at baseline, 2 weeks, 4 weeks, 8 weeks, and 3 months after procedure.

Results: Significant improvement was seen in patients in group 1 and 2, at all follow-up period, compared to the baseline measurements. Seventy-one percent of patients in group 1, compared to 62.5% in group 2 showed effective pain relief at 3-month follow-up. There was no significant difference at last follow-up (p>0.05), but a slightly better clinical and functional outcomes were observed in group 1.

Conclusions: Adjuvant saline neurolysis may provide more superior and pain relieving effects when added to preganglionic epidural injection.

Keywords: Preganglionic epidural injection; Adjuvant saline neurolysis

Sacral Alar Iliac Screw Insertion Using Three-Dimensional Computerized Navigation System

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Background: Sacral alar iliac (SAI) screw provided strong fixation to pelvis. The problems of traditional technique using intra-operative fluoroscopy included: higher amount of radiation exposure, difficulty to visualize S1 and S2 foramina, and proximity of operative hand to the C-arm. In this article, we described and evaluated the initial result of screw insertion using three-dimensional (3D) computerized navigation system.

Methods: Before the operation, computed tomography (CT) scan of the pelvis according to navigation protocol was performed to determine the diameter, length, and

location of the screws. The patient was put on prone position and patient tracker was fixed percutaneously over L5 spinous process. Intra-operative CT was then matched with the preoperative CT images. Further procedure was performed using the axial, sagittal, and coronal CT images together with navigated instrument according to preoperative planning. No further fluoroscopy was required until final checking. Stab skin incision was made and entry site was created by navigated awl. Screw path was made by navigated path finder and checked with probe. Guide wire was inserted before screw insertion. After the operation, the patient was assessed and CT scan was performed to check the position of screws.

Results: From Aug 2017 to Oct 2017, six screws were inserted using 3D navigation in three patients. The mean age of the patient was 74.3 years old and the mean operative time for each screw insertion was 15.8 minutes. No neurovascular complications, pelvic organ injury, or perforation into hip joint was observed. CT scan after the operation showed satisfactory position of all screws in both groups without hip joint violation or iliac bone perforation. The entry site and screw tip position were checked against preoperative screw planning. The mean deviation was 1.3 mm for the entry site and 2.1 mm for the screw tip.

Conclusions: 3D computerized navigation was an effective and safe method for SAI screw insertion.

Keywords: Navigation; Bone screws

Minimally Invasive Triangular Osteosynthesis for Unstable Sacral Fractures: A Case Series

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Background: Though lumbopelvic fixation can achieve rigid fixation for unstable sacral fractures, it is a relatively invasive procedure. Triangular osteosynthesis is a unilateral L5-iliac posterior instrumentation combined with an iliosacral screw fixation. We have applied minimally invasive technique for triangular osteosynthesis using percutaneous spinal instrumentations and cancellous cannulated screws. Objective of the study is to describe the clinical results of the patients with unstable sacral fractures treated by minimally invasive triangular osteosynthesis (MITOS).

Methods: We conducted a retrospective case review from 2012 to 2017. Nine patients of sacral fractures treated with MITOS were identified in our institution and were followed up for mean 13.9±7.2 months. The cases consisted of six men and three women, whose mean age was 50±24 years. Mechanisms of injury, classification of sacral fracture, type of incision, operative time, amounts of bleeding, time of full weight bearing, bone union, complications, and clinical outcomes evaluated by Majeed score were investigated.

Results: Four cases injured by falling from height, two by traffic accidents, and three by the other causes. Two patients were classified in Denis zone 1, 6 cases in zone 2, and one in zone 3. Three patients had U-shaped and one had H-shaped fractures. All patients underwent MITOS: bilateral lumbopelvic fixation and uni/bilataral iliosacral screw with central longitudinal or stab incisions. Operative time was mean 192±59 minutes, and intraoperative bleeding was mean 69±76 g. Full-weight bearing initiated at 8.4±2.4 weeks. All fractures had healed, with one pulmonary embolism and one implant loosening. Six patients had excellent clinical outcome, two patients had good, and the other had fair results, evaluated by Majeed's functional assessment system.

Conclusions: MITOS was the less invasive procedure, and it provided enough stability accelerating postoperative rehabilitation even for highly unstable sacral fractures.

Keywords: Sacral fracture; Triangular osteosynthesis; Lumbopelvic fixation; Minimally invasive surgery

Foraminal Decompression for Adult Isthmic Spondylolisthesis Using Biportal Endoscopic Spine Surgery: Preliminary Report

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Background: Decompression-only for foraminal stenosis (FS) in adult isthmic spondylolisthesis (ISDL) have been rarely reported. Biportal endoscopic spine surgery (BESS) is a newly coming technique to decompress focal lesions with preserving innocent structures for stability.

Methods: Twelve patients (age, 67.7±12.0 years; rang, 48–82 years; seven males, five females) with ISDL and FS were enrolled from January 2016 to October 2017. Twenty-one cases (right side, 9; left side, 12) of FS in 13 levels (L3–4, 1; L4–5, 4; L5–S1, 80) were decompressed using BESS. Four main lesions compressing an exiting root, including overlying spur, hypertrophied ligamentum flavum, ruptured disc fragments, and/or loose body, were removed to decompress the root completely. Pain relief on the affected leg was evaluated using Visual Analogue Scale (VAS). Complications including root injury, hematoma, postoperative infection, early revision, and/or conversion to fusion surgery were checked.

Results: All patients were followed up average 8.7 months (range, 3–18 months). VAS were immediately improved from 8.20.8 preoperatively to 4.11.1 at postoperative 7 day, 3.61.5 at 1 month and 2.01.0 at the last follow-up. Four legs had residual fatigue and intermittent pain at the last follow-up. Success rate of immediate pain relief of affecting legs by foraminal decompression were 85.7% (17/21). Revision surgery was performed in three cases to decompress an impinged exiting root wider and eliminated remnant spur under the corner of the pedicle. There was no root injury, symptomatic hematoma, infection, or conversion to fusion surgery during the follow-up period.

Conclusions: BESS showed technically feasible to decompress the foraminal lesions in adult ISDL. Immediate recovery from radicular pain was outstanding in short-term following up. Very low rate of postoperative complication was noticeable but early revision was performed because of impingement of the swollen root under the remnant spur under the pedicle. Mid-term following up for much more patients should be needed to confirm the BESS as alternative treatment for adult ISDL.

Keywords: Endoscopy; Isthmic Spondylollisthesis; Spinal Stenosis

Biportal Endoscopic Transforaminal Lumbar Interbody Fusion with Arthroscopy: Technical Note

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Background: Lumbar spine fusion is widely accepted as a treatment for various spinal pathology including degenerative spinal diseases. Since the posterior lumbar interbody fusion was developed by Cloward, various lumbar fusion methods have been introduced to date. In the case of minimally invasive surgery (MIS) transforaminal lumbar interbody fusion (TLIF), it is known to reduce muscle damage and protect the posterior ligamentous complex. However, since MIS TLIF works through the tubular retractor, there is somewhat limited instrument handling and it is difficult to confirm contralateral decompression and endplate preparation accurately. Several studies and techniques related to spinal surgery using the biportal endoscopic technique have been reported. This study described the process and technical tip of TLIF using the biportal endoscopic technique. Technically, biportal endoscopic TLIF is a sufficiently viable procedure. This technique is similar to MIS TLIF using a tubular retractor.

Methods: The Visual Analogue Scale (VAS) and Oswestry Disability Index with modified MacNab criteria was measured.

Results: The VAS improved from 7.4 to 2.7. There were two complication including L5 root palsy and dura tear.

Conclusions: Biportal endoscopic TLIF provides better visual field and reduces the damage to muscle dissection and posterior ligamentous complexes. Biportal endoscopic TLIF is achieving sufficient neural decompression, another option for alternating open lumbar fusion, and MIS fusion in degenerative lumbar disease that need fusion surgery.

Keywords: Biportal endoscopic spine surgery; Transforaminal lumbar interbody fusion; Endoscopy

Adjacent Segment Degeneration Treated with Percutaneous Endoscopic Lumbar Decompression under Local Anethesia

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Background: Adjacent segment disease (ASD) occur in 30% of lumbar fusion surgery and annual incidence is 2%–3%. The most effective treatments for ASD has not yet been determined. Fusion does not necessarily improve surgical outcome in primary spondylolisthesis. There have been reports that transforaminal approach has 2 years of

the survival rate of near 70%. This study is aimed to study decompression with percutaneous endoscopic lumbar decompression (PELD) through interlaminar and transforaminal approach for ASD treatment.

Methods: The prospective study of non-randomized case series from a single hospital by a single surgeon (author) from May 2017 to January 2018 was conducted. Patients diagnosed with radiculopathy±claudication for more than 2 months and ASD noted on preoperative magnetic resonance imaging were enrolled and patients who could not finish the complete follow-up were excluded. Patients were followed up to 6 months (immediate postoperative, postoperative 1 month, 3 months, 6 months) and Visual Analogue Scale (VAS), 36-item Short-Form Health Survey, Oswestry Disability Index (ODI), and Japanese Orthopaedic Association (JOA) scores were recorded. PELD through interlaminar approach under local anesthesia (2% xylocaine injected around the incision and around facets) was done without any sedation. Patients were discharged 1 hour after surgery.

Results: Consecutive five cases of (two males, three females; average age, 73±2 years; level, T12/L1=1, L2/3=2, L3/4=3; sedimentation sign, C=2, D=3; interlaminar approach, 4; transforaminal approach, 1; bilateral radiculopathy, 4; unilateral radiculopathy, 1) were enrolled. VAS, JOA score, and ODI revealed major improvements comparing preoperatively and postoperatively conditions (Mann-Whitney *U*-test). According to modified MacNab criteria, excellent rate was 30%, good 60%, poor 10%, total efficiency 90%, complication 10%, and recurrence rate 0%. Bleeding (neglectable) and operation time (mean, 85±20 minutes) were noted. Complications of one hyperventilation syndrome and one postoperative hematoma converted to open decompression were noted.

Conclusions: Careful selection of ASD patient with stable spinal stenosis could warrant PELD decompression as an alternative treatment. Choices of transforaminal approach and interlaminar approach should be decided according to symptoms, lesion location, and laterality.

Keywords: Adjacent segment degeneration; Percutaneous endoscopic lumbar decompression; Local anesthesia; Interlaminar and transforaminal approach

Spinal Stenosis Treated with Combined Percutaneous Endoscopic Lumbar Decompression and Radiofrequency Ablation: Case Series and Preliminary Results

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Background: Spinal stenotic patients do not necessarily have back pain and could be treated with decompression only. However, facet syndrome and sacroiliac syndrome combined with spinal stenosis were not rare and sometimes perceived as pain from mild instabilities. This study is aimed to study combined percutaneous endoscopic lumbar decompression (PELD) decompression and radiofrequency ablation for spinal stenoic patients with back pain treatment.

Methods: The prospective study of non-randomized case series from a single hospital by a single surgeon (author) from May 2017 to January 2018 was conducted. Patients diagnosed with radiculopathy±claudication for more than 2 months and no minimal instabilities noted on preoperative dynamic plain film and magnetic resonance imaging were enrolled and patients who could not finish the complete follow-up were excluded. Patients were followed up to 6 months (immediate postoperative, postoperative 1 month, 3 months, 6 months) and Visual Analogue Scale (VAS), 36-item Short-Form Health Survey, Oswestry Disability Index (ODI), and Japanese Orthopaedic Association (JOA) scores were recorded. PELD through interlaminar or transforaminal approach under local anesthesia was done. Patients were discharged one hour after surgery. Radiofrequency ablation was done within one month before and after PELD.

Results: Consecutive 7 cases of (one male, six females; average age, 69±2 years; level, L2/3=1, L3/4=2, L4/5=4, L5/S1=1; sedimentation sign, A=1, B=4, C=2; interlaminar approach, 3; transforaminal approach, 4; bilateral radiculopathy, 4; unilateral radiculopathy, 3) were enrolled. VAS, JOA score, and ODI revealed major improvements comparing preoperatively and postoperatively conditions (Mann-Whitney *U*-test). According to modified MacNab criteria, excellent rate was 90% and good 10%. Bleeding (neglectable) and operation time (mean, 140±20 minutes) were noted. No severe complications were noted.

Conclusions: Back pain of spinal stenotic patients were

sometimes attributed to mild instability noted on dynamic plain film or discogenic pain. However, careful diagnosis and treatment of facet syndrome or SI syndrome can lower the need of instrumented fusion for stable spinal stenotic patients.

Keywords: Spinal stenosis; Radiofrequency ablation; Percutaneous endoscopic lumbar decompression; Facet syndrome; Sacroiliac syndrome

Preliminary Report of Stand-Alone Transforaminal Lumbar Interbody Fusion with Cage

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Background: The purpose of this study is to determine the clinical outcome of stand-alone cage in degenerative lumbar disease.

Methods: A total of 20 patients with degenerative lumbar spine disease that had been short-term followed for 3 months were reviewed retrospectively for the preliminary report. The operation time, blood loss, and perioperative complications were evaluated. The Odom criteria and Visual Analog Scale (VAS) scores of leg and back pain were analyzed preoperatively and at 3 months of postoperative follow-up. The pre- and postoperatively radiological evaluation including fusion rate, disc height, foraminal height, segmental lordosis, total lumbar lordosis, and subsidence was also assessed.

Results: In our record, the mean VAS score of back pain and sciatica were improved during 3-month follow-up visit. During the follow-up, 85% of patients showed excellent or good outcomes by the Odom criteria. The mean intervertebral disc height and foramen height was increased from 7.5 mm and 13.3 mm to 12.0 mm and 16.7 mm after operation (p<0.001). The fusion rate was approximately only 65% after 3 months postoperatively. The segmental angle of lordosis was increased (6.5° to 10.1°) (p<0.001). The mean lumbar lordosis increased from 21.5° to 26.4°. Three complications (15%) of postoperative epidural hematoma (2/20), and wound infection (1/20) were recorded.

Conclusions: The procedure of the stand-alone transforaminal lumbar interbody fusion (TILF) with cage resulted in great postoperative satisfaction and clinical outcome. The use of stand-alone cages for TLIF may resulted in a various degree of subsidence and nonunion. However, there is no complication caused by micromotion of cage in our short-term follow-up.

Keywords: Lumbar disc herniation; Spinal fusion; Stand-alone implants

Learning Curve of Micro-endoscopic Discectomy in An Nan Hospital: Results of First 25 Cases

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Background: Foley and Smith reported an early experience of the micro-endoscopic discectomy (MED) technique in 1997, performed by a transmuscular approach using tubular retractors in combination with advanced optics of an endoscope. Proponents of the minimally invasive approach using endoscopy have claimed potential benefits of faster recovery, reduced complication rates, and improved visualization of the anatomy when compared to an open approach. However, the relative benefits and risks of specifically MED versus traditional micro-discectomy have not been well established. The aim of this study was to analyze the clinical outcome of the MED and micro-discectomy. Moreover, we will share the experience and outcome of first 25 MED cases to the spine surgeons who want to learn this technique.

Methods: A total of 72 patients with lumbar disc prolapse who were treated with MED or micro-discectomy were included in this retrospective study. The follow-up period was a least 6 months. The analytic data included the operative time, blood loss, admission day, and complications. The learning curve of MED would be discussed in this study.

Results: The MED was performed in 25 cases. The micro-discectomy was performed in 47 cases. There was no significant difference in the admission day, operative time, and complications. However, the blood loss is much less in MED (22.24 mL vs. 90.13 mL, p<0.01). One complication (4%) of recurrent disc prolapse in MED group is recorded. Two complications (4%) of poor healing wound

were noted in micro-discectomy group. According to the operative time and blood loss, it seems that the MED technique is getting stable after severe cases in out hospital.

Conclusions: Based on our clinical data, the MED appeared to be safe and efficacious compared with micro-discectomy approaches, but these results require further investigation and validation by prospective randomized studies.

Keywords: Lumbar discectomy; Microdiscectomy; Endoscopic surgery; Lumbar disc herniation

Cement-Augmented Pedicle Screw Insertion Assisted by Spinal Robotic Systems for Widespread Spinal Metastasis: A Case Report

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Background: Widespread spinal metastasis may obscure bone landmark and severely hinder surgical safety during pedicle screw insertion. Robotic assisted spinal surgery had shown a high safety profile for pedicle screw insertion. Spinal Surgical Robotic Systems (Renaissance Mazor) could help to insert pedicle screw with high screw accuracy. In this case report, we present a patient who had breast cancer with widespread spinal metastasis, pathological vertebral fracture, and spinal cord compression. She had received a palliative surgical decompression and stabilization with cement-augmented pedicle screw inserted by the assistance of spinal robotic system.

Methods: This 55-year-old female patient had breast cancer with multiple spinal metastatic pathologic fracture and spinal cord compression at T10–T12 and L3–L4. Her preoperative neurologic status was Frenkel D and her pain Visual Analog Scale (VAS) was 8. Preoperative X-ray and computed tomography (CT) scan had shown severe bone moth-eaten type cortical destruction in every spinal vertebra.

Results: Minimally invasive surgical decompression and percutaneous cement-augmented pedicle screw insertion was performed from T8–L4. Percutaneous vertebroplastys were also performed at T7 and L3. Pedicle screw insertion and vertebroplasty were assisted by the spinal robotic system. The blood loss was 550 mL and the surgical time was 325 minutes. The needed time for robot set up was 23 minutes. The patient had significant functional improvement 6 months after surgery (VAS 2, Frenkel E). The cement-augment pedicle screws were all in good position without cement leak or malposition checked by postoperative CT scan.

Conclusions: Spinal robotic system can assist minimally invasive spinal procedures for patients with spinal anatomy difficult to be assessed by intraoperative image modalities.

Keywords: Spinal robotic system; Cement-augmented pedicle screw; Widespread spinal metastasis

The Application of Enhanced Recovery after Surgery in Perioperative Period of Lumbar Fusion Surgery

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Background: Spine surgery is often combined with large operation trauma, long operation time, and many postoperative complications and accelerating postoperative rehabilitation has become an important clinical problem. We have tried the enhanced recovery after surgery (ERAS) regimen in the perioperative period of fusion surgery.

Methods: Two hundred and thirty-six patients with lumbar degenerative disorder whose fusion segments were no more than three (88 males and 148 females) were enrolled in the study. They were divided into control group and ERAS group according to their will. The control group adopted traditional perioperative interventions while the ERAS group adopted ERAS scheme in perioperative period and the follow-up time were 13.4±0.9 months. We collected Visual Analog Scale (VAS) at different time, Tthe Oswestry Disability Index (ODI), the length of stay, postoperative complications, opioid doses, the readmission rate, and degree of satisfaction to the treatment and explored implementation experience of ERAS in lumbar fusion surgery.

Results: There was no statistical significance in age, gender, body mass index, the number of surgical segment, VAS, ODI, and anesthesia grade of American Society of Anesthesiologists grade between ERAS group (119 cases)

and control group (117 cases) (p>0.05). VAS of ERAS group were lower than that of control group during 3 days after surgery, at discharge, and 1 month after operation (p<0.05) while there was no statistical significance at follow-up (p=0.251). Compared with control group, ERAS group had short length of postoperation stay, few postoperative complications, little opioid dose during 2 days after surgery, and superior degree of satisfaction (p<0.05). There was no statistical significance in rate of readmission during 1 month after surgery (p=0.339).

Conclusions: The implementation of ERAS in perioperative period of lumbar fusion surgery can alleviate postoperative pain, accelerate functional recovery, reduce the use of opioids, reduce postoperative complications, improve patients' degree of satisfaction, and ultimately achieve the purpose of rapid rehabilitation without a concomitant increase in readmission rate.

Keywords: ERAS; Lumbar fusion surgery

Inter Laminar Endoscopic Lumbar Discectomy Short-term Outcome

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Background: Interlaminar endoscopic lumbar discectomy (IELD) is a newer technique and author aimed to present short-term outcome at 12 months with one of the largest patient series.

Methods: This prospective study of case series carried out using probability consecutive sampling technique was analyzed. Study was conducted at Orthopedic Spine Institute, Doctors Hospital & Medical Center, Lahore. A sample size of 145 consecutive patients from January 1, 2105 to July 30, 2016 presented in our hospital with lumbar disc herniation (LDH) were recruited in the study and were followed prospectively. All patients had a preoperative magnetic resonance imaging and were operated by a single surgeon with the single 22 mm portal. All patients were mobilized within 6 hours after surgery and discharged within 24–48 hours post surgery.The results were evaluated by using Visual Analog Scale (VAS, 0–5) for back and leg pain and modified MacNab's criteria for clinical outcome. Patients were followed up at intervals of 2 weeks, 6 weeks, 3 months, 6 months, and 12 months.

Results: One hundred and forty-five patients were recruited in the study with the mean age of 46 years (range, 16–78 years) and the gender ratio was 1.5 males to 1 female. The mean follow-up was 12 months (range, 3–18 months). The mean VAS score for leg pain improved from 4.15 to 0.7 (p<0.05) and the mean VAS score for back pain improved from 4.0 to 0.9 (p<0.05). On modified MacNab's criteria 93% patients had excellent to good and 6% had fair outcome. The mean operative time per level was about 50 minutes. Dural punctures occurred in 2% cases. Average blood loss was 30 mL. One patient had wound infection which needed debridement and one patient presented later on with recurrent disc herniation.

Conclusions: We concluded that IELD is a safe alternative to open and microdiscectomy IELD having advantages of decrease morbidity, faster postoperative recovery, decrease hospital stay, and early return to work and cosmesis.

Keywords: Interlaminar endoscopic lumbar discectomy; Lumbar disc herniation

An Analysis of Outcomes of Percutaneous Transforaminal Endoscopic Interlaminar Approach for Calcified Lumbar Disc Herniation

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Background: The object of this study is to conduct a retrospective analysis of clinical outcomes of percutaneous transforaminal endoscopic interlaminar approach for calcified lumbar disc herniation.

Methods: From May 2014 to March 2016, 30 patients with calcified lumbar disc herniation underwent percutaneous transforaminal endoscopic surgery by interlaminar approach. The preoperative and postoperative leg raising angle measurement were used to evaluate effect, and the preoperative and postoperative Visual Analogue Scale (VAS) were used to evaluate the sciatica and/or back pain. The outcomes were evaluated by Oswestry Disability Index (ODI) and the MacNab score.

Results: The postoperative leg raising angle measurements were significantly higher than preoperative one. The postoperative VAS scales were significantly lower than preoperative one, The postoperative ODI lower than preop-

erative one. According to the modified MacNab criteria, excellent rate is 90.0%. No patient appear complications.
Conclusions: Percutaneous transforaminal endoscopic interlaminar approach for calcified lumbar disc herniation is effective in short-term, low surgical risk, and few complications.
Keywords: Calcify; Lumbar disc herniation; Percutaneous transforaminal endoscopic; Interlaminar; Clinical outcomes

Percutaneous Endoscopic Lumbar Discectomy via a Translaminar Approach for the Treatment of Highly Up and Down Migrated Disc Herniations

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Background: The object of this study is to evaluate the effects and advantages of percutaneous endoscopic lumbar discectomy (PELD) via a translaminar approach for the treatment of highly up and down migrated disc herniations.
Methods: The PED cannula is placed on the lamina percutaneously according to the position of migrated disc. With the high-speed drill the laminal interval is enlarged. The migrated disc can be then detected through the expanded laminal approach, and removed with endoscopic forceps. Twelve patients with highly migrated disc herniations underwent PELD via a translaminar approach were retrospectively analyzed. Clinical outcomes were evaluated according to pre- and postoperative Visual Analogue Scale (VAS) scores, Oswestry Disability Index (ODI) scores, and postoperative magnetic resonance imaging (MRI).
Results: The highly migrated disc herniation was completely removed in all patients, as confirmed by postoperative MRI. Radiculopathy was eased after removal of the disc migrations. The mean follow-up duration was 7 months (range, 3-12 months). The mean preoperative VAS and ODI score were decreased after the surgery.
Conclusions: The highly migrated disc herniation was completely removed in all patients, as confirmed by postoperative MRI. Radiculopathy was eased after removal of the disc migrations. The mean follow-up duration was 7 (range, 3-12) months. The mean pre-operative VAS and ODI score were decreased after the surgery.
Keywords: Translaminar; Migrated disc herniation; Percutaneous endoscopic lumbar discectomy

Cervical Discectomy Using "Keyhole" Technology through Percutaneous Posterior Transforaminal Endoscopic for the Treatment of Cervical Spondylotic Radiculopathy

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Background: The object of this study is to investigate the decompression effect and the clinical effect of cervical discectomy using "keyhole" technology through percutaneous posterior transforaminal endoscopic for the treatment of cervical spondylotic radiculopathy.
Methods: A group of 19 patients of cervical spondylotic radiculopathy received cervical discectomy using "keyhole" technology through percutaneous posterior transforaminal endoscopic, Visual Analogue Scale (VAS), and Japanese Orthopaedic Association (JOA) scores were evaluated before and post surgery 2 days 3 months.
Results: VAS scores after surgery in patients decreased significantly (p<0.05), and JOA scores after treatment increased significantly than before treatment (p<0.05).
Conclusions: Cervical discectomy using "keyhole" technology through percutaneous posterior transforaminal endoscopic can fully remove nerve root compression and quickly alleviate symptoms of cervical spondylotic radiculopathy, and clinical effect is satisfied.
Keywords: Percutaneous transforaminal endoscopic; Posterior; Cervical spondylotic radiculopathy

The Effect of the Preservation of the Posterior Longitudinal Ligament in the Percutaneous Endoscopic Lumbar Discectomy

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Background: The object of this study is to explore the clinical effects and significances of preservation of the

posterior longitudinal ligament (PLL) in the percutaneous endoscopic lumbar discectomy.

Methods: Thirty patients with percutaneous endoscopic lumbar discectomy under local anesthesia from January 2017 to March 2017 were retrospectively reviewed, including 16 males and 14 females, the age ranged from 42 to 61 years old with an average of 51.13 years old. Classification included 13 cases with axillary disc herniation, 15 cases with shoulder disc herniation, and two cases with extreme lateral disc herniation. Preservation of PLL was carried out for all patients, and clinical data and outcome were analyzed.

Results: All operations were successful and reserved posterior longitudinal ligament had no obvious hypertrophy, proliferation, and calcification. No obvious complications occurred after surgery and root symptoms were completely relieved in all patients. Visual Analogue Scale score was 4–6 in preoperative (averaged 4.47) and 0–2 in postoperative (averaged 0.6). JOA score was increased from preoperative 6–14 (averaged 9.87) to final follow-up 10–18 (averaged 13.00). There was significant differences between preoperative and postoperative.

Conclusions: Percutaneous endoscopic lumbar discectomy with posterior longitudinal ligament retained can achieve fully decompression and good clinical efficacy for the patients without obvious disease in the posterior longitudinal ligament.

Keywords: The posterior longitudinal ligament; Percutaneous endoscopic lumbar discectomy

Interspinous Process Devices: Current Evidences

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Background: The object of this study is to review the effectiveness in relieve of stenosis symptomatic/backache by interspinous process devices (IPD) in degeneration lumbar spine.

Methods: This study was performed via literature search and meta-analysis.

Results: Study shows only short term effectiveness of device. End result of the degenerative lumbar spine is stenosis and instability IPD as an alternate to conventional decompressive surgery in symptomatic lumbar spine pathology have been introduced recently in elderly patients. Various materials being used include titanium/polyetheretherketone and elastomeric compound, etc. Device is assumed to unload spine facets and restore spinal canal and foraminal diameter. It also provides stability by the distraction of spinous processes. Initial short-term results appear very satisfactory, safe with the minimally invasive surgical approach as an alternative to open decompression. Main indication being degenerative stenosis and instability. Recent studies show less than satisfactory results and increased number of complications. Only short-term studies are published and very few report long-term results.

Conclusions: IPD are implants placed by minimally invasive surgery, and they are effective only in short duration of 2–3 years.

Keywords: Interspinous process devices degeneration; Stenosis

Efficacy of Lumbar Orthosis after Posterior Lumbar Interbody Fusion: A Prospective Randomized Study

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Background: Lumbar orthoses have been used as a standard care after lumbar fusion surgery. However, there is no prospective randomized study to demonstrate the efficacy and difference between the different types of orthosis. The purpose of this study is to elucidate clinical and radiographic efficacies of lumbosacral orthosis treatment for patients treated by instrumented posterior lumbar interbody fusion (PLIF) for ≤2 segments.

Methods: Seventy-three patients treated by PLIF were randomly allocated to three groups: a group wearing a custom-made lumbosacral orthosis with metallic stays (C group); a group wearing a ready-made lumbosacral orthosis without metallic stays (R group); and a group wearing no orthosis group (N group). The patients in the C and R groups were instructed to wear orthosis for postoperative 3 months. Clinical outcomes were evaluated by the Japa-

nese Orthopaedic Association (JOA) score, the JOA-back pain evaluation questionnaire (JOABPEQ), the Roland-Morris Disability Questionnaire, and a 100-mm Visual Analog Scale for low back pain. Radiographic results were evaluated by intervertebral fusion rate and loss of correction at postoperative 2 years using the lateral radiograph.

Results: Radiographic outcomes were not significantly different among the groups. Difference in the clinical outcomes was observed only at postoperative 1 month for lumbar dysfunction domain of JOABPEQ (N group 45% vs. C group 10%, p=0.03).

Conclusions: There was no significant advantage in clinical and radiographic outcomes to the use of a postoperative lumbosacral orthosis. These results suggest that we should not choose a custom-made lumbosacral orthosis for after-treatment in the patients treated by single or 2-level instrumented PLIF, facilitating the optimization of postoperative treatment with exception of patients with multi-segmental fusion and severe osteoporosis.

Keywords: Lumbosacral orthosis; Posterior lumbar interbody fusion; Japanese Orthopaedic Association back pain evaluation questionnaire; Lumbar spine

Alteration of Lumbar Sagittal Alignment after Surgical Decompression for Lumbar Spinal Stenosis: Comparison between Decompression Alone and Decompression with Fusion

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Background: Lumbar spinal stenosis is a disorder inducing pain in buttocks and lower extremities, with or without back pain. The resulting symptoms are often exacerbated by standing, walking, or torso extension. Leaning forward could alleviate spinal stenosis and its related symptoms, but the sagittal alignment of the lumbar spine is therefore compromised. The purpose of this study was to evaluate the lumbar sagittal alignment before and after surgical decompression for lumbar spinal stenosis.

Methods: From June 2014 to Dec 2016, 94 patients who underwent surgery for lumbar spinal stenosis and were followed more than 12 months were included in this study. Fifty-four of them were treated with decompression alone and the other 50 cases were treated with decompression and mini-open transforaminal lumbar interbody fusion (TLIF group). Spinal fusion surgery was applied with segmental instability. Radiographic outcome measures included focal segmental lordotic angle, lumbar regional lordotic angle, and sacral slope at postoperative, 3 months, and 12 months. Low back pain and functional outcome were also recorded.

Results: At 3 months after surgery, the unilateral laminotomy for bilateral decompression (ULBD) group had significant improvement in both focal and regional alignment. At 12 months after surgery, the ULBD group had further improvement in both focal and regional alignment. The TLIF group had significant improvement in regional alignment but not in focal lordotic angle. There was no significant change of sacral slope at all time points in both groups. Visual Analog Scale scores for back pain and Oswestry Disability Index scores were significantly improved in both groups at 3-month and 12-month follow-up.

Conclusions: The resulting attenuation of lumbar lordosis could be improved after surgical decompression with or without fusion. In patients without instability and significant back pain, decompression alone is an effective surgical choice which could relieve symptoms related to lumbar spinal stenosis and lead to fast improvements in focal and regional sagittal alignments.

Keywords: Sagittal alignment; Decompression or fusion

What Has Occurred in Posterior Flexible Stabilization System More than 10 Years after the Surgery?: A Biomechanical and Histological Study with Retrieved Implants

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Background: The purpose of the current study was to report what has occurred in the Graf flexible stabilization system more than 10 years after the surgery, based on a biomechanical and histological analysis with the retrieved implants.

Methods: There were two males investigated with an age

of 52 and 67 years, respectively. The diagnosis was herniated nucleus pulposus at L4/5 and lumbar canal stenosis with L4 degenerative spondylolisthesis. Both patients had undergone decompression, followed by Graf ligamentoplasty at L4/5. More than 10 years after the surgery, leg pain and numbness recurred with intermittent claudication. The main pathology was canal stenosis at the adjacent level to the stabilized segment. The Graf implants were retrieved with the decompression and fusion at the adjacent segment. A biomechanical test for the retrieved implants was performed using SHIMAZU material testing machine (AGX-100 kN). Histopathological study was also performed using H&E stain, immunostaining method, and scanning electron microscopy (SEM).

Results: Preoperative plain X-ray and computed tomography showed the solid bony fusion at the segment of flexible stabilization in two patients. It was confirmed during the surgery. Macroscopically, no pathological granulomatous tissues and artificial ligament ruptures were observed. There was no screw loosening. Load-displacement curve under the tensile testing of 500 N revealed that elongation of the removed ligaments was smaller than that of the unused new ligaments. H&E staining showed no chronic inflammatory response with any debris. SEM revealed the loosening and microrupture of the ligament fibers.

Conclusions: Graf ligamentoplasty could not prevent the degenerative change of the adjacent segment more than 10 years after the surgery. The biomechanical and histological deterioration of the ligaments has actually occurred, though the solid bony fusion was obtained. The real effect of the Graf ligamentoplasty might be to obtain so-called "slow bony fusion" at the indexed segment.

Keywords: Graf flexible stabilization; Adjacent segment disease; Retrieved implants

The Influence of Diffuse Idiopathic Skeletal Hyperostosis on Physical Function in Elderly Populations

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Background: Diffuse idiopathic skeletal hyperostosis (DISH) is associated with increasing age, obesity, and diabetes mellitus. However, little is known about the clinical impacts of DISH on physical function and spinal deformity in elderly populations. The aim of this study was to elucidate the influence of DISH on physical function, spinal deformity, and health-related quality of life (HRQOL) in elderly populations.

Methods: We enrolled 504 volunteers (187 men and 304 women; mean age, 74.0 years). Height, weight, body mass index (BMI), blood pressure, grip strength, one-leg standing time, sit-and-reach, functional reach, and bone mineral density (BMD) were measured. Using whole spine standing X-rays, the prevalence, location, and numbers of fused vertebra of DISH, and spinopelvic parameters were measured. HRQOL measures, including the Oswestry Disability Index and the EuroQuol-5D were also obtained. We compared DISH subjects with control subjects selected by screening 4:1 non-DISH:DISH patients for age and sex matching. We compared the subjects with DISH in the thoracic spine (T-DISH) to those with DISH in the thoracic and lumbar spines (TL-DISH).

Results: DISH occurred more frequently in men (15.5%) than in women (4.1%). The mean age was significantly higher in subjects with DISH than those without DISH. The mean number of fused vertebra by DISH was 5.5 ±1.5, and T-DISH was observed in 57% cases. DISH group showed greater body weights, BMIs, blood pressures, and BMD in the lumbar spine compared to control group. No inter-group differences were observed in physical function, HRQOL and spinopelvic parameters. Subjects with TL-DISH had significantly lower values of sit-and-reach and functional reach than those with T-DISH.

Conclusions: DISH did not affect physical function, spinal alignment, or HRQOL in elderly subjects. However, DISH in the lumbar region could be an indicator of physical function impairments and postural instabilities.

Keywords: Diffuse idiopathic skeletal hyperostosis; Physical function; Cohort study; Adult spinal deformity; Health-related quality of life

12-Month Follow-up Surgical Outcomes of Long Segment Thoracolumbar Spine Fusion Including S2-Alar-Iliac Screws Instrumentation

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Background: Pelvic fixation with lumbosacral fusion is in extensive practice with numerous indications. Several techniques for spinopelvic fixation have been described in the literature. Although the iliac screw technique is widely practiced, it presents several challenges, including the use of connectors, more lateral surgical dissection, and some complaints of pain over the posterior pelvis. The S2-alar-iliac (S2AI) method has recently been proposed as an alternative technique that decreases the incidences of these complications. This study is aimed to finding out short-term clinical outcomes after long segment thoracolumbar spine fusion including S2AI screws instrumentation.

Methods: We retrospectively reviewed adult patients who underwent lumbopelvic fixation with S2AI screws. Clinical and radiographic outcomes were obtained preoperatively and at least 1 year postoperatively were collected, so as L5–S1 fusion status assessment.

Results: Thirty-six S2AI screws in 18 patients were evaluated. Partial periscrew lucency was identified in eight S2AI screws, and L5–S1 fusion occurred in 90% of patients. No patients had radiographic evidence of progression of sacroiliac joint (SIJ) degeneration, experienced screw backout or breakage, and required reoperation for L5–S1 nonunion.

Conclusions: S2AI screws maintained their integrity without causing SIJ degeneration or major screw-related complications in this small retrospective series with one year follow-up. Long-term results are needed to evaluate the strength of S2AI screws

Keywords: S2-alar-iliac screw; Thoracolumbar spine fusion

The Influence of Developmental Spinal Stenosis on Reoperation Risk at Adjacent Levels after Lumbar Spinal Stenosis Surgery

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Background: Developmental spinal stenosis (DSS) is characterized by a pre-existing narrowing of the bony spinal canal. In the lumbar spine, its phenotype has been classified on both radiographs and magnetic resonance imaging (MRI). Its relationship with the degree of fibrosis in ligamentum flavum has been studied. Possible candidate genes related to its genetic makeup has also been elucidated. It is possible that with such maldevelopment of the bony spinal canal patients are more prone to developing multiple level stenosis and at higher risk of reoperation. The aim of this study as such is to determine the influence of DSS on reoperation risk in spinal stenosis surgery.

Methods: This was a retrospective study of 334 patients who underwent surgery for lumbar spinal stenosis with at least 2 years of follow-up. Details regarding patient symptomatology, age, surgery performed, levels operated on, and reoperation levels were studied. Imaging parameters included the anteroposterior canal diameter per level, thickness of ligamentum flavum, severity of disc degeneration, and disc height. Influence of each parameter for adjacent level reoperation was studied with regression analysis. Odds ratios were generated.

Results: There were no significant differences between patients at baseline. Most of the index operated levels had DSS (77.6%). The overall rate of reoperation at adjacent levels was 44/334 (13.2%). Of these, 42 (95.5%) had DSS on the pre-index surgery MRIs. There was a significant likelihood of reoperation at adjacent levels if that level had DSS (p=0.026). The odds of having reoperation in levels with DSS was 5.9.

Conclusions: Our results suggest that DSS highly influences the risk of reoperation after lumbar spinal stenosis surgery. This relationship is independent on the degree of disc degeneration or age. DSS is significantly associated with poor outcomes during follow-up requiring reoperations and hence, pre-emptive decompression of these developmentally narrowed levels at the index operation may be advisable.

Keywords: Developmental spinal stenosis; Lumbar spine;

Reoperation; DSS

Risk Factors of Cage Posterior Migration after Transforaminal Lumbar Interbody Fusion: A Radiographic Analysis

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Background: Transforaminal lumbar interbody fusion (TLIF) is a widely accepted procedure for treating degenerative lumbar diseases, and posterior migration of cage is an infrequent yet catastrophic complication after TLIF procedure which might cause injury to spinal canal content. Second operation is usually required. Several risk factors were brought in prior literatures including smaller cage height, end disc of fusion, bullet-shaped cages, and longer fusion segments. The aim was to determine impact of cage position along with other factors and set radiographic parameters for intraoperative guide.

Methods: Between March 2014 and Octobor 2015, 953 patients were treated with singe or multilevel TLIF and combined bilateral pedicle screws instrumentation, and were followed for at least 6 months. Their medical records and pre- and postoperative were reviewed. Cage position in disc and other factors influencing cage posterior migration were analyzed.

Results: There were 24 out of 953 (eight men and 16 women; mean age, 69.41 years) cases with posteriorly migrated cages. It was detected after mean 4.92 months (range, 0.23–22 months) after operation. Six of them required revision surgery due to severe and non relieving back or leg pain. We randomly selected 100 patients without cage posterior migration as control group for radiographic analysis. The migrated cages were significantly placed more posterior (p<0.001) than non-migrated ones by measuring depth ratio (0.119–0.427), and they were inserted in discs with higher pre-operative disc height (11.43 mm vs. 9.27 mm, p<0.001). The migrated cages had lower cage height and disc height (-0.26 mm vs. 1.58 mm, p<0.001). There were higher but not significant rate of cage posterior migration in pear-shaped discs (p=0.68).

Conclusions: This study indicated depth of cage placement and higher preoperative disc were important factor influencing cage posterior migration. And pear-shaped disc in lateral radiograph might be risk factor of cage posterior migration.

Keywords: Transforaminal lumbar interbody fusion; Cage; Complication

A Prospective Study of Clinical Outcomes for Microscopic and Endoscopic Posterior Lumbar Decompression Surgery Evaluated with the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire and Patient Satisfaction

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Background: The Japanese Orthopaedic Association (JOA) Back Pain Evaluation Questionnaire (JOABPEQ), as a new outcome measure for patients with low back pain in order to solve the problems of the JOA score. In this study, we prospectively evaluated patient satisfaction and JOABPEQ score after microscopic/endoscopic lumbar posterior decompression surgery for lumbar canal stenosis (LCS).

Methods: In this study, 104 patients who underwent microscopic/endoscopic lumbar posterior decompression surgery for LCS were enrolled. As clinical result, JOABPEQ score was evaluated at enrollment and at 1 year after surgery. JOABPEQ includes the following five dimensions: pain-related disorders, gait disturbance, lumbar spine dysfunction, social life disturbance, and psychological disorders. To evaluate patient satisfaction, an original questionnaire (1, satisfied; 2, moderately satisfied; 3, other) was used and evaluated at 1 year after surgery. The patients were divided into two groups (group A: 1, satisfied; 2, moderately satisfied; group B: 3, other). According to the guideline of JOABPEQ, the effect of surgery was judged. The effective rate was compared in two groups. Between groups comparisons were made using the chi-square test.

Results: Among the patients, 92 patients (88.5%) were included into group A and 12 patients (11.5%) into group B. Totally, effective rate of pain-related disorders was 60.9%, lumbar spine dysfunction was 53.5%, gait disturbance was 61.8%, social life disturbance was 40.2%, and psychological disorders was 29.8%. The dimensions of pain-related

disorders, gait disturbance, and social life disturbance were significantly greater in group A (p=0.04, <0.001, 0.04). The dimensions of lumbar spine dysfunction and psychological disorders were not significantly different between two groups.

Conclusions: The dimensions of pain-related disorders, gait disturbance, and social life disturbance of JOABPEQ after microscopic/endoscopic lumbar posterior decompression surgery at 1 year related to patient satisfaction.

Keywords: Clinical outcome; Posterior lumbar decompression surgery; Japanese Orthopaedic Association Back Pain Evaluation Questionnaire; Patient satisfaction

A Prospective Study of Clinical Outcomes Evaluated with the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire and Patient Satisfaction after Posterior Lumbar Interbody Fusion and Transforaminal Lumbar Interbody Fusion

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Background: The Japanese Orthopaedic Association (JOA) Back Pain Evaluation Questionnaire (JOABPEQ), as a new outcome measure for patients with low back pain in order to solve the problems of the JOA score. In this study, we prospectively evaluated patient satisfaction and JOABPEQ score after posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF).

Methods: In this study, 83 patients who underwent C were enrolled. As clinical result, JOABPEQ score was evaluated at enrollment and at 1 year after surgery. JOABPEQ includes the following five dimensions: pain-related disorders, gait disturbance, lumbar spine dysfunction, social life disturbance, and psychological disorders. To evaluate patient satisfaction, an original questionnaire (1, satisfied; 2, moderately satisfied; 3, other) was used and evaluated at 1 year after surgery. The patients were divided into two groups (group A: 1, satisfied; 2, moderately satisfied; group B: 3, other). According to the guideline of JOABPEQ, the effect of surgery was judged. The effective rate was compared in two groups. Between groups comparisons were made using the chi-square test.

Results: Among the patients, 75 patients (90.4%) were included into group A and eight patients (9.6%) into group B. Totally, effective rate of pain-related disorders was 71.8%, lumbar spine dysfunction was 53.2%, gait disturbance was 66.7%, social life disturbance was 54.9%, and psychological disorders was 42.2%. The dimensions of, lumbar spine dysfunction and gait disturbance were significantly greater in group A (p=0.04, 0.03).

Conclusions: The dimensions of lumbar spine dysfunction and gait disturbance of JOABPEQ after PLIF/TLIF at 1 year related to patient satisfaction.

Keywords: Clinical outcome; Posterior lumbar interbody fusion; Transforaminal lumbar interbody fusion; Japanese Orthopaedic Association Back Pain Evaluation Questionnaire; Patient satisfaction

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A Prospective Study of Clinical Outcomes Evaluated with the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire and Patient Satisfaction after Microscopic/Endoscopic Herniotomy/Discectomy for Lumbar Disc Herniation

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Background: The Japanese Orthopaedic Association (JOA) Back Pain Evaluation Questionnaire (JOABPEQ), as a new outcome measure for patients with low back pain in order to solve the problems of the JOA score. In this study, we prospectively evaluated patient satisfaction and JOABPEQ score after microscopic/endoscopic herniotomy/discectomy for lumbar disc herniation.

Methods: In this study, 39 patients who underwent microscopic/endoscopic herniotomy/discectomy for lumbar disc herniation were enrolled. As clinical result, JOABPEQ score was evaluated at enrollment and at 1 year after surgery. JOABPEQ includes the following five dimensions: pain-related disorders, gait disturbance, lumbar spine dysfunction, social life disturbance, and psychological disorders. To evaluate patient satisfaction, an original questionnaire (1, satisfied; 2, moderately satisfied; 3, other) was

used and evaluated at 1 year after surgery. The patients were divided into two groups (group A: 1, satisfied; 2, moderately satisfied; group B: 3, other). According to the guideline of JOABPEQ, the effect of surgery was judged. The effective rate was compared in two groups. Between groups comparisons were made using the Fisher's exact test.

Results: Among the patients, 37 patients (94.9%) were included into group A and two patients (5.1%) into group B. Totally, effective rate of pain-related disorders was 77.8%, lumbar spine dysfunction was 79.5%, gait disturbance was 78.4%, social life disturbance was 61.5%, and psychological disorders was 56.4%. The dimensions of pain-related disorders and social life disturbance were significantly greater in group A (p=0.04, 0.001).

Conclusions: The dimensions of pain-related disorders and social life disturbance of JOABPEQ after microscopic/endoscopic herniotomy/discectomy for lumbar disc herniation.

Keywords: Clinical outcome; Lumbar disc herniation; Japanese Orthopaedic Association Back Pain Evaluation Questionnaire; Patient satisfaction

Clinical Outcomes of Anterior/Posterior Spine Fusion and Transforaminal Lumbar Interbody Fusion for L4 to S1 Spinal Stenosis

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Background: L4–5 and L5–S1 are both largest-motion joints of thoracolumbar spine so that degenerative disc disease occurred at them. This study is aimed to assess the clinical outcome and radiographic outcomes and complications of anterior/posterior spine fusion (APF) and transforaminal lumbar interbody fusion (TLIF) at for the treatment of spinal stenosis involved L4–S1 levels,

Methods: We collected patients with a total of 42 patients, between January 2016 and February 2017. All patients were cases of spinal stenosis, including L4 to S1 levels. One group was patient receiving APF and another was TLIF only. We compared the clinical results between two groups. Radiographic findings, complications, fusion solidity, and the Japanese Orthopaedic Association scores were evaluated. Furthermore, we also evaluate the adjacent segment disease according to the two groups. Both groups can achieve excellent or good therapeutic effect for L4–S1 fusion. However, for the adjacent segment disease, we found the group of outcome of APF with high rate of adjacent segment disease.

Results: Mean operative time and blood loss were comparable between the two groups. Visual Analogue Scale, Oswestry Disability Index, and Roland–Morris scores significantly improved postoperatively at 1-year follow-up in both groups. Segmental lordosis significantly improved at APF group more than TLIF group.

Conclusions: Anterior fusion and posterior instrumentation for L4–S1 has good result for a lumbar fusion in terms of clinical results, functional outcomes, fusion rates while restoring segmental lordosis and disc height.

Keywords: Anterior/posterior spine fusion; Ttransforaminal lumbar interbody fusion

Strategy for Obtaining Solid Fusion at L5–S1 in Adult Spinal Deformity: Risk Factor Analysis for Nonunion at L5–S1

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Background: Including L5–S1 interbody fusion in adult spinal deformity is important due to the amount of achievable lumbar lordosis is maximal per segment. Achieving a solid fusion is important as well owing to the debilitating low back pain and sagittal decompensation that may result from failure of achieving solid fusion.

Methods: A prospective study of 78 subjects with degenerative lumbar kyphosis (average age, 66.6 years) who underwent surgical correction including an interbody fusion of the L5–S1 with a minimum 2-year follow-up was analyzed. Fusion material were local bone, DBM (demineralization bone matrix), and allobone graft. Fusion grading were accomplished according to a previous study with three-dimensional computed tomography scan ob-

tained 3, 6, 9, 12, 24, and 36 months postoperatively. The subjects were classified into union (n=68) and nonunion group (n=10). Risk factors for nonunion were analyzed which include anterior lumbar interbody fusion (ALIF) vs. posterior lumbar interbody fusion (PLIF), metal vs. polyetheretherketone (PEEK) cage, spinopelvic fixation, S2 alar iliac fixation vs. traditional iliac fixation, malposition of S2 alar iliac screw, penetration of the sacroiliac joint, long vs. short fusion (upper instrumented vertebra below L2), and bone mineral density.

Results: The overall fusion rate was 87.2% (68/78). The fusion rate obtained at the postoperative 3 months was 41.1% (28/68), 22.1% (15/68) at the 6 months, 7.3% (5/68) at the 9 months, 10.3% (7/68) at 1 year, and 4.4% (3/68) postoperatively. The proportion of metal cage to PEEK cage and the proportion of spinopelvic fixation were significantly higher in the union group (p<0.0001, 0.0068, respectively). However there were no significant difference between the union and nonunion group with regard to the proportion of ALIF vs. PLIF, S2 alar iliac fixation vs. conventional iliac fixation, malposition or penetration of screw, and long vs. short fusion.

Conclusions: Application of a metal cage with spinopelvic fixation may be a promising method for achieving solid fusion at L5–S1 in surgically treating adult spinal deformity.

Keywords: L5–S1 fusion; cage; Iliac screw; S2 alar iliac screw; Adult spinal deformity

Retrospective Review of Short to Mid-term Outcome in Oblique Lateral Lumbosacral Fusion (OLIF51) Surgery

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Background: Oblique lateral interbody fusion (OLIF) restores disc height and enables indirect decompression in patients with lumbar spinal stenosis. Recently the concept of the technique is applied to the lumbosacral junction to achieve effective indirect foraminal decompression and lumbosacral lordosis as well as a better clinical outcome. The present study aimed to evaluate the short- to mid-term clinical and radiological outcomes of this minimally invasive lumbosacral (OLIF51) surgery.

Methods: We retrospectively enrolled 22 patients with lower back pain and radicular leg pain due to L5–S1 foraminal stenosis who underwent OLIF51 surgery (average age, 64.2 years; seven males, eight females). The control subjects were those who were case-matched 22 cases who underwent traditional posterior L5–S1 transforaminal lumbar interbody fusion (TLIF) surgery. Perioperative data and postoperative outcomes were also evaluated by using the Japanese Orthopaedic Association (JOA) score at baseline, just after, 3, 6, and 12 months. Radiological evaluation using the computed tomography scan was performed to measure and evaluate the section area of the L5–S1 foramen at the sagittal plane as well as L5–S1 lordotic angle in OLIF51 group subjects. A p-value <0.05 was considered as statistically significant.

Results: OLIF51 patients showed significantly shorter operative time in practical operative duration compared with the traditional TLIF patients as well as significantly less blood loss. The height of intervertebral cage was 10.8 mm in average. Acquired lumbosacral lordosis was 4.2˚ just after the surgery, with correction loss of 1.2˚ at final observation. Recovery of the foraminal area was increased by 41.1% just after the surgery, with a significant gradual decrease of 37.2% at 6 months, then 35.1% at the final observation. JOA score showed significantly improved and remained until the final observation.

Conclusions: OLIF51 surgery provided considerable outcome as traditional TLIF surgery with significantly improved outcomes.

Keywords: Oblique lateral interbody fusion; Transforaminal lumbar interbody fusion; Lumbosacral fusion

Does Surgical Approach Affect Outcomes in Adolescent Idiopathic Scoliosis Patients with 70° or Larger Curves with Less than 30% Curve Flexibility?

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Background: The surgical approach to managing large

adolescent idiopathic scoliosis (AIS) curves ≥70° is often based on one's clinical experience. Few studies have compared the outcomes of surgical approach based on curve flexibility (CF) of the patient. The aim of our study is to compare the operative and radiological outcomes of patients who have large AIS curves of 70° based on their CF and surgical approach: anterior+posterior surgery or standalone posterior surgery.

Methods: A prospective study of all preoperative and postoperative AIS curves ≥70° in a university hospital were reviewed. Patients were divided into two groups: group A <30% CF and group B ≥30% CF. Patients' clinical and radiological outcome data were recorded and analysed using SPSS software.

Results: Fifty-one patients (seven males, 44 females) with mean age of 14 years (range,10–18 years) and Risser stage of 4 (range, 0–5) were reviewed. Group A consisted of 20 patients with mean age of 14±2 years, Cobb angle of 84° (range, 70°–140°), and mean curve correction was 54° (range, 34°–102°). Group B consisted of three patients with mean age of 14±2 years, Cobb angle of 81° (range, 70°–102°), and mean curve correction was 60° (range, 43°–77°). There was no statistical difference found in the demographics between both groups. Multivariate analysis showed that when surgical outcomes were compared between both groups, group A had a statistically significant longer operation time (odds ratio [OR], 7.6; 95% confidence interval [CI], 1.6–36; p=0.011), longer hospital stay (OR, 3.2; 95% CI, 1.8–6.1; p=0.005), lower Cobb angle correction (OR, 0.92; 95% CI, 0.85–0.94; p=0.05), and a trend towards more blood loss. Interestingly, subgroup analysis of those who underwent anterior+posterior surgery against those who had standalone posterior surgery within each group showed no statistically significant difference in correction rates and surgical outcome.

Conclusions: This study suggests that surgical outcomes expectations for AIS ≥70° Cobb angle should be based on CF. There was no statistically significant evidence desmonstrating radiologically that anterior+posterior surgery is superior to standalone posterior surgery, suggesting the need for larger cohort studies to validate the routine need for anterior release in large rigid scoliosis curves.

Keywords: Large curve scoliosis; Severe scoliosis; Curve flexibility

Comparison between Harvesting and Preserving the Spinous Process for Adolescent Idiopathic Scoliosis

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Background: Spinous process has been routinely resected during posterior fusion of adolescent idiopathic scoliosis (AIS) for fusion bed preparation and local autologous bone graft supplement. However, spinous process was part of the posterior ligament complex and served as the anchorage of paraspinal muscles. With the development of pedicle screws instrumentation and the potential fusion ability in children, the need for resecting spinous process could be further investigated. The purpose of this study was to compare surgical outcomes between harvesting and preserving spinous process in posterior fusion of AIS.

Methods: From January 2003 to December 2008, 104 consecutive AIS patients underwent primary posterior fusion with local autologous bone grafts and following for a minimum of 24 months were reviewed. The patients were divided into a harvesting group (n=61) with the spinous process harvested, and a preserving group (n=43) with the spinous process preserved. Blood loss, radiographic assessments, and clinical outcomes were compared between the two groups.

Results: There were no significant differences in duration of surgery and peri-operative blood transfusion between the two groups. However, blood loss was statistically greater (983±446 mL vs. 824±361 mL; p=0.048) and duration of hospitalization was statistically longer (7.4±1.0 days vs. 6.8±0.8 days, p=0.003) in the harvesting group. The pre- and postoperative structural curves, correction rates, sagittal profile, loss of corrections, and incidences of pseudoarthrosis were similar in both groups. The incidence of prescribing pain medication for back discomfort during follow-up was statistically higher in the harvesting group (16/61 vs. 4/43, p=0.03).

Conclusions: The surgical outcomes and fusion rates between harvesting and preserving the spinous process were comparable. Resecting the spinous process as local autologous bone graft may not be necessary in posterior fusion for AIS patients.

Keywords: Adolescent idiopathic scoliosis; Local autologous bone graft; Pedicle screw instrumentations; Posterior fusion; Spinous process

2-Year Radiological Outcome Study of Adolescent Idopathic Lumbar Scoliosis Treated with Short Segment Anterior Fusion

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Background: Anterior spinal fusion was historically preferred in treatment for Lenke 5C curves in adolescent idiopathic scoliosis because of better curve correction, powerful derotation while preserving more motion segments. The benefit of saving distal motion segment and preventing denervation of the powerful paraspinal muscles is still a valid reason to approach from anterior. We present our experience in treating these selected group of patients with short segment fusion using monoaxial pedicle screws with staples and a one rod system.

Methods: We retrospectively reviewed patients with adolescent idiopathic scoliosis (Lenke 5) that was treated with short segment anterior fusion surgery at a single centre from 2012 to 2015. There was a total of 11 patients. One was lost to follow-up and was excluded from the study. The radiographs were assessed preoperatively then postoperatively at 2 years. Results were analyzed using statistical analysis (SPSS).

Results: There were nine females and one male patient with the average age of 16.6 years old at the time of surgery. All patients underwent anterior lumbar fusion from T12–L3, except one patient who was fused from T12 to L2. The average preoperative lumbar Cobb angle was 53.8° and corrected to 18.4° postoperatively, producing a correction rate of 65%. The fulcrum flexibility rate was 44% (p-<0.05. The fulcrum bending correction index was 104%. (p-<0.05). At the 2-year follow-up, there was no incidence of significant progression of the lumbar curve and also the thoracic non structural curve.

Conclusions: Short segment lumbar fusion surgery may be a good option to treat Lenke 5 lumbar curves, with good radiological outcomes. The fulcrum bending films provided a good indication of the flexibility of the lumbar curve despite having no ribs as anchorage points for the fulcrum.

Keywords: Anterior spinal fusion; Scoliosis; Lenke 5C; Radiological assessment

Posterior Instrumentation, Scoliosis Correction, Spinal Fusion in Lenke type 5 Curves -Analysis and Outcome

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Background: The advent of more sophisticated posterior instrumentation, spinal deformity surgeons have attained mastery in scoliosis correction with the posterior approach. An analysis and outcome needs to be evaluated to document posterior instrumentation, scoliosis correction - its efficacy in the management of Lenke type 5 curves over anterior instrumentation and curve correction.

Methods: We retrospectively evaluated AIS patients of Lenke type 5 curves who were managed with Posterior instrumentation from period June 2014 to June 2016. Twelve patients in the above period were analysed. All the patients have underwent the procedure with intraoperative traction, under neuromonitoring in Roger-Jackson table. Mean Cobb angle, Apical vertebral rotation, Apical vertebral translation, Coronal balance, Sagittal balance, Clinical waist symmetry, Radiographic shoulder height were analysed and the functional outcome was tabulated using SRS 30 questionnaire

Results: Mean age of the patients was 15.58 years .There were 6 hypokyphotic, 1 normokyphotic, 5 hyperkyphotic curves in the cohort. Mean Cobb angle reduced from 54.91 to 8.75 degrees, with mean correction cobb angle index being 84.06%. Apical vertebral rotation changed from mean Nash-Moe grade 2.41 to 0.5.Apical vertebral translation improved from 19.33 to 2.16.Mean Avr correction index, Mean Avt correction index, were being 79.25%, 88.82% respectively.Reduction in Cobb angle, Apical Vertebral rotation, Apical vertebral translation, were statistically significant (p<0.001). Clinical waist symmetry restored in all the patients.Radiographic shoulder height improved from +3.5 to +1.08 however, it was statistically insignificant. There were no implant related or neurologi-

cal complications encountered.Coronal,Sagittal balance were restored in all the patients. Functional outcome score reduced when compared to preoperative status.

Conclusions: Posterior instrumentation, scoliosis correction provides comparable results to the tradional anterior management. As the major limiting factors, an access surgeon, morbidity of anterior approach are eliminated, this method provides an alternative, effective way in correcting spinal Lenke type 5 AIS curves.

Keywords: Posterior instrumentation; Lenke type 5 curve; Adolescent idiopathic scoliosis curves

A 10-Year Radiographic Outcome Study of Anterior and Posterior Instrumented Spinal Fusion in Patients with Lenke Type 5 Adolescent Idiopathic Curves: Analysis Are We Preparing Our Patients for Adult Deformity Targets?

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Background: Both anterior and posterior instrumentation have been found to be safe and effective treatments for Lenke 5 adolescent idiopathic scoliosis (AIS) up to 2 to 5 years of follow-up. Few studies follow up beyond this duration. This study aims to compare the long-term, radiographic coronal, and sagittal outcomes of these 2 approaches up to 10 years.

Methods: Thirty-six patients who underwent anterior (n=25) or posterior instrumented spinal fusion (n=11) for Lenke 5 AIS between 2000–2003 are recruited and prospectively followed up to 10 years. Preoperative clinical data include patient's age and age of menarche. Operative data included instrumented levels, duration of surgery, and surgical blood loss. Postoperative data included duration of hospital stay, duration of intensive care unit stay, and complications. Pre- and postoperative radiographic data collected include coronal Cobb angles for structural thoracolumbar/lumbar curves, as well as sagittal angles—sagittal vertical axis, thoracic kyphosis, global lumbar angle, pelvic incidence, pelvic tilt, sacral slope, and upper and lower end vertebrae.

Results: Posterior surgery had a shorter operative time (p<0.010) and hospital stay (p<0.010). Coronal plane deformity improved by a mean of 74% in the anterior group and 71% in the posterior group. There was no significant change at 10 years in both groups (anterior p=0.455 and posterior p=0.325). Sagittal parameters remained unchanged. There was a higher incidence of proximal junctional kyphosis in the posterior (36%) compared to the anterior (20%) group (p<0.010).

Conclusions: Both anterior and posterior instrumentation and fusion are successful surgeries after 10 years of follow-up. They are comparable with regards to their ability to achieve and maintain good correction of scoliotic deformities and have a low rate of pseudoarthrosis and instrument failure. Ideal sagittal parameters are maintained up to 10 years of follow-up.

Keywords: Adolescent idiopathic scoliosis; Lenke 5; Prospective; Sagittal; Coronal

Reliability of Spino-Pelvic, Thoracic, and Magnetically Controlled Growing Rod Distractions Using Biplanar Stereoradiography

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Background: Biplanar stereoradiography (EOS) is widely used for diagnosis and monitoring of children with early onset scoliosis. However, there is a paucity of literature on the reliability of thoracic and spino-pelvic parameters on EOS imaging in children treated with magnetically controlled growing rod (MCGR). Hence the aim of study is to assess the inter- and intraobserver reliability of thoracic, spino-pelvic, and rod lengthening measurements in children treated with MCGR.

Methods: Three independent reviewers independently read a random assortment of 20 whole spine posteroanterior and lateral radiographs from patients treated with MCGR. The measurements were repeated 4 weeks after the initial read. The following radiological parameters were measured: Cobb angle of the main and compensatory curves, coronal balance, coronal T1–S1 and T1–T12 length, chest width and depth at T6, pelvic inlet width,

MCGR distracted lengths, global kyphosis, proximal and distal junctional angle, lordosis, sagittal balance, pelvic incidence, pelvic tilt, and sacral slope. Statistical analysis was performed with paired *t*-test and Cronbach's alpha for inter- and intraobserver reliability.

Results: All measurements had good or excellent intra- and interobserver reliability ($\alpha>0.8$, $p<0.05$), except measurements of the proximal junctional angle which showed only poor intra- and interobserver reliability.

Conclusions: EOS imaging is reliable for diagnosis and monitoring of children with early onset scoliosis treated with MCGR. EOS imaging is particularly excellent for assessment of MCGR lengthening. Diagnosis and interpretation of early proximal junctional kyphosis should be made with caution.

Keywords: EOS; Spinopelvic; Thoracic; Magnetically controlled growing rod; Reliability

Is It Scar Management Necessary in the Surgical Correction for the Spinal Deformity Due to Schar Contracture?

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Background: The constricture scar scoliosis is a very rare spinal deformity due to the worst healing scar caused by burn or by sepsis, abscess, and fistula. The rate is 1.1% (5/453 cases) in our continuous series in 21 years (1996–2017).

Methods: Four cases were operated with the same method: anterior releasing by discectomy above and below the apex and posterior correction-fixation by whole pedicle screws construct. The halo skull traction was applied a couple of weeks after anterior releasing.

Results: The asymmetrical development of skeletal system during growth progressively developed the scoliotic and kyphotic curve over the years. The scar management has to be considered for the very severe thick scar before the correction by different methods: anterior, posterior only, or combined anterior and posterior correction-fixation. Even with the very serious scar contractures, we have not involved in the scar orthoplastic surgery at all. The scar releasing during posterior exposure was realized by multiple transverse section of the scar from deep to superficial layer prior to the pedicle screw correction-fixation. It allows the shorter time for the spinal deformity correction without need of skin management, postoperative cast, or brace support.

Conclusions: The good result was obtained by posterior correction-fixation for the scar constricture scoliosis after anterior releasing surgery in applying the strong whole pedicle screws construct in our four cases without skin management.

Keywords: Contracture scoliosis; Combined anterior and posterior correction-fixation

Surgical Results of Scoliosis in Patients with Marfan Syndrome

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Background: Surgical treatment is recommended for the most of patients with scoliosis associated with Marfan syndrome. The study aimed to explore surgical results of scoliosis in Marfan syndrome.

Methods: Eight consecutive patients with Marfan syndrome, including two males and six females, were treated for scoliosis by a posterior instrumented fusion with pedicle screw between January 2010 to January 2013. Mean age at surgery was 14.3 years (range, 11.5–18 years). Surgical results and complications were retrospectively analyzed.

Results: The patients were followed for a mean period of 42.2 months (range, 22–65 months). The average operation time was 365 minutes (range, 300–540 minutes) and the average blood loss was 1,175 mL (range, 500–3,000 ml). The preoperative Cobb angles averaged 76.8° (range, 53°–120°). The average Cobb angle was corrected to 18.6° (range, 3°–73°) with a correction rate of 79.92% (range, 39.17%–94.34%) immediately after surgery, and 23.6° (range, 4°–77°) with a correction rate of 72.2% (range, 34.4%–92.5%) at final follow-up. The average loss of correction at follow-up was 5.0° (range, 0°–33°). No neurologic problems were found in the preoperative or postoperative period. No patient had a pseudarthrosis or failure

of instrumentation. Late wound infection at postoperative 15 months occurred in one case. Instrumentation removal, debridement plus drainage were applied, and the infection was finally controlled.

Conclusions: The posterior pedicle screw instrumentation and fusion is effective and safe for the treatment of scoliosis in patients with Marfan syndrome.

Keywords: Marfan syndrome; Scoliosis; Correction; Pedicle screws

Scoliosis after Thoracotomy in Patients of Esophageal Atresia

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Background: Scoliosis is a potential complication of esophageal atresia (EA) with or without tracheoesophgeal fistula. The incidence of scoliosis after surgery for EA has been reported to range between 6% and 50%. The possible reasons include congenital spinal anomaly, secondary to thoracotomy-induced rib fusions, and pleural scarring. The pleural scarring causes concave for the curves toward the operated side. We presented three cases of scoliosis developed after thoracotomy.

Methods: Case 1 is an an 18-year-old girl with underling EA. She received excision and anastomosis by right thoracotomy after delivery. Unfortunately, back deformity with left thoracic curvature was noted when she was 8 years. The Cobb's angle was about 10° at that time. She was lost to follow-up for 6 years and came back with 65° curvature recently. Case 2 is a 12-year-old girl. She also received excision and anastomosis by right thoracotomy at our hospital. Neck and back deformity was noted when she was 6 years, which is also left thoracic curve. The curve progressed when she was 11 years. Case 3 is a case of VACTERL (vertebral anomalies, anal atresia, cardiac malformations, tracheo-esophageal fistula, renal anomalies, limb abnormalities) syndrome with left thoracic scoliosis.

Results: The incidence of scoliosis after thoracotomy in childhood is more than 30% with female predominant. This exceeds the incidence of idiopathic scoliosis in normal population (around 2%). These three cases were all left thoracic curve. The surgery for EA was performed through right thoracotomy. All three cases have right side fused ribs. Scarring and rib fusion pulled the trunk toward the involved side. The deformity therefore appears to be caused by fusion of the ribs due the inflammatory reaction, rather than by thoracotomy itself.

Conclusions: Children undergone thoracotomy should pay much attention to their spine deformity in their early life. Close follow-up is needed more than adolescent idiopathic scoliosis because of its' easily progression potential.

Keywords: Esophageal atresia; Tracheoesophgeal fistula; Thoracotomy; scoliosis

Fulcrum Flexibility of the Main Curve Predicts Postoperative Shoulder Imbalance in Selective Thoracic Fusion of Adolescent Idiopathic Scoliosis

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Background: Postoperative shoulder imbalance (PSI) remains a common complication after corrective surgery for main thoracic (MT) adolescent idiopathic scoliosis (AIS). However, the criteria for when to extend the fusion proximally and the optimal level of curve correction is not well established. The role of MT flexibility in predicting PSI needs further examination. Hence, the aim of study is to identify preoperative predictors for PSI after corrective surgery of AIS.

Methods: A consecutive surgical cohort of AIS patients undergoing selective thoracic fusion with alternate-level pedicle screw fixation was prospectively studied. Preoperative antero-posterior, lateral and fulcrum bending radiographs were analyzed. Postoperatively, a minimum of 2 years clinical and imaging follow-up was performed of all patients. PSI was defined as a radiographic shoulder height difference of more than 20 mm.

Results: A total of 80 patients were included and 14 patients (18%) were confirmed with PSI at final follow-up. Flexibility of MT curve was an independent risk factor for PSI (odds ratio [OR], 3.3 per 10% decrease; 95% confidence interval [CI], 1.6–8.2). Twenty-seven patients had a preoperative MT flexibility of <55% (OR, 11.5; 95% CI, 2.8–46.2). Postoperative T1 tilt was significantly higher

in the PSI group (p<0.001) and a T1 tilt of more than 9° resulted in 7.2 times higher odds of developing PSI (95% CI, 2.0–26.0). Fulcrum bending correction index (FBCI) was significantly higher in the PSI group at final follow-up and 25 patients had a final postoperative MT FBCI above 120% (OR, 8.5; 95% CI, 2.3–31.0).

Conclusions: A low preoperative curve flexibility is a significant predictor for PSI. The surgical strategy should consider proximal fusion if low-flexibility MT curves and/or less aggressive MT curve correction. Achieving a level T1 should be a main priority during intraoperative correction and may require fusion of the PT curve.

Keywords: Adolescent idiopathic scoliosis; Shoulder balance; Fulcrum bending radiograph; Proximal thoracic curve; T1 tilt

Radiological and Clinical Outcome of Selective Thoracic Fusion for Lenke 1C and 2C Adolescent Idiopathic Scoliosis Patients with Minimum Follow-up of 2 Years

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Background: In Lenke 1C/ 2C curves, the choice between selective thoracic fusion (STF) versus non-selective thoracic fusion (NSTF) is controversial.

Methods: We included 44 adolescent idiopathic scoliosis patients with Lenke 1C/2C curves who underwent STF between 2012 and 2015. Radiological parameters, i.e., coronal balance (CB), shoulder balance, upper instrumented vertebra (UIV), and lower instrumented vertebra (LIV) parameters were measured preoperative, postoperative, and at final follow-up. We assessed the Scoliosis Research Society-22R (SRS-22R) scores before operation and final follow-up. We also reported the incidence of coronal decompensation, lumbar decompensation, and adding-on phenomenon

Results: Mean follow-up duration was 45.1±12.3 months and mean age was 17.0±5.1 years. At final follow-up, radiological shoulder height was -3.4±11.8 mm, clavicular angle was -0.4°±2.3°, cervical axis was 0.3°±3.6°, cervical-rib intersection difference was -1.2±4.7 mm, coracoid height difference was -1.2±10.7 mm, and T1-tilt was -1.0°±4.6°. CB was -13.0±11.5 mm, main thoracic apical vertebral translation (AVT) was 6.9±11.8 mm, and lumbar AVT was -20.4±13.8 mm. These parameters showed significant improvement from preoperative values. UIV tilt was -4.8°±4.7° and LIV tilt was 11.4°±5.5°. Lumbar cobb angle improved from 47.5±7.8° to 24.9±8.2° after operation and 23.3±9.8° at final follow-up. Nine patients (20.5%) had coronal decompensation, four patients (9.1%) had lumbar decompensation, and 11 (25.0%) patients had adding-on phenomenon. We did not perform any revision surgery. The SRS-22R scores improved significantly in the overall scores, self-image, and mental health domain

Conclusions: STF led to improvement in the radiological and clinical outcome for Lenke 1C/ 2C patients. Although no patients required revision surgery, the rate of coronal decompensation, lumbar decompensation, and adding-on phenomenon are significant.

Keywords: Selective thoracic fusion; Adolescent idiopathic scoliosis; Surgery; Decompensation

The Correlations between the Anchor Density and the Curve Correction of Adolescent Idiopathic Scoliosis Surgery

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Background: Pedicle screw instrumentation has been shown to provide better curve correction with solid three-column fixation in adolescent idiopathic scoliosis (AIS) surgery. The optimal anchor density to achieve good curve correction and avoid potential risks of screw malposition remains unclear. The purpose of the study is to analyze the correlation between curve correction and anchor density in posterior fusion of AIS.

Methods: From 2009 to 2013, 127 consecutive AIS patients were reviewed. Patients underwent primary posterior fusion with pedicle screw-based fixation and were followed up for a minimum of 24 months were included. Anchor density was defined as the number of screws per fused spinal segment. Radiographic correction parameters

were calculated and the relations with anchor density were analyzed. Patients were also divided into low- and high-density groups, based on the median anchor density to compare the three-dimensional correction parameters.

Results: For coronal and axial planes, the anchor density was not correlated with coronal curve correction or apical vertebral rotation correction. In the sagittal plane, mild but positive correlations existed between anchor density and thoracic kyphosis correction in all patients (r=0.26, p=0.003), Lenke 1 (r=0.31, p=0.02) and Lenke 1–3 patients (r=0.27, p=0.01). There were no differences between low- and high-density constructs in coronal or axial curve correction parameters. In the sagittal plane, high-density groups have significantly better thoracic kyphosis correction than low-density groups in all patients (6.2°±9.6° vs. 1.9°±9.5°, p=0.01) and Lenke 1–3 patients (5.6°±9.4° vs. 1.4°±8.5°, p=0.03).

Conclusions: In this study, the anchor density was not related to coronal or axial curve corrections in AIS surgery. Nevertheless, mild but positive correlations with anchor density were found in thoracic kyphosis correction for patients with main thoracic curves. Spinal surgeons should consider the influences of anchor density on correcting deformities when planning implant distributions preoperatively.

Keywords: Adolescent idiopathic scoliosis; Anchor density; Pedicle screws instrumentation; Posterior fusion; Thoracic kyphosis

The Reliability of Intraoperative Crossbar in Determining the Upper Instrumented Vertebra Tilt Angle

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Background: The optimal upper instrumented vertebra (UIV) tilt angle can be calculated preoperatively from the cervical supine side bending radiographs. However, there is no report describing the method in measuring the UIV tilt angle intraoperatively

Methods: One hundred adolescent idiopathic scoliosis-patients with Lenke 1/2 curves who underwent posterior spinal fusion between 2015 and 2016 with average follow-up of 2 years were recruited. Radiological parameters were measured preoperatively, postoperatively, and at final follow-up. UIV tilt angle was measured intraoperatively using cross bar

Results: Mean age was 16.2±6.2 years. Mean follow-up was 37.9±6.5 months. There were 64.0% Lenke 1 and 36.0% Lenke 2 curves. There was no significant statistical difference between the intraoperative, postoperative, and final follow-up UIV tilt for both Lenke 1 and Lenke 2 (p>0.009). There was excellent reliability in both intra- and inter-observer for both Lenke 1 and Lenke 2 where the ICC are more than 0.900. There was statistical difference between all the radiological parameters preoperatively and postoperatively except for cervical axis and UIV tilt. Similar pattern of significance was noted between all the parameters preoperatively and final follow-up. However, between postoperative and final follow-up, there were no significant difference in all parameter except for clavicle angle, coronal balance, and clavicle rib intersection difference.

Conclusions: Intraoperative crossbar usage of measuring the UIV tilt was reliable and it accurately predicted the UIV tilt angle postoperatively and at final follow-up.

Keywords: Upper instrumented vertebra; Crossbar

Surgical Outcomes Based on Cobb Angle Stratification in Adolescent Idiopathic Scoliosis Patients with Minimum Curve of 70° & Above

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Background: Few studies have analysed the surgical outcomes of adolescent idiopathic scoliosis (AIS) ≥70° based on curve size. The aim of this study is to analyse potential differences in outcomes of patients based on curve magnitude with minimum of 70° curve.

Methods: A retrospective review of all AIS cases ≥70° Cobb angle operated in a university hospital at their second postoperative year. Patients were divided into three

groups: A, 70°-79°; B, 80°-89°; C ≥90°. Patients' radiological and clinical outcome data were recorded and analysed using SPSS software.

Results: Twenty patients (one male, 19 females) with mean age of 13.8 years (range, 11–18 years) and Risser stage of 3.1 (range, 0–5) were reviewed. Group A (n=8) had mean Cobb angle of 73° (rang, 71°–76°), curve flexibility of 42% (range, 18%–57%), Cobb angle correction of 53° (range, 45°–62°), and correction rate of 72% (range, 61%–86%). Eight patients underwent posterior surgery only. Group B (n=9) had mean Cobb angle of 83° (range, 80°–89°), curve flexibility of 31% (range, 14%–51%), Cobb angle correction of 60° (range, 42°–72°), and correction rate of 70% (range, 51%–86%). Six patients underwent posterior surgery only and three patients had anterior+posterior surgery. Group C (n=3) had mean Cobb angle of 102° (range, 90°–117°), curve flexibility of 29% (range, 27%–32%), Cobb angle correction of 74° (range, 68°–82°), and correction rate of 72% (range, 68%–79%). Two patients underwent posterior surgery only and one patient had anterior+posterior surgery. There was a trend for increasing operative time (A: 349 minutes, B: 457 minutes, C: 435 minutes), hospital stay (A: 5.8 days [range, 5–9 days], B: 7.1 days [range, 4–15 days], C: 7.7 days [range, 7–9 days]), more blood loss (683 vs. 781 vs. 1,267 mL), and blood transfusions as the curve size increases in our study. There was no significant difference between the three groups in terms of correction loss, Scoliosis Research Society score, and Visual Analog Scale score at 2 years postoperatively.

Conclusions: There is a trend towards longer operative time, blood loss, and hospital stay as curve size increases and an observation of more anterior release was noted in curves ≥80°. Interestingly, similar trends of correction rate, postoperative complications, and outcome scores were found in large curves suggesting that curves 70°-90° may have similar characteristics and surgical outcomes. Larger cohort studies are needed to validate these findings.

Keywords: Adolescent idiopathic scoliosis; Large deformity magnitude; Large curve scoliosis; Cobb angle stratification

Sublaminar Bands in Severe Adolescent Idiopathic Scoliosis Curves: Its Impact on Curve Correction, Spinal Balance, and Functional Outcome

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Background: Sublaminar bands, its impact on curve correction, spinal balance, and functional outcome in the scoliotic curve correction need to be elucidated to proclaim its significance over pedicle screws at the concave apical sites of the curve.

Methods: We have retrospectively analysed severe adolescent idiopathic scoliosis (AIS) curves (more than 75°) operated with posterior instrumentation, either with sublaminar bands, or pedicle screws at concave apical sites from the period to June 2014 to June 2016. All the patients were operated with intraoperative traction underr neuromonitoring in Roger Jackson table.

Results: There were 12 treated with pedicle screw (group 1) and nine patients with sublaminar bands (group 2) at concave apical implant sites. The mean Cobb angle reduced from 84.41° to 14.58° in group 1 and from 94.66° to 27.55° in group 2. The mean apical vertebral rotation changed from Nash-Moe grade 2.91 to1.16 in group 1 and from 3.0 to 1.88 in group 2. The mean apical implant density was 1.283 in group 1 and 1.0 in group 2. The mean correction Cobb angle index, mean correction apical vertebral rotation index, and mean correction apical vertebral translation index were being 82.72, 60.13, and 84.48, respectively in group 1 and were 70.89%, 37.33%, and 68.58%, respectively in group 2. The mean correction in apical vertebral rotation was high in group 1 cohort than group 2 cohort. Mean change in Cobb angle in both groups were statistical significant (p<0.01). Both groups had comparable functional outcome score with Scoliosis Research Society-30 questionnaire.

Conclusions: Pedicle screws play a great role in correcting the apical vertebral rotation at the concave apical sites, then sublaminar band; however, bands have a great role to play in vertebrae with dysmorphic pedicles, and its utility should be increased by spinal deformity surgeons to provide optimal curve correction,spinal balance and functional outcome.

Keywords: Sublaminar bands; Pedicle scres; Concave apical sites; Adolescent idiopathic scoliosis curves

Relationship of the Potential Risk of Spinal Cord Injury by Pedicle Screw and Vertebral Morphology in Adolescent Idiopathic Scoliosis

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Background: Few studies have investigated the relationship between vertebral morphology and the distance from the spinal cord to the medial wall of the pedicle as a potential risk factor for pedicle screw-related spinal cord injury on Lenke type 1 thoracic single-curve adolescent idiopathic scoliosis (AIS).

Methods: Twenty-seven patients with a mean age of 15±1.8 years (range, 12–19 years) classified as having Lenke type 1 AIS (1A: 15 cases, 1B: eight cases, 1C: four cases) were analyzed. The mean Cobb angle of the main curve was 55.9°±14.4°. Axial computed tomography myelography images were selected from the T4 to T12 vertebrae, and 243 images were analyzed. Outer cortical pedicle width, inner cortical pedicle width, pedicle length, chord length, transverse pedicle angle, the angle of rotation (RAsag) of the vertebra, and the distance between the spinal cord and concave (Dc) and convex pedicles (Dv) were calculated from landmark locations.

Results: The mean concave cortical pedicle width was larger than the mean convex cortical pedicle width at T4, T5, T11, and T12 ($p<0.05$) and smaller than the mean convex cortical pedicle width around the apex of the curve from T7 to T9 ($p<0.05$). The mean RAsag increased in degree from T4 to T8 and decreased in degree from T8 to T12. The mean Dc was smaller than the mean Dv around the apex of the curve from T6 to T11 ($p<0.05$). Dc was significantly correlated with the concave outer ($r=0.269$, $p<0.001$) and inner cortical pedicle width ($r=0.230$, $p<0.001$).

Conclusions: The distance from the spinal cord to the medial wall of the pedicle was significantly correlated with outer and inner cortical pedicle width, and the potential risk of spinal cord injury by pedicle screw is increased with insertion into a narrower pedicle, especially on the concave side around the apex.

Keywords: Scoliosis; Vertebral morphology

Three Column Fixation: A Dynamic Method in Scoliosis Surgery

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Background: Scoliosis is a complex three-dimensional (3D) deformity characterized by coronal, sagittal, and horizontal plane deviation. Non-operative treatment is a widely accepted approach. A significant number of cases need surgical intervention. Revolutionary design and capability of spinal instruments have drastically changed the principle of scoliosis correction by surgical intervention.

Methods: From February 2009 to July 2017, 91 cases of scoliosis underwent surgical intervention at National Institute of Traumatology & Orthopaedic Rehabilitation and Bangladesh Spine & Orthopaedic Hospital, BSOH and other private hospitals in Dhaka. Sixty-four were female and 27 were male and age ranged from 14 to 38 years. Pedicle screw instrumentation has advantages of rigid fixation with improved 3D correction and it has been accepted as a reliable method with a high margin of safety. Accurate placement of the pedicle screws is important to reduce possible irreversible complication. So, all cases were corrected by transpedicular screws and rods and one case stabilized by sub laminar wring. Eighty-eight cases were managed by only posterior approaches and three cases required both anterior releases, costoplasty, and posterior stabilization as well. In every case fusion was done in selected segments.

Results: Total follow-up time was about 7 years (range, 6 months–7 years). All patients were assessed in terms of correction of deformities, cosmesis, and functional outcome. Seventy-one patients had average coronal plane Cobb angle measuring about 70° preoperatively and 17.12° immediate postoperative period. Four patients (4.4%) developed neurological deficit. Three regained completely but another one regaining her neurological deficit very slowly. There were malposition of screws in 11 cases (12%), painful prominence of screws in nine cases (10%), full flexion lack in nine cases (9.9%), and super-

ficial infection in one case (1%). Eighty percent patients improved cosmetically.

Conclusions: Overall outcome in surgical treatment of scoliosis in terms of cosmesis and patient expectation by transpedicular screws and rod system was satisfactory.

Keywords: Three column fixation; Posterior approach

Efficacy of Cell Salvage as Blood Conservation Technique in Scoliosis Surgery

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Background: The use of cell salvage is widely practised in scoliosis corrective surgery to reduce the need of allogenic transfusion. However, there is a paucity of evidence with regard to its efficacy. This study aims to determine the efficacy of intraoperative cell salvage in posterior spinal fusion surgery.

Methods: A retrospective analysis was performed in 89 patients who underwent single-staged posterior spinal fusion surgery for adolescent idiopathic scoliosis in 2016 in a university teaching hospital. All patients received intraoperative cell salvage (ICS) as part of institutional protocol. Mean intraoperative blood loss was 909 ml. They were categorised into two groups: group A (<900 mL blood loss, n=50) and group B (>900 mL blood loss, n=39).

Results: The mean age and weight was 16.1 years, 46.8 kg and 17.0 years, 49 kg for group A and B, respectively. Preoperative baseline characteristics such as blood volume (3,121 vs. 3.346 mL), Cobb's angle (57.6° vs. 66.8°), number of levels fused (9.7 vs. 12.4), and number of screws (12.4 vs. 15.3) were higher in group B compared to group A. Blood volume returned by ICS were 260 mL and 560 mL for groups A and B, respectively. For both groups, 47% of total intraoperative blood loss was returned via ICS. Analysis of the pre- and postoperative (72 hours) haemoglobin levels did not show statistical significance between groups A and B (preoperative: 13.4 vs. 13.7 g/dL and postoperative: 11.1 vs. 10.7 g/dL). None of the subjects received perioperative allogenic blood transfusion or reported complications from the use of cell salvage.

Conclusions: Intraoperative cell salvage is effective in conserving blood when used in posterior spinal fusion surgery. Postoperative haemoglobin levels did not differ significantly between the higher and lower blood loss groups. In this study, cell salvage managed to recover about 47% of intraoperative blood loss in both groups.

Keywords: Scoliosis; Cell salvage; Blood loss

Application of Two-Parameter Scoliometer Values for Predicting Scoliotic Cobb Angle

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Background: Adolescent idiopathic scoliosis is seen in combination with lumps from back. These lumps contribute to inclination, which can be measured by a scoliometer. To the authors' knowledge, there are no previous formulas combining thoracic and lumbar scoliometer values simultaneously to predict thoracic and lumbar Cobb angles, respectively. This study aimed to create more accurate two-parameter mathematical formulas for predicting thoracic and lumbar Cobb angles.

Methods: The patients diagnosed with idiopathic scoliosis in an outpatient clinic were enrolled. The maximal trunk rotations at the thoracic and lumbar regions were recorded with a scoliometer. Right asymmetry hump was deemed positive (+), and left asymmetry hump was deemed negative (−). The Cobb angles were measured with a Picture Archiving and Communication System. Statistical analysis included Pearson's correlation coefficient, multivariate regression, and Bland–Atman analysis.

Results: One hundred and one patients were enrolled in our study. The average thoracic curve (TC) was 23.3°±1.8°, while the average lumbar curve (LC) was −23.3°±1.4°. The thoracic inclination (TI) and lumbar inclination (LI) were 4.5±0.7 and −5.9±0.6, respectively. The one-parameter formula for the TC was TC=2.0 TI+14.3 (r=0.813); for the LC, it was LC=0.9 LI-16.9 (r=0.409). By multivariate regression, the two-parameter formulas for TC and LC were TC=2.6 TI−1.4 LI (r=0.931) and LC=−1.5 TI+2.0 LI (r=0.874), respectively. The two-parameter formulas were more accurate than the one-parameter formulas.

Conclusions: Based on the results of these two-parameter

formulas for TC and LC, the Cobb angles can be predicted more accurately by the readings of the scoliometer. Physicians and other healthcare practitioners can thus evaluate patients with scoliosis more precisely than before with a scoliometer.

Keywords: Cobb angle; Idiopathic scoliosis; Nash–Moe rotation; Rib hump; Scoliometer

Effectiveness of Nighttime Brace in Preventing Progression of Idiopathic Scoliosis

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Background: Compared to full-time brace, nighttime brace is molded into an overcorrected and side-bending position, thus having greater in-brace correction than full-time brace for idiopathic scoliosis. Besides, it is has less psychosocial impacts, hence improving patient compliance. The purpose of this study was to evaluate the effectiveness of nighttime brace in preventing the progression of mild to moderate idiopathic scoliosis.

Methods: From Jan 2015 to Mar 2017, a total of 20 patients were enrolled to wear nighttime braces for at least 8 hours during their sleep, and to follow-up in the outpatient department every 4 to 6 months. At every visit, supine in-brace and standing out-of-brace anteroposterior radiographs were taken. Cobb angle, Risser grade, and curve type were recorded, while in-brace correction rate was calculated. Cobb angle progressed less than 5° was considered successful.

Results: The mean initial and final Cobb angles of major curve were 28.3°±5.8° and 27.8°±9.4°, respectively. Three patients (15%) had curve progression, while 17 patients (85%) had Cobb angle changes ≤5°. Hence, the success rate in preventing curve progression was 85%. The progression group had a lower in-brace correction rate than the non-progression group (58.1%±32.5% vs. 87.8%±32.5%), but there is no statistical significance (p>0.05). Thus, double major curve was found to have significant correlation in patients with curve progression (p=0.039).

Conclusions: The present study validated the efficacy of conservative treatment by nighttime brace in mild to moderate idiopathic scoliosis (Cobb angle 20°–40°). Patients with double major curve could have a higher risk of brace failure.

Keywords: Scoliosis; Orthosis; Nighttime brace

Spinal Growth Tethering Leads to Asymmetric Growth of the Apical Vertebra in Scoliosis

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Background: Anterior spinal growth tethering (ASGT) is a relatively new non-fusion method of spinal growth modulation for treating scoliosis. The purpose of this study was to evaluate if ASGT results in asymmetrical apical vertebral body growth associated with progressive scoliosis correction.

Methods: A retrospective review of patients treated with ASGT between 2011 and 2014 was conducted. Simultaneous biplanar X-rays and >17 months of follow-up without tether breakage were required for inclusion. From three-dimensional reconstructions based on the biplanar images various dimensions/angles of each apical vertebra were serially quantified. Patients were divided into two groups: those with scoliosis correction/improved Cobb angle and those with no correction/continued progression. The rate of change over time in each variable of interest (Cobb angle, apical vertebral body height [convex, concave, anterior, posterior] measurements, apical vertebra wedging angles [coronal, sagittal]) was calculated for the individual patients and compared between groups utilizing nonparametric statistics.

Results: Of 13 subjects included, nine had progressive improvement of their scoliosis and four worsened or did not improve. Follow-up ranged from 17–36 months with 4–7 postoperative visits. Mean age at ASGT placement was 11.8±1.8 years. All patients were Risser 0. Mean preoperative scoliosis Cobb angle was 51°±11° (range, 35°–69°), which was reduced to 34°±8° by the first postoperative visit. Over time, the correction group demonstrated significantly less apical vertebral wedging in the coronal plane (average rate of change -0.11°/mo) compared to the no correction group (0.04°/mo, p=0.02). The correction group showed increased vertebral height over time on the

concave side of the curve (0.11 mm/mo), as compared to the no correction group (0.01 mm/mo, p=0.005).

Conclusions: ASGT in immature patients with thoracic scoliosis has the potential to asymmetrically modulate the growth of the apical vertebra. Greater concave sided growth was associated with greater degrees of overall Cobb angle correction.

Keywords: Tethering; Scoliosis

Mean 6-Year follow-up of Magnetically Controlled Growing Rod patients with Early Onset Scoliosis

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Background: The literature is limited regarding the mid- to long-term follow-up as well as those who have reached skeletal maturity for magnetically controlled growing rod (MCGR) patients. The aim of study was to analyze patients with mean 6-years of follow-up and those at skeletal maturity.

Methods: This was a prospective study of early onset scoliosis patients with minimum 4 years of follow-up. Parameters under study included coronal and sagittal Cobb angle, T1–12, T1–S1 and instrumented lengths, and the expected and achieved distraction length gains. Relationship between timing of rod exchanges with changes in rate of lengthening of the MCGRs was studied. Graduates were studied pre-, immediately post-, and 2-years post-final surgery. Any complications were noted.

Results: A total of 10 patients with mean age of 6.3 years at diagnosis and 6.1 years of follow-up were studied. Mismatch between the expected and achieved rod lengthening was observed and increased with usage. Rate of lengthening reduced after the 1st year of use but improved back to initial rates after rod exchanges. There was a reoperation rate of 40% for rod distraction failure and proximal foundation problems. Of the 10 subjects in this study, five (50%) were graduates. Four went onto a final fusion and one had rod removal without fusion. Only mild further improvements in all radiological parameters were observed pre- and post-final surgery. No curve progression was observed for the rod removal only patient. All post-final surgery parameters remained similar at 2-years post-final surgery.

Conclusions: At average 6-year follow-up and half of the study population reaching skeletal maturity, this study provides an outlook of the end of MCGR treatment. Although this is a fusionless procedure, the instrumented segments do experience stiffness limiting further correction and length gain during the final surgery whether fusion or rod removal is performed.

Keywords: MCGR; Long-term follow-up; Early onset scoliosis; Magnetically controlled growing rod; Graduates

Unplanned Return to Operation Room Following Growing Spinal Constructs in Early Onset Scoliosis: 4-Year Follow-up

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Background: Growing spinal constructs are routinely used for treatment of early onset scoliosis (EOS) and are followed by repeated planned expansion procedures. Studies have reported variable rate of complications following these surgeries—out of which many complications requires unplanned return to operation room (OR) which demands extra resources. The purpose of this study is to evaluate the incidence and risk factors associated with the same.

Methods: Medical records of 12 patients of growing spinal implants for EOS with an average follow-up of 4 years, operated by single surgeon were evaluated for unplanned surgeries. Data was analyzed to find out rate and cause of unplanned surgeries and relationship with age at index surgery, type of implant, and diagnosis.

Results: The study included seven growing rod, four vertical expandable prosthetic titanium rib (VEPTR), and one hybrid constructs, operated from 2011 to 2017 with a mean age at index surgery of 5.5 years range, 2–8 years) and average follow-up of 49.58 months (range, 14–76 months). Eight out of 12 patients had one or more unplanned surgeries till final follow-up (66.67%). Out of total 72 surgeries, 34 were unplanned (47.22%), including 26 for implant related complications (14 rod/screw breakage, 12 screw/anchor pull-out), five infections, one wound dehiscence, and two neurodeficits. Surgical management included 22 implant revisions, eight implant removal, three debride-

ment, and one wound coverage procedure. Twenty-six out of 49 surgeries (53.06%) following growing rod and eight out of 23 surgeries (34.78%) following VEPTR were unplanned (difference insignificant, p=0.15). With age at index surgery <5 years, 20 out of 35 (57.14%) surgeries were unplanned and with age >5 years, 14 out of 37 (37.84%) were unplanned (difference insignificant, p=0.10).

Conclusions: Growing spinal constructs in EOS requires frequent unplanned return to OR which should be foreseen by the surgeon and explained to the parents before surgery.

Keywords: Growing spinal constructs; Early onset scoliosis; Unplanned return; Operation room

Effect of Sitting Posture on Development of Scoliosis in Duchenne Muscular Dystrophy Cases

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Background: In Duchenne muscular dystrophy (DMD) cases scoliosis usually develops after feet off; progresses rapidly during the pubertal growth spurt needing spinal fusion. Our clinical impression is that scoliosis among non-ambulatory DMD boys in Nepal is less severe compared to those with wheel-chair life. Non-ambulatory boys in Nepal spend many hours sitting on the floor without supported seating systems. The strength and endurance of the muscles supporting the spine and specific hip have not been documented in DMD.

Methods: Twenty-two non-ambulatory DMD boys were included in the study. The 24-hour posture diary card was filled by boys and/or parents. Muscle charting was done. Hip joint contracture, pelvic tilt, and maintenance of the lumbar lordosis were evaluated photographically using photo-reflective markers. Photo-images were evaluated by a special computer program and radiographs were taken to evaluate the presence of scoliosis and its severity, and to measure lumbar lordosis.

Results: Average age of the boys was 15.1±4.0 years, and was non-ambulant for 48.6 months. The average Medical Research Council muscle strength score was 39.7% and the average EK functional severity score was 12.5. The boys used to sit cross-legged on the floor for 8.1±3.5 hr/day without side supports. Household use of wheel-chair was rare. The mean Cobb angle was 15.1° (range, 0°–70°), only 4 boys (18%) had scoliosis of >30°. Optimal accuracy in predicting scoliosis was obtained with a lumbar angle of -6° as measured by skin markers. The lumbar angle of ≤-6° and better functional ability were associated with less scoliosis. Use of cross-legged sitting postures during the day was associated with a lumbar angle ≤-6° (odds ratio, 0.061; 95% confidence interval, 0.005–0.672; p=0.022).

Conclusions: Lordotic lumbar posture could protect against the development of scoliosis in Nepalese DMD boys, possibly influenced by widespread cultural use of cross-legged sitting postures.

Keywords: Duchenne muscular dystrophy; Lumbar lordosis; Floor sitting; Scoliosis ; Lumbar lordosis; Floor sitting; scoliosis

Progression of Spinopelvic Parameters in Patients with Thoracolumbar Adult Spinal Deformity: A 2-Year Longitudinal Follow-up

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Background: Recent advancements in the understanding of sagittal alignment have improved surgical outcomes in patients with adult spinal deformity (ASD). However, sagittal parameters reported in the literature are limited to measurements performed at a specific time point. The aim of this longitudinal study was to analyse the risk factors for the progression of sagittal alignment parameters

in ASD patients.

Methods: A prospective study of patients with minimum of 2-year follow-up was conducted in a university hospital. Radiological and clinical parameters were captured and analyzed using SPSS software.

Results: One hundred and sixty-eight patients (142 females, 26 males) with mean age of 66.4 years (range, 40–92 years), menarche of 13.5 years (range, 10–19 years), and menopause of 51.1 years (range, 38–67 years) were reviewed. Average Cobb angle was 26.1° (range, 17°–70°). Seventy point two percent of patients had Nash and Moe grade 2 apical rotation. Mean sacral slope was 25.4° (range, 0°–54°), mean pelvic tilt (PT) was 24.2° (range, 3°–49°), and mean pelvic incidence was 55.6° (range, 30°–90°). Seventy-seven patients (46%) had radiological scoliosis progression of ≥5° at 2-year follow-up. Mean Cobb progression was 8.0°±3.6° (range, 5°–27°). Multivariate analysis showed that reversal of lumbar lordosis of ≥0° (odds ratio [OR], 7.0; 95% confidence interval [CI], 1.8-27; p=0.005) is a predictor of scoliosis progression. Sixteen patients (10%) had ≥5 cm sagittal vertical axis (SVA) progression, with mean progression of 66.6±19 mm. Multivariate analysis showed that more kyphotic thoracolumbar angle predicts for SVA worsening (OR, 1.04; 95% CI, 0.10–1.07; p=0.005). Fifty-six patients (33%) had ≥5° progression in PT, with mean progression of 9.25°±7.80. Univariate analysis showed that increasing thoracolumbar angle, SVA, and T1-pelvic angle predicted for PT progression. Ninety-one percent of patients improved more than the established minimum clinically important difference (MCID) in Visual Analogue Scale. 83% of patients improved more than the MCID in Oswestry Disability Index. The spearman correlation between radiological progression and clinical outcome was poor (r=0.23).

Conclusions: The reversal of lumbar lordosis is a predictor for Cobb progression, and a kyphotic thoracolumbar angle with poor global alignment and increased T1-pelvic angle predicts sagittal parameters deterioration. Despite radiological deterioration, >80% of patients improved with conservative treatment with good clinical outcome scores.

Keywords: Sagittal parameters; Spinopelvic parameters; Adult spinal deformity; Cobb angle progression

The Cranial Sagittal Vertical Axis Is a Better Radiographic Measure to Predict Clinical Outcomes in Adult Spinal Deformity Surgery than the C7 Sagittal Vertical Axis

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Background: Our study aimed to confirm the correlation between the cranial sagittal vertical axis (CrSVA) and patient-reported outcomes and to compare clinical correlation between CrSVA and C7 SVA in adult spinal deformity (ASD) patients.

Methods: One hundred and eight consecutive ASD patients were evaluated using the EOS two-dimensional/three-dimensional radio-imaging device. A vertical plumb line from the cranial center was utilized to measure the distance to the posterior corner of S1 (CrSVA-S), and to the centers of the hip (CrSVA-H), the knee (CrSVA-K), and ankle (CrSVA-A), as well as measuring the standard C7 SVA. We analyzed the correlation between each CrSVA parameter with the Oswestry Disability Index ODI and Scoliosis Research Society form (SRS-22r).

Results: All four CrSVA measures demonstrated strong correlation with the ODI and SRS-22r total score and the pain, self-image, and function subscores. Of note, CrSVA-A (global SVA) also strongly correlated with the SRS satisfaction subscore. Univariate linear regression showed similar results. The strongest predictor of outcomes was CrSVA, not C7 SVA; (CrSVA-H for ODI, SRS total score, and the pain, self-image, and function subscores; and global SVA for satisfaction and mental health subscores).

Conclusions: The clinical correlation effect of outcome scores to the CrSVA measures is validated. Global SVA has an especiallystrong correlation with ODI and all the SRS subscores. Our study confirms that CrSVA is a stronger predictor of preoperative clinical outcomes than the C7 SVA in adult deformity patients.

Keywords: Adult spinal deformity; Health related quality of life; C7 sagittal vertical axis; Cranial sagittal vertical axis

Preoperative Simulation of Pedicle Subtraction Osteotomy for Treating Sagittal Deformity of the Spine

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Background: Pedicle subtraction osteotomy (PSO) is a powerful technique to correct sagittal malalignment of the spine. Inadequate correction during PSO may lead to poor functional outcome. Preoperative simulation using computer software, such as Surgimap, could help the surgical planning in order to achieve better results of correction.

Methods: Two protocols of preoperative simulation were compared for their prediction accuracy of sagittal parameters including pelvic incidence minus lumbar lordosis (PI-LL), pelvic tilt (PT), and sagittal vertical axis (SVA) in 24 patients. PT method targeted 20° of PT postoperatively. Fixed wedge angle (FWA) method aimed to simulate a 30° wedge correction at the level of PSO. The location of PSO was decided by the results of simulation. The differences between these two methods were evaluated by Student *t*-test.

Results: PT method could predict postoperative SVA, PI-LL, and PT more accurately than FWA method although statistical significance was shown only in the SVA parameter. The achievement rate was around 80% in three parameters by PT method. Larger variation of achievement rates was noticed in FWA method. The difference of osteotomy angle (proposed osteotomy angle according to simulation minus actual osteotomy angle) was significantly smaller in PT method than in FWA method.

Conclusions: PT method could provide more reliable simulation of PSO than FWA method, even though computerized simulation software did not take possible reciprocal changes in the unfused segments into considerations. PT method of simulation could provide suggestions of PSO location and angle for preoperative planning of PSO. Since sagittal parameters are highly correlated to clinical functions, better outcomes could be expected if accurate correction is achieved.

Keywords: Spine deformity; Computerized simulation protocol

Do All Adult Spinal Deformity Patients with Probable Pseudarthrosis Need Revision Surgery?: Minimum 5-Year Follow-up Study

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Background: Pseudarthrosis after pedicle subtraction osteotomy (PSO) is a frequent indication for revision surgery which also leads to pain and disability. However, minimal data exits regarding nonoperative management as a treatment option for probable pseudarthrosis after PSO. We hypothesize that not all patients with pseudarthrosis after PSO need revision surgery. Therefore, the purpose of this study was to report radiographic and clinical outcomes at a minimum of 5 years after detection for nonoperative management and to analyze the characteristics of probable pseudarthrosis after PSO.

Methods: Nineteen consecutive patients with implant breakage indicating probable pseudarthrosis after PSO surgery without severe pain and disability were treated with nonoperative management. Radiographic and clinical outcome analysis was performed.

Results: SVA, proximal junctional angle, and thoracic kyphosis achieved by a PSO were maintained after detection of pseudarthrosis through ultimate follow-up. Lumbar lordosis (LL) and PSO angle decreased at ultimate follow-up. There was no significant change in Oswestry Disability Index (ODI) scores and Scoliosis Research Society (SRS) total score, or subscales of pain, self-image, function, satisfaction, and mental health between detection of pseudarthrosis and ultimate follow-up. Patients with SVA greater than 11 cm presented significantly worse ODI and SRS total score, as well as the pain, self-image, and function subscales. The common characteristics of probable pseudarthrosis were unilateral rod breakage (n=13) at any site and bilateral rod breakage (n=3) at the non-PSO site (lumbosacral junction) in which anterior spinal fusion at L5–S1 was performed.

Conclusions: Nonoperative management of probable pseudarthrosis after PSO offers acceptable radiographic and clinical outcomes even at 5 years after detection of the pseudarthrosis. However, the outcome scores decreased as

the SVA increased. The patients with unilateral rod breakage at any site or bilateral rod breakage at non-PSO site may lead to successful results by nonoperative management.

Keywords: Pedicle subtraction osteotomy; Pseudarthrosis; Conservative management; Minimum 5-year follow-up

Risk Factors for Rod Fracture after Posterior Corrective Surgery in Adult Spinal Deformity: Multivariable Logistic Regression Analysis

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Background: Rod fracture (RF) is one of the most common complications in adult spinal deformity (ASD) surgery. The purpose of the current study was to determine what are the risk factors for RF after the correction surgery for the patients with ASD.

Methods: A retrospective review was conducted on consecutive surgical cases with ASD from 2011 to 2015. Thirty patients (28 females, 2 males; an average age of 64.3 years) met inclusion criteria, based on Scoliosis Research Society-Schwab ASD classification, with a minimum 1-year follow-up. The sagittal vertical axis, lumbar lordosis (LL), pelvic tilt, pelvic incidence (PI), and PI-LL were measured on the standing X-P (anteroposterior and lateral view) before and after the surgery. The number of instrumented segments, correction rate, presence of Extreme lateral interbody fusion and any osteotomies, and bone union were evaluated. The patients were divided into two groups: RF and non-RF. Stepwise procedure in multivariable logistic regression analysis was performed to determine which factors were predictive of the occurrence of the RF (p<0.05). Odds ratios (OR) were also calculated.

Results: We recognized 12 RF cases during follow-up. Risk factors for RF were the numbers of instrumented segments (OR, 1.29) and preoperative PI-LL (OR, 1.04). Receiver operating characteristic curves were made for the number of instrumented segments, preoperative PI-LL, and LL. The optimal cut-off value was estimated to be 10 segments. Preoperative PI-LL was associated with the difference in LL between pre- and postoperative. The cut-off value of the preoperative PI-LL and the difference in LL between pre- and postoperative was 34° and 28°, respectively.

Conclusions: The current study demonstrated that the higher correction of the deformity was obtained, the more frequent RF occurred. The surgical and postoperative rehabilitation strategy should be taken into account to reduce the RF in the surgical treatment for the patients with ASD.

Keywords: Adult spinal deformity; Surgery; Rod fracture

Extensive Corrective Fixation Surgeries for Adult Spinal Deformity Improves Postoperative Gait Endurance: A 6-Minute Gait Analysis

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Background: Patients with adult spinal deformity (ASD) usually present with gait disturbances accompanied by global sagittal malalignment. The purpose of this study is to determine whether corrective fixation surgery improves gait endurance in patients with ASD postoperatively.

Methods: Of the 50 patients with ASD who underwent corrective surgery at our hospital between September 2014 and December 2015, 14 (all women; mean age, 70 years [range, 61–82 years]) were included in this study. Gait analysis data were acquired preoperatively and for a minimum of one year postoperatively. A 6-minute gait analysis was conducted using a video camerar. Walking posture and speed were measured during the first and last minutes. Sagittal balance was calculated as the angle between the plumb line on the side and the line connecting the greater trochanter and pinna while walking (gait-trunk tilt angle).

Results: The preoperative radiographic parameters lumbar lordosis (LL) 9, pelvic tilt (PT) 37, pelvic incidence (PI)-LL 43, and sagittal vertical axis (SVA) 107 mm improved to LL 49, PT 24, PI-LL 3, and SVA 34 mm, respectively, postoperatively (all p<0.01). Preoperatively, the gait-trunk tilt angle significantly shifted forward from 8.3° to 12.0° during the first and last minutes in the 6-minute gait

analysis (p=0.003). Walking speed significantly decreased from 85.4 to 77.9 m/sec from the first to the last minute (p=0.006). However, postoperatively, the gait-trunk tilt angle was maintained at 3.2° and 3.5° (p=0.496) during the first and last minutes in the 6-minute gait analysis, and walking speed was also maintained at 85.1 m/sec and 81.8 m/sec during the first and last minutes (p=0.199).

Conclusions: Our results suggest improved global sagittal alignment after corrective fusion from the thoracic spine to the pelvis in ASD patients, which contributed to improvement in the middle-distance gait endurance for a minimum of 1 year postoperatively.

Keywords: Adult spinal deformity; Gait analysis

Spinal Correction Surgery Enables Long-term Relief of Gastroesophageal Reflux Disease Symptoms in Adult Spinal Deformity

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Background: Gastroesophageal reflux disease (GERD) is reported to be one of the complications for adult spinal deformity. The impact of corrective surgery on short-term GERD improvement was reported. However, the long-term effect of the spinal correction on GERD symptom is not yet to be revealed.

Methods: We investigated 230 adult spinal deformity patients over the age of 18 years, who underwent at least 5 vertebrae levels of spinal correction at least 2-year follow-up. We used the questionnaire named as frequency scale for the symptoms of GERD (Frequency Scale for the Symptoms [FSSG]) with GERD 62% sensitivity and 59% specificity for GERD diagnosis at the cut-off value 8 points. Preoperatively 90 patients (39.1%) had over 8 points examined by FSSG. Using standing whole spine X-ray parameters. Each X-ray parameters showed significant improvement after surgery. Analysis of variance, chi-square test, Bonferroni, and t-*t*est were used for statistical analysis.

Results: Mean follow-up period was 4.1 years. Among the 90 patients with the preoperative FSSG value of over 8, 78 (86.7%) showed improvement of the score at 6 months postoperatively. The preoperative values significantly improved from 16.4 to 4.8 immediately after operation and was maintained significant lower than preoperatively at the 1st, 2nd, and 5th postoperative year with the scores of 9.7±8.1, 9.6±8.1, and 8.7±7.8, respectively (p<0.001). In 67 cases (86%) FSSG was maintained better than just after operation and in 11 cases (14%) FSSG got worse at 2 years postoperative. X-ray analysis showed no significant different between FSSG maintained and worsened group.

Conclusions: In adult spinal deformity patients, GERD symptoms are immediately improved after operation and the improvement is maintained throughout the 5th postoperative year. Thus patients with GERD symptoms due to adult spinal deformity have good operative indication for deformity correction.

Keywords: Adult spinal deformity; Surgery; Gastroesophageal reflux disease

Does Corrective Fusion Surgery Improve Cardiac Dysfunction Associated with Adult Spinal Deformity?: A Prospective Study

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Background: There are no reports clarifying whether cardiac dysfunction occurs in adult spinal deformity (ASD) cases and whether cardiac function is improved after corrective fusion surgery. The purpose of this study was to investigate whether cardiac dysfunction occurs in ASD cases and whether it can be improved following corrective fusion surgery.

Methods: Patients who underwent corrective fusion surgery from January 2016 to July 2017 were recruited and divided into two groups according to Δ left ventricular outflow tract (ΔLVOT) velocity as follows: group A, LVOT velocity decreased more than cm/sec postoperatively and group B, the others. Echocardiography and whole-spine radiography were performed at the first visit and 2 weeks postoperatively. All of the echocardiography imaging tests were performed by a cardiologist at our hospital. Ejection

fraction (EF) and LVOT velocity were used as measures of cardiovascular function. Sagittal vertical axis (SVA) was measured.

Results: Overall, 43/47 patients were recruited, including 12 men and 31 women, with an average age of 65 years. There were four patients (9%) in group A and 41 (91%) in group B. The respective preoperative and postoperative average SVA, EF, and LVOT velocity were 48 mm, 61%, and 200 cm/sec in group A and 98 mm, 64%, and 150 cm/sec in group B and 30 mm, 59%, and 113 cm/sec in group A and 38 mm, 65%, and 163 cm/sec in group B. LVOT velocity in group A was significantly higher preoperatively and lower postoperatively than in group B. Two cases of group A were accompanied by round back deformity, and the other two had left oblique take off deformity. One of the round back deformity cases was accompanied by LVOT stenosis (velocity=303 cm/sec) preoperatively, which disappeared postoperatively (velocity=112 cm/sec).

Conclusions: Corrective fusion surgery improve cardiac dysfunction associated with ASD.

Keywords: Adult spinal deformity; Cardiac function

Pulmonary Dysfunction in Cases of Severe Adult Spinal Deformity

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Background: There are few comparative reports of adult spinal deformity (ASD).

Methods: Severe ASD patients who underwent corrective fusion surgery and whose % vital capacity (VC) was less than 80% were included. Pulmonary function tests, thoracic computed tomography, and whole spine radiography were performed at the first visit and during the final follow-up. VC, FEV1.0%, and thoracic capacity were measured to evaluate pulmonary function. Cobb angle and kyphosis angle were measured.

Results: Case 1: Her kyphosis angle was 170° (42-year-old woman). Posterior vertebral column resection was performed to correct her spinal deformity due to spondyloepiphyseal dysplasia. At her first visit, VC, FEV1.0%, and thoracic volume were 370 mL, 87%, and 729 mL, respectively. She underwent respiratory rehabilitation for 2.5 years preoperatively. Her VC, FEV1.0%, and thoracic volume improved to 640 mL, 91%, and 942 mL, respectively, immediately after surgery and to 690 mL, 82%, and 1305 mL, respectively, at 2 years after surgery. Case 2: Her Cobb angle was 69° (55-year-old woman), and her kyphosis angle was 89°. Her VC, FEV1.0%, and thoracic volume were 1,170 mL, 87%, and 1,637 mL, respectively. Posterior fusion surgery was performed to correct her syndromic spinal deformity due to acromegaly. Her scoliosis angle, kyphosis angle, VC, FEV1.0%, and thoracic volume improved to 21°, 63°, 900 mL, 98%, and 2,044 mL, respectively, at 4 years after operation. Case 3: Her Cobb angle was 87° (59-year-old woman), and her kyphosis angle was 86°. Her VC, FEV1.0%, and thoracic volume were 1,600 mL, 94%, and 3,122 mL, respectively. Posterior fusion surgery was performed to correct her adult idiopathic scoliosis. Her Cobb angle, Kyphosis angle, VC, FEV1.0%, and thoracic volume improved to 53°, 62°, 1,640 mL, 99%, and 3,113 mL, respectively, at 1 year after operation.

Conclusions: Appropriate respiratory rehabilitation and corrective fusion surgery improve respiratory function in severe ASD patients.

Keywords: Adult spinal deformity; Pulmonary function

Prevalence and Predictors of Pressure Injuries from Spine Surgery in the Prone Position: Do Body Morphological Changes During Deformity Correction Increase the Risks?

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Background: Spine surgery performed in the prone position is at risk of developing pressure injuries which can lead to morbidity, prolonged hospitalization and patient dissatisfaction. Particularly in deformity correction surgery where long surgical duration and intraoperative changes in body morphology can potentially increase this risk, we hope to study the prevalence and predictive factors for developing this complication. We also aim to correlate morphological changes that occurs during spinal deformity correction.

Methods: Cases of pressure injuries following spine surgery in the prone position were reviewed to ascertain prevalence and determine risk factors. Data including patient factors (age, gender, height, weight, body mass index, American Society of Anesthesiologists grade, comorbidities, neurological status, spine diagnosis) and surgical factors (approach, type of surgery, number of screws, levels of surgery, duration of surgery) was collected. Multivariate analysis was performed to identify independent risk factors. A subsequent prospective analysis of all spinal deformity patients undergoing surgical correction was performed via intraoperative measurements of body morphological changes and shifts in truncal positions was performed to determine significance and causes of pressure injuries

Results: The prevalence of pressure injuries is 23.0%. Previous skin problem (p=0.034), myelopathy (p=0.013), spinal deformity (p=0.010), operative duration >300 minutes, and surgery >4 levels are significant, independent predictors of pressure injuries. Spinal deformity patients are at increased risk following corrective surgery presumably due to a changes in body morphological and truncal shifts in position (odds ratio [OR], 3.31; p=0.010). Furthermore, they are also likely to require extensive surgery involving more than 4 levels (OR 9.10, p=0.006) and involve long operative duration > 300 minutes (OR, 8.12; p=0.005).

Conclusions: Pressure injuries are prevalent in patients undergoing spine surgery in the prone position. Multiple risk factors exist and should be addressed to prevent this complication. Such patients undergoing corrective surgery are particularly at risk of developing pressure injuries.

Keywords: Deformity correction; Pressure injuries

Two Different Type of Stooping Posture after Sacropelvic Fixation for Degenerative Sagittal Imbalance

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Background: Rigid lumbosacral fusion with iliac screw fixation has been recommended to reduce stooping posture. However, few studies have addressed stooping posture without proximal junctional kyphosis (PJK) and PJK, which are different types of sagittal malalignment after long fusion. The purpose of this study is to investigate different risk factor between stooping posture without PJK and with PJK after long instrumented fusion with sacropelvic fixation in degenerative sagittal imbalance (DSI).

Methods: Eighty patients who had undergone surgical correction for DSI were included. Univariate and multivariate analysis for clinical and radiological factors including paravertebral muscles were conducted for respective risk factors. In subgroup analysis, the comparison including clinical outcomes was evaluated between two different stooping postures.

Results: Forty patients (50%) developed stooping posture. Out of these, 22 patients developed PJK (27.5%) and stooping posture without PJK in 18 patients (22.5%). The independent risk factors in global stooping posture were more fusion levels (hazard ratio [HR], 3.109), less change in sacral slope (SS; HR, 1.221), and less change in thoracic kyphosis (TK; HR, 1.264) while great postoperative pelvic tilt (PT; HR, 1.105), and less change in SS (HR, 1.084) in PJK. Global stooping group was found in patients who had under-correction of sagittal parameters such as changes in lumbar lordosis (LL), postoperative PI-LL, postoperative sagittal vertical axis (SVA), and optimal correction as well as paravertebral muscle weakness directly compared with PJK group. Regarding clinical outcomes, the back Visual Analog Scale at last follow-up was significantly higher in PJK group, and re-operations were also different.

Conclusions: Under-correction of sagittal parameters was a risk factor of both stooping posture without and with PJK. Global stooping posture was significantly associated with lesser correction of sagittal alignment combined with the weakness of paravertebral muscles. Clinical outcomes were also significantly different between two groups.

Keywords: Degenerative sagittal imbalance; Stooping posture; Proximal junctional kyphosis; Risk factor; Paravertebral muscles

The Impact of the Release of Anterior Longitudinal Ligament on the Restoration of Lumbar Lordosis in Adult Spinal Deformity Surgery

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Background: To compare the radiographic outcomes in adult spinal deformity correction whether anterior longitudinal ligament (ALL) release is or not.
Methods: From Janurary 2008 to December 2014, 41 adult spinal deformity patients (men, 15, women, 26; mean age, 70.26 years) who were diagnosed with degenerative lumbar disease (lumbar degenerative kyphosis, 31 patients; degenerative lumbar scoliosis, 10 patients) were enrolled. All patients had 4-level lumbar interbody fusion for L2-S1 and were followed-up for at least 2 years. The patients were divided into two groups whether the ALL release was performed. The ALL release group (n=21) performed oblique lateral interbody fusion. The ALL preserve group (n=20) performed direct lateral interbody fusion. Radiographic studies were taken preoperatively, at 2 months postoperatively, and at final follow-up. Lumbar lordosis and segmental lordosis angles were evaluated on the radiographs.
Results: Lumbar lordosis angle were 13.91° and 21.81° preoperatively (ALL release/ALL preserve) and increased to 56.06° and 53.65° at 2 months postoperatively, and decreased to 49.51° and 48.80° at the final follow-up. The ALL release group presented more restoration of lumbar lordosis than the ALL preserve group (p=0.041). However, there was no significant difference between two groups in the loss of total correction (p=0.27). The correction angle of segmental lordosis was 9.45°/5.85°(ALL release/ALL preserve) in L2–3, 12.29°/5.28° in L3–4, 16.20°/9.49° in L4–5 and 11.12°/11.12° in L5–S1. The correction angle of segmental lordosis at L3–4 and L4–5 was significantly higher in the ALL release group (p=0.009, p=0.009). However, there was no statistical difference between two groups in the loss of segmental correction (p=0.48).
Conclusions: The ALL release group presented better restoration of lumbar lordosis and segmental lordosis compared to the ALL preserve group.

Keywords: Anterior longitudinal ligament release; Lumbar lordosis; Segmental lordosis; Adult spinal deformity

Application of Posterior Vertebral Column Resection to Reconstruction of Vertebral Body Defect in the Lumbar Spine

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Background: Defect of vertebral body (VB) caused by fractures/nonunions, infections, or other conditions can lead to instability, deformity, and imbalance of the spine. Reconstruction of the VB defect is crucial to restore stability and alignment. Anterior strut graft is always employed for reconstruction of VB defect. This study presents the application of posterior vertebral column resection (PVCR) on reconstruction of VB defect in lumbar spine as well as its technical challenges and clinical outcomes.
Methods: From October 2010 to November 2017, 17 patients underwent PVCR for reconstruction of lumbar VB defect. Procedures included PVCR and insertion of a strut graft with preservation of lumbar spinal roots. At the beginning, spinal instrumentation was typically in a 2-above-2-below construct, except two cases with L4 lesions were done with 2-above-1 (screw-hook)-below construct. Evaluations included clinical outcomes and radiographic findings.
Results: Diagnosis included fracture nonunion (six in L1, three in L2, two in L3, two in L4), pincer fracture with pre-existing spinal stenosis (one in L4), infection of tuberculosis (one in L5), infection of non-tuberculosis mycobacterium (one in L5), and post-infectious destruction (one in L1). All patients had improvements at back pain and neurologic deficits after surgery. In 13 patients with preoperative kyphosis, 32° (range, 22°–48°) correction was achieved and maintained rate at 1 year was 88.1% (range, 29%–116%). Subsidence of strut grafts into adjacent endplates was noted in most of the patients but it was not negatively affected the clinical outcomes. Revision surgery was done to one patient due to early loosening of implants.
Conclusions: This study presented the application of PVCR on reconstruction of lumbar VB defect. Because lumbar spinal roots are functionally important and should

be preserved, special technical challenges exists when PVCR is performed in the lumbar spine. PVCR could be considered as an alternative of front-and-back surgery for reconstruction of VB defect.

Keywords: Posterior vertebral column resection; Vertebral body; Defect; Lumbar spine

Activity of Daily Living after Long Level Fusion in Adult Spinal Deformity: Compared with over 60-Year-Old Degenerative Spine Patients without Adult Spinal Deformity

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Background: There is still debate how surgeons could decide treatment methods for old aged adult spinal deformity, operatively or not. There were lack of information how long level fusion impact daily activities, especially sedentary Asian lifestyle. In Asia, impaired activity of daily living (ADL) is much more important issue because of different lifestyle.

Methods: Patients were categorized three groups; group 1 was over 60-year-old aged degenerative spine disease without deformity, group 2 was ASD patients who did not have surgery, and group 3 was ASD patients who had surgery for deformity correction. Patients were evaluated using answer Oswestry Low Back Pain Disability Questionnaire and Assessment ADL for sedentary Asian culture (ADL-SA) questionnaire.

Results: Group 1 showed nearly full functions in every activity (ADL-SA=41.4). ADL-SA scores of group 2 was similar to group 1 (p=0.452). However, get up from bottom (p<0.001), and pick up object (p<0.001) were impaired. After long level fusion, ADL was impaired but gradually improved by time. From postoperative 1 year, total ADL score recovered to acceptable range. However, among ADL, activities associated sedentary lifestyle (get up from bottom, wipe floor, pick up object, and sit cross-legged) were still impaired after 2 years postoperatively.

Conclusions: ADL was impaired after long level fusion however it would improve as time goes by. However, among ADL, activities associated sedentary lifestyle were still impaired. Hence give enough information to patients about limited activities before decided operation.

Keywords: Activity of daily living; Sedentary lifestyle; Long level fusion; Adult spinal deformity

Perioperative Surgical Complications Related to Oblique Lumbar Interbody Fusion in Adult Spinal Deformity Correction

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Background: Oblique lumbar interbody fusion (OLIF) approach is considered the solution to the troubles of anterior and lateral lumbar interbody fusion techniques. However, current studies are limited to small cohort sizes, short-term follow-up, and short level correction for degenerative lumbar diseases but adult spinal deformity should be correct much more lumbar lordosis or long level fusion.

Methods: During 1 week after OLIF surgery, acute perioperative complication was investigated. A complication classification based on the relation to surgical procedure and effect duration was used. Moreover, the collected data were classified into radiological states and clinical symptoms. Radiologic results including the cage location and sagittal alignment were also assessed with plain radiography.

Results: In 14 patients, 20 segments experienced change of cage status; in five patients, six segments had sinking down cages; and in 12 patients, 14 segments cage were displaced. Among them, the one segment of one patient migrated posteriorly and other cages were rotated. In clinical symptoms, postoperative ileus (16.2%) in six patients, severe postoperative pain (8.1%) in three patients, transient hip flexor weakness (10.8%) in four patients, and transient thigh pain/numbness (5.4%) in two patients were reported. No patient suffered permanent neurologic injury.

Conclusions: There is more to complications than we expect. The end plate injuries such as cage displacement, sinking down of cage were occurred frequently and its

incidence was 37.8%. Because adult spinal deformity patients were usually old age, have poor bone quality, and wedging disc space, got the end plate damage during preparation easily. Furthermore over correction bigger than lumbar lordosis at full extension view, risk of end plate injuries was increased. So, using proper cage size considering height of disc space at full extension view is key role to avoid acute end plate injury. Immoderate cage insertion to correct too much lumbar lordosis could make unexpected perioperative complication.

Keywords: Oblique lumbar interbody fusion; Adult spinal deformity; Complication

Post-tetanic Transcranial Motor Evoked Potentials Augments the Amplitude of Compound Muscle Action Potentials Recorded from Innervated and Non-Innervated Muscles

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Background: Transcranial electrical stimulation used to produce motor evoked potentials (TES-MEP) and subsequent compound muscle action potential (CMAP) recording is widely used to monitor motor function during surgery when there is risk of damaging the spinal cord. Nonetheless, some muscles do not produce CMAP amplitudes sufficient for intraoperative monitoring. The objective of this study is to investigate the utility of tetanic stimulation at single and multiple peripheral nerve sites for augmenting CMAP amplitudes recorded from innervated and non-innervated muscles.

Methods: Twenty-four patients with cervical myelopathy who underwent decompression surgery at our department between November 2005 and March 2007 were included. CMAP amplitude was used as a physiologic measure. We used two patterns of tetanic peripheral nerve stimulation for each patient. The first pattern consisted of tetanic stimulation of the left tibial nerve only (pattern 1), and the second pattern consisted of tetanic stimulation of the bilateral median nerves and left tibial nerve (pattern 2).

Results: CMAP amplitudes from all muscles were augmented by both tetanic stimulation patterns compared to conventional TES-MEP recording; however, pattern 2 elicited the greatest augmentation of CMAP amplitudes, especially for CMAPs recorded from the bilateral abductor pollicis brevis muscles.

Conclusions: Although tetanic stimulation of a single peripheral nerve increased CMAP amplitudes recorded from both innervated and non-innervated muscles, CMAP amplitudes were best augmented when the corresponding nerve received tetanic stimulation. Additionally, tetanic stimulation of multiple nerves rather than a single nerve appears to provide better augmentation.

Keywords: Compound muscle action potential; Intraoperative monitoring; Motor evoked potentials; Spinal surgery; Tetanic stimulation

The Use of Simvastatin Carrier System in Rabbit Posterolateral Spinal Fusion

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Background: The using of bone graft is the most important process and in lumbar spine fusion. However, the supply of autograft or allograft bone is limited in some situations, and the artificial bone grafts have to be used. In order to improve the artificial bone grafts fusion rate, many augmentation methods were studied previously. In our study, we used the rabbit spinal fusion model to investigate the effects of SIM/PLGA/HAp delivery system on spinal fusion with artificial bone graft.

Methods: Fifteen New Zealand white rabbits were randomized into five groups: blind group (BL, n=3), autograft (AU, n=3), PLGA only (PL, n=3), artificial graft only (AR, n=3), and artificial graft with PLGA (AP, n=3), and were underwent bilateral inter transverse process spinal fusion at L5–L6. After operation, all rabbits underwent radiographic examination to evaluate the fusion mass every 4 weeks, and until the end of 3rd month, when the rabbits were euthanized. After euthanized, the new bone formation were analyzed by three-dimensional reconstructive computed tomography (CT), then were undergoing histological evaluation by H&E stain and quantified by the

software of Image-Pro Plus.

Results: Under radiographic examination, well solid fusion was noted only in the group of autografts, and partial fusion was noted in AR and AP groups. In CT images, the new bone formation was analyzed by the software of Skyscan 1076, but the results showed no significant differences. The quantification of H&E stain was analyzed by one-way analysis of variance and showed that there are significant differences between the AR and AP group (p=0.0082).

Conclusions: In our study, there were significant differences between AR and AP group. It seems that use Simvastatin in the delivery system could enhance the bone fusion with artificial graft, and there is worthy of further study. In other words, this carrier system has potential in clinical application to facilitate spinal fusion.

Keywords: SIM/PLGA/Hap; Spine fusion

Plastrum Testudinis Treating Glucocorticoid-induce Osteoporosis by Down-Regulating TNFR2

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Background: To explore the effect of Plastrum Testudinis treating glucocorticoid-induce osteoporosis in Wnt/β-catenin pathway by down-regulating tumor necrosis factor receptor 2 (TNFR2).

Methods: Animal experiment: Thirty Sprague-Dawley rats were randomly divided into blank group, model group, and Plastrum Testudinis group. Model group and Plastrum Testudinis group were subcutaneously injected with dexamethasone, and were successfully gaveged with 0.9% sodium chloride solution and Plastrum Testudinis, respectively. Lumbar spine were taken after 12 weeks. mRNA expression of TNFR2, β-cantenin, and GSK3β in lumbar vertebra were detected by quantitative polymerase chain reaction. Protein expressions of TNFR2, p-β-cantenin, and p-GSK3β were detected by Western blot. Cell expeiment: Cell Counting Kit-8 was used to detect the proliferation of bone mesenchymal stem cells (BMSCs) at different concentrations for 1, 3, 5, 7, and 14 days. Alkaline phosphatase (ALP) and alizarin red staining were used to detect the effect of plastrum testudinis extracts (PTE) on osteogenic differentiation of BMSCs. The expression of TNFR2, β-cantenin, GSK3βm RNA expression, TNFR2, p-β-cantenin, and p-GSK3β protein expression were detected by Western blot.

Results: Compared with blank group, the level of β-catenin in glucocorticoid-induced osteoporosis (GIOP) group was significantly decreased (p<0.01), the expression of TNFR2 and GSK3β in animal experiment were significantly increased. The expression of β-catenin in PT group was significantly higher than that in GIOP group (p<0.05). The expression of TNFR2 and GSK3βin PT group were significantly lower than that in GIOP group (p<0.05). Compared with the blank group, the expression of TNFR2 and p-β-catenin in GIOP group were significantly increased (p<0.01) and the expression of p-GSK3β was significantly decreased (p<0.001).Compared with GIOP group, TNFR2 and p-β-catenin in PT group were significantly decreased (p<0.05) and p-GSK3β significantly increased (p<0.05). In cell experiments, after 14 days of osteogenic induction, ALP positive staining was significantly stronger after PTE intervention, and the number of positive cells increased significantly. Alizarin red staining showed that the number of positive staining cells in PTE group was significantly more than control group. The expressions of TNFR2 and p-β-catenin were significantly down-regulated and the expression of p-GSK3β up-regulated in PTE, OI, and PTE+OI group.

Conclusions: Plastrum Testudinis can promote the proliferation, osteogenic differentiation, and mineralization of BMSCs. It can effectively resist GIOP. The Plastrum Testudinis may resist the GIOP through down-regulating the Wnt/β-catenin pathway by inhibiting TNFR2.

Keywords: Glucocorticoid-induced osteoporosis; Plastrum Testudinis; Tumor necrosis factor receptor 2; Wnt/β-cantenin; GSK3β

Extracts from Plastrum Testudinis Reverse Glucocorticoid-Induced Spinal Osteoporosis of Rats via Targeting Osteoblastic and Osteoclastic Markers

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Background: Extracts from plastrum testudinis (PTE), an important traditional Chinese medicine, have been demonstrated promotion of osteoblastic function *in vitro*.
Methods: This study aims to investigate the protective effect of PTE on glucocorticoid-induced osteoporosis (GIOP) *in vivo* and analyze therapeutic targets of PTE on GIOP. Sprague-Dawley rats were randomly assigned to two experiments: preventive and therapeutic experiments, in which rats respectively received oral PTE at the same time of glucocorticoid injection or after glucocorticoid injection inducing osteoporosis. Bone mineral density, microarchitecture, biomechanics, bone metabolism markers, and histomorphology were evaluated. mRNA and protein expression of osteoprotegerin (OPG), cathepsin K (CTSK), runt-related transcription factor 2 (Runx2), and metalloproteinase-9 were examined. Results showed bone quality and bone quantity were significantly elevated by PTE.
Results: Histomorphometry showed thicker and denser bone trabeculars and more osteoblasts and less osteoclasts in group of PTE intervention. The mRNA expression of OPG was significantly up-regulated whereas expression of CTSK was significantly down-regulated in different groups of PTE intervention. Stronger immunostaining for Runx2, and weaker immunostaining for CTSK were observed in groups of PTE intervention.
Conclusions: This demonstrated that PTE may reverse GIOP in prevention and management via targeting OPG, Runx2 and CTSK in mRNA and protein levels.
Keywords: Glucocorticoid-induced osteoporosis; Extracts from plastrum testudinis; Prevention; Management

Mechanism of Carapax et Plastrum Testudinis Improving Bone Mass, Microarchitecture, Biomechanics, and Bone Metabolism

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Background: This study aims to study the improving effect of kidney-invigorating Chinese herbal Carapax et Plastrum Testudinis on bome mass, microarchitecture, biomechanics, and bone metabolism and explore the associated molecular mechanism.
Methods: Forty 4-month Sprague-Dawley rats were randomly divided into four groups: control group, model group, alendronate group, and Carapax et Plastrum Testudinis group. Model group, alendronate group, and Carapax et Plastrum Testudinis group received injection of dexamethasone, and then treated with normal saline, alendronate, and Carapax et Plastrum Testudinis by gavage for each group. Lumbar and serum were collected for analysis after 3 months. Bone mass of lumbar was detected by dual-energy X-ray absorptiometry, microarchitecture of lumbar was detected by micro-computed tomography, biomechanics of lumbar was detected by compressive test, morphological change of lumbar was observed by HE method, the expression of PINP (propeptide N-terminal of type 1 procollagen) and β-CTX (β C-terminal cross-linked telopeptide of type 1 collagen) were detected by ELISA, and mRNA expression of runt-related transcription factor 2, SP-7, cathepsin K (CTSK), and AP-1 were detected by polymerase chain reaction.
Results: The bone mineral density, bone mineral content, AREA, trabecular number, trabecular thickness, and compressive strength in control, alendronate, and Carapax et Plastrum Testudinis groups were higher than model group ($p<0.05$, $p<0.01$), while trabecular space, PINP, and β-CTX were lower than model group ($p<0.05$, $p<0.01$).
Conclusions: Carapax et Plastrum Testudinis might reverse glucocorticoid-induced osteoporosis by reducing bone turnover markers; and CTSK might be one of the targets of Carapax et Plastrum Testudinis improving bone mass, microarchitecture, bone strength, histological structure, and bone turnover in molecular level.

Keywords: Glucocorticoid-induced osteoporosis; Carapax et Plastrum Testudinis; Micro-CT; Bone biomechanics; Molecular mechanism

Promotion Effect of Extracts from Plastrum Testudinis on Alendronate against Glucocorticoid-Induced Osteoporosis in Rat Spine

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Background: Alendronate (ALN) is a key therapeutic used to treat glucocorticoid-induced osteoporosis (GIOP), but may induce severe side effects. We showed earlier that plastrum testudinis extracts (PTE) prevented and treated GIOP *in vivo*. However, clinically, PTE is seldom used alone.

Methods: We reveal the synergistic effect of ALN and PTE can treat GIOP of the rat spine and define the mechanism. Sprague-Dawley rats were randomly assigned to four groups: a vehicle group, a GIOP group, an ALN group, and an ALN+PTE group. Each group was further divided into two experimental phases, including dexamethasone (DXM) intervention and withdrawal. Bone mass, microarchitecture, biomechanics, bone-turnover markers, and histomorphology were evaluated. The mRNA and protein expression levels of cathepsin K (CTSK) and runt-related transcription factor 2 (Runx2) were detemined.

Results: ALN+PTE improved bone quantity and quality, bone strength, bone turnover, and mitigated histological damage during glucocorticoid intervention and withdrawal. The therapeutic effect was better than that afforded by ALN alone. ALN+PTE reduced CTSK protein expression, promoted Runx2 mRNA and protein expression to varying extents, and more strongly inhibited bone resorption than did ALN alone.

Conclusions: Overall, the synergistic effect mediated by ALN+PTE reversed GIOP during DXM intervention and withdrawal via affecting CTSK and Runx2 expression at mRNA and protein levels.

Keywords: Plastrum testudinis; Glucocorticoid-induced osteoporosis; Cathepsin K; Runt-related transcription factor 2

Comparison of Zuogui Pills and Yougui Pills on Osteogenic Differentiation of Bone Mesenchymal Stem Cells

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Background: This study aims to compare the effects and mechanism of zuogui pills and yougui pills on osteogenic differentiation on rat MSCs.

Methods: Mesenchymal stem cells were cultured by aseptic method and the high and low dose serums of Zuogui pill and Yougui pill were respectively prepared. MSCs were devided into control group (CON), Zuogui pill low dose group (ZD), Zuogui pill high dose group (ZG), Yougui pill low dose group (YD), Yougui pill high dose group (YG). Cell Counting Kit-8, alkaline phosphatase, and alkaline phosphatase (ALP) staining were used to detect the cell proliferation and osteogenic activity. Polymerase chain reaction (PCR) was used to detect mRNA expression of fibronectin type III domain-containing 5 (FNDC), runt-related transcription factor 2 (Runx2), osterix, bone morphogenetic protein-2 (BMP2), and PPARγ; Western-blot was used to detect the protein expression of FNDC5, Western blot and BMP2.

Results: Proliferation of cells revealed an upward trend within 7 days and ZD and YG groups increased significantly compared with other groups. ZD, ZG, and YG group were significantly higher than CON group after 7 days. ALP staining showed the positive rate in each group were higher than CON group at the 3rd and 7th day. PCR showed that on the 7th day, the expression of Runx2 and osterix in ZG group were significantly higher than CON group ($p<0.05$). The expression of Tgif2 in other groups and PPARγ in ZG and YG groups were significantly lower than CON group ($p<0.05$). The expression of FNDC5 protein in ZG group was higher than CON. The expression of Runx2 protein in ZG and YG groups were significantly higher than that in the ZD and YD groups. After 7 days, the level of FNDC5 proteinin ZG group was significantly higher than CON, ZD and YD groups ($p<0.05$), and ZD group was significantly higher than YD group ($p<0.05$). The expression of BMP2 and Runx2 protein in each group

were significantly higher than CON group ($p<0.05$).

Conclusions: Both Zuogui pill and Yougui pill can promote the osteogenic differentiation of bone mesenchymal stem cells. Zuogui pill is slightly stronger than Yougui pill in promoting osteogenic activity and differentiation. The differences between the two drugs may be related to the up-regulation of FNDC5, BMP2, and Runx2 expression.

Keywords: Zuogui pill; Yougui pill; Osteogenic differentiation; Molecular mechanism; Bone mesenchymal stem cells

Effects of Combined Ovariectomy with Dexamethasone on Rat Lumbar Vertebrae

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Background: We investigated the effects of combined ovariectomy with dexamethasone treatment on rat lumbar vertebrae in comparison with osteoporosis induced via ovariectomy or dexamethasone alone,and analysis of the associated molecular mechanism.

Methods: Sixty-two female Sprague-Dawley rats (3 months) were randomly divided into five groups: an untreated baseline (BL) group; those receiving a sham operation (SHAM); those receiving adexamethasone injection alone (DEXA); those undergoing bilateral ovariectomy (OVX); and those subjected to both ovariectomy and dexamethasone injection (OVX-DEXA). Animals in the BL group were euthanized at the beginning of the experiment, whereas animals in the remaining groups were euthanized at the end of the 1st month (M1), 2nd month (M2), or 3rd month (M3). Bone mineral density (BMd), bone microarchitecture, biomechanical properties of vertebrae, serum levels of estrogen, amino-terminal propeptide of type I collagen (PINP), and b-Ctelopeptide of type I collagen were measured. In addition, we examined biglycan, runt-related transcription factor 2, osteoprotegerin, lipoprotein receptor-related protein-5, cathepsin K, and sclerostin mRN expression.

Results: Bone mineral content and BMD were markedly lower in the OVX-DEXA group compared with OVX group at all time points examined. The relative bone surface (BS/TV, bone surface density, mm–1), relative bone volume (BV/TV, trabecular bone volume ratio, %), and trabecular number (Tb.N, 1/mm) were markedly lower in the OVX-DEXA group compared with remaining groups, whereas trabecular separation (Tb.Sp, mm) was markedly higher in OVX-DEXA group compared with the remaining groups at M2 or M3. The OVX-DEXA group showed lower compressive strength and lower stiffness compared with the other groups at M2 and M3. Compressive displacement and energy absorption capacity were also markedly lower in OVX-DEXA group compared with OVX group at M3. Estradiol levels were markedly lower in OVX-DEXA group compared with the other groups. Biglycan, runt-related transcription factor 2, osteoprotegerin, and lipoprotein receptor-related protein-5 were down-regulated in DEXA, OVX, and OVX-DEXA groups compared with BL and SHAM groups, whereas cathepsin K and sclerostin were up-regulated in the OVX-DEXA group compared with the DEXA and OVX groups.

Conclusions: Ovariectomy combined with dexamethasone induced more serious osteoporosis in the rat lumbar spine than either ovariectomy or dexamethasone alone. The combined effect may be due to a combination of suppressed bone formation and increased bone resorption related to an estradiol deficit.

Keywords: Dexamethasone; Lumbar vertebra; Mechanism; Osteoporosis; Ovariectomy

Effect of Jinkui Shenqi Pills on Bone Differentiation of Bone Mesenchymal Stem Cells by Regulating FNDC5 and BMP2 Genes

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Background: This study aims to investigate the effect of Jinkui Shenqi pills on osteogenic differentiation of bone mesenchymal stem cells (BMSCs) by regulating fibronectin type III domain-containing 5 (FNDC) and bone morphogenetic protein-2 (BMP2) genes.

Methods: BMSCs were cultured by whole bone marrow

adherence method. The osteoblast differentiation process of BMSCs was treated with blank serum and high- and low-dose of kidney qi pills respectively. The proliferation and toxicity of Jinkui Shenqi pill on BMSCs were detected by Cell Counting Kit-8 (CCK8). The osteogenic differentiation activity of cell supernatant was detected by alkaline phosphatase (ALP) activity. The osteogenic differentiation ability of cells was detected by lkaline phosphatase (AKP) staining. RT-qPCR and Western blot were used to detect the expression of FNDC5 and BMP2 miRNA and protein.

Results: CCK8 results showed that the cell proliferation in each group increased from day 1 to day 7, and showed a decreasing trend after 7 days, there was no significant difference in proliferation. The activity of AKP in SG group was significantly higher than CON and SG group (p<0.01). The difference between SD group and CON group were not statistically significant, but SD group higher than CON group. At the 7th day, the activity of AKP of SG and SD goup were higher than CON group (p<0.05). The positive rate of ALP staining in SG group and SD group were higher than CON group, while the ALP staining rate in SG group was higher than SD group. The expression of FNDC5 mRNA in SD group were significantly higher than CON group and SG group (p<0.05). While there was no significant difference between SD group and CON group, but SD group was higher than SG group (p<0.05). The expression of BMP2 mRNA in SG and SD group were significantly higher than CON group at 3th and 7th day (p<0.01). The level of FNDC5 and BMP2 in SG and SD group were significantly higher than those in CON group (p<0.05).

Conclusions: The serum of Jinkui Shenqi pill may promote the osteogenesis and differentiation of BMSCs by up-regulating FNDC5 and BMP2 gene levels.

Keywords: Jinkui Shenqi pill; Fibronectin type III domain-containing 5; Bone morphogenetic protein-2; Gene; Osteogenic differentiation

Effect of Zuogui Pills on the Differentiation Ability of miR34a in Bone Mesenchymal Stem Cells

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Background: This study aims to investigate the effect of Zuogui pills on the differentiation of bone mesenchymal stem cells (BMSCs) by miR34a.

Methods: BMSCs were cultured and treated with rat blank serum and high- and low-dose Zuogui pill for osteoblast differentiation. Osteogenic differentiation of BMSCs was detected by Cell Counting Kit-8 and alkaline phosphatase (AKP) activity. Osteogenic differentiation ability was detected by alkaline phosphatase (ALP) staining. Polymerase chain reaction and Werstern blot were used to detect miR34a, Tgif2, runt-related transcription factor 2 (Runx2) and PPARγ mRNA, and protein level.

Results: Proliferation of BMSCs increased from day 1 to 7 and declined between 7th and 14th days. At 7th day, AKP activity in left low and left high group were significantly higher than blank group (p<0.01). At 7th day, the positive rate of ALP staining in left high and left low group were significantly higher than blank group. At 3th day, the expression of miR34a mRNA in the two Zuo Gui group were higher than blank group. The expression of Tgif2 and PPARγ2 mRNA were lower than blank group. At 7th day, the expression of miR34a mRNA in left high group was significantly higher than that in the blank group(p<0.05).The expression of Tgif2 mRNA in Zuo Gui groups were lower than blank group. The expression of PPARγ mRNA in left high group was lower than blank group (p<0.05). At 3th day, the level of Tgif2 protein in the left high group was significantly lower than that in the blank group (p<0.01). However, the level of Runx2 protein in left low group was higher than that in the blank group (p<0.01). At 7th day, the level of Tgif2 protein in the left high group was significantly lower than that in the blank group (p<0.001), Runx2 protein in left low and left high group were significantly higher than blank group (p<0.05).

Conclusions: Zuogui pills can promote the proliferation

and osteogenic differentiation of BMSCs. The mechanism may be that the expression of miR34a is inhibited by inhibiting the expression of Tgif2, and the expression of PPRAγ and the osteogenic transcription factor Runx2 are down-regulated.

Keywords: Zuogui pills; miR34a; Tgif2; Runt-related transcription factor 2; PPARγ

Effect of Osteoporosis Induced by Ovariectomy on Vertebral Bone Defect/Fracture in Rat

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Background: Osteoporotic vertebral fracture (OVF) is a worldwide health concern and lacks sufficient basic studies. Suitable animal models should be the foundation for basic study and treatment of OVF. There have been few studies on the development of animal models of osteoporotic vertebral bone defects. OVF models using various animal species should be developed to evaluate the therapeutic strategy in preclinical testing.

Methods: We developed an OVF model in rats. Rat osteoporosis was induced by ovariectomy (OVX), and 3 months after OVX, a 3-mm diameter hemispheric vertebral bone defect was developed in lumbar vertebra 6 (L6). By sagittal plain X-rays of the rats, their bone quantity, bone microarchitecture, and histomorphology were analyzed: 3 months after OVX, rats showed significantly lower bone quantity, relative bone volume, and total volume bone mineral density.

Results: After the vertebral bone defect had developed for 16 weeks, no significant indication of self-healing could be observed from the sagittal plain X-rays, three-dimensional images, and histomorphology.

Conclusions: These results indicate that the rat model of osteoporotic vertebral bone defect, induced by OVX and a 3-mm diameter hemispheric vertebral bone defect, can sufficiently mimic OVF patients in clinic and provide a sound basis for subsequent studies.

Keywords: Osteoporosis; Vertebral bone defect/fracture; Ovariectomy; Rat; Pathology section

Explore Mediation of Autophagy in Glucocorticoid-Induced Osteoporosis Based on Kidney Yin and Yang Theory

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Background: Autophagy plays an important role in regulating bone homeostasis. It is a self-protection process which is a response to the intracellular and extracellular stimulation. Autophagy is of specific clearance and metabolism, which is similar to mutually opposing and constraining and interdependent and mutually promotion of yin-yang theory of Chinese medicine.

Methods: The CNKI, ChinaInfo, VIP, PubMed, Cochrane library, and EMBASE databases were systematically searched from the inception dates to December 20, 2017, using the keywords Guwei, Yin and yang theory, autophagy, and glucocorticoid-induced osteoporosis to explore the mediation of autophagy in GIOP based on the kidney yin and yang theory.

Results: Glucocorticoid- induced osteoporosis (GIOP) belongs to category of Guwei in Chinese medicine, which is closely related to the kidney. The kidney stores essence, governs the bones, and engenders marrow. Kidney essence is a metaplasias kidney qi that includes kidney yin and yang. Imbalance of kidney yin-yang has a close relationship with GIOP.

Conclusions: To regulate and control kidney yin-yang to mediate autophagy may be a treatment way to GIOP.

Keywords: Guwei; Yin and yang theory; Autophagy; Glucocorticoid -induced osteoporosis

Study on Chinese Medicine Theory of Senile Osteoporosis Based on Kidney Determining the Condition of the Bone and Marrow

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Background: This study aims to explain the relationship

between senile osteoporosis (SOP) and kidney determining the condition of the bone and marrow theory, through summary of connotation of kidney determining the condition of the bone and marrow in Chinese and Western medicine.

Methods: The CNKI, ChinaInfo, VIP, PubMed, Cochrane library, and EMBASE databases were systematically searched from the inception dates to December 20, 2017, using the keywords Chinese medicine theory, senile osteoporosis and kidney determining the condition of the bone and marrow to explore the relationship between SOP and kidney determining the condition of the bone and marrow theory.

Results: The SOP belongs to the category of Guwei in Chinese medicine and the pathogenesis of it is closely related to the kidney. The fundamental pathogenesis of SOP is deficiency of the kidney, desiccated bone and reduced marrow. The ancient and modern physicians often use prescription for reinforcing kidney and strengthening bone to treat SOP. The kidney is the origin of congenital constitution and it stores essence, which engenders marrow that nourishes bone. The theory of kidney determining the condition of the bone and marrow relates to the overall, organ, cell, molecule, gene, and other levels.

Conclusions: To combine advantages of TCM syndrome differentiation and Western medicine, which is of guiding significance for exploration and treatment the SOP.

Keywords: Chinese medicine theory; Senile osteoporosis; Kidney determining the condition of the bone and marrow

Promotion of Synapse Regeneration by Using self-Polymerized Dendritic Polypeptide Scaffold for Spinal Cord Tissue Engineering

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Background: Tissue engineering can be used for nerve regeneration after spinal cord injury, many natural and artificial scaffold are not applicable because of poor mechanical properties and cell compatibility. Polypeptides with fine three-dimensional structure and cell compatibility and are widely used in tissue engineering. The purpose of this study was to clarify the neuronal differentiation of neural stem cells (NSCs) by using self-polymerized dendritic polypeptide for spinal cord tissue engineering.

Methods: NSCs were isolated from cerebral cortex of neonatal Sprague-Dawley rats. Conventional media was triggered the 1wt% nano peptide solution self polymerizated to formed a nano gel. The gel was tested by scanning electron microscope and transmission electron microscope. NSCs were inoculated onto gel or on polylysine-coated slides with fetal bovine serum or not. Fifty-eight mice were randomized divided into the following four groups. NSCs were transplanted into spinal cord injury models. Then we test the density of NF-positive axons in the spinal cord injury area at 8 weeks after surgery and MS score of the locomotive function of hind limbs among mice of four groups.

Results: NSCs were showed anti-nestin (+), anti-NSE (+), and anti-GFAP (+). The gel tested by scanning electron microscope was showed thick wall structure, and another one tested by transmission electron microscope was showed dendritic nanofibers, which contains several spacings. The cells in serum group were differentiate into neurons, but non serum group were not.

Conclusions: These results indicate that the self-assembling peptide nanofiber scaffold were cytocompatible to NSCs which were differentiated into neurons. A large number of axonal regeneration and recovery of joint function were appeared. The self-polymerized peptide can be used as excellent tissue engineering materials.

Keywords: Neural stem cells; Differentiation; Polypeptide

Diffusion-Weighted 7.0T Magnetic Resonance Imaging in Assessment of Intervertebral Disc Degeneration in Rats

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Background: Intervertebral disc degeneration (IDD) is a major cause of disc protrusion, likely to be associated with decrease of water content. This research aimed to evaluate IDD by diffusion–weighted imaging (DWI) with a 7.0

Tesla (T) magnetic resonance imaging (MRI) machine.

Methods: Total of 24 healthy Sprague-Dawley rats were randomly selected and divided into four groups (A, B, C, and D), each consisting of three males and three females (28, 42, 56, and 70 days old, respectively). All the rats were imaged with a 7.0T MRI, producing T2WI, T1WI, and functional DWI sequences. Data were collected and apparent diffusion coefficient (ADC) charts were constructed. Nucleus pulposus and annulus fibrosus regions were identified, several regions of interest were chosen, and their ADC values were obtained. After imaging, rats were sacrificed and their intervertebral discs (L1–L6) were dissected, yielding a total of 144 discs. Protein was extracted for the purpose of Western blotting. Comparison among multiple samples used one−way analysis of variance and least significant difference methods.

Results: 7.0T MRI revealed evident decrease in signal intensity within intervertebral discs of Sprague-Dawley rats with age. Mean ADC values of different intervertebral regions were positively correlated with aggrecan and type II collagen content (aggrecan: r=0.631, p<0.01; type II collagen: r=0.680, p<0.01)

Conclusions: 7.0T MRI−DWI could be applied to effectively diagnose and research early IDD in tiny variations

Keywords: Apparent diffusion coefficient; Diffusion−weighted imaging; Intervertebral disc degeneration; magnetic resonance

Establishment of a Rat Osteoporotic Model by Ovariectomy Combined with Glucocorticoid Exposure

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Background: There are many postmenopausal women taking hormone, which leads to much loss of bone mass,further inducing fragility fractures. The studies on the hormone exposure combined with ovariectomy-induced osteoporotic model are still immature, and the related molecular mechanism remains unclear.

Methods: Thirty 3-month-old female Sprague-Dawley rats were randomly divided into blank control, sham, and model groups (n=10 per group). The rats in the blank control group received no intervention; rats in the sham group were clipped off a little of coeliac adipose tissue; the model rats received bilateral ovariectomy and 4-week administration of glucocorticoid.

Results: At 4 weeks after modeling, compared with blank control and sham groups, the model group showed significantly lower bone mineral density of the femur, number of bone trabeculae and bone volume/total volume, and significantly wider bone trabecular spacing. Additionally, the model group revealed the damaged bone trabecular structure and thiner cortical bone. The expression level of runt-related transcription factor 2 (Runx2) was downregulated whereas both collagen type 1α1 and peroxisome proliferators activated receptor γmRNA were upregulated in the model group.

Conclusions: These findings suggest that ovariectomized rats exposed to glucocorticoid rapidly develop femur osteoporosis, maybe by downregulating the expression of Runx2, as well as upregulting collagen type 1α1 and peroxisome proliferators activated receptor γmRNA.

Keywords: Osteoporosis; Dexamethasone; Ovary; Tissue engineering

Research Advancement of Calcium Phosphate and Calcium Sulfate Scaffolds in Bone Tissue Engineering

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Background: It is a hotspot that calcium phosphate and calcium sulphate as the main ingredients are combined with one or more other materials to improve or increase the performance of bone tissue engineering scaffolds.

Methods: The articles related to the bone tissue engineering published during January 2000 to June 2015 were retrieved from CNKI and PubMed databases by computer. The key words were "bone tissue engineering, scaffold, calcium phosphate, calcium sulphate, vascularization" in Chinese and English, respectively.
Results: Calcium phosphate and calcium sulfate are characterized as having good biocompatibility, biodegradability, osteoconductivity, and complete bone substitutability. However, single use of calcium phosphate or calcium sulfate scaffold has certain disadvantages, both of which are difficult to fully meet the requirements of the bone defect repair. Improvement can be acquired in the mechanical strength, injectability and biodegradability, as well as drug-loading and pro-angiogenesis of the scaffold in combination with other materials.
Conclusions: In the basal and clinical research, we should explore and develop ideal scaffolds in on the basis of therapeutic aim. However, most of the scaffold studies are still at the extracorporeal and animal experiment stage, and the comparative studies on composite scaffolds and optimal proportion of those composite scaffolds still need to be further investigated.
Keywords: Calcium phosphates; Calcium sulfate; Tissue engineering

Zuo-Gui-Wan Extracts Reverse Glucocorticoid-Induced Osteoporosis of Rats via Targeting Let-7F and Autophagy Related Genes

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Background: Zuo-Gui-Wan (ZGW) have traditionally been used in Asian medicine for treating bone metabolism diseases, including glucocorticoid-induced osteoporosis (GIOP). Our study aims to explore the therapeutical effect of ZGW extracts on GIOP of rats, and the underlying molecular mechanisms of ZGW extracts in GIOP were performed.
Methods: Sprague-Dawley rats were randomly divided into three groups: CON group, dexamethasone (DEXM) group, and ZGW group, in which rats respectively received vehicle, DEXM injection, and oral ZGW at the same time of DEXM injection. Bone quantity, microarchitecture, biomechanics, histomorphology, blood serum alkaline phosphatase (AKP) activity, and the ultrastructure of osteoblasts were evaluated. mRNA expression of let-7f, autophagy related genes (mTORC1, beclin-1, ATG12, ATG5, and LC3), runt-related transcription factor 2 (Runx2), and cathepsin K (CTSK) were examined.
Results: ZGW extracts significantly improved bone mass and quality, compressive strength; mitigated histological damage; increased blood serum AKP activity; improved osteoblasts autophagic and apoptotic characteristics; and decreased the number of cytosolic autophagosomes in osteoblasts. Moreover, ZGW extracts promoted let-7f, mTORC1, and Runx2 mRNA expression, reduced beclin-1, ATG12, ATG5, LC3, and CTSK mRNA expression.
Conclusions: These results indicated that ZGW extracts may reverse glucocorticoid-induced spinal osteoporosis of rats through the activation of let-7f and the inhibition of autophagy.
Keywords: Let-7f; Autophagy related genes; Zui-Gui-Wan extracts; Glucocorticoid-induced osteoporosis

Effect of Olucocorticoid Withdrawal on Glucocorticoid Inducing Bone Impairment

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Background: Glucocorticoid withdrawal after a short-term use was common in clinical practice like immediate post-transplant period. However, previous studies without setting age-control group failed to determine whether the bone mineral density (BMD) recovery was sufficient and whether it is necessary to accept anti-osteoporosis therapy

after glucocorticoid withdrawal. This study was to investigate the effect of glucocorticoid withdrawal on bone impairment in glucocorticoid-induced osteoporosis rats.

Methods: Sprague-Dawley rats (3 months) were randomly divided into two treatment groups: an untreated age-control group (Con, n=12); another group receiving a dexamethasone injection (DEXA, n=12). Animals in the Con group were euthanized at 3rd month (M3) and 6th month (M6), respectively. Six rats in the DEXA group were euthanized at M3, whereas glucocorticoid intervention was withdrew in the remaining animals of DEXA group, which were euthanized at the end of M6. Bone mass, bone microarchitecture, biomechanical properties of vertebrae, morphology, serum levels of propeptide N-terminal of type 1 procollagen (PINP) and β C-terminal cross-linked telopeptide of type 1 collagen (β-CTX) were evaluated.

Results: Compared with the Con (M3) group, the Con (M6) group showed significantly better bone quantity, morphology, and quality. Compared with the Con (M3) group, the DEXA (M3) group showed significantly lower bone mineral content (BMC), BMD, bone surface density (BS/TV), trabecular bone volume ratio (BV/TV), trabecular number (Tb.N), trabecular thickness (Tb.Th), volumetric BMD (vBMD), bone strength, compressive displacement, energy absorption capacity, PINP levels, β-CTX levels, and damaged trabecular morphology. And the same change trend was observed in the comparison between the Con (M6) group and DEXA (M6) group. Compared with the DEXA (M3) group, the DEXA (M6) group showed significantly higher BMC, BMD, and AREA, but no significant difference in BS/TV, BV/TV, SMI, Tb.N, Tb.Th, Tb.Sp, vBMD, bone strength, bone stiffness, compressive displacement, energy absorption capacity, PINP levels, and β-CTX levels.

Conclusions: These results indicate that the reverse effect of glucocorticoid withdrawal for 3 months on bone impairment in GIOP rats was insufficient, which implied that related anti-osteoporosis treatment might be still necessitated after glucocorticoid withdrawal in clinical setting.

Keywords: Glucocorticoid; Withdrawal; Osteoporosis

Extracts from Plastrum Testudinis Promote BMSCs Proliferation and Osteogenic Differentiation via let-7f-5p Targeting TNFR2/PI3k/Akt signaling Pathway

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Background: The osteoprotective effect on glucocorticoid-induced osteoporosis (GIOP) in vivo and osteogenesis effect *in vitro* of the extracts from plastrum testudinis (PTE) have been demonstrated in previous studies. However, its effects and mechanisms of action on promoting bone mesenchymal stem cells (BMSCs) osteogenic differentiation remain to be determined. The present study aimed to determine the effect of PTE on BMSCs proliferation and osteogenic differentiation, and to elucidate the possible mechanism of their action.

Methods: BMSCs proliferation was examined with a cell proliferation assay Cell Counting Kit-8 (CCK-8), alkaline phosphatase staining was used to visualize early BMSCs differentiation, and Alizarin red staining was performed to determine the BMSCs osteogenic mineralization ability. The mRNA expression level of let-7f-5p, TNFR2, TRAF2, PI3K, Akt, β-catenin, and GSK3β were measured by quantitative real time reverse transcription-polymerase chain reaction. The protein expressions of tumor necrosis factor receptor 2 (TNFR2), TNF receptor-associated factor 2 (TRAF2), phosphatidylinositol 3-kinase (PI3K), p-Akt, p-β-catenin, and p-GSK3β were measured by Western-blot assay. The functional targeting relationship of let-7f-5p and TNFR2 was determined by luciferase reporter assays.

Results: We found that 30 μg/mL was the optimum concentration for PTE intervention. PTE significantly promoted BMSCs osteogenic differentiation and mineralization after 7 days culture and 14 days culture, respectively. And the combination of PTE and osteogenic induction exhibited significant synergies. Moreover, PTE up-regulat-

ed let-7f-5p and β-catenin mRNA expression, and down-regulated TNFR2, TRAF2, PI3K, Akt, and GSK3β mRNA expression. PTE inhibited TNFR2, TRAF2, and β-catenin protein expression, and promoted p-PI3K, p-Akt, and p-GSK3β protein expression. We also demonstrated that TNFR2 is a functional target of let-7f-5p.

Conclusions: Together, these results showed that PTE may promote BMSCs proliferation and osteogenic differentiation via let-7f-5p targeting TNFR2/PI3K/Akt signaling pathway.

Keywords: Extracts from plastrum testudinis; let-7f-5p; TNFR2/PI3k/Akt signaling pathway; BMSCs; Osteogenic differentiation