

O146

**CANCER RISK AND THE USE OF BONE MORPHOGENETIC PROTEIN**Carragee E.<sup>1</sup>, Chu G.<sup>1</sup>, Weiner B.<sup>2</sup>, Hurwitz E.<sup>3</sup>, Comer G.<sup>1</sup>, Park D.<sup>4</sup>, Yoon T.<sup>5</sup><sup>1</sup>Dept. of Orthopaedic Surgery Stanford School of Medicine, Redwood City, CA; <sup>2</sup>Division of Spine Surgery, The Methodist Hospital Texas Medical Center, Houston, TX; <sup>3</sup>Dept. of Public Health Sciences, John A. Burns School of Medicine, University of Hawaii, Honolulu; <sup>4</sup>Orthopedic Surgery, William Beaumont Hospital, Royal Oak; <sup>5</sup>Orthopedic Surgery, Atlanta VAMC and Dept of Orthopaedics Emory University, Atlanta, GA, USA

**Introduction:** BMP-2 is a growth known to have in vitro effects on the growth and invasiveness of malignancies. Although only approved to be used in a limited dose and exposure in spinal fusion, BMP-2 is commonly used off-label and in high dosages. The effect of BMP-2 on the incidence of cancer in clinical use has been a concern since human use was first proposed.

**Methods:** A multicenter, prospective, randomized, controlled, trial enrolled 518 patients with degenerative conditions of the lumbar spine who received either high dose BMP-2 (40 mg) with compression resistant matrix (AMPLIFY), or autogenous bone graft for posterolateral fusion. A total of 463 evaluable patients received treatment from 63 spine surgeons at 29 investigational sites. Exclusion criteria for the study included presence of active malignancy or prior history of malignancy (except for basal cell carcinoma of the skin). Patients were followed at intervals with greater than 70% follow-up through 3 years after surgery. Cancer events were record and presented in FDA documents.

**Results:** Twenty cancer events occurred in the BMP-2 group compared with 5 in the control group over five years. Three patients in the BMP-2 group developed multiple new malignancies compared to no patients in the control group. At the primary study endpoints of two and three years after surgery, 5.5-fold and 4.0-fold more patients in the BMP-2 group developed at least one new cancer compared with controls ( $p = 0.024$  and  $p=0.033$ , respectively). Accounting for patients with multiple cancers, the rate ratio for cumulative new cancers was 6.7 ( $p = 0.025$ ) at the two years and 5.4 ( $p = 0.014$ ) at three years.

**Conclusion:** High dose BMP-2 was associated with an increase in new malignancies. These data require careful consideration for the large number of patients receiving high dose BMP-2. Patients with an elevated risk for cancer may not be appropriate candidates for application of BMP-2 in spinal surgery.

O147

**SERUM BIOMARKERS DEMONSTRATE GREATER CORRELATION WITH LOW BACK PAIN IN OLDER ADULTS THAN MRI**Sowa G.A.<sup>1,2</sup>, Huang W.<sup>1</sup>, Perera S.<sup>3</sup>, Kusturiss M.B.<sup>1</sup>, Bechara B.<sup>2</sup>, Agarwal V.<sup>4</sup>, Boardman J.<sup>4</sup>, Camacho-Soto A.<sup>1</sup>, Davies C.<sup>2</sup>, Vo N.<sup>2</sup>, Kang J.<sup>2</sup>, Weiner D.<sup>3</sup><sup>1</sup>Dept. of Physical Medicine and Rehabilitation, University of Pittsburgh, Pittsburgh; <sup>2</sup>Dept. of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh; <sup>3</sup>Dept. of Medicine, University of Pittsburgh, Pittsburgh; <sup>4</sup>Dept. of Radiology, University of Pittsburgh, Pittsburgh, USA

**Introduction/Aim:** Intervertebral disc degeneration (IDD), as assessed by imaging studies, is ubiquitous among older adults, and has poor correlation with symptoms. Our objective was to examine in older adults with chronic low back pain the relationship between plasma biomarkers and pain intensity, activity limitation, and magnetic resonance imaging (MRI) evaluated IDD.

**Methods:** We recruited a cohort of 44 adults age 65 or older with axial low back pain for  $\geq 3$  months. Exclusion criteria included

serious illness, acute pain flare, contraindication to MRI, lumbar surgery, radiation of pain into the lower extremities, dementia, uncontrolled psychiatric illness, knee or hip osteoarthritis, or other pain more severe than back pain. Clinical outcome measures included pain intensity (0-10 and McGill Pain Short Form), depression, Roland-Morris Questionnaire, the short physical performance battery, and repetitive trunk rotation. Plasma samples were analyzed for E-selectin, RANTES (inflammatory markers), TIMP-1 (inhibitor of catabolic enzymes), CTX-II, CS846 (markers of matrix turnover), and NPY (stress biomarker) by ELISA assay. Conventional non-gadolinium lumbar MRI was obtained and analyzed quantitatively and clinically.

**Results:** Serum biomarkers demonstrated greater association with pain intensity (RANTES  $R^2 = 0.2-0.25$ ; NPY  $R^2 = 0.22$ ) and disability (RANTES  $R^2=0.2$ ) than MRI ( $R^2 = 0-0.07$ ). Statistically significant ( $p<0.05$ ) additional gains in explained variability of clinical metrics over MRI were noted for TIMP-1, RANTES, NPY, CS846, and CTX-II. The strongest such independent association was between NPY levels and depression ( $R^2 = 0.29$ ). Combining biomarkers demonstrated even greater explanatory power, with moderate associations between RANTES/NPY and depression ( $R^2 = 0.36$ ) and CS846/NPY and McGill affective score ( $R^2 = 0.3$ ).

**Discussion/Conclusion:** These results demonstrate associations in novel biomarkers with clinical status, above and beyond the contribution of MRI. These novel serum based biomarkers reflect potential targets for use in designing individualized treatment for older adults with low back pain.

O148

**A NOVEL MOLECULAR TARGETED THERAPY FOR SPINAL MRSA INFECTION**Kuramoto T.<sup>1</sup>, Ishii K.<sup>1</sup>, Nagai S.<sup>2,3</sup>, Funao H.<sup>1</sup>, Kobayashi K.<sup>1</sup>, Hirai M.<sup>5</sup>, Sasaki A.<sup>4</sup>, Okada Y.<sup>4</sup>, Chiba K.<sup>1</sup>, Koyasu S.<sup>2</sup>, Toyama Y.<sup>1</sup>, Matsumoto M.<sup>1</sup><sup>1</sup>Dept. of Orthopaedic Surgery, School of Medicine, Keio University, Shinjuku, Tokyo; <sup>2</sup>Dept. of Microbiology and Immunology, School of Medicine, Keio University, Shinjuku, Tokyo; <sup>3</sup>Core Research for Evolutional Science and Technology (CREST), Japan Science and Technology Agency (JST), Tokyo; <sup>4</sup>Dept. of Pathology, School of Medicine, Keio University, Shinjuku, Tokyo; <sup>5</sup>Katayama Co., Ltd, Osaka, Japan

**Introduction:** Although Vancomycin (VC) is the most common antibiotic agent against MRSA infections, its clinical use is associated with several problems including insufficient delivery to infection sites and nephrotoxicity. It is known that sialyl Lewis X on the leukocytes recognizes its ligand E-selectin in the vascular endothelium, resulting in the leukocytes migration to the extravasacular infection sites. Utilizing this mechanism, we have established a novel drug delivery system for the spinal infection, in which E-selectin targeted liposome encapsulating VC (VC-Lip) was used as drug carriers.

**Materials and Methods:** The concentration of VC in the VC-Lip averaged 54.5mg/ml and the adequate antibacterial effect was obtained *in vitro*. For *in vivo* evaluation, the mouse model of MRSA (luminescent strain) infection in the paraspinal muscles was used. Daily intravenous administration of VC (VC group: VC15mg/kg), VC-Lip (VC-Lip group: VC22 $\mu$ g/kg approximately 1/1000 smaller dose than that of VC group), or Lip (no VC: control group) were conducted for 10days and the therapeutic effects were evaluated by bio-imaging, serologic and histologic analyses.

**Results:** In bio-imaging, signals of VC-Lip and Lip accumulated to the infection site were detected immediately after the administration. Signals of MRSA significantly decreased 12hours after the administration only in VC-Lip and VC groups and completely disappeared only in VC-Lip group on 7days. Serologic analysis showed the resolution of infection only in VC-



Lip group, but not in the VC group or control group on 14 days. The pathological findings of the paraspinal muscle revealed that less inflammation and muscle damage were observed in VC-Lip group than in the VC groups and control groups.

**Discussions:** The novel molecular targeted therapy for spinal MRSA infection has been established. Surprisingly, liposome encapsulating an extremely small amount of VC (approximately 1/10000 of standard VC administration) was effective for suppression of the paraspinal MRSA infection. This result is attributable to the specific features of the VC-Lip including 1) long-time circulation in the body, 2) specific target, 3) drug stability.

**Conclusions:** The novel molecular targeted therapy for spinal MRSA infection was established. This therapeutic strategy can be a safe and effective alternative to standard intravenous administration of VC.

#### O149

##### INHIBITING BRAIN-DERIVED NEUROTROPHIC FACTOR (BDNF) AT THE PUNCTURED INTERVERTEBRAL DISC DOWNREGULATES PAIN-RELATED NEUROPEPTIDE PRODUCTION IN DORSAL ROOT GANGLIA IN RATS

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**Introduction:** BDNF - a neurotrophin in DRG neurons - is known to be anterogradely transported to the spinal cord and transmits pain signals existing in the central nervous system. A previous study has recently reported its presence in the peripheral sites of degenerative IVDs, although its association with discogenic pain remains unclear.

The present study aimed to investigate the association between BDNF and pain-related sensory innervation of multiple-punctured lumbar IVD in rats.

**Methods:** Forty female Sprague-Dawley rats were equally divided into four groups: naïve, sham, and two agent-treated groups (vehicle (saline-treated) and anti-BDNF (anti-BDNF antibody) group). L5-6 IVDs of the agent-treated rats were exposed and injured by repeated punctures. The retrograde neurotracer Fluoro-Gold (FG) and treatment agents were intradiscally applied. In the sham group, FG alone was applied onto uninjured IVD. One week later, L1-3 DRGs were harvested and immunolabeled for the inflammatory pain-related calcitonin gene-related peptide (CGRP), i.e., the pain marker. The proportions of FG-labeled CGRP-immunoreactive (-ir) DRG neurons were assessed. BDNF concentration of each L5-6 IVD was measured using enzyme-linked immunosorbent assay (ELISA).

**Results:** FG-labeled DRG neurons were almost equally prevalent at each DRG level. The proportions of FG-labeled CGRP-ir DRG neurons in the two agent-treated groups were significantly elevated ( $P < .05$ ) compared with the naïve and sham groups and were significantly decreased in the anti-BDNF group as compared to the vehicle group ( $P < .05$ ). BDNF concentrations were elevated maximally in the vehicle group but suppressed in the anti-BDNF group.

**Conclusions:** Direct intradiscal application of the anti-BDNF antibody significantly suppressed both CGRP production and the local concentration of BDNF. Our results indicate a possible association between the local production of BDNF and the pathophysiology of discogenic pain.

#### O150

##### FINDINGS OF CEREBROSPINAL FLUID CONTENT IN PATIENTS WITH LUMBAR SPINAL STENOSIS

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**Introduction:** The role of cerebrospinal fluid (CSF) in lumbar degenerative diseases is still unknown. The CSF surrounding the cauda equina may contribute as a source of nutrition and remover of nerve metabolism. It was reported that the protein concentration in the CSF was often increased in patients with sciatica caused by disc herniation. However there is few data about CSF findings of lumbar spinal stenosis (LSS). We analyzed the finding of CSF content in patients with LSS.

**Methods:** Two hundred one patients who had lumbar spinal stenosis (117 males and 84 females, from 46 to 94 years old, an average of 69) were studied. The CSF was harvested by lumbar puncture on the occasion of myelography, and was examined its content especially amount of protein and cell number. These data were compared with clinical and myelographical findings.

**Results:** The amounts of protein in the CSF of 140 cases (78%) were increased beyond normal range. The degree of increase was related to number of stenosis level. Median amount of CSF protein was 71.8 mg/dl in one level stenosis, 84.9 mg/dl in two levels, 106.5 mg/dl in three levels and 143 mg/dl in more than four levels. The increased numbers of cell in CSF were seen in 33 cases (16%). It was also related to number of stenosis level. Median account of cells were 5.9/mm<sup>3</sup> in one level stenosis, 6.4/mm<sup>3</sup> in two levels, 7.7/mm<sup>3</sup> in three levels and 10.7/mm<sup>3</sup> in more than four levels.

**Conclusions:** Protein increase in the CSF content was highly seen in patients with LSS. The degree of concentration was related to number of stenosis level. An increased CSF protein content may be related to the damage of the nerve root due to compression.

#### O151

##### CHRONIC EXPOSURE TO TOBACCO SMOKE INDUCES PROTEOLYSIS OF DISC AGGREGAN

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**Introduction/Aim:** Tobacco smoking increases the risk of intervertebral disc degeneration (IDD), which underlies many spinal disorders resulting in disability and tremendous economic loss. However the mechanisms by which smoking affects intervertebral discs are largely unknown due to the paucity of well-controlled studies. Perturbation of matrix proteoglycan (PG) homeostasis, by increasing catabolic and/or decreasing anabolic activities, promotes IDD. Hence, this study investigated the effects of long-term exposure of tobacco smoke on disc PG homeostasis using mice as a model system.

**Materials/Methods:** Three-month old C57BL/6 mice were exposed to tobacco smoke by direct inhalation (5 cigarettes/day, 5 day/week for 6 months). Disc proteoglycan content (DMMB assay), proteoglycan synthesis (<sup>35</sup>S-sulfate incorporation) and collagen synthesis (collagenase-sensitive <sup>3</sup>H-proline incorporation) were measured. MMP- and ADAMTS-mediated cleavage of aggrecan interglobular domain (IGD) terminating in VDIPEN<sup>-341</sup> and NITEGE<sup>-373</sup>, respectively, were analyzed by Western blot from disc tissue using the antibodies raised against these neopeptides.



**Results:** Compared to unexposed control, discs of exposed mice showed a 50%±9% reduction in PG content, 41%±7% reduction in PG synthesis, and 60%±11% reduction in collagen synthesis. Exposure to tobacco smoke dramatically increased MMP-and ADAMTS-mediated proteolysis of disc aggrecan IGD.

**Discussion:** Long-term direct exposure of mice to tobacco smoking showed dramatic loss of disc matrix PG. Unexpected and novel is the finding of smoke-induced proteolysis of aggrecan IGD, which is extremely detrimental as it results in the loss of the entire glycosaminoglycan-attachment region of aggrecan, which is vital for attracting water to counteract compressive forces.

**Conclusion:** These findings further confirm tobacco smoke as a key contributor to IDD. Furthermore, the data provide a novel mechanistic insight, indicating that IDD is a result of both reduced PG synthesis and increased degradation of a key disc extracellular matrix protein. Our results suggest identification and inhibition of specific metalloproteinases responsible for smoke-induced aggrecanolytic as a potential therapeutic strategy in tobacco smokers.

## O152

### GLUCOSAMINE SUPPLEMENTATION HAS A NEGATIVE EFFECT ON INTERVERTEBRAL DISC MATRIX

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**Introduction/Aim:** A CDC report from 2009 reported that many patients are using glucosamine supplementation for low back pain (LBP), without significant evidence to support its use. Because disc degeneration is a major contributor of LBP, we explored the effects of glucosamine on disc matrix homeostasis in an animal model of disc degeneration.

**Methods:** Eighteen skeletally mature New Zealand White rabbits were divided into four groups: control, stab, glucosamine, and stab+glucosamine. Glucosamine treated rabbits received daily oral supplementation with 107mg/day (weight based equivalent to human 1500mg/day). Stab surgery involved puncturing the annulus fibrosus (AF) of 3 lumbar discs with a 16G needle to induce degeneration. Serial MRIs were obtained. Discs were harvested at 20 weeks for determination of glycosaminoglycan (GAG) content and histological analyses. Relative gene expression was measured by RT-PCR.

**Results:** Non-degenerated discs of glucosamine treated rabbits had significantly lower GAG content in the NP and AF compared to discs of untreated rabbits. No significant difference in GAG was seen in degenerated discs. However, the MRI index of glucosamine treated degenerated discs was significantly lower than that of untreated degenerated discs. Histological examination of all discs treated with glucosamine showed lower cellularity, fibrosis and loss of demarcation between the NP and AF. In non-degenerated discs, aggrecan gene expression was increased and MMP-3 decreased in both the NP and AF in response to glucosamine, whereas degenerated discs treated with glucosamine demonstrated decreased aggrecan and increased MMP-3 gene expression in NP and AF.

**Discussion/Conclusion:** In this study, glucosamine appears to negatively affect disc matrix as observed by decrease total disc GAG content, decrease in the MRI index, worsening fibrosis on histological analysis, and decreased aggrecan gene expression. This data suggests that glucosamine may be harmful to disc matrix, and may have differing effects in normal and degenerated discs.

## O153

### DOMINANT INVOLVEMENT OF APOPTOSIS RELATIVE TO AUTOPHAGY IN A RAT TAIL SUSTAINED STATIC COMPRESSION LOADING-INDUCED DISC DEGENERATION MODEL

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**Introduction/Aim:** Cell decrease plays an important role in intervertebral disc degeneration. Apoptosis, a programmed cell death, has frequently been described as the major contributor; however, its detailed induction pathway still remains unclear. Autophagy, a cell survival process, has not been the focus of disc research. To elucidate the involvement of these mechanisms through the degeneration process, a longitudinal animal model study was designed.

**Materials and Methods:** Forty-eight 12-week-old male Sprague-Dawley rat tails were instrumented with an Ilizarov-type device with springs and loaded statically at 1.3 MPa for up to 56 days. After X-ray, MRI, and histomorphological assessments, experimental loaded and distal-unloaded control discs were analyzed by real-time RT-PCR and immunohistochemistry for apoptosis- and autophagy-related genes and TUNEL staining.

**Results:** Continuous disc height loss in X-ray, lower intensities in MRI, histological degeneration, and decreased DAPI-positive cells were observed. PCR analysis demonstrated, in the apoptotic death-inducing signaling complex pathway, *TNFA*, *FasL*, and *Fas* were up-regulated while apoptosis-initiator *caspase-8* demonstrated little up-regulation. In the mitochondrial pathway, apoptosis-inducer *Bad*, *Bax*, *Bid*, apoptosis-inhibitor *Bcl-2*, *SIRT1*, and apoptosis-initiator *caspase-9* showed significant up-regulation from 7 days. Apoptosis-executioner *caspase-3* was similarly up-regulated. Apoptosis-regulator *p53* and its inhibitor *MDM2* and *MDM4* were also up-regulated. In the autophagic pathway, autophagy-suppressor *mTOR*, autophagy-regulator *ULK1*, *Atg5*, *Atg7*, and *Atg12* were up-regulated. However, autophagosome-formative *LC3a*, *LC3b*, and *Beclin1* showed little to no up-regulation throughout. In immunohistochemistry, cleaved caspase-3- and TUNEL-positive cells increased from 7 through 56 days both in NP and AF while *Bcl-2*- and *SIRT1*-positive cells decreased with degeneration. *LC3* and *Beclin1* also decreased consistently.

**Discussion/Conclusion:** Sustained static compression induced a dominant involvement of apoptosis, particularly the mitochondrial pathway, relative to autophagy. Loss of *Bcl-2* and autophagy may contribute to the acceleration of apoptotic cell death in disc degeneration.



O203

### DOES PROVOCATIVE DISCOGRAPHY CAUSE CLINICALLY IMPORTANT INJURY TO THE LUMBAR INTERVERTEBRAL DISC? A TEN-YEAR MATCHED COHORT STUDY

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**Introduction:** Provocative discography, an invasive diagnostic procedure involving disc puncture and injection, is purported to detect discogenic sources of back pain in discs with otherwise unremarkable imaging findings. The clinical validity and utility of this test is unproven. Disc puncture in experimental settings can cause rapid disc degeneration in animal studies. Whether this effect occurs in humans exposed to modern discography injections is unknown.

**Methods:** Subjects (n = 75) without current low back pain problems were recruited to participate in a study of discography at the L3 – S1 discs. A closely matched control cohort was simultaneously recruited to undergo the evaluation except for discography injections. Subjects were followed by serial protocol evaluations at 1, 2, 5 and 10 years after enrollment. Interval and cumulative adverse lumbar spine events were recorded. The primary outcomes were lumbar disc surgery events and diagnostic imaging (CT or MRI) events.

**Results:** Of enrolled 150 subjects, 71 discography subjects completed the baseline evaluation, as did 72 of the control subjects. At ten-years follow-up 57 discography and 53 control subjects completed all interval surveillance evaluations. There were 16 lumbar surgeries in the discography group, compared with 4 in the control group (p = 0.016; Kaplan-Meier Log-Rank Test). Medical visits, CT and MRI examinations (p = 0.044; Kaplan-Meier Log-Rank Test), work loss and prolonged back pain episodes were all statistically more frequent in the discography group compared to controls subjects.

**Conclusion:** Disc puncture and injection, even with small gauge needle and low pressure techniques, can cause significant clinical disc problems in a minority of exposed subjects.

O204

### IS ADJACENT SEGMENT DEGENERATION (ASD) ASSOCIATED WITH PREEXISTING DISC DEGENERATION?

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**Introduction:** Although the acceleration of adjacent disc degeneration seemed to be related with lumbar fusion, it remains unclear whether ASD is newly created by fusion or aggravated from a pre-existing disease. We investigated the changes of intervertebral disc herniation (IDH) and spinal stenosis (SS) at adjacent levels in association with pre-existing lesions.

**Materials and Methods:** A total of 187 patients who had undergone spinal surgery (ALIF 74, PLF 72, decompression 41) for lumbar degenerative diseases and had taken MRI at the time of index treatment and at least 2-year follow-up were included. The changes of IDH and SS at the adjacent levels of surgery were examined using repeated MRIs by three different observers. Age, gender, duration, type of surgery, and pre-existing disc degeneration was analyzed to identify the relevant risk factors for the changes of IDH and SS.

**Results:** The mean follow-up duration was 66.5±35.5 months (range, 24–192 months). Neither de novo occurrence of IDH and

SS nor aggravation of the previous IDH and SS was not different among the ALIF, PLF and decompression surgery.

	IDH (%)			SS (%)		
	De novo	aggra- vation	no change	De novo	aggra- vation	no change
ALIF	4.0	3.2	2.3	4.4	6.3	3.0
PLF	2.2	2.1	3.3	3.4	7.6	0.9
Decom- pression	2.9	3.0	1.8	2.8	5.8	3.0
<i>P</i>	0.961	0.903	0.566	0.510	0.792	0.392

The only significant factor for the occurrence of IDH and SS was pre-existing disc degeneration (OR 2.361, 95% CI 1.310-4.258). Pfirrmann grade 3 was the most vulnerable for IDH and SS.

**Discussion:** Although spinal fusion may cause the biomechanical stress on its adjacent levels, lumbar fusion did not affect the changes of IDH and SS at the adjacent levels. Pre-existing disc degeneration is the most suspicious etiology for the occurrence of ASD.

O205

### ADJACENT SEGMENT DEGENERATION AND SAGITTAL SPINOPELVIC ALIGNMENT IN A MEAN 16-YEAR FOLLOW-UP OF LUMBAR SPINAL FUSION

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**Introduction/Aim:** Number of studies indicated the importance of congruent spinopelvic alignment, however, the definition of congruity and its impact on surgical outcome have not been well documented. We previously reported that congruent spinopelvic alignment was associated with less frequent development of sagittal malalignment and degenerative changes in healthy volunteers (Spine 2004). Aim of this study was to investigate the relationship between baseline sagittal spinopelvic alignment and clinical/radiological outcomes of lumbar spinal fusion for degenerative diseases.

**Materials and Methods:** A final total of 55 patients who underwent lumbar spinal fusion during 1978-98 and could be followed clinically and radiologically with upright lumbar or whole spine radiographs were included. Sagittal spinopelvic parameters including lumbar lordosis, sacral slope, and pelvic incidence (PI) were measured using baseline, immediate postoperative, and follow-up radiographs. Changes in osteophyte length, disc height, and disc angle at adjacent to fused levels were evaluated using previously reported techniques (Spine 2006). Adjacent segment degeneration (ASD) was defined as 1) osteophyte increase >5mm, 2) disc height decrease >5mm, 3) disc angle change in kyphosis >5°. Clinical outcome was evaluated using Prolo score. Lumbopelvic alignment was defined as congruent if L1-5 lordosis was within the magnitude of 70-90° of sacral inclination angle, using immediate postoperative radiographs.

**Results:** Patients' mean age at surgery was 58.5 years and mean follow-up period was 16.2 years. ASD was found in 24 patients (43.6%), which was associated with significantly worse Prolo score (p=0.0034). A Cox proportional hazards analysis indicated that younger age at surgery (p=0.0209), the use of pedicle screw instrumentation (p=0.0015), and congruent lumbopelvic alignment (p=0.0045) was associated with better clinical score. Subjects with congruent lumbopelvic alignment (p=0.0302) and large PI (p=0.0474) showed reduced incidence of ASD.

**Conclusions:** Better lumbopelvic congruity after index spinal



fusion led to better clinical and radiological outcomes. Patients with large PI might be advantageous because of increased capacity of sagittal compensation for suboptimal alignment at fused segment.

## O206

### SPINE CURVATURE IS HERITABLE AND ASSOCIATED WITH DISC DEGENERATION

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**Introduction/Aim:** Degenerative spondylosis (DS) is common in middle age and elderly and, if severe, may lead to respiratory compromise and abdominal content crowding. Lumbar disc degeneration (LDD) is known to be heritable but the relationship with spine curvature is unclear. We performed an MR and plain radiograph study on well characterised twins ([www.twinsuk.ac.uk](http://www.twinsuk.ac.uk)) known to be representative of the general population.

**Materials and Methods:** Sagittal MR images were coded for LDD on a 4-point scale over 4 subphenotypes: disc signal intensity, disc height, anterior osteophytes and disc bulge and summed over the 5 lumbar discs to give a summary LDD score. We determined the angle of lumbar lordosis and thoracic kyphosis, using Spineview™ software applied to lateral long spine radiographs taken at the same time as MRI. Twins having vertebral fracture were excluded. A classical twin study was performed to determine the relative contributions of genetic and environmental factors to spine curvature.

**Results:** Complete phenotype data were available on 246 female twins, 110 monozygotic (MZ) and 136 dizygotic (DZ) twins. Mean age was 64.3 years (range 40.1–79.3); age was associated with increasing lumbar lordosis and thoracic kyphosis. The AE model (comprising additive genetic and unique environmental factors) was the most suitable model for both curves (by the Akaike information criterion). Heritability estimate = 59% (42–71%) for lumbar lordosis; and 61% (46–74%) for thoracic kyphosis. After adjusting for age and BMI, lumbar lordosis was significantly associated with a number of features of LDD including disc signal intensity and osteophytes.

**Discussion:** Lumbar lordosis and thoracic kyphosis of the spine have considerable heritable component. Furthermore, lumbar lordosis is significantly associated with many of the features of LDD.

**Conclusion:** That the spine curves themselves are heritable suggests that a search for individual gene variants influencing curve would be a reasonable next step. This would inform the biology underlying the normal degenerative process and might throw light on the pathology of other scoliotic conditions.

## O207

### LIGATION OF LUMBAR ARTERIES INDUCES EXTRACELLULAR MATRIX CHANGES IN INTERVERTEBRAL DISCS AS SHOWN BY MRI T2-MAPPING AND HISTOLOGICAL

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**Introduction/Aim:** The intervertebral disc (IVD) is supplied by capillaries arising in the vertebral bodies and penetrating the subchondral bone. We hypothesized that reducing the blood supply to the lumbar spine causes micro-environmental changes within the lumbar IVD. We previously reported that diminished flow in the lumbar arteries created changes in MRI T2 values in corresponding IVDs in a rabbit lumbar artery ligation model. The purpose of this study was to evaluate MRI and histological

changes of the IVDs in this rabbit lumbar artery ligation model.

**Methods:** New Zealand White rabbits (n=20) were used in this study. Under general anesthesia, the abdominal aorta was exposed and the third and fourth lumbar arteries were double-ligated using vascular clips. The blood flow to the L3/L4 disc (the caudal disc) was reduced by ligation of the third lumbar artery and that of the L5/L6 disc by ligation of the fourth lumbar artery. The blood flow of the L4/L5 disc was lessened by ligation of both the third and fourth lumbar arteries. The L2/L3 disc was used as the control. At 4, 8 and 12 weeks after surgery, five rabbits per group were sacrificed and processed for T2-mapping (sagittal 3.0-MRI) and histological analyses.

**Results:** A significant reduction in the T2-value in caudal, bilateral and cranial discs was observed at 4 and 8 weeks after the surgery, compared to the control discs. Histologically, condensation of the extracellular matrix of the nucleus pulposus tissue was seen (p<0.01) The ligation of lumbar arteries significantly (p<0.05) affected the histological total score of corresponding IVDs.

**Discussion:** The results of the MRI and histological studies suggest that diminished flow in lumbar arteries affect changes in the extracellular matrix metabolism of the IVD.

## O208

### MULTIPARAMETRIC MAGNETIC RESONANCE IMAGING OF NORMAL AND DEGENERATIVE LUMBAR INTER-VERTEBRAL DISCS

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**Introduction:** Magnetic resonance imaging (MRI) has been shown to improve the diagnosis and management of patients with intervertebral disc (IVD) related disorders. Multiparametric MRI offers the possibility of noninvasively assessing multiple aspects of pathophysiological processes that exist simultaneously, thereby further assisting in patient treatment management. The purpose of this study is to determine the correlation between relaxation parameters (T1-rho and T2), diffusion properties including fractional anisotropy (FA) and mean diffusivity (MD) measured by diffusion tensor imaging (DTI), and degenerative grades in human IVD based on T2-weighted MRI.

**Methods:** Twenty-one subjects (mean age = 41.3 years; age range = 24–61 years; gender: 10 females, 11 males) with no prior spine surgery were recruited. Sagittal T2-weighted, T1-rho, T2, FA and MD MRI of the lumbar spine were obtained. All images of the lumbar spine were acquired using a 3T Achieva scanner. High-resolution T2-weighted discs were qualitatively graded by two spine specialists in consensus according to Schneiderman's classification (score range: 0 to 3). T1-rho, T2, FA and MD maps were quantitatively assessed based on a voxel-by-voxel basis.

**Results:** By visual inspection, the nucleus pulposus (NP) and annulus fibrosus (AF) in IVDs were distinctively separable on the all quantitative maps while some of the discs on T2-weighted images did not show a clear difference between the NP and the AF. The Schneiderman grades and subjects' age significantly correlated with all parameters (p<0.001). Univariate analysis demonstrated that T1-rho correlated significantly with MD and FA (r = 0.729 and -0.715, respectively; p<0.001 for both). Quantitative T2 also correlated significantly with MD and FA (r = 0.805 and -0.811, respectively; p<0.001 for both). In addition, T1-rho showed significant correlation with quantitative T2 (r = 0.824; p<0.001).

**Conclusions:** In this study, we performed quantitative multiparametric MRI to investigate its sensitivity to changes in tissue microstructure of *in vivo* human lumbar IVDs. Our results suggest that each imaging parameter may attribute different sensitivity to tissue properties.



## O209

**IS OVERWEIGHT ASSOCIATED WITH LOW BACK PAIN IN ADOLESCENCE?**

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**Introduction:** The association between obesity and low back pain (LBP) is a contentious issue. We evaluated whether persistent overweight increases the risk of LBP among adolescents in a prospective setting.

**Material and Methods:** The study population, the Oulu Back Study, was drawn from the Northern Finland Birth Cohort 1986. The final study sample in the analysis of body mass index (BMI) included 1,668 adolescents (56% females). The clinical subcohort of 790 subjects (57% females) was used in the analysis of waist circumference (WC) and body adipose tissue percentage (fat %). The area under the curve (AUC) method was used to assess BMI from 8 to 16 years and from 16 to 18 years, and WC from 16 to 19 years. Fat % was assessed at 19 years. The association of these measures with LBP during the past 6 months was evaluated separately for incident (reporting LBP at 18 but not at 16 years) and persistent LBP (reporting LBP at both time points). Relative risks (RR) and their 95% confidence intervals (95% CI) were adjusted for smoking, physical activity and family's socioeconomic status at 16 years and stratified by gender.

**Results:** BMI from 16 to 18 years (but not from 8 to 16 years) was associated with incident LBP (RR 1.09 per 2 kg/m<sup>2</sup>; 95% CI 1.00-1.18) among females but not among males. Among males, only WC was associated with incident LBP (RR 1.13 per 3 cm; 95% CI 1.00-1.27). Overweight was not associated with persistent LBP.

**Conclusion:** Overweight seems to be associated with incident LBP in adolescence although there are dissimilarities between genders.

## O210

**BELIEFS INFLUENCE PATIENTS' CARE-SEEKING BEHAVIOUR FOR LOW BACK PAIN**

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**Introduction:** Not all people suffering with low back pain (LBP) seek care for their problem. Pain intensity appears to be a consistent predictor of care-seeking behaviour, but accounts for only some of the variance; we hypothesised that beliefs about back pain may explain some of the remaining variance.

**Methods:** A questionnaire-booklet was mailed to a random sample of 2'860 individuals participating in an epidemiological study of musculoskeletal health. It contained: the Back Beliefs Questionnaire (BBQ), the Fear-Avoidance Beliefs Questionnaire (FABQ; activity-related and work-related scales), and questions about sociodemographics, LBP characteristics and LBP-related care-seeking in the last month ("yes" = visit to specialist, GP, physiotherapist, or other practitioner; "no" = none of these).

Stepwise multiple logistic regression was used to identify predictors.

**Results:** 2'507/2'860 (88%) individuals completed the questionnaire; 1'071 (43%) reported current LBP, 301 (28%) of which had sought care. In univariate analyses, sex, age, pain-intensity, pain-frequency, BBQ, limitations in everyday activities, FABQ-activity and FABQ-work scores were all significantly related to care-seeking (all p<0.01). In multiple regression, current pain (OR (95%CI) 1.593 (1.339-1.895), p <0.0001), limitations in everyday activities (OR 1.019 (1.008-1.030), p =0.001), female gender (OR 1.72 (1.23-2.41), p=0.002), and high FABQ-work scores (1.02 (1.005-1.040), p=0.011) contributed significantly to the final model.

**Conclusions:** "Inappropriate" (negative) beliefs were associated with increased care-seeking, even when controlling for current pain, limitations in everyday activities and gender. Educational interventions have previously been shown to influence beliefs and may represent a useful means of reducing the demand on our healthcare systems associated with LBP.

## O211

**CONSIDERABLE LONG TERM REDUCTION OF PAIN AND HEALTHCARE USE IN PATIENTS WITH CHRONIC LOW BACK PAIN AFTER A SHORT INTENSIVE PAIN MANAGEMENT PROGRAM**

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**Introduction:** While cognitive behavioral interventions are effective in treating patients with Chronic Low Back Pain (CLBP), the reported effects are small and short lived.

**Aim:** To evaluate the 2-year results of an intensive, cognitive behavioral pain management program for patients with CLBP. Moreover, to compare the 1-year results with best available evidence in spinal surgery<sup>1</sup> and rehabilitation programs<sup>2</sup>.

**Patients and Methods:** The 2-week residential program was conducted in collaboration with orthopedic surgeons and evaluated in a cohort study. Assessments: baseline, end of program, 1 month, 1 and 2-year follow-up. Outcomes: functioning, quality of life (QoL), and pain. Healthcare indicators, as measured at baseline and at 2-year follow-up: analgesic use and visits healthcare providers. Analyses: changes over time on outcomes using repeated measures manova. Effect sizes (Cohen's *d*), percentages reaching minimal clinical important difference (MCID), and percentages of improvement in indicators of healthcare use were calculated. To compare with literature relative rates of treatment improvement, Standardized Morbidity Ratios (SMR), were computed.

**Results:** Of the 107 patients, baseline average CLBP-duration 11 years, 90(84%) completed the 1-year and 85(79%) the 2-year follow-up. For all outcomes improvement immediately after the program was maintained. Large effect sizes were found for functioning (*d*=1.6) and QoL (*d*=1.4), and more than 65% reached preset MCID. Healthcare use reduced: at baseline all patients consulted their general practitioner and medical specialist at least once, whereas at follow-up 73% reported no visits to healthcare providers. Analgesic use decreased, and work participation increased from 68% to 81%. An SMR of 98% (spinal surgery) and 136% (rehabilitation program) was calculated.

**Conclusion:** Excellent and consistent results are shown in CLBP-patients who participated in this intensive program. They improved greatly in functioning, pain and QoL. Healthcare use decreased substantially and most of the patients are at work. In addition, the study results are comparable with results of spinal surgery and better than less intensive rehabilitation programs.



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**O212****SUBGROUPING PATIENTS WITH CHRONIC LOW BACK PAIN**

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**Introduction:** Chronic Low Back Pain (CLBP) is among the most common complaints why patients visit a spine surgeon. For surgeons it is a challenge to identify etiology and to implement an adequate treatment plan for. Therefore, guidelines<sup>1,2</sup> and a recently published systematic review<sup>3</sup> recommend to develop a system that helps to direct both surgical and nonsurgical interventions.

**Aim:** To develop a guideline for spine surgeons to decide which patients with CLBP should be seen in clinic, and subsequently which patients should be considered for an invasive or for non-invasive intervention.

**Patients and Methods:** A formal consensus method (Modified Delphi-procedure) in 4 steps was performed to select clinical relevant items for the decision tool. (1) Based on literature all items predicting (persistent) CLBP were listed and levels of evidence were assigned. (2&3) In two email-rounds with spine surgeons, anesthesiologists, rheumatologists, rehabilitation physicians, physical therapists, psychologists ( $n_{total} = 29$ ) the items were evaluated on clinical importance. (4) In a consensus meeting the list was finalized and a framework with arrangement of items in domains was constructed. In every Delphi-round a cut-off of  $\geq 70\%$  for acceptance of an item was set in advance.

**Results:** Based on the Delphi-method, five domains (sociodemographic, pain, somatic [red flags], psychological [yellow flags], and functioning & quality of life) were identified, and 28 of the initial 49 items (57%) were included. With these items a questionnaire was developed, including a Clinical Decision Guideline\_version1.0, which is relevant for decision-making and choice of intervention. The questionnaire is now implemented web-based in the patient-based tool of the Swedish Spine Register.

**Conclusion:** This is the first questionnaire and clinical decision guideline available, created with a rigorous scientific basis that is designed for patient-triage. We will present the questionnaire at Spineweek. We expect that this relatively simple tool, based on validated questionnaires and current evidence, will considerably help in daily spine practice to select the right patients for the right practitioners. By doing so we expect to increase clinic efficiency and improve outcomes. At present we are constructing a prospective consecutive cohort to validate the questionnaire and the clinical decision tool.

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**O213****THE EFFECT OF REQUIRED PHYSIATRIST CONSULTATION ON SURGERY RATES FOR BACK PAIN**

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**Introduction/Aims:** Spine surgery rates are highly variable by region and are increasing without evidence of a concordant decrease in the burden of disease. Efforts to curb misuse of surgery have not shown large changes, especially across different provider groups. As nonsurgical spine experts, physiatrists might provide patients with a different perspective on treatment options. This study was developed to determine whether an insurer rule requiring physiatrist consultation before non-urgent surgical consultation would affect surgery referrals and surgery rates.

**Methods:** This was a prospective interventional trial across multiple healthcare systems. In 2007 an insurer required patients with non-urgent spine surgical consultations in Western Michigan, USA to first have a single visit with a physiatrist, who received extra compensation for the assessment. Surgical consultation and surgical rates were compared between 2006–2007 and 2008–2010. An automated telephone survey of patients who had been evaluated by physiatrists was performed to assess patient satisfaction.

**Results:** After intervention, physiatry referrals increased 70%, surgical referrals decreased 48%, and the total number of spine operations dropped 25%, with concomitant decrease in advanced imaging (-17.7%) and spine care cost per insured person (-12.1%). While spinal fusion rates dropped, the percentage of fusion operations increased from 55% to 63% of all surgeries. No significant change in spinal injections or EMG testing was found, and similar changes were found for physiatrists employed by practices with surgeons vs. independent physiatrists. Of 740 patients surveyed (48% response rate), 74% were satisfied or very satisfied with the physiatry consultation. Only 40% of patients who had previous spine surgery were satisfied. Although surgical rates decreased at all regional hospitals and all surgical groups, there were substantial shifts in market share.

**Discussion/Conclusion:** Mandatory physiatrist consultation prior to surgical consultation resulted in decreased surgical rates and back pain cost, with continued patient satisfaction, across a large region.



O214

### TOTAL DISC REPLACEMENT FOR CHRONIC LOW-BACK PAIN: A COCHRANE REVIEW

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**Introduction/Aim:** The aim of this systematic review was to assess the effect of total disc replacement for chronic low back pain due to lumbar degenerative disc disease.

**Materials and Methods:** A comprehensive search in CENTRAL, MEDLINE, EMBASE, BIOSIS, ISI, FDA and CBRG databases was conducted. Reference lists and citation tracking results of included studies were checked. Randomized controlled trials (RCTs) comparing disc replacement with any other intervention were included. Risk of Bias was assessed using Cochrane criteria. Quality of evidence was graded according to the GRADE approach. Two authors independently selected studies, assessed risk of bias of the studies and extracted data.

**Results:** We included seven RCTs with a follow-up of 24 months, with only one extended to five years. There was a high risk of bias in the included studies due to sponsoring, absence of blinding, and inadequate or unclear techniques for randomization and allocation concealment. Six studies compared disc replacement against fusion and found that the mean Improvement in Oswestry score was 4.3 (95% CI 1.9 to 6.7) higher in the disc replacement group at 24 months with a low quality of evidence. Choice of control group (circumferential or anterior fusion) did not result in different outcomes. One study compared disc replacement against rehabilitation and found a difference of 6.9 points (95% CI 2.1 to 11.7) on the Oswestry score favoring disc replacement. Changes in pain scores were not consistently reported.

**Discussion:** Although significant, the short-term differences in Oswestry score improvement were small and not beyond the generally accepted clinically important differences.

**Conclusion:** Total disc replacement seems to have limited clinical advantage over fusion with to date unclear long-term effects. This intervention should only be used in controlled settings until these effects are clear.

O215

### WHO SHOULD HAVE SURGERY FOR SPINAL STENOSIS? TREATMENT EFFECT PREDICTORS IN SPORT

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**Introduction:** SPORT demonstrated a positive surgical treatment effect (TE) for spinal stenosis (SpS) at the group level. However, individual characteristics may affect TE. No prior studies have evaluated TE modifiers in SpS.

**Aim:** To determine modifiers of the TE of surgery (the difference between surgical and nonoperative outcomes) for SpS using subgroup analysis.

**Patients and Methods:** The study design was a combined prospective randomized controlled trial and observational cohort study of SpS with an as-treated analysis. SpS patients were treated with either surgery (n=419) or nonoperative care (n=235) and were analyzed according to treatment received. Fifty-three baseline variables were used to define subgroups for calculating

the time-weighted average TE for the Oswestry Disability Index (ODI) over 4 years ( $TE = \Delta ODI_{surgery} - \Delta ODI_{nonoperative}$ ). Variables with significant subgroup by\* treatment interactions ( $p < 0.05$ ) were simultaneously entered into a multivariate model to select independent TE predictors.

**Results:** Other than smokers, all analyzed subgroups including at least 50 patients improved significantly more with surgery than with nonoperative treatment ( $p < 0.05$ ). Multivariate analysis demonstrated: baseline ODI  $\leq 56$  (TE -15.0 vs. -4.4 ODI  $> 56$ ,  $p < 0.001$ ), not smoking (TE -11.7 vs. -1.6 smokers,  $p < 0.001$ ), neuroforaminal stenosis (TE -14.2 vs. -8.7 no neuroforaminal stenosis,  $p = 0.002$ ), predominant leg pain (TE -11.5 vs. -7.3 predominant back pain,  $p = 0.035$ ), not lifting at work (TE -12.5 vs. -8.5 lifting at work,  $p = 0.017$ ), and the presence of a neurological deficit (TE -13.3 vs. -7.2 no neurological deficit,  $p < 0.001$ ) were associated with greater TE.

**Conclusion:** With the exception of smokers, patients who met strict inclusion criteria improved more with surgery than with nonoperative treatment, regardless of other specific characteristics. However, TE varied significantly across certain subgroups, and these data can be used to individualize shared decision making discussions about likely outcomes. Smoking cessation should be considered prior to surgery for SpS.

O216

### POOR SURGICAL OUTCOMES OF LUMBAR SPINAL STENOSIS WITH DEPRESSION - A COHORT STUDY

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**Introduction:** Preoperative depression relates to poor surgical outcomes among lumbar surgery. The purpose of this study was to examine an influence of depression on QOL and surgical outcomes in lumbar spinal stenosis patients.

**Materials and Methods:** The objective of this study was 102 consecutive patients with lumbar spinal stenosis who received decompression surgery. Numerical rating scales (NRS:0-10) of low back pain, leg pain, leg numbness, Roland-Morris disability questionnaire (RDQ), short form-36 (SF-36) were evaluated before and 1 year after surgery prospectively. Satisfaction rate was also evaluated (unsatisfied: 0 - very satisfied: 10). Self-Rating Questionnaire for Depression (SRQ-D) was evaluated before surgery for detecting depression. The objectives were divided into two groups with or without depression (depression was defined as SRQ-D  $> 10$ ). NRS, satisfaction rate, RDQ and SF36 were compared between two groups. Statistical analysis was performed by Mann-Whitney's U test and paired t-test. A p value less than 0.05 was considered significant.

**Results:** Depression was revealed in 22 patients by SRQ-D before surgery. There were no significant differences in preoperative NRS of low back pain, leg pain, leg numbness, physical functioning (PF), bodily pain (BP), social functioning (SF) and physical component summary (PCS) of SF36. RDQ deviation score, role physical (RP), general health perception (GH), vitality (VT), role emotional (RE), mental health (MH), and mental component summary (MCS) were lower in patients with depression. These results indicated that QOL was worse in stenosis patients with depression. One year after surgery, NRS of low back pain and leg numbness were higher in patients with depression. Satisfaction rate was significantly lower. The scores of RDQ, RF, RP, BP, SF, GH, VT, RE, MH, and MCS were significantly lower in the patients with depression compared with the patients without depression. In patients without depression, NRS of symptoms, RDQ, and PF, RP, BP, VT, SF, RE, MH, and MSC scores in SF36 were improved 1 year after surgery. Patients with depression showed no significant improvements in symptoms and QOL scores.

**Discussion:** The results of this study suggested that preoperative depression related to low QOL and poor surgical outcomes. It is important to evaluate the state of depression before surgery.





O217

**SPORT PREDICTORS OF TREATMENT EFFECT IN DEGENERATIVE SPONDYLOLISTHESIS**Pearson A.M.<sup>1,2</sup>, Lurie J.D.<sup>1,2</sup>, Tosteson T.D.<sup>2</sup>, Zhao W.<sup>1,2</sup>, Abdu W.A.<sup>1,2</sup>, Weinstein J.N.<sup>1,2</sup><sup>1</sup>Dartmouth Medical School, Hanover; <sup>2</sup>The Dartmouth Institute for Health Policy and Clinical Practice, Hanover, USA

**Introduction:** The treatment effect of surgery (TE) may vary with patient and disease characteristics. While the Spine Patient Outcomes Research Trial (SPORT) demonstrated a significant advantage for surgery at 4 years for the "average" degenerative spondylolisthesis (DS) patient meeting specific inclusion criteria, we hypothesized that certain subgroups might benefit more or less from surgery relative to nonoperative treatment.

**Aims:** To determine if TE varied across subgroups in order to identify patients with specific characteristics that could predict TE and aid in decision-making.

**Patients and methods:** 601 DS patients with radiculopathy and/or claudication lasting at least 12 weeks were enrolled, and 395 had undergone surgery within 4 years. The others were treated exclusively nonoperatively. Fifty-five baseline variables were used to define subgroups for calculating the time-weighted average TE for the Oswestry Disability Index (ODI) over 4 years ( $TE = \Delta ODI_{\text{surgery}} - \Delta ODI_{\text{nonoperative}}$ ). Variables with substantial subgroup\*treatment interactions ( $p < 0.05$ ) in minimally adjusted analyses were simultaneously entered into a multivariate model to select independent TE predictors ( $p < 0.05$ ).

**Results:** All subgroups including at least 50 patients improved significantly more with surgery than with nonoperative treatment ( $p < 0.05$ ). Multivariate analyses demonstrated that age  $\leq 67$  (TE -15.7 vs. -11.8 for age  $> 67$ ,  $p = 0.014$ ), female gender (TE -15.6 vs. -11.2 for males,  $p = 0.01$ ), the absence of stomach problems (TE -15.2 vs. -11.3 for those with stomach problems,  $p = 0.035$ ), neurogenic claudication (TE -15.3 vs. -9 for those without claudication,  $p = 0.004$ ), reflex asymmetry (TE -17.3 vs. -13.0 for those without asymmetry,  $p = 0.016$ ), opioid use (TE -18.4 vs. -11.7 for those not using opioids,  $p < 0.001$ ), not taking antidepressants (TE -14.5 vs. -5.4 for those on antidepressants,  $p = 0.014$ ), dissatisfaction with symptoms (TE -14.5 vs. -8.3 for those satisfied or neutral,  $p = 0.039$ ), and anticipating a high likelihood of improvement with surgery (TE -14.8 vs. -5.1 for anticipating a low likelihood of improvement with surgery,  $p = 0.019$ ) were independently associated with greater TE.

**Conclusion:** While DS patients improved more with surgery than with nonoperative treatment, TE varied significantly across subgroups.

O218

**THE EFFICACY AND FEASIBILITY OF A PROSTAGLANDIN E1 DERIVATIVE IN PATIENTS WITH LUMBAR SPINAL STENOSIS; A MULTICENTER, DOUBLE BLINDED, RANDOMIZED COMPARATIVE STUDY WITH ACECLOFENAC**Lee H.M.<sup>1</sup>, Kim D.J.<sup>2</sup>, Shin D.E.<sup>3</sup>, Moon S.H.<sup>1</sup>, Suk K.S.<sup>4</sup>, Park S.Y.<sup>5</sup><sup>1</sup>Dept. of Orthopaedic Surgery, Yonsei University, Severance Hospital, Seoul; <sup>2</sup>Dept. of Orthopaedic Surgery, Ewha Womens University, Mokdong Hospital, Seoul; <sup>3</sup>Dept. of Orthopaedic Surgery, Cha University, Cha Hospital, Seoul; <sup>4</sup>Dept. of Orthopaedic Surgery, Kyunghee University, Medical Center, Seoul; <sup>5</sup>Dept. of Orthopaedic Surgery, Korea University, Anam Hospital, Seoul, Korea

**Introduction:** Lumbar spinal stenosis (LSS) most commonly affects elderly population and its symptoms are back pain, leg pain and neurologic claudication. Nonsurgical treatment is usually used in patients with mild and moderate symptoms of LSS. As far as drug therapy is concerned, only NSAIDs have been administered. Oral PGE1 derivatives is a vasodilator and increases blood flow and inhibits platelet aggregation. There has been little evidence about the effectiveness of PGE1 derivatives in patients with LSS. We performed this study for comparing the clinical effects and utility of 8 weeks of NSAIDs with PGE1 in patients with LSS

**Materials and Methods:** We performed a multicenter, double blinded, randomized comparative trial in which patients with LSS over 50 year-old as confirmed by MRI were randomly assigned to PGE1 group (PG) or Aceclofenac group (AC). Outcomes were assessed at initial and at 4th and 8th weeks. The primary outcome was the changes of walking distance (treadmill test) until onset of symptoms. The secondary outcomes were the pain relief at back, leg and leg numbness using VAS and the functional improvements using ODI.

**Results:** A total of 116 patients were enrolled, and 94 (47 of 59 in PG and 47 of 57 in AC) completed the 8 weeks follow up. (82%) In terms of differences between baseline and 8-week, PG group showed significant improvement walking distance, compared to AC group. Regarding cauda equina symptoms and functional improvement, both groups showed significant improvements between baseline and 8-week, but there was no significant difference between two groups. No serious adverse effects were reported in either group.

**Conclusion:** In this study, PG E1 was found to be more effective on the improvement of walking distance compared to Aceclofenac. And it also showed the comparative improvement of pain and functional outcomes of patients with LSS. Therefore, PG E1 can be considered to a likely candidate for drug therapy in patients with LSS.

O219

**THERAPEUTIC EFFICACY OF PREGABALIN FOR PATIENTS WITH LEG SYMPTOMS DUE TO LUMBAR SPINAL STENOSIS**Takahashi N.<sup>1,2</sup>, Arai I.<sup>1</sup>, Kayama S.<sup>1</sup>, Ichiji K.<sup>1</sup>, Fukuda H.<sup>1,2</sup>, Kaga T.<sup>1,2</sup>, Konno S.<sup>2</sup><sup>1</sup>Dept. of Orthopaedic Surgery, Southern TOHOKU General Hospital, Koriyama City; <sup>2</sup>Dept. of Orthopaedic Surgery, Fukushima Medical University School of Medicine, Fukushima City, Japan

**Introduction:** Pregabalin (PGB) is a well-accepted treatment for patients with neuropathic pain. However, the efficacy of PGB for patients with lumbar spinal stenosis (LSS) remains unknown. The aim of this study was to analyze the efficacy of PGB for patients with LSS.

**Methods:** A total of 162 patients (mean age, 67.9 years) presenting



with LSS between 2009 and 2011 were divided into two groups, a PGB group (n=62; 29 males, 33 females) and a Control group (n=60; 30 males, 30 females). Patients in the PGB group were treated with both non-steroid anti-inflammatory drugs (NSAIDs) and PGB, while patients in the Control group were treated with only NSAIDs. Demographics and clinical characteristics between patients in the two groups were not significantly different. Inclusion criteria and exclusion criteria were defined in this study. We compared the two groups in terms of a) the duration of pain, i.e., within, or more than, three months after leg symptoms were evoked, and b) the type of neurogenic intermittent claudication (NIC), i.e., radicular, caudal or mixed. Numerical Rating Scale (NRS) and Roland-Morris Disability Questionnaire (RDQ) scores were examined before and after three months of treatment. The change in NRS was classified into three grades: Grade 1, NRS increased by more than two points (aggravation); Grade 2, NRS changed by less than two points (unchanged); and Grade 3, NRS decreased by more than two points (recovery).

**Results:** There was a significantly greater number of Grade 3 cases in the PGB group than in the Control group ( $p=0.027$ ). Over three months after leg symptoms were evoked, there was a significantly greater number of Grade 3 cases in the PGB group than in the Control group ( $p=0.049$ ). There was no statistically significant difference between the groups regarding radicular- and caudal-type NIC. For mixed-type NIC, however, there was a greater number of Grade 3 cases and a fewer number of Grade 1 cases in the PGB group compared to the Control group ( $p=0.043$ ). The RDQ score for the PGB group was significantly lower than that for the Control group ( $p<0.001$ ).

**Conclusion:** Treatment using both NSAIDs and PGB was more effective for relief of leg symptoms due to LSS compared with treatment using only NSAIDs in the chronic phase over three months after symptoms were evoked, and prevented aggravation of subjective symptoms in patients with mixed-type NIC.

## O220

### MAGNITUDE OF DURAL TUBE COMPRESSION DOES NOT SHOW A PREDICTIVE VALUE FOR SYMPTOMATIC LUMBAR SPINAL STENOSIS FOR ONE YEAR FOLLOW-UP: A PROSPECTIVE COHORT STUDY

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**Introduction:** It is well known that dural tube compression is necessary for lumbar spinal stenosis (LSS), however, dural tube compression do not always show symptom. The purpose of this study was to assess the relationship between the magnitude of dural tube compression on MRI and LSS symptom for longitudinal follow-up.

**Methods:** Four-hundred and fifty-nine people agreed to participate and were interviewed and received conventional MR imaging of lumbar spine. The presence of LSS was assessed by a specially designed questionnaire (Sensitivity 0.84, Specificity 0.78, BMC Musculoskel Disord 2007). Roland-Morris Disability Questionnaire (RDQ) and SF-36 were also evaluated. The dural sac cross-sectional area (L1/2 - L5/S1) on T2 weighted image was measured by using conventional method described by Hamanishi (J Spinal Dis 1994). After one year, 355 people (follow-up rate 77.3%) could be assessed for LSS using the same questionnaire. There were no patients who received operation of LSS for one year.

**Results:** 1) Twenty-seven of 48 people (56.3%) were judged as LSS positive in less than 25mm<sup>2</sup> of the smallest dural tube area, 27 of 102 (26.5%) in 25-49.9 mm<sup>2</sup>, 32 of 108 (29.6%) in 50-74.9 mm<sup>2</sup>, 17 of 76 (22.4%) in 75-99.9 mm<sup>2</sup> and 25 of 125 (20%) in more than 100mm<sup>2</sup>, respectively. These results indicated that

the severe dural tube compression did not always show clinical symptom of LSS.

2) By a multiple logistic regression analysis, only two factors, the presence of LSS (Odds ratio 4.925) and normative value of RDQ score at the first year (Odds ratio 4.304), statistically influenced on the presence of LSS at one-year follow-up.

**Conclusion:** For one-year follow-up, magnitude of dural tube area (mm<sup>2</sup>) did not affect the presence of LSS directly. Further studies are needed to clarify the relationship between symptomatic and asymptomatic groups that show dural tube compression anatomically.

## O221

### A RANDOMIZED TRIAL OF BALLOON KYPHOPLASTY AND NON-SURGICAL MANAGEMENT FOR TREATING ACUTE VERTEBRAL COMPRESSION FRACTURES: VERTEBRAL BODY KYPHOSIS CORRECTION AND SURGICAL PARAMETERS

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**Background:** Vertebral fractures (VCF) are often painful and lead to reduced quality of life (QOL). We compared the efficacy and safety of balloon kyphoplasty (BKP) to non-surgical management (NSM) over 24 months in patients with acute painful fractures.

**Methods:** Adults with one to three VCF were randomized within 3 months from onset of pain to undergo bilateral BKP (n=149) or NSM (n=151). Subjective QOL assessments (e.g., SF-36 PCS) and objective functional (Timed up and go [TUG]) and vertebral body kyphotic angulation (KA), were assessed over 24 months; we also report surgical parameters and adverse events temporally related to surgery (i.e. within 30-days).

**Results:** Kyphoplasty was associated with greater improvements in SF-36 PCS scores when averaged across the 24-month follow-up period, compared with NSM (overall treatment effect 3.24 points, 95% CI, 1.47–5.01;  $p=0.0004$ ). Kyphoplasty also resulted in greater functionality by assessing TUG (overall treatment effect -3.00 seconds, 95% CI,  $\square$ 1.0 to  $\square$ 5.1;  $p<0.0043$ ). At 24 months, the change from baseline in KA was statistically significantly improved in the kyphoplasty group (average 3.1° of correction for BKP versus 0.8° for NSM,  $p=0.003$ ). On average, IBT inflation pressures were 178 (left) and 180 (right) psi; IBT inflation volumes were consistent with cement volumes at 2.4 cc per side. The most common adverse events within 30-days were back pain (20 BKP, 10 NSM) new vertebral fracture (11 BKP, 7 NSM), nausea/vomiting (12 BKP, 4 NSM) and UTI (10 BKP, 3 NSM). There were two device-related serious adverse events in the second year that occurred at index vertebrae (a spondylitis and an anterior cement migration).

**Conclusion:** Compared with NSM, BKP improves patient function and QOL when averaged over 24-months and results in better improvement of index vertebral body kyphotic angulation.



O222

### COST-BENEFIT ANALYSIS OF TREATMENTS FOR VERTEBRAL COMPRESSION FRACTURES

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**Introduction:** Vertebral compression fractures (VCFs) can be treated by nonsurgical management or by minimally invasive surgical treatment including vertebroplasty and balloon kyphoplasty. This study sought to characterize the cost to society for treating VCF diagnosed patients by nonsurgical management, vertebroplasty, or kyphoplasty. We hypothesized that surgical treatments for VCFs using vertebroplasty or kyphoplasty would be a cost-effective alternative to nonsurgical management for the Medicare patient population.

**Methods:** Cost per life year gained for VCF patients in the U.S. Medicare population was compared between operated (kyphoplasty and vertebroplasty) and non-operated patients and between kyphoplasty and vertebroplasty patients, all as a function of patient age and gender. Life expectancy was estimated using a parametric Weibull survival model (adjusted for comorbidities) for 858,978 VCF patients in the 100% Medicare dataset (2005-2008). Median payer costs was identified for each treatment group for up to 2 years following VCF diagnosis, based on 67,018 VCF patients in the 5% Medicare dataset (2005-2008). A discount rate of 3% was used for the base case in the cost-benefit analysis, with 0% and 5% discount rates used in sensitivity analyses.

**Results:** After accounting for the differences in median costs and using a discount rate of 3%, the cost per life year gained for kyphoplasty and vertebroplasty patients ranged from \$1,674 to \$6,324 and from \$2,086 to \$11,926, respectively, compared with non-operated patients.

**Discussion:** Among patients for whom surgical treatment was indicated, kyphoplasty was found to be cost-effective, and perhaps even cost saving, compared to vertebroplasty. Even for the oldest patients, greater than 85y in age, both interventions would be considered cost-effective in terms of cost per life year gained (LYG).

**Conclusion:** The results of this study are expected to be useful in the ongoing public policy debate regarding the future role of surgical treatment in the management of VCF patients. As available resources for new innovations in health care become increasingly scarce, public discourse should center on cost and utility, not simply cost. In this regard, the evidence from the present study would suggest that vertebral fracture treatments appear to be cost effective when applied in the Medicare population.

O223

### PATHOGENIC FACTORS AFFECTING BACK PAIN AND DELAYED NEUROLOGIC PARALYSIS IN PATIENTS WITH OSTEOPOROTIC VERTEBRAL COLLAPSE

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**Background:** Late collapse after osteoporotic vertebral fracture (OVF) has some unclear points regarding the pathophysiology. We retrospectively reported case series and analyzed the pathogenesis of delayed nerve palsy and pain after OVF.

**Materials and Methods:** We investigated 66 cases of delayed paralysis and pain after OVF. The paralysis was divided into five types: spinal cord (EM); conus (CON); cauda equina (CE); nerve

root (SNR); mixed (MIX). The degree of paralysis was determined using Frankel classification. Lower back pain (LBP) when standing erect was evaluated using VAS scale. We evaluated existence of leg pain. CT was used to measure the area of the remained spinal canal (Area R) and the occupancy ratios of bony fragments (RBO).  $\Delta$ WR and  $\Delta$ angle expressed as changes in vertebral wedging rate and changes in Cobb angle respectively were measured with radiographs in supine and sitting forward bending position. We investigated the relationship among delayed paralysis and pain and each clinical and radiological factor.

**Results:** The type of paralysis; EM: 6 cases, CON: 6 cases, CE: 3 cases, SNR: 18 cases, MIX: 11 cases, and only pain and numbness: 25 cases. The degree of paralysis; C: 14 cases, D: 27 cases, and E: 25 cases. The degree of nerve palsy significantly associated with low Area R, low RBO, and low LBP. There were 29 Patients with SNR (42%) which risk factor was high  $\Delta$ angle. Average VAS was 62.3 mm which was significantly related with high RBO and tended to be associated with high  $\Delta$ WR. Existence of leg pain was significantly associated with high  $\Delta$ angle, low degree and SNR type of paralysis, and tended to be associated with high  $\Delta$ WR.

**Discussion:** The relationship between RBO and delayed nerve palsy after OVF has been reported, and supported by this study. Although there was no relationship between local instability and nerve palsy, the type of SNR that was high incidence was associated the local instability. LBP when standing erect and leg pain were related to spinal instability.

**Conclusions:** Because majority of patients with osteoporotic vertebral collapse showed radiculopathy, it is important to consider the treatment options regarding this pathophysiology.

O224

### IMPACT OF INITIAL TREATMENT INTERVENTIONS ON THE PATIENT OUTCOME IN OSTEOPOROTIC VERTEBRAL FRACTURE

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**Introduction:** The treatments for osteoporotic vertebral fracture (OVF) have not been clearly established. We performed a prospective multicenter study to examine whether initial treatment interventions for OVF influence patient outcomes.

**Materials and Methods:** A total of 382 OVF patients (63 men and 319 women; mean age, 76.3 years) from 25 institutes were enrolled in this clinical study. All the patients were treated conservatively without any surgical intervention. The patient outcomes were evaluated at 6 months after fracture on the basis of QOL (SF-36), ADL (the Japanese long-term care insurance system), back pain (VAS), cognitive status (MMSE), nonunion (the presence of an intravertebral cleft), and vertebral collapse, which were used as the response variables. Further, type of corsets, hospitalization, painkillers after injury, and osteoporosis drugs after injury were the explanatory variables in treatment interventions. To evaluate the independent effects of treatment interventions on patient outcome, we performed multivariate logistic regression analysis and obtained odds ratios (OR) adjusted for potential confounding effects of age, sex, level of fracture, presence of middle column injury, pain VAS at enrollment, and previous use of steroid.

**Results:** The treatment intervention factor significantly affecting the patient outcomes was hospitalization, which was associated with reduced ADL (adjusted OR, 2.78). There was no significant difference in the type of corsets. In the adjusting factors, presence of middle column injury was significantly associated with prolonged back pain, reduced ADL, nonunion, and vertebral



collapse (OR = 1.75, 2.20, 3.60, and 2.41, respectively). A vertebral fracture in the thoracolumbar spine was significantly associated with nonunion, and male sex was significantly associated with deterioration of cognitive status (OR = 5.52 and 3.12, respectively). No other examined variables were significant risk factors for patient outcomes.

**Discussion:** This study proved that type of corsets, except plaster body cast, did not affect the patient outcomes at 6 months after OVF. The presence of middle column injury was a significant risk factor common to both clinical and radiological outcomes. In future, the problem of establishment of a systematic treatment for cases with middle column injury needs to be addressed.

## O225

### PATHOMECHANISM OF INTRAVERTEBRAL CLEFTS IN OSTEOPOROTIC COMPRESSION FRACTURES OF THE SPINE

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**Study Design:** MR-angiography and histologic findings of the segmental artery and vertebral body in delayed posttraumatic vertebral collapse were investigated.

**Objectives:** To clarify pathomechanism of delayed posttraumatic vertebral collapse with intravertebral vacuum cleft (IVC).

**Summary and Background Data:** Delayed vertebral collapse with IVC is not an uncommon in osteoporotic vertebral compression fracture. However, the pathomechanism is poorly understood, although the current hypothesis is indicated bone ischemia.

**Methods:** Preoperative evaluation using MR-angiography and CT were performed in 22 patients. Among of 22 patients 12 patients underwent corpectomy and anterior interbody fusion. Out of 12 patients undergone surgical intervention, biopsy was performed for left segmental artery in 5 patients. Bone surrounding IVC in 12 patients were harvested and microscopically observed.

**Results:** MR-angiography demonstrated occlusion of bilateral segmental artery in 9 of 22 patients. Seven patients showed occlusion of unilateral segmental artery. Six patients showed no occlusion of a segmental artery. Microscopically left segmental artery in three patients was completely obstruction by thrombosis. Histologic examination of necrotic bone shows fragile trabecular bone and sparse osteocytes.

**Conclusion:** The delayed collapse of vertebral body with IVC might be caused by occlusion of the segmental artery, resulting in ischemic necrosis of the vertebral body.

## O226

### ACUTE PROXIMAL JUNCTIONAL FAILURE FOLLOWING LONG POSTERIOR FUSION FOR SPINAL DEFORMITY: RISK FACTORS AND RADIOGRAPHIC ANALYSIS COMPARING THORACOLUMBAR TO UPPER THORACIC FAILURES

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**Introduction:** Acute proximal junctional failure (APJF) is a challenging complication following spinal deformity surgery. Recent data indicates APJF is not a homogeneous entity; multiple etiologies exist for APJF. Little data exists comparing APJF in the thoracolumbar spine (TL-APJF) to APJF in the upper thoracic spine (UT-APJF). Purpose: identify demographic and radiographic characteristics of patients suffering TL-APJF vs. UT-APJF.

**Materials and Methods:** Multi-center, retrospective analysis of spinal deformity patients suffering APJF within 6 months of posterior instrumented fusion >4 levels. APJF defined as 15 degree postop increase in kyphosis between upper instrumented vertebra (UIV) and UIV+2, fracture of UIV or UIV+1, or need for proximal extension of fusion. TL-APJF= failures between T7-L2; UT-APJF = failures between T1-6. APJF etiology defined as fracture (FX), soft tissue failure (ST), or UIV fixation failure (UFF). Demographic, operative and radiographic parameters were evaluated.

**Results:** 63 patients, mean age 65 years (range 14-81), mean fusion levels 9.1 (range 4-17), met inclusion criteria. TL-APJF were older, had fewer fusion levels, and greater change in lumbar lordosis (LL) vs. UT-APJF (p<0.05; Table). Preop to postop changes in UIV/UIV+2 angle, sagittal vertical axis (SVA), pelvic incidence (PI), and pelvic tilt (PT) were similar TL-APJF vs. UT-APJF (table). FX was most common failure mode in TL-APJF, ST was most common in UT-APJF (p<0.05; table). FX were older than ST (69.2 vs. 58.4, respectively; p<0.05). Change in UIV/UIV+2, SVA, PI, PT and LL were similar between FX and ST. Time of APJF onset and body mass index (BMI) was similar TL-APJF vs. UT-APJF and FX vs. ST.

**Conclusion:** APJF following spinal deformity surgery is a heterogeneous complication. Discrete considerations include level of UIV and mode of failure. Older patients and constructs with UIV in the TL spine most commonly fail via vertebral fracture while younger patients and constructs with UIV in the UT spine fail through soft tissue. Further research is needed to delineate effective preventative measures.



## O227

**LUMBAR DISC HEIGHT DISTRIBUTIONS DURING TORSION**

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**Introduction:** Spinal torsion cannot be described with planar images. Instead of linear disc height (DH) measurements, true quantification of the intervertebral gap is achieved with a DH distribution, which can be then used to describe positions other than supine. The objective of this study was to analyze disc distribution patterns during torsion *in vivo*.

**Methods:** Eighty-one volunteers were CT-scanned both in supine and in right 50° rotation positions (IRB-approved, 23-59 y.o.). Virtual models of each intervertebral gap representing the disc were created with the inferior endplate of each 'disc' set as the reference surface and separated into five anatomical zones: four peripheral and one central, corresponding to the footprint of the annulus fibrosus and nucleus pulposus, respectively. DHs in both positions were compared with ANOVA, with significance set at  $p < 0.05$ .

**Results:** Mean neutral DH was  $7.32 \pm 1.59$  mm. With 50° rotation, a small but significant increase to  $7.44 \pm 1.52$  mm ( $p < 0.0002$ ) was observed. The right side showed larger separation in most levels, except at L5/S1. The posterior and right zones increased in height from neutral to rotated position of the spine ( $p < 0.0001$ ), while the left, anterior and central decreased. On average, the height of each lumbar IVD during rotation was greater than its height while the spine was neutral.

**Discussion:** Overall, mean DH increases with rotation. Additionally, torsion causes DH increases in the peripheral zones. With rotation to the right, disc height in the right lateral zone increase opposed a decrease in the left lateral zone. Similarly, the posterior zone increased while the anterior zone decreased. This might be caused by the specific structural configuration of the spine at such levels, especially the facet joints orientation and segmental lordosis.

**Conclusion:** This study quantified important tensile/compressive changes in DH during torsion. The implications of these mutually opposing changes on facet contact mechanics are still unknown. Future studies could implement this deformation data in disc strain analyses.

## O228

**MILD DEGENERATION DECREASES VISCOELASTIC MODULI OF THE NUCLEUS PULPOSUS IN A LARGE ANIMAL MODEL**

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**Introduction:** Intervertebral disc (IVD) degeneration is an important target for regenerative strategies. Biomechanical properties of both the healthy and degenerated nucleus pulposus (NP) should be considered in the development of replacement materials. The objective of this study was to determine viscoelastic and mechanical characteristics of the NP in normal and mildly degenerated discs in a goat model.

**Methods:** In eight adult Dutch milk goats, three lumbar IVDs were chemically degenerated using Chondroitinase ABC (CABC), confirmed with radiography and MRI. After sacrificing, neutral zone (NZ) stiffness and range of motion (ROM) were determined sagittally, laterally and rotationally using a mechanical testing device. After frozen storage and subsequent thawing, the NPs were isolated with a trephine and oscillatory shear experiments

were performed on a stress-controlled rheometer in parallel plate configuration. The elastic and viscous shear modulus follow from the ratio between shear stress and strain.

**Results:** Disc height on radiographs and signal intensity on MRI were significantly lower (6% and 22%) after CABC treatment. CABC-injected IVDs in lateral bending and axial rotation had significantly lower NZ stiffness and larger ROM than controls. In rheometry, large inter-animal differences were observed (shear modulus ~12-41 kPa). However, within goats, the elastic and viscous modulus were significantly lower (10-12%) after mild degeneration. The loss tangent, indicating energy dissipation, remained constant.

**Discussion:** In mild disc degeneration, loss of disc height and MRI changes, decreased NZ stiffness and increased ROM have all been described, corroborating our model. Viscoelastic moduli of the degenerated goat NP have not been reported before and seem to lie in range within human values. A significant, yet small decrease in shear moduli was observed after mild degeneration, compared to the relatively large inter-animal variation. From a tissue engineering perspective, this observation suggests that changes due to mild degeneration seem less important when developing NP replacement materials.

## O229

**FLEXIBILITY TESTING OF LUMBAR SPINE FUNCTIONAL SPINAL UNITS USING A ROBOT/UPS TESTING SYSTEM**

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**Introduction/Aim:** In-vitro biomechanical testing is widely performed, however differences in testing apparatuses, loading conditions, etc. have made findings of different groups difficult to compare. Unconstrained, pure-moment loading in the three primary degrees of freedom (DOF) has been recommended as a standardized protocol. Traditional robotic "hybrid control" utilizes feedback from a 6DOF load cell to modify displacement control and permits active control of all loads experienced by the specimen. The minimization of off-axis loads and updating center of rotation (COR) calculations allow the application of pure moments and determine the specimen's preferred motion path. Previous reports have validated the efficacy of robotics-based testing system's ability to apply a (standard) pure moment. However, it is still unclear if this method, which is fundamentally different from traditional testing methods, can produce kinetics comparable with average literature values.

**Materials and Methods :** Specimens were mounted using clinical pedicle screws in the testing system that consists of a robotic manipulator (Staubli RX90) and an on-board six-axis load cell (JR3 Inc). The robot operates under hybrid (adaptive displacement) control to simulate a flexibility test (6.0 Nm maximum). Prior to testing N=2 fresh-frozen human lumbar spines (41+/-9.9yrs) were sectioned into functional spinal units (FSUs), L3-4 and L5-S1. The specimens were subjected to three cycles of flexion/extension (FE), axial rotation (AR) and lateral bending (LB) and range of motion (ROM, mean+/-SEM) of the (preconditioned) third cycle were recorded using an optical tracking system (VICON 460).

**Results:** Composite segmental ROM as recorded by the optical tracking system equaled FE= $9.82 \pm 1.32$ , AR= $3.97 \pm 0.65$ , LB =  $8.87 \pm 1.12$  degrees. L3-4 equaled FE= $9.07 \pm 3.10$ , AR= $3.39 \pm 1.46$ , LB =  $10.01 \pm 0.25$  degrees. L5-S1 equaled FE= $10.58 \pm 3.01$ , AR= $4.54 \pm 1.30$ , LB =  $7.73 \pm 3.11$  degrees.

**Discussion:** The individual and composite ROM for L3-4 and L5-S1 FSU fell within one standard deviation of the average ROM reported by White and Panjabi (1990) for all DOFs.

**Conclusion:** The results provide evidence for continued utilization and development of robot-based spine testing systems.



O230

### SAGITTAL LUMBAR AND PELVIC ALIGNMENT IN STANDING AND SITTING POSITION IN ADULTS

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**Introduction:** Previous studies on spinal sagittal alignment in the sitting position mainly focused on lumbar alignment without pelvic alignment with no discussion of gender difference. Therefore, we set out to elucidate the differences in sagittal lumbar and pelvic alignment between the standing and sitting positions in men and women.

**Materials and Methods:** We investigated the relationships between sagittal lumbar and pelvic alignment between the standing and sitting positions in 50 healthy adults. The following parameters were measured on lateral lumbar spine standing and sitting radiographs: lumbar lordotic angle (LLA), sacral slope (SS), pelvic tilting angle (PT) and pelvic morphologic angle (PI).

**Results and Discussion:** The mean values of LLA, SS, PT and PI in the standing and sitting positions were as follows: LLA,  $33.3 \pm 11.2^\circ$ ,  $16.7 \pm 11.2^\circ$ ; SS,  $37.2 \pm 7.1^\circ$ ,  $18.5 \pm 10.9^\circ$ ; PT,  $9.9 \pm 7.4^\circ$ ,  $28.2 \pm 10.8^\circ$ ; and PI,  $36.1 \pm 14.9^\circ$ ,  $28 \pm 9.6^\circ$  (means  $\pm$  standard deviation [SD]), respectively. Regarding the change from the standing to sitting positions, the LLA, SS and PT were  $-16.6^\circ$  ( $-49.8\%$ ),  $-18.7^\circ$  ( $-50.3\%$ ) and  $18.3^\circ$  ( $+84.8\%$ ), respectively ( $p < 0.01$ ). In the sitting position, lumbar lordosis decreased and there was retroversion. LLA, SS and PT showed no statistically significant gender-based differences in the standing position, but there was a marked difference in LLA and SS in the sitting position. LLA was markedly larger in women, and PT was independent of gender in the standing position. However, in the sitting position, LLA was markedly larger and PT was smaller in women possibly because in the sitting position, lumbar-pelvic sagittal alignment is affected by gender difference in the pelvic bone. In the sitting position, there is less lordosis. This may account for the difference in long fusion in the lumbar spine between walking (standing) patients and non-walking (sitting) patients. In determining the optimal position for lumbar spinal fusion, the patient's ability to ambulate upright in a lordotic position is the preferred outcome, and is best achieved by duplicating the position in a standing radiograph.

O231

### PATIENTS WITH LUMBAR SEGMENTAL INSTABILITY PRESENT MORE SEVERE LOW BACK PAIN THAN THOSE WITHOUT INSTABILITY

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**Introduction:** There has been no clear evidence on a relationship between lumbar segmental instability and low back pain. The purpose of this study was to investigate the relation base on a biomechanical definition of instability using a novel intraoperative measurement (IOM) system (JNS 2008).

**Materials and Methods:** One hundred eleven patients (M/F=56/55, average age 66.9 years) with degenerative diseases were included. Instability was determined as a segment with neutral zone (NZ)  $> 2$  mm/N using IOMS (JBJS 2011). The symptom was compared between the patients with instability and those without instability by using SF-36 (physical function) and visual analog scale (VAS) of low back and leg pains. Surgical procedures were determined during surgery with IOM system: if NZ  $< 2$  mm/N, laminoplasty was scheduled (Group L); if the NZ was  $\geq 2$  mm/N, decompression and transforaminal lumbar

interbody fusion (TLIF) were indicated (Group T). 29 patients in Group L (M/F=16/11, 68 years) and 9 in Group T (M/F=3/6, 59.9 years) with L4-5 lesion were evaluated 3 years after surgery.

**Results:** Clinical symptoms of the patients with instability were significantly severe than those of the patients without instability (SF-36: 36.5 vs 49.6, VAS: 74.1 vs 61.6,  $p < 0.05$ ). Following surgery, physical function in SF-36 improved significantly in both groups ( $p < 0.05$ ). VAS of low back pain and leg pain also significantly decreased ( $p < 0.05$ ).

**Discussion:** The etiology of low back pain has not been clearly addressed. Although variety of causes such as degenerative disc and/or facet joint, spinal deformities, or even psychological factors are considered to affect low back symptom, our procedure, the first biomechanical definition of segmental instability in clinical setting, could show a relationship between segmental instability and low back pain. Furthermore, the surgical treatment determined using IOM system was effective.

**Conclusion:** Lumbar segmental instability, if it is clearly defined in biomechanical stand point of view, can be a factor to affect low back symptom.

O232

### ON THE EXTENT AND NATURE OF NUCLEUS-ANNULUS INTEGRATION

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**Introduction:** The disc nucleus is generally viewed as a hydrostatically functioning entity largely separate from its surrounding inner annulus and endplates. The boundary between nucleus and annulus is acknowledged as being difficult to define. This study investigated whether or not there is a substantial degree of structural integration between the nucleus and inner annulus.

**Methods:** 10 mm thick sagittal slabs were cut from the central region of ovine lumbar discs. The annulus-nucleus transition region was isolated and the resulting samples were subjected to tensile loading. Samples for microstructural examination were stretched to about 5 times their original separation, formalin-fixed in this extended state and then decalcified. Cryosections cut in an oblique plane that incorporated one of the inner annulus fibre bundle directions were then examined microscopically. A second group of samples was loaded to tensile failure.

**Results:** The annulus-nucleus boundary was shown to support an average load of 5.7N. This tensile loading resulted in the fibrous structure of the nucleus being drawn into approximate alignment in the transverse stretch direction with an associated reverse in-pulling of the inner annular layers. At higher magnification, the horizontally aligned nucleus fibres were seen to turn through approximately  $90^\circ$ , spreading out into the surrounding annular layers.

**Discussion:** The nucleus contains a convoluted but highly structured network of fibres of varying lengths which appear to integrate with the inner annulus and confer substantial transverse interconnectivity which can be demonstrated mechanically. This new evidence, together with previously demonstrated nucleus-endplate connectivity, makes it clear that the nucleus cannot be considered as a separate entity. We propose that this structural integration provides the nucleus with tethered mobility that supports physiological functions distinct from the primary strength requirements of the motion segment.

**Conclusions:** Substantial integration exists between the nucleus and inner annulus; they cannot be considered as separate entities. We propose that this interconnectivity supports the physiological environment of the disc.



O233

### MICROMECHANICS OF ANNULUS-ENDPLATE INTEGRATION

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**Introduction:** The endplate is a structurally important region. It marks the transition between the stiff vertebrae and the compliant disc and is thus a region of potentially high stress concentration. The effectiveness of anchorage of the annulus fibres in the endplate will clearly influence the overall strength of the motion segment. Failure of this endplate region is known to be associated with disc herniation. This study investigated the mechanism of annular fibre-endplate anchorage.

**Methods:** Motion segments from the lumbar region of mature ovine spines were isolated, subjected to a range of loading conditions including compression, flexion and/or mild torsion, fixed in these states and then decalcified. Samples incorporating the posterior annulus-endplate were cryosectioned along the plane of one of the lamellar fibre directions to obtain oblique sections. To gain a clearer understanding of the anchorage system in a three-dimensional sense, additional samples were prepared from the anterior part of the disc and cryosectioned along the frontal coronal plane. Sections were imaged in their fully hydrated state using differential interference contrast optical microscopy.

**Results:** The annular fibre bundles have a tendency to subdivide into sub-bundles on entering the endplate to form a 3-D multi-leaf morphology where each leaf is separated by cartilaginous endplate matrix. The coronal sections revealed the transition between lamellae at the annulus-endplate junction.

**Discussion:** The branched morphology increases the interfacial area between bundle and matrix in proportion to the number of sub-bundles formed. Given the limited thickness of the endplate and the intrinsic strength of the interface bond between bundle and endplate matrix, this morphology is consistent with a mechanism of optimal shear-stress transfer wherein a greater strength of annular fibre anchorage is achieved over a relatively short insertion distance.

**Conclusion:** Microstructural comparison between the relaxed and the compressed / flexed / torsioned states provided further insights into the micromechanics of the annulus-endplate anchorage system, particularly its branched morphology which optimizes the structure for higher strength.

O234

### A LARGE-SCALE POPULATION-BASED STUDY OF MODIC CHANGES OF THE LUMBAR SPINE

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**Introduction:** Modic changes (MC) are vertebral bone marrow and endplate signal changes on MRI, commonly associated with low back pain (LBP). To date, no large-scale population-based study accounting for various demographics, lifestyle factors, and clinical parameters has been addressed to determine the distribution and risk factors associated with MC of the lumbar spine. As such, the following population-based study was performed to determine the prevalence, potential determinants and clinical relevance associated with MC of the lumbar spine.

**Methods:** A cross-sectional population-based study of 2,449

male and female Southern Chinese (mean age: 40.4 years; age range: 10 - 80 years) was performed assessing sagittal T2-weighted lumbar MRIs for the presence of MC and other radiographic findings. Subject demographics, lifestyle factors, and low back pain were also assessed.

**Results:** The prevalence of MC was 6%, increasing exponentially with advancing age (R square = 0.83). MC occurred predominantly at the lower lumbar region (82.6%). Following multivariate regression modeling (adjusting for demographic and lifestyle factors), the presence of disc degeneration, disc bulge, and Schmorl's nodes increased the likelihood of MC ( $p < 0.01$ ). The presence of historical and past year LBP were associated with MC ( $p < 0.05$ ). MC were also positively correlated with symptom severity ( $p < 0.001$ ). Assessing the different determinants associated with MC throughout the lumbar segments, lifestyle factors significantly affected the lower lumbar spine. Subjects who were both smokers and overweight/obese had a higher likelihood of MC (OR: 2.15; 95% CI: 1.27 - 3.63) at the lower lumbar spine than normal/underweight non-smokers.

**Conclusion:** Based on the largest MRI study to assess Modic changes, determinants of MC vary throughout the lumbar spine. MC predominantly occur in the lower lumbar spine, and are highly associated with disc degeneration, and the presence and severity of LBP. Smokers who were overweight/obese had an increased likelihood of MC involving the lower lumbar spine.

O235

### MODIC (ENDPLATE) CHANGES IN THE LUMBAR SPINE: BONE MICROARCHITECTURE AND REMODELING

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**Introduction:** This report, expands on a previous pilot study, analyzing the bone microarchitecture and remodelling characteristics associated with Modic changes in human lumbar vertebrae, of adults undergoing spinal surgery for degenerative disease.

**Materials and Methods:** Thirty-one patients underwent elective spinal surgery with lumbar vertebrae showing Modic changes on pre-operative lumbar MRI. The cases were subdivided as follows: Modic I (n=8), Modic II (n= 19), Modic III (n=4). The patients were 59±12 years. A transpedicular vertebral body biopsy (25x3mm) was taken in all patients. Micro-computed tomography (micro-CT) scans of the biopsies were carried out providing 3D analysis of bone microarchitecture, to calculate bone volume fraction, trabecular thickness and trabecular number. Histological sections (von Kossa and H&E) were also prepared for analysis of tissue-level bone remodeling.

**Results:** Micro-CT analysis revealed a significantly higher bone volume fraction in Modic type III compared to Modic I and II ( $p < 0.05$ ). The increase in bone volume fraction was associated with increased trabecular number ( $p < 0.05$ ) and trabecular thickness ( $p < 0.01$ ). Histological analysis showed reduced osteoid surface in Modic II, compared to Modic I and III ( $p < 0.05$ ). In Modic III, a trend towards reduced erosion surface was found compared to Modic I and II ( $p = 0.13$ ). In Modic III significantly higher osteoid surface to erosion surface ratio was found, compared to Modic I and II ( $p < 0.05$ ).

**Discussion:** This study's findings on expanded data from a previous pilot study confirm that bone microarchitectural and remodelling differences between Modic types are statistically significant.

**Conclusion:** This study confirms the clinical MRI findings that Modic III changes are consistent with a more stable sclerotic phase of the pathology, with significantly higher bone volume fraction compared to Modic I and II.



O236

**LUMBAR MODIC CHANGES – IN LOW- AND HIGH-FIELD MRI**Bendix T.<sup>1,2</sup>, Sorensen J.S.<sup>3</sup>, Henriksson G.A.C.<sup>4</sup>, Bolstad J.E.<sup>5</sup>, Narvestad E.K.<sup>6</sup>, Jensen T.S.<sup>3,7</sup><sup>1</sup>Institute of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense;<sup>2</sup>Spine Center Copenhagen, Glostrup Hospital, Glostrup; <sup>3</sup>Spine Centre of Southern Denmark, Lillebaelt Hospital, Middelfart;<sup>4</sup>Chiropractor Private practice, Odense, Denmark; <sup>5</sup>Chiropractor Private practice, Kongsberg, Norway; <sup>6</sup>Dept. of Radiology, Copenhagen University Hospital Rigshospitalet, Copenhagen;<sup>7</sup>Institute of Regional Health Services Research, University of Southern Denmark, Odense, Denmark

**Introduction/Aim:** It is a challenge to give patients with low back pain (LBP) a specific diagnosis. Modic changes as seen on MRI have been reported to be a possible source of pain. However, it is unclear if the diagnosis is dependent of the field strength. The aim was to investigate if there is a difference in findings of lumbar Modic changes in low-field (0.3 Tesla) magnetic resonance imaging (MRI) as compared to high field (1.5 Tesla).

**Materials and Methods:** Design: cross-sectional observational study. Twenty patients with Modic changes, 11 women and 9 men (mean age 53.6, range 29-81), with or without sciatica, seen in a Danish outpatient LBP clinic were included. All patients had MRI scans on both a high-field and a low-field MRI scanner. Two radiologists evaluated all lumbar endplates independently using a standardized evaluation protocol. Kappa statistics were used to analyze the inter-observer reproducibility. To analyze the difference between low- and high-field MRI we used paired t-test.

**Results:** The total number of Modic changes diagnosed with high-field MRI, was significantly higher as compared to low-field MRI. However, 3-4 times as many Modic type 1 changes were found with low-field MRI as compared to high-field. Contrarily, with high-field MRI type 2 changes were diagnosed twice as often.

**Discussion:** We cannot conclude from this study which field strength gives results closest to the truth. Maybe STIR should be used for routine high-field MRI-scans of LBP-patients.

**Conclusion:** There was a significant difference between low- and high-field MRI regarding the overall prevalence of any Modic change, but this had opposite directions for type 1 and 2. The type of MRI unit should be taken into consideration when diagnosing patients with Modic changes.

O237

**3-D MESOSTRUCTURAL IMAGING OF THE ANNULUS FIBROSUS USING OPTICAL COHERENCE TOMOGRAPHY**Han S.K.<sup>1</sup>, Chen C.W.<sup>1</sup>, Wierwille J.<sup>1</sup>, Chen Y.<sup>1</sup>, Hsieh A.H.<sup>1,2</sup><sup>1</sup>Dept. of Bioengineering, University of Maryland, College Park;<sup>2</sup>Dept. of Orthopaedics, University of Maryland, Baltimore, USA

**Introduction:** Mechanical function of the intervertebral disc (IVD) is strongly influenced by tissue architecture. Currently, approaches have focused on macro- or micro-scale measurements. Phenomena at intermediate scales, however, are also likely to be important in tissue mechanics and mechanobiology, but are not well understood. The objective of this study was to investigate the three dimensional (3-D) mesoscale structures of the annulus fibrosus (AF) using Optical Coherence Tomography (OCT).

**Methods:** IVDs were prepared from ovine lumbar spines. Swept-source Fourier-domain OCT was performed using a laser-generated broadband spectrum of 100 nm at 1300 nm (8  $\mu$ m axial and 15  $\mu$ m transverse resolutions under a 4 x objective, NA=0.1). The laser scanned a 10 x 10 x 1.8 mm<sup>3</sup> volume, from which a 512 x 512 x 512 pixel resolution volumetric image was acquired.

**Results:** Using OCT, we were able to resolve in 3-D several

key features that highlight the mesostructural inhomogeneity of the AF (Figure 1a, b). Specifically, physical collagen fiber orientations could be visualized not only across lamellar layers but also within each layer (Figure 1b, d). Additionally, the inter-/trans-lamellar bridging network was also readily identifiable and can be reconstructed (Figure 1c).

**Discussion:** This study demonstrates the capability for OCT to be used as a method for characterizing mesoscale AF architectures. Since OCT is non-invasive, non-destructive, and has relatively good tissue penetration depth (~1 mm), it can be used to improve our understanding of complex 3-D discontinuities in annular lamellae and their implications on IVD anatomy and mechanics in both health and disease.

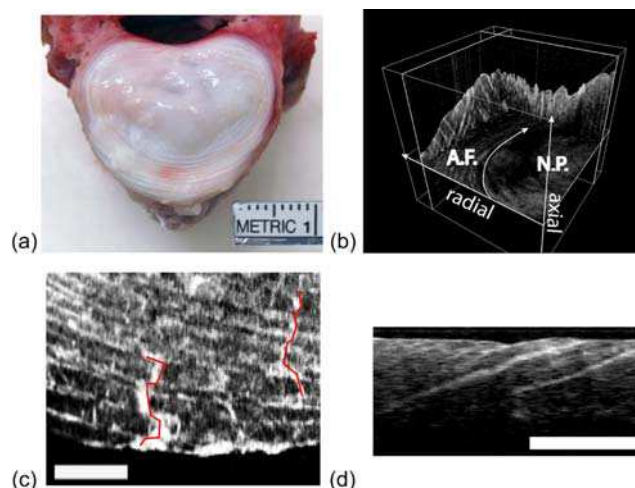


Figure 1. (a) Photo of imaged ovine IVD; (b) 3-D OCT image of IVD (N.P.: Nucleus Pulposus); (c) transverse image view of outer AF (red lines indicate inter-/trans-lamellar bridging networks in a single cross-sectional plane, scale bar = 1 mm); (d) 2-D image of a lamellar layer in-plane (scale bar = 1 mm).

O238

**CHEMICAL EXCHANGE SATURATION TRANSFER (CEST) AND T2 MAPPING IN SUBJECTS WITH INTERVERTEBRAL DISC DEGENERATION**Kim M.<sup>1</sup>, Chan Q.<sup>1</sup>, Anthony M.P.<sup>1</sup>, Samartzis D.<sup>2</sup>, Cheung K.M.C.<sup>2</sup>, Khong, P.L.<sup>1</sup><sup>1</sup>Dept. of Diagnostic Radiology, University of Hong Kong, Pokfulam; <sup>2</sup>Dept. of Orthopaedics & Traumatology, University of Hong Kong, Pokfulam, Hong Kong

**Introduction:** Intervertebral disc degeneration (IVD) on MRI is an etiological factor associated with low back pain. The (IVD) has been well acknowledged to degenerate as characterized by biochemical and morphological changes. T2 relaxation time has been suggested to be sensitive to changes in collagen and water content in cartilage and in the IVD. In the disc, the investigators have quantified chemical exchange saturation transfer (CEST) and its specificity as well as its correlation capacity for glycosaminoglycan (GAG) content (gagCEST). However, the correlation between conventional qualitative MRI assessment (T2-weighted) and quantitative MRI measurement, such as T2 and CEST, remains unknown. In this study, we aimed to investigate the association between CEST, T2 and degenerative grades in IVD using T2-weighted MRI in human subjects.

**Methods:** Twenty-one subjects (8 females, 13 males; median age = 34; age range= 24-58 years) with no prior spine surgery were recruited. Sagittal T2-weighted, CEST and T2 MRI of the lumbar spine were obtained. All images of the lumbar spine



were acquired using a 3T Achieva scanner. High-resolution T2-weighted discs were qualitatively graded according to Schneiderman's classification (score range: 0 to 3). CEST and T2 maps were quantitatively assessed based on a voxel-by-voxel basis.

**Results:** A decreasing trend of CEST and T2 values with increasing grade of degeneration was noted. The mean CEST values in L3/4, L4/5 and L5/S1 discs with Schneiderman grades 0 (n = 41), 1 (n = 7) and 3 (n = 5) were  $7.17 \pm 1.10$  %,  $6.00 \pm 0.83$  %,  $2.85 \pm 0.39$  % and  $1.84 \pm 0.27$  %, respectively. The mean T2 values in discs with Schneiderman grades 0 (n = 41), 1 (n = 7) and 3 (n = 5) were  $109.74 \pm 12.40$  ms,  $83.84 \pm 6.19$  ms,  $71.70 \pm 3.44$  ms and  $65.16 \pm 2.97$  ms, respectively. Schneiderman grade was correlated with both CEST ( $r = -0.67$ ,  $p < 0.001$ ) and T2 ( $r = -0.71$ ,  $p < 0.001$ ). The correlation between CEST and T2 values was  $r = 0.73$  ( $p < 0.01$ ). A discriminatory effect was noted between early and end-stage IVD degeneration for T2 and CEST imaging, respectively.

**Conclusions:** Our results showed that CEST and T2 decreases with increasing grade of disc degeneration and that CEST values significantly correlated with T2. Our findings propose useful quantitative imaging tools with discriminatory capacity to assess early and end-stage IVD degeneration.

### O239

#### GADOLINEUM-ENHANCED MRI OF THE LUMBAR SPINE HAS NO ADDITIVE VALUE OVER NON-ENHANCED MRI IN THE EVALUATION OF PATIENTS WITH PERSISTENT SCIATICA

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**Introduction/Aim:** Gadolinium-enhanced Magnetic resonance imaging (Gd-MRI) of the lumbar spine is generally performed in the evaluation of patients with persistent sciatica after lumbar disc surgery. The objective of this study was to evaluate interobserver agreement among expert readers regarding the enhancement by gadolinium of scar tissue, herniated disc tissue and affected nerve root.

**Methods:** The study population consisted of 283 patients who were included in the Sciatica trial and were randomized to surgery or prolonged conservative care (Peul et al., NEJM 2007). Participants underwent Gd-MRI both at baseline and after 1 year. Two neuroradiologists and one neurosurgeon independently evaluated all MR images. Kappa coefficients were used to assess the interobserver reliability.

**Results:** At baseline, the interobserver agreement among all three readers regarding staining of the considered affected nerve root and disc herniation was 0.31 and 0.41 respectively. At one year, agreement regarding staining of the affected nerve root was 0.10, for the presence of disc herniation it was 0.67, while for staining of disc herniation agreement was 0.32. The agreement with regard to the presence of scar tissue was 0.59. All readers marked scar tissue as enhanced in at least 97%, when they considered it present, which led to a multirater agreement regarding the staining of scar tissue of 97.6%.

**Discussion:** There was a low interobserver agreement among spine experts regarding the staining of the disc herniation and regarding the affected nerve root. The interobserver agreement regarding the presence of scar tissue was surprisingly low compared to the high interobserver agreement regarding its staining.

**Conclusion:** Gadolinium-enhanced MRI of the lumbar spine has

no additive value over non-enhanced MRI in the evaluation of patients who do not recover from sciatica after surgery.

### O240

#### ADDITIVE VALUE OF MAGNETIC RESONANCE IMAGING BEYOND CLINICAL ASSESSMENT IN THE EVALUATION OF PATIENTS WHO DO NOT RECOVER FROM SCIATICA

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**Introduction/Aim:** Magnetic Resonance Imaging (MRI) is often repeated in the evaluation of patients who do not recover from sciatica. However, the association between findings on MRI and clinical course is controversial. The objectives of this study were to describe radiological findings, their changes over time, and to correlate these MRI findings to clinical outcome.

**Methods:** The study population consisted of 283 patients who were included in the Sciatica trial and were randomized to surgery or prolonged conservative care (Peul et al., NEJM 2007). Participants underwent MRI and a neurological examination both at baseline and after 1 year. The majority opinion of two neuroradiologists and one neurosurgeon regarding different MRI findings was correlated to outcomes as assessed by means of the patient's report of perceived recovery, the Roland Disability Questionnaire and the visual-analogue scale for leg and back pain using logistic regression.

**Results:** After one year 38 percent of surgically treated patients had an abnormal disc contour (disc herniation or bulging disc) compared to 76 percent of conservatively treated patients. In the majority of cases the nerve root compression at baseline had disappeared or was reduced after one year. No significant correlation existed between favourable outcome and MRI findings or changes in MRI findings over time. The variables consequently correlated with recovery were the neurological examination findings.

**Discussion:** Contrary to MRI findings, neurological examination findings were correlated to clinical outcome.

**Conclusion:** Repeating MRI has no additive value beyond clinical assessment in the evaluation of patients who do not recover from sciatica. In addition, given the high disc abnormalities after one year and the absence of a correlation between disc abnormalities and clinical outcome, repeating an MRI as a preoperative standardized procedure can be debated.

### O241

#### LUMBAR VERTEBRAL ENDPLATE LESIONS: ASSOCIATIONS WITH DISC DEGENERATION AND BACK PAIN HISTORY

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**Study Design:** An autopsy study with back pain history data.

**Objective:** To determine the associations between various types of lumbar vertebral endplate lesions and disc degeneration (DD) and back pain history.

**Summary of Background Data:** The well-innervated vertebral body and bony endplate have been suspected as a source of common back pain. Yet, related clinical evidence has been rare. Previously, we observed four types of lumbar endplate lesions with



distinct morphological features and distribution patterns. Their pathogenic origins and roles in DD and back pain remain unclear.

**Methods:** From a lumbar spine archive of 136 men (mean age 52 years), back pain, back injury and occupation history data for 69 subjects and discography data for 443 discs from 109 subjects were available for study. Back pain history was categorized as none, occasional or frequent. Judged from discography, DD was graded using a four-point scale. Endplate lesions were classified as Schmorl's nodes, fracture, erosion or calcification, and lesion size was rated as none, small, moderate or large. The associations between endplate lesion findings and DD, back pain history, back injury and occupation history were examined.

**Results:** Overall, the presence of endplate lesions was associated with frequent back pain (OR=2.57,  $p=0.004$ ), but not with occasional back pain. In particular, large endplate lesions were associated with both occasional (OR=8.68,  $p=0.038$ ) and frequent (OR=17.88,  $p=0.004$ ) back pain. This association remained after further controlling for DD. Also, the presence of each type of endplate lesion was associated with adjacent DD. Endplate lesions, DD and pain (OR=2.40~9.71,  $p=0.000$ ~0.040), with larger lesions associated with more severe DD. Endplate erosion lesions were more strongly associated with adjacent DD, as compared with Schmorl's nodes (OR=2.85,  $p=0.001$ ). While back injury history was associated with the presence of fracture and erosion lesions, heavy occupation was associated with the presence of Schmorl's nodes.

**Conclusions:** Endplate lesions are associated with back pain, as well as being closely associated with adjacent DD, with a clear dosage effect. Different types of endplate lesions appear to have different magnitudes of pathological influence on the adjacent disc. Lumbar endplate lesions may be an important key to better understanding both disc degeneration and back pain.

#### O242

##### DISK DYNAMIC COMPRESSION IN RATS PRODUCES PERSISTENT INCREASES IN INFLAMMATORY MEDIATORS IN DISKS AND INDUCES PERSISTENT NERVE INJURY AND REGENERATION OF THE AFFERENT FIBERS INNERVATING DISKS

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**Introduction:** Sensory nerve fibers in intervertebral disks (IVDs) and inflammatory mediator responses have been verified in animal models of IVD injury. However, the IVD injury in animals incompletely models degenerated human IVDs causing diskogenic low back pain because human IVDs are also subject to compression. The purpose of the current study is to examine production of inflammatory mediators in IVDs and neuropeptides in dorsal root ganglia (DRGs) in rat models of IVD compression or/and injury.

**Methods:** Experimental groups (controls, IVD injury, IVD compression, and their combination) of Sprague Dawley rats were prepared. Fluoro-Gold (FG) was applied into coccygeal IVDs. Inflammatory mediators in IVDs, including NGF, TNF- $\alpha$ , IL-1- $\beta$ , and IL-6, were quantified using ELISA. DRGs were immunostained for CGRP (neuropeptides), ATF-3 (marker of nerve injury), and GAP43 (marker of nerve regeneration).

**Results:** The upregulation of inflammatory mediators was transient in the IVD injury group, but delayed and persistent in the IVD compression group. In the combination group, the

upregulation of inflammatory mediators was persistent through 8 weeks. The proportion of CGRP-immunoreactive (IR) neurons among FG-labeled neurons, remained significantly higher in the IVD injury, compression, and combination groups, than in the controls. In contrast, increases in the proportions of ATF-3-IR or GAP43-IR neurons in the IVD injury group animals were transient, but persistent in the compression and combination groups compared with controls.

**Conclusions:** Disk injury in rats produces persistent increases in neuropeptides in DRGs, but only transient increases in inflammatory mediators in IVDs. On the other hand, disk compression in rats produces a persistent increase in inflammatory mediators in IVDs and neuropeptides in DRGs. Moreover, disk compression induces persistent nerve injury and regeneration of the afferent fibers innervating IVDs.

#### O243

##### INHIBITION OF NF- $\kappa$ B ACTIVITY AMELIORATES AGE-ASSOCIATED DISC DEGENERATION IN A MOUSE MODEL OF ACCELERATED AGING

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**Introduction/Aim:** Activity of NF- $\kappa$ B, a family of transcription factors activated in response to a variety of stressors, increases with age and is implicated in the pathogenesis of numerous age-related pathologies. Because NF- $\kappa$ B activity is upregulated in aged discs, we hypothesized that blocking NF- $\kappa$ B activation would slow the onset of age-dependent disc degenerative degeneration (IDD). To test this hypothesis, we used the *Ercc1*<sup>- $\Delta$</sup>  mouse model of a human progeria in which we had previously established as an accurate model of spine aging.

**Materials/Methods:** Systemic inhibition of NF- $\kappa$ B activation was achieved either genetically by deletion of one allele of the NF- $\kappa$ B subunit p65 (*Ercc1*<sup>- $\Delta$</sup> *p65*<sup>-/-</sup> mice) or pharmacologically by chronic intra-peritoneal administration of the NEMO Binding Domain (8K-NBD) peptide to block the formation of the upstream activator of NF- $\kappa$ B, I $\kappa$ B Inducible Kinase (IKK), in *Ercc1*<sup>- $\Delta$</sup>  mice. Disc cellularity, total proteoglycan content and synthesis of treated mice and untreated controls were assessed.

**Results:** Decreased matrix proteoglycan content, a hallmark of IDD, and elevated disc NF- $\kappa$ B activity were observed in discs of progeroid *Ercc1*<sup>- $\Delta$</sup>  and naturally aged wild-type mice compared to young wild-type mice. Systemic inhibition of NF- $\kappa$ B by the 8K-NBD peptide in *Ercc1*<sup>- $\Delta$</sup>  mice increased disc proteoglycan synthesis and ameliorated loss disc cellularity and matrix proteoglycan. Similar results were confirmed genetically by using *Ercc1*<sup>- $\Delta$</sup> *p65*<sup>-/-</sup> mice.

**Discussion:** The 8K-NBD peptide has been shown to be efficacious in animal models of inflammatory bowel disease, muscular dystrophy, and arthritis. Here we show that treatment of an accelerated aging animal model with the same therapeutic peptide decreased disc proteoglycan loss, in addition to previously reported therapeutic effects of reduced vertebral osteoporosis and delayed onset of kyphosis.

**Conclusion:** These findings demonstrate that the IKK/NF- $\kappa$ B signaling pathway is a key mediator of age-dependent IDD and represents a therapeutic target for mitigating disc degenerative diseases associated with aging.



O333

### RECOVERY OF MOTOR DEFICIT ACCOMPANYING SCIATICA—SUBGROUP ANALYSIS OF A RANDOMIZED CONTROLLED TRIAL

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**Introduction/Aim:** In patients with sciatica due to a lumbar disc herniation (HNP), it is generally recommended to reserve surgical treatment for those who suffer from intolerable pain or those who demonstrate persistent symptoms after conservative management. Controversy exists about the necessity of surgical intervention for those patients that have an additional motor deficit. The aim of this study is to compare the recovery of motor deficit among subjects treated surgically to those receiving prolonged conservative treatment.

**Materials and Methods:** This study focuses on a subgroup of the patients randomized for surgical or prolonged conservative treatment in the Sciatica trial (Peul et al., NEJM 2007), being 150 subjects whose symptoms were accompanied by moderate or severe (MRC 3-4) motor deficit. Repeated neurological examinations were performed at baseline, and at 8, 26 and 52 weeks. MRI was obtained at baseline and at 52 weeks.

**Results:** Baseline severity of motor deficit was graded moderate in 84% of subjects and severe in 16% of subjects. At one year, complete recovery of motor deficit was found in 79% of subjects treated surgically and 83% subjects receiving conservative treatment. Motor deficit recovered significantly faster among subjects treated surgically, but the difference was no longer significant at 26 or 52 weeks. Severe motor deficit at baseline (OR 5.5) and  $\geq 25\%$  HNP occupancy of the spinal canal (OR 6.7) were the most important risk factors for persistent deficit at 1 year.

**Discussion:** The recovery of motor deficit does not differ among subjects treated surgically or conservatively. Risk factors for persistent motor deficit were severe motor deficit at baseline and a HNP encompassing  $\geq 25\%$  of the spinal canal.

**Conclusion:** In this subgroup of patients from the Sciatica trial with a moderate or severe paresis, 81% of patients made full recovery within one year. No additional long-term benefit could be demonstrated from early surgery.

O334

### LONG-TERM CLINICAL AND RADIOLOGICAL OUTCOMES AND THEIR CORRELATION AFTER OPEN DISCECTOMY FOR LUMBAR DISC HERNIATION

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**Background:** Open lumbar discectomy (OLD) has shown to be a clinically beneficial treatment option for lumbar disc herniation. However, long-term correlations between clinical and radiological outcomes after OLD are not well established.

**Methods:** Participants included in this study consist of 79 patients who had undergone single level OLD with a minimum of 10 years follow-up. There were 40 male and 39 female patients with a mean age  $53.6 \pm 13.4$  years. The average length of follow-up was  $15.3 \pm 6.1$  years. The 79 patients were divided into 4 sectors based on years of follow-up: 10 to 14 years Sector 1, 15 to 19 years Sector 2, 20 to 24 years Sector 3 and over 25 years follow-up made up Sector 4. Clinical outcomes were evaluated per sector using the Back Visual Analogue Scale (Back VAS), the Leg Visual Analogue Scale (Leg VAS), and the Oswestry Disability Index (ODI). Radiological outcomes were evaluated

by local kyphosis (LK), lumbar lordosis (LL), anterior disc height ratio (ADHR), posterior disc height ratio (PDHR), Knutsson's sign (KS), traction spur (TS), claw spur (CS), upper end plate sclerosis (UEPS), lower end plate sclerosis (LEPS), anterior listhesis (AL), retrolisthesis (RL), lateral listhesis (LL), AP angulation of the operative segment (AAOS), and motion of the operative segment (MOS). The number of radiological findings (NRFs) was scored on a 10 point scale by assigning 1 point for each finding.

**Results:** The Back and Leg VAS and ODI sectors were preoperatively 8.47, 8.37, and 65.8; they were improved to 2.69, 2.53, and 17.9, respectively, in sector 1 and deteriorated to 5.50, 6.75, and 21.5 in sector 4. LK, LL, ADHR, PDHR, TS, and MOS were decreased in sector 3 and 4. KS, CS, UEPS, LEPS, AAOS, and NRF were increased in sector 3 and 4. There was a significant correlation between NRF and back VAS ( $p=0.039$ ).

**Conclusions:** Clinical outcomes improved in sector 1, but deteriorated slowly over time. Radiological degenerative changes increased over time after OLD. Radiological stabilization was observed in sector 3 and 4. Although radiologic stabilization occurred, clinical outcome was deteriorated over time.

O335

### EFFECT OF WAITLIST-TIME ON PAIN IMPROVEMENT AFTER ELECTIVE SURGICAL LUMBAR DISCECTOMY

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**Introduction/Aim:** In Canada, access to elective surgical lumbar discectomy (ESLD) is commonly managed through waitlists. Duration from waitlist enrolment to surgery extends preoperative symptom duration and reflects the delay in treatment imposed by the health care system. *Aim.* To determine if system-imposed waitlist-time affects the likelihood of improvement post-ESLD.

**Methods:** *Design.* Combined retrospective and prospective cohorts. *Patients.* 291 participants, aged  $\geq 16$  years, with sciatica from confirmed disc herniation, recruited at time of waitlist enrolment for ESLD. *Outcomes.* Change in worst symptom (back/leg pain) intensity on 11-point numerical rating scale, re-categorized into six ordinal "improvement" groups. *Analysis.* Waitlist-time was dichotomized at 12-weeks. Multivariable ordinal regression was used to control measured confounders while estimating the odds of improvement at six months post-operatively.

**Results:** Waiting  $\geq 12$ -weeks independently predicted lower odds of improvement at six months post-ESLD (proportional odds ratio: 0.63 [95% CI: 0.39-1.02]; continuation odds ratio: 0.66 [95% CI: 0.45-0.98]). Compensation, depression, symptom duration and baseline pain intensity also independently predicted improvement.

**Discussion:** Like symptom duration, longer waitlist-time negatively affects post-ESLD improvement. However, unlike symptom duration, waitlist-time has a clear inception point, and is both objectively measurable and potentially modifiable when surgery is being contemplated.

**Conclusions:** Longer waitlist-time diminishes the likelihood of improvement post-ESLD. Future studies are needed to determine if the costs of funding for more procedures is sufficiently balanced by the clinical/societal benefits of earlier access.



O336

### A RANDOMIZED, DOUBLE-BLIND, PLACEBO-CONTROLLED TRIAL OF ETANERCEPT DELIVERED BY THE TRANSFORAMINAL EPIDURAL ROUTE FOR THE TREATMENT OF SYMPTOMATIC LUMBOSACRAL DISC HERNIATION

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**Introduction/Aim:** Recent evidence has implicated the inflammatory cytokine, tumour necrosis factor alpha (TNF $\alpha$ ) as a major cause of radiculopathy associated with symptomatic lumbar disc herniation (LDH). This study evaluated the safety and efficacy of three different doses of the TNF $\alpha$  inhibitor, etanercept versus placebo for the treatment of symptomatic LDH.

**Materials and Methods:** Subjects between 18-70 years with persistent lumbosacral radicular pain (6-26 weeks duration), with a radiological diagnosis of LDH, and an average leg pain intensity of at least 5/10 were randomized to one of four groups; 0.5 mg, 2.5 mg, 12.5 mg etanercept or 2 mls of normal saline (placebo). All subjects received two consecutive injections, two weeks apart, of the same treatment and dose delivered via the transforaminal epidural route. Post contrast radiographs were assessed by an independent reader to confirm appropriate epidural contrast flow.

Subjects were reviewed 2, 4, 8, 12 and 26 weeks following the second injection. Outcome measures included mean daily worst leg pain (WLP), average leg pain (ALP), worst back pain (WBP), average back pain (ABP), in clinic pain (ICP), Oswestry Disability Index (ODI), patient global impression of change (PGIC) and tolerability.

**Results:** 49 subjects were randomized to receive placebo (12), 0.5 mg etanercept (12), 2.5mg etanercept (13), 12.5 mg etanercept (12). Both intention to treat (ITT N=49) and per protocol (PP N=37) populations were analysed.

The most effective dose across all outcomes measures was 0.5mg etanercept. Subjects receiving this dose showed a clinically and statistically significant reduction in WLP compared to placebo from 2 to 26 weeks, both in the ITT population (p=0.019) and the PP population (p=0.022).

50% of subjects in 0.5 mg cohort reported a 100% reduction in WLP 4 weeks post treatment, versus 0% of subjects in the placebo cohort. ODI scores for subjects receiving 0.5 mg and 2.5 mg etanercept showed a clinically significant percentage decrease compared to placebo.

The overall incidence of adverse events was similar in the placebo and etanercept groups.

**Discussion:** The strong signal of efficacy and the absence of any drug-related side effects suggest that epidural etanercept could offer a safe and effective non-operative treatment for symptomatic LDH.

**Conclusion:** Transforaminal epidural etanercept (0.5mg dose) provided 50-100% relief of pain for at least 3-6 months for more than one-half of subjects with persistent moderate to severe radicular pain.

O337

### DO L5 AND S1 NERVE ROOT COMPRESSIONS PRODUCE RADICULAR PAIN IN A DERMATOMAL PATTERN?

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**Introduction:** Doubt has been cast over the accuracy of dermatome charts. This study investigated a large group of patients with known lumbar nerve root compression (NRC), and identified whether their radicular pain corresponded with the predicted distribution on a dermatome chart.

**Materials and Methods:** The study included 209 patients that presented with lumbar radiculopathy. MRI scanning confirmed L5 NRC in 106 and S1 NRC in 103. Each patient used an interactive computer assessment program to record their pain on a body map image. The coordinates were then used to compare the sensory distribution to a standard dermatome chart.

**Results:** Of those patients with L5 NRC, 56 recorded pain on the anterior aspect of the body map image, with 36 patients (64%) registering pain within the L5 dermatome and 17(30%) within the S1 dermatome. 94 recorded pain on the posterior aspect of the body, of which 31 (33%) registered pain within the L5 dermatome and 49 (52%) in the S1 dermatome.

Of those patients with S1 NRC, 40 recorded pain on the anterior aspect of the body map image, with 18 patients (45%) registering pain within the S1 dermatome and 28 (70%) on the L5 dermatome. 80 recorded pain on the posterior aspect of the body, of which 45 (56%) registered pain within the S1 dermatome and 23 (29%) in the L5 dermatome.

**Discussion:** Although the study found that patients did experience pain within the corresponding boundary on the dermatome chart, it was not exclusive to that zone. With the exception of the anterior aspect of L5, pain was experienced more in other lumbar dermatomes.

**Conclusion:** The location of pain is not a reliable indicator of the compromised nerve root which must be confirmed by imaging. Individual variation in dermatomal distribution is substantial.

O338

### IN AN ANIMAL MODEL OF POSTEROLATERAL ARTHRODESIS BMP-2 TRIGGERS POSTOPERATIVE ALLODYNIA AND LOCAL DRG INFLAMMATION

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**Introduction:** Despite clinical observation, the mechanisms behind rhBMP-2 associated post-operative radiculitis remain undefined. Our group has recently shown that rhBMP-2 triggers spinal cord scarring and inflammation when applied near a penetrating lesion. Therefore, we hypothesized that exogenous BMP-2 infiltrates the dorsal root ganglion (DRG) and elicits a response leading to functional changes associated with pain.

**Materials and Methods:** A total of thirty-three (33) rats underwent a right side L5-6 posterolateral arthrodesis using either rhBMP-2 or saline control on a collagen sponge. Animals were divided into two follow-up groups: 1week (n=16) and 4weeks (n=16). Postoperatively, mechanical hyperalgesia was checked using the Von Frey test performed at 1,3,7,10 days, and once weekly thereafter. Gait was assessed using the digital walkway system. At the respective survival time-points, rats were perfused and the DRG and spinal cords analyzed for inflammatory markers and pain pathway neuropeptides using immunohistochemistry (IHC).



**Results:** Functionally, no differences in postoperative right hind limb pain were detected on day 1. However, by day 3, rats receiving rhBMP-2 became significantly more sensitive to right paw poking compared to saline controls ( $p < 0.05$ ). Mechanical hyperalgesia persisted through day 7 ( $p < 0.05$ ). In addition, BMP-2 treated rats exhibited a decrease in right hind toe spread compared to controls on days 3 and 7 ( $p < 0.05$ ), demonstrating extremity pain according to this model. Functional tests at later time-points revealed no differences between the groups ( $p > 0.05$ ). At 1 week, IHC analysis of the L4 and L5 DRGs revealed a pronounced inflammatory response (ED-1) glial activation (GFAP) in the BMP-2 group compared to controls ( $p < 0.05$ ).

**Discussion/Conclusion:** Despite preserving the facet joint intra-operatively, and not exposing the DRG directly to the protein, we observed a significant inflammatory reaction within the ganglion in rats receiving BMP-2. This correlated with significant functional pain. It appears that the transient post-operative allodynia may be triggered by the BMP-2 induced inflammatory cascade.

**O339**

**QUANTITATIVE ASSESSMENT OF RETROGRADE EJACULATION USING SEMEN ANALYSIS, COMPARISON TO A STANDARDIZED QUALITATIVE QUESTIONNAIRE, AND INVESTIGATING THE IMPACT OF RHBMP-2**

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**Introduction:** Retrograde ejaculation (RE) has long been known as a potential complication of anterior lumbar interbody fusion (ALIF). Studies performed to date have depended primarily on patient self-report of RE. Recently there has been increased attention paid to RE with respect to the use of recombinant human bone morphogenetic protein-2 (rhBMP-2). The purposes of this study were to: 1) identify RE incidence measured by quantitative semen analysis, 2) compare the rate to questionnaire assessment, and 3) determine if the occurrence varied with rhBMP-2 use.

**Methods:** This was a prospective, blinded study involving 41 male patients undergoing anterior/posterior interbody fusion at L4-5 and/or L5-1. Thirty-nine patients (95.1%) were workers' compensation. Subjects went to a preselected cryobank for pre-operative semen and urine analysis. Subjects returned 3 to 6 months post-operatively for repeat testing and were also evaluated by the principle investigator using a standardized questionnaire to conduct an interview to evaluate RE. ALIF was performed with femoral ring allograft: in 21 patients rhBMP-2 was used and in 20 it was not.

**Results:** Based on quantitative semen and urine analysis, 9.8% (4/41 patients) had RE. Of patients treated with rhBMP-2, two (9.5%) had RE. Of 20 patients treated without rhBMP-2, two (10.0%) had RE. RE rates in the two groups were not statistically significantly different ( $p > 0.80$ ; Fisher exact test). One RE patient in each group resolved spontaneously. Patient responses to the interview questionnaire (completed by 36 patients) resulted in 15 (41.7%) cases of RE being identified, including the four confirmed by quantitative analysis.

**Discussion:** Quantitative assessment of RE based on semen and urine analysis occurred in approximately 10% of patients. Results reported based on patient self-report were much higher than supported by the qualitative analysis.

**Conclusions:** Based on quantitative semen and urine analysis, RE was not more common in patients who's ALIF included the use of BMP. RE rates not based on quantitative analysis may be over-estimated.

**O340**

**CLINICAL COMPLICATIONS FOLLOWING rhBMP-2 USE IN A MINIMALLY INVASIVE TRANSFORAMINAL LUMBAR INTERBODY FUSION**

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**Background Context:** Recent reports of post-operative radiculitis, bone osteolysis, and symptomatic ectopic bone formation after transforaminal lumbar interbody fusions (TLIF) are a cause for concern. This study analyzes complications associated with the usage of rhBMP-2 in patients undergoing a minimally invasive (MIS) TLIF.

**Methods:** A retrospective review of all patients undergoing an MIS TLIF (single surgeon) at our institution was performed. Patients underwent a minimally invasive laminectomy with bilateral facetectomy, single transforaminal lumbar interbody fusion cage, unilateral pedicle screw fixation and 12 mg of BMP-2 (Large kit). Patients were evaluated at 6 months and 1 year with CT scan evaluation for evidence of neuroforaminal bone growth, osteolysis or cage migration. Cost data including direct cost/procedure for both index and revision surgeries were collected.

**Results:** 573 patients were identified that underwent MIS TLIF with rhBMP-2 (2007-2010) with 1 year of post-operative follow-up and CT imaging. The mean age was 48.7 (Range 27-82). Of the 573 patients, 10 (1.7%) required an additional 15 procedures based upon recalcitrant radiculopathy and CT evidence of neuroforaminal bone growth (**Figure 1**), vertebral body osteolysis, and/or cage migration.

Bone overgrowth was associated with nerve impingement/radiculopathy in all 10 patients. Osteolysis and cage migration occurred in 2 (18%) of these same 10 patients. Fifteen revision surgeries were required in the ten patients (**Table 1**). Average total costs were calculated per index procedure (\$19,224), and average additional total direct costs equaled \$14,785.

**Discussion:** Potential causes of ectopic bone formation and vertebral osteolysis in MIS TLIFs include improper dosage in a contained space that prevents the egress of the post-operative BMP-2 fluid collection.

**Conclusion:** Management and surgical treatment of rhBMP-2 complications have a substantial cost for the patient and surgeon and needs to be considered with the off-label use of rhBMP-2.

**TABLE 1: Revision Surgeries**

Surgical Level	Number of patients	Number of revision surgeries	Description of Revision Surgeries	Average Duration from previous surgery (months)	Additional CT Scan and Clinical Notes
L4-L5	4	7	- 5 Revision Laminoforamintomies with neurolysis - 1 patient also required a lumbar dural repair and an additional procedure for irrigation and debridement of the lumbar wound	8.8 (Range 0.9-24.7)	-In addition, two patients with cage migration and osteolysis
L5-S1	6	8	- 9 Revision Laminoforamintomies with neurolysis	7.8 (Range 1.7-16.3)	-One of these patients had an additional large calcified fluid collection extending from the disk space causing L5-S1 nerve root compression.





**Figure 1:** Axial CT scan (left) and Sagittal CT scan (right) showing left neuroforaminal bone growth at L5/S1

### O341

#### EFFECTIVENESS AND SAFETY OF RECOMBINANT HUMAN BONE MORPHOGENETIC PROTEIN-2 VERSUS LOCAL BONE GRAFT IN PRIMARY LUMBAR INTERBODY FUSION

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**Background:** Recombinant Human Bone Morphogenetic Protein-2 (rhBMP-2) is often used in posterior lumbar interbody fusions (PLIF) and transforaminal lumbar interbody fusions (TLIF), but is associated with complications. Recent evidence suggests using local bone graft (LBG) may be sufficient to induce fusion. The aims of this study were to compare clinical outcomes, fusion rates and rates of complications in PLIF and TLIF procedures with either rhBMP-2 and LBG or LBG alone used as the graft.

**Methods:** All patients who underwent primary one- or two- level PLIF/TLIF between August 2007 and August 2010, under a single surgeon, were identified from the surgeon's records. In November 2008 the surgeon changed from routinely using LBG to using LBG and rhBMP-2, limiting selection bias. A retrospective review of prospectively collected data pre-operatively and up to 12-months post-operatively was performed. Data collected

included visual analogue scale (VAS) pain scores for back and leg, Oswestry disability scores (ODI), Short Form 36 (SF-36), standing lumbar radiographs, and clinical notes.

**Results:** Seventy-seven patients met the study criteria and 70 consented to be part of the study. Fifty-one were treated with rhBMP-2 and 19 with LBG. At 12-month follow up no significant differences were seen in VAS, ODI or SF-36 scores. 94.4% of the LBG group and 88.2% of the rhBMP-2 group went on to show radiographic evidence of fusion by 12-month follow-up ( $p=0.37$ ). The rhBMP-2 group had a higher complication rate (41.2% versus 10.5%, IRR=3.91,  $p=0.05$ ). The most common complication associated with rhBMP-2 was radiculitis (27.5%).

**Conclusion:** In comparison we found no difference in clinical outcomes, comparable rates of fusion and a significant increase in complication rates with rhBMP-2. Using rhMP-2 may unnecessarily increase the price and risk of complication in routine PLIF and TLIF procedures when LBG is sufficient.

### O342

#### INCONSISTENCIES BETWEEN ABSTRACTS AND MANUSCRIPTS IN PUBLISHED PAPERS ABOUT LUMBAR SPINE SURGERY

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**Introduction:** Randomized controlled trials (RCTs) represent the gold standard upon which evidence-based treatment decisions are made. Inconsistencies between an abstract and manuscript can mislead readers' interpretation of findings and conclusions. Abstract findings are often cited without reference to the manuscript itself. In other fields of medicine, studies have shown discrepancies between RCT abstracts and manuscripts.

**Objective:** It was the current study's purpose to perform a comparison of RCT abstracts and manuscripts published in recent spinal literature.

**Methods:** A literature search of RCTs published in Spine, The Spine Journal, and Journal of Spinal Disorders and Techniques during a ten year period (2001-2010) was performed. All articles described as randomized trials concerning lumbar spinal surgery were selected. Articles were analyzed using a standardized 21-item questionnaire to collect data regarding inconsistencies or bias in the abstract compared to the manuscript. Abstracts were considered deficient if they contained data that were either inconsistent with the manuscript or if they failed to include important findings from the manuscript. Four reviewers reported on the 40 articles that met the inclusion criteria. Each article was reviewed by two reviewers. In the event of conflicts in analysis, resolution was achieved through discussion between the reviewers.

**Results:** At least one inconsistency was found in 75% of studies. Despite the word "randomized" appearing 75% of titles and 92.5% of abstracts, the method of randomization was not described in 37.5% of manuscripts and (if described) was considered unacceptable in 28%. The primary outcome of the study was clearly stated in only 22.5% of abstracts and 47.5% of manuscripts. Pertinent negatives were not reported in 40% of the abstracts. Relevant statistically significant results were reported in only 60% of abstracts.

**Conclusions:** Abstracts are discrepant with full manuscripts in a surprisingly high proportion of articles. Authors, editors, and peer reviewers should strive to ensure that abstracts accurately represent the data in RCT manuscripts.



O343

### THE EFFECT OF EARLY INITIATION OF REHABILITATION AFTER LUMBAR SPINAL FUSION: A RANDOMIZED CLINICAL STUDY

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**Study Design:** A multicenter RCT including 82 patients.

**Objective:** To examine the effect of early initiation of rehabilitation after instrumented lumbar spinal fusion.

**Background:** Lumbar spinal fusion has been performed for more than 70 years. Yet, only few studies have examined patients' subsequent rehabilitation. Group-based rehabilitation is both efficient and cost-effective in rehabilitation of lumbar spinal fusion patients.

**Methods:** Patients with degenerative disc diseases undergoing instrumented lumbar spinal fusion were randomly assigned to initiate their rehabilitation 6 weeks (6w-group) or 12 weeks after lumbar spinal fusion (12w-group). Both groups received the same group-based rehabilitation. Primary outcome was the Oswestry Disability Index (ODI). Secondary outcome was the Dallas Pain Questionnaire (DPQ), the Low Back Pain Rating Scale, and absence from work. Wilcoxon rank sum test was used to compare the groups in terms of differences from baseline to 6 months and 1-year follow-up.

**Results:** According to the ODI, at 1-year follow-up, the 6w-group had a median reduction of -6(-19;4) compared with -20(-30;-7) in the 12w-group ( $p<0.05$ ). The DPQ showed overall the same tendency and within daily activities were a significantly reduced in favour of the 12w-group ( $p<0.05$ ). For back pain, the 6w-group had a median reduction of -2.2 (-3.0;-0.7) similar with -3.3 (-4.7;-1.7) in the 12-w group ( $p<0.05$ ). The results at 6 months of follow-up were comparable. No difference was found according to return to work 1-year post surgery.

**Conclusion:** Early start of rehabilitation (6 weeks versus 12 weeks) after lumbar spinal fusion resulted in inferior outcomes. The improvements in the 12w-group was four times better than that of the 6w-groups indicating that the start-up time of rehabilitation is an important contributing factor for the overall outcome.

O344

### PRESURGICAL PSYCHOLOGICAL SCREENING: A NEW ALGORITHM, INCLUDING THE MMPI-2-RF, FOR PREDICTING SPINE SURGERY RESULTS

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**Introduction:** The literature supports that psychological factors are related to spine surgical outcomes. Presurgical psychological screening (PPS) combines psychological interview, testing, and medical chart review to derive a prognosis for surgery outcome. The purposes of this prospective study were to: determine

which scales of the MMPI-2-RF psychological evaluation were related to surgical outcome, revise the current PPS based on that information, and examine effectiveness of PPS in predicting outcome.

**Methods:** Cluster analysis was performed of MMPI-2-RF scores from 324 patients. After revising the PPS algorithm, outcome is reported for 120 surgical patients who have completed follow-up. Outcome measures included Oswestry Disability Index, Pain Rating, emotional state rated on Likert-type scales, vocational status, and satisfaction.

**Results:** Cluster analyses revealed 4 distinct MMPI-2-RF clusters. Scales significantly correlated with outcome were demoralization, dysfunctional negative emotions, malaise, stress/worry, and self-doubt. Incorporating these findings into the PPS algorithm, 41 patients were predicted to have good outcome (Group G), 47 fair-to-good outcome (Group FG) and 32 fair or fair-to-poor outcome (Group F). Group G has somewhat better outcomes than FG, while Group F had significantly ( $p<0.05$ ) lower satisfaction scores and significantly greater scores ( $p<0.05$ ) on the Oswestry and pain scales, as well as greater levels of depression, anger, and irritability.

**Discussion:** Multiple MMPI-2RF scales were related to outcome. The PPS was revised based on those results. There was a strong relationship between the PPS surgical outcome prognosis and actual outcome. Use of PPS may improve outcome by not performing elective surgery on patients predicted to have a poor result.

**Conclusions:** Several MMPI-2-RF scales were strongly associated with reduced surgery results, those reflecting the highest overall level of emotional distress. The PPS algorithm was effective in predicting surgical outcomes. Patients in the G and FG groups obtain much better surgical results than those in the F or FP groups.

O345

### DO WE AGREE ON LEVEL OF EVIDENCE (LOE), AND DOES AUTHOR DESIGNATED LOE INFLUENCE ACCEPTANCE OF ABSTRACT FOR PODIUM PRESENTATION?

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**Introduction:** Level of Evidence (LOE) derived from a clinical study determines its scientific impact. This study investigates:

- The influence of LOE, as determined by the authors, on acceptance of the abstract for podium presentation in SRS annual meeting;
- Agreement between authors vs. independent reviewers on LOE determination.

**Material:** First 643 blinded abstracts were rated by authors for LOE when submitted. This data was used to evaluate the influence of LOE on acceptance. Secondly, the 115 abstracts that were accepted for podium presentation, were rated for LOE by five blinded reviewers, who did not participate in original review process. The agreement on LOE between the authors vs each of the five independent reviewers (rater) were evaluated by adjusted Kappa analysis.

**Results:** Acceptance of an abstract for podiums presentation was strongly influenced by LOE as designated by the authors [level I=24%, level II=20%, and level III and IV=9% each]. Acceptance for poster presentation was also influenced to a lesser extent [level I=28%, level II=21%, and level III=16% and level IV=12%]. 80% of LOE level IV abstracts were rejected. The agreement on LOE varied between the rater-pairs, ranging



from kappa 0.2 to 0.5. The overall agreement was poor. For all observers combined, the agreement was kappa 0.3.

**Conclusion:** This study indicates that there is a strong influence of the LOE as rated by the authors, on acceptance of abstract for presentation in a scientific meeting. However, the agreement between the observers in determination of LOE is poor. There is a need for better understanding of LOE amongst the scientific community, particularly when LOE is considered in drafting Evidence Based Medicine, and Clinical Practice Guidelines.

#### O346

##### ASSOCIATION OF COMPLEMENTARY AND ALTERNATIVE MEDICINE USE AND HEALTH CARE EXPENDITURES FOR SPINE PROBLEMS

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**Introduction/Aims:** Health care costs associated with complementary and alternative medicine (CAM) use by patients with spine problems has not been studied in a nationally representative sample. We estimated the total and spine-specific expenditures among CAM and non-CAM users with spine problems.

**Materials and Methods:** Adults (> 17 years) with self-reported spine problems from 2002-2008 were identified in the Medical Expenditure Panel Survey. CAM users were those who reported seeing a chiropractor (75% of users), massage therapist (18.8%), acupuncturist (6.9%), homeopathic physician (3.4%), or an unspecified CAM provider (4.5%). Linear regression and propensity score matching were used to examine mean expenditure differences between CAM and non-CAM users while controlling for patient characteristics, socioeconomic factors, and health status. Design variables were used to account for multistage sampling.

**Results:** We included 12,036 respondents, including 35.8% who were CAM users. CAM users had better health, lower comorbidity, higher educational and socioeconomic status compared to non-CAM users. Compared to non-CAM users, the adjusted annual medical costs among CAM users was \$424 lower (95%CI \$240, \$609;  $p < 0.001$ ) for spine-related costs, and \$796 lower (95%CI \$121, \$1470;  $p = 0.021$ ) for total medical costs. Using propensity matching, CAM users had \$526 lower spine-specific costs ( $p < 0.001$ ) and \$298 lower for total health care costs ( $p = 0.403$ ). Primary differences were due to lower inpatient expenditures among CAM users.

**Discussion:** Our study is the first to generalize the findings from previous reports that CAM use does not increase overall medical spending and even suggests possible cost savings.

**Conclusion:** While CAM use does not appear to add to medical spending, the causal association with expenditures remains unclear in these cross-sectional data. Future research might benefit from approaches that minimize confounding.

#### O347

##### TRENDS IN UTILIZATION AND EXPENDITURES FOR SPINE-RELATED PROBLEMS IN THE UNITED STATES

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**Introduction/Aims:** We update previously conducted analyses that use nationally representative surveys and discharge databases to describe trends in inpatient, outpatient, prescription medications, and emergency department utilization and costs for back and neck problems in the United States.

**Materials and Methods:** We summarized data from the 2000-2008 Medical Expenditure Panel Survey, the National Ambulatory Medical Care Survey, the Nationwide Inpatient Sample, and select State Inpatient Databases and State Ambulatory Surgery Databases. Medical encounters for spine-related problems were identified using an algorithm based on the *International Classification of Disease and Current Procedural Terminology*. We describe age- and sex-adjusted trends in inpatient, outpatient, pharmacy, and emergency department utilization for spine problems directly standardized to the U.S. Census population. Inflation-adjusted expenditures were described using both incremental and direct costing method.

**Results:** In 2008 approximately 27 million people in the United States sought medical care for a back or neck problem (11.9% treated prevalence), including 18.3% who received public insurance (a 21% increase since 2000). Incremental health expenditures attributed to spine problems increased from 2000 (\$61.0 Billion) until 2004 (\$108 Billion) before stabilizing through 2008 (\$80.0 Billion). Similarly, direct costs specifically related to spine problems increased from 2000 (\$22.1 Billion) until 2005 (\$32.6 Billion) before stabilizing through 2008 (\$30.4 Billion). The population rate of fusion for all ages, payers, and vertebral regions was 140.2 per 100,000 U.S. residents, a 44% increase since 2000.

**Discussion:** While back and neck problems continue to account for a large proportion of health care utilization and expenditures, total spine related expenditure increases have slowed since 2004.

**Conclusion:** Future research should examine whether recent trends in utilization and expenditures are associated with changes in population measures of safety and effectiveness.





O378

### COMPENSATION HINDERS FUNCTIONAL RECOVERY IN LUMBAR SPINAL FUSIONS – OR DOES IT? THE BENEFITS OF A NO FAULT, UNIVERSAL COMPENSATION SYSTEM

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**Introduction:** It is often regarded that compensation for injury results in inferior outcomes following lumbar spinal fusion (LSF). Characteristics of compensation patients include psychosocial disadvantageous factors, benefits linked to disability and unpredictable coverage in an adversarial system. An experimental trial of no fault, universal, time limited compensation for whiplash suggests reduction of pain, disability and cost (1). The New Zealand Accident Compensation Corporation (ACC) system is a no fault, universal compensation system and therefore represents an ideal method of examining this form of compensation when applied to LSF, in a non-experimental population.

**Methods:** A systematic review was performed to examine the difference in functional outcomes after LSF in workers compensation (WC) compared with non-WC (NWC) patients. We searched Medline (1966-2011), Embase (1980-2011), and the Cochrane controlled trials register. In addition, a prospective study of functional outcomes in 390 New Zealand LSF patients was performed to investigate results in ACC (179) and non-ACC (211) patients. Comparison of differences in the WC and ACC environments was performed.

**Results:** 21 studies satisfied the inclusion criteria. Eight reported results for WC only. 12 out of the remaining 13 studies found NWC patients had significantly better outcomes than WC. Only 11 studies reported functional outcome measures, with the remaining ten studies excluded due to confounding factors. In the prospective study arm, ACC patients demonstrated equivalent good outcomes at long term follow up when compared to non-ACC patients, as measured by RMDQ, LBOS and SF-12v2 PCS, MCS, and SF-6D.

**Discussion and Conclusions:** This systematic review confirmed the deleterious effect of WC on outcomes after LSF. This effect was not seen in ACC patients in NZ, where the functional gains in the ACC patients were comparable with the non-ACC patients at long term follow up. The postulated cause of this observation is that ACC is a universal no fault compensation system.

#### Reference:

- Cassidy JD, Carroll LJ, Côté P, Lemstra M, Berglund A, Nygren A. Effect of eliminating compensation for pain and suffering on the outcome of insurance claims for whiplash injury. *N Engl J Med.* 2000 Apr 20;342(16):1179-86.

O379

### DENSIProbe SPINE: FIRST CLINICAL EXPERIENCE WITH INTRAOPERATIVE MEASUREMENT OF BONE QUALITY

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**Introduction:** The measurement device called DensiProbe Spine consists of a modified pedicle probe and an electronic system to measure the peak torque to break-away of trabecular bone in the vertebral body at the site of the pedicle screw tip. Previous reported in vitro validation on human cadaver vertebrae showed a highly significant ( $r = 0.90$ ;  $p = 0.002$ ) correlation between peak torque measured by DensiProbe Spine and regional bone mineral density (BMD) and cut-out of the pedicle screw in a biomechanical test setup ( $r = 0.959$ ,  $p = 0.003$ ).

**Methods:** Prospective monocentric case series with 30 patients undergoing transpedicular instrumentation. All patients underwent areal BMD measurement by DXA. The DensiProbe device was used on one side for each instrumented level, and a transpedicular bone biopsy of the contralateral side was collected and apparent BMD measurements were performed by micro-CT. All measurements were performed by one surgeon who was blinded to the BMD and peak torque data. Subjective impression of bone strength was reported and cement augmentation of the screws performed when indicated.

**Results:** In all patients the handling of the DensiProbe was feasible and unproblematic. No adverse events related to the measurement occurred. Operation time was prolonged by 1.65 minutes per level. In one patient with low BMD (10.7 mgHA/ccm) and torque (0.116 Nm) implant migration was reported, and in eight cases the screws were augmented with cement (mean BMD 13.5 mgHA/ccm, mean torque 0.283 Nm). A significant correlation ( $p < 0.001$ ;  $R = 0.427$ ) between apparent BMD and break-away torque was found. Also DensiProbe was significant superior predicting bone quality compared to the surgeon's tactile impression.

**Discussion:** First clinical experience with DensiProbe Spine shows that intraoperative measurement of bone quality is safe and feasible. The results of peak torque measurement correlate to local bone density and (in vitro) to pedicle screw migration. A larger multicenter study is planned to evaluate the predictive value of this tool, and to define a range where cementation is indicated.

O380

### IS IT BENEFICIAL TO REMOVE THE PEDICLE SCREW IMPLANTS AFTER FUSION IN THORACOLUMBAR FRACTURES?

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**Introduction:** Removal of posterior spinal implants after a successful spinal fusion is a common procedure in thoracolumbar fractures. However, there are still ongoing controversies regarding the advantages and drawbacks of the implant removal. We aimed to investigate the clinical and radiologic outcomes concerning the implant removal after fusion in thoracolumbar fractures.

**Materials and Methods:** Thirty-three patients had undergone an implant removal surgery after a posterior fusion with pedicle screw fixation for thoracolumbar fractures. The mean duration after the index surgery was  $25.3 \pm 17.6$  months. A control cohort of 38 consecutive patients with thoracolumbar fractures that had pedicle screw implants was enrolled. Subjects were followed for more than two years, with clinical parameters (VAS and ODI) and radiologic parameters (vertebral compression ratio and segmental angle) documented during follow up.

**Results:** Demographic variables regarding age, gender, level and type of fracture, radiologic parameters, and compensation status at the index surgery were homogeneous between the two groups. Clinical and radiologic outcomes at the time of removal surgery in the removal group were similar with those of the control group. After 4-year follow-up from the index surgery, radiologic parameters were not different between the two groups. VAS was significantly lower in the removal group ( $2.9 \pm 1.5$ ) than the control group ( $3.8 \pm 1.5$ ) ( $P = 0.028$ ). ODI was also lower in removal group ( $13.8 \pm 8.1$ ) than control group ( $18.5 \pm 11.0$ ) ( $P = 0.042$ ).

**Discussion:** Removal of implant after a successful spinal fusion alleviated pain and disability in patients with thoracolumbar fractures. Further investigation regarding the implant-related pain is needed.

O381

### TWO STATE COMPARISON OF THE SAFETY OF LUMBAR FUSION OPERATIONS AMONG WORKERS' COMPENSATION PATIENTS

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**Introduction/Aims:** We compared complication and repeat surgery rates following lumbar fusion among worker compensation patients in two states. Washington State's utilization review requires documented instability and limits initial fusions to a single level. California has a binding second opinion and separate hardware reimbursement.

**Materials and Methods:** Worker compensation patients ( $n = 8,849$ )



undergoing lumbar fusion for degenerative conditions without significant comorbidity were identified in the 2005-2007 State Inpatient Database. We identified whether each patient had a subsequent lumbar operation, device complication, wound problem, or life-threatening complication within 3 months. Logistic regression was used to compare the rates of complications and reoperation between the two states, controlling for patient characteristics and comorbidity.

**Results:** California's workers were more likely than those in Washington to have axial pain (41.0% versus 33.4%) and herniated disc (33% versus 24%), and less likely to have stenosis (7.3% versus 16.0%) or spondylolisthesis (15.0% versus 21.9%). Circumferential approaches (14.0% versus 7.1%), 3+ disc levels fused (10.0% versus 5.0%), and bone morphogenetic protein (46.1% versus 19.4%) were higher in California, as were adjusted reoperation rates (5.9% versus 1.3%; OR 4.76 95%CI 3.23 – 7.76), device complications (2.8% versus 0.4%; OR 6.67; 95%CI 3.85 – 11.1), wound problems (1.3% versus 0.8%; OR 1.72; 95%CI 0.98 – 3.13), and life-threatening complications (0.6% versus 0.2%; OR 2.41; 95%CI 1.22 – 4.76). Mean charges for fusions in California were \$68,604 compared to \$27,453 in Washington.

**Discussion:** Utilization management policies for lumbar fusion in Washington State were associated with less invasive operations, lower inpatient costs, and improved safety, compared to California's system.

**Conclusion:** Approval and reimbursement policies among workers' compensation programs may result in substantial differences in the cost and safety of spinal fusion. Future work should examine whether these systems resulted in similar return-to-work or patient-reported outcomes.

### O382

#### CRANIAL FACET JOINT VIOLATIONS BY PERCUTANEOUSLY PLACED PEDICLE SCREWS ADJACENT TO A MINIMALLY INVASIVE LUMBAR SPINAL FUSION

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**Background Context:** Protecting cranial facet joint is a modifiable risk factor that may decrease the incidence of adjacent segment disease after lumbar spinal fusion. Percutaneously instrumented screws may more frequently violate cranial facet joints because of its potential limitation for screw entry site selection. To our knowledge, however, there is no study that has evaluated the cranial facet joint violations adjacent to minimally invasive lumbar fusion related with percutaneously placed pedicle screws.

**Purpose:** We investigated the incidence and relating factors of cranial facet joint violations by percutaneous pedicle screws.

**Study Design/Setting:** A retrospective study of prospectively collecting data.

**Patient Sample:** The sample comprises 184 pedicle screws percutaneously placed at the cranial fusion segments in 92 patients who underwent minimally invasive lumbar spinal fusion.

**Outcome Measures:** The facet joint violations adjacent to a cranial fusion segment were examined on the postoperative computed tomography (CT) scans.

**Methods:** Two independent observers retrospectively examined all of the postoperative CT images. A facet joint was considered violated if any of the following situations were encountered: pedicle screw clearly within the facet joint; pedicle screw head clearly within the facet joint; pedicle screw and/or screw head within 1mm from or abutting the facet joint, without clear joint involvement.

**Results:** The incidence of the violations was 50% (46/92) of all patients and 31.5% (58/184) of all screws, which was significantly higher than a previously reported rate with traditional open procedure (50% versus 23.5% of all patients,  $p < 0.001$ ; 31.5% versus 15.2% of all screws,  $p < 0.001$ ). The violations occurred approximately 3.3 times more frequently at the most cranial pedicle screws of L5 pedicle

than at the other pedicles (70.8% versus 42.6%, odds ratio [OR] = 3.3,  $p = 0.021$ ). Logistic regression analysis revealed a significant trend toward reducing the incidence of the violations as increasing the year of surgery (OR = 0.7,  $p = 0.008$ ). The incidence showed no significant relationships with patient age, gender, body mass index, preoperative diagnosis, the number of fused segment, or the screw placed side.

**Conclusions:** Our data raise a concern about the higher incidence of cranial facet joint violations with percutaneously placed pedicle screws than previously reported rate with traditionally instrumented screws. Furthermore, greater care should be taken to avoid cranial facet joint violations when surgeon is a novice to percutaneous pedicle screw placement and/or minimally invasive fusion surgery is considered at L5-S1 segment.

### O383

#### INTRAOPERATIVE EPIDURAL PRESSURE IN PATIENTS WITH POSITIVE VS. NEGATIVE SEDIMENTATION SIGN UNDERGOING SPINAL SURGERY

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**Introduction:** The Nerve Root Sedimentation Sign (SedSign) in transverse magnetic resonance imaging (MRI) has been shown to discriminate well between selected patients with and without lumbar spinal stenosis (LSS). Previously it was demonstrated that a positive SedSign appears to identify patients who are less likely to benefit from non-surgical treatment. It is still unknown which potential mechanisms may be responsible for the absence of nerve root sedimentation in transverse MRI scans in cases of severe LSS.

**Aim:** We aimed to identify the pressure values causing a positive SedSign in patients undergoing spinal surgery for LSS.

**Patients and Methods:** We measured the intraoperative epidural pressure in five patients with LSS and a positive SedSign and in five patients without LSS and a negative SedSign. Epidural pressure was measured using a Codman™ catheter in prone position under radiology at different locations in the lumbar spinal canal.

**Results:** Patients with a negative SedSign had a mean epidural pressure of 9 mmHg (min 8, max 11mmHg) independent of the location of the measurement. Breath and puls-synchronous waves accounted for 1-3 mmHg. In patients with mono-segmental LSS and a positive SedSign the epidural pressure above and below the stenosis was similar (8 and 9 mmHg respectively; min 7, max 12 mmHg). At the level of the stenosis the mean epidural pressure was 23 mmHg (min 21, max 26 mmHg). Whereas cranial of the stenosis a breath and puls-synchronous wave could be demonstrated, this wave was absent below the stenosis. There was no significant correlation between the diameter of the spinal canal and the level of the stenosis.

**Conclusion:** We conclude that in patients with LSS as a consequence of the increased epidural pressure (1) lumbar nerve roots are tethered at the level of the stenosis inhibiting the sedimentation of these nerve roots to the dorsal part of the dural sac in supine position, and (2) no breath and puls-synchronous wave below the stenosis can be detected. However, these findings need confirmation in larger patient samples. Future research is warranted investigating the correlation between an increased epidural pressure and the level of lumbar stenosis.



## SP01

### PREDICTION OF RAPID PROGRESSION OF FAILURE IN A LUMBAR DISC UNDER CYCLIC LOADING - CONTINUUM DAMAGE MECHANICS FORMULATION IN A FINITE ELEMENT MODEL

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**Introduction:** Epidemiological studies have identified repetitive bending and lifting as a major risk for disc prolapse. It is hypothesized that disc failure will occur preferentially in the posterior annulus under cyclic loading and will progress faster under complex loading modes than single axis bending.

**Methods:** Damage accumulation in a lumbar disc under cyclic loading was simulated by incorporating continuum damage mechanics formulation in a poro-elastic finite element model of L4/L5 motion segment. Failure cycle was identified by a sharp increase in the annulus damage volume against a small increment in the number of load cycles. Complex loading was simulated by the application of the bending moments in single or multiple directions in concert with the compressive pre-load.

**Results:** Both cyclic compressive loading with a peak value of 400 N and cyclic bending moments of 6 Nm in the three principal directions without compressive pre-load did not create a rapid propagation of failure in the disc regardless of the number of applied load cycles. However, compressive load with a peak magnitude of 800N produced rapid progression of failure in 50,800 cycles. Cyclic load of 6 Nm bending moments combined with 800 N compressive load decreased the number of cycles to disc failure by 50%(flexion), 32%(lateral bending), 18%(axial rotation) and 71%(flexion + axial rotation + lateral bending) as compared to number of cycles to disc failure under uni-axial cyclic compressive loading. Damage initiated and accumulated in the posterior region of the disc at the annulus endplate interface.

**Conclusions:** The current finite element model emphasized the role of compressive load and bending moments in the lumbar disc herniation. Results were consistent with the experimental and clinical observations in terms of the region of failure, magnitude of applied loads and the number of load cycles to failure.

## SP02

### THE IMPACT OF BONE MINERAL DENSITY AND DISC DEGENERATION ON TORSION BIOMECHANICS OF THE HUMAN LUMBAR SPINE FOLLOWING LAMINECTOMY

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**Introduction/Aim:** The effect of lumbar laminectomy and the impact of bone mineral density (BMD) and disc degeneration on torsion behaviour are unknown. We studied the influence of these factors on torsion moment to failure (TMF) and torsion stiffness (TS) by mechanical testing of human cadaveric lumbar spines. We hypothesize that torsion strength and stiffness of lumbar spinal segments are reduced by laminectomy while also being affected by BMD and disc degeneration.

**Materials and Methods:** Ten cadaveric lumbar spines were obtained (age 75.5, range 59-88 years). Low BMD (DXA) was defined as a BMD value below the median (0.76 g/cm<sup>2</sup>). Disc degeneration (MRI) was assessed and scaled to mild or severe degeneration. Laminectomy was performed either on L2 (5x) or L4 (5x). Motion segments L2-L3 and L4-L5 were isolated from

each spine. TMF and TS (TS-1: 20-40% of TMF; TS-2: 60-80% of TMF) were measured under 1600N axial compression.

**Results:** Treated segments showed smaller TMF (17.6%;  $p=0.041$ ), TS-1 (34.1%;  $p<0.001$ ) and TS-2 (30.1%;  $p=0.027$ ) than untreated segments. Low BMD had a negative effect on TMF. In the high BMD group, TMF was 58.9Nm (43.8-79.2) and decreased to 34.9Nm (23.7-51.2) after laminectomy. In the severe degenerated group, TS-1 was 12.1Nm/° (4.6-21.9) and decreased to 9.4Nm/° (5.6-14.3) after laminectomy. With mild degeneration, TS-1 was 7.6Nm/° (6.4-8.4) and decreased to 6.1Nm/° (1.5-10.3). Effects on TS-2 were similar, but not significant. Neither TMF nor its interaction with laminectomy was affected by disc degeneration.

**Discussion:** Laminectomy substantially reduces torsion strength and stiffness. Low BMD significantly decreased TMF. Stiffness properties of lumbar segments were found to be depending on the severity of disc degeneration, especially in combination with laminectomy.

**Conclusion:** BMD and severity of disc degeneration should be considered in surgical decision-making.

## SP03

### IS MOVEMENT OF THE LUMBAR SPINE IMPORTANT TO POSTURAL STABILITY?

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**Introduction:** Lumbar spine movement is argued to make a significant and critical contribution to the maintenance of postural stability. Recent work reported a reduced spine movement and a concomitant compromised postural recovery in people with low back pain<sup>1</sup>. However, in that study it was not possible to exclude other causes for the compromised postural control, such as poor spine proprioception, which has also been implicated in pain. Resolution of this question requires investigation of the effect of manipulation of trunk flexibility on balance control. The only previous study that has manipulated spine flexibility also restricted hip motion<sup>2</sup>.

**Aim:** This study aimed to examine the temporal and spatial characteristics of postural recovery with and without restriction of lumbar movement using a rigid lumbar corset.

**Method:** Postural responses of twenty healthy participants with and without a tailor-made corset were measured following backward and forward anteroposterior support surface translation at three amplitudes (small, medium and large). Time taken to recover postural stability, postural steadiness (excursion of centre of pressure [COP]) and the number of postural adjustments made during postural recovery were examined.

**Results:** Postural recovery was compromised when wearing the lumbar corset as evident by significantly increased excursion of COP, the number of postural adjustments made during postural recovery, and the associated time, following perturbation in both directions. The compromise was greater following large amplitude perturbations.

**Discussion:** These data support the hypothesis that lumbar spine movement is essential for maintenance of postural stability. Despite the preservation of hip motion, motion at this joint was not sufficient to maintain optimal postural recovery. Taken together these data confirm the potential for compromised spinal motion in back pain (either due to passive restraint or active muscle stiffening) to underpin balance dysfunction in this group.

#### References:

1. Mok et al. *Spine* 36:E45-52;
2. Gruneberg et al. *Exp Brain Res* 157:472-485

## SP04

**STRUCTURAL HEALTH MONITORING (VIBRATION) AS A DIAGNOSTIC TOOL TO IDENTIFY SPINAL PATHOLOGIES: A TWIN STUDY USING MRI VALIDATION**Kawchuk G.N.<sup>1</sup>, Hartvigsen J.<sup>2</sup>, Edgecombe T.<sup>1</sup>, Prasad N.<sup>3</sup><sup>1</sup>Dept. of Physical Therapy, University of Alberta, Edmonton, Canada; <sup>2</sup>Institute for Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark; <sup>3</sup>Mathematical and Statistical Science, University of Alberta, Edmonton, Canada

**Introduction:** Structural health monitoring (SHM) is a vibration-based engineering technique used to evaluate industrial assemblies (e.g. bridges, electrical components) in order to provide unique diagnostic information about structural integrity and functional capacity. While attempts have been made to adapt SHM for spinal evaluation, the invasive nature of SHM has limited its clinical application. The aim of this study was to determine if SHM can be used non-invasively to identify known spinal pathologies in live human subjects.

**Materials and Methods:** Ten pairs of identical twins were identified through the Danish Twin Registry. Magnetic resonance imaging (MRI) of each subject was obtained in order to determine if the twins were pathologically concordant or discordant. A vibration source was then pressed non-invasively into the T12 spinous process of each subject. The resulting vibration response was recorded from accelerometers adhered to the skin overlying the L1-L5 spinouses. From these data, three different outcome measures were computed (peak frequency, area under curve, root mean square) for each subject and sensor. A paired t-test was employed to determine if these outcome measures differed significantly within twin pairs.

**Results:** Based on the MRIs, discordant twin pairs (n=6) were observed to have one of the following pathologies in only one twin individual: compression fracture, disc degeneration, hemangioma, laminectomy and disc prolapse. In discordant twins, peak frequency was found differ significantly between subjects. As expected in concordant twins (n=4), all three outcome measures were found to be statistically similar. Further inspection of vibration data suggests the presence of unique vibration signatures for specific pathologies.

**Discussion/Conclusion:** SHM was capable of identifying unique pathological differences in the lumbar spines of identical twins. These pathologies appear to have unique SHM signatures. Our results suggest that SHM has potential as an MRI alternative in the initial diagnosis and temporal monitoring of spinal pathologies.

## SP05

**GAIT ANALYSIS UNDER REAL-LIFE CONDITIONS IN PATIENTS PRESENTING WITH LUMBAR SPINAL STENOSIS**Kulik G.<sup>1</sup>, Pittier R.<sup>1</sup>, Paraschiv-Ionescu A.<sup>2</sup>, Tzinieris N.<sup>1</sup>, Aminian K.<sup>2</sup>, Schizas C.<sup>1</sup><sup>1</sup>DAL OTR, CHUV, Lausanne; <sup>2</sup>STI, EPFL, Lausanne, Switzerland

**Introduction:** The diagnosis of lumbar spinal stenosis (LSS) is based on patient history, clinical picture, and radiological findings. Although walking limitation is the cardinal sign of LSS, reports on its relation to symptom severity are contradictory. Our primary aim was to quantify the gait parameters monitored under long time real life condition using ambulatory devices, in patients with LSS undergoing either conservative or surgical treatment. Secondary, differences of gait between surgical and non surgical candidates were evaluated.

**Patients and Methods:** Twenty eight patients (71.4 years, SD 10.4y), referred to a spinal surgeon with symptoms attributed to radiological stenosis of varying degrees and with neurogenic claudication were included. Walking parameters were monitored

during 8 hours daily over a period of five consecutive days, prior to any treatment (non-surgical, or surgical), using 2 miniature gyroscopes on thigh and shank. Periods >10s were analyzed with regards to walking speed, cadence, stride length and walking distance as well as gait variability. Walking distance and gait variability (expressed as coefficient of variability CV) were evaluated for the three longest periods recorded in each subject. Statistical differences were analysed using t-test.

**Results:** A total of 3757 walking episodes >10sec were analysed. Average values for cadence speed, and stride length were 99 ±6.5 steps/min, 3.1±0.8 km/h, and 1±0.2 m respectively in non-surgical group and 97±10.6 steps/min, 2.9±0.6 km/h, and 1±0.2 m in surgical group. The average values of CV for speed, cadence and stride length were 0.12, 0.07 and 0.09 respectively in the non-surgical group and 0.14, 0.06 and 0.12 in the surgical group, representing a smaller gait variability in the non surgical. There was a trend towards longer walking distances, for the three longest monitored walking periods, in the non surgical group (239±304m vs 110m±111, p=0.01)

**Conclusion:** We found better walking capacities and less gait variability in the non surgical group. Severity of symptoms and stenosis appear to have a measurable impact as observed in our two groups of patients. To our knowledge no previous study looked at physical activity over such a prolonged period in several subjects in the context of LSS. Future research into the reversibility of the aforementioned differences following treatment is underway.

## SP06

**ANNULUS FISSURES ARE MECHANICALLY AND CHEMICALLY CONDUCTIVE TO THE INGROWTH OF NERVES AND BLOOD VESSELS**Stefanakis M.<sup>1</sup>, Al-Abbasi M.<sup>1</sup>, Harding I.<sup>3</sup>, Pollintine P.<sup>1</sup>, Dolan P.<sup>1</sup>, Tarlton J.<sup>2</sup>, Adams M.A.<sup>1</sup><sup>1</sup>Centre for Comparative and Clinical Anatomy, University of Bristol, Bristol; <sup>2</sup>Matrix Biology Group, University of Bristol; <sup>3</sup>Dept. of Orthopaedics, Frenchay Hospital, Bristol, UK

**Introduction:** Recent population studies have shown a quantitative relationship between the extent and severity of lumbar disc degeneration, and a history of severe back pain. Discogenic back pain is particularly associated with fissures in the annulus fibrosus, and with the ingrowth of nerves and blood vessels. We speculate that these features of severe human disc degeneration are themselves related: we hypothesise that fissures in the annulus of degenerated human discs are mechanically and chemically conducive to the ingrowth of nerves and blood vessels.

**Materials and Methods:** Three complementary studies were performed. Firstly, 15 cadaveric discs that contained a major annulus fissure were subjected to 1 kN compression, while a miniature pressure transducer was pulled through the disc to obtain distributions of matrix compressive stress perpendicular to the fissure axis. Secondly, safranin O staining was used to evaluate focal loss of proteoglycans from within annulus fissures in 25 surgically-removed disc samples. Thirdly, in 21 cadaveric discs, proteoglycans (sulphated glycosaminoglycans, sGAG) and water concentration were measured biochemically in disrupted regions of annulus containing one or more fissures, and in adjacent intact regions.

**Results:** Reductions in compressive stress within annulus fissures averaged 36% - 46% (and could have been greater at the fissure axis). Stress reductions were greater in degenerated discs, and were inversely related to nucleus pressure (R<sup>2</sup>=47%, P = 0.005). Safranin O stain intensity indicated that proteoglycan concentration was typically reduced by 40% at a distance of 600 µm from the fissure axis, and the width of the proteoglycan-depleted zone increased with age (P<0.006, R<sup>2</sup> = 0.29) and with



general proteoglycan loss ( $P < 0.001$ ,  $R^2 = 0.32$ ). Disrupted regions of annulus contained 36 - 54% less proteoglycans than adjacent intact regions from the same discs, although water content was reduced only slightly.

**Conclusion:** Annulus fissures provide a low-pressure micro-environment that allows focal swelling and proteoglycan loss, leaving a matrix that is conducive to nerve and blood vessel ingrowth.

#### SP07

### ALTERATION OF BLOOD PERFUSION IN VERTEBRAE OF SUBJECTS WITH SCHEUERMANN'S DISEASE: PRELIMINARY RESULTS

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**Introduction:** Scheuermann's Disease (SD) causes hyperkyphosis of the thoracic spine at early adolescence and its radiological findings are vertebral body wedging, vertebral endplate irregularities and premature disc degeneration. It has been established that SD has a major genetic contribution but aetiology is unknown. In this preliminary study, perfusion at lumbar vertebrae and intervertebral disc diffusion of a contrast agent were studied with serial post-contrast MRI in 6 subjects affected by SD.

**Methods:** 6 subjects (all men, 29-49 years old) diagnosed with SD and 20 control (all men, 30-47 years old) with unrelated low back pain were enrolled in the study. Each of them underwent a series of 1.5 Tesla MRI: one pre-contrast plus six time points (5 minutes, 10 minutes, 2 hours, 4 hours, 6 hours) after Gadoteridol injection. Image analysis was performed as described in (Rajasekaran, 2004)<sup>1</sup> and the contrast agent concentration was esteemed by the Enhancement Percentage (EP) in 12 ROI for each lumbar vertebra.

**Results:** All levels presenting Modic changes (that alter blood perfusion) were excluded, leaving 17 levels affected by SD and 81 as control. Differences were established with Rank Sum Test. EP was significantly lower in disc affected by SD at Vertebral Bone (VB) at 5 and 10 minutes, 2 and 4 hours ( $p < 0.001$ ), in cranial SubChondral Bone at 5 minutes ( $p = 0.005$ ), in caudal SCB at 5 min and 10 min ( $p < 0.001$ ), in the upper End Plate Zone at 2 hours ( $p = 0.039$ ), at 4 hours ( $p = 0.007$ ), in EPZ down at 5 minutes ( $p = 0.005$ ) and at 10 minutes ( $p = 0.01$ ).

**Discussion:** Data show a reduce blood perfusion in VB and SCB in lumbar vertebra of adults affected by SD. This observation should be verified by broader studies, possibly involving adolescent at the onset of the disease, but it may suggest reduce blood flow at VB as a possible primary cause for the disc and vertebral degeneration typical of the pathology.

#### Reference:

1. Rajasekaran S, Naresh Babu J, Arun R, et al. ISSLS prize winner. A study of diffusion in human lumbar discs. *Spine*, 2004;29:2654-67.

#### SP08

### NUCLEUS PULPOSUS CELLS EXPRESSING HBMP-7 CAN PREVENT THE DEGENERATION OF ALLOGENIC INTERVERTEBRAL DISC IN A CANINE TRANSPLANTATION MODEL

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**Introduction:** To investigate the nucleus pulposus cells expressing hBMP-7 to prevent the degeneration of allogenic intervertebral disc in canine transplantation model.

**Methods:** Eighteen canine lumbar intervertebral disc (IVD) were obtained from 5 canine and cryopreserved in liquid nitrogen for 8-12 weeks. Nucleus pulposus cells (NPCs) were isolated from the lumbar intervertebral discs of a 1-year-old beagle dog. The first passage cells were transfected by rAAV2-hBMP7 vector. After 2 weeks post-transfection, NPCs were injected into IVD for constructing the biological IVD. 18 beagle dogs were randomly divided into 3 groups (6 animals in each group) received the transplantation of disc injected by NPCs transfected by rAAV2-hBMP7, NPCs or no cells respectively. MRI and X-ray of all dogs were performed at 4, 12, and 24 weeks after operation. At 24 weeks after operation, all dogs were sacrificed and the lumbar spines were harvested for the biomechanical analysis and then the intervertebral disc allografts were explanted for histology staining analysis, ectogenic NP cell tracing and hBMP mRNA expressing analysis according to the study protocol.

**Results:** X-ray shows that the fine bone fusion between intervertebral disc allograft and adjacent intervertebral body were observed in all three groups. Disc height variance index (DHVI) of three groups is no differences at 24 weeks. MRI scan showed that the intervertebral disc allografts injected NP cells expressing hBMP-7 have a slighter signs of degeneration than the intervertebral disc allografts injected NP cells or no NP cell injection. The range of motion of left-right rotation in the intervertebral disc allograft without NP cells injection was bigger than that of NP cells expressing hBMP7 and NP cells at 24 weeks. PKH-26-labeled cells were identified at the intervertebral disc allograft at 24 weeks, providing evidence of the survival of the injected NP cells. The extracellular matrix analysis demonstrated the discs injected by NP cells expressing hBMP7 to have a more extracellular matrix than either the disc injected by NP cells or no cells injection.

**Conclusion:** The present study demonstrated that NP cells expressing hBMP7 could survival at least 24 weeks and prevent the degeneration of the transplanted intervertebral discs in a beagle model. This solution might have a potential role in preventing the intervertebral disc allograft degeneration in long time follow-up.

#### SP09

### RAPID AND EARLY BONE FORMATION PREVENTS PREMATURE STRUCTURAL COLLAPSE OF BIO-DEGRADABLE mPCL-TCP USED IN PORCINE ALIF

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**Introduction:** Time-dependent implant failure continues to be a major bottleneck limiting the application of bioresorbable scaffolds as cage devices in spinal interbody fusion. Systematic integration of computer-aided technologies in biomaterial fabrication has been used to optimize scaffold architecture to further improve structural integrity. Bioresorbable mPCL/TCP scaffolds were fabricated from poly (epsilon-caprolactone) beta-

tricalcium phosphates to mimic trabecular bone architecture so as to enhance load bearing/sharing during bone healing. The present study aims to evaluate the dynamic interplay between scaffold performance and bone ingrowth in a large animal model of anterior lumbar interbody fusion (ALIF).

**Methods:** Twenty seven pigs were randomized into three equal groups for 2-level (L2/3; L4/5) ALIF viz: 1) mPCL/TCP + rhBMP-2; 2) mPCL/TCP + bone marrow stromal cells and 3) mPCL/TCP alone. Animals received calcein and alizarin injections to label newly formed bone. Operated segments were harvested at 3, 6 and 9-months for micro-CT, histology, backscattered electron microscopy (BSE) with energy dispersive x-ray spectroscopy (EDX) and biomechanical analyses.

**Results:** Newly formed bone was observed in all groups at 9 months. However, early bone ingrowth was observed only in rhBMP-2 group at 3 months. The highest bone volume was with rhBMP-2 while the lowest was with scaffolds-alone. Whereas a complementary relationship between bone formation and scaffold erosion was observed by volumetric analysis from micro-CT, an inverse relationship between bone formation and scaffold fragmentation was revealed by microstructural analyses. This was consistent with findings from BSE/EDX and histology.

**Discussion:** The main weakness of bioresorbable scaffolds is their inability to sustain cyclical loading which often results in premature aging, structural collapse, and implant failure. Here, we observed differences in the in vivo performance of mPCL/TCP depending on the rate and volume of new bone ingrowth. These findings suggest that rapid and early bone formation as well as peri-implant bone adaptation could be key factors preventing the premature collapse of advanced bioresorbable scaffolds in interbody fusion applications.

## SP10

### TISSUE ENGINEERED CONSTRUCT (TEC) PREVENTS DISC DEGENERATION AFTER NUCLEOTOMY IN A RAT MODEL

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**Introduction:** Back pain, a significant source of morbidity in our society, is directly linked to the pathology of the intervertebral disc. We have developed a novel scaffold-free three-dimensional tissue-engineered construct (TEC) derived from cultured mesenchymal stem cells (MSCs) as a unique approach for cartilage repair. This study explores the use of TEC derived from synovial MSCs as a cell-based therapy for intervertebral disc regeneration.

**Methods:** Synovial MSCs were isolated enzymatically from rat synovial membranes as previously reported. For development of the TEC, cells were cultured at the density of  $4.0 \times 10^5/cm^2$  in HG-DMEM in the presence of 0.2mM ascorbic acid 2-phosphate for 2 weeks. The monolayer cultured cell-matrix complex was then detached from cell-substratum interface by addition of shear stress to convert to suspension culture. The cell-matrix complex immediately starts active contraction to develop the three dimensional tissue engineered construct (TEC, Fig1). To explore the use of TEC in degenerative spine, rat caudal intervertebral discs were denucleated and treated with TEC (controls were denucleation only). 9 male Sprague Dawley rats (300-400 g) were used, and two most cranial tail discs were treated in each rat, giving 3 discs per group per time point. At 2, 8 and 12 weeks after implantation, the animals were euthanized and discs were evaluated for disc height based on micro-CT analysis, histology including Safranin O staining, and disc grade based on a scoring system.

**Results:** At the 8-week and 12-week time point, control group experienced severe disruption of the end plate, growth plate,

and annulus. In the TEC-treated discs, disc height was better preserved and the histologic score was significantly improved relative to control group (Fig2).

**Discussion:** This study shows that TEC may prevent postnucleotomy disc degeneration in vivo. Larger animals and longer time points will be necessary to further judge potential clinical impact.

## SP11

### THE EFFECT OF SSRI ON PAIN-RELATED BEHAVIOR INDUCED BY NUCLEUS PULPOSUS APPLIED ON THE NERVE ROOT IN RATS

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**Introduction:** Antidepressants are used for neuropathic pain independent of depression. Paroxetine is one of the selective serotonin reuptake inhibitors and acts to inhibit presynaptic reuptake of serotonin (SSRI). However, effects of SSRI on pain related behavior and biochemical analysis compared with NSAIDs are little known. The purpose of this study was to examine pain-related behavior after administrated either SSRI or NSAIDs using a nucleus pulposus (NP) applied rat model.

**Methods:** Adult female Sprague-Dawley rats (n=250) were used in this study. In the NP model, NP harvested from the tail was applied to the left L5 dorsal root ganglion (DRG). Animals in the NP model were divided into five groups; 0.2mg/kg paroxetine (NP+PL), 0.8mg/kg paroxetine (NP+PH), 0.2mg/kg meloxicam (NP+M), combination of 0.8mg/kg paroxetine and 0.2mg/kg meloxicam (NP+M+PH), saline (NP+S). Animals received 0.3ml of each drug orally once daily for 10 days after surgery. Animals in the sham group did not receive NP on the left L5 DRG. Mechanical withdrawal thresholds were determined using von Frey test for 35days after surgery (n=12 in each group). The number of TNF-immunoreactive (IR) neurons in DRG and Iba1-IR microglia in spinal cord (SC) were evaluated using immunohistochemistry. Expression of TNF in the left L5 DRG were examined using western blotting. Statistical differences were assessed using Bonferroni test. P values less than 0.05 were considered significant.

**Results:** In the four treatment groups, the thresholds decreased for 7 days, while the thresholds increased from 14 days to 28 days compared with the NP+S group (p<0.05). In the NP+S (non-treatment) group, the number of TNF-IR neurons in the DRG and TNF expression level increased for 14 days. In the NP+M group, TNF-IR neurons and the TNF expression level group significantly decreased at day 7 and day 14 compared with the NP+S group. There was no significant difference of TNF-IR and TNF expression level between the NP+PL and NP+S groups. In the NP+M and NP+PL groups, the number of Iba1-IR microglia in SC significantly decreased at day 7 and day 14 compared with the NP+S group.

**Conclusion:** According our results, the mechanisms of analgesic effect are different between the SSRI and NSAIDs.



## SP12

**REMOVAL OF MITOCHONDRIA-GENERATED REACTIVE OXYGEN SPECIES DELAYS AGE-ASSOCIATED DISC DEGENERATION**

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**Introduction/Aim:** Reactive oxygen species (ROS) and free radicals are byproducts of oxidative metabolism that cause cellular damage and are implicated in the pathogenesis of age-related diseases. Mitochondria are the main cellular sites of ROS production. Recent studies reported a positive correlation between mitochondria dysfunction and age-associated disc cellular senescence and apoptosis. Hence we hypothesize that reducing mitochondria-generated ROS would slow the onset of age-related intervertebral disc degeneration (IDD). We tested this hypothesis by chronically treating the *Ercc1*<sup>-D</sup> mouse model of accelerated aging with XJB-5-131, a mitochondria-targeted free radical scavenger previously demonstrated to be therapeutic in rodent models of hemorrhagic shock and sepsis.

**Materials and Methods:** Five weeks old siblings pairs of *Ercc1*<sup>-Δ</sup> mice were treated with XJB-5-131 or oil carrier control (intraperitoneal injections, 2mg/Kg, 3x/week, 15 weeks). Total proteoglycan content (safranin-O histology, DMMB assay) and synthesis (<sup>35</sup>S-sulfate incorporation) were measured. Transmission electron microscopy (TEM) was performed to assess disc mitochondria number and morphology in *Ercc1*<sup>-Δ</sup> mice and wild-type littermates.

**Results:** TEM showed greater mitochondrial death in discs of *Ercc1*<sup>-Δ</sup> mice compared to their wild-type littermates. Compared to oil-treated *Ercc1*<sup>-Δ</sup> controls, discs from XJB-5-131 treated *Ercc1*<sup>-Δ</sup> mice showed greater (1.3x) proteoglycan matrix content and higher (1.9x) rate of proteoglycan synthesis.

**Discussion:** *Ercc1*<sup>-Δ</sup> mouse model of a human progeria had previously established as an accurate model of spine aging. Treatment of *Ercc1*<sup>-Δ</sup> mice with a mitochondria-targeted ROS scavenger decreased disc proteoglycan loss. This result is consistent with our in vitro studies which showed XJB-5-131 is able to rescue reduced proteoglycan synthesis mediated by oxidative stress in human disc cells grown at high oxygen (20% vs. 5% oxygen).

**Conclusion:** The findings in this study suggest that oxidative damage originating from mitochondria dysfunction plays an important role in disc health. The mitochondrial-targeted ROS free radical scavenger XJB-5-131 is potentially therapeutic in delaying the onset of age-related IDD.

## SP13

**A NOVEL BIOCOMPATIBLE "SUPERGLUE" FOR REPAIR OF SPINAL DISC HERNIATION -BIOMECHANICAL INTRA-DISCAL PRESSURIZATION EVALUATION**

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**Introduction:** Torn annulus following spinal disc herniation and fissures in degenerated intervertebral discs are currently not repaired clinically. The purpose of this study was to evaluate the biomechanical adequacy of a novel three-arm star polyisobutylene cyanoacrylate [Ø(PIB-CA)<sub>3</sub>] to repair torn annulus and to withstand physiologic intradiscal pressure.

**Materials & Methods:** Bovine lumbar functional spinal units

were repaired with Ø(PIB-CA)<sub>3</sub> (n=12) or with a control octyl cyanoacrylate [O-CA] (n=6) after introduction of a posterolateral stab wound measuring 9 mm wide and 20 mm deep into the intervertebral disc. Static pressurizations up to 1.7 MPa for 10 seconds and 3.5 MPa for 10 seconds were carried out through anterior intradiscal injection of water. Specimens were monitored for leakage through the repair sites.

**Results:** Intradiscal pressurization resulted in observable increase in disc height. In the control group, 5 of 6 specimens survived static pressurization up to 1.7 MPa while only 1 survived pressurization up to 3.5 MPa. In the study group, 2 specimens leaked initially at 0 MPa and 1 leaked at 1.7 MPa. The remaining 9 of 12 specimens withstood static pressurization up to 3.5 MPa.

**Discussion:** This novel biocompatible "superglue" has potential in revolutionizing spinal treatment. Repair of torn annulus could result in reduced rate of disc re-herniation after microdiscectomy while repair of annular fissures in degenerated spines might prevent ingrowth of nerve endings and possibly discogenic back pain. As polyisobutylene is a rubbery material, degenerated nucleus pulposus injected with Ø(PIB-CA)<sub>3</sub> might be able to achieve restored pressure within the disc space. The long-term presence of a biopolymer adhesive within the intervertebral disc remains to be evaluated.

**Conclusion:** The current study provides promising biomechanical evidence that this novel "superglue" could adequately repair torn annulus and withstand physiologic intradiscal pressure. Further testing is underway.

## SP14

**ROLE OF FACET JOINT TROPISM IN LUMBAR DISC HERNIATION**

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**Study Design:** Analytical cross-sectional hospital-based cohort study.

**Objective:**

1. To determine whether there is an association between facet tropism and the occurrence of lumbar disc herniation at that level.
2. In patients with facet tropism at the herniated disc level, to determine whether there is an association between facet tropism and the side of disc herniation (sagittal or coronal).

**Background:** Facet tropism is defined as asymmetry between left and right facet joint angles and is postulated as a possible etiological cause in occurrence of disc herniation. A correlation in literature is still being debated.

**Methods:** 60 patients (18-40 years) with single disc herniation(L3-L4, L4-L5, or L5-S1) were selected. Exclusion criteria included multiple/recurrent disc herniation, spondylolisthesis, transitional vertebra, scoliosis, previous surgery/trauma/infection and significant facet arthropathy. Facet angles were measured using 3 Tesla MRI by two surgeons and mean taken to minimize bias. Facet tropism was defined as difference of 10 degrees in facet joint angles between right and left sides. Normal adjacent disc was used as control. We also examined if disc herniated towards the side of more coronally oriented facet.

**Results:** Overall we found a statistically significant association of facet tropism with lumbar disc herniation (p= 0.0009). However, analysing each level separately, an association of facet tropism with lumbar disc herniation was found to be statistically significant at the L5S1 level (p= 0.0094) but not at L4L5 level (p= 0.145).

Of 19 cases having tropism at the herniated disc level, the disc had herniated towards the sagittally-oriented facet in 13 (p = 0.11).

**Conclusion:** Statistically significant association exists between facet tropism and lumbar disc herniation at L5-S1. Same does not hold true at L4-5. There is no statistically significant association between facet tropism and the side of the disc herniation (sagittal or coronal) but the numbers were small.

## SP15

**INTRADISCAL INJECTION OF AUTOLOGOUS PLATELET-RICH-PLASMA IMPROVED DISCOGENIC LOW BACK PAIN—PRELIMINARY PROSPECTIVE CLINICAL STUDY**

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**Introduction:** Intervertebral disc degeneration is an important clinical problem; however, an effective treatment has not been established. Activated platelets release many growth factors that facilitate tissue repair. Platelet-rich-plasma (PRP) has been demonstrated to influence the metabolism of intervertebral discs both *in vitro* and *in vivo*. Based on the results of basic studies, we performed a preliminary clinical trial to determine the safety and efficacy of an intradiscal injection of autologous PRP in patients with discogenic low back pain.

**Methods:** Inclusion criteria for this study included chronic low back pain without leg pain for more than 3 months; one or more lumbar discs (L3/L4 to L5/S1) with evidence of degenerative changes on magnetic resonance imaging (MRI); and at least one symptomatic disc, confirmed using standardized provocative discography. PRP-releasate, isolated from clotted PRP, was injected into the center of the nucleus pulposus. Outcome measures included the use of a visual analog scale (VAS) and the Roland-Morris Disability Questionnaire (RDQ), as well as X-ray and MRI (T2-quantification).

**Results:** Data were analyzed from 12 patients (8 men, 4 women; mean age 34.9 years-old). The average follow-up period was 9.8 months. Following treatment, no patient showed adverse events or significant narrowing of disc height. The mean pain score before treatment (VAS: 7.7±1.2; RDQ: 13.5±3.8) was significantly decreased at one month; this was sustained for 12 months after treatment (VAS: 3.1±3.2; RDQ: 2.9±4.2; p<0.01). The mean T2 values did not change significantly after treatment (Pre-treatment: 51.5±4.8 [ms], 4 months: 49.4±10.6 [ms], 12 months 50.7±2.6 [ms]).

**Discussion:** The intradiscal injection of autologous PRP in patients with low back pain has been shown to be safe and effective for twelve months following treatment. Future randomized controlled clinical studies should be performed to evaluate the effects of this therapy.

## SP16

**BODY-MASS INDEX MODULATES ASSOCIATION OF PHYSICAL ACTIVITY WITH LOW BACK PAIN**

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**Aim:** To characterize predictors of chronic low back pain (CLBP) and the association of CLBP with physical activity and body mass index (BMI).

**Materials and Methods:** NHANES is a cross-sectional US population-based survey. 6,796 subjects from the 2003-2004 cohort underwent 7-day accelerometry activity monitoring. Summary measures of activity were computed based on intensity cut-offs, percentile intensities, and bout. CLBP is defined as affirmative response to the presence of low back pain greater than 1 month. Demographics, social history, and comorbidities are used to build adjusted weighted logistic regression models constructed using Akaike Information Criterion (AIC). To control

for BMIs, domain analysis is employed in a stratified analysis.

**Results:** All displayed estimates are significant at level  $\leq 0.05$ . The baseline risk of CLBP increases in step with BMI at 5.2% for overweight (26-30), 7.7% for obese (31-35), and 11.6% for ultra-obese (36+). Age effect is only seen in the normal weight group; compared to baseline (20-30 years) OR is 5.2 for age 30-40 and 6.2 for age 40-50. Smoking is consistently the strongest predictor of CLBP across the BMI spectrum (OR 1.6-2.9). In the overall model, the best physical activity predictors of CLBP are in the moderate and high intensity ranges with small effects (OR 0.98 and 0.996 per SD increase, respectively). When broken down by BMI, however, increased time spent in sedentary ranges, by two measures, is associated with CLBP in the obese group (OR 1.03 and 1.09). Increased time in moderate intensity activity is protective in the overweight group (OR 0.98).

**Discussion:** By leveraging complex survey logistic regression analysis in conjunction with penalized model selection using AIC, we are able to build parsimonious explanatory models of chronic low back pain in the US population. We discover that in contrast to the muted overall effects for physical activity measures, in different BMI groups we find strong effects in different ranges and profiles of physical activity.

**Conclusion:** A rigorous statistical study of the NHANES database has revealed different structures of physical activity association with chronic low back pain and BMI.

## SP17

**THE ASSOCIATION BETWEEN LOW BACK PAIN AND LUMBAR SPINE BONE DENSITY AND TRUNK MUSCLE MASS IN A POPULATION BASED CROSS SECTION STUDY**

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**Study Design:** Population based The Fourth Korea National Health and Nutrition Examination Survey (K-NHANES) was conducted in 2009.

**Objective:** To investigate the association of low back pain (LBP) with structural changes in lumbar spine including bone density and paraspinal muscles.

**Introduction or Background:** LBP is the one of major health issue in public and has a huge impact on the increasing medical and economic cost. Epidemiological studies have identified many individual, psychosocial, and occupational risk factors for LBP. However there has been a limit on analyzing the association between LBP and structural changes in lumbar spine. Although, the role of variables in socioeconomic and other medical diseases in low back pain has been well investigated, the changes of muscle mass and bone quality and their roles in development of LBP has not been precisely evaluated. A Fuller understanding of the risk factors associated with the structural changes in lumbar spine is critically important for preventing the development of LBP.

**Materials and Methods:** The health survey comprised a representative total sample of 12,722 persons. Among them, 7920 persons, which had bone density, trunk muscle mass and anthropometric measurement, were participated in this study. People who have LBP were defined to be diagnosed previously by medical specialists. The relationship between LBP and lumbar spine bone density (t-score) and trunk muscle mass was investigated using multivariable logistic regression analysis. Demographic, socioeconomic, lifestyle and other medical factors were also included in the analysis.

**Results:** It was estimated that there were 15.5% of study population has been diagnosed LBP previously. Logistic





regression analysis demonstrated lower trunk muscle mass (OR 0.545, CI 0.299-0.992) and higher lumbar spine t-score (OR 1.133, CI 1.027-1.250) were significantly associated with diagnosis of LBP. Other factors including gender, age, occupation, education, drinking and depression have been identified as associating factors of LBP.

**Conclusion:** In this study, we identified that LBP has been associated not only with socioeconomic and medical status, but also with structural changes in spine including bone density and trunk muscle mass. Although, this study doesn't reveal whether spinal structures are of any causal importance in the development of LBP, this study supports the principle that the strengthening the spinal structures would be one possible preventive strategy for the development of LBP. Further efforts to investigate the causal relationship of LBP with spine structures and their relation to the treatment outcomes are needed.

SP18

**FAILURE ANALYSIS OF PATIENTS IN A US IDE TRIAL OF A POSTERIOR DYNAMIC STABILIZATION SYSTEM (PDS) WHO DID NOT ACHIEVE PRIMARY SUCCESS ENDPOINTS**

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**Introduction:** Pedicle screw based posterior dynamic stabilization systems have been evaluated in two Food and Drug Administration sponsored investigational device exemption studies in the United States. The Dynesys trial resulted in a non-approval recommendation from the FDA advisory panel and the Stabilimax trial was halted due to grit-blasted screw failures. Evaluation of patients who failed to meet the primary measures of success may provide valuable information to help design further studies, and define clinical indications.

**Methods:** The Stabilimax FDA IDE enrolled patients with back and leg pain due to spinal stenosis in a prospective, randomized clinical trial. Decompressive surgery was performed at a single level between L3 and S1. The patient then received posterior pedicle screw fixation with posterolateral fusion, or stabilization without fusion provided by the Stabilimax system. Evaluations were performed clinically and radiographically pre-operatively, and at 6 weeks, 3,6,12,18, and 24 months post-operatively. Primary outcome measures included ZCQ (Zurich Claudication Questionnaire), and VAS (Visual Analog Score). Secondary outcome measures included ODI (Oswestry Disability Index). All patients also underwent radiographic evaluation with independent review. Historical data is provided from public FDA records on the Dynesys trial.

**Results:** Sixty consecutive single level investigational patients were enrolled at 19 study sites. The average age was 59.4 years with 35 females and 25 males enrolled. 40% (24/60) of patients did not reach primary endpoint success at 2 years. There were 44 independent failure modes in these 24 patients including 27% (16/60) who failed to reach ZCQ success, a 12% (7/60) re-operation rate, a 10% (6/60) device removal rate, a 10% (6/60) screw fracture rate, and a 10% (6/60) VAS failure rate. Each failure mode is reviewed. With regard to screw fractures, no statistically significant difference is noted in overall success rate for screw fractured patients versus those without fractures. Correlation of age, BMI, smoking status, pre-operative disc height, degree of spondylolisthesis, severity of spinal stenosis and screw size with likelihood of success or failure is presented.

Table 1 shows a comparison of the Stabilimax failure rates with those from the Dynesys trial. The global clinical outcomes (ZCQ and ODI) are the greatest cause of failure. VAS leg pain failures and reoperations have similar, lesser failure rates. Implant fracture rates are near zero for most devices.

Outcome	Stabilimax	Dynesys	Posterolateral fusion (Dynesys control)
ZCQ failure	27% (16/60)	N/A	N/A
ODI failure	13% (8/60)	24% (42/175)*	30% (21/70)*
VAS failure	10% (6/60)	13% (22/173)*	27% (19/70)*
Reoperation	12% (7/60)	5% (7/140)	16% (9/57)
Implant fractures	10% (6/60)	1.2% (3/253)*	0.0% (0/70)*

\*Includes one and two level cases

**Conclusion:** Failure analysis of US IDE clinical trials of posterior dynamic stabilization systems show that clinical failure is much more likely than implant failure. Implant failure, specifically, screw fracture does not correlate with clinical failure. Small numbers of patients enrolled prevent firm statistical conclusions about clinical predictors of failure, however trends indicate younger patients, those with greater BMI, and smokers had increased failure risks.

SP19

**A CROSS-SECTIONAL STUDY OF LUMBAR LESION IN 262 RHEUMATOID ARTHRITIS PATIENTS**

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**Background:** The cervical lesion in rheumatoid arthritis (RA) has been well studied, however the lumbar lesion in RA have been paid less attention. There are only a few reports have described the prevalence of lumbar lesion. The purpose of this study was to assess lumbar lesion in RA patients and to evaluate the factors related lumbar lesion.

**Material and Methods:** A total of 262 patients who fulfilled the revised criteria of the American Rheumatism Association were included in this study. The background of RA was assessed based on the following points: age, duration of disease, low back pain assessed by visual analog scale (VAS), DAS-28 ESR, and RA stage and class by Steinblocker's criteria. We examined the prevalence of lumbar lesion (degenerative lumbar scoliosis (DLS), lumbar spondylolisthesis (LS) and vertebral fracture (VF) on plain X-rays. We analyzed the correlations between the lumbar lesion and the background factors.

**Results:** The prevalence of lumbar lesion was 56.9% (DLS, LS, and VF were 35.9%, 31.7% and 16.4% respectively). RA class, DAS-ESR and VAS were significantly high in the patients with lumbar lesion.

**Discussion:** The previous study reported the prevalence of DLS, LS and VF in elder Japanese were 17.4%, 8.9%, and 17.8% respectively. Therefore, the prevalence of DLS and LS were considered to be higher in this study population. Erosion of endplate and/or facet joint may be the cause of the high prevalence of lumbar lesion. In the patients with lumbar lesion, RA class and DAS-ESR was significantly high. That implied the activity of RA might effect on incidence of lumbar lesion.

**Conclusion:** The prevalence of lumbar lesion was high in RA patients. RA class, DAS-ESR and VAS was significantly high in the patients with lumbar lesion.



## SP20

**ASSOCIATION OF BODY MASS INDEX IN EARLY CHILDHOOD WITH LUMBAR DISC DEGENERATION AT 21 YEARS**

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**Introduction:** There are no studies on association between early childhood body mass index (BMI) and lumbar disc degeneration (DD) later.

**Materials and Methods:** The Oulu Back Study includes children who belong to the Northern Finland Birth Cohort 1986 and have been followed up to 21 years. Data from child health clinic records were used to derive BMI at birth, at adiposity peak (AP), and at adiposity rebound (AR). Lumbar MRI was performed using a 1.5-T scanner at the age of 21. Lumbar intervertebral discs were graded as normal (0), mildly (1), or moderately degenerated (2) according to the Pfirrmann grading. The sum score of lumbar DD was categorized as 0, 1-2 or at least 3. The associations of BMI at birth, AP and AR with DD were analyzed using multinomial logistic regression with and without adjustment for relevant confounders, stratified by gender.

**Results:** Of the 520 scanned subjects, 46% had no DD, 38% had sum score of 1 or 2, and 16% sum score of at least 3. In the univariate models BMI at birth among females and BMI at AR among males were positively associated with DD sum score of at least 3 (OR 1.3; 95% confidence interval (CI) 1.0-1.7 and OR 1.8; 95% CI 1.1-2.7, respectively). In adjusted models the results weakened among females, while among males the associations between BMI at AP and AR with DD sum score of at least 3 strengthened (OR 2.0; 95% CI 1.1-3.7 and OR 2.2; 95% CI 1.4-3.7).

**Conclusions:** High BMI at AP and AR in early childhood increased the likelihood of lumbar DD at the age of 21 among males. This novel finding may help to understand the pathomechanisms of DD.

## SP21

**ANUMERICAL MODEL OF CELL VIABILITY IN DEGENERATED LUMBAR INTERVERTEBRAL DISCS**

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**Introduction:** Degeneration of the intervertebral disc may be initiated and supported by an impairment of the nutrition of the disc cells. The aim of this work is to investigate the effect of endplate calcification, water loss, reduction of the disc height and cyclic mechanical loading on the sustainability of the disc cell population, by using a numerical model.

**Materials and Methods:** Simulations were carried out with a verified in-house finite volume code. Oxygen, lactate and glucose diffusion, production and consumption were modeled with nonlinear coupled partial differential equations. Oxygen and glucose consumption and lactate production were expressed as a function of local oxygen concentration, pH and cell density. Cell viability criteria were based on the local glucose concentration and pH. The effect of cyclic disc compression was modeled as convective solute transport. Degeneration was modeled by reducing the water content of the disc, reducing the solute

diffusivities in the cartilaginous endplates and the disc height.

**Results and Discussion:** Considering a disc with a normal water content, cell death was initiated in the center of the nucleus for oxygen, glucose and lactate diffusivities in the cartilaginous endplate lower than 20% of the physiological values. The initial cell population could not be sustained even for not calcified endplates when a reduction of diffusion inside the disc due to water loss was modeled. Alterations in the disc shape such as height loss, which shortens the transport route between the nutrient sources and the cells, and cyclic mechanical loads, could enhance cell nutrition processes.

**Conclusions:** The reduction of diffusion of nutrients and metabolic waste products inside the intervertebral disc due to the loss of the disc water content and calcification of the endplates has the potential to reduce the cell density in the intervertebral disc, thus supporting the degenerative process.

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## SP22

**SURGICAL SOFT-TISSUE TRAUMA CAUSES DISC DEGENERATION – AN IN VIVO ANIMAL STUDY ON GOETTINGEN MINIPIGS**

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**Introduction:** Biological treatment options such as disc-cell-therapy have been proposed for only moderately degenerated discs. Therefore, surgical exposition of the disc is needed. However, the effect of surgery related soft-tissue damage on the maintenance of disc degeneration is poorly understood. Therefore, this study analyzes, if disc degeneration can be induced only by the surgical approach.

**Materials and Methods:** We used an established model with adult minipigs offering biomechanical properties similar to humans. 12 Animals underwent surgery using an anterolateral retroperitoneal approach to the lumbar spine. At each animal, 2 discs were only exposed whereas 2 other discs were exposed and partially nucleotomized with a 16G-biopsy-needle. Animals received a second revision surgery after 12 weeks, using the same approach and all discs were exposed again. 13 or 24 weeks after first surgery, animals were sacrificed. Disc height was measured in the central part of the disc by micro-CT. Disc degeneration was evaluated by a semi-quantitative histo-degeneration-score. 3 untreated control animals served as controls.

**Results:** After the second surgery, increased scar tissue and less vascularisation was found around the lumbar vertebral bodies on the side of the approach.

Most degenerative changes were found after partial nucleotomy ( $p < 0.05$ ) and additional annular damage was detectable, with a trend to higher degeneration scores after 24 weeks; disc height was significantly reduced compared to all other groups ( $p < 0.05$ ; 3.2 and 3.3 mm).

Discs that were only surgically exposed also revealed significant degenerative changes including increased osteophytes; disc height was also significantly reduced compared to healthy control discs from animals without surgery ( $p < 0.05$ ; 3.7 and 3.8 mm versus 4.6 mm).

**Discussion:** Surgical exposure of lumbar discs caused significant disc degeneration without further disc manipulations. Reduced nutrient supply to the disc, caused by less vascularized scar tissue seems to be a reason, which will be analyzed by additional immunohistological stainings against CD31.

**Conclusion:** Surgical soft-tissue damage can be a stimulus for disc degeneration.



SP23

**RELATIONSHIP BETWEEN PAIN, PATIENT EXPECTATIONS, AND SATISFACTION FOLLOWING SPINE SURGERY**

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**Introduction:** The purpose of this study was to investigate the relationships between patient expectations, changes in pain levels, and satisfaction with spine surgery outcome.

**Materials and Methods:** Data were collected prospectively for 160 patients. Patients completed 0 to 10 numerical rating scales (NRS) asking their current pain intensity and what they expected their pain to be after surgery. Post-operatively, patients completed NRSs indicating current pain level, how well their outcome met expectations, and satisfaction.

**Results:** Post-operatively, the mean current pain level was significantly greater than expected ( $p < 0.05$ ; see table) although it was significantly improved from pre-operative ( $p < 0.05$ ; improved significantly, but not to the level expected). Among patients who met expectation (compared pre-operative expected value with post-operative pain) 98.0% scored 7 or greater on NRS asking how well surgery met expectations. Among patients whose post-operative pain was at or below expected level, 96.0% scored 7 or greater on the satisfaction scale. Only two patients' expected pain value was met or exceeded, but they were not satisfied. Significantly more patients were satisfied when comparing those whose expectations were met (96.0%) vs. those whose expectations were not met (62.2%).

Self-reported values	Median	Significance (Wilcoxon; $p < 0.01^*$ )
<b>Pre-op:</b>		
Current pain level	7.0	
Expected pain level after surgery	2.0	< pre-op current pain*
<b>Post-op:</b>		
Current pain level	4.0	< pre-op current pain*; and > expected*
Did surgery meet expectation	7.0	
Satisfaction	7.0	NA
<b>Calculated values</b>		
Difference between pre-op and expected post-op pain level	3.0	NA
Difference between expected and post-op pain level	2.0	NA

**Discussion:** Pain improved significantly, but not to the level expected. However, patients were satisfied. There was a high rate of agreement between asking post-operatively if expectations were met and calculating if expectations were met based on pre-operative expected pain levels and post-operative current pain level.

**Conclusions:** Patients whose expectations were met were highly satisfied; however, failure to reduce pain to expected level did not preclude being satisfied.

SP24

**DOES THE HARVESTING OF POSTERIOR ILIAC CREST AUTOGRAFT CONTRIBUTE TO SHORT OR LONG TERM FUNCTIONAL IMPAIRMENT IN PATIENTS UNDERGOING POSTERIOR LUMBAR FUSION?**

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**Introduction:** Harvesting posterior iliac crest bone graft (ICBG) may result in pain, with increased surgical time and complications. It is however the 'gold standard' against which alternatives are compared. There is a risk that symptoms may be overstated in questionnaires investigating ICBG, with potential for confusion between ICBG pain and lumbar origin pain. This study aims to assess the functional status of patients having ICBG for posterior lumbar fusion (PLF), compared to patients where local/laminectomy bone (LB) only was used to achieve PLF.

**Methods:** A cohort of 96 patients underwent primary PLF with decompression for treatment of spinal stenosis and degenerative spondylolisthesis. All patients underwent fusion with pedicle screw instrumentation. 71 patients had ICBG, whilst 25 had LB. Roland Morris Disability Questionnaires (RMDQ) and Low Back Outcome Scores (LBOS) were administered preoperatively, at 1 year, and at the long term follow up (LTFU) time point. The SF12v2 was only administered at LTFU. Results were analysed by t-tests and tests of proportions, and expressed as mean  $\pm$  standard error.

**Results:** Group characteristics were similar apart from duration of follow up, which was longer in the ICBG group. Baseline characteristics and preoperative RMDQ and LBOS were not significantly different. At one year the RMDQ scores for the ICBG and LB group was  $4.6 \pm 0.65$  and  $4.5 \pm 0.96$  ( $p > 0.05$ ) respectively. LBOS scores were  $52.3 \pm 2.5$  (ICBG) and  $50.6 \pm 3.3$  (LB) ( $p > 0.05$ ). These improvements were highly significant compared with preoperative scores. LTFU scores for the ICBG and LB groups were RMDQ:  $6.3 \pm 0.9$  and  $5.0 \pm 1.1$  ( $p > 0.05$ ), and LBOS:  $41.5 \pm 2.4$  and  $48.1 \pm 3.2$  ( $p > 0.05$ ). The SF-12v2 gave PCS and MCS scores for the ICBG and LB groups respectively as  $38.3 \pm 1.6$  and  $37.4 \pm 2.4$  ( $p > 0.05$ ), and  $49.2 \pm 1.6$  and  $52.2 \pm 2.2$  ( $p > 0.05$ ).

**Discussion and Conclusions:** This study shows that in patients undergoing PLF, harvesting ICBG does not have a deleterious influence on short or long-term functional outcomes. It suggests that questionnaires specifically directed to donor site symptoms may risk overstating donor site pain or that the ICBG donor site may be blamed for other sources of symptoms. Obviously local bone may be preferred for PLF but harvesting of ICBG should not be avoided if required.

SP25

**CARTILAGE BIOMARKERS IN DEGENERATIVE LUMBAR SCOLIOSIS**

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**Introduction/Aim:** Degenerative lumbar scoliosis (DLS) develops following degeneration of intervertebral discs and facet joints. Several biomarkers have been used for the evaluation of osteoarthritis of limb joints. In this study, we assessed the serum cartilage metabolites to evaluate whether they can serve as biomarkers for DLS.

**Material and Methods:** Seventy-two DLS patients over 40 years



of age (mean 68.2 yrs) with Cobb angle  $> 10^\circ$  were included in this study. Mean Cobb angle was  $25.9^\circ$  ( $11.4$  to  $73.0^\circ$ ). Thirty-six patients without deformity (Cobb angle  $< 10^\circ$ , mean 67.2 yrs) were served as controls. Serum levels of hyaluronic acid (HA), keratan sulfate (KS), cartilage oligomeric matrix protein (COMP), collagen type II cleavage (C2C) and procollagen type II C-propeptide (CPII) were measured. The degree of osteoarthritis of the lumbar spine, hip and knee joints were assessed using Kellgren Lawrence (KL) grade.

**Results:** Serum levels of KS (DLS  $1.18 \pm 0.46$ , control  $0.94 \pm 0.37 \mu\text{g/ml}$ ), COMP (DLS  $778.1 \pm 355.1$ , control  $626.4 \pm 315.0 \text{ ng/ml}$ ) and CPII (DLS  $1928.2 \pm 1368.5$ , control  $1411.1 \pm 775.3 \text{ ng/ml}$ ) were significantly higher in DLS group than the control group. There were no significant differences in serum levels of HA or C2C. There was a significant positive correlation between Cobb angle and CPII level in DLS group ( $R=0.32$ ). KL grade of the lumbar spine was significantly higher in DLS group than the control group (DLS  $3.5 \pm 0.6$ , control  $2.4 \pm 1.0$ ), whereas no significant differences were observed in knee and hip joints.

**Discussion:** This is the first study that evaluated the cartilage biomarkers in DLS patients. This study suggests that synthesis and degradation of type II collagen are promoted in DLS patients as indicated by the increase in serum CPII and COMP, respectively.

**Conclusion:** As type II collagen is a major component of collagens in nucleus pulposus and facet joint cartilages, its enhanced turnover may be related to development and progression of DLS.

## SP26

### EPIDEMIOLOGIC STUDY OF DEGENERATIVE LUMBER SCOLIOSIS: ANALYSIS OF 276 VOLUNTEERS

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**Introduction:** Degenerative lumbar scoliosis is usually defined as more than 10 degree of Cobb angle. This is just radiographic definition. There is little literature regarding the relationship between the degree of Cobb angle and clinical symptom. The purpose of this study was to clarify how the magnitude of Cobb angle affects pain, disability and QoL.

**Methods:** 276 people (male 96, female 180) agreed to participate and received standing position of lumbar spine radiography. Numerical rating scale of low back pain (0: no pain, 10: worst pain), ADL disturbance by low back pain (no ADL disturbance, disturbed a little, disturbed severely) and Japanese version of Roland and Morris Disability Questionnaire (RDQ).

**Result:** 1) People with more than 15 degree showed much severe pain (Cobb angle 0-4.9 degree: NRS=4.7,5-9.9: 4.5, 10-14.9: 4.7,15-19.9: 7.5, 20-: 7.7).

2) There was no statistically significant difference between the magnitude of Cobb angle and the degree of ADL disturbance.

3) People with more than 20 degree showed less than normative value of standardized RDQ score (deviated score) of the national norm (50>: less low-back-pain related function rather than the average Japanese patient who suffered from low back pain) (Cobb angle 0-4.9 degree: RDQ deviated score=53.9,5-9.9: 54.6, 10-14.9: 54.3,15-19.9: 54.1, 20-: 42.9).

**Conclusion:** From the point of view on pain and disability, degenerative lumbar scoliosis might be defined by 15-20 degree of Cobb angle.

## SP27

### GLOBAL ANALYSIS OF SAGITTAL SPINAL ALIGNMENT IN MAJOR DEFORMITIES: CORRELATION BETWEEN LACK OF LUMBAR LORDOSIS AND FLEXION OF THE KNEE

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**Introduction/Aim:** It has become well recognised that sagittal balance of the spine is the result of an interaction between the spine and the pelvis. Knee flexion is considered to be the last compensatory mechanism in case of sagittal imbalance, but only few studies have insisted on the relationship between spino-pelvic parameters and lower extremity parameters. Correlation between the lack of lumbar lordosis and knee flexion has not yet been established.

**Materials and Methods:** A retrospective study was carried out on 28 patients with major spinal deformities. The EOS system was used to measure spinal and pelvic parameters and the knee flexion angle; the lack of lumbar lordosis was calculated after prediction of lumbar lordosis with two different formulas. Correlation analysis between the different measured parameters was performed.

**Results:** Lumbar lordosis correlated with sacral slope ( $r = -0.71$ ) and moderately with knee flexion angle ( $r = 0.42$ ). Pelvic tilt correlated moderately with knee flexion angle ( $r = 0.55$ ). Lack of lumbar lordosis correlated best with knee flexion angle ( $r = 0.72$  and  $r = 0.63$  using the two formulas, respectively).

**Discussion/Conclusion:** This is the first series of major deformities analysing the knee flexion angle as a compensatory mechanism for sagittal imbalance. Knee flexion was well correlated to the lack of lumbar lordosis and, depending on the importance of the former parameter, the best procedure to correct sagittal imbalance could be chosen.

## SP28

### A COMPARISON OF PELVIC INCIDENCE, LUMBAR LORDOSIS AND LUMBAR SAGITTAL BALANCE IN PATIENTS WITH NONSPECIFIC LOW BACK PAIN, DEGENERATIVE STENOSIS, SPONDYLOLISTHESIS AND HEALTHY VOLUNTEERS

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**Introduction:** The aim of this prospective study is to compare radiographic pelvic parameters and lumbar sagittal balance across the different cohort of patients who present with chronic low back pain.

**Materials and Methods:** The parameters of pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), lumbar lordosis (LL) and lower lumbar lordosis (LLL) were analysed on lateral standing radiographs of the lumbosacral spine in 42 patients with nonspecific chronic low back pain (Group A), 30 patients with symptomatic degenerative stenosis (Group B), 13 patients with lytic listhesis (Group C) and 12 patients with degenerative listhesis (Group D). These were compared to a group of 40 healthy volunteers. As an index for radiographic evaluation of lumbar sagittal balance, the horizontal distance between the lumbar plumbline from the centre of L1 vertebral body to the posterior corner of the S1 endplate (LASD) was utilized.

**Results:** The control group (age  $33 \pm 11$ ) had PI ( $46.8 \pm 7.8^\circ$ ), PT ( $9.8 \pm 7.4^\circ$ ), SS ( $36.7 \pm 7.8^\circ$ ), LL ( $60.4 \pm 12.5^\circ$ ), LLL ( $40.6 \pm 8.3^\circ$ ) and LASD ( $-15.7 \pm 19.2 \text{ mm}$ )

Group A (age  $41.9 \pm 10.3$ ) had significant decrease in LLL ( $37.1 \pm 6.3^\circ$   $p=0.034$ ) and anterior displacement of LASD ( $-2.7 \pm$



22.3mm p=0.006)

Group B (age 45.5 +/-11.4) had significant decrease in LLL (37.1+/-6.3° p=0.007) and anterior displacement of LASD (9.4+/-28.7mm p<0.001)

Group C (age 40.1+/-15.2) had significantly larger PI (72.0+/-11.6° p<0.001), PT (20.9+/-7.4° p<0.001), SS (51.2+/-11.2° p<0.001), reduced LLL (35.5+/-11.9° p=0.06) and anterior displacement of LASD (41.0+/-18.5mm p<0.001)

Group D (age 57.6 +/-11.9) had a significantly larger PI (64.5+/-13.6° p<0.001), PT (22.4+/-11.5° p<0.001), SS (42.0 +/-9.3° p=0.05), reduced LLL (25.6 +/-14.0° p<0.001), and anterior displacement of LASD (34.2 +/-36.6mm p<0.001).

**Conclusion:** All patient groups had statistically significant anterior shift of the lumbar plumbline (LASD) and reduced lower lumbar lordosis compared to the control group. The pelvic parameters however, were only found to be significantly larger in patients with spondylolisthesis.

## SP29

### READMISSION RATE AFTER SPINE FUSION FOR ADULT DEFORMITY

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**Introduction:** Cost-effectiveness in spine surgery is determined by the incremental impact of surgery compared with alternative care, and the duration of the effect. Readmission and reoperation have a significant impact on the cost of care for adult deformity. The objective of this study is to compare the hospital readmission rates after short, medium and long spinal fusions for adult scoliosis, and to identify risk factors for readmissions.

**Methods:** Retrospective study design of all primary admissions for a diagnosis of adult spinal deformity, and readmissions within 90 days. Cases were identified using an administrative claims database from 2006 to 2011. Readmission rates were calculated using a validated algorithm for administrative claims data analysis. All surgical procedures and readmissions underwent confirmatory chart review.

**Results:** 738 patients were identified using administrative claims; 694 patients remained eligible after chart review. Surgeries included 95 short fusions (1-3 levels), 321 medium (4-8 levels), and 278 long fusions (>8 levels). The overall 90-day readmission rate was 10.4% by administrative claims algorithm, and 10.1% by chart review. Using the claims algorithm, the 90-day readmission rate was 3.6%, 11.3%, and 14.4% for short, medium, and long fusions, compared to 4.2%, 9.0%, and 13.3% by chart review. The leading causes of readmission were infection at 30 days and failure of instrumentation at 90 days.

**Discussion:** The overall 90-day readmission rate was 10.1%; an administrative claims algorithm determined a slightly higher rate of 10.4%. Chart review was required to identify readmissions that were unrelated to spine pathology. Longer spine fusions are associated with higher rates of readmission at 30, 60, and 90 days.

**Conclusion:** We present a validated algorithm for identification of adult deformity cases and readmissions based upon administrative claims data. Early readmission rates are higher for long fusions than shorter fusions in adult deformity surgery. An accurate assessment of readmission rates is important in determining the cost of surgery for adult spinal deformity.

## SP30

### RADICULOPATHY IN ADULT SCOLIOSIS: SCIATIC PAIN RELATES TO THE FRACTIONAL CURVE AND FEMORAL PAIN RELATES TO THE MAIN LUMBAR CURVE - A CT ANALYSIS

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**Introduction:** At least half of adults with symptomatic degenerative scoliosis present with radiculopathy, described as sciatica or cruralgia. Anatomic studies suggest critical foraminal dimensions. The purpose of this study is to demonstrate a correlation between radiculopathy and foraminal stenosis in patients with adult scoliosis.

**Methods:** 48 scoliosis patients (384 foramina) – 16 cruralgia (F) and 18 sciatic pain (S). The symptomatic foramen of Group F (L2-3 and L3-4) and Group S (L4-5 and L5-S1) were compared to asymptomatic foramina. Global and regional alignments were measured from standardized radiographs; 3D CT-reconstructions were used (Vitrea 3.0 workstation) were used to measure: foraminal height and foraminal area, lateralolisthesis (Ploumis - Spine 2006). Data is presented as mean±SD. Chi-square, T-test and Pearson's coefficients were calculated; Inter-, intra-observer reproducibility (Cohen's kappa). A p<0.007 was considered significant (Bonferroni).

**Results:** Inter-observer agreement k= 0.6092 - 0.8679. In 15 of 16 patients with cruralgia (F) presented foraminal stenosis (<50mm<sup>2</sup>) of the concavity of the main lumbar curve (L2-L3 or L3-L4), and 16 of 18 patients with sciatica (S) presented with stenosis of the concavity of the fractional curve (L4-L5 or L5-S1). Group S had significantly smaller foraminal height (7.8±2.5mm vs. 12.1±3.1mm, p<0.0001) and area compared to asymptomatic foramina (30.1±14.3mm<sup>2</sup> vs. 57.6±28.7mm<sup>2</sup>, p<0.0001). Group F had significantly smaller foraminal height (9.2±3.2mm vs. 12.1±3.1mm, p<0.0001) and area versus asymptomatic foramina (30.1±15.2mm<sup>2</sup> vs. 57.6±28.7mm<sup>2</sup>, p<0.0001). Foraminal height correlated with foraminal area (r=0.68-0.85; p<0.0001).

**Conclusions:** A clinical-anatomic correlation is present between leg pain and foraminal stenosis at the concavity of the coronal curves. Femoral nerve pain represents stenosis at the concavity of the main lumbar curve, and sciatica represents stenosis at the concavity of the fractional curve. This finding should guide surgical strategies.

## SP31

### SURGICAL OUTCOME OF NEUROGENIC BLADDER ASSOCIATED WITH LUMBAR SPINAL STENOSIS

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**Introduction:** The purpose of this study is to investigate the extent to which lumbar spinal stenosis (LSS) patients with neurogenic bladder (NB) achieve improvement in the bladder function after lumbar decompressive surgery. Moreover, a correlation between neurological and urological recovery was investigated.

**Materials and Methods:** Among the 174 LSS patients operated from 2007 to 2010, 23 LSS patients who complained severe lower urinary tract symptoms underwent urodynamic study (UDS). Among them, 16 patients (9 men, 7 women, age 71.1±7.3) were diagnosed with NB by UDS and were enrolled. Twelve laminectomy and 4 partial laminectomy were performed, and segmental fusion was added to 9. For neurological evaluation,

a modified JOA scoring system (mJOA: the bladder score subtracted, full score = 29) was used preoperatively and at the 12-month follow-up. For subjective evaluation of the bladder function, international prostate symptom score (I-PSS: full score 35 points, 0 means normal) and the QOL index (full score 6 points, 0 means "very satisfied") were used. UDS were repeated postoperatively at an average of  $3.1 \pm 1.2$  months. Among the various objective parameters of UDS, Watt's factor (WF) was used to represent detrusor contractility of the bladder. For statistical analysis Wilcoxon signed-rank and Mann-Whitney's U test were used.

**Results:** All 16 patients demonstrated neurological recovery postoperatively. Average mJOA score was  $15.5 \pm 4.6$  preoperatively, and improved to  $22.6 \pm 3.6$  postoperatively ( $p = 0.0004$ ). Average recovery rate of mJOA score was  $51.9 \pm 23.7\%$ . Preoperative I-PSSs related to voiding, storage symptoms and the QOL index were  $6.3 \pm 4.8$ ,  $4.9 \pm 2.3$  and  $4.3 \pm 1.4$  respectively. Postoperatively, they decreased (improved) to  $3.7 \pm 3.5$ ,  $2.9 \pm 1.9$  and  $2.4 \pm 1.3$  respectively ( $p < 0.003$ ). Total I-PSSs improved in 15 patients. WF increased in 12 and decreased in 3 patients, and changed from  $8.2 \pm 7.0$  to  $15.4 \pm 14.0$  postoperatively ( $p = 0.02$ ). Comparison between neurological and urological parameters did not show any significant correlation.

**Discussion:** In the current study, 94% and 75% of LSS patients with NB achieved subjective and objective recovery in the bladder function after surgery, respectively, at a relatively earlier postoperative stage. A relationship between neurological and urological recovery was not established, in other words, LSS patients with NB could expect substantial bladder function recovery regardless of the severity of neurological deficit.

### SP32

#### IS THERE A RELATIONSHIP BETWEEN THE CROSS-SECTIONAL AREA OF THE DURAL SAC AND POST-OPERATIVE SYMPTOMS?

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**Background:** Relationship between MRI findings and clinical symptoms shortly after lumbar surgery is unknown. We evaluated the relationship between the cross-sectional area (CSA) of the dural sac on MRI and postoperative symptoms.

**Materials and Methods:** We enrolled 103 patients (61 men, 42 women; mean age,  $64.5 \pm 15.9$  years) who underwent lumbar surgery with spinal canal decompression from 2007 to 2011. Within 7 days after surgery, lumbar MRI of the intra-operative decompression region was used to determine the vertebral level with the smallest CSA. The post- and preoperative CSAs of the same vertebral level were compared. Subjects with clinical symptoms of nerve compression (lower extremity pain, muscle weakness, and urination disorder) at the time of MRI were classified under group A ( $n = 46$ ); those without symptoms were classified under group B ( $n = 57$ ). Increase percentage of dural sac area was defined as (early postoperative CSA - preoperative CSA)/preoperative CSA  $\times 100$ .

**Results:** The mean preoperative CSAs of groups A and B were  $65.4 \pm 7.3$  mm<sup>2</sup> and  $84.3 \pm 6.7$  mm<sup>2</sup>, respectively ( $P = 0.06$ ). The early postoperative CSA was significantly lower in group A ( $72.6 \pm 6.3$  mm<sup>2</sup> vs.  $127.4 \pm 6.7$  mm<sup>2</sup>,  $P < 0.001$ ). Clinical symptoms were present in 76% (26 of 34) of subjects with early postoperative CSA of  $< 75$  mm<sup>2</sup> and in 29% (20 of 69) of subjects with early postoperative CSA of  $\geq 75$  mm<sup>2</sup>, showing a significant difference ( $p < 0.001$ ). The dural sac area in subjects with suction drains at the time of MRI ( $n = 34$ ) increased by  $134 \pm 26\%$ , which was

significantly different from the subjects without suction drains ( $n = 58$ ;  $59 \pm 15\%$ ;  $p = 0.016$ ).

**Discussion/Conclusions:** Insufficient enlargement of the dural sac and lower CSA is associated with clinical symptoms and is likely due to epidural hematoma. CSA  $< 75$  mm<sup>2</sup> in the early postoperative period is associated with clinical symptoms, including lower extremity pain, muscle weakness, and urination disorders.

### SP33

#### STUDY OF DURAL SAC CROSS-SECTIONAL AREA IN ACUTE AND CHRONIC PHASES FOLLOWING LUMBAR DECOMPRESSION SURGERY

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**Introduction:** There are some reports which compared dural sac area between the preoperative phase and acute postoperative phase, however, no report exist which compared acute postoperative phase to chronic phase. The purpose of this study is to compare dural cross-sectional area changes in acute with chronic phases following lumbar decompression surgery.

**Materials and Methods:** Of 105 patients who underwent lumbar decompression surgery from September 2007 to May 2011, and whose MRI image was obtained within 1 week of the surgery, 83 patients (38 male, 45 female; mean age, 65.6 years) who underwent another MRI 1 month postoperatively were studied. Dural sac cross-sectional area was measured within 1 week (acute phase) and after 1 month (chronic phase) of the surgery by using T2 axial plane images of MRI. While operating on multiple vertebrae, the acute phase cross-sectional area following lumbar decompression surgery was measured at their smallest transverse area. The preoperative and postoperative acute and chronic phase cross-sectional areas were measured at the same site. The relationship between dural sac area and the age and the presence of the dural injury was studied.

**Results:** Mean area of the dural sac preoperatively, and acute and chronic phase postoperatively was  $71.2 \pm 4.9$  (5–220) mm<sup>2</sup>,  $102.2 \pm 5.7$  (3–240) mm<sup>2</sup>, and  $164.1 \pm 6.9$  (47–322) mm<sup>2</sup>, respectively. The mean area showed significant ( $p < 0.001$ ) increase between the preoperative stage and the postoperative acute phase, and between the postoperative acute and chronic phases. Patients with preoperative dural sac area of  $< 60$  mm<sup>2</sup> showed significantly smaller dural sac area ( $p < 0.001$ ) at postoperative acute and chronic phases as compared to patients with preoperative dural sac area of  $60$  mm<sup>2</sup>. No significant increase was observed in dural sac area with regard to the presence or absence of dural injury.

**Conclusion:** Dural sac area significantly increased between the postoperative acute and chronic phases.



## SP34

**SPINOUS PROCESS SPLITTING DECOMPRESSION VS CONVENTIONAL DECOMPRESSION FOR DEGENERATIVE LUMBAR CANAL STENOSIS- A RANDOMISED CONTROL STUDY**

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**Introduction/Aim:** Lumbar spinous process splitting decompression (LSPSD) preserves the muscular and ligamentous attachments of the posterior elements and is thought to avoid the drawbacks of conventional midline decompression (CMD) like paraspinal muscle atrophy and trunk extensor weakness while providing wide exposure. This prospective randomized control study compared the functional outcome and the extent of paraspinal muscle damage between LSPSD and CMD

**Materials and Methods:** 51 patients with degenerative lumbar canal stenosis (LCS)( $\leq 3$  levels) were randomly allocated into two groups: LSPSD (28 patients) or CMD (23 patients). Patients with grade 1 spondylolisthesis or instability were excluded. Paraspinal muscle damage was assessed by Creatine Phosphokinase-MM isoenzyme (CPK-MM) and C-Reactive Protein (CRP). Functional outcome was assessed by Japanese Orthopaedic Association (JOA) score, Neurogenic Claudication Outcome Score (NCOS), Visual Analogue Scale for Back pain (BPVAS) and Neurogenic Claudication (NCVAS).

**Results:** 51 patients of mean age 56 years (range 35-76) were followed up for a mean 12.8 months (range 6-18 months). JOA score recovery rate (48.2% for LSPSD group and 56.7% for CMD group), NCOS improvement (36.4 for LSPSD and 32.3 for CMD), BPVAS (2.46 for LSPSD and 2.96 for CMD), NCVAS (1.93 for LSPSD and 1.74 for CMD) did not show any statistically significant difference between two groups. Rise in CRP (mg/dL) on postoperative day 1 and day 3 (57.9 and 45.3 respectively for LSPSD and 38.7 and 57.4 for CMD) and CPK MM (IU/L) (214 and 222 respectively for LSPSD and 293 and 282 for CMD) also did not show any statistically significant difference.

**Discussion:** LSPSD provides wide exposure for decompression in LCS while preserving the musculoligamentous attachments of the posterior elements. However, whether this theoretical advantage translates to a better functional outcome is not conclusively proven. This study did not find any statistically significant difference in the functional outcome or elevation of markers of muscle damage between these two groups.

**Conclusion:** Lumbar spinous process splitting decompression provides wide exposure for decompression in lumbar canal stenosis with comparable results to that of conventional midline decompression.

## SP35

**PROSPECTIVE COHORT STUDY OVER 4 YEARS ON THE PROGNOSIS OF LUMBAR SPINAL CANAL STENOSIS IN REMISSION WITH CONSERVATIVE TREATMENTS**

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**Background:** Surgery is basically indicated for lumbar spinal stenosis (LSS), when cases exhibit aggravation even after responding to non-surgical treatment. In this study, a prospective cohort study was performed to clarify the prognosis and prognostic factors of LSS cases that had previously been ameliorated by conservative treatment.

**Methods:** From 2005 to 2007, 142 patients with LSS underwent in-bed conservative treatment. Of 142 patients, 82 patients whose symptoms improved were registered in this study, while 60 patients were excluded due to unimproved symptoms or previous lumbar surgery. At the final follow-up period averaging 63.0 months ( $> 4$  years), the records of 65 patients (36 men and 29 female with an average age of 72.6) were available (follow-up rate: 79.3%) and their clinical prognosis assessed. In addition, the findings from their radiogram, myelogram and MRI were examined to extrapolate the prognosis by logistical regression analysis.

**Results:** Only 17 of 65 patients (26.2%) exhibited aggravated symptoms during follow-up period (group A) with worsening of radicular pain (8 cases) and intermittent claudication (9 cases), of these, 16 patients were treated surgically. While 48 of 65 patients (73.8%) improved or maintained their symptoms at discharge (group G) until the follow-up period. In group G, 9 cases had no symptoms and 14 cases presented requiring no ongoing treatment. Statistical analysis between the two groups indicated cauda equina or mixed type (odds ratio 6.12,  $p=0.033$ ), complete block in the myelogram (odds ratio 31.19,  $p=0.036$ ), and the existence of motor weakness (odds ratio 5.57,  $p=0.034$ ) were the significant aggravation factors during follow-up period.

**Conclusion:** This prospective cohort study of LSS ameliorated by initial conservative treatment confirms a good prognosis. However, 26.2% of the patients exhibited aggravation during follow-up period. Therefore, LSS with cauda equina or mixed type, complete block in the myelogram, or motor weakness should be followed carefully because of the possibility of aggravation.

## SP36

**REVISION AFTER LUMBAR DECOMPRESSION FOR SPINAL STENOSIS**

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**Introduction/Aim:** Decompression for spinal stenosis is one of the most common types of lumbar spine surgery. Little is known about the incidence of same-level repeat surgery when simple decompression is performed.

**Materials and Methods:** Patients were selected from our local Outcomes database (in connection with Eurospine's Spine Tango Registry): degenerative spinal stenosis as main pathology (+/- other degenerative conditions), no previous surgery, decompression without fusion, 5 years' follow-up. Repeat



surgery constituted that performed on the same level as the initial surgery, as identified from patients' reports, the hospital information system, and our Outcomes database.

**Results:** 21/259 (8.1%) patients underwent same-segment re-operation; their baseline clinical data did not differ from that of the no repeat surgery group, although they tended ( $p=0.053-0.07$ ) to have slightly worse back pain levels and COMI values. The repeat surgery group was significantly younger ( $64.8\pm 9.4y$ ) than the no repeat group ( $72.4\pm 9.9y$ ). The % repeat surgeries were 10.7% for patients graded ASA1, 9.2% for ASA2, 6.8% for ASA3 and 0% for ASA4. Of those with repeat surgery, 48% had undergone hemilaminectomy/laminectomy at the index surgery; in those with no repeat surgery, it was 31% ( $p=0.11$ ). Most revision surgeries (80%) were performed in the first 18mo after the initial surgery.

**Discussion:** The incidence of repeat surgery 5y after simple lumbar decompression was low (8.1%) and decreased with age and more severe comorbidity. It increased slightly with laminectomy or hemilaminectomy. Following a peak incidence in the first 18 mo, it then declined and remained low. The higher rates of revision previously reported in the literature may relate to the use of different inclusion criteria: fusion at the index operation, patients with previous surgery, cases with further surgery done at a different level of the lumbar spine are all likely to influence reported revision rates.

**Conclusion:** Simple decompression for lumbar spinal stenosis in selected patients provides a good long-term outcome with infrequent need for further surgery at the same segment.

### SP37

#### PATIENTS PERCEIVE INCREASED LIMITATIONS IN ADLS DUE TO LUMBAR SPINAL STIFFNESS FOLLOWING INSTRUMENTED ARTHRODESIS OF THE ENTIRE LUMBAR SPINE

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**Background:** Increasing numbers of patients are undergoing lumbar spine arthrodesis for adult spinal deformity in the United States. While these surgeries are often successful in relieving pain and correcting deformity, an intended goal of these procedures is a loss of lumbar range of motion. This motion loss may potentially lead to difficulties in activities of daily living (ADL's) despite improvements in pain and spinal alignment. Previous studies have validated a 10 question survey (Lumbar Spine Disability Index, LSDI) and found that limitations in ADL's resulting from stiffness track separately from Oswestry Disability Index scores in lumbar spine fusion patients. To date no prospective studies have been carried out to assess how patients perceive functional limitations due to stiffness following extended lumbar arthrodesis for adult spinal deformity.

**Purpose:** To determine adverse functional impact of spinal stiffness after fusions of the entire lumbar spine for adult spinal deformity.

**Study Design:** Prospective cohort study.

**Patient Sample:** 16 consecutive adult deformity patients undergoing 5- or more levels of posterior instrumented lumbar fusion at a single center.

**Outcome Measures:** Lumbar Spine Disability Index (LSDI).

**Methods:** The LSDI, SF-36 and ODI were administered pre-operatively and at 2-year follow-up to patients undergoing

posterior or combined anterior/posterior instrumented fusion of the entire lumbar spine. All patients also completed a 3-item satisfaction questionnaire at final follow-up. Comparisons between pre- and post-operative scores were made with a paired t-test.

**Results:** There was a non-significant trend toward an increase in stiffness related limitations in activities of daily living as measured by LSDI score from preoperatively to 2-year postoperatively of 6.47% (95%CI (-)6.13%-17.47%,  $p=0.2909$ ). At 2 year follow-up, 43% (6/14) felt that their stiffness represented a "significant impact on their life and overall activity level". 100% (14/14), stated they would undergo surgery again, and 93% (13/14 responders) felt that the limitations due to stiffness were "a satisfactory trade-off" for increased function and decreased pain after surgery.

**Conclusions:** After two years, patients undergoing instrumented fusion of the entire lumbar spine for adult spinal deformity report slightly increased difficulties with certain ADL's due to stiffness when compared to preoperative values. The majority of patients studied, however, indicated that this increase in stiffness related disability was an acceptable trade-off for the decreased pain and overall increase in function obtained through surgery and would undergo surgery again.

### SP38

#### NOVEL AND MINIMALLY INVASIVE INTERVENTION FOR LOW BACK PAIN ASSOCIATED WITH DEGENERATIVE LUMBAR SCOLIOSIS IN THE ELDERLY

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**Introduction:** The cause of low back pain (LBP) in degenerative lumbar scoliosis (DLS) is unclear. We speculated that vertebral bone marrow lesions adjacent to vertebral endplates on MRI are strongly correlated with the presence of LBP associated with DLS in the elderly. We performed a novel surgical intervention: percutaneous transpedicular intervertebral vacuum PMMA injection (PIPI). The aim of this study is to compare the clinical outcome of PIPI and non-surgical treatment for LBP associated with DLS in the elderly.

**Materials and Methods:** 95 patients (mean 76 years) with vertebral bone marrow lesions associated with painful DLS underwent PIPI. The mean follow-up period was 22 months. As a control, 40 patients (mean 75 years) with painful DLS were treated non-surgically for 6 months. PIPI was performed under bi-plane fluoroscopic guidance and general anesthesia. A 14-gauge bone needle was inserted into the intervertebral vacuum through a percutaneous and transpedicular approach. After vacuumography, opacified PMMA was injected into the intervertebral vacuum cavity. The outcomes were evaluated using the Oswestry Disability Index (ODI; 0-100) and visual analog scale (VAS; 0-10).

**Results:** Before PIPI, the mean VAS and ODI scores were 8.3 and 53. Compared with that before PIPI, the mean VAS and ODI were significantly improved in the initial 1 month (2.5; 29,  $p<0.001$ ), and good results were maintained 3 years following PIPI (4.9; 38,  $p<0.001$ ). Systematic MRI showed improvement of vertebral bone marrow lesions in 68% of subjects at 1 year and in 86% at 2 years following PIPI. In non-surgically treated patients, the mean VAS and ODI did not improve 6 months following systematic conservative treatments (8.4; 52) compared with those before treatment (8.8; 56). The vertebral bone marrow lesions did not improve 6 months following non-surgical treatments.

**Conclusion:** LBP improve immediately after PIPI compared with non-surgical treatments. PIPI could be a novel and minimally invasive intervention for LBP associated with DLS in the elderly.





## SP39

**WILTSE VERSUS MIDLINE APPROACH FOR DECOMPRESSION AND FUSION OF THE DEGENERATIVE LUMBAR SPINE - A PROSPECTIVE COHORT COMPARISON**

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**Background:** The Wiltse bilateral muscle splitting approach represents an alternative to traditional midline approach to the lumbar spine for decompression and fusion of degenerative conditions.

**Hypothesis:** When comparing Wiltse to midline approaches our primary null hypothesis was that there is no difference in rates of surgical site infection (SSI). The secondary null hypothesis was that there would be no difference in the rates of secondary surgery within.

**Methods:** Between July 2005 and June 2008 we identified 183 Wiltse cases and 53 midline cases of single or two level lumbar fusion, matched for age, gender, co-morbidities, number of levels fused and history of previous surgery. There was a minimum of 3-year follow-up and statistical analysis was performed using Fishers exact test and one sided p values.

**Results:** Mean age ( $p=0.02$ ), length of hospital stay ( $p=0.008$ ) and intra-operative blood loss ( $p<0.001$ ) were significantly lower in the Wiltse group. There was no difference in the mean length of the surgical procedure ( $p=0.689$ ). In the Wiltse group there was a greater use of bone graft alternatives, in particular BMP ( $p=0.005$ ). The rate of SSI was 1.9% Wiltse versus 7.5% Midline ( $p=0.11$ ). The rate of second surgery within 3 years was higher in the Midline group ( $p=0.025$ ). Delayed wound complication (23 vs 0%) and adjacent segment failure (10% vs 0%) higher in the Midline group, while pseudarthrosis was higher in the Wiltse group (25% vs 7%).

**Conclusions:** The Wiltse approach is a viable alternative for 1 or 2 level lumbar arthrodesis with lower rates of SSI and lower blood loss. Secondary surgery for junctional failure is less common, but pseudarthrosis is more common.

## SP40

**HOSPITAL AND SURGEON VARIATION IN COMPLICATIONS AND REPEAT SURGERY FOLLOWING LUMBAR FUSION FOR COMMON DEGENERATIVE DIAGNOSES**

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**Introduction/Aims:** Empirical performance data for postoperative complications and repeat surgery following lumbar fusion for common diagnoses have not been examined across hospitals and surgeons. We sought to examine how the choice of instrumentation, number of levels fused, use of bone morphogenetic protein, and surgical approach influence the variation in the rates of complications and repeat surgery.

**Materials and Methods:** We identified adults (mean age 56 years, 60% female) undergoing an initial inpatient lumbar fusion surgery in Washington State from 2004-2007 for degenerative conditions without significant comorbidity ( $n = 5,864$ ). We identified whether or not each patient had a subsequent spine operation, device complications, wound problem, life-threatening complication, or died within 90 days of the index procedure. Logistic regression models with hospital and surgeon random effects were used to examine the variation in the rates of complications and repeat surgery, controlling for patient characteristics and comorbidity.

**Results:** Spondylolisthesis accounted for the largest proportion of the fusions (32.1%), followed by degenerative disc disease (31.0%), stenosis (20.4%), herniated disc (13.5%) and scoliosis (3.0%). Complications within 90 days occurred in 4.8% of patients, and 2.2% had a reoperation. Surgeon factors account for 45% and 75% of the variation in hospital complication and reoperation rates, respectively. Operative features accounted for 37% and 19% of the variation in surgeons' complication and reoperation rates, respectively.

**Discussion:** Quality improvement efforts that focus on surgeons' discretionary use of operative features may be more important than those that target hospitals. However, uncertainty surrounding estimates of safety makes profiling individual surgeons challenging. At a policy level, the question is whether collective interventions based on surgeon level safety data, with this known imprecision, will lead to better care.

**Conclusion:** Data on complications and repeat surgery may be useful to inform policies that aim at making spinal fusion safer.

## SP41

**DIAGNOSES ASSOCIATED WITH LUMBAR FUSION SURGERY IN THE ELDERLY U.S. POPULATION FROM 2000-2008**

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**Introduction/Aim:** Evidence of effectiveness of lumbar fusion for treating spondylolisthesis has grown in the past decade; however, fusion for axial back pain remains controversial. It is not known how indications for this procedure have changed. We describe recent trends in the rates and volume of lumbar fusion surgery by diagnosis for the U.S. elderly population.

**Materials and Methods:** Analysis of administrative claims for fee-for-service Medicare beneficiaries aged 65+ was undertaken to identify lumbar fusion surgeries with exclusions made for fracture, spinal cord injury, congenital/ other anomaly, inflammatory spondylopathy, osteoporosis, and previous spine surgery. Age- and sex-adjusted rates per 100,000 for the U.S. Census resident population over age 65 years were estimated by diagnosis in 2000 and 2008. Hierarchical diagnoses were defined from most to least specific as scoliosis, spondylolisthesis, stenosis, herniated disc, and axial back pain and the distribution of cases by diagnosis was estimated in each year.

**Results:** The overall rate of lumbar fusion surgery increased from 49.5 (95%CI: 48.7, 50.2) to 91.7 (90.7, 92.6) per 100,000 with 17,627 and 35,119 surgeries identified in 2000 and 2008, respectively. The absolute rate change was largest for back pain (+17.3) followed by spondylolisthesis (+9.9), stenosis (+7.1), herniated disc (+4.8), and scoliosis (+3.1). Back pain accounted for 23.4% of case volume in 2000, and this increased to 31.6% in 2008. In contrast, stenosis accounted for 37.1% of cases in 2000 and 27.7% in 2008, while volumes remained stable for spondylolisthesis (~24%) and herniated disc (~13%).

**Discussion:** Rates of lumbar fusion surgery increased for all diagnoses, but were largest for the least specific diagnosis. Controversy over the effectiveness of fusion surgery for those with back pain in the absence of a more specific diagnosis raises concerns regarding the appropriateness of these operations.

**Conclusion:** Axial back pain diagnoses accounted for the largest increase in lumbar fusion surgery in the US Medicare population.

## SP42

**ADJACENT DISC DISEASE AND REVISION SURGERY FOLLOWING 360-DEGREE LUMBAR FUSION - A 10-YEARS PROSPECTIVE STUDY**

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**Introduction:** Circumferential lumbar fusion has shown to be superior to isolated instrumented posterolateral fusion at short-term outcome. However, few reports investigate long-term outcome, specially regarding the appearance of adjacent disc disease and the reintervention rate.

**Patients and Methods:** A total of 73 patients underwent lumbar fusion involving one to three levels (from February 1998 to January 2000) within a prospective study. Autologous iliac bone graft was used for fusion supplementation in all cases. Patients were evaluated preoperatively, at 2.5 years follow-up and 10 years as after surgery with static and dynamic radiographic studies, CT scan and MRI. Analyzed parameters included the fusion rate, adjacent disc disease (ADD) and the reintervention rate. Patients were also analyzed with the Oswestry-Disability index (ODI), VAS scores, and the patient self-satisfaction questionnaire.

**Results:** At 2.5-year follow-up there was a decrease in pain according to VAS (from 8.4 preop to 4), average ODI score was 30.5, an excellent and good self-satisfaction rate of 82.8%, and a 100% radiologic fusion rate. None of the patients exhibited ADD at this time. There was only a single case of revision surgery because of pedicle screw malposition. At 10-years follow-up, fusion rate remains in 100%. Clinical outcome according to ODI (65.6) and VAS scores (8) showed a clear worsening. Excellent and good self-satisfaction rate decreases to 41.1%. ADD was detected in 37 cases (50.7%). The clinical worsening of ADD patients conducted to new surgical treatment in 18 of these cases (24.6% of the total series).

**Conclusion:** Circumferential lumbar fusion provides high fusion rate although this factor had no relationship to long-term clinical status. From 2.5-year to 10-year follow-up outcome worsened significantly. Due to the high occurrence of ADD, the indications for 360-degree lumbar fusion should be revised, being stricter when selecting patients. Extreme rigid fusions such as the circumferential fusion technique deserve therefore a certain criticism.

## SP43

**ENDPLATE DEFECTS FOLLOWING LUMBAR DISCECTOMY: A PROSPECTIVE STUDY**

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**Background:** Lumbar discectomies are a very common procedure with generally good clinical outcomes. Some patients will experience post-operative back pain and the potential sources for that pain are poorly understood. One potential source is the vertebral endplates which are known to be innervated and can be damaged by a disc herniation or by the decompressive surgery. The goal of this study was to document the changes that occur in lumbar endplates following discectomies and to assess associations between endplate changes and clinical outcomes.

**Methods:** The changes that can occur in lumbar endplates following single-level discectomy were assessed from X-rays, CT and MRI exams preoperatively and at yearly intervals up to 5 years following discectomy surgery. At least partial data were available for 260 endplates in 137 patients. The geometry of

osseous defects in the endplates was measured from the CT exams and the changes that occur adjacent to the endplates were assessed from the MRI exams. In addition, previously validated clinical outcome assessments were collected at each time-point. Descriptive statistics were used to describe endplate defect size and logistic regression and analysis of variance was used to identify potential associations between endplate and vertebral body changes and clinical outcomes. **Results:** Approximately 14% of the endplates had osseous defects (Schmorl's nodes) prior to surgery, this increased to 24% in the endplate on the inferior side of the treated disc and almost 43% of endplates superior to the treated disc. This change occurred within the first year and remained relatively constant over the next few years. New defects tended to occur toward the posterior aspects of the endplates and tended to be somewhat larger than lesions measured at PreOp. Disc signal intensity worsened and disc height decreased following surgery. New Modic changes were also observed. None of these changes appeared to have a significant association with whether or not the patient achieved clinically significant improvements in outcome scores. **Conclusion:** Although this study has several limitations, it nevertheless provides evidence that osseous defects in the endplates at the level of a lumbar discectomy may be a relatively common finding following surgery, along with disc height loss, loss of disc signal intensity, and Modic changes. The clinical significance of these imaging findings could not be identified in this study.

## SP44

**SURGICAL TECHNIQUES FOR SCIATICA DUE TO HERNIATED DISC: A SYSTEMATIC REVIEW**

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**Introduction/Aim:** Disc herniation with sciatica accounts for five percent of low-back disorders but is one of the most common reasons for spine surgery. The goal of this study was to update the 2007 Cochrane review on the effect of surgery for sciatica due to disc herniation.

**Materials and Methods:** A comprehensive search in CENTRAL, MEDLINE, EMBASE, CINAHL, PEDRO, and ICL databases was conducted. Reference lists and citation tracking results were also checked. Only randomized controlled trials of surgical interventions for sciatica due to disc herniation were included, excluding comparisons on chemonucleolysis, prevention of scar tissue and conservative treatment. Two review authors independently selected and assessed the risk of bias. Quality of evidence was evaluated by GRADE.

**Results:** Sixteen studies were included, of which four had a low risk of bias. Studies showed that microscopic discectomy compared to open discectomy results in a longer operation time of 12 minutes (95% CI 2 to 22) and shorter incision of 24 mm (95% 7 to 40), with a 2.0 mm (95% CI 0.6 to 3.4) lower VAS leg pain with a moderate quality of evidence. There were conflicting results regarding tubular discectomy versus microscopic discectomy for back pain and surgical duration. There was a lack of studies on other minimally invasive techniques.

**Discussion:** Both clinical outcome and surgical morbidity did not



differ beyond clinical relevance between surgical techniques.

**Conclusion:** From the current published clinical trials, few conclusions can be drawn due to limited amount and quality of evidence and those differences that were found are clinically insignificant.

#### SP45

### HOSPITAL AND SURGEON VARIATION IN REPEAT SURGERY RATES FOLLOWING DECOMPRESSION FOR HERNIATED DISC

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**Introduction/Aims:** Repeat lumbar spine surgery is generally an undesirable outcome. However, little is known about variation in reoperation rates, which may be due to patient characteristics, disease severity, hospital characteristics, or surgeon-related factors. We examined hospital and surgeon variation in reoperation rates following lumbar herniated disc surgery in relation to published benchmarks.

**Materials and Methods:** We used a Washington State hospital discharge registry to identified adults who received an initial inpatient lumbar decompression for herniated disc from 1997- 2007. We performed a mixed-effect logistic regression, controlling for patient age, sex, insurance, and comorbidity, to examine the hospital and surgeon variation in reoperation rates within 90 days, 1- and 4-years.

**Results:** Our cohort included 29,529 patients with a mean age of 47.5 years, 61% privately insured, 40.7% female, and 15% having any comorbidity. The adjusted mean rate of reoperation among surgeons were 1.9% at 90-days (95%CI 1.4 - 2.4), 6.1% at 1-year (95%CI 4.8% - 7.7%), and 13.2% at 4-years (95%CI 11.3% - 15.5%). Multilevel random-effect models suggested that variation across surgeons was greater than that of hospitals, and that this effect increased with longer surveillance.

**Discussion:** We observed a marked variation in reoperation rates among surgeons and among hospitals for a primary lumbar discectomy, a relatively simple spinal surgery. Substantial variation persisted after adjustments for were made for patient demographics, insurance and comorbidity, suggesting uncertainty about indications for repeat surgery, variations in perioperative care, or variations in quality of care.

**Conclusion:** Quality measures based on empirical performance data may help patients make better choices about whether and where to have surgery. Data on reoperation rates may help patients to be better informed of the risks, and to guide policies to make spinal surgery safer and its effects more durable.

#### SP46

### VOLUMETRIC CHANGES OF LUMBAR INTERVERTEBRAL DISC HERNIATION IN NON-OPERATIVE PATIENTS

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**Introduction:** To investigate the volumetric changes of lumbar intervertebral disc herniation in non-operative patients.

**Materials and Methods:** Clinical outcomes and magnetic resonance images (MRI) of 34 patients with symptomatic lumbar herniated nucleus pulposus (HNP), treated conservatively, were analyzed. The mean period from the baseline to follow-up MRI was 22.6±16.3 months. The volume of HNP (mm<sup>3</sup>) and the degree of HNP migration (Komori classification) were analyzed. Morphologic changes on MRI fell into four categories (disappearance, marked decrease, slight decrease, no change) with HNP classified into three types (protruded, extruded, sequestered) using T1-weighted sagittal images. The sequestered disc classified by the extent of migration (to proximal 1/3, middle 1/3, distal 1/3 of vertebral body height). The Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) were used to evaluate clinical outcomes.

**Results:** Significant resorption of HNP was shown at the follow-up MRI. The mean initial mass was 1300.7±792.6mm<sup>3</sup> and the mean follow-up mass was 826.9±536.0mm<sup>3</sup>. The mean mass change was 473.8±309.9mm<sup>3</sup>. In type 1 HNP (intact PLL), the morphologic change shows slight decrease or no changes (14/16). In type 2 or type 3 HNP (ruptured PLL), herniated disc markedly decreased or disappeared (13/18). There was statistically significant difference (Fisher's Exact test, p=0.001). Distally migrated sequestered HNP material were more resorbed than proximally migrated HNP (proximal 1/3, 60% resorption; middle 1/3, 75% resorption; distal 1/3, 86% resorption). However, clinical symptom alleviation was not correlated with HNP displacement and amount of resorption (p=0.323, p=603 respectively). Radiating pain and back pain subsided during the follow-up period.

**Discussion:** Transligamentous extension of herniated disc materials through the ruptured PLL was important to its reduction in size. Disappearance of HNP was seen frequently in much more migration happened.

**Conclusion:** Clinical outcome of conservative treatment to HNP was good. However, clinical outcome did not depend on the HNP migration and amount of resorption.

#### SP47

### HOW FAST THE SENSORY SYMPTOMS, NUMBNESS, PARESTHESIA AND PAIN RESOLVES AFTER NERVE ROOT DECOMPRESSION – A PROSPECTIVE STUDY WITH PATIENT'S SELF-RECORDED PAIN DRAWING

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**Introduction:** Sensory symptoms of lumbar or cervical nerve root compression may include pain, paresthesia and numbness. These modalities may resolve following surgical decompression of a nerve root at a different rate, but this has never been reported in the literature.

The goal of this study was to evaluate the rate of resolution of pain vs. paresthesia vs numbness following decompression of a nerve root from patients' self recorded pain drawing.

**Methods:** 65 patients (30M, 35F) with cervical (n=23) or lumbar (n=42) radiculopathy, improved from neurologic symptoms



following decompression surgery. The motor deficit recovery was recorded by the treating physician, but the sensory deficits were recorded by the patients themselves in a pain drawing before surgery and periodically until 1 year follow-up. The pain drawing was recorded by the patients on a touch-screen computer, which digitally recorded the intensity and distribution of different sensory modalities using different colors.

**Results:** The pain (burning, stabbing or aching) component of the sensory symptom improved sharply, soon after surgery, and the maximum improvement was recorded as early as 6 weeks post-op. Pain relief did not significantly change during the subsequent visits until 1 yr follow-up.

Paresthesia (tingling, pins and needles etc.) improved gradually during the 6 weeks and 12 weeks follow-up and reached a plateau at 6 month after surgery.

Numbness improved much slowly, and continued to improve at a slow but steady pace until 1 year, and did not reach a plateau even at 1 year.

**Conclusion:** This is the first study, using patients self-recorded data that indicate the pain improves soon after nerve root decompression, reaching maximum pain relief at 6 weeks. Paresthesia make a slow improvement over months, and the numbness improves at a much slower pace, and continue to improve even beyond 1 year.

#### SP48

##### PREVALENCE OF GUTTMAN ERROR IN PF SCORES IN THE SPORT IDH COHORT

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**Aims:** Many clinicians use patient reported HRQoL outcomes to inform practice. Although many instruments are considered reliable and valid for use in clinical research, there is little evidence for the reliability and validity of these scores when applied at the patient level. The aim of this study was to estimate the prevalence of Serious Guttman Error (SGE) on SF36 PF subscale in the SPORT intervertebral herniated disc (IDH) cohort.

**Methods:** The PF scale has 10 items each scored on a 3-point limitation scale. GE for any unidimensional scale is determined by: ordering the items by difficulty; identifying all disordinal item pairs—i.e., when less difficult items have higher limitation ratings than more difficult items; and weighting each disordinal pair based on the differences in the item-pair difficulties. SGE in this study was defined when observed GE was more than 15% of the possible error.

**Results:** The IDH cohort had 925 patients with complete PF scores from baseline through 1-year follow-up. Mean age was 53.7 years and 50.2% were female. Principal components analysis confirmed the PF scale had a unidimensional structure (1<sup>st</sup> and 2<sup>nd</sup> eigenvalues 6.02 and 0.99). The overall, SGE rate was 7.1%, with rates varying from 0% for PF scores of 0 and 100, to more than 11% for PF scores of 10, 15, 20, and 25. Rates were stable across baseline to 1-year assessment intervals.

**Discussion:** SGE suggests that a patient's response pattern is inconsistent and, therefore, invalid, meaning that the score may not lead to a reasonable interpretation: use of invalid scores may result in inappropriate treatment choices that lead to worse outcomes and complications.

**Conclusion:** When patient's reports are used as a basis for informing treatment options, then electronic medical records capturing these data should be programmed to detect SGEs and reduce their likelihood. Careless errors may be averted by alerting the patients to check their responses. If SGEs persist, they should be flagged so that clinicians are aware that the score may be invalid.

#### SP49

##### OUTCOME OF TREATMENT OF POST-OPERATIVE SPINE SURGICAL SITE INFECTIONS: PREDICTORS OF TREATMENT SUCCESS AND FAILURE

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**Introduction/Aim:** Surgical site infection (SSI) is an important complication after spine surgery. The management of SSI is characterized by significant variability and there is little guidance regarding an evidence-based approach. The purpose of this paper is to report the treatment and outcome of 225 SSIs, and to identify risk factors associated with treatment failure.

**Patients and Methods:** Retrospective study of consecutive spine surgeries between July 2005 and July 2010 were studied retrospectively. Treatment success was defined as resolution within 90 days with at least one year with no further surgeries. Treatment failure included delayed resolution (>90 days treatment), persistence (implant removal/reimplantation), or death. Fisher's exact or X<sup>2</sup> test and logistic regression were used to identify significant associations.

**Results:** 225 surgical site infections were identified. Microbial distribution of 222 cultured cases: 44% Staphylococcus aureus (28% MSSA, 16% MRSA), 35% polymicrobial, 27% Staphylococcus epidermidis, 16% Enterococcus, 10% E coli, 7% P acnes, 5% Pseudomonas, 5% Enterobacter, 3% Fungi, and 3% culture negative. Early resolution was achieved in 92% of 50 non-instrumented cases and 73% of 147 instrumented cases. A total of 43 cases had treatment failure including patients with ongoing infection after 90 days of treatment (23 cases), the need to remove and/or implants (15 cases), and death due to sepsis (5 cases). Risk factors for treatment failure included late infection (first detected more than 90 days after, 38%), fusion with fixation to ilium (67%), poly microbial (68%), > 6 spine levels (67%), instrumented (73%) and P acnes (43%). Multivariate regression revealed late infection (P = 0.011) was the most significant independent risk factor associated with treatment failure.

**Conclusion:** Post-operative spine infections were treated with aggressive surgical debridement and antibiotic therapy. Superficial infection, short fusion and MSSA were predictors of early resolution. High rates of treatment failure occurred in cases with late infection, long instrumented fusions, poly microbial infections, and P acnes. Removal of implants and direct or staged reimplantation may be a useful strategy in cases with high risk of treatment failure.

#### SP50

##### DID THE PATHOGEN IDENTIFICATION CONTRIBUTE TO THE TREATMENT COURSE IN THE PYOGENIC SPONDYLITIS?

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**Introduction:** An antibiotics administration is the principle of the pyogenic spondylitis (PS) treatment. It is assumed that pathogen-unknown cases are difficult to be treated while the pathogen-identified cases are easy. The purpose of this study is to investigate whether the pathogen identification contributed to the treatment course of the pyogenic spondylitis in the last decade.

**Methods:** A total of sixty-six PS cases (excluding the surgical site infection) from 2001 to 2010 were retrospectively investigated. All cases were subjected to a needle biopsy and/or a blood culture. The clinical profile and the time course of the treatment



were compared between the pathogen-identified cases (Group P, n=33) and the pathogen-unknown cases (Group N, n=33). A significant level was set at  $p=0.05$ .

**Results:** No significant differences were found between the two groups in the age ( $P=66.7$  yrs,  $N=66.1$  yrs), the proportion of the compromised host ( $P=60.6\%$ ,  $N=60.6\%$ ), the variety of the antibiotics ( $P=3.1$  drugs,  $N=3.0$  drugs), the rate of the surgical intervention ( $N=43.2\%$ ,  $N=48.5\%$ ). The time to C-reactive protein (CRP) negative conversion from start of the treatment was also not significantly different between the two groups ( $P=65.0$  days,  $N=67.8$  days). The identified pathogens in the P group were *S. aureus* including MRSA (60.6%), *S. epidermidis* (12.1%), *S. pyogenes* (12.1%), *E. coli* (6.1%) and others (9.1%).

**Discussion:** The current results unexpectedly showed that the pathogen identification did not lead to shortening of the treatment course in the last decade. One reason is that the empirical administration of the antibiotics succeeded to some extent because the major pathogens of the PS were Gram-positive cocci. Another reason may be that the administration method (quantity, the number of times, the administration interval) of antibiotics was not appropriate even in the pathogen-identified cases. Antibiotics except anti-MRSA drugs were uniformly administered twice a day and were easily changed to another drug when the patients' CRP did not show a response. This study does not deny the importance of the pathogen identification. More strict antibiotics administration based on the Pharmacokinetics/Pharmacodynamics theory may improve the treatment course in the PS.

## SP51

### TOTAL MOTION GENERATED IN THE UNSTABLE THORACOLUMBAR SPINE DURING MANAGEMENT OF THE TRAUMA PATIENT: A COMPARISON OF METHODS IN A CADAVER MODEL

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**Introduction:** The proper pre-hospital and in-house management of patients with unstable spinal injuries is critical for prevention of secondary neurologic injury. We sought to analyze the amount of motion generated in the unstable thoracolumbar spine during various maneuvers and transfers that a trauma patient would typically be subjected to prior to definitive fixation.

**Materials and Methods:** Five fresh cadavers with surgically created unstable L1 burst fractures were tested. The amount of angular motion between the T12 and L2 vertebral segments was measured using a Fastrak, three-dimensional, electromagnetic motion analysis device (Polhemus Inc., Colchester, VT). A total sequence of maneuvers and transfers were then performed that a patient would be expected to go through from the time of injury until surgical fixation. These included: spine board placement and removal, bed transfers, lateral therapy, and turning the patient prone onto the operating table. During each of these, we performed what we felt to be the best and most commonly used techniques for preventing undesirable motion at the injury level. **Results:** During the turn prone for surgery there was statistically more angular motion in each plane for manually turning the patient versus the Jackson table turn ( $p<0.05$ ). Bed transfer using a spine board with log-roll technique resulted in more motion in all three planes, and this reached statistical significance for axial

rotation ( $p=0.018$ ) and lateral bending (0.030). During spine board placement and removal there was more motion in all three planes with log-rolling, although this did not reach statistical significance. During lateral therapy there was statistically more motion in all planes with the log-roll and pillow placement technique ( $p<0.005$ ). The total motion was decreased by 50% when using an alternative to log-roll technique throughout.

**Discussion:** Although it is unknown how much motion in the unstable spine is necessary to cause secondary neurologic injury, minimizing motion of the spinal column to an absolute minimal is desirable. We have demonstrated the angular motion incurred to the unstable thoracolumbar spine as experienced by the typical trauma patient from the field to positioning in the operating room using a best and most commonly used techniques. Each step along the way is additive and can result in catastrophic consequences for the patient.

**Conclusion:** As previously reported, using the log-roll technique consistently results in unwanted motion at the injured spinal segment.

## SP52

### HOW WELL DO ROLAND MORRIS SCORES REFLECT THE ACTUAL PERFORMANCE ON FUNCTIONAL TESTS IN PATIENTS WITH CHRONIC LBP?

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**Introduction/Aim:** Disability reported by patients with chronic LBP (cLBP) does not always relate well to performance in traditional physical tests of impairment (e.g. back strength, fatigability, etc.). Therefore tests using more "functional" activities that challenge for example trunk mobility and movement speed have been suggested as alternative "objective" outcome measures. We examined the relationship between self-reported disability and a battery of such functional tests.

**Materials and Methods:** 37 patients with cLBP took part ( $45\pm 12$  y; 23f, 14m), 32 of which also underwent 9 weeks physiotherapy. Before and after therapy, the Roland Morris disability questionnaire (RM) was completed and a battery of 8 simple tests with previously documented reliability were performed (stair climb, prolonged flexion, stand to floor, lift test, sock test, roll-up test, pick-up test, fingertip to floor test).

**Results:** At baseline, there were significant correlations between the scores on the RM and each of the functional tests, ranging from  $r=0.33$  (sock test) to 0.51 (fingertip to floor) ( $p<0.05$ ). The correlation between a sum index score for all tests and RM was  $r=0.60$  ( $p<0.001$ ). The effect size (standardised response mean) for the change in RM score pre-treatment to post-treatment was 0.54; the corresponding value for the functional test index was 0.73. The correlation between the treatment change-scores for RM and the functional test index was 0.55 ( $P=0.001$ ).

**Discussion:** There were significant, moderately high correlations between self-reported activity limitation and objectively-measured performance. The fingertip to floor test delivered the most clinically relevant information, as judged by its relationship with the RM scores.

**Conclusion:** The test battery appears to provide a valid measure of activity limitation in patients with back pain and may be a useful tool to complement or substantiate self-report measures to assess treatment outcome after physiotherapy.



## SP53

**DOES BALLOON KYPHOPLASTY IMPROVE GLOBAL SPINAL ALIGNMENT IN PATIENTS WITH OSTEOPOROTIC VERTEBRAL FRACTURES?**

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**Introduction/Aim:** Balloon kyphoplasty (BKP) has been established as a standard procedure for treatment of osteoporotic vertebral fractures, whereas it is unclear whether or not BKP improves global spinal alignment. The objectives of this study are to review radiographic and clinical outcomes of BKP for osteoporotic vertebral fractures, and to evaluate its effect on global spinal alignment.

**Materials and Methods:** A total of 54 consecutive patients who had undergone BKP for osteoporotic vertebral fractures or non-unions were reviewed retrospectively. They were 9 males and 45 females with a mean age of 77 years. 31 patients (57%) had pre-existing vertebral fractures, and eight were subsequent fractures related to spinal instrumentation. Fracture levels were thoracic spine (T6-T10) in 13, thoracolumbar spine (T11-L2) in 40, and lumbar spine (L3-L5) in five patients. Clinical outcomes were evaluated using visual analog scale (VAS) of back pain. Radiographic assessment was performed using standing whole spine radiographs. The parameters included vertebral kyphosis angle, mid-vertebral body height, and anterior deviation of C7 plumb line (C7PL). Mean follow-up period was 15 months. Paired t-test was used for statistical comparison.

**Results:** BKP significantly improved VAS of back pain from 53/100 to 19/100 ( $p < 0.0001$ ). Vertebral kyphosis angle significantly decreased from 17 degrees to 12 degrees; mid-vertebral body height was significantly reduced from 12mm to 15mm ( $p < 0.0001$ ). Anterior deviation of C7PL was 30mm before the procedure and 37mm at the follow-up: the difference was not significant ( $p = 0.52$ ). Despite pre-existing vertebral fractures, anterior deviation of C7PL did not change after the procedure. In 16 patients with a minimum 2-year follow-up, two patients (13%) had subsequent fractures after BKP.

**Discussion/Conclusion:** BKP contributed to significant pain relief and improvement of local vertebral alignment, but did not have impact on global spinal alignment. Although balloon use had advantages to create cavity to fill with PMMA cement safely and to control local vertebral alignment, surgeons should know its limitations in the treatment of sagittal imbalance after vertebral fractures.

## SP54

**DISADVANTAGES OF USING OSWESTRY DISABILITY INDEX IN DEVELOPING COUNTRIES AND THE NEED FOR THE MODIFICATIONS**

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**Aim of the Study:** Oswestry disability index is one of the commonest outcome measure used in degenerative disc disease. We conducted a study, to know the usefulness of this index in our country and made an attempt to identify the difficulties in using this index.

**Materials and Methods:** We evaluated 100 patients with proven clinical and radiological evidence of degenerative disc disease using Oswestry disability index. ODI was done by two independent observers (a resident and then by author himself). Interobserver variation was noted and the areas in questionnaire which showed high variation were specifically analyzed for the cause of such variation.

**Results:** There was significant interobserver variation ranging from 6 to 32 points which is highly significant. Questionnaire. No. 10 (travelling), questionnaire No 3 (lifting weights), questionnaire no. 4 (walking) and

No. 6 (standing) in that order, showed significant variations between the two observers ( $\kappa$  less than 0.5). We found that there are two main reasons for this variation, a) some of activities are not needed by the person even in his routine daily work, leading to speculative answer, b) diurnal variations in pain and subsequent activity restriction, requiring proper interpretation by the person asking questionnaire. 54% of patients opined that their work do not include lifting weights and hence they cannot accurately say how much weight they can lift, while 72 patients opined that their work do not require any traveling and hence it would be difficult to give correct score on that. In order to overcome these errors, we suggest certain modifications, based on regular demands of a working person in our country and include activities like bending forwards, sitting in floor, squatting and walking on uneven surface. These new modifications need to be tested in subsequent studies.

**Conclusions:** Oswestry disability index may not be suitable for developing countries like India in current form and may need certain modifications.

## SP55

**EFFICACY OF PHYSICAL EXAMINATIONS TO DIAGNOSE EARLY-STAGE SPONDYLOLYSIS**

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**Introduction:** Magnetic resonance imaging (MRI) is useful for the early diagnosis of spondylolysis, even when spondylolysis is not detectable by plain X-ray. However, because of high cost, MRI cannot be utilized in all adolescent patients with low back pain. The purpose of this study was to investigate the usefulness of physical examinations as a screening test for early-stage spondylolysis.

**Materials and Methods:** Seventy-eight adolescent patients (mean age: 14.4 years; range: 11-17 years; male: 55 female: 23) with low back pain, but no spondylolysis detected by X-ray, were included. All patients were evaluated by the following physical examinations, in which provocation of concordant pain is considered to be a positive result: percussion test (on spinous processes), pelvic flexion test (in supine position), and hyperextension and hyperflexion tests (in standing position). All patients were also evaluated by MRI for diagnosing early-stage spondylolysis only detectable by MRI. To evaluate the usefulness of the tests, the sensitivity and specificity of each test were investigated.

**Results:** MRI showed that 51.3% of patients had early-stage spondylolysis. The sensitivity and specificity, respectively, of each test were: percussion test (80%, 73.5%), negative result of pelvic flexion test (87.5%, 72.2%), hyperextension test (75%, 11%), and negative result of hyperflexion test (65%, 66%). To improve specificity, we investigated a combination of the percussion and pelvic flexion tests. The sensitivity and specificity of the combined test were 70% and 96.8%, respectively.

**Conclusion:** Pain provocation on hyperextension is generally recognized to be a physical sign of spondylolysis. However, our study showed extremely low specificity of the hyperextension test, suggesting that it is not useful for diagnosing early-stage spondylolysis. The pelvic flexion test and percussion test showed relatively high sensitivity and specificity, moreover, the combined pelvic flexion and percussion test improved specificity to 96.8%. Therefore, we suggest that the combined test is effective for diagnosing early-stage spondylolysis.



## SP56

**GENDER DIFFERENCES OF RADIOGRAPHIC FINDINGS IN PATIENTS WITH LUMBAR SPONDYLOLYSIS**Sakai T.<sup>1</sup>, Takao S.<sup>2</sup>, Sairyō K.<sup>3</sup>, Nishitani H.<sup>2</sup>, Yasui N.<sup>1</sup><sup>1</sup>Dept. of Orthopaedic Surgery, Tokushima University, Tokushima;<sup>2</sup>Dept. of Radiology, Tokushima University, Tokushima; <sup>3</sup>Dept. of Orthopaedic Surgery, Teikyo University, Kawasaki, Japan

**Introduction/Aim:** Spondylolysis is thought to be a stress fracture of the pars interarticularis that occurs frequently in adolescent sports players. Some patients with spondylolysis concomitantly have various deformities of the lumbosacral region, including slippage of the vertebral body (spondylolisthesis) and/or wedging deformity. The aim of this study is to investigate the gender differences of the lumbar spine in adults with spondylolysis using multidetector computed tomography (CT).

**Materials and Methods:** A total of 117 patients (39 women and 78 men) with lumbar spondylolysis were included in the study. Mean patient age was 63.0 (22 to 87) years. Patients underwent abdominal and pelvic CT with a single multidetector CT scanner for reasons unrelated to lower back pain. All measurements (Degree of slippage, Lumbar index, Lumbar lordosis) were performed using mid-sagittal and mid-coronal lines.

**Results:** Of the 117 subjects with spondylolysis, including five with multiple-level spondylolysis, there were 124 vertebrae with spondylolysis. In adult lumbar spines with unilateral spondylolysis, there was no significant difference between the incidence of spondylolisthesis in male (11.8%) and female subjects (0%). However, in those with bilateral spondylolysis, there was a significantly higher incidence of spondylolisthesis in female subjects (90.9%) than in males (66.2%). Furthermore, females with bilateral spondylolysis had significantly more slippage than males. Lumbar index and lumbar lordosis were not significantly different between male and female subjects, and did not significantly correlate with slippage.

**Discussion:** In subjects with bilateral spondylolysis, there was a significantly higher incidence of spondylolisthesis in female subjects than in males. Furthermore, female subjects with bilateral spondylolysis had significantly more slippage than males. Therefore, to treat acute spondylolysis in adolescents, it is important to obtain bony union at least unilaterally to prevent further slippage, especially in female subjects.

**Conclusion:** Females with bilateral spondylolysis had significant more slippage than males.

## SP57

**DEGENERATIVE SPONDYLOLISTHESIS: THE ROLE OF A WEAKENED ABDOMINAL WALL**

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**Introduction/Aim:** Degenerative spondylolisthesis (DS) is thought to arise from failure in torsion with females more vulnerable due to their bony anatomy. The abdominal wall has been estimated to provide 95% of resistance to torsion. The anterior abdominal wall is stretched during childbearing and a previous study found an association between DS and pregnancy. The aim was to further examine the association of weakened anterior abdominal muscles and DS.

**Methods:** This was a prospective observational study of all new patients 50 yrs of age or older presenting with mechanical LBP. Details of age, height, weight, children, pregnancies and open abdominal operations were recorded. The presence of rectus separation and ventral hernia was determined when the supine patient's head and shoulders were elevated. CT or MRI images were examined for DS and the displacement was graded.

**Results:** 205 patients were enrolled over a 5-month period. Mean ages (years) were 70.5 for DS males, 65.9 for non-DS males, 72.0 for DS females and 64.9 for non-DS females. BMI for males and females with and without DS was similar. DS was present in 28 of 98 males and in 56 of 107 females (M:F=1:2). DS was multilevel in 30% of females compared with 7% of males (p=.017).

There was a significant association between DS and ventral hernia (p=.009), rectus separation (p=.024), open abdominal surgery (p=.022) and pregnancy (p=.03). Ventral hernia was present in 64.3% of DS males compared with 37.1% of non-DS males. Rectus separation was detected in 71.4% of DS males, 52.9% of non-DS males, 51.8% of DS females and 35.3% of non-DS females.

**Discussion/Conclusion:** DS and rectus separation are both very common in patients over 50 years of age presenting to a spinal surgical clinic. The associations of DS with rectus divarication, previous open abdominal surgery and childbearing support the view that a weakened anterior abdominal wall is a significant causative factor for DS. The findings have particular relevance to prevention as well as conservative and surgical management of DS.

## SP58

**LONG-TERM CLINICAL OUTCOMES AFTER MICRO-ENDOSCOPIC DECOMPRESSION SURGERY FOR LUMBAR SPINAL STENOSIS INCLUDING DEGENERATIVE SPONDYLOLISTHESIS**

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**Introduction:** As a surgical treatment of degenerative lumbar spondylolisthesis, lumbar spinal fusion is recommended based on prospective clinical studies (SPORT). The authors have developed a minimally invasive laminotomy using spinal endoscopy to lumbar spinal disorders since 1998. The novel microendoscopic laminotomy (MEL) technique helps to preserve the facet joints, posterior ligament complex and soft tissues as much as possible. The purpose of this study was to prospectively investigate the long-term clinical outcomes of microendoscopic decompression for lumbar spinal stenosis (LSS) including degenerative spondylolisthesis (DS).

**Methods:** From 2002 to 2006, all patients, who developed a surgical treatment for LSS on L4/5 single level, underwent MEL surgery at the authors' institute. A total of 159 patients (79 males, 80 females; mean age: 68 years) were reviewed prospectively. They were divided into two groups by with (DS group: 71pts) or without (Control group: 88pts) degenerative spondylolisthesis. The following items were evaluated preoperatively and 5-years postoperatively: Japanese Orthopaedic Association scoring system (JOA score), the recovery rate, SF-36, and clinical affected factors. All parameter were analyzed statistically (p<0.05).

**Results:** Excluded from death, cerebral infarction, dementia, or terminal cancer, 132 patients (DS: 61pts, Control: 71pts) were finally reviewed. There were no significant differences in sex, age and preoperative JOA score between two groups. The JOA recovery rate in DS and Control groups was respectively 64.8±25.8% and 63.6±21.9% (p>0.05). The mean %slip of DS group was 18.1% preoperatively and 16.8% 5-years postoperatively (p>0.05). By this scoring system, the success rate of MEL was good or excellent results in 70% patients of both groups. However, five patients of each group underwent additional spinal fusion caused by insufficient spinal decompression, bulging intervertebral disc.

**Discussion:** The ideal technique for LSS is to maintain the spinal stability while allowing sufficient decompression, and

thus to prevent the morbidities of spinal fusion. MEL technique consists of the bilateral decompression by unilateral approach, and maintained the spinal stability for the long-term after surgery. **Conclusions:** This observation suggests that, compared with LSS without DS, MEL offered a similar long-term clinical outcome of with DS. MEL is a candidate for surgical treatment of LSS including DS.

#### SP59

### THE RELATIONSHIP BETWEEN PERFORMANCE AND TRADITIONAL OUTCOMES OF PAIN, FUNCTION AND QUALITY OF LIFE IN PEOPLE WITH SPONDYLOLISTHESIS AND LUMBAR SPINAL STENOSIS

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**Introduction:** Performance (actual function in day to day life) has been identified as an important outcome in spine research. We have recently begun to objectively measure performance using activity monitors (accelerometers). Yet, it is not clear how performance measurements relate to traditional outcomes of pain, function, and quality of life.

**Methods:** Subjects were >50, undergoing decompression with single level fusion for spondylolisthesis and LSS. One week before surgery subjects wore an activity monitor for 7 days, completed the Self-Paced Walking Test and a questionnaire including the Oswestry Disability Index (ODI), Swiss Spinal Stenosis Questionnaire and SF-36. Performance was measured with activity counts, steps/day and sedentary time (duration of time spent <100 counts/minute). Maximum continuous activity (capacity) was defined as the maximum number of consecutive minutes above 'light intensity' activity (>100 counts/minute).

**Results:** Subjects (n=19) were 66.7±7.8 years old and 78% were female. Total activity (counts/week) was related only to male sex (r=0.54) and steps/day associated only with BMI (r=0.53) (p<0.05). Sedentary time was associated with leg pain (r=0.72), back pain (r=0.60) and male sex (r=0.53) (p<0.05). None of the performance variables were correlated significantly with the walking test, or self-report measures of disability (ODI), or physical function (Swiss Spinal Stenosis Questionnaire). Maximum continuous activity was correlated with leg pain (r=0.52), BMI (r=0.47), Emotional (r=0.49) and Mental Health (r=0.55) measures.

**Conclusion:** Performance measures were not significantly correlated with outcomes commonly used to measure function and disability. This suggests that current outcome tools are not capturing the construct of performance. Because improvement in daily function is an important goal of intervention, performance measurements should be added to future outcome batteries. Given the strong relationship with pain, sedentary time may become an outcome of choice when examining performance.

#### SP60

### PERIOPERATIVE OUTCOMES, COMPLICATIONS, AND COSTS ASSOCIATED WITH LUMBAR SPINAL FUSION IN OLDER PATIENTS WITH SPINAL STENOSIS AND SPONDYLOLISTHESIS: ANALYSIS OF THE US MEDICARE CLAIMS DATABASE

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**Introduction/Aim:** Among elderly patients with spinal stenosis and spondylolisthesis, lumbar spinal fusion is commonly performed to facilitate spinal decompression and stabilization. However, recent reports of excessive perioperative morbidity and soaring healthcare costs with fusion have led to the search for methods to improve the safety profile and to lower costs for this important surgical treatment. The purpose of this study is to quantify the perioperative outcomes, complications, and costs associated with posterior spinal fusion among Medicare enrollees with spinal stenosis and spondylolisthesis using a national Medicare claims database.

**Materials and Methods:** The 5% systematic sample of Medicare claims data (2005-2009) was used to identify and track the outcomes of patients who received any form of posterior spine fusion (PSF) for lumbar spinal stenosis (LSS) or spondylolisthesis. Surgical patients were identified by standard PSF procedural coding, while diagnoses of LSS and spondylolisthesis were identified using specific ICD-9 coding. Enrollees further required a minimum of 2 years' follow-up, and claim history of at least 12 months prior to surgery. Patients' length of stay, discharge status, incidence and type of complications, and treatment costs following PSF were evaluated.

**Results:** A final cohort of 1,672 PSF patients was included. LSS and spondylolisthesis were the primary diagnoses for 58.7% and 18.9% of the patients, respectively, and were the secondary diagnoses for the remaining patients. Of the 1,672 PSF patients, 50.7% had LSS only; 10.2% had spondylolisthesis only; and 39.1% had both LSS and spondylolisthesis. For the overall cohort, the average age was 71.4 +/- 7.9, and the average length of stay was 4.6 +/- 3.2 days. While 42.2% of the patients had routine discharges, a majority of the patients (54.6%) were discharged to an outside facility or required home health services (18.0%, 19.4%, and 17.2% were discharged to skilled nursing facilities, home health services, and rehabilitation facilities, respectively). At 3 months, 1 year, and 2 years post-operative, the incidence of spine reoperation was 19.9%, 24.0%, and 28.0%, respectively, while readmission for complications was 34.5%, 41.4%, and 47.9%, respectively. The overall average payment for the PSF patients was \$36,230 +/- \$17,020, \$46,840 +/- \$31,350, and \$61,610 +/- \$46,580 at 3 months, 1 year, and 2 years, respectively, and corresponded to an overall cost to Medicare of \$60.6 million, \$78.3 million, and \$103.0 million for treating these patients.





## Complication Rates - Overall

Complication	3 mo. f/u	1 year f/u	2 years f/u
Spine reoperation	19.9%	24.0%	28.0%
Infection	3.83%	4.90%	5.92%
Spinal cord injury	0.60%	0.66%	0.78%
Nerve root injury	0.06%	0.12%	0.12%
Dural tear/puncture	5.02%	5.50%	5.98%
Pneumonia	4.43%	7.78%	13.1%
PE	1.85%	2.51%	3.50%
Myocardial infarction	1.97%	2.81%	4.49%
Mechanical complications	3.47%	5.50%	8.49%
Hemorrhage/hematoma	2.81%	3.89%	4.84%
Lumbar spine fracture	2.45%	3.29%	4.19%
Postlaminectomy syndrome	11.8%	19.1%	25.4%
Wound infection	4.61%	6.10%	7.00%
UTI	17.9%	30.3%	40.9%
Non/mal-union	1.73%	3.05%	4.13%
Readmission (for above complications)	34.5%	41.4%	47.9%
Removal of hardware	1.56%	2.51%	4.25%

**Conclusions:** Over half of the PSF-treated patients in this study had LSS alone, suggesting that factors other than spondylolisthesis play a significant role in the decision to recommend spinal fusion in this elderly population. One in 4 elderly fusion patients being treated for LSS or spondylolisthesis was reoperated on the spine within 2 years, and nearly 1 in 2 readmitted for a surgery-related complication. This data highlights several areas where improvements can be made in the effective delivery and cost of surgical care for patients with spinal stenosis and spondylolisthesis.



P239

### COMPARISON OF DIFFERENT POSTERIOR INSTRUMENTATION SYSTEMS IN ACHIEVING STABILITY TO SUPPLEMENT TRANSFORAMINAL LUMBAR INTERBODY FUSION (TLIF): A BIOMECHANICAL CADAVER STUDY

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**Background:** Instrumentation has been shown to increase the fusion rates in the lumbar spine. Surgeons are continuously trying to achieve the goals of spine surgery using less invasive techniques. A new minimally invasive device has been approved to fixate two adjacent interspinous (IS) processes while the fusion occurs between the two vertebrae.

**Aim:** To biomechanically compare different fixation systems for stability supplementation in a TLIF.

**Materials and Methods:** Seven specimens from T12 to the sacrum were mounted to the testing robot. A stability comparison was performed on L3-4 rotations for the following scenarios: 1) intact spine, 2) TLIF, 3) TLIF with IS Fixation Device (ISD), 4) TLIF with ISD and unilateral pedicle screws, 5) TLIF with bilateral pedicle screws. (All instrumentation: Lanx, Broomfield, CO). The test robot applied a continuous pure moment cycle ( $\pm 5$  Nm) in flexion-extension (FE), lateral bending (LB) and axial rotation (AR). Intersegmental rotations were measured using an optoelectronic camera system. Statistical analysis was performed to compare the differences between treatments.

**Results:** The study found no statistically significant difference in the range of motion (ROM) in FE among the stand alone ISD, ISD with unilateral pedicle screws, and bilateral pedicle screws specimens. There was no statistical difference between the ROM of ISD plus unilateral screws and bilateral pedicle screws in any motion direction (FE, LB and AR).

**Conclusion:** In this study, the ISD stabilized the spine in only FE comparably to bilateral pedicle screws. ISD with unilateral pedicle screws and bilateral pedicle screws were shown to be statistically equivalent in providing stability in all directions after a TLIF.

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### BIOMECHANICAL EFFECT OF DYNAMICALLY STABILIZING THE ADJACENT SEGMENT TO A ONE LEVEL LUMBAR FUSION

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**Introduction:** On indication for dynamic stabilization is its use as transition instrumentation adjacent to a solid fusion to protect that adjacent level from excessive compensating motion. The aim of this study is to assess the effect of dynamic stabilization on adjacent levels.

**Materials and Methods:** Seven human specimens T12-sacrum were used. The test conditions were: (1) Intact spine (2) Fusion of L4-5 with bilateral pedicle screws and titanium rods. (3) Pedicle-screw dynamic stabilization construct (Zimmer, Warsaw, IN) at L3-4. A robotic system applied continuous pure moment ( $\pm 2$  Nm) in flexion-extension (FE) with and without follower load, lateral bending (LB) and axial rotation (AR). Intersegmental rotations were measured and statistically compared.

**Results:** In FE only, the rigid instrumentation at L4-5 caused an increase in motion at adjacent levels, L1-2 and L2-3 only. The placement of the dynamic construct at L3-4 caused a significant increase in motion at all tested adjacent levels.

In FE with follower load, instrumentation at L4-5 affected only sub-adjacent level, L5 – S. The dynamic construct caused a significant increase in motion at the adjacent levels, T12 – L1, L1-2 and L5 – S1.

In LB, instrumentation at L4-5 increased motion at only T12 – L1. The dynamic construct at L3 – L4 caused an increase in motion at T12 – L1, L1-2, L2-3 and L5 – S1.

In AR, only the placement of the dynamic construct at L3-4 caused a significant increase in motion of the adjacent levels, L2-3 and L5 – S1.

**Conclusion:** The dynamic stabilization system had the same stability as a rigid construct. Its addition to the adjacent level (L3-4) to the fusion (L4-5) in deed protected the adjacent level from excessive motion. However, it essentially transformed a 1 level into a 2 level lumbar fusion with exponential transfer of motion to the fewer remaining discs.

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### MODAL TESTING IS A VALID METHOD FOR MEASURING THE MECHANICAL PROPERTIES OF HUMAN LUMBAR MOTION SEGMENTS

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**Aim:** Structural vibration testing is a non-destructive measurement technique which applies only low forces and small deformations to assess the integrity of a structure and is therefore a promising method to study the mechanical properties of the spine in vivo. Previously, the feasibility of structural vibration testing was established in animal models with artificially induced spinal injuries. Therefore the first purpose of the current study was to examine the sensitivity of vibration testing to naturally existing degenerative changes in aged human spinal segments in which stiffness alterations are less pronounced and probably multifactorial. Furthermore, since quasi-static mechanical testing is considered the "gold standard" for assessing intervertebral stiffness, the second purpose was to examine if the mechanical properties derived from vibration testing and quasi-static testing correlate.

**Methods:** 6 Cadaver human spines (L1-L5) were loaded quasi-statically in pure bending and torsion, while an optical system measured the angular rotations of the individual motion segments. Subsequently, the polysegmental spines were divided in L2-L3 and L4-L5 segments and a shaker was used to vibrate the upper vertebra, while its response was obtained from accelerometers in anteroposterior and mediolateral directions. From the resulting frequency response function the eigenfrequencies (ratio between stiffness and mass) and vibration modes (pattern of motion) were determined.

**Results:** The vibration results showed clear eigenfrequencies for flexion-extension, lateroflexion and axial rotation for all segments. Furthermore, the correlation between static and dynamic tests was significant when the eigenfrequencies were compared to the neutral zone stiffness ( $r=0.67$ ,  $p=0.01$ ).

**Conclusion:** The findings from this study show that structural vibration testing can be used to assess the mechanical properties of human lumbar motion segments. In the future, this method might be used to study the mechanics of the spine in vivo.



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### KINEMATIC CHARACTERISTICS OF POSTURAL STABILITY IN INDIVIDUALS WITH AND WITHOUT RECURRENT LOW BACK PAIN

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**Background and aims:** Even though a number of studies have evaluated postural adjustments based on kinematic changes in subjects with low back pain (LBP), lumbar spine stability has not been examined for abnormal postural responses with visual feedback. The purpose of this study was to evaluate the stability in three regions of the spine based on dominance side and visual feedback. Subjects with (n=26; 9 men, 17 women) and without (n=28; 11 men, 17 women) recurrent low back pain (LBP) participated in this study.

**Methods:** All subjects were asked to maintain single leg standing balance with the contralateral hip flexed 90 degrees for 25 seconds. The outcome measures included the duration of standing balance and the combined stability based on the rotation (Rxyz) with and without visual input. The spine regions included the upper and lower thorax and lumbar axes relative to the core spine axis which represent spine root.

**Results:** The subjects without recurrent LBP demonstrated longer hold durations than the subjects with recurrent LBP ( $F=12.81$ ,  $p=0.001$ ). The combined stability was significantly different based on dominance side ( $F=4.37$ ,  $p=0.04$ ), visual input ( $F=11.33$ ,  $p=0.001$ ), and spinal region ( $F=101.72$ ,  $p=0.002$ ). In addition, the combined stability of the spinal region had an interaction with visual input between groups ( $F=4.50$ ,  $p=0.03$ ). The combined stability of the spine root ( $0.52 \pm 0.03$ ) was lowest compared to the other regions of the spine in subjects with recurrent LBP.

**Conclusions:** The kinematic changes of postural stability are different based on dominance side and visual feedback between subjects with and without recurrent LBP. Possible kinematic rehabilitation training of the core spinal axis could be used in the prevention of falls. Follow-up, randomized controlled trials are needed to investigate the characteristics of postural adjustability in order to enhance both biomechanical and neuromuscular function in subjects with recurrent LBP.

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### A KINEMATIC ANALYSIS OF THE CORE SPINE AND PELVIS DURING LATERAL BENDING IN SUBJECTS WITH AND WITHOUT CHRONIC LOW BACK PAIN

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**Background and Aims:** The kinematic measurement of the core spine and pelvis during lateral bending is important to consider since the motion is evident in various functional daily activities. Although a number of studies have reported three-dimensional kinematic changes by radiography, the quantitative contribution of the dominant side difference during trunk lateral bending has not been carefully investigated.

**Methods:** Participants were 44 individuals (29 men and 15 female) with low back pain (LBP) ( $43.1 \pm 17.4$  years) and without chronic LBP ( $39.7 \pm 18.7$  years). All participants were asked to perform trunk lateral bending to the dominant and non-dominant sides with a bar five times repeatedly. The outcome measures included three dimensional rotational angle displacements for the pelvis and core spine (spinal root axis).

**Results:** There was a sagittal ( $T = -2.24$ ,  $p = 0.03$ ) and transverse ( $T = 2.39$ ,  $p = 0.02$ ) axis difference on the core spine to the dominant side during lateral bending between the control and patient groups. During non-dominant side lateral bending,

transverse axis was significantly different between control and patient group ( $T = 2.16$ ,  $p = 0.03$ ). Although there was no group interaction with region ( $F = 2.41$ ,  $p = 0.12$ ) and side ( $F = 2.12$ ,  $p = 0.15$ ), there was an interaction between group, side, and three dimensions ( $F = 5.47$ ,  $p = 0.02$ ).

**Conclusions:** During trunk lateral bending, the transverse rotation axis in the pelvis demonstrated significantly different changes compared to the non-dominant side. Changes in the sagittal and transverse axes of the core spine demonstrated significantly different results compared to the dominant side during lateral bending between groups. The results of this study indicated that there was a different angular displacement based on dominance side.

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### HUMAN RESPONSE TO SINGLE AND COMBINED SINUSOIDAL VERTICAL VIBRATION-REVISITED

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**Introduction/Aim:** Task performance decrement has been reported with exposure to combined vibration<sup>1</sup>. As no erector spinae activity was recorded then, the present work reproduced that study to investigate how back muscle response would have contributed.

**Materials and Methods:** Fourteen, right-handed males were exposed to three trials of four vertical vibration conditions while sitting upright on a steel tractor seat with no back support or physical postural reminders. Vertical vibration conditions were: no vibration, vibration at 2.5 Hz, vibration at 5.0 Hz, and vibration combining 2.5 Hz with 5.0 Hz. The vibration acceleration levels were  $0.69 \text{ ms}^{-2}$  rms. Subjects concentrated on a simple four-limb task during testing. Erector spinae (EMG) activity was calibrated, recorded and ensemble-averaged.

**Results:** Not all subjects responded. The left erector spinae responded more often than the right. The participants were able to respond cyclically to the 2.5 Hz and 5 Hz vibration conditions when encountered independently, but only responded to the 2.5 Hz component of the combined vibration condition.

**Discussion:** A balanced posture with respect to the vertical acceleration could explain the lack of response in many subjects. Chronic involuntary exercise of the muscles opposite the dominant hand could explain why the left erector spinae responded more often than the right. Responding only at 2.5 Hz to a combined signal would allow an acceleration at 5.0 Hz, the seated human's natural frequency, to apply forces to the spine. This could explain both the performance decrement noted above as well as mechanical degradation of the system.

**Conclusions:** These findings raise questions about the ability of the musculoskeletal control system to cope with a complex vibration.

#### Reference:

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### TO DETERMINE THE ASSOCIATION BETWEEN ANATOMIC LANDMARKS OF LUMBAR SPINE AND AGE: A POSTMORTEM STUDY OF 1072 CADAVERIC HUMAN SPECIMENS

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**Introduction:** Certain anatomic measurements of vertebrae such as the body diameter and interpedicular distance are per se considered fixed i.e. these are congenitally influenced rather than by progressing age. However with increasing age, the forces and various stresses transferred to the vertebrae are altered due to changes in soft tissues and ligaments which in turn may cause expansion of the vertebral body which further causes VBD and IPD to increase with advancing age.

**Aim:** To evaluate the association between anatomic landmarks of lumbar spine and age to test the hypothesis that certain anatomic landmarks are not affected by age.

**Methods:** 1072 cadaveric human specimens from Hamann-Todd Osteological Collection in Cleveland were examined. The lumbar vertebrae were measured with digital caliper. The body diameter was measured as the anteroposterior distance of vertebral body, while the interpedicular distance was measured from the superior aspect.

Linear regression analyses were used to determine the relationship between each of body diameter and interpedicular parameters correcting for confounding factors of sex and race.

**Results:** In all the specimens, there was a significant association of increasing body diameter with advancing age at all levels (L1-L5) with  $p < 0.02$ . Changes in the interpedicular distance were significantly associated with advancing age at L1/2, L2/3, L3/4 levels ( $p < 0.02$ ).

**Conclusions:** This study suggests some association of body diameter and interpedicular distance with increasing age. The fact that lumbar spine is more lordotic at L4 and L5 levels, the stress on L4 and L5 will be more anteriorly located. Thus the vertebral body will expand but the IPD which is posterior would not be affected as much. L1, L2, L3 on the other hand being axially oriented have an even distribution of stress, and as a result both the VBD and IPD expand. This may explain why lumbar stenosis occurs so frequently at the lower lumbar levels while it is relatively uncommon at upper lumbar spine.

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### LUMBAR DISK DEGENERATION IS ASSOCIATED WITH CANAL AREA AND INTERPEDICULAR DISTANCE: A STUDY OF 1072 HUMAN CADAVERIC SPECIMENS

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**Introduction:** Subjects with congenital lumbar stenosis may have altered spinal biomechanics due to the fact that anatomic parameters are shortened. It is not known if these structural differences lead to alterations in forces across the disk spaces, which in turn may change the amount of degeneration which occurs with age. The aim of this study is to find out if there is an association between degenerative disc disease and canal area of lumbar spine.

**Materials and Methods:** 1072 cadaveric specimens were examined for evidence of facet and disc arthrosis in lumbar spine. Based on studies by Kettler, we used grading systems for facet arthrosis and disc degeneration from Grade 0 to 4 on a continuum from no arthritis to ankylosis. Digital calipers were used to measure sagittal canal diameter, IPD and PL. Canal area at each level was calculated using a formula. A standard

distribution for each level was created, and values that were 2SD below mean were considered as being "congenitally stenotic". Linear regression test was used to find the association of DDD with canal area and interpedicular distance.

**Results:** Lumbar DDD was significantly associated with canal area at the L5/S1 level ( $p < 0.05$ ). Subjects with canal stenosis were found to have 1.76 times more endplate degeneration at L5/S1 level as compared to normal subjects. A significant association was found between IPD and DDD at levels L1/2, L2/3, and L3/4 ( $p < 0.05$ ). Subjects with congenitally stenotic IPD were found to have 10% more DDD.

**Conclusions:** Based on our study skeletal specimens, there is a significant association between DDD and canal area at L5/S1. This suggests that a congenitally small canal at this level predisposes to advanced degeneration. Likewise, subject with a decreased IPD at L1/2, L2/3, and L3/4 are predisposed to DDD at these levels. This may help the clinician predict which levels are at risk of advanced degeneration.

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### IS L5 PEDICLE LENGTH INCREASED IN SUBJECTS WITH SPONDYLOLYSIS? AN ANATOMIC STUDY OF 1072 HUMAN CADAVERIC SPECIMENS

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**Introduction:** In congenital spondylolisthesis, it is thought that as L5 slips on S1, the pedicle may become elongated in response to the instability in an attempt to bridge the defect. Whether patients with spondylolysis which is largely developmental in nature also develop elongation of the pedicles is unknown. The purpose of this study is to find out if L5 pedicle length is increased in patients with spondylolysis.

**Materials and Methods:** 952 normal human cadaveric specimens and 120 spondylolytic specimens from the Hamann-Todd Osteological Collection, Cleveland were examined by a single examiner. Baseline data including age, sex and race of specimens were collected. Digital calipers were used to measure the pedicle lengths at the L5 level. Linear regression analysis was performed to compare the L5 pedicle lengths in spondylolytic and normal patients.

**Results:** Linear regression demonstrated a significant association of increased L5 pedicle length in subjects with spondylolysis ( $p < 0.01$ ). The average L5 pedicle length in subjects with spondylolysis was 6.02 mm (1 SD = 1.43 mm) as compared to 4.31 mm (1 SD = 0.87 mm) in normal subjects. In spondylolytic specimens, pedicles start to elongate after the age of 40. The pedicle lengths increase progressively from 5.6 mm at 40 years to 6.2 mm at 70 years with a 1-2% increment every decade. Pedicle length remains constant after the age of 70 years.

**Conclusions:** Based on our study of a large population of adult skeletal specimens, it appears that spondylolysis is associated with increased L5 pedicle lengths. A difference of approximately 29% was identified in normal subjects versus those with spondylolysis. The progressive increase in pedicle length with age suggests that pathological changes occur in bony anatomy of L5 vertebrae, in as early as adolescence when the condition develops.



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### A DEFINITION FOR CONGENITAL STENOSIS OF THE LUMBAR SPINE: AN ANATOMIC STUDY OF 1072 POSTMORTEM SPECIMENS

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**Introduction:** Congenital lumbar stenosis occurs when the bony anatomy of the cervical canal is smaller than expected. This may predispose an individual to symptomatic neural compression. No studies have defined congenital lumbar stenosis (CLS) based on the normal population. The diagnosis is currently made based on radiographic studies which is subjective at best. Anatomic measurements are needed that will accurately predict if CLS is present. The aim of this study is to provide a working definition for CLS based on anatomic measurements of skeletal specimens for establishing parameters that will accurately predict CLS.

**Materials and Methods:** 1072 adult skeletal specimens from the Hamann Todd Collection in the Cleveland Museum of Natural History were selected. Digital calipers were used to measure the following (L1-S1): sagittal canal diameter (sd), interpedicular distance (ipd), and pedicle length (pl). Canal area at each level was calculated using a formula that was verified by computerized measurements. A standard distribution for each level was created and values that were 2SD below mean were considered for CLS. Once defined, an analysis of deviance was performed to identify parameters that were predictive of CLS. Logistic regression analysis was used to determine odds ratios for CLS using these parameters.

**Results:** CLS was defined at each level as: L1/2=2.07cm<sup>2</sup>; L2/3=2.04cm<sup>2</sup>; L3/4=2.00cm<sup>2</sup>; L4/5=1.95cm<sup>2</sup>; L5/S1= 1.85cm<sup>2</sup>. The sd and ipd were found to be predictive of CLS. Predictive values were sd<16mm and ipd<21.5mm yielded sensitivities and specificities of 85-95% at each level. Logistic regression demonstrated an OR>35 between these parameters and presence of CLS with at each level. Pedicle length was not a good predictor of CLS.

**Conclusions:** Based on our study of a large population of adult skeletal specimens, we defined CLS at each level. Values of sd<16mm or ipd<21.5mm strongly predict the presence of CLS at all levels L1/2- L5/S1.

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### ESTABLISHMENT OF A LUMBAR TORG RATIO TO PREDICT CONGENITAL LUMBAR STENOSIS: A STUDY OF 420 POSTMORTEM SUBJECTS

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**Introduction:** The cervical Torg ratio of 0.8 has since been used as a screening tool in determining the presence of congenital cervical stenosis. However there have been no studies done to define Torg ratio in lumbar spine for predicting congenital lumbar stenosis (CLS). Prior studies have relied on small sample sizes and stenosis was defined by plain films only. Torg ratios have never been correlated with the actual calculated canal area as derived from anatomic specimens. The aim of this study is to provide an analysis of lumbar Torg ratio in predicting CLS based on objective measurements of skeletal specimens.

**Materials and Methods:** 420 adult skeletal specimens from the Hamann Todd Collection in the Cleveland Museum of Natural History were selected. Digital calipers were used to measure the sagittal diameter, interpedicular distance, pedicle length and vertebral body diameter. Canal area at each level was calculated using a geometric formula. A standard distribution curve for

canal area and Torg ratio was created and values that were 2SD below mean were considered as being congenitally stenotic. Regression analyses was performed to determine if the Torg ratio was associated with canal area, and if a "below normal" Torg ratio was predictive of CLS.

**Results:** Torg ratio <2SD was defined at L1= 0.43, L2= 0.43, L3= 0.41, L4= 0.38, L5= 0.37. Regression analysis revealed significant association of Torg ratio with canal area (p<0.01). Torg ratio below 2SD predicted canal stenosis at L2, L3, L4 and L5 (p<0.01). Using Torg ratio < 0.5 predicted stenosis with a sensitivity of 86% and specificity of 52% at all lumbar levels.

**Conclusions:** Based on our study, we defined the lower limit of normal Torg ratio at each lumbar level. The Torg ratio of <0.5 predicts CLS with high sensitivity and can be a useful radiological tool for CLS screening.

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### IS CONGENITAL STENOSIS OF THE CERVICAL SPINE ASSOCIATED WITH CONGENITAL LUMBAR STENOSIS? AN ANATOMIC STUDY OF 1072 HUMAN CADAVERIC SPECIMENS

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**Introduction:** Congenital stenosis (CS) of the cervical (CCS) and lumbar spine (CLS) occur when the bony anatomy of the spinal canal is smaller than expected predisposing an individual to symptomatic neural compression. While tandem stenosis is known to occur in 5-25% of individuals, it is not known whether this relationship is due to an increased risk of degenerative disease in these individuals, or whether this finding is due to the tandem presence of a congenitally small cervical and lumbar canal. The aim of this study is to determine if the presence of CCS is associated with CLS.

**Materials and Methods:** 1072 adult skeletal specimens from the Hamann Todd Collection in the Cleveland Museum of Natural History were selected. Canal area at each level was calculated using a formula that was verified by computerized measurements. Values that were 2SD below mean were considered as being congenitally stenotic. Linear regression analysis was used to determine the association between the additive canal areas at all levels in the cervical and lumbar spine. Logistic regression was used to calculate odds ratios for CS in one area if CS was present in the other.

**Results:** A positive association was found between the additive area of all cervical and lumbar levels (p<0.01). A positive association was also found between the number of CS cervical and lumbar levels (p<0.01). Log regression also demonstrated a significant association between CS in the cervical and lumbar spine with an odds ratio of 0.2 (p<0.05).

**Conclusions:** Based on our study of a large population of adult skeletal specimens, it appears that CS of the cervical spine is associated with CS of the lumbar spine. Thus, the presence of tandem stenosis appears to be, at least in part, related to the tandem presence of a congenitally small cervical and lumbar canal.

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### THE STUDY OF TRUNK MOTOR CONTROL DURING TRACKING TASKS IN COMBINED EXERTIONS

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**Background:** Several studies emphasize that a possible contributor to the persistence and recurrence of low back pain (LBP) is changes in trunk motor control. Using a novel tracking system, recent studies suggested that the tracking task can substantially challenge trunk motor control and can be a useful method to quantify trunk control during combined exertions. The objective of this study was to investigate trunk motor control during target tracking tasks in torque-torque plane with different time parameter interference and speeds over a broad range of directions.

**Materials and Methods:** The tracking system included a moving target circle, which moved on a straight line in the desired direction from 0 to 50% of individual's maximal voluntary contraction (MVC) with speed of 4 to 10% MVC/Sec. Twenty asymptomatic subjects instructed to exert isometric contractions in 12 pure and combined angles. Trunk control was quantified by measuring constant error (CE) and variable error (VE).

**Results:** The results of the repeated measures ANOVA demonstrated that CE and VE were significantly affected by the angle of exertion ( $P < 0.001$ ) during the tracking tasks. The *post hoc* analysis indicated that significantly higher levels of CE and VE were found during isometric combined and rotational exertions relative to uniaxial flexion and extension exertions.

**Discussion:** The results of the present study showed that trunk motor control was significantly compromised during tracking tasks in combined directions. These results suggested that the tracking task can be a useful method to quantify trunk motor control in multidirectional tasks.

**Conclusions:** Since few studies have investigated trunk motor control during tracking tasks, these findings may contribute to reveal the link between possible risk factors of low back injury and complex and strenuous exertions. Future research will be necessary to expand this protocol in assessment and training of trunk function in patients with LBP.

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### BIOMECHANICAL EFFECT OF FOUR-ROD TECHNIQUE ON LUMBO-SACRAL FIXATION: AN IN VITRO HUMAN CADAVERIC INVESTIGATION

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**Study Design:** An *in vitro* biomechanical study.

**Objectives:** To compare the *in vitro* biomechanical effect of a novel four-rod lumbosacral reconstruction technique, to that of conventional techniques in a human cadaveric lumbar-pelvic model and determine the benefit of adding supplementary rods fixation.

**Summary of Background Data:** Extension of long fusions to the sacrum remains a difficult clinical challenge. Recently a technique that proposes novel use of 4 supporting longitudinal rods across the lumbo-pelvic junction has been reported. No comparative *in vitro* biomechanical testing has been previously done.

**Methods:** Seven fresh-frozen cadaveric lumbar-pelvic spines were prepared and tested for BMD. The intact cadaver underwent a flexibility test first, followed by the instrumented construct. The three constructs tested included S1 screws alone (group 1), S1

screws plus iliac screws (group 2), and Four-Rod Technique (group 3). Rotational angles of the L1-S1 and L5-S1 segment were measured to study the immediate stability. Nondestructive, multidirectional flexibility analyses included four loading methods followed by a destructive flexural load to failure using a MTS machine. Lumbosacral peak range of motion and ultimate failure load of the three reconstruction techniques were statistically compared using a one-way analysis of variance combined with a Student-Newman-Keuls *post hoc* test.

**Results:** The average BMD value was  $0.81 \pm 0.09$  g/cm<sup>2</sup>. The ROM of the three fixation constructs were significantly smaller than the contact group in all the 6 directions ( $P < 0.05$ ). In the lateral bending, the ROM of group 2 and 3 were significantly smaller than group 1 ( $P < 0.05$ ), but there were no difference between group 2 and 3 ( $P > 0.05$ ). In flexion-extension, the ROM of group 1 and 3 were significantly smaller than group 2 ( $P < 0.05$ ), but there were no difference between group 1 and 3 ( $P > 0.05$ ). In axial rotation, the ROM of group 3 were significantly smaller than group 1 and 2 ( $P < 0.05$ ), but there were no difference between group 1 and 2 ( $P > 0.05$ ).

**Conclusion:** The four-rod technique achieved stable biomechanical effects in the lumbo-sacral fixation. Especially in the axial rotation, the four-rod technique had better stability than the S1 screws and S1 screws + iliac screws groups.

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### THE EFFECT OF SLIDING RODS ON KINEMATICS AND LOAD SHARING IN A PEDICLE SCREW ROD SYSTEM: AN IN VITRO STUDY

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**Introduction:** Variety of posterior dynamic stabilization was biomechanically evaluated, and even clinically introduced, but design factors independent to any specific implants, such as optimal stiffness and number of degrees of freedom, haven't been analyzed in detail. Sliding rods allowing two degrees of freedom (translation and rotation along the rod) should make pedicle screw fixation incorporate well with treated segment. Therefore, the present study aimed to investigate stabilizing and load sharing effect of a conventional pedicle screw-rod fixation with sliding rods, and compare it against rigid fixation.

**Methods:** Seven porcine lumbar spine specimens (L2-L5) were loaded in a custom-made spine machine with pure moments of  $\pm 5.0$  Nm in flexion/extension, left/right lateral bending and left/right axial rotation. The flexibility test was performed on the intact first, then repeated on 2 injury status (Posterior wide decompression and cage insertion) implanted with either a sliding-rod fixation or a rigid fixation on the L3-L4 segment. Four strain gauges were glued on anterior-lateral vertebral bodies of L3 and L4 on both sides. The range of motion, the neutral zone, slide translation along rods and strains were determined.

**Results:** Compared to the intact, two fixations reduced segmental motion significantly in flexion, extension and lateral bending, but couldn't constrain the motion in axial rotation. Compared to the rigid fixation, the sliding-rod fixation limited the motion lesser (flexion:  $1.6^\circ$  vs  $0.8^\circ$ ,  $P < 0.05$ ; extension:  $1.4^\circ$  vs  $0.9^\circ$ ; lateral bending:  $2.7^\circ$  vs  $0.9^\circ$ ,  $P < 0.05$ ; axial rotation:  $1.9^\circ$  vs  $1.7^\circ$ ) and resulted in larger compressive strain on vertebral bodies in flexion and lateral bending. There was interaction whereby cage insertion resulted in better stabilization for the sliding-rod fixation and worse stabilization for the rigid in flexion ( $P = 0.02$ ) and axial rotation ( $P = 0.01$ ). Length of the sliding-rod changed 1.5 mm in flexion, 1.0 mm in lateral bending and 0.1 mm in axial rotation.

**Discussion:** Like a rigid fixation, the sliding-rod fixation offered stabilization in all directions except in axial rotation. Sliding-rod mechanism could incorporated better with the spine and reduce the load on the implant.



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### BIOLOGIC RESPONSES OF RAT INTERVERTEBRAL DISCS TO MECHANICAL LOADING USING A DYNAMIC ORGAN CULTURE SYSTEM

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**Introduction/Aim:** Mechanical loading to Intervertebral disc (IVD) is considered to initiate IVD degeneration. Our aim was to elucidate the biologic responses to mechanical stimuli using a dynamic organ culture system.

**Materials and Methods:** Twenty-four 16-week-old male Sprague-Dawley rats were used. IVD tissues between the 7th and 8th caudal vertebrae were subjected to dynamic compressive stimuli (1.3MPa, 1Hz) in a dynamic organ culture system for 7 days. Cultured tissues without stimuli were used as control. Histological analysis using Masuda's grading scale and immunostaining for mechanoreceptor CD44 and integrin  $\alpha 5$  and  $\beta 1$  subunits were performed. Real-time RT-PCR mRNA-quantification for *aggrecan*, *collagen type-2*, *MMP-3*, *ADAMTS-5*, *CD44*, and *integrin  $\alpha 5$  and  $\beta 1$  subunits* was performed both in the nucleus pulposus (NP) and annulus fibrosus (AF) tissues.

**Results:** The median histological grade of experimental group was 6.5 and significantly higher than 4.0 of control group, with an increased score in the NP. In experimental and control group, immunostaining demonstrated positivity for CD44 and integrin  $\alpha 5$  and  $\beta 1$  both in the NP and AF. Immunopositivity for integrin  $\alpha 5$  and  $\beta 1$  in the AF was stronger than the NP. The mRNA expression of *aggrecan* and *collagen type-2* was significantly up-regulated both in the NP and AF. *MMP-3* showed significant up-regulation in the NP. *ADAMTS-5* was not affected in the NP and AF. The expression of *integrin  $\alpha 5$  and  $\beta 1$*  was significantly up-regulated in the AF, although *CD44* was not affected in the NP and AF.

**Discussion/Conclusion:** Mechanical stimuli initiated IVD degeneration particularly apparent in the NP and obviously increased integrin  $\alpha 5$  and  $\beta 1$  expression in the AF. Mechanoreceptors may play an important role in the early stage of IVD degeneration.

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### BONE CEMENT AUGMENTATION OF PEDICLE SCREWS IMPROVES ROTATIONAL RIGIDITY IN THE LUMBAR SPINE

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**Introduction/Aim:** Pedicle screw loosening is a well-recognized clinical problem, especially in osteoporotic bone. Bone cement augmentation of pedicle screws has been reported to improve screw pull-out strength by as much as 150%. However, it has also been reported that pullout is not the mechanism by which this failure occurs. Therefore, the objective of this study was to analyze the rigidity of pedicle screw augmentation in response to six degree of freedom (DOF) pure moment testing.

**Materials and Methods:** Three screws (6.5mm x 40mm), one in screw in each pedicle and a third screw was inserted bicortically at the midline of the vertebral body, were used to mount the lumbar cadaver specimen to the robot (Staubli RX90) / UFS (JR3) testing system. The specimens were subjected to three cycles (6.0 Nm) of flexion/extension (FE), axial rotation (AR) and lateral bending (LB) and kinematics of the (preconditioned) third cycle were recorded using a five-camera optical tracking system (VICON 460). L3-4 (n=2) and L5-S1 (n=2) functional spinal units

were tested in the following sequence: (1) no bone cement, (2) bone cement (BC, Simplex P, Stryker).

**Results:** Without BC the motion in the fixture/bone screw interface was between ~15-20% (FE=18.9%, AR=15.7%, LB=17.0%). The motion was reduced to ~10-15% (FE=9.3%, AR=15.7%, LB=13%) with BC application. These data were amplified by the joint stiffness with the smallest magnitude fixture motion (AR -0.1°-0.3°) resulting in the largest (~15%) fixture motion vs total ROM.

**Discussion:** This study showed modest improvements in rotational rigidity (5-10%) with BC augmentation. It should be noted that physiologic levels of loading (6.0 Nm) were used in this study as opposed to failure loads possibly diminishing the effect of BC augmentation. Additionally, this study was performed using cadaver specimen and therefore does not account for variables such as bony remodeling.

**Conclusion:** A novel method for assessing pedicle screw rigidity was presented which offers a more physiologic representation than standard pull-out testing.

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### MULTIPLE FREEZE-THAW CYCLES AND CUMULATIVE TESTING ON INTERVERTEBRAL FLEXIBILITY OF HUMAN CADAVERIC LUMBOSACRAL SPINE

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**Introduction:** Previous studies determined that single episode of freeze-thaw cycle and long-term freeze storage of cadaveric spinal specimens do not affect biomechanical properties. The effects of repeated freeze-thaw cycles and extended ambient exposure, on both between-day and within-day variation in biomechanical properties, have not been previously documented. The purpose of this study was to evaluate the cumulative effects of multiple freeze-thaw cycles and repeated flexibility tests on the three-dimensional kinematics of the human lumbosacral spine.

**Materials & Methods:** Three spinal motion segments were subjected to eight sets of repeated flexibility tests in flexion-extension (FE), lateral bending (LB) and axial rotation (AR) on each of eight separate test days (total sets = 64). The motion segments were stored in a freezer for at least 24 hours between test days. Two-way repeated measures ANOVA were carried out to evaluate between-day and within-day effects on range of motion (ROM) and neutral zone (NZ) at  $\alpha=0.05$ .

**Results:** Significant effects from repeated freeze-thaw were found between-days for intervertebral ROM and NZ in FE, LB and AR (all  $p<0.001$ ). No significant within-day variation were observed for FE ROM ( $p=0.10$ ), LB ROM ( $p=0.36$ ), AR ROM ( $p=0.46$ ), FE NZ ( $p=0.83$ ), LB NZ ( $p=0.42$ ) and AR NZ ( $p=0.72$ ). Post-hoc analyses indicated that significant differences in between-day variation started after the fourth freeze-thaw and flexibility test cycle. The effects of a single episode of freeze-thaw were not apparent between consecutive test days.

**Discussion:** The biomechanical properties of the human cadaveric spinal specimen were significantly affected between-day by the freeze-thaw cycles but were not affected within-day by ambient conditions and repeated flexibility tests. In-vitro biomechanical studies with repeated measure design should be carried out without an episode of freeze-thaw cycle between tests.

**Conclusion:** Repeated freeze-thaw cycles had significant effect on between days properties while extended ambient exposure and cumulative freeze-thaw cycles had no significant effect on biomechanical properties within subsequent test day.

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**THE POSITIVE EFFECTS OF VERTEBRAL ENDPLATE CONFORMED PCL-HA TISSUE SCAFFOLD ON ENDPLATE STRESS DISTRIBUTION AND STABILITY IN SPINAL FUSION: A FINITE ELEMENT STUDY**

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**Introduction:** In thoracolumbar region, 7-30% of fusion failure may lead to pseudarthrosis. From a biomechanical perspective, the non-conformity of the graft to the endplate surface could contribute to pseudarthrosis due to sub optimal stress distributions. The objective of this study is to understand the effect of endplate-graft conformation on endplate stress distribution and compare load sharing and stability for conformed and non-conformed grafts.

**Methods:** An experimentally validated FE model of the L4-L5 FSU was modified to simulate two types of inter body grafts (cortical bone, and polycaprolactone (PCL)- 25%hydroxyapatite (HA) tissue scaffold), with and without endplate-conformed surfaces along with pedicle-screw and rod posterior instrumentation system. The conformed surface matched the end plate morphology on either side. Appropriate material properties were assigned. The models were fixed at the inferior-most surface of L5 and were subjected to 400 N follower load and 7.5 Nm of flexion/extension moment.

**Results:** The flexion-extension motion decreased by almost 93% with cortical bone graft and 90% with PCL+25%HA scaffold, compared to intact.

Table 1: The percentage decrease in the maximum Von Mises stress for conformed graft with respect to non-conformed graft at the L4-IEP (inferior endplate) and L5-SEP (superior endplate) during flexion and

Interbody graft type	Decrease in maximum stress (in % during extension)		Decrease in maximum stress (in % during flexion)	
	L4 IEP	L5 SEP	L4 IEP	L5 SEP
Cortical	30.1	11.9	13.6	2.6
PCL+25%HA	41.3	23.9	12.2	5.6

The stress distribution for the endplate conformed grafts was more uniform as compared to the non-conformed grafts; the maximum stress was lower as well (Fig 1a & b). Furthermore, the stresses were lesser for the conformed PCL-HA graft, compared to cortical graft, Table 1.

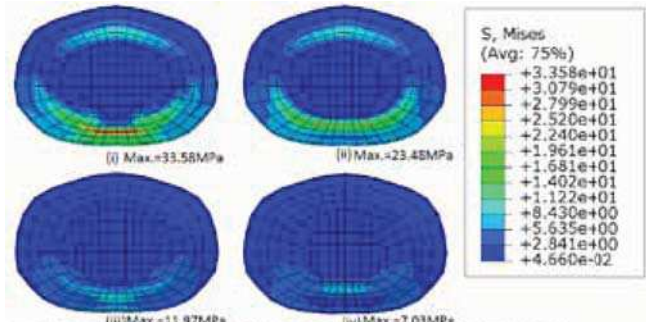


Figure 1a: Stress contours at the inferior endplate of L4 vertebra during extension. (i) Non-conformed cortical graft, (ii) conformed cortical graft, (iii) non-conformed PCL+25%HA graft, (iv) conformed PCL+25%HA graft

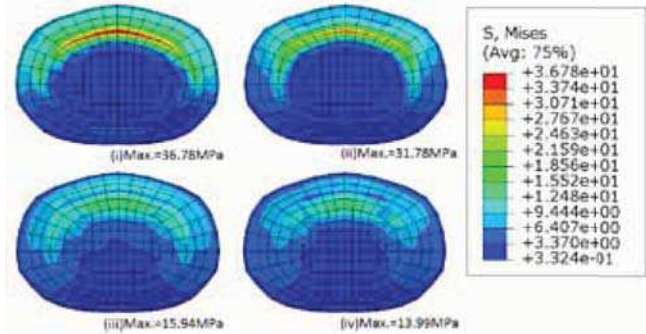


Figure 1b: Stress contours at the inferior endplate of L4 vertebra during flexion. (i) Non-conformed cortical graft, (ii) conformed cortical graft, (iii) non-conformed PCL+25%HA graft, (iv) conformed PCL+25%HA graft

**Discussion and Conclusions:** The stability provided by the PCL+25%HA graft is similar to the cortical grafts. The stress distributions in the endplate suggest that the load sharing is better with the conformed PCL + 25%HA graft which might reduce the graft subsidence possibility. Modern biomanufacturing techniques for tissue scaffold manufacturing, in concert with the patient's endplates CT data, allow the scaffold to be manufactured prior to surgery. These scaffolds can be loaded with stem cells to promote fusion. Our group is pursuing research along these lines.

P259

**FATIGUE FAILURE OF DYNAMIC STABILIZATION DEVICES CAN BE PREDICTED BY PEDICLE-TO-PEDICLE DISTANCE CHANGES IN THE LUMBAR SPINE**

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**Introduction:** Most dynamic stabilization devices for lumbar spine permit adequate range of motion on bench testing. Despite that fatigue failure is common. Pedicle-to-pedicle (P-T-P) distance tracking may explain the mismatch in the kinematics between the devices vs. normal lumbar motion segment. To the authors' knowledge no such study was reported in the literature. Aim of this study is to explore the continuous tracking of the P-T-P distance in cadaver lumbar spine, and compare it after stabilization with Dynesys.

**Methods:** The motion segments between L3-4, L4-5 and L5-S1 were tested from six cadaver lumbar spine specimen, in flexion-extension in a six-degrees-of-freedom spine tester. Dynesys pedicle screws were inserted at the adjacent vertebra and a tracking marker was placed at the screw head. The instant location of the cranial screw-head compared to the caudal one was tracked with a motion capture device, in flexion-extension motion in. Dynesys device was then implanted between the pedicle screws, and the tests were repeated.

**Results:** In the intact motion segment the cranial pedicle screw





traveled anterior-posterior direction during flexion-extension; (6.8±1mm at L3-4, 7.2±3mm at L4-5, and 5.5±5mm at L5-S1). The travel distance was equivalent to the range of angular motion of the corresponding motion segment. Dynesys instrumentation did not significantly alter this anterior-Posterior travel. However, continuous tracking showed the direction of travel was different with Dynesys.

In the intact motion segments, the pedicle screw head travel involved change in the longitudinal P-T-P distance, which was largest at L5-S1 (5.1±2mm) and smallest at L3-4 (4.8±2mm). The P-T-P distance was shortest in extension and longest at the end of flexion. Dynesys instrumentation stopped any change in the longitudinal distance between the pedicle screws.

**Conclusion:** Although Dynesys device permitted almost normal angular motion and antero-posterior travel of the pedicle screw-heads, it does not allow the elongation or shortening with flexion-extension. This mismatch in the kinematics may predict fatigue failure of the devices.

## P260

### DYNAMIC SPINAL STIFFNESS CHANGES IN AN IN VIVO MODEL OF SPONDYLOLYSIS

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**Introduction:** The role of spondylolysis in lumbar spine instability is an important biomechanical parameter to be clinically evaluated. The purpose of this study was to quantify the biomechanical consequences of spondylolysis using a dynamic spinal stiffness methodology in an *in vivo* ovine model.

**Methods:** In six adolescent Merino sheep, bilateral spondylolytic defects were created at L5 (Spondylolysis) and instability confirmed radiologically. Six age matched sheep were similarly incised with a posterior approach but their pars undisturbed (Control). Single-blind biomechanical and histological examinations were conducted at six month surgical follow-up. Dynamic spinal stiffness were quantified *in vivo* at L5 during 32 cycles of swept-sine (0.5 to 20 Hz) oscillatory loading (~40 N, ~10% of body weight). Adjacent segment y- and z-axis vertebral accelerations were further quantified across the lesion during the experiments by means of accelerometers rigidly fixed to the L4 and L6 spinous processes. L5 DV stiffness (load/deformation, N/m) and accelerations were calculated over six trials and averaged for each mechanical excitation frequency in each group. Levene's test preconditioned independent t-tests conducted for equality of means to compare spinal stiffness and vertebral accelerations between the groups at each frequency.

**Results:** Histological examination in the spondylolysis group revealed bony healing of the spondylolytic defects and fibrous pseudarthroses. Fibrous ankylosis of the adjacent facet joints was seen in half of the animals. Disc pathology was not observed. Mean DV stiffness ranged from 4.95 to 19.26 N/mm for the spondylolysis group compared to 3.79 to 15.20 N/mm for controls. A mean L5 DV stiffness increase in the spondylolysis group ranged from 17% to 51% for all mechanical excitation frequencies examined which was significant at eleven distinct frequencies (P<.05). A shift in the resonant frequency from 3.79 Hz to 4.95 Hz was also observed in the spondylolysis group. Significantly decreased adjacent segment vertebral accelerations were found

in the Spondylolysis group for most frequencies (P<.05).

**Conclusion:** Surgically induced spondylolysis resulted in appreciable spinal remodeling that was confirmed histologically and biomechanically in this ovine model. Dynamic spinal stiffness alterations and adjacent segment motion changes at certain mechanical excitation frequencies play important roles in understanding spinal stability.

## P261

### FINITE ELEMENT INVESTIGATION OF THE EFFECT OF SPINA BIFIDA ON LOADING OF THE VERTEBRAL ISTHMUS

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**Introduction:** Lumbar spondylolysis correlates with Spina Bifida Occulta (SBO) in 67% of cases. There has not been any study that has demonstrated biomechanical or genetic predispositions to explain the high coexistence of these two pathologies.

The aim of this study is to conduct a finite element (FE) analysis of the altered load transfer in combined axial rotation and anteroposterior shear in SBO and to see if a bifid arch results in increased strain across the isthmus of the loaded inferior articular process.

**Methods:** FE models of the intact spine and SBO (L4-S1) including ligaments were loaded axially to 1kN and an axial rotation of 3° was applied. Bilateral stresses, alternating stresses and strains on the lateral inferior lines of the L5 isthmus in both intact and SBO models were assessed and compared.

**Results:** Under 1kN axial load and rotation the maximum stresses observed in the ipsilateral L5 isthmus in the intact spine model increased from 24.24 MPa to 31.03 MPa respectively. Under 1kN axial load and cyclic rotational loading the mean stresses observed on inferior L5 isthmus during a single cyclic load in the intact spine model compared to the SBO model increased from a 13,54MPa compressive stress to a 12.71 MPa tensile stress respectively. When assessing the equivalent alternating shear stress amplitude, this was found to be 13.64 MPa for the intact model and 22.57 MPa for the SBO model. From this it is estimated that under repetitive axial load and rotation, shear fatigue failure will occur at 10 million cycles in the intact model and 69,956 cycles in the SBO model.

**Conclusion:** In SBO, the load transfer through the vertebral arch in axial rotation is lost and mechanical demand on the isthmus is significantly increased. Stresses across the L5 isthmus in axial rotation increase by 67.8% and 219.2% in the intact and SBO model respectively, predisposing the SBO population to early fatigue fracture.



P263

### THE INFLUENCE OF DISC DEGENERATION OF THE SUPERIOR ADJACENT SEGMENT ON THE STRESS OF THE CORRESPONDING SEGMENT AFTER LUMBAR FUSION

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**Introduction:** The purpose of this study was to investigate the influence of disc degeneration *per se* of the superior adjacent segment on the stress at the corresponding segment after one segment lumbar fusion using the validated finite element (FE) models.

**Methods:** In the validated FE model (L2–L4), three intact models and three L3–L4 fusion models with different grades of disc degeneration (normal, mild, moderate) at the L2-3 were simulated. Under compressive preload and four pure moments, the intradiscal pressure and maximal von Mises stress of the annulus at the L2-3 segment were analyzed and compared between fusion and intact models with each grade of L2-3 disc degeneration.

**Results:** In all models, the L2-3 disc degeneration led to increase of maximal von Mises stress of annulus and decrease of intradiscal pressure at the corresponding disc under four moments. In the models represented each grade of disc degeneration, fusion model demonstrated the higher intradiscal pressure and maximal von Mises stress at superior adjacent segment than intact model. Compared to intact model, percent increases of both maximal von Mises stress and intradiscal pressure of fusion model at the superior adjacent segment were similar among three grades of disc degeneration.

**Discussion:** The present study demonstrates that the grade of disc degeneration at superior adjacent segment would not affect the amount of increment of the stress at the superior adjacent segment after one segment lumbar fusion. These results alludes that the extension of fusion level does not seem to be warranted under the pretext of preventing ASD.

**Conclusion:** The disc degeneration *per se* of superior adjacent segment cannot contribute to the increase of disc stress at the corresponding segment after lumbar fusion.

P264

### CHANGES IN RECRUITMENT OF PSOAS MAJOR IN PEOPLE WITH RECURRING BACK PAIN WHEN SITTING ARE SPECIFIC TO MUSCLE REGION AND PATIENT SUBGROUP

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**Introduction:** Conservative and pharmacological Interventions for low back pain (LBP) have been described that target the psoas major (PM) muscle, yet little is known of whether and how this muscle is changed in this clinical population. This study aimed to investigate whether activation of this muscle is modified in people with recurring episodes of low back pain. Secondary aims were to determine whether activation differed between anatomically discrete regions of the muscle, and whether the activation differed between different clinical subgroups of patients.

**Materials and methods:** Ten volunteers with recurring episodes of LBP and nine pain-free controls participated in this study. Participants with LBP were grouped into those with high and low

erector spinae (ES) electromyographic activity (EMG) recorded when sitting with a lumbar lordosis. Participants adopted three specific sitting postures with unique spine and hip angles. Fine-wire electrodes were inserted with ultrasound guidance into fascicles of PM arising from the transverse process (PM-t) and vertebral body (PM-v).

**Results:** When people with LBP were analysed as one group, PM EMG did not differ between groups in any sitting postures. However, when subgrouped, those with low ES EMG in the lordotic posture had greater PM-v EMG in the flat posture and compared to the painfree group. For the high ES EMG group, PM-t and PM-v EMG was less than that for the low ES EMG group in the short lordotic posture.

**Discussion:** These data highlight both greater and lesser EMG activity of PM depending on the specific patient subgroup. These observations were specific to anatomical region of the PM muscle and sitting posture.

**Conclusion:** Findings suggest redistribution of activity between muscles that have a potential extensor moment in LBP and provide potential insight into clinical practice. The data point to observations that may assist matching interventions to subgroups within the LBP group.

P265

### HOLDING YOUR BREATH: DOES GLOTTIS CLOSURE INFLUENCE THE CONTROL OF THE SPINE?

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**Introduction/Aim:** There is ongoing debate whether breath holding is advantageous for control of the spine. The argument in support of this proposal is that maintenance of upright posture involves control of thoracic and abdominal pressures and that closure of glottal structures (a primary determinant of airflow) aids the control of thoracic pressure and should be important for control of postural stability. This study aimed to investigate the effect of modulation of airway control on upright postural stability during postural perturbations.

**Materials and Methods:** Standing balance was gently perturbed in the sagittal plane during 7 breathing/voicing tasks that ranged from completely closed (breath-hold), to partially opened (voicing) or completely open (sigh) glottal conditions in 11 healthy adults. Balance was perturbed by release of a load attached to the trunk to induce either backward or forward motion. Quality of control of the spine and overall body posture were measured as the peak amplitudes of displacement of the thorax and center of pressure (CoP) in response to the perturbations.

**Results:** When the glottis was completely open (sigh), thoracic displacement in response to the perturbation was greater than in all other conditions, regardless of direction of perturbation ( $P<0.002$ ). The absolute amplitude of CoP displacement was greater with backward perturbation ( $P=0.001$ ) and was greater at both extremes of glottal modulation (glottis closed and completely open) than when the glottis was partially opened during counting out loud ( $P<0.04$ ).

**Discussion:** These results show that airway modulation affects postural control during upright perturbations. The thorax was more stable when the glottis was engaged than when it was forced to remain open. Control of CoP displacement appeared more optimal during the natural dynamic mid-range airway modulation of voicing when compared with the extremes of complete glottis closure (likely to enhance trunk stiffness) and complete glottis opening (likely to reduce trunk stiffness). Taken together these observations provide evidence that glottis closure



enhances spine control (which may be ideal for tasks with high spinal load), but optimal control of balance requires more flexible control of trunk cavity pressures.

## P266

### TRANSFORAMINAL LUMBAR INTERBODY FUSION: WHICH CONSTRUCT CONFIGURATION PROVIDES THE OPTIMAL BIOMECHANICAL STABILITY?

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**Introduction:** Transforaminal lumbar interbody fusion (TLIF) remains an appealing surgical option for treating radicular symptoms. However, the optimal antero-posterior construct configuration to adequately stabilize the segment remains unknown. The current investigation aims to evaluate the acute stability afforded by a PEEK TLIF spacer (standard and crescent (Cr) shaped) with unilateral (Uni) and bilateral (Bi) posterior instrumentation using finite element analysis.

**Methods:** An experimentally validated FE model of the L3-5 spinal segments was used. The model was modified to simulate surgical decompression at L4-5 via a complete facetectomy (Uni or Bi), partial annulotomy and a full discectomy. The following reconstructive options were then applied to the decompressed segment: 1) Uni spacer + Uni rod; 2) Cr spacer + Uni rod; 3) Uni spacer + Bi rod; 4) Cr spacer + Bi rod; 5) Bi spacer + Bi rod. The inferior surface of the L5 vertebra was immobilized and a bending moment of 10 Nm was applied to recreate flexion (Flex), extension (Ext), left and right lateral bending (LB, RB), left and right axial rotation (LR, RR). ROM and maximum stresses in the posterior instrumentation were computed and compared for different models.

**Results:** There was a significant decrease in ROM with all reconstructive conditions when compared to intact. However, over 50% of intact ROM remained in LB with unilateral posterior fixation; compared to less than 10% for bilateral pedicle screw reconstruction. Furthermore, the calculated stress at the cephalad pedicle screw/rod interface was 5 and 3 times greater for unilateral posterior constructs under Flex and LB, respectively, compared to bilateral fixation. The shape of an interbody spacer did not appear to affect the stress levels experienced by posterior implants.

**Discussion/Conclusions:** For a TLIF procedure interbody spacers combined with bilateral posterior fixation offer greater stability compared to unilateral posterior augmentation. Moreover, shape or number of interbody implants did not affect segmental stability with bilateral posterior instrumentation. Finally, the increased posterior device stress observed in all loading modes with unilateral pedicle screws may accelerate implant loosening or construct failure.

## P267

### CEMENT DISTRIBUTION FOLLOWING VERTEBROPLASTY AFFECTS RESTORATION OF MECHANICAL FUNCTION

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**Introduction/Aim:** Vertebroplasty helps restore mechanical function and spinal load-sharing following vertebral fracture, but these effects can be variable. We investigated whether mechanical restoration, at fractured and adjacent levels, is

influenced by cement distribution.

**Materials and Methods:** Fourteen pairs of three-vertebra cadaver spine specimens (aged 67-92 yr) were compressed to induce fracture. One of each pair underwent vertebroplasty with PMMA, the other with a resin (Cortoss). Before and after vertebroplasty, compressive stiffness was determined, and stress profilometry was performed by pulling a pressure-transducer through each disc whilst under 1.0kN load. Profiles indicated intradiscal pressure (IDP) and compressive load-bearing by the neural arch at fractured and neighbouring levels. Micro-CT was used to quantify cement fill in anterior and posterior halves of each augmented vertebral body and in the region immediately adjacent to the fractured endplate which invariably accompanied vertebral compression fracture.

**Results:** Cement distribution differed significantly between Cortoss and PMMA. For PMMA, restoration of IDP in the disc adjacent to the fracture was influenced most by greater volumetric fill of the whole vertebral body ( $R=0.64$ ,  $P<0.01$ ) and greater fill in the region adjacent to the fractured endplate ( $R=0.67$ ,  $P<0.05$ ) whereas IDP in the non-adjacent disc was dependent only on anterior fill ( $R=0.67$ ,  $P<0.05$ ). For Cortoss, restoration of IDP in the adjacent disc was associated with a greater posterior fill ( $R=0.67$ ,  $P<0.05$ ) whereas specimen stiffness was improved by greater cement fill adjacent to the fractured end-plate ( $R=0.56$ ,  $P<0.05$ ).

**Discussion:** Cement distribution had variable effects at fractured and neighbouring levels that were dependent upon the cement type. However, increased cement fill immediately adjacent to a fractured endplate was linked more consistently to restoration of mechanical function.

**Conclusion:** Optimising cement placement to support fractured endplates may help improve mechanical function following vertebroplasty.

## P268

### BIOMECHANICAL EVALUATION OF ANTERIOR AND OBLIQUE LUMBAR SPACERS WITH INTEGRATED PLATE FIXATION

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**Introduction/Aim:** Biomechanical flexibility testing of stand-alone ALIF's has shown little difference between devices. Cyclic loading may offer a more realistic prediction of clinical performance for stand-alone ALIF's and may also differentiate between devices. This study evaluated an anterior and oblique stand-alone ALIF implant with integrated fixation plates in terms of range of motion (ROM), pullout and fatigue.

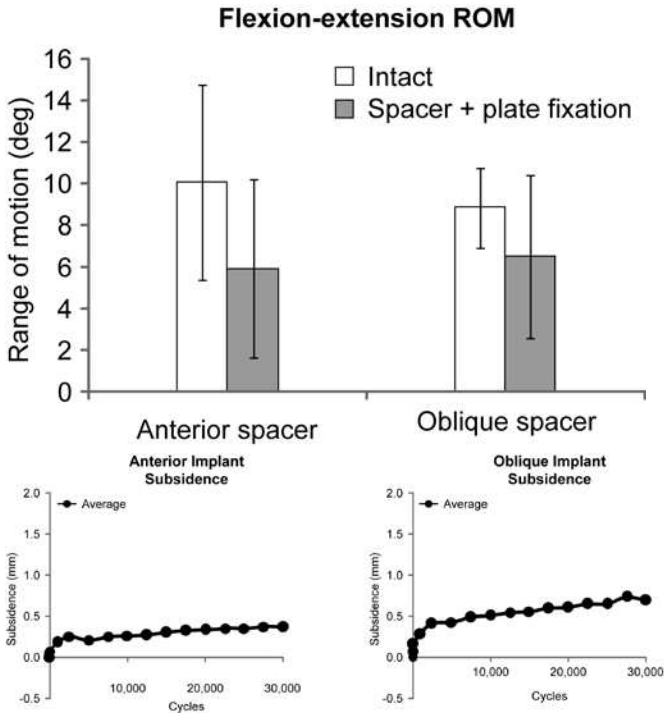
**Materials and Methods:** Cadaveric lumbar motion segments were tested with anterior and oblique interbody spacers with integrated plate fixation. Flexibility testing ( $n=6$  anterior,  $n=7$  oblique) was conducted intact and on the spacer + plate fixation. Moments of  $\pm 6$ Nm with a 50N preload were applied and ROM was quantified. Pullout tests were then performed on the spacer + plate fixation. 30,000 cycles of flexion-extension and lateral bending fatigue testing ( $n=6$  anterior,  $n=7$  oblique) were conducted by applying pure moments of  $\pm 5$ Nm at 1 Hz with a 400N follower load to additional specimens with spacer + plate fixation. Subsidence was measured fluoroscopically.

**Results:** A significant reduction in ROM was found for the anterior spacer + fixation plates compared to intact but there was no difference between oblique and anterior implants. The peak pullout loads were similar at  $637 \pm 192$  N and  $651 \pm 127$  N for the anterior and oblique implants, respectively. Subsidence averaged  $0.4 \pm 0.3$  mm for the anterior and  $0.7 \pm 0.5$  mm for the

oblique implants after fatigue testing.

**Discussion:** ROM data was comparable to prior reports of available stand-alone ALIF's. The pullout loads achieved by each device suggest that they are unlikely to displace during daily activities. Fatigue testing found minimal subsidence except in three oblique specimens where overstuffing the disc space may have resulted in endplate micro-fracture.

**Conclusion:** The devices tested in this study had similar flexibility to prior reports. A fatigue testing protocol was developed and implemented in a stand-alone ALIF construct with anchoring plates. Subsidence was minimal when the vertebral endplates were intact.



**P269**

**BIOMECHANICS OF A NOVEL EXPANDABLE INTERBODY DEVICE AS COMPARED TO BAK CAGE**

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**Introduction:** The biomechanics of a novel expandable interbody device design, VariLift-L, was compared with the BAK cage using an experimentally validated L4-L5 FSU finite element model under stand-alone conditions. Our hypotheses were that the stand-alone *in-situ* lordotic expandable device provides stability similar to the non-expandable cages and will have a reduced tendency to subside and migrate.

**Methods:** An experimentally validated intact finite element model of the L4-L5 FSU was altered to model expandable VariLift-L and BAK devices in a stand-alone fashion. The PLIF surgical procedure was simulated for placement of both implants. The models were subjected to a 400N compressive pre-load and an 8.0Nm moment. Segmental kinematics, and loads at the endplate-implant interface were computed and compared among cases.

**Results:** The VariLift-L expandable device resulted in more reduction in motion (47% of intact) compared to the BAK (54% of intact) in extension. Similar effects were observed in flexion (33% of intact) and axial rotation (12% of intact) loadings. In lateral bending, the BAK and VariLift-L models had similar reductions in motion (21% of intact). In all loading modes the normal load for

the VariLift-L device were similar to those of the BAK cage. The VariLift-L device demonstrated higher shear loads compared to the BAK cage.

**Conclusions:** Due to its trapezoidal shape and *in-situ* lordotic expandability, the tendency of the VariLift-L device to migrate into the canal and subside into the endplate will be lower than that for BAK cylindrical cage. This shape expandability act to resist A-P shear forces in the flexion mode. The expandable device has the advantage of adjusting its outer profile to the lordotic angle of the treated segment, ensuring a better contact between the device and endplates. Biomechanically, the VariLift-L interbody fusion device is a good solution for fusion surgery of the lumbar spine segment without posterior instrumentation. Our data supports clinical observation of VariLift-L cage's reduced tendency to subside and migrate.

**P270**

**THE BIOMECHANICAL CONSEQUENCES OF ROD REDUCTION FOLLOWING FACETECTOMY IN THE LUMBAR SPINE**

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**Introduction:** Residual mismatch between pedicle screw-rod constructs is frequently encountered and corrected through rod reduction tools or by readjustment of the screw depth. The deleterious effect of rod reduction on intact thoracic spine specimens has previously been shown. This study sought to investigate the biomechanical effects of rod reduction and screw re-insertion on the lumbar spine following facetectomy.

**Methods:** Nine (n=9) three-segment, human lumbar spine specimens were tested following facetectomy. Pedicles were instrumented with 6.5mm screws and insertional torque (IT) was measured during screw placement. On the left side, a rod with no residual rod-screw mismatch was placed. Then, on the right side an intentional 5mm rod-screw mismatch was contoured and reduced using a rod-reduction device. To simulate screw repositioning, one screw was backed out and reinserted while re-insertional torque was measured. Screws were pulled out "in line" with the screw axis to determine pullout strength (POS) in Newtons (N).

**Results:** Rod reduction significantly decreased pedicle screw POS compared to controls (961±352N versus 613±563N). Two of nine screws (22.2%) had outright failure during rod reduction. Screw reinsertion did not significantly decrease POS (943±352N versus 803±422N) despite having a significant decrease in IT compared to control IT (9.56±in-lbs versus 6.38±4.61in-lbs).

**Discussion and Conclusion:** As in the thoracic spine, rod reduction decreases lumbar pedicle screw POS. Increasing the flexibility of the spine, through total facetectomy, does not negate the effects of rod reduction. Despite a significant decrease in IT, screw repositioning/reinsertion did not decrease POS, suggesting that a decreased IT does not affect biomechanical fixation strength.



P271

### VAS SCORES AND TORSO MOTIONS IN LOW-BACK PAIN SYMPTOMATIC PATIENTS

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**Introduction:** The influence of torsion in low back pain (LBP) is still not clearly defined from a clinical viewpoint. Most of the available basic science literature considers torsion and spinal instability as important biomechanical factors in spine degeneration, but there is no correlation attempted to actual pain description. This study aimed to bridge that gap by logging Visual Analogue Scale (VAS) scores of subjects after recording images of flexion/extension and torsional movement of the spine *in vivo*.

**Materials and Methods:** Thirty-nine LBP symptomatic subjects (IRB-approved, 24M/15F, age: 25-59) were subjected to flexion-extension radiographs and CT scanning in five torso-rotation positions: supine (neutral), and both 30°/50° towards Left/Right. Before/after each scanning session and position, patients were asked to rate their pain or discomfort according to a 10 point VAS, with grade 10 assigned to the worst pain ever experienced. T-tests were used to determine any differences between positions with alpha=0.05.

**Results:** The following comparisons of post-image/position VAS scores and p-values are reported: neutral-vs.-flexion: 0.4983; neutral-vs.-extension: 0.2134; neutral-vs.-30°(Right): 0.0002; neutral-vs.-50°(Right): <0.0001; neutral-vs.-30°(Left): 0.076; neutral-vs.-50°(Left): <0.0001. Symmetry was shown between left and right positions with p>0.4328 for all four cases. An increment in rotation also showed larger VAS scores in consequence: from 30° to 50° to the right (p=0.005), and from 30° to 50° to the left: p<0.0001.

**Discussion:** Pain scores are higher with increasing range of rotational motion. Conversely, comparing scores between the neutral position and each one of the flexed/extended positions did not show statistical differences. The relevance of torsion was demonstrated as pain-inducing initiator in this study. Imaging at prescribed positions constitutes a repeatable factor to induce pain in symptomatic patients.

**Conclusion:** While pain is subjective, data shows increasing scores with larger ranges of axial torsion, showcasing the assessment of torsion's influence in LBP. Future work includes evaluation of the painful side, with data from pain maps.

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### IMAGE-BASED 3D-CHARACTERIZATION OF THE LUMBAR SPINAL CANAL GEOMETRY *IN VIVO*

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**Introduction:** Clinically available methods to measure the AP diameter of the spinal canal do not take into account the spinal obliquity, producing inaccurate measurements. This study aims to measure the geometry of the lumbar spinal bony canal in asymptomatic and low back pain subjects using *in vivo* 3-dimensional CT data.

**Materials and Methods:** CT data from 90 subjects (IRB-approved, 48M/42F, ages: 20-59, 58 symptomatic, 32 asymptomatic). This geometry was exported as point-clouds for analysis and posterior-wall eigenvectors were determined and used as reference to measure the bony canal AP diameter. A floating spherical coordinate system was established to act as

a central pivoting point for a virtual cone that traveled along the spinal canal capturing its contour. The algorithm recorded the canal AP diameter, defined as the least distance within this boundary, and was not necessarily contained in the CT-image plane. The minimum, maximum, and mean AP diameters were calculated at the L1-L5 levels. Intervertebral discs were graded according to the Pfirrmann MRI scale. Statistical significance was set at p<0.05 and determined with ANOVA.

**Results:** Symptomatic subjects had significantly smaller minimum diameters than asymptomatic subjects. Minimum diameter also decreased with increasing grade of disc degeneration. Discs with grade 2 degeneration had significantly larger min. diameters than grades 3, 4, and 5. Across levels, L1 had significantly larger minimum diameters than L2-L5, and significantly larger average diameters than L2-L3. There was no significant difference between age groups.

**Discussion:** The fact that greater disc degeneration showed smaller minimum diameters is consistent with the literature suggesting degenerative changes in the intervertebral disc can cause narrowing of the spinal canals from related mechanical changes.

**Conclusions:** This initial finding of significant differences in AP diameter between LBP patients and controls could implicate narrowing of the spinal canal in the etiology of chronic LBP. Future studies with this approach will lead to more accurate findings of the anatomical factors related to lumbar disorders than with 2D-methods

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### LUMBAR FACET JOINT CENTROIDS AS A FUNCTION OF SPINAL LEVEL AND AGE

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**Introduction:** Spinal segmental motion and load transmission are affected by the facet joints (FJs). The aim of this study was to determine the FJ position with respect to the vertebral body and its relationship to spinal level and age.

**Methods:** *In vivo* measurements of the lumbar FJ position (L1-L5) were performed on 87 volunteers (43M/44F: 23-59y.o.). Subject-based CT models were analyzed using 3D methods to locate the centroid of the facet joint and distances between centroids in the same vertebral body were thus determined.

**Results:** Both vertical and horizontal distances measured from each FJ centroid towards the mid-axial and mid-coronal plane, respectively, of the vertebral body's posterior wall decreased significantly in the lower levels. Interfacet width increased with each successive lower level, while interfacet height significantly decreased. With age, both vertical distances between inferior FJ centroid and the posterior wall's mid-axial plane and interfacet heights had decreasing tendencies; however, the anterior-posterior distance and interfacet width increased.

**Discussion:** Data indicate level-specific position changes in superior/inferior FJ centroids. The rectangles formed by connecting FJ centroids within each of the L1-L3 levels, become trapezoids with wider bases in L4-L5. Lines connecting the centroids of the superior and inferior facets were almost parallel to the vertebral body posterior wall. These characteristics appear to be beneficial in axial compressive load transmission from the superior facet to the inferior facet without creating bending moments and shear forces. The present study also showed age-related migration of the FJ centroid position towards the posterolateral side and the interfacet height decreased due to shortening of the inferior process. Decreases in interfacet height with age can be explained by an age related decrease in disc height.

**Conclusion:** Accurate FJ position is indispensable in evaluating

the motion segment kinematics and load transmission of the spinal column. Furthermore, FJ position may also provide important information for studies on spinal disorders such as lumbar canal stenosis and spondylolisthesis.

## P274

### IN VIVO MEASUREMENT OF MORPHOLOGICAL CHANGES IN THE HUMAN LUMBAR SPINE PEDICLE

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**Introduction:** Numerous studies have investigated the effects of lumbar level and gender on pedicle morphology. However, studies on the effects of aging are limited. Age-related changes on the pedicle morphology may be related to painful conditions such as lumbar canal stenosis. The aims of this study were to evaluate age-related changes in pedicle morphology using 3D models *in vivo*, and investigate the correlation with canal diameter.

**Methods:** *In vivo* measurements of the lumbar pedicle morphology and canal width (L1-L5) were performed on 89 healthy volunteers (IRB-approved, 46M/43F, 23-59 y.o.). CT scans provided geometrical data exported as point clouds. The 3D-analytical technique developed in our laboratory and used in this study to measure pedicle the isthmus width, interpedicle width, and lumbar spinal canal width is described in detail elsewhere.<sup>1,2</sup>

**Results:** Pedicle isthmus width was larger with age at L1, L2 and L5. Conversely, bony canal width did not show significant changes with age in all lumbar levels. Interpedicle width increased gradually at L1, L4, and L5 with age. All parameters increased gradually with successive lower levels.

**Discussion:** The present study is the first to investigate age-related changes in pedicle morphology from 3D CT models. In our study, isthmus width increased significantly with age as a consequence of age-related periosteal bone formation. The increase in interpedicle width indicates a lateral shift of the pedicle with age. Information on age-related pedicle dimensional changes is important for spinal surgery, especially for procedures using pedicle fixation. Since pedicle thickness is essential for safe pedicle screw fixation, future work includes routines to analyze the evolution of pedicular cortex thickness in this same cohort.

**Conclusion:** The bony canal width did not show age-related changes despite the increase of the pedicle width with age. The increase in interpedicle width counterbalanced the increase in the pedicle width to prevent canal stenosis.

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## P275

### EFFECT OF HIP ABDUCTION EXERCISE WITH PELVIC FIXATION ON RECRUITMENT OF DEEP TRUNK MUSCLES

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**Introduction/Aim:** To determine the posture of abduction in the side-lying that effective for promoting deep trunk muscle activity.

**Methods:** Ten healthy men with no history of lumbar spine disorders participated in the study. Fine-wire electrodes were

inserted into the both deep multifidus (DM). In addition, surface electrodes were attached to the both Superficial multifidus(SM), Iliocostal lumborum (IL), Longissimus thoracic (LT), Rectus abdominis (RA), Transverse abdominis/Obliquus internus (TA/OI), Obliquus externus (OE) and Gluteus medius (GM). Electromyographic signal amplitude was measured during hip abduction in the side lying position with general and with upper leg caudally pushed (hip joint is the axis of rotation). Tow-way analyses of variance were used to compare muscle activity level among exercises.

**Results:** The exercise showing the greater activity level for the DM was hip abduction in the side lying position with upper leg caudally pushed. There were significant main effects for the ipsi-lateral DM in modified exercise. However, there were no significant main effects on other muscles in abdomen and back of trunk. Furthermore, the change of the EMG amplitudes of the Contra-lateral DM muscles showed a significant difference.

**Discussion:** Trunk muscles activities were measured using intramuscular and surface electrodes during hip abduction in the side-lying with or without pelvic fixation to examine which exercise would be more effective to activate deep trunk muscles. Our study showed that hip abduction in the side-lying with pelvic fixation might be more effective than hip abduction without pelvic fixation for recruiting deep trunk muscles for spinal dynamic stabilization.

**Conclusion:** The results demonstrate that the hip abduction in the side-lying with upper leg pushing caudally is more effective.

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## P277

### TAPPING INSERTIONAL TORQUE PREDICTS BETTER PEDICLE SCREW FIXATION AND OPTIMAL SCREW SIZE SELECTION

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**Introduction/Aim:** Previous studies have evaluated screw insertional torque (IT) and its direct correlation with pullout strength. We set out to investigate the effects of tapping IT on pedicle screw fixation strength.

**Materials and Methods:** A pilot study with five specimens were instrumented using optimal tap size (1mm less than pedicle width), and the optimal tapping IT was found to be 2.5in-lbs, and 1.5in-lbs was used as a paired comparison. Next, 15 specimens (n=30 pedicles) were probed and tapped with increasing tap size until threshold torque was reached (Group 1:1.5in-lbs; Group 2:2.5in-lbs). Screw size was determined by adding 1 mm to the tap size that crossed the threshold torque value.

**Results:** The pedicle screw pullout strength was significantly increased (23%) in Group 2 (877.9 ± 235.2 N) compared to Group 1 (712.3 ± 223.1 N) (p=0.017). The mean pedicle screw diameter was significantly increased in Group 2 (5.70 ± 1.05 mm) compared to Group 1 (5.00 ± 0.80 mm) (p=0.0002). There was also an increased rate of optimal pedicle screw size selection in Group 2 with 9 of 15 (60%) pedicle screws compared to Group 1 with 4 of 15 (26.7%) pedicle screws within 1 mm of the measured pedicle width. There was a moderate correlation for tapping IT with both screw IT (r=0.54) and pedicle screw POS (r=0.55).

**Conclusion:** Our findings suggest tapping IT directly correlates with pedicle screw IT, pedicle screw pullout strength, and optimal pedicle screw size. We recommend incrementally increasing tap size until a tapping insertional torque threshold of 2.5 in-lbs is reached, which may maximize fixation strength and obtain optimal pedicle 'fit and fill' with the largest screw possible.



P278

### IL-1-BETA AND TNF-ALPHA MODULATION OF HUMAN ANNULUS CELLS: CHEMOKINE AND CHEMOKINE RECEPTOR EXPRESSION AND PRODUCTION

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**Background:** Chemokines are important secondary inflammatory mediators released by cells in response to stimuli. They bind to cell surface receptors and act as second-order cytokines with specialized functions in inflammation. The role of these mediators in disc degeneration has received little attention. To extend our previous findings of production of IL-8 and monocyte chemoattractant protein by cultured annulus cells, we utilized a novel assay to simultaneously detect/quantify production of multiple chemokines following exposure to IL-1-beta or TNF-alpha.

**Materials and Methods:** Following IRB approval, annulus cells were cultured from 11 patients with disc degeneration (5 from grade II-III discs, and 6 grade IV-V). Cells were cultured in 3D collagen sponges and exposed to either control conditions or treated with either  $10^{-2}$ pM IL-1-beta or  $10^{-3}$ pM TNF-alpha for 14 days. Conditioned media were assayed using Procarta Cytokine Human 30 Plex Assay plates/Bio-Plex Array Reader. Disc specimens were paraffin embedded/sectioned for immunolocalization of CXCR2 and CXCR6. Additional specimens were studied with Affymetrix microarray analyses. Statistical analyses utilized SAS, version 9.2 for repeated measures ANOVA and paired t-tests.

**Results:** IL-1-beta and TNF-alpha exposure resulted in significant elevations in interferon-gamma, MIP (macrophage inflammatory protein)-1-alpha, GRO-alpha, and eotaxin ( $p \leq 0.0001$  vs. control). Other chemokines, however, showed significantly greater increases with TNF-alpha exposure vs. IL-1beta (MCP-1 and -3, IP 10, RANTES and MIP-1-beta) ( $p \leq 0.0001$ ). Immunohistochemistry and microarray analysis confirmed expression of receptors for CXC chemokines (CXCR2, CXCR6, CXCR1m CXCR4) and for CC chemokines (CCR1, CCR2, CCR3, CCR6, CCR7, CCR8).

**Conclusions/Discussion:** Findings demonstrate that disc cells constitutively produce CC-chemokines (MIP-1-alpha and beta, MCP-1 and -3, and eotaxin) and CXC-chemokines (GRP-alpha, RANTES and IP10) in response to IL-1-beta and TNF-alpha. Data confirmed expression of CXC- and CC-receptors. For some chemokines, IL-1-beta and TNF-alpha differentially regulated expression. Data suggest that annulus cells are primary effector cells as well as target cells, and thus can mediate physiological immune-related processes during disc degeneration by both autocrine and paracrine signaling.

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### ALENDRONATE CHONDROPROTECTIVE EFFECTS ON DISC CELLS IN VITRO: DOSE-RESPONSE STUDIES AND THE EFFECTS OF ALENDRONATE ON GLYCOSAMINOGLYCAN PRODUCTION AND CELL METABOLISM UNDER LOW OSMOTIC AND HYPOXIC CONDITIONS AS SEEN IN DEGENERATED DISC

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**Background:** Bisphosphonates have been widely used for treatment of osteoporosis. Recently, alendronate may have chondroprotective effects that could be of relevance in osteoarthritis. Proteoglycan loss is one of the first signs of disc

degeneration; however, there is little information regarding the effect of alendronate on the glycosaminoglycan (GAG) accumulation in disc tissue. The goals of this study were to determine the role of extracellular osmolality and oxygen tension in regulating production of GAG by alendronate and its effects on disc matrix turnover.

**Materials and Methods:** Cells were isolated from the NP of bovine caudal discs, encapsulated in alginate beads, and cultured in DMEM containing 6% FCS at 400 mOsmol at cell densities of 4 million cells/ml. They were then cultured for 5 days under 21% oxygen with  $10^{-1}$  -  $10^{-12}$  mol/l alendronate; cell cultured without alendronate served as control and the effects of osmolality and oxygen concentration were compared. Encapsulated cells were divided into 2 groups: one to be incubated at 270 mOsmol as seen in degenerated discs and one to be incubated at 400 mOsmol as seen in healthy discs with  $10^{-8}$  mol/l alendronate and without alendronate as control. These groups were further divided into the following 2 different oxygen tension in each culture media conditions: (1) 5%  $O_2$  as seen in healthy discs and (2) <1%  $O_2$  as seen in degenerated discs. Lactate production was measured enzymatically and GAG accumulation was examined using a DMB assay. Rate of sulfate GAG synthesis was measured using a standard  $^{35}S$ -sulfate radioactive method.

**Results:** Alendronate at concentrations of  $10^{-10}$  -  $10^{-8}$  mol/l potentiated the GAG production per million cells by cells in 5 days culture. The potentiated effect was maximal at  $10^{-8}$  mol/l. Pathologic conditions as seen in the degenerated disc (270 mOsmol, <1% oxygen) apparently decreased GAG production, cell metabolism (lactate production) and GAG synthesis. Alendronate-induced increases are prevented by inhibition of cell metabolism under pathologic conditions, but alendronate increased GAG production, cell metabolism and GAG synthesis in healthy conditions (400 mOsmol, 5% oxygen).

**Conclusion:** This data suggest that alendronate may have chondroprotective effects on disc cells preventing disc degeneration.

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### INHIBITING IKB KINASE-B DOWN-REGULATES INFLAMMATORY MEDIATORS IN INJURED DISKS AND NEUROPEPTIDES IN DORSAL ROOT GANGLIA INNERVATING INJURED DISKS IN RATS

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**Introduction:** Human and animal studies have suggested that up-regulation of inflammatory mediators in damaged IVDs causes diskogenic low back pain. Blocking individual inflammatory mediators is ineffective; however, inflammatory mediator stimuli often require I $\kappa$ B kinase- $\beta$  (IKK $\beta$ ) to activate NF- $\kappa$ B. Thus this study aimed to elucidate the efficacy of IKK $\beta$  inhibitor on inflammatory mediators in IVDs or on neuropeptides in the DRG neurons that innervate them.

**Methods:** Male Sprague-Dawley rats were divided into 3 groups: sham, saline (disk-injury plus saline), and IKK $\beta$  (disk-injury plus anti-IKK $\beta$ ). To induce injury, IVDs were exposed and repeatedly punctured.

Experiment 1 (n=27 rats): 4-14 days post-injury, coccygeal (Co) 5/6, Co6/7 and Co7/8 IVDs were resected and TNF-alpha, IL-1beta and IL-6 levels were quantified using ELISA.

Experiment 2 (n=15 rats): The neurotracer fluorogold (FG) was injected into injured L5/6 IVDs and uninjured sham group IVDs to detect DRG neurons. One week post-surgery, L1-L6 DRGs were resected and immunolabeled with the pain marker CGRP. The proportions of FG-labeled CGRP-immunoreactive DRG neurons were assessed.

**Results:** Experiment 1: IVD levels of TNF-alpha (through 2 weeks), IL-1beta (at 4 days), and IL-6 (at 4 days) were significantly higher in the saline group than the sham group, and significantly higher in the IKK $\beta$  group than the saline group ( $p < 0.05$ ). Experiment 2: In all groups, FG-labeled DRG neurons of the L5/6 IVD were distributed throughout L1 to L6, peaking at L2 ( $p < 0.05$ ). At all time points, the percentage of CGRP-immunoreactive FG-labeled DRG neurons was significantly higher in the saline group than the sham group, and significantly lower in the IKK $\beta$  group than the saline group ( $p < 0.05$ ).

**Discussion:** Injury-induced up-regulation of inflammatory mediators within IVDs as well as neuropeptides of their DRG neurons can be suppressed by inhibiting IKK $\beta$ . This finding helps elucidate the mechanism by which IKK $\beta$  inhibitors alleviate diskogenic low back pain.

## P281

### THE INFLUENCE OF TUMOR NECROSIS FACTOR (TNF) ALPHA DERIVED FROM NUCLEUS PULPOSUS ON NERVE

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**Introduction:** Chemical inflammation induced by inflammatory cytokines is considered a mechanism of neuropathic pain caused by a herniated lumbar disc. One of the main inflammatory cytokines that induces chemical inflammation is tumor necrosis factor alpha (TNF $\alpha$ ). Because TNF $\alpha$  exists in various cells, it is difficult to determine the spread of TNF $\alpha$  originating from a prolapsed nucleus pulposus. In this study, we examined the spread of TNF $\alpha$  originating from nucleus pulposus.

**Methods:** Nucleus pulposus of the lumbar spine was extracted from male C57BC/6 wild-type mice. Subsequently they were applied to the right sciatic nerve of TNF $\alpha$ -KO mice, following a pinch of the nerve for two seconds. Seven days after treatment, the sciatic nerve, dorsal root ganglion (DRG) neurons, and spinal cord were resected and examined immunohistochemically to detect TNF $\alpha$ . The TNF $\alpha$ -positive cells were counted in each mouse type by three observers.

**Results:** TNF $\alpha$ -positive cells were observed in sciatic nerve and DRG cells, but not in the more proximal part of DRG or spinal cord. The proportion of TNF $\alpha$  positive cells in all the DRGs was 17 $\pm$ 3%.

**Conclusions:** We consider that after TNF $\alpha$  from nucleus-pulposus invaded the sciatic nerve, it was transferred to the DRG cells by axonal transport. However, because TNF $\alpha$  was not observed in the spinal cord, we hypothesize that the TNF $\alpha$  that reaches the DRGs indirectly causes the release of other pain transmitters to the spinal cord as a mechanism of herniated disc pain.

## P282

### ORGAN CULTURE MODEL FOR SIMULATION OF DISC CELL THERAPY

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**Introduction:** Treatment of disc degeneration by cell-therapy is a challenge because of the harsh environment in degenerated discs. Due to the lack of suitable in vivo models for disc degeneration, we tested a bovine organ culture system for in vitro simulation of biological repair strategies by injection of serum albumin hydrogel with/without GFP-labeled mesenchymal stem cells into needle-punctured discs.

**Methods:** In eight experiments, standardized punches with intact nucleus and few surrounding annulus lamellae were prepared from the caudal discs of 16 bovine tails. For prevention of disc swelling, part of the samples were maintained at constrained conditions compared to unconstrained parallel cultures. The nucleus was needle-punctured 24hrs prior to injection. 50 $\mu$ l of albumin-hyaluronan-hydrogel with/without GFP-labeled cells was injected into the nucleus pulposus. At day 1, 7 and 14 each two parallel cultures were analyzed by histology, fluorescence microscopy and DMMB assay to determine GAG release into the culture media.

**Results:** In the constrained group, swelling of the disc punches was prevented with maintenance of the original disc height in contrast to the unconstrained samples. In the center of punctured discs an increased occurrence of cell clusters could be observed. GFP-labeled cells could be detected close to the injection site and in cell clusters at each time point. Matrix around the cells close to the injection site showed a more intense Alcian blue staining suggesting a locally increased GAG deposition. However, total GAG content of the organ cultures decreased with time in culture and was not altered by cell injection in both constrained and unconstrained conditions.

**Discussion:** Our organ culture approach allows cell injection at well-defined culture conditions into a disc environment with progressive decrease of proteoglycan concentration. Injected GFP-labeled cells appeared to survive and to be metabolic active. Ongoing experiments with variation of environmental conditions will allow us to evaluate biological repair strategies under standardized in vitro conditions.

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## P283

### EFFECT OF AUTOPHAGY ON ANNULUS FIBROSUS CELL MATRIX HOMEOSTASIS

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**Introduction/Aim:** Intervertebral disc degeneration is characterized by degradation of extracellular matrix. Autophagy, the process by which cells break down damaged components, is an important survival mechanism following stress (e.g. starvation). Recent chondrocyte studies have reported the protective role of autophagy. We hypothesized autophagy could induce anabolic response in disc cells. Our aim was to elucidate the effect of autophagy in disc cell matrix homeostasis.

**Materials and Methods:** Fibrochondrocytes from the annulus





fibrosus (AF) of 6-month-old female New-Zealand-White rabbits were used. 1) To understand the role of autophagy, cell viability and proliferation were assessed by WST-8 and Picogreen assays under varying supply of nutrients (HBSS or F-12 with 0%FBS, 1%FBS, and 10%FBS) and an autophagic inducer, Rapamycin (100nM or 1µM in 10%FBS F-12). 2) To confirm the induction of autophagy, immunofluorescence for autophagic markers, LC3 and HMGB1, was performed. 3) To assess the effect of autophagy on matrix, glycosaminoglycan content, proteoglycan synthesis, and aggrecan, MMP3, and ADAMTS5 mRNA-quantification by real-time RT-PCR were measured.

**Results:** 1) Cell viability was reduced by starvation (52% in 1%FBS, 35% in 0%FBS, and 5% in HBSS compared to 100% in 10%FBS after 48 hours) and Rapamycin (85% in 100nM and 70% in 1µM). Starved or Rapamycin-stimulated cells showed lower proliferation (3,326/mm<sup>2</sup> in 1%FBS, 6,514/mm<sup>2</sup> in 1µM-Rapamycin 10%FBS, and 28,120/mm<sup>2</sup> in 10%FBS after 14 days). 2) Starved or Rapamycin-stimulated cells exhibited increased LC3 expression with a 6-hour peak and HMGB1 release from the nucleus to cytoplasm at 24- and 48-hour culture. 3) Starved or Rapamycin-stimulated cells demonstrated higher glycosaminoglycan content (1.8-fold after 48 hours), proteoglycan synthesis (2.6-fold), and aggrecan expression (1.8-fold) and lower MMP3 expression (0.4-fold). ADAMTS5 showed significant up-regulation in response to starvation and Rapamycin (5.9-fold).

**Discussion/Conclusion:** Starvation- and Rapamycin-induced autophagy limits proliferation and promotes anabolic effects on AF cell matrix. The unexpected observation of ADAMTS5 up-regulation may represent a novel regulatory step of autophagy.

## P284

### THE CHARACTERISTICS OF DORSAL ROOT GANGLION NEURONS AND SENSORY INNERVATION OF LUMBAR INTERVERTEBRAL DISCS IN RABBITS

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**Introduction:** Many reports regarding discogenic low back pain have investigated the sensory innervation of lumbar intervertebral discs (IVDs) and associated pain mechanisms in mice and rats. Typically, the examination of relationships between IVD imaging and sensory nervous system changes are challenging because evaluations using MRI and IVD tissue engineering are difficult in small animals such as mice and rats. The purpose of this study was to investigate the characteristics of sensory dorsal root ganglion (DRG) neurons innervating the lumbar IVD in rabbits.

**Methods:** Five 12-week-old male New Zealand white rabbits were used. The retrograde neurotracer Fluoro-Gold was applied to the surface of L6/7 discs to label their innervation by DRG neurons. Fourteen days after surgery, bilateral Th13 to L7 DRGs were harvested and sectioned. The Fluoro-Gold-labeled neurons at each DRG level were evaluated, and the size of DRG neurons was divided into small cell (<30µm in diameter) or large cell (>30µm in diameter).

**Results:** The Fluoro-Gold-labeled neurons were present in the bilateral DRGs from Th13 through L7. The proportions of Fluoro-Gold-labeled neurons were 6.4% in Th13, 9.7% in L1, 11.5% in L2, 11.6% in L3, 12.0% in L4, 14.0% in L5, 16.6% in L6, and 18.3% in L7. There were no significant differences in the number of Fluoro-Gold-labeled neurons among the DRG levels. In Fluoro-Gold-labeled neurons, the proportion of small cells was 81.3%, and the proportion of large cells was 18.7% (p<0.05).

**Discussion:** In the current study, rabbit lumbar IVDs were innervated by multiple levels of DRG in a similar fashion as

previously reported for rats. The proportion of small cells in rabbit DRG neurons innervating IVDs was over 80%, and these are considered to be related to pain transmission. These findings will contribute to evaluations of IVDs by MRI and help to understand relationships between pain associated with IVD degeneration and sensory innervation in future studies.

## P285

### A NEW ANIMAL MODEL OF DEGENERATIVE DISC DISEASE SEEN IN HUMAN

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**Introduction/Aim:** Intervertebral disc degeneration is thought to contribute to low back pain. Many experimental animal models, which were achieved by direct injuries such as a needle puncture, have been reported to elucidate the pathophysiological mechanism. Considering clinical relevancy, however, these models are clearly different from patients with degenerative disc disease (DDD). The purpose of this study was to establish an animal model of DDD, which showed evidence of pain behavior, without direct invasion.

**Materials and Methods:** Twenty male Sprague-Dawley rats were divided into three groups. In the sham group (n=6), only exposure of bilateral L4-5 facet joints was performed. The experimental group underwent resection of bilateral L4-5 facet joints (n=10). Naïve rats were served as the control (n=4). After the surgery, behavioral analysis was performed utilizing the Cat-Walk method over time. As a radiological analysis, dynamic lumbar lateral X-rays were taken at the time when behavioral changes were observed. After taking X-rays, the lumbar spine was harvested for the histological and immunohistochemical analysis. Relationships between behavioral, radiological and histological changes were examined.

**Results:** Seven weeks after surgery, walking abnormality including a decrease in optical intensity of posterior feet, which was thought to be a pain-related behavior, were observed only in the experimental group. Radiographic analyses revealed segmental hypermobility accompanied by increment of disc height and anterior osteophyte formation in all and 80% of rats in the experimental group, respectively. Degeneration and expression of proinflammatory cytokines were seen in the experimental group.

**Discussion:** In the present study, lumbar facetectomy resulted in delayed abnormal walking patterns. Changes of the disc height suggest segmental instability of the lumbar spine and might induce biological abnormalities of the intervertebral disc. This animal model is a first report of disc degeneration without direct invasion and may be useful to elucidate mechanisms of DDD seen in human.

**Conclusions:** We developed an animal model which a lumbar facetectomy resulted in intervertebral disc degeneration and delayed abnormal walking pattern.

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### THE MODULATION OF INTERVERTEBRAL DISC DEGENERATION BY HEME OXIGENASE-1 IN BACH 1 DEFICIENT MICE

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**Introduction:** Intervertebral disc is one the most important structures for stabilizing spinal column. But it easily loses its function as a result of degeneration affected by several causes. Intervertebral disc degeneration is considered of an important factor of low back pain. And recently oxidative stress has been shown to be an important factor in various conditions, and is considered a cause of intervertebral disc degeneration. Bach 1 deficient mice express high levels of Heme oxygenase-1 (HO-1) mRNA and protein in various organs, which protects cells from oxidative stress. Some studies have shown that oxidative stress relates to arteriosclerosis, ischemic heart disease and spinal cord injury. The purpose of this study is to clarify the correlation between oxidative stress and intervertebral disc degeneration using Bach 1 deficient mice.

**Materials and Methods:** C9-10 caudal discs in 12 weeks old Bach 1 deficient and wild type murine tails were punctured using a 29 gauge needle. The progress of the disc degeneration was evaluated histologically at pre-puncture and at 1, 2, 4, 8, 12 weeks post-puncture. Sagittal sections were stained using hematoxylin and eosin (HE) or safranin-O fast green (SO). Histological degeneration was investigated using a semiquantitative grading. Immunohistochemistry at each term was examined for HO-1 expression. TUNNEL assay was performed to detect apoptosis cells.

**Result:** Histological scoring showed significant difference at 8 and 12 weeks after puncture between the two groups. Immunohistochemistry revealed high expression of HO-1 in the nucleus pulposus of Bach 1 deficient mouse, but very low in wild type mouse. The rate of apoptosis cells in Bach 1  $-/-$  mice was significantly higher at 1 and 2 weeks post-puncture than in wild type mice.

**Conclusion:** The results of this study suggest that HO-1 modulates IVD degeneration. High HO-1 expression can repress the degenerative process of the intervertebral disc, reducing the number of apoptosis cells.

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### BMP-7 INHIBITS TNF- $\alpha$ INDUCED UPREGULATION OF THE ADAMTS-4 AND ADAMTS-5 AGGREGANASES BY ANTAGONIZING NF $\kappa$ B ACTIVITY

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**Introduction/Aims:** TNF- $\alpha$  is an inflammatory cytokine that can upregulate the activity of ADAMTS aggreganases that catabolize the extracellular matrix in intervertebral discs. BMP-7 is an anabolic molecule that directly stimulates synthesis of the extracellular matrix. However, the effects of BMP-7 on TNF- $\alpha$  and its subsequent effects on ADAMTS aggreganases are not known. We hypothesize that BMP-7 can reduce the effect of TNF- $\alpha$  upregulation of the ADAMTS aggreganases through the NF $\kappa$ B pathway.

**Methods:** Human intervertebral disc cells (collected from surgical waste) were cultured in alginate beads, and treated with TNF- $\alpha$ , or TNF- $\alpha$  plus BMP-7, pharmacological inhibitor of ERK1/2 (U01260), p38 (SB203580), or NF $\kappa$ B (BAY 11-7082). The mRNAs levels of target genes were measured by real-time PCR,

and the protein levels were determined by the Western blots. The NF $\kappa$ B activity was analyzed by measured phosphorylation and nuclear translocation of the NF $\kappa$ B complex p65 and p50.

**Results:** TNF- $\alpha$  induced expression of the catabolic regulators ADAMTS-4 and ADAMTS-5, and activated the transcription factor NF $\kappa$ B complex p50 and p65 in the intervertebral disc cells. Inhibition of NF $\kappa$ B activity abrogated TNF- $\alpha$ -mediated upregulation of ADAMTS-4 and ADAMTS-5 mRNAs and proteins. BMP-7 treatment blocked TNF- $\alpha$  induced up-regulation of ADAMTS-4 and ADAMTS-5 mRNAs and proteins. BMP-7 treatment suppressed TNF- $\alpha$  induced activation of NF $\kappa$ B complex p50 and p65, and blocked TNF- $\alpha$  induced nuclear localization of NF $\kappa$ B complex p50 and p65.

**Discussion:** Our data indicates that TNF- $\alpha$  induces upregulation of the intervertebral disc catabolic regulators ADAMTS-4 and ADAMTS-5 through activation of the transcription factor NF $\kappa$ B. Our data also indicates that BMP-7 inhibits TNF- $\alpha$  induced upregulation of the ADAMTS-4 and ADAMTS-5 by antagonizing NF $\kappa$ B activity. This inhibition of catabolism is different from BMP-7's ability to increase synthesis of disc matrix.

**Conclusion:** BMP-7 has anabolic effects on disc matrix through inhibition of TNF- $\alpha$  induced catabolism of disc matrix as well as the previously known property of increasing matrix synthesis.

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### NOTCH SIGNALING PATHWAY REGULATES PROGRAMME CELLULAR DEATH OF INTERVERTEBRAL DISC CELLS

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**Introduction/Aim:** The pathogenesis of intervertebral disc (IVD) degeneration remains unclear. This study was designed to demonstrate the role of Notch signaling pathway in the programmed cellular death (PCD) of IVD cells and to assess the influence of Notch on the phenotype changes of IVD cells.

**Materials and Methods:** First-passage rat annulus fibrosus (AF) and nucleus pulposus (NP) cells were used in the current study. Cells were cultured for autophagy and apoptosis induction by starvation, with or without DAPT, the Notch signal inhibitor. The changes of phenotype markers (collagen type I, type II and aggrecan) of AF and NP cells and degeneration-related genes (MMP3, 9, 13, 14 and ADAMTS 4, 5, 15) were recorded with real-time PCR. The changes of autophagy or apoptosis incidence of AF and NP cells were also evaluated by immunoblotting and flow cytometry.

**Results:** During autophagy and apoptosis process of AF and NP cells, the mRNA of Notch-1, Notch-3 and Delta like ligand-1 were highly expressed. We found a significant decrease in the survival rate of IVD cells when cells were treated with DAPT. Specifically, we found that autophagy of IVD cells significantly decreased, which was accompanied with an increase in apoptosis incidence. The mRNA expression of MMP 13 and ADAMTS 15 were significantly inhibited by DAPT when the mRNA expression of MMP 3, 9, 14 and ADAMTS 4, 5 increased.

**Discussion/Conclusion:** Notch signaling pathway may play an important role in the PCD of IVD cells. The expression of MMP 13 and ADAMTS 15 is regulated by Notch signaling pathway. Notch ligands may be tightly involved in the survivability of IVD cells during the degenerative process in the spine.



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### TIME- AND DOSE-DEPENDENT CYTOTOXICITIES OF IOXITALAMATE AND INDIGOCARMINE IN HUMAN NUCLEUS PULPOSUS CELLS

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**Introduction:** Ioxitalamate (Telebrix 300) is an ionic iodinated contrast medium (CM) commonly used for discography or PELD (percutaneous endoscopic lumbar discectomy), though it has side effects such as anaphylactic shock and renal toxicity. Indigocarmine is an organic compound dye with a distinctive blue color that is commonly used during PELD to stain the acidic, degenerated nucleus pulposus. Although ioxitalamate and indigocarmine are widely used in spinal surgery, there have been no reports on their effects on nucleus pulposus (NP) cells. We studied the toxicity of both ioxitalamate and indigocarmine to NP cells.

**Materials and Methods:** NP cells were obtained via discectomy from lumbar disc patients and isolated. NP cells were cultured in three-dimensional (3D) alginate beads with 0.001, 0.1, 10, and 100 mg/ml ioxitalamate, 0.00001, 0.001, 0.1 and 10 mg/ml indigocarmine, or a mixture of both for 1, 2 or 3 days. The living cells were analyzed with trypan blue staining. FACS analysis using Annexin V and propidium iodide (PI) and 3D alginate bead immunostaining was performed to identify live, apoptotic, and necrotic cells.

**Results:** Ioxitalamate, indigocarmine, and their combination induced statistically significant NP cell injury that was both time- and dose-dependent ( $p < 0.05$ ). Also, at the same concentration, ioxitalamate was more cytotoxic than was indigocarmine or the combination ( $p < 0.05$ ). All three treatments also showed dose-dependent cytotoxicity according to flow cytometry and immunostaining.

**Conclusion:** Ioxitalamate and indigocarmine are toxic to human NP cells in vitro in a time- and dose-dependent manner. We assume that ioxitalamate and indigocarmine may have similar effects in patients undergoing discography and PELD. Thus, we suggest that ioxitalamate and indigocarmine should be used carefully at low concentrations.

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### IS PAIN BLOCKAGE SAFE? THE VIEWPOINT BASED ON NUCLEUS PULPOSUS CELL CYTOTOXICITY

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**Introduction:** Local anesthetics combined with corticosteroids are commonly used for management of back pain in interventional spinal procedures. Several recent studies suggest cytotoxicity of bupivacaine, whereas others report protective and cytotoxic effects of corticosteroids on chondrocytes and intervertebral disc cells. Considering the frequent use of these agents in spinal interventions, it is meaningful to know how they affect intervertebral disc cells.

**Materials and Methods:** Nucleus pulposus cells were isolated from human disc specimens from patients undergoing surgery due to disc herniation or degenerative disc disease. They were grown in three-dimensional alginate beads for one week to maintain their differentiated phenotypes and to allow for matrix formation before analysis. After one week of culture, the cells were exposed to bupivacaine (0.1%, 0.25%, 0.5%, and 1%) or bupivacaine (0.1%, 0.25%, 0.5%, and 1%) with 1mg triamcinolone for 1, 3, or 6 hours. Cell viability was measured using trypan blue exclusion assay and flow cytometry. Live-cell/dead-cell fluorescent imaging was assessed using confocal microscopy.

**Results:** Trypan blue exclusion assays demonstrated dose- and

time-dependent cytotoxic effects of bupivacaine on human nucleus pulposus cells. Similar but reduced cytotoxicity was observed after exposure to the combination of bupivacaine and 1mg of triamcinolone. Flow cytometry showed a dose-dependent cytotoxic effect of bupivacaine on nucleus pulposus cells after three hours of exposure. The reduced cytotoxicity of bupivacaine combined with 1mg triamcinolone was also confirmed in flow cytometry. Confocal images showed that the increase in dead cells correlated with the concentration of bupivacaine. But fewer cells died after exposure to several different concentrations of bupivacaine combined with 1 mg triamcinolone than did after exposure to bupivacaine alone.

**Conclusions:** The combination of bupivacaine and triamcinolone induced dose- and time-dependent cytotoxicity on human intervertebral disc cells in vitro, but the cytotoxicity was much weaker than that of bupivacaine alone. This study shows a potential protective influence of triamcinolone on intervertebral disc cells.

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### DOES GLUCOSE DEPRIVATION INFLUENCE GENE EXPRESSION AND MECHANOSENSITIVITY OF NUCLEUS PULPOSUS CELLS AFTER LONG-TERM CULTURE?

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**Introduction:** With proceeding disc degeneration and calcification of the endplate, the main route of transport of nutrients and metabolites to the nucleus pulposus (NP) cells is impaired. The reduced nutrient supply is supposed to be a key contributor to disc degeneration. Aim of this study was to investigate the influence of glucose deprivation on mechanical stimulation after long-term 3D culture.

**Material and Methods:** NP cells isolated from bovine caudal discs ( $n=7$ ) were transferred to alginate bead culture for 3 weeks in high glucose (22.5mM) chondrogenic medium supplemented with 10ng/ml TGF- $\beta_1$ . After redifferentiation, part of the samples was exposed to reduced glucose concentration (5mM) for 3 days. Afterwards, glucose concentration was further reduced to 0mM, 0.5mM and 5mM for 24h. Subsequently, half of all samples were mechanically loaded by hydrostatic pressure for 30min at 0.1Hz and 2.5MPa. Gene expression of matrix molecules and catabolic enzymes was analysed by real-time RT-PCR.

**Results:** After redifferentiation with TGF- $\beta_1$ , gene expression of matrix molecules was increased compared to day 0. By contrast, MMP13 expression was decreased. Subsequent reduction of glucose concentration significantly decreased expression of matrix molecules but increased MMP13 expression. Mechanical stimulation led to greatest effects in cells, which were not exposed to glucose reduction and were maintained in medium supplemented with TGF- $\beta_1$ . In cells exposed to glucose reduction, the mechanically induced changes in gene expression were minimal and no correlation with glucose concentration could be pointed out.

**Discussion:** Despite a successful redifferentiation of NP cells, subsequent glucose deprivation revealed a strong down-regulating impact on gene expression of matrix molecules and increased MMP13 expression. Application of hydrostatic pressure could not change these results. However, in high glucose chondrogenic medium supplemented with TGF- $\beta_1$ , hydrostatic pressure increased expression of matrix molecules and decreased expression of catabolic enzymes. These findings may indicate an interaction of glucose supply, presence of TGF- $\beta_1$  and mechanical loading which will be investigated in ongoing studies.

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### INFLAMMATORY PAIN PATTERN AND PAIN IN LUMBAR EXTENSION ARE ASSOCIATED WITH MODIC 1 CHANGES - A CASE-CONTROL STUDY

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**Introduction/Aim:** To compare the clinical characteristics of low back pain (LBP) patients with and without Modic 1 changes in a case-control study.

**Materials and Methods:** Patients consulting for non-specific chronic LBP with Modic 1 changes on a recent (<6 months) lumbar MRI were prospectively included (Modic group). A control group matched for age and gender was built up, with LBP patients with no such changes. In both groups, patients were evaluated by questionnaires (Dallas Pain Questionnaire, Roland-Morris Disability Questionnaire) and a physical examination (including lumbar range of motion). Pain characteristics including the presence of pain at night, worse pain at awakening and morning stiffness, were recorded. At least one of these 3 items characterized an inflammatory pain pattern. Responsiveness to NSAIDs or oral steroids was recorded. Univariate and multivariate analysis were used.

**Results:** 60 patients were included in each group. We found no significant difference between groups for sedentary work ( $p=0.25$ ), morning stiffness >60 minutes ( $p=0.10$ ), awakening at night ( $p=0.08$ ), worse pain at awakening ( $p=0.07$ ), back stiffness ( $p=0.12$ ), scoliotic list ( $p=1$ ), worse pain in flexion ( $p=0.99$ ). Modic group had significantly more frequent inflammatory pain pattern ( $p=0.006$ ) and worse pain in extension ( $p<0.005$ ). On multivariate analysis, sedentary work (OR=0.22 [0.05-0.93]), pain in extension (OR=11.2 [3.1-40.4]) and inflammatory pain pattern (OR=4.5 [1.2-16.9]) were significantly associated with Modic 1 changes. Modic group responded better to oral steroids when prescribed ( $p=0.004$ ). When back pain was unilateral, the Modic 1 changes were almost always on the same side.

**Discussion:** Our study brings evidence for the inflammatory nature of the Modic 1 changes.

**Conclusion:** Pain in lumbar extension and an inflammatory pain pattern were the most characteristics features of Modic 1 patients. When encountered, these signs and symptoms should prompt the clinician to ask for a lumbar MRI.

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### DIFFERENTIAL INVOLVEMENT OF ADAMTS-5 IN THE EARLY STAGE AND MMP-3 IN THE MODERATE TO LATE STAGE OF DISC DEGENERATION IN A RAT TAIL - MULTI-DURATIONAL STATIC COMPRESSION MODEL

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**Introduction/Aim:** Intervertebral disc degeneration is characterized by extracellular matrix degradation. Our objective was to elucidate the variety of matrix degradation event using a multi-durational static compression model.

**Materials and Methods:** Eighty-four 12-week-old male Sprague-Dawley rat tails were attached with an Ilizarov-type device with springs, loaded statically at 1.3 MPa, and divided into three groups: loaded for the first day (D1-group), loaded for the

first 7 days (D7-group), and continuously loaded (D56-group). Observation for up to 56 days was performed using X-ray, MRI, histology, real-time RT-PCR—MMP-3, ADAMTS-5, aggrecan-1, and collagen type 2-a1—and immunohistochemistry—MMP-3, ADAMTS-5, aggrecan neopeptides cleaved by MMPs and by aggrecanases.

**Results:** In X-ray, disc height recovered in D1- and D7-groups after loading removal, and the progressive loss was observed in D7-group (54% at 56 days) while D1-group kept the height (78%). Disc height in D56-group decreased continuously (29%). In MRI and histology, degenerative changes progressed with the loading period in every group. In real-time RT-PCR, MMP-3 demonstrated significant up-regulation from 7 days in D7- (5.5-fold at 56 days) and D56-groups (9.8-fold) while showed no change throughout in D1-group. ADAMTS-5 demonstrated no change in D7- and D56-groups while showed up-regulation in D1-group at 56 days (2.9-fold). Aggrecan-1 and collagen type 2a-1 were significantly down-regulated in every group. % immunopositive cells of <sup>342</sup>FFGVG increased at 56 days in every group with increased MMP-3 immunopositivity. <sup>374</sup>ARGSV and ADAMTS-5 showed the same trend but both decreased at 56 days in D56-group.

**Discussion:** Multi-durational static compression induced varying stage of degeneration. ADAMTS-5 and MMP-3 up-regulation may be indications of the early and moderate to late stages of disc degeneration, respectively.

**Conclusion:** This rat tail model should prove useful to understand the differentiation of longitudinal matrix degradation in intervertebral disc degeneration.

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### STRESS-MEDIATED REGULATION OF INTERVERTEBRAL DISC CELLS' PROLIFERATION

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**Introduction/Aim:** Intervertebral disc (IVD) is characterized by an extremely low cellularity and rate of proliferation, most probably due to the absence of vascularization and of the consequent problematic nutrition. Accordingly, this low cell number is probably necessary for the maintenance of IVD homeostasis. In addition, IVD cells are continuously exposed to intense stresses, such as osmotic and oxidative, during daily activities. Aim of this work was the investigation of the role of these stresses on the proliferation of IVD cells, as well as the underlying molecular mechanisms.

**Materials and Methods:** The proliferation of intervertebral disc cells was measured by the incorporation of tritiated thymidine or bromodeoxyuridine into DNA, as well as by direct cell counting. Activation of signaling pathways was estimated by western analysis, while cell cycle regulation by FACS analysis. DNA damage and repair were evaluated by comet assay, immunofluorescence against  $\gamma$ H2AX and host cell reactivation assay. The presence of reactive oxygen species was estimated by using DCFH-DA.

**Results:** We have found that increased osmolality inhibits intensely IVD cell proliferation by activating the stress kinase p38MAPK, thus inducing an arrest in the G2 phase of the cell cycle. In addition, it provokes DNA damage and the subsequent activation of the ATM-p53-p21<sup>WAF1</sup>-pRb signaling axis, leading to a G1 phase arrest. On the other hand, several factors that provoke an oxidative stress, i.e. they increase intracellular reactive oxygen species, inhibit also the proliferation of IVD cells by using similar molecular mechanisms. Finally, we showed that the proliferation of IVD cells after stimulation with growth factors, such as PDGF or IGF-I, that is achieved via the activation of the MEK/ERK and PI-3K/Akt intracellular signalling pathways, is



considerably inhibited under hyperosmotic conditions.

**Conclusion:** Our results indicate that the several stresses IVD cells face during daily activities control cell proliferation and thus can be important for the regulation of tissue homeostasis.

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## P295

### MECHANICAL STRESS LOADING OF CERVICAL INTER-VERTEBRAL DISC IN CILP TRANSGENIC MICE PROMOTES INTERVERTEBRAL DISC DEGENERATION

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**Introduction:** Lumbar disc disease (LDD) is one of the most common musculoskeletal disorders accompanied with intervertebral disc degeneration. We have recently reported that CILP, encoding cartilage intermediate layer protein, shows a highly significant association with LDD. We also demonstrated that the CILP protein inhibits TGF- $\beta$ -induced transcriptional activation of cartilage matrix genes in nucleus pulposus (NP) cells *in vitro* by binding to TGF- $\beta$ 1 and down phosphorylation of Smads. We established transgenic mice that show differential expression of CILP in the intervertebral disc tissues and analyzed whether CILP is responsible for enhanced disc degeneration. We have reported that CILP transgenic mice promote lumbar disc degeneration. To investigate the effects of mechanical stress loading, we established cervical mechanical instability model of CILP transgenic mice and analyzed the intervertebral disc degeneration.

**Materials and Methods:** Expression plasmids of the full-length mouse CILP cDNA were constructed using Col11a2 promoter/IVS1 that enables differential expression in the intervertebral disc tissues; 453mCILP<sup>int</sup> transgenic mice induces CILP expression specifically in the NP of the intervertebral disc, whereas 742mCILP transgenic mice does not. Cervical mechanical instability model established by Miyamoto et al. was produced with each line. The detailed histological evaluation of the cervical spine was performed using Safranin-O staining.

**Result:** 453mCILP<sup>int</sup> transgenic mice showed significantly degenerate than normal mice in Safranin-O staining. The cervical disc herniation was seen in 453mCILP<sup>int</sup> transgenic mice group. 742mCILP transgenic mice showed slightly degenerate than the normal mice.

**Conclusion:** 453mCILP<sup>int</sup> transgenic mice showed severe cervical intervertebral disc degeneration under mechanical stress condition. These findings suggest CILP seems to be directly involved in the pathomechanism of the intervertebral disc disease.

## P296

### DO THE ADJACENT LEVEL INTERVERTEBRAL DISCS DEGENERATE AFTER A LUMBAR SPINAL FUSION? AN EXPERIMENTAL STUDY USING A RABBIT MODEL

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**Introduction:** The purpose of our study was to use a rabbit model in a twelve-month experiment to determine the long-term changes in the intervertebral discs at the levels adjacent to two fused lumbar levels.

**Methods:** Nine New Zealand white, female rabbits: four rabbits in the control group and five rabbits in the experimental group. The five rabbits in the experimental group underwent a posterolateral two-level lumbar spinal fusion from L3 to L5. The changes in the lumbar discs were assessed using radiographs, MR images and histology at six months and twelve months.

**Results:** The results at six months are less clear than those at twelve months. The results at twelve months for the experimental group are: 1) the intervertebral disc height decreased at the caudad adjacent level and to a lesser extent at the cephalad adjacent level; 2) the MRI scores for the discs at the caudad and cephalad adjacent levels showed severe loss of signal intensity as compared to the discs at the same levels in the control group. This loss was more pronounced at the caudad level; 3) the histological analysis showed severe degenerative changes with a lack of live cells in the nucleus pulposus and in the endplate at the caudad adjacent level. At the cephalad level, live cells were apparent (albeit few) in the nucleus pulposus, and there was a more normal looking endplate with live cells.

**Discussion:** The intervertebral discs at both the cephalad and the caudad levels adjacent to the two fused lumbar levels in this rabbit-model experiment carried out over twelve months showed degenerative changes as assessed using disc height measurements, MR images and histology, and the effect was more severe at the caudad adjacent level.

## P297

### A REPRODUCIBLE PAPAINE-INDUCED IN-VITRO DISC DEGENERATION MODEL FOR THE STUDY OF INJECTABLE NUCLEUS PULPOSUS THERAPY

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**Introduction:** An *in-vitro* disc degeneration model (DDM) will be a useful tool to evaluate the performance of the injectable nucleus pulposus (NP) tissue engineering scaffold in a disc environment. The aims of the study are to characterize a range of DDM with various severity of GAG and water loss and to determine the response of MSC introduced in this DDM.

**Materials and Methods:** Bovine caudal IVDs with endplates were isolated and papain (3, 15, 30, 60, 150 U/mL) or PBS were injected into the disc and kept in culture for 10 days. Cell viability of the NP was assessed by Live/Dead stain and confocal microscopy. Overall matrix composition was evaluated by staining the non-decalcified tissues sections with safranin-O and fast green. Disc hydration of the bovine tail disc injected with papain and PBS after 2 days was assessed by magnetic resonance imaging (MRI) using T2\* protocol. Human MSCs were labeled with a fluorescence cell membrane tracker, and injected into the nucleus as cell suspension in a DDM or a PBS control



disc. MSC viability was evaluated after 2 days as above.

**Results:** Cell viability of the papain digested NP was maintained at around 75% after 10 days for all of the injected papain concentrations. GAG was completely lost in the discs injected with 30- 60U/mL papain and created a small cavity in the center while the AF maintained intact. When injecting 150U/mL papain, the AF was collapsed and half of the disc hydration was lost as shown in the MRI result. MSC cell viability was significantly higher when injected into this DDM than injected bluntly into the control.

**Discussion:** This DDM allows the testing of various injectable NP therapeutic strategies under adjustable culture condition. The sub-optimal survival of MSCs injected into the DDM indicated that need of a cell carrier for introducing cells into a medium degenerated disc.

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### ANTI TNFalpha ANTIBODY AND ANTI IL-8 ANTIBODY COCTAIL RECOVER MECHANICAL HYPERALGESIA IN HERNIATED DISC MODEL

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**Introduction/Aim:** We have been clarified intervertebral disc (IVD) and macrophages interaction induces TNFalpha, IL-6, IL-8 and PGE2 production and play major role for mechanical hyperalgesia in herniated disc model; autologous coccygeal IVD autograft and spinal nerve ligation model. We have been also clarified IL-6 and PGE2 productions are TNFalpha dependent but IL-8 production is TNFalpha independent in IVD and macrophages interaction. The aim of this study is to determine the efficacy of the anti TNFalpha neutralizing antibody and anti IL-8 neutralizing antibody for herniated disc model.

**Materials and Methods:** Sprague-Dawley male rats' L5 spinal nerve was explored and ligated with 10-0 Nylon ligature, and a coccygeal IVD was autografted on ligated spinal nerve (n=32). The next day of the surgery, the rats were divided four groups and gently injected following antibodies and saline around the autografted IVD; anti TNFalpha neutralizing antibody, anti IL-8 neutralizing antibody, anti TNFalpha/IL-8 neutralizing antibody cocktail and saline. Antibody concentration was determined by 24 hours IVD and macrophages co-culture experiment and ND<sub>50</sub> of neutralizing antibody. Paw withdrawal mechanical threshold (PWMT) was measured 3, 5, 7, 11 and 14days after the surgery. PWMT was compared saline group with antibody administrated groups.

**Results:** Anti TNFalpha/IL-8 antibody cocktail significantly recovered PWMT from 3days to 14days after the surgery. Anti TNFalpha antibody recovered PWMT at 5, 7 days after the surgery. The degree of the PWMT recovery of anti TNFalpha/IL-8 cocktail surpassed anti TNFalpha antibody alone or anti IL-8 antibody alone. Anti IL-8 antibody alone was not effective for mechanical hyperalgesia in autologous IVD autograft and spinal nerve ligation model.

**Discussion:** The existence of TNFalpha independent inflammation, such as IL-8, could be one of the reasons of ineffectiveness of anti TNFalpha antibody administration for herniated disc disease.

**Conclusion:** Anti TNFalpha/IL-8 neutralizing antibody cocktail can be effective for herniated disc disease.

## P299

### MRI CHANGES OF INTERVERTEBRAL DISCS AFTER CEMENT AUGMENTATION

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**Introduction:** Cement augmentations are very common nowadays, providing good results in fracture management of the spine. However, little is known about the influence of cement augmentation to the intervertebral disc. Since disc nutrition is highly dependable on endplate diffusion, cement augmentation might provoke diffusion insufficiency and hence trigger degeneration. This study focuses on MRI outcomes after single or multiple cement augmentations.

**Material and Methods:** 15 patients were included (f/m 10/5; mean age at surgery 67.1±6.9 yrs). In total, 3 traumatic and 20 osteoporotic fractures were treated with cement augmentation. MRI scans were performed pre-operatively in the osteoporotic patients and after 15.2±5.5 mo for all patients. 7 had a long-term MRI follow-up after 85.7±10.9 mo. Oner and Pfirrmann classification were used to assess disc changes.

**Results:** 43 discs were examined in total. 3 discs were in-between bi-segmental cement augmentations. Pfirrmann grades: 3:19 (44.2%); 4: 15(34.9%); 5:5 (4.6%) pre-op. 7 (16.3%) discs had injuries pre-op. Only 3 discs showed progressive degeneration at first follow-up of one Pfirrmann grade (all 3 to 4). All were located in the thoraco-lumbar region. At long-term follow-up, two further discs showed degeneration of one grade. Interestingly, none of the discs with bi-segmental cement augmentation showed degeneration.

**Conclusion:** According to this data, cement augmentation does not appear to have significant influence on disc degeneration. Even after a long post-operative period, the Pfirrmann grade remains unchanged in the majority of cases. However, this patient group is very senior, having already degenerative disc changes pre-operatively which might influence the outcome in this study. Since cement augmentation is considered as treatment option in younger patients, it might be useful retaining data of patients with lower post-operative Pfirrmann grades in a long-term follow-up for disc degeneration.



P300

### EXOGENOUS SIRT1 SHOWS DIFFERENT EFFECTS ON PROLIFERATION ACTIVITY IN HUMAN INTERVERTEBRAL DISC DEPENDING ON THE DIFFERENCE OF THE DEGENERATION STAGE

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**Introduction/Aim:** We previously reported the longevity factor SIRT1 was present in human intervertebral disc (IVD) cells. We hypothesized the effect of SIRT1 might change depending on the stage of disc degeneration. The aim of this study was to investigate the effect of exogenous SIRT1 on cell proliferation activity in different degeneration stage of human IVD cells.

**Materials and Methods:** Human nucleus pulposus (NP) cells were consensually obtained from eleven patients (13-71 year-old, mean 36.8 year-old) during surgical procedures from lumbar spinal stenosis (LSS; n=2), lumbar disc herniation (LDH; n=4) or idiopathic scoliosis (n=5) patients. After three-days pre-culture, recombinant human SIRT1 (rhSIRT1) was transfected to NP cells using Pro-DeliverIN™. Samples was divided into two groups, earliest degeneration group consisting of idiopathic scoliosis samples and advanced degeneration group consisting of LSS and LDH samples. Cell proliferation activity was measured by the WST-8 assay using Cell Counting Kit-8. The proliferation activity of the cells in each well was normalized by the cell number.

**Results:** The cell number was significantly decreased both in earliest and advanced degeneration groups with SIRT1 treatment. The normalized proliferation activity of advanced degeneration group was significantly decreased by both treatment of 10  $\mu$ M and 100  $\mu$ M SIRT1 (10  $\mu$ M; -59.4%, 100  $\mu$ M; -46.4%, as %control). In contrast, SIRT1 treatment significantly up-regulated the normalized proliferation activity in earliest degeneration group (10  $\mu$ M; +37.5%, 100  $\mu$ M; +60.6%, as %control).

**Discussion:** Our results demonstrated that earliest and advanced degeneration group showed different responses to SIRT1 treatment. rhSIRT1 significantly stimulated normalized proliferation activity in earliest degeneration group. The different effects of exogenous SIRT1 may help NP cells survive in deteriorating harsh biological environment with advancement of disc degeneration.

**Conclusion:** Depending on the difference of the degeneration stage, exogenous SIRT1 showed different effects on proliferation activity in human IVD.

P301

### LRP1 FUNCTIONS AS A NEUROTROPHIC RECEPTOR IN DORSAL ROOT GANGLION SENSORY NEURONS

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**Introduction:** Neurons that are injured in the peripheral nervous system (PNS) have an increased capacity for regeneration compared with neurons in the CNS. PNS regeneration reflects, at least in part, the activity of Schwann cells, which de-differentiate and provide scaffolds for regenerating axons. We have shown that LRP1 is expressed by Schwann cells mainly after PNS injury and plays an important role in the Schwann cell response to injury, promoting survival and migration. LRP1 also is expressed by many neuronal populations and has been implicated in axonal outgrowth by a pathway that may involve Src family kinases (SFK) and Trk. The goal of this study was to determine whether

LRP1 functions as a neurotrophic receptor in sensory neurons.

**Materials and Methods:** Primary cultures of DRG neurons were prepared from rat embryos (day 15). The cultures were treated every 2 days with 10  $\mu$ M uridine and 10  $\mu$ M 5-fluoro-2'-deoxyuridine to select for neurons.

**Results:** Previously characterized LRP1 ligands, including the LRP1-binding domain of  $\alpha$ 2-macroglobulin (RBD) and the hemopexin domain of MMP-9 (PEX), both of which were expressed as GST fusion proteins, promoted sensory neuron survival, as determined by measuring cleaved caspase-3, and robust axonal outgrowth. GST (control) was inactive. The ability of RBD and PEX to promote axonal outgrowth was confirmed by measuring GAP43 mRNA. The RBD induced sustained activation of ERK/MAP kinase in DRG neuronal cell cultures, comparable to nerve growth factor- $\beta$ . Furthermore the SFK inhibitor, PP2, blocked neurite outgrowth in response to the RBD but not nerve growth factor- $\beta$ . These results suggest that LRP1 ligation in sensory neurons activates the SFK/Trk-dependent pathway previously demonstrated in cerebellar granular neurons. In co-cultures of sensory neurons with Schwann cells, the RBD increased the receptivity of the neurons for myelination. As a result, expression of the myelin-associated proteins, P0 and MAG, was significantly increased.

**Discussion:** The ability of LRP1 in sensory neurons to promote survival, axonal outgrowth, and receptivity to myelination qualifies LRP1 as a true neurotrophic receptor.

P302

### ANNULAR FIBROSIS RESPONSE TO EX-VIVO STATIC COMPRESSION OF RABBIT FUNCTIONAL SPINAL UNITS

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**Introduction:** Mechanical loading of the intervertebral disc influences biological processes including disc matrix homeostasis. Ex-vivo models permit control of loading and environmental variables within a preserved disc matrix. A novel system that loads viable functional spinal units (FSUs) has been developed to better approximate in-situ conditions. Because long-term static loading appears to degrade AF matrix and promote inflammation, acute biological responses to static loading were investigated ex-vivo.

**Materials and Methods:** Freshly harvested rabbit L4-5 FSUs are mounted within a chamber that interfaces with an axial testing machine. Media (10% FBS) is pumped through the chamber (1.25 ml/min), and temperature and gas concentrations are controlled to 37 °C and 5/5% CO<sub>2</sub>/O<sub>2</sub> preserving adequate viability (>80%). FSUs are subjected to 15 cycles of preconditioning followed by 4 or 24 h of constant compression (1.0 MPa). Fresh (t=0) discs (L3-4) and unloaded, intra-incubator, temporally-matched FSUs (L2-3) serve as controls. Outcome measures include relative gene expression of MMP-1, -3, ADAMTS-4, -5, TIMP-1, COX-2, and aggrecan, and Safranin O and immunohistochemistry staining of BC-3, an aggrecan breakdown fragment.

**Results:** Comparing loaded to unloaded FSUs, MMP-3 expression was increased by 28-fold at 4h (n=6) and 12.4-fold at 24 h (n=3). Aggrecan expression doubled from 4h (n=3) to 24h (n=3). MMP-1, ADAMTS-4, -5, COX-2 and TIMP-1 were up-regulated at both time-points (2.4-3.7-fold, n=2-3). Proteoglycan content did not change with loading. Aggrecan fragments were detectable but differences based on loading were not observed.

**Discussion:** Static loading in this system showed up-regulation of both catabolic and anabolic genes, which may reflect an acute remodeling response. The marked up-regulation of MMP-3 may

indicate its involvement as a key control point in the response to mechanical loading.

### P303

#### THE BEHAVIOR OF THE INTERVERTEBRAL DISC CELLS UNDER THE OXYGEN CONDITION

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**Introduction:** The nucleus pulposus, core part of intervertebral disc (IVD) is an avascular and hypoxic tissue in which IVD metabolism maintains. GLUT-1 expression is also stimulated in a variety of cells under hypoxic condition, a response that is mediated by the transcription factor HIF-1 $\alpha$ . Among various phenotypes, type II collagen and glucose transporter-1 (GLUT-1) proved to be phenotypical signature of nucleus pulposus. Simulated conditions with various lower oxygen concentrations might reveal valuable information regarding IVD matrix metabolism. Therefore, the objective of this study is to evaluate behavior of IVD cells such as matrix gene expressions under various hypoxic condition.

**Materials and Methods:** Human disc tissues were collected during surgery from patients (age range 45-59 years) with degenerative lumbar conditions and cultured. The IVD cells were seeded at a cell density of 70 cells cm<sup>-1</sup> for protein and RNA isolation in hypoxia condition (1% O<sub>2</sub>, 5% CO<sub>2</sub>, 37 °C; 6% O<sub>2</sub>, 5% CO<sub>2</sub>, 37 °C) and normoxic condition (21% O<sub>2</sub>, 5% CO<sub>2</sub>, 37 °C) for five days. MTT assay was utilized for cell proliferation. RT-PCR was performed to detect expressions of aggrecan, type II collagen HIF-1 $\alpha$  and GLUT-1 at the mRNA, western blot was used for proteoglycan synthesis.

**Results:** There is no significant difference in cell proliferation among groups. The expressions of aggrecan, type II collagen GLUT-1, and HIF-1 $\alpha$  mRNA increased in hypoxic condition as comparing with normoxic condition. Furthermore, the expression of proteoglycan at protein level increased in hypoxic condition.

**Summary and Conclusion:** IVD cells in hypoxic condition demonstrated increase in matrix component mRNA and proteoglycan synthesis without hazardous effect on cellular proliferation. Hence hypoxic condition renders phenotypical maturation in IVD cells, which provided important mechanism for disc tissue engineering in hypoxia. Chemically hypoxic inducer such as deferroxamine would be next study.

### P304

#### EP1/3 PATHWAY SUPPRESSES EXAGGERATION OF IL-1-INDUCED COLLAGENASES BY A SELECTIVE COX-2 INHIBITOR IN HUMAN IVD CELLS

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**Introduction:** Degeneration of intervertebral disc (IVD) has been considered to be an initial process of developing chronic low back pain (LBP). Although selective COX-2 inhibitors have been a favourable treatment for LBP, we, last year, provided evidences that IL-1-induced collagenases gene expression were exaggerated by a selective COX-2 inhibitor and were inhibited by exogenous PGE2 in human IVD cells. In the present study, in order to identify the prostanoid receptors that lead to suppression of collagenases expressions, the effect of EP1-4 agonists were investigated in isolated human IVD cells.

**Materials and Methods:** Isolated cells from human IVD were

pre-incubated with a selective COX-2 inhibitor (NS-398) and then stimulated with IL-1 in the presence or absence of PGE2 or selective EP1-4 agonists for 24 hours. Collagenases (MMP-1 and -13) and EP1-4 expressions were quantified by realtime-PCR.

**Results:** IL-1 induced the expression of both MMP-1 and -13 in IVD cells. These were further exaggerated when the cells were pre-treated with NS-398 whereas exogenous PGE2 strongly inhibited these expressions. EP2 receptor was the highest followed by EP1 and EP3 and 4 were negligible at mRNA level. EP1/3 but not EP2 and 4 agonist inhibited the expression of both MMP-1 and -13 expressions in human IVD cells.

**Discussion:** Selective COX-2 inhibitors have been widely used for treating patients with LBP. Our previous results suggested that selective COX-2 inhibitors might accelerate the degeneration of IVD by enhancing collagenases expression. In the present study, we demonstrated the possibility that activation of EP1/3 pathway attenuates the over-expression of collagenases by a selective COX-2 inhibitor. Our results suggest that EP1/3 signalling known to increase calcium level may play a suppressive role for collagenases expressions in human IVD cells.

**Conclusion:** EP1/3 signaling pathway down-regulates the over-expression of collagenases caused by selective COX-2 inhibitors therefore it can be a therapeutic target for IVD degeneration.

### P305

#### EFFECTS OF INTERVERTEBRAL DISC CELLS ON THE MORPHOLOGY OF DRG AND NERVE ROOTS: AN *IN VIVO* STUDY

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**Background:** Basic science and clinical observations have indicated that interaction between the intervertebral discs (IVD) and neural structures is of importance in spinal pain production. Previous work has demonstrated an inhibition and a reduction of the neurite outgrowth and diameter, after exposure to notochordal cells (NC) and/or chondrocyte-like cells (CHC) from IVD. The aim of the present study was to investigate the neuropathology of DRG and nerve roots after exposure to NC or CHC in an *in vivo* disc herniation rat model.

**Material and Methods:** L4 nerve root and DRG of 15 Sprague Dawley rats were exposed to nucleus pulposus (NP) (positive control), NC, CHC or F12 (cell diluent) and compared to a sham group (surgery procedure control). After 1 week the nerve roots and their DRGs were harvested. Neuropathological examinations were performed with light microscopy technique in a blinded manner.

**Results:** Focal and segmental nerve root and DRG damages, i.e. degenerated axons, demyelination and Schwann cell proliferation were observed after exposure of NC, CHC and NP.

**Discussion and Conclusion:** This is the first examination of DRG and nerve root morphology after exposure to NC or CHC in an *in vivo* model. The results indicate that both NC and CHC, may structurally affect neural tissue. One may also assume that not only spinal nerve roots but also local nerve fibers and nerve endings in surrounding structures, could be affected in corresponding ways if such neural tissue is exposed to NC or CHC, in clinical situations like disc herniation and disc degeneration. Both cell types investigated in this study, NC and CHC, are present in human IVDs. Recently, NCs have been shown to be present not only in children but also in adulthood of humans.

### P306





## DIFFERENT EFFECTS ON EVOKED THALAMIC NEURONAL ACTIVITY BY TWO CELL POPULATIONS DERIVED FROM NUCLEUS PULPOSUS

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**Background:** Nucleus pulposus (NP) leakage onto a dorsal root ganglion (DRG) is believed to contribute to disc hernia related pain. It has been demonstrated that activity evoked in the contralateral thalamus following stimulation of sciatic nerve A delta fibres increases within 20 minutes of NP exposure in the rat<sup>a</sup>. NP is composed of at least two cell populations, chondrocyte-like cells (CHC) and notochordal cells (NC). The aim of the study was to compare the possible contribution of these two cell populations to the NP induced thalamic activity.

**Material and Methods:** Neuronal responses in the contralateral thalamus of adult anaesthetised Sprague-Dawley rats were recorded when stimulating the ipsilateral sciatic nerve at A delta intensities (20-50T). 25 000 NC (n=6) or 25 000 CHC (n=6) sorted from donor rat NP was applied onto the L4 DRG and evoked responses recorded for 40 minutes. Freshly harvested NP from a donor rat was thereafter applied on the same DRG and recordings continued for additionally 40 minutes.

**Results:** Application of CHC on the DRG increases evoked thalamic responses from baseline (100%) to 140% (n.s.), similar to responses of NP after 20 minutes (138%)<sup>1</sup> while NC depress evoked responses to 62% (p<0.05). The cell suspension medium alone did not evoke any changes. Application of NP after NC increased the evoked thalamic activity while no further increase was observed following NP after CHC.

**Discussion and Conclusion:** CHC and NC have different effects on evoked thalamic activity. CHC effects are similar to NP effects and it is therefore possible that CHC, the major cell population found in adult human intervertebral discs, may be the main contributor to the increase in thalamic activity evoked by NP. This observation may have clinical implications for the development of disc hernia related pain.

### Reference:

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## P307

### EP2/4 RECEPTOR SUPPRESSES THE EXPRESSION OF NGF IN HUMAN IVD CELLS

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**Introduction:** Chronic low back pain (LBP) is a major clinical problem that results in physical disability and decreased productivity. One of the possible mechanisms of low back pain has been considered that peripheral nerve fibers invade into the degenerated intervertebral disc (IVD). Nerve growth factor (NGF) is known to induce nerve ingrowth. Our previous data showed that exogenous prostaglandin E2 (PGE2) had a negative feedback role for NGF expression in IVD. Although selective COX-2 inhibitors have been used for treating those patients trying to inhibit PGE2 production, hence PGE2 receptors' effects on the nerve ingrowth have been unclear. The roles of PGE2 receptors on the regulation of NGF in IVD cells were investigated.

**Materials and Methods:** The IVD tissues were obtained from lumbar canal stenosis' patients who were conducted a surgery. IVD cells were cultured in monolayer and pre-incubated with a selective COX-2 inhibitor (NS-398) for 30 min and then stimulated

with interleukin-1 (IL-1) in the presence of EP1-4 agonists for up to 24h. The expression of NGF mRNA was measured by realtime-PCR.

**Results:** IL-1 stimulated the expression of NGF in IVD cells, peaked at 6 hours. This expression was exaggerated when the cells were pre-treated with NS-398. Conversely, exogenous PGE2 suppressed its expression. The IL-1-stimulated NGF expression was suppressed by EP2 and 4 receptor agonists but not by EP1 and 3 agonists.

**Discussion:** Selective COX-2 inhibitors have been widely used for treating patient with LBP. Our previous data indicated that PGE2 may have a negative feedback role for IL-1-induced expression of NGF in IVD. In the current study, NGF expression was suppressed by EP2 and 4 agonists, suggesting that EP2 and 4 signalling that is known to increase cAMP may have a role for suppressing the expression of NGF in IVD cells.

**Conclusion:** EP2 and 4 signalling pathway down-regulates the NGF expression in IVD cells.

## P308

### CELL VIABILITY IN HUMAN SAMPLES OF HERNIATED INTERVERTEBRAL DISC: IMPLICATIONS FOR BIOLOGICAL THERAPIES

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**Introduction:** Increasing interest is being placed on cell therapy as a treatment for intervertebral disc degeneration. Previous work suggests that cells isolated from the degenerate intervertebral disc have a limited potential for regeneration, with a large proportion of the cells necrotic and/or senescent<sup>1</sup>. However, cells isolated from surgical samples have already been used in the clinic for cell therapy. Due to these differing opinions, this study was designed to assess the viability of cells present in surgical samples of degenerate intervertebral disc tissue.

**Materials and Methods:** Samples of herniated and degenerate discs were obtained from patients undergoing routine discectomy and processed within 2 hours of excision. A piece of each sample was incubated in a chloromethyl fluorescein diacetate (CMFDA)/ethidium homodimer (EH) solution in the dark for 2 hours at 37°C. Cryosections were taken throughout the tissue depth and visualised with a fluorescent microscope. Cell viability was measured by counting at least 200 cells.

**Results:** Twenty-one surgical disc samples from patients, aged 17-57 years, have been examined. Preliminary results show that 74±13% of cells are alive after excision. Cell viability was fairly consistent throughout the sections of the discs, apart from a predominance of dead cells being seen around the periphery. This may be derived from trauma during dissection. Cell viability was not significantly altered by patient gender but there was a negative correlation between cell viability and patient age (r=-0.62).

**Discussion:** These results indicate that the viability of cells in human intervertebral discs is higher than reported elsewhere in the literature, although different methods of assessment were used.

**Conclusions:** This study indicates that shortly after excision, surgical samples of discs contain cells of which >70% are viable. This suggests that they may be appropriate for cell therapy, although no characterisation of cell type or assessment of functionality was made in this study.

### Reference:

- 1 Trout et al., *Anat Rec* (1982) 204(4):307-14

P309

### ANTI-INFLAMMATORY EFFECT OF PLATELET-RICH PLASMA ON NUCLEUS PULPOSUS CELL WITH RESPONSE OF TNF- $\alpha$ AND IL-1

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**Introduction:** The purpose of this study is to investigate the anti-inflammatory effect of platelet-rich plasma (PRP) modulated by collagen matrix on human nucleus pulposus (NP) cell responded to pro-inflammatory cytokines such as TNF- $\alpha$  and IL-1.

**Methods:** NP cells derived from human discs were cultured in monolayer, and maintained in the collagen matrix prior to the addition of recombinant human interleukin-1 (IL-1) and tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ). IL-1 and TNF- $\alpha$  were applied in the presence or absence of PRP, which was collected from human volunteers using a commercially available platelet concentration system. The response was investigated using real-time PCR for mRNA expression of type II collagen, aggrecan, matrix metalloproteinase-3 (MMP-3), and cyclooxygenase-2 (COX-2).

**Results:** IL-1 and TNF- $\alpha$  treatment of human IVD cells resulted in an increase of gene expression for the MMP-3, and COX-2 and a decrease of the gene expression for matrix genes (aggrecan, type II collagen). However, co-treatment with PRP restored the level of the expression of aggrecan and type II collagen significantly. These events correlated with down-regulation of COX-2 and MMP-3 after PRP application.

**Discussion:** The combination of PRP and collagen matrix markedly suppressed cytokine-induced pro-inflammatory degrading enzymes and mediators, and rescued the gene expression about matrix synthesis, thereby stabilizing NP cell differentiation. Therefore, PRP might restore a physiological microenvironment beneficial for maintaining NP cell homeostasis from the inhibition of IL-1 and TNF- $\alpha$ .

**Conclusion:** The inflammatory response by TNF- $\alpha$  and IL-1 were significantly diminished by PRP with collagen matrix, and the chondrogenic gene expressions were rescued by PRP from the inhibition of IL-1 and TNF- $\alpha$  under the modulation of collagen matrix. These findings suggest that PRP might be a therapeutic candidate for prevention of disc degeneration.

P310

### MODULATING THE MICROENVIRONMENT OF DIFFERENTIATING hMSCS THROUGH RNA INTERFERENCE

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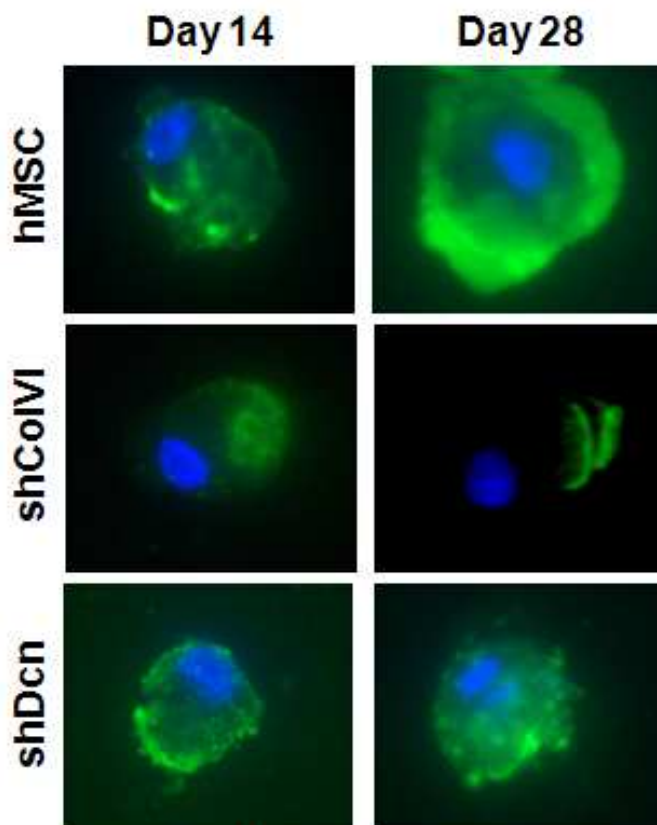
**Introduction:** The use of human mesenchymal stem cells (hMSCs) induced towards a nucleus pulposus (NP) cell phenotype has been considered in regenerative strategies. Differentiating hMSCs develop a pericellular matrix (PCM) rich in type VI collagen (ColVI) and proteoglycans, such as decorin. Modulating the function of the PCM may be important in the success of such strategies. This study analyzes the contributions of ColVI and decorin in regulating mechanotransduction events in differentiating hMSCs through RNA interference (RNAi).

**Methods:** Lentiviral vectors were used to effect stable shRNA-mediated silencing of either *col6a1* (shColVI) and *dcn* (shDcn) in hMSCs, with a GFP vector as a control. Infected and non-infected hMSCs were cultured in 2% alginate beads for 7, 14, or 28 days in chondrogenic medium. Viability and protein silencing

were confirmed using fluorescence staining and Western blotting, respectively. Effects on PCM formation were determined by ColVI immunofluorescence. Agarose gel-embedded hMSCs with their PCM intact were loaded using a custom device and cell deformations measured to determine functional implications of gene silencing.

**Results:** Infected and non-infected hMSCs remained viable over the course of the experiment. Protein silencing was verified for shColVI infected cells with lower band intensities for  $\alpha 1(VI)$  and  $\alpha 2(VI)$  at day 14 when compared to GFP infected cells. Immunofluorescence showed that the ColVI network is decreased by shColVI and disrupted by shDcn (figure). In cell deformation experiments, counter to the expected outcomes, non-infected and GFP infected controls exhibited greater decreases in aspect ratio than shColVI and shDcn infected cells.

**Discussion:** RNAi can be used to modulate the micromechanical environment in differentiating hMSCs to examine individual protein's contributions to mechanotransduction. Knocking down *col6a1* showed a decrease in the amount of translated ColVI protein, while improving resistance to deformation. This may be due to a reorganization of PCM and/or cytoskeletal elements. Further studies will be needed to elucidate the role of the structural microenvironment in mechanotransduction of differentiating hMSCs.



**Figure: ColVI immunostaining of non-infected, shColVI, and shDcn hMSCs cultured in chondrogenic medium for 14 or 28 days.**



P311

### INFLUENCE OF PRILOCAINE, IOPAMIDOL AND CORTISOL ON INTERVERTEBRAL DISC CELL PROLIFERATION: DOES MEDICATION ROUTINELY USED FOR DISCOGRAPHY INFLUENCE INTERVERTEBRAL DISC BIOLOGY?

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**Introduction:** Eugene Carragee<sup>1</sup> was the first to prove that provocative discography may contribute to intervertebral disc degeneration. Disc degeneration can be induced either by mechanical trauma caused by the puncturing needle or as a pharmacological effect of the drugs instilled into the disc. Aim of the presented study was to test the influence of Cortisol, Prilocaine and Iopamidol on nucleus pulposus cells under an in vitro setting.

**Materials and Methods:** The nucleus pulposus was excised from 12 bovine tail intervertebral discs and monolayer cell cultures were generated. 48 cultures containing  $5 \times 10^6$  cells each were divided in 4 sample groups and incubated in either standard cell culture medium (control group) or medium supplemented with the test substances. The dose rate was adapted based on a total dose of 3 ml Iopamidol (Jopamiro 200), 1 ml Prilocaine (Xylanest 2%) and 10 mg Cortisol (Volon A 10) per nucleus pulposus. Cell count, viability, proliferation and differentiation features were analysed.

**Results:** After 24 hours, a significant decrease in cell counts was observed in all three test groups. Population doubling time was 16 hours in the control group cultured in standard medium and increased to 25 hours (Iopamidol), 21 hours (Cortisol) and 38 hours (Prilocaine) after incubation in discography medication ( $p < 0,001$ ). Cell viability was slightly, but not significantly decreased in all medication groups. Cells incubated in Prilocaine were significantly smaller ( $p < 0,01$ ) and showed clearly reduced pseudopode formation. Incubation in Prilocaine and Iopamidol also significantly reduced glycosaminoglycan synthesis.

**Discussion:** Although only a small decrease in cell viability was observed in all 3 substances tested, cell count and proliferation decreased significantly. Incubation in Prilocaine inhibited pseudopode formation and might therefore interfere with intercellular signalling and cell migration.

Glycosaminoglycan syntheses was significantly decreased after contact with Prilocaine as well as Iopamidol. These observations suggest that all 3 medications tested might interfere with biological repair mechanisms of the intervertebral disc and therefore contribute to a further degeneration of the intervertebral disc.

#### Reference:

1 Carragee EJ et al. Spine (Phila Pa 1976). 2009 Oct 1;34(21):2338-45

P312

### REGULATION OF DISC CELL DENSITY BY NUTRIENT SUPPLY

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**Introduction/Aims:** In avascular cartilages and three-dimensional gel cultures, viable cell density is inversely related to cartilage or gel thickness and is close agreement with that predicted by diffusional theory. The aim of this work was to determine if the same relationship holds true in the intervertebral disc nucleus pulposus.

**Materials and Methods:** Discs from 4 different levels of young adult bovine tails were dissected out together with adjacent vertebrae. The nucleus tissue was digested, DNA content was measured using picogreen and related to cell density. The

vertebral bodies were fixed, decalcified and the vascular network visualised histochemically by detection of endogenous peroxidase in red blood cells. Density and diameter of perforations through the subchondral bone were measured using scanning electron microscopy.

**Result:** The heights of discs increased 3 fold with change in level in the caudal-cranial direction. Cell density was significantly higher in the larger discs than in the smallest discs. The vascular supply/area feeding the disc was much denser in the larger than the smaller vertebrae. The fractional area of holes perforating the subchondral plate was 14% for the largest discs compared to 4.5% for the smallest discs.

**Discussion:** Here cell density of bovine caudal discs did not vary inversely with disc height) as expected. Other avascular tissues such articular cartilage are freely exposed to nutrient media at their surfaces and hence cell density is governed directly by diffusion through the matrix. However, this is not the case for the disc where nutrients are supplied by blood vessels of the vertebrae. Thus the fall in vascular supply to the smallest discs, decreased available nutrients and hence the viable cell density which could be maintained in these discs despite their small height. These results could partly explain why atherosclerosis of vertebral arteries leads to disc degeneration.

**Conclusion:** These results demonstrate the importance of the vertebral blood supply in maintaining disc cellularity and health and have implications for the pathogenesis of disc degeneration and for success of biological repair therapies.

P314

### ALLOGENEIC ARTICULAR CHONDROCYTES SURVIVED IN THE DEGENERATING RABBIT INTERVERTEBRAL DISC IN VIVO

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**Introduction:** Transplanting cells to repopulate the intervertebral disc (IVD) and to provide growth signals to resident cells may be effective in reversing disc degeneration. We hypothesize that allogeneic articular chondrocytes will survive in the relatively immune privileged environment in the IVD. We have used infrared, fluorescent and enzymatic methods to track allogeneic articular chondrocytes injected into degenerating rabbit IVDs in vivo.

**Materials and Methods:** Articular chondrocytes from New Zealand White rabbit knees were isolated and cultured in vitro. The cells were transduced with recombinant adenovirus expressing red fluorescent protein (RFP) and  $\beta$ -galactosidase ( $\beta$ -gal) (Ad-RFP- $\beta$ -gal). Additionally, cell membranes were labeled with infrared dye. Rabbit IVD degeneration was induced by needle puncture. Four weeks post-injury, labeled, transduced chondrocytes were injected into injured IVDs. At 2 weeks or 8 weeks post-injection, the rabbits were sacrificed and the IVDs were isolated and imaged with an infrared scanner to locate and quantify the dye-labeled cells. Functional  $\beta$ -gal activity was assessed using the  $\beta$ -gal assay. RFP was detected by confocal microscopy.

**Results:** The average infrared fluorescence intensity in the IVDs was 25,885 counts/mm<sup>2</sup> (n=4 discs) at 2 weeks post-injection, and 27,663 counts/mm<sup>2</sup> (n=11 discs) at 8 weeks post-injection. There was no significant difference in the average infrared intensity levels between these time points ( $p = 0.8403$ ). At both time points, the IVDs were stained positive for  $\beta$ -gal activity and RFP was detected. RFP fluorescence intensity and  $\beta$ -gal activity decreased at 8 weeks post-injection compared with the 2-week time point, suggesting that transgene expression decreased with time.

**Discussion:** Our studies using cells labeled with infrared dye demonstrated that cells injected into the degenerated discs remained in the discs for up to 8 weeks. The presence of RFP and  $\beta$ -gal activity in the chondrocytes transduced with recombinant adenovirus, Ad-RFP- $\beta$ -gal, further suggests that the cells have remained viable 8 weeks after injection.

**Conclusion:** These results have demonstrated the feasibility of using allogeneic articular chondrocytes for disc repair.

### P315

#### CULTURED PRIMARY SENSORY NEURONS FROM THE RABBIT DORSAL ROOT GANGLION RESPOND TO CAPSAICIN: AN IN VITRO MODEL FOR INFLAMMATORY PAIN

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**Introduction:** Intervertebral discs are considered the main pain generators in the spine. Disc cells are capable of producing a complex mixture of cytokines and other inflammatory mediators that may stimulate nerve endings. Subsequent to receiving peripheral sensory stimulation, central branches of the sensory neurons release neurotransmitters (e.g., Substance P) to the dorsal horn of the spinal cord. Capsaicin is compound that is often used in neuropathic pain models. To develop an in vitro assay to identify factors that stimulate Substance P, we established a dorsal root ganglion (DRG) cell culture system using capsaicin stimulation.

**Materials and Methods:** DRG were isolated from the young adult New Zealand White rabbits after euthanasia; and cells were released by serial collagenase and trypsin digestion. Cells were then cultured in complete media with nerve growth factor and cytosine  $\beta$ -D-arabinofuranoside in plates coated with amine. Cultures were immunostained with neuron and glia specific antibodies. Cells were stimulated with different concentrations of capsaicin; then Substance P levels were examined by enzyme-linked immunoassay.

**Results:** Immunostaining studies showed that the DRG cell cultures contained both primary sensory neurons and astrocytes. Cultures treated with increasing concentrations of capsaicin released larger amounts of Substance P. Capsaicin at 25  $\mu$ M stimulation resulted in a 4.3-fold increase in Substance P compared with untreated control (n=7; P < 0.05). Capsaicin at 50  $\mu$ M or 500 $\mu$ M concentration resulted in 7.0 or 13.0-fold increase in Substance P release, respectively (n=6, 7; P < 0.05).

**Discussion:** We have confirmed that primary cultured rabbit DRG cells respond in a dose-dependent manner to capsaicin stimulation by releasing Substance P. Cytokines detected in patients with discogenic back pain and disc herniation could be tested in this system.

**Conclusion:** We have established a DRG cell culture system to screen the ability of substances to induce a pain response. This culture system should prove useful for researchers studying back pain.

### P316

#### VERTEBRAL BONE REMODELING IN DISC DEGENERATION – QUANTITATIVE MICRO-CT ANALYSIS IN A PORCINE NUCLEOTOMY MODEL

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**Introduction:** Changes in vertebral endplate sclerosis and permeability seem to be a crucial aspect in the course of disc degeneration. Detailed information on microstructural changes of the subchondral bone of the endplates and the trabecular vertebral bone is missing, especially whether bony remodeling runs parallel with disc remodeling or not. Therefore, the goal of this study was to analyze this in an established disc degeneration model on minipigs.

**Materials and Methods:** Animals were divided into 3 groups. Group 1 and 2 received partial nucleotomy with a 16G-biopsy-cannula to induce moderate disc degeneration and were followed for 13 and 24 weeks, respectively. Group 3 did not receive surgery and served as controls. A total of 24 discs and 48 endplates with subchondral bone and trabecular vertebral bone were analysed histologically and by quantitative micro-CT. Standardized elliptical volumes of interest were analyzed by Skyscan-micro-CT-software.

**Results:** Both group 1 and 2 showed disc degeneration with significant loss of disc height, higher disc- and endplate-degeneration-scores, fibrous scarring and loss of notochordal cells (p<0.05 compared to controls). Micro-CT revealed less sclerosis (BV/TV) and reduced trabecular thickness of subchondral bone underneath the endplates 13 weeks after nucleotomy compared to untreated controls (p<0.05 group 1 vs. group 2 and 3); after 24 weeks, however, values turned back to those of controls again. The same correlation was found in more distant trabecular vertebral bone, though BV/TV values were lower. Separate analysis of changes above and below the operated disc did not show differences.

**Discussion:** Contrary to the concept of simultaneous bony endplate sclerosis and disc degeneration, we found reduced BV/TV and trabecular thickness early after nucleotomy induced disc degeneration. At later stages of disc degeneration, sclerosis was not higher than in healthy controls, indicating that disc degeneration can proceed independently from endplate sclerosis.

**Conclusion:** The vertebral bone is highly reactive to disc disturbances but does not automatically react with increased sclerosis.

### P317

#### CHANGE IN PAIN BEHAVIOR AND CELLULAR ACTIVITY IN DORSAL HORN AFTER PULSED RADIOFREQUENCY ON CHRONIC RADICULOPATHIC PAIN

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**Introduction/Aim:** This study is to investigate the effect of pulsed RF on pain-related behavior and the change in cellular activity of spinal dorsal horn after pulsed RF on DRG in chronic radiculopathic pain.



**Methods:** Following establishment of mechanical allodynia and thermal hyperalgesia on the ipsilateral hindpaw, rats with radiculopathic pain behavior were randomly assigned to pulsed RF (+) and pulsed RF (-) groups (n = 6 for each group) and the pulsed RF procedure was performed on the ipsilateral DRG (left L5) by placement of the electrode perpendicularly to the DRG on 30 days after the surgery. Stimulation parameters were set as follows: 2 bursts/sec, pulse duration = 20 msec, output voltage = 45 V, maximum temperature = 42 °C, and stimulated time = 120 sec. Mechanical allodynia and thermal hyperalgesia were tested on the five time points, 1, 3, 10, 20 and 30 days after pulsed RF. At thirty one days after pulsed RF, expressions of OX-42 (for microglia), phosphorylated form of ERK (pERK), and NK1 (for neurokinin 1, receptor for substance P) were examined.

**Results:** After the pulsed RF treatment in chronic radiculopathic models, the withdrawal threshold for mechanical stimuli on both hindpaws was markedly increased throughout the experimental periods and the withdrawal latency for heat stimuli on both hindpaws was increased during 14 days. The expressions of OX-42, pERK and NK1 were dramatically attenuated in microglia or dorsal horn of L5 spinal cord after the pulsed RF stimulation on DRG.

**Discussion:** Even though the chronic long-standing radiculopathic pain, the mechanical allodynia was reversed by pulsed RF for the long duration. The thermal hyperalgesia was attenuated by the stimulation for 14 days. The treatment of pulsed RF on DRG also results in the decrease of microglial activity, and the reduced expression of pERK and NK1 on the spinal dorsal horn, which might be implicated with the attenuation of pain behavior.

**Conclusion:** This study demonstrated that pulsed RF application on the DRG might modulate or interrupt the activities of primary afferent impulses from injured neurons to microglial signaling in the spinal dorsal horn.

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### P318

#### WHO IS LIKELY TO DEVELOP PERSISTENT LOW BACK PAIN? A LONGITUDINAL ANALYSIS OF PROGNOSTIC OCCUPATIONAL FACTORS

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**Introduction:** Socioeconomic costs of persistent low back pain (LBP) exceed the costs of acute and subacute LBP by far. This makes the early identification of patients at risk of developing persistent LBP essential. By differentiating risk from protective factors, these factors could be addressed proactively to limit the associated socioeconomic burden.

**Aim:** To identify factors influencing the progression of acute/subacute LBP to the persistent state.

**Patients and Methods:** Prospective inception cohort study of patients attending a health practitioner for their first episode of acute/subacute LBP. Patients were assessed at baseline addressing occupational, psychological, biomedical and demographic/lifestyle factors and followed up over six months according to the recommendations from the Multinational Musculoskeletal Inception Cohort Study (MMICS) Statement. Multivariate logistic regression analysis was performed separately for the variables groups of the four different domains,

controlling for age, gender and body mass index. The overall predictive value was calculated for the full regression models of the different domains. Finally, all significant variables from the different domains were combined into a final predictor model.

**Results:** The final four-predictor model predicted 51% of variance of persistent LBP and included 'resigned attitude towards the job' (OR 1.73; CI95% 1.16-2.59), 'social support at work' (OR 0.54; CI95% 0.32-0.90), 'functional limitation' (OR 1.05; CI95% 1.01-1.10) and 'duration of LBP' (OR 1.04; CI95% 1.02-1.06). The accuracy of the model was 83%, with 92% of non-persistent and 67% of persistent LBP patients correctly identified.

**Conclusion:** In this study of patients with acute/subacute LBP, 'resigned attitude towards the job' increased the likelihood of persistent LBP at six months. Addressing this factor with workplace interventions has the potential to modify the outcome. 'Social support at work' was a protective factor meaning that development of persistent LBP was less likely. It can therefore be considered as resource for prevention of persistent LBP. Findings from this study confirm the requirement for measurement of occupational factors in screening tools for patients at risk of developing persistent LBP. Further research is required to investigate different types of social support at work regarding their prognostic influence on the development of persistent LBP.

### P319

#### PREDICTORS OF SICKNESS ABSENCE IN PATIENTS WITH A NEW EPISODE OF LOW BACK PAIN IN PRIMARY CARE

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**Introduction:** Although there is a call for early risk prediction of sickness absence, specific prognostic factors of low back pain (LBP) related sickness absence have not yet been established in either clinical or research settings. This study examines predictors of sickness absence in patients presenting to a health practitioner with acute/subacute LBP.

**Aim:** To identify baseline-variables that detect patients with a new LBP episode at risk of sickness absence and to identify prognostic models for sickness absence at different time points after initial presentation.

**Patients and Methods:** Prospective cohort study investigating 310 patients presenting to a health practitioner with a new episode of LBP at baseline, three-, six-, twelve-week, six-month follow-up, addressing work-related, psychological and biomedical factors. Multivariate logistic regression analysis was performed to identify baseline-predictors of sickness absence at different time points.

**Results:** The best prognostic model comprised 'job control', 'depression' and 'functional limitation' as predictive baseline-factors of sickness absence at six-week follow-up (sensitivity 43.5; specificity 96.5; overall predictive value 89.0) with 'job control' being the best single predictor (OR 0.49; 95%CI 0.27 – 0.89). This model explained 46% of variance of sickness absence at six-week follow-up (p < 0.001).

The second best model included 'job control' (OR 0.64; 95%CI 0.42 – 0.96) as the only significant predictive baseline-factor for sickness absence at three-week follow-up (sensitivity 45.2; specificity 94.7; overall predictive value 83.9). This model explained 39% of variance of sickness absence (p < 0.001). Sickness absence at a time point beyond six weeks could not be predicted.

**Conclusion:** For patients with acute/subacute LBP, the model has the greatest predictive ability for sickness absence at six weeks after initial presentation to a health practitioner. The

prediction of sickness absence beyond six weeks is limited, and health practitioners should re-assess patients at six weeks, especially if they have previously been identified as at risk of sickness absence. This would allow timely intervention with measures designed to reduce the likelihood of prolonged sickness absence. Further research is warranted investigating assessment at different time points, to identify the optimal time at which to re-assess at risk acute/subacute LBP patients in order to accurately predict sickness absence.

### P320

#### COURSE OF RECOVERY IN PATIENTS WITH ACUTE LOW BACK PAIN – DOES DEPRESSION MATTER?

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**Introduction:** While there is extensive knowledge on the course of acute low back pain (LBP), little is known about the course of recovery of acute LBP patients as a function of depression.

**Aim:** To determine if the course of recovery in patients with acute LBP differs in relation to the presence/ absence of depression and to identify the best time point for an intervention against LBP-associated depression.

**Patients and Methods:** Prospective cohort study of 286 patients with acute LBP. Patients were assessed at baseline and followed up over six months addressing psychological, occupational, biomedical and demographic/ lifestyle factors. Recovery was defined as improvement in functional limitation measured by the Oswestry Disability Index (ODI); depression was defined by the Zung depression scale. Repeated-measures analysis of covariance (ANCOVA) was employed with ODI as repeated factor, age, gender and body mass index as co-variables, depression and all other potential prognostic factors as between-subject factors. A second ANCOVA was performed with depression as dependent variable and functional limitation, pain intensity and job stressors as potential predictor variables.

**Results:** Eighteen per cent of study participants were classified as depressive. In these patients the course of recovery was slower than in non-depressive patients. ODI scores in the non-depression-LBP group decreased over time, whereas scores in the depression-LBP group remained at the same level ( $F(3.295, 431.607)=4.63$ ;  $p<0.01$ , partial  $\eta^2=0.034$ ; Figure 1). High functional limitation ( $F(1.261)=15.79$ ;  $p<0.001$ , partial  $\eta^2=0.057$ ), high pain intensity ( $F(1.260)=6.84$ ;  $p<0.01$ , partial  $\eta^2=0.026$ ) and a high job stressor index ( $F(1.252)=8.95$ ;  $p<0.01$ , partial  $\eta^2=0.034$ ) were predictors of depression at baseline. Further, the presence of depression caused maintenance of LBP especially after six weeks.

**Conclusion:** The presence of depression has a negative influence on the course of recovery in patients presenting with a new episode of LBP. Therefore, depression should be included in screening instruments for patients with acute LBP to identify those at risk of delayed recovery at an early stage. Further research is required investigating interventions at different time points, to identify the optimal time at which to treat acute LBP patients with concomitant depression in order to reduce the socioeconomic costs of delayed recovery.

### P321

#### DISC DEGENERATION IN LUMBAR SPINE PRECEDES OSTEOARTHRITIC CHANGES IN THE HIP: A POSTMORTEM STUDY OF 350 HUMAN SPECIMENS

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**Introduction:** WA Saunders studied 150 patients and found that lumbar DDD was three times more common in patients with hip OA. However it is not clear whether the spinal degeneration led to hip arthritis or if the hip degeneration led to spinal decompensation. The aim of this study is to determine which degenerative process precedes the other.

**Materials and Methods:** 350 human cadavers from the Hamann-Todd Osteological collection in Cleveland were examined for evidence of endplate arthrosis in lumbar spine and OA changes in the hip. Degeneration of the lumbar endplates was graded on a scale of 0 to 4 using the Eubanks modification of the Kettler classification. The hips for each specimen were also graded for degeneration on a scale from 0-3, as per the Abdullian modification of the Cooperman classification for hip degeneration. Linear regression was used to analyze the relationship between hip OA and lumbar endplate degeneration. Fisher exact tests were performed with subjects grouped by decade of age, and to identify differences in each age group.

**Results:** Hip OA is significantly associated with endplate degeneration at L1, L3 and L5 levels ( $p < 0.02$ ). In the age group of 20 to 29 years, 35% specimens had evidence DDD in at least one lumbar level as compared to only 17% with hip OA changes. At 70 yrs 100% specimens had evidence of DDD in lumbar vertebrae while hip OA changes were present in only 50%. Fisher exact tests demonstrated significant differences in each age group ( $p<0.01$ ).

**Conclusions:** Based on our study of a large population of adult skeletal specimens, it appears that lumbar DDD changes precede hip OA, with one third of the population in their 20's showing evidence of early DDD of lumbar spine. Lumbar DDD changes are present in all subjects over 70 years of age while OA changes in hip are present in only 50%.

### P322

#### STUDY OF FACTORS AFFECTING OUTCOME OF CONSERVATIVE TREATMENT OF LUMBAR DISC HERNIATION

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**Introduction:** Conservative management still remains a major treatment modality of Lumbar disc herniations. Response to conservative management depends on variety of factors including patient's personality, clinical presentation and MRI appearance. We studied pretreatment clinical, functional and MRI characteristics of our series of conservatively treated patients and correlated with the final outcome in terms of pain relief and ODI score.

**Material and Methods:** Retrospective data from 2004 to 2009 of patients treated conservatively for diagnosed lumbar disc herniation was collected. Patients with neurodeficit (MRC Grade<3/5), progressive neurodeficit, Cauda Equina syndrome and agonizing rest pain were treated surgically and were excluded from the study. A total of 101 patients with more than 1 year follow up were included for the study and their pretreatment clinical data (back and leg VAS, ODI scores) and MRI data (disc



morphology, nerve root compression, vertebral height and disc height) were recorded. Follow up Clinical data, functional scoring and MRI data was done prospectively.

**Results:** Mean age of patients was 41.67±12.19 years with 40 females and 61 males. Mean duration of follow up was 2 years. The mean pretreatment back and leg VAS improved from 2.98 to 1.66 and 7.85 to 2.11 respectively. The ODI improved from 58% to 17% with 74 excellent, 27 good results and no poor or fair results. Pretreatment disc grade was grade 3 in 20, grade 4 in 78 and remaining grade 5 which showed improvement at final follow up with grade 1 in 65, grade 2 in 32, grade 3 in 7 and grade 4 in 2. When final outcome in terms of ODI and leg pain VAS was compared with pretreatment factors, only grade of nerve root compression positively affected the outcome in more patients with severe nerve root compression responding better to conservative management. Age, gender, disc morphology, disc height and vertebral height did not affect the outcome.

**Conclusion:** Conservative management of lumbar disc herniation gives good to excellent outcome at midterm follow up. Favorable outcome was directly proportional to severity of nerve root compression.

### P323

#### FRACTURE UNION AND QUALITY OF LIFE IN PATIENTS WITH OSTEOPOROTIC VERTEBRAL FRACTURE TREATED WITH RIGID OR SOFT EXTERNAL SUPPORT

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**Background:** Bone union generally serves as a primary endpoint in the treatment of fractures. However this concept has long been neglected in the treatment of osteoporotic vertebral fractures (OVFs).

**Materials and Methods:** Forty-eight patients suffering from OVFs, who had been treated with a plaster cast followed by a rigid orthosis, composed of the cast group. Forty-three patients, who had been treated with a soft orthosis, composed of the soft orthosis group. These groups were compared regarding demographic data, union status of OVFs, visual-analog scale (VAS), the Roland and Morris disability (RMD) questionnaire, the Oswestry Disability Index (ODI), and the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ). Vertebrae showing any measurable changes in the vertebral body height between supine and sitting lateral radiographs were referred to as "unhealed". The average follow-up period was 9.1 months for the cast group and 20 for the soft orthosis group.

**Results:** In the cast group, 87% of the vertebrae was referred to as union. In contrast, the union rate in the soft orthosis group was 63%. Nevertheless, none of the local kyphosis angle, VAS, RMD, ODI scores, domains of JOABPEQ were significantly different between them. In contrast, patients with healed OVFs showed significantly better RMD scores, ODI than those with unhealed.

**Discussion:** This is the first report demonstrating the efficacy of rigid external support in the healing of OVF. Measurement of dynamic vertebral mobility serves as a simple diagnostic tool of union status of OVFs. While the role of external support in the treatment of OVF has been limited to pain control, it may have been underestimated in the literature.

**Conclusions:** Along with pain and QOL of the patients, union status should be evaluated in studies addressing therapeutic efficacy of the treatments of OVF.

### P324

#### THE STATISTIC ANALYSIS OF THE FACTORS TO INDUCING THE VEGFR2 POSITIVE ENDOTHELIAL CELLS IN THE LIGAMENTUM FLAVUM

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**Object:** Vascular endothelial growth factor receptor 2 (VEGFR2) plays an important role in the tissue angiogenesis. We studied the factors involved in appearance of the VEGFR2 positive endothelial cells in the adult human ligamentum flavum with statistical method.

**Materials and Methods:** The ligamentum flavum was surgically obtained from 32 patients (34~76 yo, mean 61.6 yo; 17 males, 15 females; 3 thoracic and 29 lumbar; 6 disc herniation, 11 canal stenosis, 4 spondylosisthesis, 6 ossification, 1 superior facet syndrome, 2 ganglion cyst, 1 lipomatosis, and 1 meningioma). The grade of degeneration was Grade 0 in 3 cases, Grade 1 in 5 cases, Grade 2 in 12 cases and Grade3 in 11 cases. Specimens were pathologically stained with HE, EVG, AZAN, Congo red and immunohistochemically examined with CD31, CD34, VEGFR2, vWF. The relationship between VEGFR2 immunoreactivity and other factors including the clinical data (age, instability of flexion and extension, thickness of ligaments on CT myelography) was analyzed by Pearson's correlation coefficient test.

**Results:** Correlations were observed between VEGFR2 positive endothelial cell appearance and age ( $r = -0.29$ ), instability ( $r = -0.33$ ), thickness of ligament ( $r = 0.16$ ), the grade of degeneration ( $r = 0.20$ ), deposition of the amyloid ( $r = -0.06$ ), CD34 positive stromal cell appearance ( $r = 0.41$ ), VEGFR2 positive stromal cell appearance ( $r = 0.34$ ), and CD34 positive endothelial cell appearance ( $r = 0.83$ ).

**Discussion:** Aging and instability were considered as inhibitory factors for VEGFR2 positive endothelial cell appearance. Expressions of VEGFR2 and CD34, whose correlation appeared to be very strong, may play an important role in angiogenesis in the ligamentum flavum. The VEGF-related angiogenesis has been reported to be involved in CD34 positive endothelial progenitor cell appearance in the adult human and the results of the present study demonstrates a similar mechanism underlying the angiogenesis in the ligamentum flavum.

**Conclusion:** The VEGFR2 positive endothelial cell appearance in the adult human ligamentum flavum angiogenesis has a strong correlation with CD34 positive cell appearance.

### P326

#### SYMPTOMATIC LAMINOLYSIS IN ADOLESCENT ATHLETES

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**Introduction/Aim:** Bony defects in the spine are divided into three main types: spondylolysis, pediculolysis, and laminolysis. Lumbar spondylolysis is a well-known stress fracture that occurs frequently in adolescent athlete. Pediculolysis means stress fracture of the pedicle that sometimes occurs subsequent to unilateral spondylolysis. Laminolysis is a rarely reported stress fracture similar to spondylolysis and pediculolysis and sometimes causes low back pain (LBP). However, its pathomechanism has not been elucidated. In this paper, we report four adolescent athletes with symptomatic laminolysis.

**Materials and Methods:** Mean age of the four patients with symptomatic laminolysis was 15.8 (range: 15–17) years. All subjects experienced severe LBP exacerbated by extension of

the lumbar spine. To make a correct diagnosis of laminolysis, as plain X-ray findings were subtle, multi-detector 3-dimensional CT, MRI were performed. Furthermore, to elucidate the mechanisms, we performed a biomechanical study.

**Results:** Two types (hemilaminar type, and intralaminar type) radiologically in the laminolysis were found. MRI demonstrated a high intensity on STIR images, which could indicate inflammation. From the biomechanical study, we found that the hemilaminar type was thought to be subsequent to contralateral spondylolysis, while the intralaminar type might be a result of a stress fracture due to repetitive extension loading.

**Discussion:** We found two types of laminolysis: hemilaminar type and intralaminar type. The former has a cleft in the unilateral pars and the latter has a coronal fracture line though both laminae. In a biomechanical study, Sairyō et al. reported that extension loading causes a more coronally oriented fracture line, while rotational loading causes a more sagittally oriented fracture line. Therefore, the intralaminar type is considered to result from a stress fracture due to repetitive extension loading. In the presence of hemilateral spondylolysis, axial rotation of the contralateral pedicle and pars interarticularis increases stress an average of 6.8-fold, with a 12.6-fold increase being the highest.

**Conclusion:** There were two types (hemilaminar type, and intralaminar type) radiologically in the laminolysis.

### P327

#### LIMAPROST ALFADEX AND NONSTEROIDAL ANTI-INFLAMMATORY DRUGS FOR SCIATICA DUE TO LUMBAR SPINAL STENOSIS

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**Introduction/Aim:** It has been considered that PGE<sub>1</sub> administration increases blood flow of the nerve root and, thereby improves neurogenic intermittent claudication and disability in patients with lumbar spinal stenosis (LSS). However, it has not been clarified whether PGE<sub>1</sub> itself alleviates pain associated with LSS-induced radiculopathy. The aim of this study is to compare the efficacy of limaprost, an oral prostaglandin E<sub>1</sub> derivative (PGE<sub>1</sub>), with nonsteroidal anti-inflammatory drugs (NSAIDs) and combination therapy.

**Patients and Methods:** This study was a multicenter, prospective randomized trial. Patients with LSS who had radiculopathy assessed based on a self-reported diagnostic support tool were randomized into three treatment groups. Limaprost (group A), NSAIDs (group B), or limaprost plus NSAIDs (group C) were administered orally for 6 weeks. Low back pain (LBP), leg pain, cold sensation of foot, and leg numbness were measured by a numerical rating scale both at rest and on movement. The Roland-Morris Disability Questionnaire (RDQ), Short Form (SF)-36, and subjective satisfaction were assessed as secondary outcomes.

**Results:** Sixty-one patients were finally enrolled in the study. Each treatment significantly reduced radicular pain on movement, and earlier response and better outcomes were confirmed in group C. An apparent alleviation of LBP and a decrease in RDQ score was seen in groups B and C. Cold sensation at rest was reduced in groups A and C. In group C, the SF-36 subscales for physical function and body pain showed a significant improvement. There were no significant differences among groups in subjective satisfaction at the final follow-up.

**Discussion:** Limaprost induced a reduction in radicular pain and cold sensation; however, there was no apparent improvement in LBP or health-related QOL. A combination of limaprost plus NSAIDs showed more favorable outcomes than monotherapy with either agent.

**Conclusion:** Limaprost could reduce sciatica and combination therapy with limaprost plus NSAIDs showed the best efficacy.

### P328

#### 3D-CT ANALYSIS ON PRESERVATION OF POSTERIOR ELEMENTS AFTER MICROENDOSCOPIC DECOMPRESSION SURGERY FOR LUMBAR FORAMINAL STENOSIS

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**Introduction:** Spinal surgeons have struggled to decompress hidden zone pathology without removing the isthmus and the facet joint to cause spinal instability. Preservation of these posterior elements has led to the detriment of an adequate decompression of the foramen, while adequate decompression has been completed at the expense of the posterior elements, which has possibly led to subsequent instability. The aim of this study is to evaluate preservation rates of the posterior elements when we choose microendoscopic decompression surgery for lumbar foraminal stenosis (MED-FS) and assess the efficacy of this minimally invasive technique on prevention of iatrogenic instability.

**Materials and Methods:** The authors retrospectively reviewed data obtained in 47 consecutive patients (26 males and 21 females, averaged age at surgery 68.9 years) who underwent MED-FS. Clinical results were evaluated according to the JOA score (points), VAS (mm) for low back pain, leg pain and numbness before surgery and at final follow-up. The percentage of the posterior elements preservation was calculated using the following equation: percentage of preserved posterior elements = the length of the postoperative posterior elements / the length of the preoperative posterior elements × 100.

**Results:** The mean FU period was 2 years and 1 month. Clinically symptomatic iatrogenic instability was infrequent. No case required secondary fusion due to low back pain, but three patients required revision surgery to correct insufficient decompression in the foramen. In the remaining patients, the mean JOA score was 14.5 before surgery and 22.0 at the final FU. The JOA scores improved significantly after surgery. The mean recovery rate was 55.3%. The mean VAS score of low back pain, leg pain and numbness significantly decreased from 54.5, 71.0 and 53.4 preoperatively to 32.5, 25.8 and 25.0, respectively. The mean percentages of preserved isthmus and facet were 97.3% and 94.5%, respectively.

**Discussion:** MED-FS can reduce postoperative segmental spinal instability and achieve good postoperative clinical outcomes in patients with FS. MED-FS provides surgeons with good visibility and improves preservation of the posterior elements utilizing the property of its oblique view and angled surgical equipment. This procedure has produced long-lasting favorable outcomes.

**Conclusion:** Novel minimally invasive surgery may replace conventional open methods.





P329

### MEASUREMENT OF THE LOW BACK MUSCLE ACTIVITIES DURING LUMBAR STABILIZATION EXERCISES

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**Introduction:** There have been often reported that selective training for lumbar multifidus muscle (MF) is important to stabilize the lumbar spine. The purpose of this study was to determine which lumbar stabilization exercise was effective on MF.

**Methods:** Informed consent to inclusion in this study was obtained from 13 healthy adult men. Each subject was performed the following 6 exercises: four-point kneeling with right leg extension (A), four-point kneeling with left arm and right leg extension (B), sitting lean-forward (C), bridge (D), bridge with right leg extension (E), bridge with left leg extension (F). The muscle activities of the right MF and right lumbar part of the iliocostalis lumborum muscle (LIL), and right thoracic part of the iliocostalis lumborum muscle (TIL) were measured using the surface electrodes. Average amplitudes, which were obtained during the exercises, were normalized to the amplitude in maximal voluntary contraction (MVC) for each muscle, then the %MVC values, MF/LIL and MF/TIL ratios were calculated. The results were statistically compared among the 6 exercises by One-way ANOVA.

**Results:** The %MVC values of MF in E (mean, 57.1%) and F (51.9%) were significantly higher than in the other 4 exercises. The %MVC value of LIL in E (61.0%) and that of TIL in E (50.9%) were significantly higher than in the other 5 exercises. The MF/LIL ratio in A (2.1) and the MF/TIL ratio in A (3.5) were significantly higher than in the other 5 exercises.

**Discussion:** These findings suggest that E and F exercises are effective on training MF, LIL, and TIL, however, these are high load exercises and poorly efficient concerning the selective training for MF. On the other hand, the MF/LIL and MF/TIL ratios during four-point kneeling with right leg extension were significantly higher than the other exercises. Therefore, the lumbar stabilization exercise on four-point kneeling with right leg extension is efficient concerning the selective training for right side lumbar multifidus muscle. These findings may be available and be important for clinicians in selecting exercises.

P330

### THE EFFECTS OF PROOPIOMELANOCORTIN GENE TRANSFECTION IN A RAT LUMBAR DISC INJURY MODEL

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**Introduction:** Lumbar intervertebral disc degeneration sometimes causes chronic low back pain. Recently, opioids have been widely used in the treatment of various kinds of pain, but produce various side effects. On the other hands, endogenous opioids are clinically safe, but they are not used for clinical

treatment because of their fast metabolism. Endogenous opioid genes transferred to cells *in vivo* could produce analgesia without side effects. This study investigated the effects of POMC (proopiomelanocortin, the precursor for  $\beta$ -endorphin, an endogenous opioid) gene transfection using radial shock waves (RSWs) in a rat lumbar disc injury model.

**Materials and Methods:** Male Sprague-Dawley rats were used. The retrograde neurotracer Fluoro-Gold was applied to the surfaces of L4/5 discs to label their innervating DRG neurons. Of 15 rats, 5 were in a non-punctured disc sham surgery control group, whereas the other 10 were in experimental groups in which intervertebral discs were punctured with 24-gauge needles. Half of these 10 were injected with 100 $\mu$ g POMC gene into their left gastrocnemius muscle before exposure to RSWs. Seven days after surgery, blood was sampled from the heart, and blood  $\beta$ -endorphin concentrations were assayed using ELISA. L1-L6 DRGs from all groups were harvested, sectioned, and immunostained for calcitonin gene-related peptide (CGRP, a pain-related neuropeptide).

**Results:**  $\beta$ -endorphin blood levels increased significantly in the POMC group ( $p < 0.01$ ). In Fluoro-Gold-labeled neurons, the proportion of CGRP-immunoreactive neurons was 38.4% in the control group, 68.3% in the puncture group, and 54.1% in the POMC group. The proportion of CGRP-immunoreactive neurons was therefore significantly increased in the puncture group compared with the control group ( $p < 0.05$ ) and significantly decreased in the POMC group compared with the puncture group ( $p < 0.05$ ).

**Discussion:** CGRP was upregulated in DRG neurons innervating damaged discs. However, POMC gene transfection suppressed CGRP expression. These findings suggest the effectiveness of POMC gene transfection using RSWs for the treatment of discogenic low back pain.

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### IS ACTIVATION OF TRANSVERSUS ABDOMINIS AND OBLIQUUS INTERNUS ABDOMINIS ASSOCIATED WITH LONG-TERM CHANGES IN CHRONIC LOW BACK PAIN?

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**Objective:** To investigate associations between deep abdominal muscle activation and long-term pain outcome in chronic nonspecific low back pain (LBP).

**Methods:** Recruitment of transversus abdominis (TrA) and obliquus internus abdominis (OI) during the abdominal drawing in manoeuvre and anticipatory onset of abdominal muscle activity was recorded with ultrasound. Recordings were done before and after 8 weeks with exercises for 109 patients. Pain was assessed with a numeric rating scale (NRS) (0-10) before and one year after intervention. Associations between muscle activation and long-term pain were examined by linear and logistic regression methods.

**Results:** Participants with a combination of low baseline lateral slide in TrA and increased slide after intervention had better odds for long-term clinically important pain reduction ( $\geq 2$  points on NRS) compared to participants with small baseline slide and no improvement in slide (OR = 14.70, 95% CI 2.41 to 89.56). There were no associations between contraction thickness ratios in TrA or OI and pain at one year follow-up. TrA lateral slide before intervention was marginally associated with a lower odds ratio for clinically important improvement in pain at one year follow-up (OR = 0.76, 95% CI 0.62 to 0.93). Delayed onset of the abdominal muscles after the intervention period was weakly associated with higher long-term pain.

**Discussion:** Altered function in TrA has been found in LBP, including changes in timing and changes in contraction thickness and slide. But the connection between recruitment of TrA and OI and long-term low back pain is not known. In this study, improved TrA lateral slide among participants with low baseline slide was associated with clinically important long-term pain reduction. High baseline slide and delayed onset of abdominal muscles after the intervention period were weakly associated with higher pain at one year follow-up.

### P332

#### ANALYSIS OF ADOLESCENT PATIENTS WITH MRI SIGNAL CHANGES IN THE ADJACENT PEDICLE IN FRESH LUMBAR SPONDYLOLYSIS

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**Introduction/Aim:** Recent advances of diagnosis using MRI provide us with early diagnosis of spondylolysis. Therefore, bony healing can be expected before the defects are completed. In this study, we examined adolescent patients with MRI signal changes in the adjacent pedicle in fresh lumbar spondylolysis, and analyzed the prevalence comparing with the previous one from the multidetector CT analysis (Sakai, et al. Spine 2009).

**Materials and Methods:** A total of 98 adolescent patients (31 women and 67 men) with MRI signal changes in the adjacent pedicle in fresh lumbar spondylolysis were included in the study. The MRI signal changes are defined as high signals using fat-suppressed images. Mean patient age was 13.6 (9 to 18) years.

**Results:** In the 98 patients, MRI signal changes were detected in 150 adjacent pedicles of 101 vertebrae. Of them, only 67 (66.3%) corresponded to L5, and 34 (33.7%) to L3 or L4. In addition, out of 34 vertebrae with signal changes in L3 or L4, 11 (32.4%) were accompanied with the terminal-stage spondylolysis (no MRI signal change) in L5.

**Discussion:** In the previous report using multidetector CT to detect the terminal-stage spondylolysis in adult population, L3 or L4 spondylolysis was found in only 8.8% (Sakai, et al. Spine 2009). However, in this study, MRI signal changes indicating fresh spondylolysis were found in L3 or L4 (33.7%). This discrepancy suggested the L3 or L4 spondylolysis could be healed conservatively or spontaneously. In addition, L3 or L4 fresh spondylolysis often accompany with the terminal-stage spondylolysis in L5. Therefore, even if L5 terminal-stage spondylolysis is detected, we need to pay attentions to L3 or L4 fresh spondylolysis as well, particularly in patients with severe low back pain. MRI would be warranted for correct diagnosis.

**Conclusion:** This study based on MRI showed a higher prevalence of L3 or L4 spondylolysis than those based on CT.

### P333

#### MRI-BASED DIAGNOSIS AND FOLLOW-UP PROGRAM FOR ADOLESCENT ATHLETES SUFFERING FROM EARLY-STAGE LUMBAR SPONDYLOLYSIS

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**Background:** Lumbar spondylolysis (LS) is a common cause of low back pain in adolescent athletes. The early diagnosis and treatment is crucial for an earlier return to full activity. While Magnetic Resonance imaging (MRI) has enabled us to diagnose early-stage LS, the proper timing for patients to restart sport activities remains controversial.

**Materials and Methods:** Diagnostic criteria of early-stage LS include acute low back pain, lack of LS in plain radiographs and high signal intensity at the pars interarticularis in STIR-MR images. Between April 2010 and June 2011, 29 adolescent athletes met the criteria. There were 22 boys and 7 girls with the average age of 14.5 years (11-17). Levels of affected vertebra were L3 in 4 patients, L4 in 13 and L5 in 12. Eight patients exhibited bilateral lesions. Treatment consisted of discontinuation of sport activities, soft lumbar brace, and physical therapy. At the time the size of the high signal intensity area was decreased by 80% or more in follow-up STIR-MR images, a CT scan was taken to evaluate bony healing. Those confirmed having LS healed were allowed to return to sport activities. Patients showing bony healing and those with no healing CT images were compared with regard to demographics.

**Results:** The duration from diagnosis to follow-up CT scans was 60 days on average (28-95). At this time, 20 patients (69%) showed bony healing of LS. The remaining 9 patients included 5 cases with bilateral SL and 3 cases with chronic LS at the adjacent vertebra.

**Discussion:** In the literature, the patients with early-stage LS returned to sport activities 3 months after diagnosis on average. Our study indicated the possibility of an earlier return with exception of complicated cases.

**Conclusion:** A decrease by 80% of the high-signal area at STIR-MR images serves as an indicator for allowing the adolescent athletes with early-stage LS to return to the sports activity.

### P334

#### A NOVEL BACTERIA-RESISTANT IMPLANT PREVENTS IMPLANT-ASSOCIATED INFECTION

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**Introduction:** Implant-associated infection of the spine often requires prolonged use of antibiotics and surgical debridement, and is one of the most serious surgical complications that should be avoided. Current bacteria-resistant implants do not always provide consistent antibacterial effects *in vivo*. We report a novel technique of uniformly-dense ionic silver coating that provides a significant antibacterial effect *in vivo*.

**Materials and methods:** A novel bacteria-resistant implant was fabricated as follows: i) formation of hydroxyapatite (HAp)



film on titanium implant, ii) surface modification of HAp film with inositol phosphate (IP6), and iii) fixation of Ag<sup>+</sup> ions on the HAp films surface-modified with the IP6. Inductively coupled plasma atomic emission spectrometer was used for determination of the amount of Ag<sup>+</sup> ions. To evaluate the antibacterial effect of implants *in vitro*, either ionic silver-coated or non-coated titanium pin simulating a spinal rod was placed on bioluminescent strain of *Staphylococcus aureus* (*S. aureus*). Then, bacterial photon intensity (PI) was measured by bio-imaging (BI). For *in vivo* analyses, *S. aureus* was inoculated into the medullary cavity of the femur, and either ionic silver coated (ionic silver group) or non-coated titanium pin (control group) was inserted. Bacterial PI was measured sequentially by BI. Serological and histological analyses were also performed.

**Results:** Ionic silver-coated titanium pins produced significantly larger growth inhibition zones against the bacteria ( $P < 0.001$ ). In the mouse infection model, sequential analyses of bacterial luminescence revealed that mean PI in the ionic silver group was significantly lower than that in the control group ( $P < 0.01$ ). Surprisingly, no bacterial signals were detected at 21 days in the ionic silver group. Serum Interleukin-6 and C reactive protein levels in the ionic silver group were significantly lower in early phase and after day 14, respectively ( $P < 0.01$ ). Histological manifestations of osteomyelitis such as proliferation of fibroblasts and development of sequestrum were found less frequently in ionic silver group.

**Discussion:** Ionic silver coating successfully provided consistent antibacterial effect *in vivo*. Since this coating is achieved by immersion reaction, it can be applied to complicated structure and various materials used in spinal implants.

**Conclusion:** This novel ionic silver coating technique can be applied to various spinal implants for prevention of implant-associated infection.

### P335

#### LUMBO-PELVIC SAGITTAL ALIGNMENT IN PATIENTS WITH LUMBAR CANAL STENOSIS ACCOMPANIED BY INTERMITTENT CLAUDICATION

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**Introduction:** It is known that in lumbar spinal canal stenosis (hereinafter LCS) with cauda equine intermittent claudication, lumbar spinal alignment is changed in the sitting posture, dural outer pressure is decreased, and blood flow of the cauda equine is improved, leading to disappearance of lower extremity symptoms. In this study, we measured spine / pelvis sagittal alignment in the standing and sitting postures in order to examine the relationship between the occurrence of cauda equine intermittent claudication due to LCS and the alignment of lumbar spine and pelvis.

**Materials and Methods:** Subjects were 49 patients (mean age 69.4) and 39 younger adults (mean age 31.5 years) with lumbar spinal canal stenosis with cauda equine intermittent claudication as a chief complaint without pain in the sitting posture. Plain lateral radiographs of the lumbar spine were taken in the standing posture and sitting posture with backrest on, and lumbar lordotic angle (LLA), sacral slope angle (SS), and pelvic rotation angle (PA) were examined.

**Results and Discussion:** Alignment changes between the standing and sitting postures included LLA 17.9° and 9.2°, SS 18.3° and 11.3°, and PA 19.7° and 12.8° in the ordinary group and LCS group, respectively. The correlation coefficient between lumbar spinal lordosis and pelvic rotation was  $r = 0.60$ ,  $p < 0.01$  in the ordinary group, and  $r = 0.35$ ,  $p = 0.02$  in the LCS group. It is known that in cauda equine type LCS, lumbar spinal lordosis

is reduced due to change with time in addition to cauda equina syndrome, and the results in this study revealed that in the cauda equine type LCS group, the interlock property of lumbar spine with the pelvis (compensatory action) was decreased in comparison with the younger ordinary group. Namely, in both the ordinary and LCS groups, the pelvis tilts forward, sacral slope is increased, and lumbar spinal lordosis is increased in the standing posture; however, in the LCS group, alignment is rigid in the ratio of standing / sitting posture.

### P336

#### EFFICACY OF EPIDURAL ADMINISTRATION OF ANTI-INTERLEUKIN-6 RECEPTOR ANTIBODY ONTO SPINAL NERVE FOR TREATMENT OF SCIATICA IN PATIENTS WITH LUMBAR SPINAL STENOSIS

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**Introduction:** Interleukin-6 (IL-6) is thought to play a crucial role in the radicular pain caused by lumbar spinal stenosis. However, efficacy of inhibition of IL-6 for sciatica in patients with lumbar spinal stenosis has not been clarified. The purpose of the current study was to examine the effect of the anti-IL-6 receptor monoclonal antibody, tocilizumab, on radicular pain by its direct application onto spinal nerves in patients with lumbar spinal stenosis.

**Materials and Methods:** Fifty patients with low back and radicular leg pain caused by spinal stenosis were investigated. In 20 patients we infiltrated 2.0 mL of lidocaine and 80 mg of tocilizumab onto the affected spinal nerve, and 2.0 mL of lidocaine and 3.3 mg of dexamethasone was used in 30 patients. Low back pain, leg pain, and leg numbness were evaluated during 1 month after spinal nerve infiltration.

**Results:** Infiltration of tocilizumab was more effective than dexamethasone for leg pain (3 days, 1, 2, and 4 weeks), low back pain (3 days, 1, 2 and 4 weeks), and leg numbness (3 days, 1 and 2 weeks). No adverse event was observed in either group.

**Discussion and Conclusion:** Our results indicate that direct application of an anti-IL-6 receptor monoclonal antibody, tocilizumab, onto the spinal nerve produced reduction of radicular leg pain, numbness, and low back pain without adverse event. IL-6 may be one of inducer of pain caused by spinal stenosis in humans.

### P337

#### LUMBAR MUSCLE ENDURANCE IN ELDERLY PATIENTS WEARING SOFT LUMBAR CORSETS

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**Introduction:** Soft lumbar corsets were recommended to manage low back pain (LBP). However, it still remains questionable whether wearing soft lumbar corset may weaken lumbar muscle and result in long term dependence.

**Purposes of the Project:** This study was aimed to investigate the effect of lumbar corset on muscular function with muscle endurance evaluation using surface electromyography (SEMG).

**Material and Methods:** A total of 11 female patients with low back pain were assessed by a series of SEMG measurements and visual analog scale (VAS). SEMG data were recorded from paraspinal muscles at L2-5. Instantaneous root mean square

(IRMS) and instantaneous median frequency (IMF) analyses were used to evaluate muscular fatigability respectively. A.

**Results:** The IRMS value significantly abated after the subjects wore lumbar corset ( $p < 0.05$ ) and a slight decrease in the MF slope was found. In other words, the low back muscular contraction activities and the rate of lumbar muscle fatigue could be reduced instantly by wearing lumbar corset. The fatigability of lumbar muscle tended to increase when subjects had worn for 6 weeks. However, it gradually decreased to a baseline state after this period. This illustrates that the rate of lumbar muscle fatigue could be reversible. On the other side, the VAS results revealed a decline in LBP level after lumbar corsets were worn.

**Conclusions:** The spinal compressive load could be alleviated by wearing lumbar corset as it could abate the lumbar muscle myoelectric activities. Moreover, the symptoms of LBP could be relieved by wearing lumbar corset. Even though wearing lumbar corset for 6 weeks would aggrandize the rate of lumbar muscle fatigue, the fatigability of lumbar corset would gradually abate to an original condition while lumbar corset were taken off. No serious and permanent side effect is caused by wearing lumbar corset. Lumbar corset could be considered as an effective and safe tool for the treatment of LBP.

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### P338

#### TRANSLATION AND VALIDATION STUDY OF THE PERSIAN VERSION OF THE FEAR AVOIDANCE BELIEFS QUESTIONNAIRE

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**Background:** The Fear Avoidance Beliefs Questionnaire (FABQ) is a standard measure that is widely used to evaluate the pain-related avoidance views in patients with low back pain (LBP). The objective of this study was to translate the FABQ into Persian (Iranian Language) and to evaluate the internal consistency, reliability and validity of the FABQ.

**Materials and Methods:** The translation and cultural adaptation of the original questionnaire were carried out in accordance with the published guidelines. To investigate construct validity, the correlations between the FABQ and the Oswestry Disability Index (ODI), Hospital Anxiety and Depression Scale (HADS), the Short-Form Health Survey-12 (SF-12), and Pain (VAS) were investigated in 200 patients with LBP. The FABQ was completed by 30 patients in 2 rounds with a 24 hours interval to test reliability. The internal consistency was examined by Cronbach's-alpha coefficient.

**Results:** The Pearson correlation coefficient between the physical and work scales of the Persian FABQ and the ODI, HADS and pain intensity showed positive associations in the expected directions ( $P < 0.001$ ). There were negative correlations between the Persian FABQ and the SF-12 sub-scales that all were significant ( $P < 0.001$ ). The results of Intra-class Correlation Coefficient (ICC) and Cronbach's-alpha coefficients were satisfactory in Persian FABQ.

**Discussion:** The findings indicated that the Persian version of the FABQ has satisfactory reliability, internal consistency, and construct validity to measure pain-related avoidance beliefs in patients with LBP.

**Conclusions:** The Persian FABQ can be employed by clinicians

and researchers in medical, surgical and rehabilitation settings in future outcome studies in Iran.

### P339

#### SPINO-PELVIC RHYTHM AND ITS CORRELATIONS WITH TIGHT HAMSTRINGS

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**Introduction:** It has been reported that low back pain and tight hamstrings may have strong correlations each other. In this study, we investigated the spino-pelvic rhythm during the trunk forward bending motion, and attempted to clarify the specific feature of the rhythm in subjects with the tight hamstrings.

**Methods:** Eighteen healthy male adults without low back pain participated as a volunteer (aged between 20 and 40 yrs). First, we measured the finger-to-floor distance (FFD) at the upright posture, and the value was indicated as 100%. Using a spinal mouse machine, spinal alignment was measured at the following 4 points, i.e., (1) upright posture meaning 100% of FFD, (2) forward bend at 50% of FFD, (3) 25% of FFD and (4) 0% of FFD meaning finger contacting the floor. The changes of the angle of thoracic and lumbar spine as well as the pelvis were calculated.

**Results and Discussion:** From posture 1 to 2 (phase I), spino-pelvic angle moved 104 degree entirely. In this phase, lumbar spine moved mainly. In the second phase (posture 1 to 2), it changed only 16 degree. Interestingly, all but 2 showed negative value in the thoracic motion, meaning thoracic spine extended 4 degree during the trunk flexion motion. In this phase, lumbo-pelvic rhythm showed 2 patterns. In 7 subjects, pelvic motion was greater than the lumbar motion, and remaining showed opposite. In subjects without tight hamstrings (SLRT angle was greater than average of the population), 85% of them showed the pelvic dominant pattern; while, 65% of subjects with tight hamstrings showed lumbar dominant motion. Only 7 subjects could conduct the posture 4. In this phase, only slight motion was noted in the spine and majority of the entire motion was found in the pelvis.

**Conclusion:** We, first, proposed that the paradoxical thoracic motion in the forward bending motion. There are 2 patterns regarding the lumbo-pelvic rhythm, i.e., lumbar dominant or pelvic dominant. In the flexible subject without tight hamstrings showed the pelvic dominant motion. It conclusion, flexible hamstrings may decrease the mechanical loading in the lumbar spine during the trunk motion.

### P340

#### EFFICACY OF THE VIDEO EXERCISE PROGRAM FOR THE LOW BACK PAIN AND PHYSICAL MOBILITY IN THE ELDERLY

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**Introduction:** Low back pain (LBP) affects physical mobility and often triggers disuse syndrome in the elderly. The earliest intervention is necessary to prevent the need for long-term care. This study aimed to 1) develop an exercise program that the elderly could sustainably perform in the community or at home, 2)



investigate whether video or pamphlet is superior as the exercise instruction medium and 3) verify the most useful measure for evaluating this kind of intervention.

**Methods:** We produced two kinds of teaching media, video and pamphlet, describing edited versions of 10 established physical exercises and mobility training. As a pilot study, the changes in pulse rate, percutaneous oxygen saturation and the Borg scale rating of perceived exertion were examined using 20 elderly volunteers. Separately, 120 elderly subjects (mean age, 72.2 years) were recruited and divided into three groups: 1) *group V* (n=43) performed the exercises while watching the video; 2) *group P* (n=41) performed the exercises while reading the pamphlet; 3) *group C* (n=36) did not perform the exercises. Before and three months after the intervention, we evaluated: 1) visual analogue scale (VAS) of low back and knee pain; 2) single-leg stand time; 3) 6 m walk time; 4) Roland–Morris Disability Questionnaire; 5) Oswestry Disability Index; and 6) Short Form-8.

**Results:** The exercise program provided a moderate physical load to the elderly without imposing an excessive cardiopulmonary burden. In group V, a significant improvement was observed in VAS of low back pain, single-leg stand time, 6 m walk time and the physical component summary scale of the Short Form-8, whereas in group P, a significant improvement was observed only in single-leg stand time and the physical component summary scale. No significant change was observed in any parameter for group C.

**Conclusion:** There is a possibility that the video exercise program is an effective tool for improving LBP and locomotive ability in the elderly.

**Conflict of Interest:** We have nothing to declare concerning this study.

#### P341

##### DIAGNOSTIC EFFICACY OF BIPORTAL CORE NEEDLE BIOPSY WITH SALINE FLASH IN PYOGENIC SPONDYLODISCITIS

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**Introduction:** It is important to isolate a causative microorganism in treating pyogenic spondylodiscitis. Here we developed a biportal core needle biopsy technique and evaluated its safety and efficacy.

**Materials and Methods:** Between April 2009 to July 2011, 11 consecutive patients with thoracolumbar pyogenic spondylodiscitis underwent the core needle biopsy. The biopsies were performed 2.6 days on average after the initial visit. There were 9 male and 2 female with the mean age of 70.4 (56-79) years. The biopsy technique was as follows; a patient was placed in the prone position. Using two fluoroscopies, two 8-gage bone biopsy needles were inserted bilaterally into the affected disc through a posterolateral approach under local anesthesia. Transpedicular approach was not used. Disc tissue specimens were collected. Subsequently saline was injected through a needle and collected from the other needle. Half of the tissue specimens were submitted for pathological diagnosis and the remaining half for bacterial culture. The collected saline was also submitted to bacterial culture.

**Results:** Disc specimens were successfully collected from 10 patients, and the saline from all 11 patients. All the disc specimens showed migration of neutrophils. Notably there were cancer cells in addition to neutrophils in one case, leading to the diagnosis of infection with vertebral metastasis. Bacterial cultures came back positive in 9 patients (82%), including Methicillin-resistant *Staphylococcus aureus*, Methicillin Resistant *Coagulase-*

Negative *Staphylococci* and *E.coli* in 2 patients, respectively. There were no complications.

**Discussion:** Our biportal core needle biopsy technique provided both tissue and fluid samples, resulting in the histological evidence of spondylodiscitis in 91% and isolation of a causative organism in 82% of the patients. Pathologic evaluation was crucial in ruling in tumors and other types of infection such as tuberculosis.

**Conclusion:** The present biopsy technique is simple, safe and efficacious in diagnosis of thoracolumbar bacterial infection and neoplasm.

#### P342

##### EFFECTS OF SELECTIVE REHABILITATION ON THE PATIENTS WITH CHRONIC LUMBAR SPINAL PAIN

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**Introduction:** Pain in the lumbar spine is generally designated as low back pain (LBP). Chronic LBP is the most common cause of long term disability. LBP affect about 80% of individuals some times in their life, and is the leading cause of disability also. This people become disable and become burden for the society and they cannot contribute anything for the country. An effort was done to reduce the disability of this people by this study. A prospective randomized clinical trial was done to observe the effects of selective rehabilitation on the patients with chronic LBP.

**Methods:** A total of 139 patients were selected and divided randomly into two groups. Group-A was treated with NSAID and selective rehabilitation and Group-B was treated with NSAID only. NSAIDs in the form of Naproxen (250 mg) twice daily orally was given in both the groups. Selective rehabilitation treatments in the form of activities of daily living instructions, assistive devices and exercise were given in group-A only. Assessment of the patients were done by Visual Analogue Scale, Schober's test, Oswestry Disability Index and Modified Zung Index. Student's t-test and Chi-squared test was done as required to see the level of significance.

**Results:** Improvement was found in both groups after treatment (P=0.001). But in comparison, more improvement was found in the patients receiving selective rehabilitation treatment (p=0.001).

**Discussion:** In the present study, both the group were benefited by the treatment. But the patients given rehabilitation treatment showed more improvement. So, rehabilitation treatment may play an important role to reduce the disability of the patients with chronic lumbar spinal pain.

#### P343

##### WALKING DISTANCE AS A MEASURE OF DISABILITY IN LUMBAR SPINAL STENOSIS

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**Background and Purpose:** Walking distance is used as a measure of the severity in lumbar spinal stenosis (LSS). The purpose of this study was to examine:

- 1) What is the agreement between self-reported and treadmill-based walking capacity?
- 2) Are these measures reproducible over a six months' period?
- 3) Is the self-reported walking distance associated with patients' self-assessed functional capacity?

**Patients and Methods:** A randomized controlled trial assessing the effectiveness of surgical treatment on LSS was conducted. 94 patients were randomized into surgical (n = 50) or conservative (n = 44) treatment. The patients' functional capacity was assessed at baseline, and at 6 months follow-up. Walking capacity was examined by self-report and walking test on a treadmill. Oswestry Disability Index (ODI) was used to assess the patients' self-reported functional capacity.

**Results:** There was a fair agreement between self-reported and treadmill-tested walking distance at baseline (kappa 0.43; 95% confidence interval [95 % CI] 0.29 to 0.56). Among the 44 patients with conservative treatment, the treadmill-measured walking distance was more reproducible after six months than the self-reported distance; the intra-class correlation coefficients (95% CI) were 0.75 (0.51 to 0.92) and 0.41 (0.00 to 0.78), respectively. The self-reported walking distance was inversely related with ODI both at baseline and at the 6 months follow-up. Change in self-reported walking distance from randomization to the follow-up at six months showed an inverse association with respective change in ODI.

**Interpretation:** The treadmill measurement was more reproducible than the subjective evaluation of walking ability. Self-report and performance test yielded quite distinct information on walking capacity, and therefore they complement each other.

#### P344

##### EFFICACY OF RH-PTH 1-34 FOR OSTEOPOROTIC VERTEBRAL FRACTURES - IS FRACTURE HEALING ENHANCED?

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**Introduction/Aim:** Recombinant human PTH 1-34 (Teriparatide) has been increasingly used as the first line treatment for severe osteoporosis, which stimulates bone formation and might have a potential advantage to enhance fracture healing. The current study aimed to evaluate the efficacy of rh-PTH 1-34 for osteoporotic vertebral fractures, and to investigate whether or not it might enhance the fracture healing.

**Materials and Methods:** We reviewed 22 patients who had fresh vertebral fractures related to osteoporosis and treated by rh-PTH 1-34. They were 5 males and 17 females with a mean age of 76 years. Fresh fractures were diagnosed by MRI. Mean bone mineral density of lumbar spine was 0.679 g/cm<sup>2</sup> (65% of YAM). 15 patients (68%) had pre-existing vertebral fractures. Clinical outcomes were evaluated using visual analog scale of back pain. Radiographic parameters included vertebral kyphosis angle and mid-vertebral body height. Fusion status was assessed using flexion-extension radiographs and CT scan (multi-planar reconstruction). Mean follow-up period was 5.3 months. A historical cohort of 52 patients who had fresh vertebral fractures treated by bisphosphonates was used as a control group.

**Results:** Significant pain relief was achieved by rh-PTH 1-34 treatment; VAS decreased from 81/100 to 22/100 at the final follow-up (p<0.01, paired t-test). Vertebral kyphosis angle and body height were 10 degrees and 17 mm before the treatment, and 13 degrees and 14mm at the final follow-up, respectively. Fusion rate was 91% (20/22 patients) in overall; 86% in those with pre-existing vertebral fractures, and 100% in those without pre-existing vertebral fractures. In the control cohort, VAS decreased from 74/100 to 40/100; overall fusion rate was 82%.

**Discussion/Conclusion:** PTH originally had an effect to increase serum calcium through bone resorption, whereas intermittent exposure to PTH stimulates osteoblast to enhance new bone formation. The current study suggested that rh-PTH 1-34 treatment significantly improved back pain related to osteoporotic vertebral fractures, and had favorable results in fusion rate when compared with bisphosphonate treatment.

#### P345

##### PAIN CATASTROPHIZING IN PATIENTS WITH CHRONIC LOW BACK PAIN AFFECTS PAIN-RELATED DISABILITY, BUT NOT PAIN SEVERITY

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**Introduction/Aim:** Pain catastrophizing is a multidimensional construct comprising elements of magnification, rumination and helplessness. Catastrophizing is thought to be an important risk factor for chronic pain and disability, and contributes to heightened anxiety and depression. To improve the detection of risk factors, prevention and treatment of pain, therefore, it is important to obtain an increased understanding of the function of pain catastrophizing in patients with chronic low back pain (CLBP). The purpose of this study was to clarify if pain catastrophizing influenced pain severity, depression, anxiety, and impairment of activities of daily living (ADL) in patients with CLBP.

**Materials and Methods:** One hundred patients with CLBP were participated in this study. There were 57 males and 43 females. The mean age was 62.5 years. They were required to complete a set of questionnaires, which consisted of Pain Catastrophizing Scale (PCS), Pain Anxiety Symptoms Scale-20 (PASS-20), Hospital Anxiety and Depression Scale (HAD), Roland-Morris Disability Questionnaire (RDQ), and Visual Analogue Scale (VAS) for LBP. Subjects were classified as high or low catastrophizers, based on a median split of residual catastrophizing scores. Data in the two groups were analyzed by ANOVA. P values < 0.05 were considered significant.

**Results:** There were no significant differences in age, gender, chronicity and VAS for low back pain between two groups. In the high catastrophizers, however, the scores of PASS-20, anxiety scale of HAD, depression scale of HAD and RDQ were statistically higher than those in the low catastrophizers.

**Discussion:** In patients with CLBP, a high level of pain catastrophizing was strongly related to the fear of pain, anxiety, depression, and daily disability, but not pain duration and severity. Pain catastrophizing influenced impairment of ADL and emotional responses to pain. It is important to evaluate pain catastrophizing in treatments for patients with CLBP.

**Conclusions:** Pain catastrophizing influences impairment of ADL and psychological distress, but not pain severity in patients with CLBP.

#### P346

##### COULD MAGNETIC RESONANCE ENHANCEMENT STUDY PREDICT POOR OUTCOME OF OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURE?

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**Introduction/Aim:** Osteoporotic vertebral compression fractures (VCF) are common in routine medical condition and usually treated by conservative management. In some patients, VCF healing is impaired and correlated with persistent back pain and progressive kyphotic deformity. Intravertebral cleft (IVC) may be responsible for nonhealing VCF. The purpose of this study were to: 1) investigate usefulness of contrast enhanced magnetic resonance (MR) images of VCF that can early detect for nonhealing VCF, and 2) identify the relationship between IVC and instability using radiographic images.

**Materials and Methods:** We retrospectively reviewed the records and radiographic images of 255 patients with single level of VCF who were treated by vertebroplasty. The findings on the plain



radiograph, computed tomography (CT), and MR images were classified after enrollment in the study. Affected vertebral bodies with IVC were defined as an avascular area (nonenhanced area on enhanced T1-MR images). Among these, was subdivided into Kummell group (vacuum cleft on CT images). Comparison between the Kummell group, IVC group, and without IVC group were conducted study with foci on dermographic factors, operation findings, radiographic images and clinical results. The visual analogue scale was used to determine the relief of back pain after 1 year follow-up.

**Results:** One hundred sixty four vertebrae (64.3%) had IVC and 25 patients (9.8%) were enrolled in Kummell group. IVC occurred predominantly in the thoracolumbar junction (78.8%). Nonenhanced area on enhanced T1-MR images showed similar to the distribution of loose bone area on CT images. The statistical analyses revealed that VCF with IVC, presence of middle column injury and a confined high signal intensity on T2-MR images were significant risk for instability.

**Discussion:** The incidence of nonhealing VCF was reported 13.5%, indicating limited outcomes for conventional treatment for VCF. IVC is frequently associated with spinal instability, which causes prolonged back pain and occasionally leads to progressively kyphotic deformity.

**Conclusion:** IVC is more common than has been previously appreciated. Nonenhanced area on enhanced T1-MR images can independently associate the presence of IVC.

### P347

#### THE CHIROPRACTIC HOSPITAL-BASED INTERVENTIONS TREATMENT OUTCOMES (CHIRO) STUDY: VARIATION IN OUTCOMES BETWEEN CHIROPRACTORS

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**Introduction:** Internationally developed clinical practice guidelines (CPG) for acute back pain endorse spinal manipulative therapy (SMT), yet North American primary and secondary care physicians and surgeons often cite chiropractic practice variation as a barrier to patient referral. The impact of practice diversity, and consistency, on chiropractic patient outcomes is unknown.

**Aim:** To explore the variation in outcomes between chiropractor-specific patient groups receiving standardized treatment for acute low back pain.

**Methods:** *Design.* Prospective nonrandomized trial. *Inclusion.* Ages 19 – 59; QTF categories I and II; pain duration of 2 – 4 weeks. *Exclusion.* “Red flag” conditions; contraindications to high velocity low amplitude (HVLA) SMT. *Treatment.* Standardized CPG-based care including  $\leq$  4 weeks of lumbar HVLA SMT. *Comparison groups.* Four groups based on attending chiropractor. *Outcomes.* Change in Roland Disability (RDQ) at 24 weeks (primary); changes in SF-36 bodily pain (BP) and physical functioning (PF) at 8, 16 and 24 weeks (secondary).

**Results:** *Primary.* After adjusting for confounders, a trend toward a significant overall difference between chiropractor-specific groups was detected on RDQ change at 24 weeks ( $P=0.10$ ). *Secondary.* Significant overall differences were observed between groups on RDQ change at 8 weeks ( $P=0.02$ ), and PF change at 8 ( $P=0.05$ ) and 24 weeks ( $P=0.0008$ ). Improvements on all outcomes occurred within each group over time.

**Discussion:** While not always statistically significant, clinically important differences in RDQ and PF change were observed between patient groups at individual time points, indicating that some patient groups improved more than others.

**Conclusions:** Standardized CPG-based care including HVLA-

SMT for acute low back pain is associated with patient outcomes that vary significantly between, but are universally positive within, chiropractor-specific treatment groups. Future studies for identifying clinician-centred determinants of improvement are encouraged.

### P348

#### COMPARISON OF TRUNK MUSCLE ACTIVITY DURING THREE DIFFERENT PRONE BRIDGE EXERCISES

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**Introduction/Aim:** Prone bridge exercises are used to activate the deep trunk muscles. We have reported that elbow-toe exercise produced the most muscular activation for the transversus abdominis (TrA). However, the differences in trunk muscle activity compared to other prone bridge exercises are not clear. The purpose of this study was to compare trunk muscle activity during 3 different prone bridge exercises.

**Materials and Methods:** Fifteen healthy men participated in this study. Wire electrodes were inserted in both the TrA and multifidus (MF), and surface electrodes were attached to the bilateral rectus abdominis (RA), external obliques (EO), and erector spinae (ES). Electromyographic activity during elbow-toe, elbow-knee, and hand-knee exercises was measured. During each exercise, all the participants were instructed to maintain a posture involving lifting of their left arm and right leg. The activity of each muscle (%MVC) during the different exercises was compared using one-way analysis of variance.

**Results:** There was no significant difference in the activity of the TrA during the different exercises. The activity of the bilateral RA and EO was significantly greater during the elbow-toe exercise than during the other exercises. The activity of the left ES ( $28.2 \pm 10.8$  %MVC) was significantly greater during the elbow-knee exercise than during the elbow-toe exercise. The activity of the bilateral ES and MF was significantly greater during the hand-knee exercise than during the other exercises.

**Discussion:** The TrA activity remained similar during different prone bridge exercises involving lifting of their extremities. Additionally, our results suggested that of the 3 prone bridge exercises, the elbow-toe exercise activated the superficial abdominal muscles, and the elbow-knee and hand-knee exercises activated the back muscles.

**Conclusion:** This study revealed the differences of trunk muscle activity during 3 prone bridge exercises.

### P349

#### LOCAL APPLICATION OF INTERLEUKIN-1B TO THE DORSAL ROOT GANGLION INDUCES TUMOR NECROSIS FACTOR-ALPHA IN THE DORSAL ROOT GANGLION AND RESULTS IN APOPTOSIS OF THE DORSAL ROOT GANGLION CELLS AND MECHANICAL ALLODYNIA

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**Introduction:** Cytokines, including TNF- $\alpha$  and IL-1 $\beta$ , have been shown to be present in nucleus pulposus cells. Recently, it was reported that local application of nucleus pulposus induces an inflammatory reaction at the surface of the DRG. The present study was performed to

examine the inflammatory reaction at the surface of the DRG exposed to nucleus pulposus with special reference to the role of IL-1 $\beta$ .

**Materials and Methods:** The L4-5 facet joint was removed in rats (Sham, n=16). Recombinant IL-1 $\beta$  was applied beside the L4 DRG to mimic L4-5 disc herniation (IL-1 $\beta$  application, n=32). The L4 DRGs were resected 24 hours after surgery. Sections of the specimens were observed by light microscopy using HE staining to confirm the inflammatory reaction. Sections were processed for immunohistochemistry using antisera to TNF- $\alpha$ , single-stranded DNA, and Caspase 3. Mechanical and thermal nociceptive thresholds were also tested.

**Results:** At the site of application of IL-1 $\beta$ , an inflammatory reaction, including edema of the tissue, was observed at the surface of the DRG. Deformities of the cell nuclei were observed in the inflammatory reaction. The presence of TNF- $\alpha$  was confirmed in these cells. The presence of single-stranded DNA and Caspase 3 were also confirmed in these cells, indicating apoptosis of the DRG cells. No reaction was observed in the sham. After the application of 0.14 ng IL-1 $\beta$ , significant differences were observed in mechanical stimulation thresholds.

**Conclusion:** IL-1 $\beta$  seems to play a role in the induction of apoptosis in the DRG, which was similar to the apoptosis induced by the herniated nucleus pulposus. As the application of IL-1 $\beta$ , which induced apoptosis of the DRG cells, showed mechanical allodynia, the reaction of the DRG induced by IL-1 $\beta$  may be related to pain.

### P350

#### EFFECT OF MRI ON PERCEPTION OF DISABILITY IN LOW BACK PAIN

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**Introduction:** To determine whether patients' perception of back pain/disability may change after Magnetic Resonance Imaging (MRI).

**Method:** Twenty-five patients with chronic low back (LBP) pain not responding to conservative management underwent MRI as a preliminary assessment towards surgical treatment. All patients completed a pain self efficacy questionnaire (PSEQ) and illness behaviour questionnaire (IBQ) before undergoing MRI and were then assessed within two weeks and counselled on the imaging findings by the senior author (OLO). Within another two weeks all 25 patients completed another set of PSEQ and IBQ.

**Results:** The average age in the series was 50.6 with 9 men and 16 women. The mean PSEQ score changed from 26.68 pre-MRI (SD: 11.73) to 29.8 (SD: 10.88). The difference was statistically significant ( $P < 0.017$ ) using a paired sample T test. Disease Affirmation (DA), scale, derived from IBQ, remained unchanged. Total scores of DA scale were compared with pre and post PSEQ for each patient. A statistically significant inverse relationship between DA scale and PSEQ was observed (Pearson product moment correlation = -0.63)

**Discussion:** DA scale is an important dimension of IBQ in predicting inappropriate behavioural symptoms and signs. High scoring patients on DA scale are expected to display more somatic complaints without clear organic explanation. This was in keeping with the results of this study where after consultation post-MRI patients with high DA scale scores had lower PSEQ scores. Previous reports had suggested a potentially unfavourable effect of MRI on LBP patients' perception of disability. In this study, however, confidence and perception of LBP disability not only did not worsen but actually improved after MRI.

### P351

#### MRI EVALUATION OF LUMBAR ENDPLATE EROSION FOR RHEUMATOID ARTHRITIS PATIENTS

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**Introduction:** Bone erosion is well known boney pathological findings of the joints in rheumatoid arthritis (RA). But there are few studies focused on lumbar endplate erosion in RA. The aim of this cross sectional study was to investigate the prevalence and risk factors of lumbar endplate erosions using MRI.

**Patients and Methods:** A total of 201 RA patients without any previous spinal surgeries were investigated by cervical and lumbar plain radiographs and MRI. The lumbar endplate erosions were defined as irregularity and low intensity change on sagittal T1WIs. We classified the erosion into 4 grade, 0:none – 3:severe, according to occupied area of erosion at each lumbar intervertebrae, then sum of the grading score of each intervertebrae were calculated. We performed multiple linear regression analysis to investigate the association of lumbar endplate erosion with the patients' background, the condition of RA, cervical lesions associated with RA, thoracolumbar vertebral fracture, lumbar spondylolisthesis, lumbar scoliosis, and sum of Pfirrmann score of each intervertebrae. Low back pain was evaluated by visual analog scale.

**Results:** A total of 142 patients had any lumbar endplate erosions on MRI; grade 1: 191 intervertebraes (19%), grade 2: 73 intervertebraes (7%), and grade 3: 76 intervertebraes (8%). The mean sum of lumbar endplate erosion grade was 2.81 $\pm$ 3.22. The multiple linear regression analysis showed that RA stage, vertebral fracture, spondylolisthesis, and Pfirrmann score were significantly associated with increased lumbar endplate erosion score ( $R^2=0.28$ ,  $p<0.05$ ). There was no relationship between low back pain and lumbar endplate erosion.

**Discussion:** This study clarified that lumbar endplate erosion in RA patients were related to not only the activity of RA but also lumbar degenerative change. Lumbar endplate erosion by RA may accelerate lumbar degenerative change, relating to the high incidence of lumbar involvement lesion; vertebral fracture 16%, spondylolisthesis 26%, scoliosis 34%.

**Conclusion:** RA stage, vertebral fracture, spondylolisthesis, and Pfirrmann score were associated with increased lumbar endplate erosion.

### P352

#### STUDY OF EFFICACY AND SAFETY OF HYPERBARIC OXYGEN THERAPY FOR LUMBAR SPINAL STENOSIS

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**Introduction:** Hyperbaric oxygen therapy (HBO) involves the process applying 100% oxygen at atmospheric pressures greater than sea level, which has been used clinically to treat a variety of diseases including burns, athletic injury, and cerebral ischemia. Lumbar spinal stenosis (LSS) in the pathogenesis of which may be involved in the cauda equina, nerve root compression and ischemia. The purpose of this study was to investigate the effects and safety of HBO on patients with LSS.

**Methods:** Thirty-nine patients diagnosed with LSS using MRI were divided into two groups, HBO group (19 patients) and non-HBO group (20 patients) at random. HBO therapy consisted of placing patients inside a hyperbaric





treatment tank where they received 100% oxygen at a pressure of 2.0 atmospheres absolute (ATA). During each treatment, patients were exposed from room pressure to 2.0 ATA pressure (15 minutes), received a 60 minutes treatment and then returned normal room pressure (15 minutes). Patients were treated 2 or 3 times a week, an average of 10 times. About a month after walking away at the last observation before and after HBO, stride, Visual Analog Scale (VAS), JOA score, JOABPEC, was examined for the presence of adverse events. In the non-HBO group a month after walking away at the last observation when the first examination, stride, Visual Analogue Scale (VAS), JOA score, and evaluate the JOABPEC, was investigated.

**Results:** In the group HBO, walking distance, stride, VAS (pain), JOA score, significant improvement is observed before and after HBO, VAS (numbness) ( $P < 0.05$ ) JOABPEC social life and disability ( $P < 0.05$ ), psychological disorders ( $P < 0.05$ ), gait dysfunction ( $P < 0.005$ ), pain-related disability ( $P < 0.005$ ) in the field, showed significant improvement compared with pretreatment. Meanwhile, the non-HBO group no significant differences were observed in any field. A case of tinnitus as an adverse event group HBO (5.2%) admitted to, was very minor symptoms can be treated with time until the final exam.

**Discussion:** Previous researches indicated that HBO improved blood flow, decreased edema, and acute inflammation associated neuropathy and thus decreased pain.

### P353

#### INFLUENCE OF MECHANICAL STRESS ON PAIN RELATED TO OSTEOPOROSIS: DYNAMICS OF SENSORY NERVE TRANSMISSION OF PAIN IN THE CAUDAL VERTEBRAE UNDER COMPRESSION USING A RAT MODEL OF OSTEOPOROSIS

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**Introduction:** We have previously reported that inflammatory mediators secreted by osteoclasts increased the expression of calcitonin gene-related peptide (CGRP), a marker of inflammatory pain in dorsal root ganglia (DRG) neurons innervating lumbar vertebrae of osteoporotic rats. We sought to determine whether osteoporotic pain is simply inflammatory pain. We focused on the possibility that pain is exacerbated by mechanical stress on the vertebral body, particularly in elderly people. The purpose of this study was to examine the dynamics of sensory nerve transmission of pain and the effect of mechanical stress on osteoporotic pain using a caudal vertebrae compression model in osteoporotic rats.

**Materials and Methods:** As an osteoporosis model, we used female rats ovariectomized (OVX) at 5 weeks ( $n = 24$ ). Fluoro-Gold (FG) was applied the periosteal surface of a caudal vertebra to detect DRG neuronal cells innervating the caudal vertebra. After FG-labeling, we divided into two groups: OVX+CMP group ( $n=12$ ) with K-wires inserted above and below a caudal vertebral body compressed using rubber bands and OVX group ( $n = 12$ ) without compression. One, 2, 4 and 8 weeks after FG-labeling, bilateral S1 to S3 DRGs were resected ( $n=3$  for each). In FG-labeled neurons, expression of CGRP and activating transcription factor 3 (ATF3), a marker of neuropathic pain were compared between two groups using immunohistochemistry.

**Results:** The proportions of FG-labeled CGRP immunoreactive neurons in the OVX+CMP group were significantly elevated at 4 and 8 weeks compared with the OVX group ( $p < 0.05$ ). The proportion of FG-labeled ATF3 immunoreactive neurons significantly increased compared with the FG-positive OVX group at 8 weeks ( $p < 0.05$ ).

**Discussion:** The rat caudal vertebra compression model with

osteoporosis expressed significantly more ATF3 in DRG cells at 8 weeks. This suggests that micro nerve injury occurred in sensory neurons innervating caudal vertebra of these osteoporotic rats. Therefore, mechanical stress may possibly exacerbate osteoporotic pain.

### P354

#### RELATIONSHIP OF PAIN WITH OBJECTIVE QUANTIFICATION OF MR IMAGES IN OLDER ADULTS WITH CHRONIC LOW BACK PAIN

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**Introduction/Aim:** Studies have demonstrated the unreliability of subjective MRI based parameters to identify pain generators in chronic low back pain patients. Advancements in computer image analysis provide objective quantitative measurements of lumbar disc features. The goal of this study is to identify relationships between objectively measured parameters and self-reported pain.

**Materials and Methods:** Two radiologists evaluated 39 axial and sagittal T1 and T2 weighted MRI images of chronic low back pain patients (age > 65 years) and graded 4 subjective lumbar disc parameters (T2 signal intensity, nucleus shape, Modic changes, and osteophytes) whose sum is the cumulative MRI score. Objective parameter, %MRIindex, was calculated from T2 sagittal images as the product of the lumbar disc area and disc signal intensity. Discs were sorted from least to most degenerative relative to each parameter. Pearson correlation coefficient and multiple linear regression analysis were performed between pain score (0-10) and each parameter.

**Results:** %MRIindex of the least degenerated disc had the greatest positive ( $R^2 = 0.47$ ) correlation with participant pain score, and %MRIindex of the most degenerated disc had the greatest negative ( $R^2 = -0.48$ ) correlation with participant's pain score. The greatest  $R^2$  corresponding to the best regression fit was attributed to %MRIindex ( $R^2=0.43$ ). All parameters from the cumulative MRI score had correlation and  $R^2$  that were lower than %MRIindex.

**Discussion:** The most degenerated discs as assessed by an objective qualitative parameter in older adults contributed least to the participant's low back pain, while the least degenerated disc contributed the most to the pain. This finding may be unique to this population, in whom the most severely degenerated discs may no longer be active pain generators.

**Conclusion:** The objective parameter, %MRIindex, has a potential to be an imaging biomarker used by clinicians to identify possible pain generators in older adults with low back pain.

### P355

#### LOW BACK PAIN AND STIFFNESS

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**Background:** Low back pain (LBP) is defined as pain, muscle tension or stiffness. Stiffness has not received much scientific attention, although most patients with LBP are complaining of stiffness. The aims were: First, to assess the scope of stiffness; second, to assess the intra-rater reliability of stiffness, and third, to

investigate the association between MRI-changes, stiffness and pain, respectively.

**Materials and Methods:** Cross-sectional clinical study of patients with chronic non-specific LBP.

**Outcome Measures:** Socio-demographic variables, pain and stiffness (0-10), activity limitations, education and profession level, and degenerative MRI changes.

**Methods:** The data were analyzed by linear regression, intraclass correlation coefficient (ICC), minimal detectable change (MDC) and Cohen's Kappa coefficient.

**Results:** Of 218 included patients, 14% had a normal MRI, 85 % decreased signal, 10% Modic Type 1, 38% type2, and 40% HIZ. Stiffness bothered 93%: 86% had 'morning-stiffness' and 94% 'stiffness after inactivity'. Patients rated 'Stiffness after inactivity' as mean (SD) 6.4 (2.8) and 'Pain at activity' as 6.0 (2.4). The MDC for pain and stiffness, ranged from 0.4 to 1 point. ICC from 0.78 to 0.97 and Kappa values from 0.2 to 1.0. There was significant association between MRI-changes and stiffness.  $\beta = 0.22$ , CI [0.04, 0.40].

**Discussion:** The majority of the patients were bothered with stiffness, and especially with 'morning stiffness' and 'stiffness after inactivity'. Morning stiffness is a central symptom in inflammatory back diseases and is considered to be related to inflammation. Although non-specific LBP does not include back pain with inflammation, there is growing evidence for local and persistent inflammation caused by disc degeneration, which might contribute to stiffness.

**Conclusion:** This study indicates that the stiffness bothers patients as much as pain. The reliability for stiffness was good. There was a significant association between MRI-changes and stiffness. Further studies are warranted to explore the role of stiffness in LBP.

### P357

#### NO ASSOCIATION BETWEEN CLINICAL FEATURE AND THE FINDINGS OF THE DORSAL ROOT GANGLION ON MR MYELOGRAM IN LUMBAR DISC HERNIATION

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**Introduction:** Previous studies noted that the association between clinical feature and the findings of the dorsal root ganglion (DRG) in lumbar disc herniation. However, there was no study that was precisely analyzed by statistical methods considering confounding factors to detect the association. We investigated the patients with lumbar disc herniation to detect the association by using logistic regression analysis.

**Methods:** Fifty-two patients with monoradicular symptoms for lumbar disc herniation were examined. MR myelography was performed for all patients. Logistic regression analyses were performed to investigate the association between dependent variables and independent variables containing generation (20s-70s), gender, disease duration, intervertebral level, involved root, location of root compression, location of DRG and location of herniation. Dependent variables were as follows: low back pain, lower limb pain, lower limb numbness, spinal sign, root tension sign, sensory disturbance and motor paralysis.

**Results:** Flexion restriction was associated with gender. Tendency in male was detected ( $P=0.022$ , odds ratio; OR 0.105, 95% confidence interval; 95%CI 0.015-0.720). Extension restriction was associated with involved nerve. Tendency in cranially situated nerve root was detected ( $P=0.043$ , OR:0.112, 95%CI:0.013-0.937). Simultaneous flexion-extension restriction was associated with generation and intervertebral level. Tendencies in young generation and in cranially situated level

were detected (generation; $P=0.022$ , OR:0.263, 95%CI:0.084-0.825, intervertebral level; $P=0.046$ , OR:0.000, 95%CI:0.000-0.771). Root tension sign was associated with generation and intervertebral level. Tendencies in young generation and in cranially situated level were detected (generation; $P=0.002$ , OR:0.303, 95%CI:0.142-0.647, intervertebral level; $P=0.039$ , OR:0.019, 95%CI:0.000-0.821). No association was detected between dependent variables and the other independent variables including DRG findings.

**Discussion:** This study was analyzed by logistic regression analysis that considers confounding factors. It shows the association between physical signs and the several factors containing generation, gender, intervertebral level and involved root. It also shows no association between clinical feature and DRG findings.

### P358

#### THE EFFECT OF DURATION OF SYMPTOMS ON HEALTH-RELATED QUALITY OF LIFE IN PATIENTS WITH LOW BACK AND/OR LEG PAIN

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**Introduction/Aim:** Back symptom is major public health issues in developed countries. Many studies have focused on the association of low back symptom with health-related quality of life (QOL), and the effect of variable treatment methods on health-related QOL. Few studies have investigated the effect of symptom duration on the health-related QOL. The aim of this study was to clarify the impact of duration symptoms on health-related QOL in patients with low back and/or leg pain.

**Material and Methods:** A total of 329 patients with low back pain and/or leg pain completed the Short-Form 8 (SF-8) as health-related QOL measure and Roland-Morris Disability Questionnaire (RMDQ) as disease specific measure. There were 165 women and 164 men with a mean age of 48. Two hundred eighty one patients complained of low back pain and 48 patients complained of both low back and leg pain. Duration of symptom was classified into 4 groups as super-acute phase (within 1 week), acute phase (1-3 weeks), sub-acute phase (4 weeks to 3 month) and chronic phase (over 3 months).

**Results:** Both Physical Component Summary (PCS) and Mental Component Summary (MCS) scores in the SF-8 were significantly lower in patients with leg pain than those without leg pain (PCS: 40 v 44, MCS: 45 v 49,  $p<0.01$ ), although RMDQ score was almost same (RMDQ: 10 v 9, NS). In patients without leg pain, PCS score in super-acute phase were significantly higher in any other phase (super-acute: 46, acute: 42, sub-acute: 40, chronic: 41,  $p<0.01$ ), and MCS score in sub-acute phase were significantly lower compared to that in super-acute and acute phases (super-acute: 52, acute: 50, sub-acute: 46, chronic: 47,  $P<0.05$ ). On the other hand, in patients with leg pain, both PCS and MCS scores were not significantly different among the 4 phases (PCS; super-acute: 40, acute: 38, sub-acute: 41, chronic: 40. MCS; super-acute: 49, acute: 43, sub-acute: 43, chronic: 47), although the scores were lowest in acute or sub-acute phases. RMDQ scores were not significantly different among the 4 phases in patients with or without leg pain.

**Discussion:** The effect of symptom duration on the health-related QOL varied with the clinical symptom, and the health-related QOL was lowest in the sub-acute phase (4 weeks to 3 months). This should be kept in mind in interpreting the outcome of health-related QOL in patients with back symptoms.



P359

### EFFICACY OF EXTENSIBLE AND INEXTENSIBLE LUMBOSACRAL ORTHOSES IN THE MANAGEMENT OF LOW BACK PAIN

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**Introduction:** Lumbosacral orthoses (LSO) are commonly used for the management of low back pain (LBP), but the literature provides conflicting evidence for their effectiveness. Physical properties of the LSO affect the stiffness of the trunk and may affect the clinical outcome. The purpose of this study was to assess the clinical outcome when two types of LSOs were used for two weeks along with standard care (SC) for LBP.

**Methods:** 94 subjects, 18 to 85 years old, with current LBP participated in this study. Exclusion criteria included pregnancy, fracture, neurological disease, poor health, or eminent surgery. Subjects were randomized into one of 3 treatment groups: 1) SC (drugs, advice, physical therapy), 2) an extensible LSO (ELSO) (Mueller Sport Care adjustable back brace) and SC, or 3) an inextensible LSO (ILSO) (Aspen QuikDraw RAP) and SC. Subjects completed a history, Modified Oswestry Disability Index (ODI), Patient Specific Functional Scale (PSFS), pain rating (NPR), and Fear Avoidance Beliefs Questionnaire (FABQ). These questionnaires were repeated again at two weeks.

**Results:** The groups did not differ in gender proportion, BMI, waist and hip circumference, initial pain, pain duration, ODI, PSFS, and FABQ measures ( $p>0.05$ ). Only ILSO resulted in a significant change in ODI:

Table 1: Changes in clinical outcome measures (means and standard deviations).

SC	ELSO+SC	ILSO+SC	p-value	
VAS	2.9(2.9)	3.3(3.2)	3.8(3.2)	0.49
ODI	<b>2.4(12.2)</b>	7.4(15.2)	<b>14.1(17.7)</b>	<b>0.01</b>
PSFS	-0.4(2.2)	-1.1(2.0)	-1.8(2.5)	0.06

Numbers needed to treat to achieve a 50% reduction in ODI were 29 for ELSO and 4 for ILSO.

**Discussion:** The results indicate that the ILSO+SC reduced disability from LBP. There was a trend of ILSO improving the patients' function. These results are likely related to the ILSO augmenting trunk stiffness.

**Conclusions:** The use of ILSOs may be beneficial to some patients with LBP and appears to be more effective in reducing disability than ELSOs.

P360

### COMPARISON OF POSTURAL CHANGE AND MUSCLE FATIGUE BETWEEN DIFFERENT TYPES OF LUMBAR CORSETS

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**Introduction:** Low back pain (LBP) is a common problem and reduces quality of life (QOL). One of the causes is imbalance of posture. Various lumbar corsets are used for LBP as the lumbar support of conservative treatment. However, a choice of corset type and benefit of corsets are unclear. The purpose of this study was to investigate postural change and muscle fatigue between

two types of lumbar corset.

**Methods:** The subjects were twenty nurses with LBP of grade 3 or more on the numerical rating scale (NRS) of 0-10. They were divided into two groups at random: a lumbosacral corset (YB) group and an undershirt type support (SA) group (n=10 in each group).

In order to investigate muscle fatigue, mean power frequency (MPF) was measured at the bilateral erector spinae (L1/2, L4/5) before (baseline) and one month after using the lumbar corset. Spinal alignment was measured by the change of kyphosis angle at thoracic and lumbar vertebrae using a spinal mouse system. Each item was performed before and after 20 minutes walking on a treadmill (speed 3.0km/h, tilt angle 5 degree). NRS and Roland-Morris Disability questionnaire (RDQ) were performed to evaluate the LBP-associated QOL. Statistical differences were assessed using Student's t test. P values less than 0.05 were considered significant.

**Results:** Muscle fatigue of erector spinae did not occur at one month in either group. Muscle fatigue in the YB group showed lower tendency compared with the YB group, but without statistical significance. At the baseline, there was no difference in the change of spinal alignment between the two groups. At one month, lumbar lordosis persisted in the SA group before and after walking, but decreased in the YB group after walking. NRS was  $3.6 \pm 1.8$  and  $2.7 \pm 2.3$ , and RDQ scores were  $1.5 \pm 1.6$  and  $1 \pm 1.5$  in SA group and YB group respectively. There were no significant differences of NRS and RDQ scores between the two groups one month after using corsets.

**Conclusion:** Undershirt type corsets prevent the imbalance of spinal posture. This might be useful for patients with LBP.

P361

### A POSITIVE STRAIGHT LEG RAISE AND A HISTORY OF CONSTANT LEG PAIN ARE BOTH CHARACTERISTICS OF SCIATIC RADICULITIS

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**Introduction:** Common inflammatory conditions of sciatic nerve roots have many characteristics that are either poorly documented or just taken for granted. This study compares clinical outcomes of those with and those without true sciatic radiculitis.

**Material and Methods:** Assessment of radiculitis and mechanical LBP was conducted in accordance with the Saskatchewan Spine Pathway triage methodology for patients treated non-operatively at 40 spine-care clinics between January 2008 and June 2010 (n=1908).

Of the 1908 patients studied, 343 were reported to have leg dominant pain. Of those, only 55 had a positive straight leg raise (SLR); 32 had constant pain and 23 had intermittent pain. Comparisons of outcomes were conducted between those with: 1) constant leg pain and positive SLR, 2) intermittent leg pain and positive SLR, and 3) back dominant pain and normal neurology.

**Results:** The mean age of the cohort was 39.3 years (SD= 11.9, range= 18-65) with 60.5% males. The constant pain/SLR group had significantly more females ( $p=0.03$ ) and higher baseline pain rating ( $p<0.001$ ) than the other two groups.

After adjusting for baseline differences between groups, multivariable logistic regression analysis revealed that the constant leg pain/SLR had significantly more pain and longer treatment duration than the other two groups ( $p<0.05$ ).

There were no statistically significant differences in change in pain and length of treatment between the intermittent leg pain/SLR and back dominant pain/normal neurology groups.

**Discussion:** The intermittent leg pain/SLR group had clinical features that behaved similarly to those with normal neurology.

**Conclusion:** These findings suggest that intermittent leg pain does not represent radiculitis. A diagnosis of radiculitis must

include two important components: 1) a history of constant pain, 2) a positive straight leg raise.

### P362

#### LUMBAR STENOSIS: REPRODUCIBILITY OF CENTRAL CANAL, LATERAL RECESS AND NEURAL FORAMINA DIMENSIONS OBTAINED WITH A STANDARDIZED PROTOCOL

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**Introduction:** Gold standard criteria to define radiologic lumbar stenosis do not exist, yet lumbar spine imaging is often used to corroborate clinical symptoms. To progress toward a radiologic diagnosis of lumbar stenosis, we devised a standardized protocol for measuring central spinal canal, lateral recess and neural foramina dimensions.

**Methods:** We performed our measurement protocol and assessed its reproducibility on lumbar quantitative computed tomography scans obtained in the MrOS Study, a cohort of 5994 community dwelling US men aged  $\geq 65$  years. Baseline (2000-2002) scans were randomly selected for 44 men, 16 of whom also had repeat scans obtained at a subsequent study visit (2007-2009). Two men with laminectomy were excluded, leaving 56 scans. Image processing was performed at the L4-L5 disc space by two raters (H.C., N.C) blinded to all visit data. Measures obtained were anterior-posterior (AP) diameters (mm) of the osseous and ligamentous borders of the central canal, area (mm<sup>2</sup>) of the ligamentous central canal border, and narrowest AP diameter of each lateral recess and neural foramen. Agreement between raters was assessed with the intraclass correlation coefficient (ICC).

**Results:** Central canal diameters were similar among raters and mean differences were within 1 mm (Table). For all central canal measures, the ICCs were 0.70 indicating good reproducibility. Lateral recesses and neural foramina were often too narrow to measure. Therefore, we present percent concordance between raters with these variables categorized as absent (0mm) or present ( $>0$ mm). Raters achieved high concordance (76%-88%) for the absence or presence of diameter in these structures. Results were similar when stratified by study visit.

**Discussion:** Dimensions of the spinal canal where lumbar stenosis occurs were measured with satisfactory reproducibility on QCT scans using our standardized protocol. This work represents a key initial step toward developing a radiologic diagnosis of lumbar stenosis.

### P363

#### RANDOMIZED CONTROLLED CLINICAL STUDY OF OSTEOPOROTIC VERTEBRAL FRACTURES BY USING MAGNETIC RESONANCE IMAGING

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**Introduction:** Osteoporotic vertebral fractures (OVFs) can be detected by plain radiography, but misdiagnosis is not uncommon. Magnetic resonance imaging (MRI) allows us to diagnose OVFs, because bone marrow bleeding and edema are demonstrated. We performed a randomized controlled clinical study of the diagnosis of OVFs by MRI.

**Materials and Methods:** A total of 86 patients were divided into two groups. Group A (n=44) received Ca (800 mg) and VitD3

(0.5  $\mu$ g), while group B (n=42) received these medicines + bisphosphonates. A diagnosis of OVF was confirmed by a low intensity on T1WI and a high intensity on STIR images. Follow up was performed for at least one year (group A: n=21; group B: n=23), and patients were evaluated for new fractures, bony union, and collapse.

**Results:** In 17 patients, it was difficult to diagnose OVFs on plain radiographs, but MRI enabled correct diagnosis; and a single fracture was found in 10 patients at the initial hospital visit. There were 18 patients with multiple fresh fractures ( $\geq 2$ ), 12 with continuous multiple fractures, and 11 with other fractures. At follow up, MRI showed almost completed bony union within 6 months in both groups, while new OVFs occurred in four patients from group A (n=21) and two patients from group B (n=20). The collapse rate ranged from 0~66.7% (28.5%) in group A and from 0~86.7% (36.5%) in group B to 9.3~72.2% (48.0%) in group A and 9.1~86.7% (52.6%) in group B. If the intensity of the fracture is low on T1WI images and mix of low, isointense and high on T2WI and STIR images, this indicates acute severe collapse due to a burst fracture.

**Conclusion:** Diagnosis of OVFs by MRI is 100% accurate and effective. MRI not only demonstrates the fracture line, but also hemorrhage and edema in the bone marrow. We can avoid severe vertebral body collapse resulting in spinal deformity by employing MRI, even if it is more expensive.

### P364

#### EPIDEMIOLOGY OF LUMBAR SPINAL STENOSIS - MULTICENTER COHORT STUDY

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**Background:** Epidemiological evidence of lumbar spinal stenosis (LSS) is not enough because its definition has not been clearly established. The objective of this multicenter cohort study was to determine the degree of severity and define the disease state of LSS using common outcome measures.

**Materials and Methods:** Patients who visited the hospitals located in 3 regions in Japan who were diagnosed with LSS were prospectively enrolled in this study. LSS was defined according to the North American Spine Society guidelines. Patients who had already been treated for LSS were excluded. A total of 249 patients (134 males) with a mean age of 71.5y were enrolled. Assessments were made based on an LSS diagnostic support tool, the degree of stenosis from MRI, EuroQol (EQ5D), Zurich Claudication Questionnaire (ZCQ), Hospital Anxiety and Depression Scale (HADS), and Pain DETECT (a diagnostic tool for neuropathic pain).

**Results:** Of the 249 patients, 89.5% scored 7 points or higher with the diagnostic support tool. MRI revealed that 3.2% had no stenosis, 14.6% had stenosis  $<1/4$ , 26.3% had between  $1/4-1/2$ , 32.4% had between  $1/2-3/4$ , and 23.5% had  $>3/4$ . The mean score for EQ5D was  $0.615 \pm 0.10$ . The symptom and function scores for ZCQ were  $2.94 \pm 0.78$  and  $2.25 \pm 0.67$ , respectively. The total score for HADS was  $10.5 \pm 6.6$ , and 44.9% of the patients showed positive for depression. The mean score for PainDETECT was  $11.7 \pm 6.2$ ; 38.1% of patients scored 13 points or higher had neuropathic pain 'probably' and 13.8% had 'definitely'.

**Discussion:** This study prospectively enrolled LSS patients using a universal definition for LSS. It appears that this study reflected the degree of severity and conditions of LSS patients. Further investigations will be performed over the following year to predict the treatment progress and prognosis of LSS.



Table. Between-rater reproducibility: measurement of spinal canal dimensions with a standardized protocol

	No. scans with measure	Rater 1	Rater 2	Difference	Intraclass correlation coefficient
		Mean (sd)	Mean (sd)	Mean (sd)	
<b>Central canal measures</b>					
Osseous diam (mm), AP	56	18.7 (2.4)	19.5 (2.6)	-0.8 (1.8)	0.70
Soft tissue diam (mm), AP	55	13.3 (2.8)	13.4 (3.0)	-0.04 (2.3)	0.70
Soft tissue area (mm <sup>2</sup> )	53	168.0 (62.2)	184.6 (65.1)	-16.6 (50.8)	0.71
<b>Lateral recess, disc level</b>					
	Diameter	N (%)	N (%)	N (%) concordant between raters	
Narrowest diam. (mm), left	0 mm	14	13	49 (88%)	
	>0 mm	42	43		
Narrowest diam. (mm), right	0 mm	14	9	36 (86%)	
	>0 mm	42	47		
<b>Neural foramen, disc level</b>					
Narrowest diam. (mm), left	0 mm	15	28	32 (76%)	
	>0 mm	41	28		
Narrowest diam. (mm), right	0 mm	16	20	34 (81%)	
	>0 mm	40	36		

Diam=diameter, AP=anterior-posterior, mm=millimeter

### P365

#### SAFETY AND QUANTIFIED SHORT-TERM EFFECTS OF A CLINIC-BASED INTENSIVE 12-WEEK LUMBAR STABILIZATION EXERCISE AFTER LUMBAR SPINAL FUSION

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**Introduction/Aim:** The aim of this study is to evaluate safety and quantified short-term effects of a clinic-based intensive 12-week lumbar stabilization exercise (LSE) after lumbar spinal fusion.

**Materials and Methods:** Twenty-four female patients (mean age: 58 years (43-68), who underwent 1 or 2 segment posterior lumbar interbody fusion (PLIF), participated in this study. The patients were subdivided into Exercise (n=12) and Usual care (n=12) group. The Exercise group was provided with a clinic-based LSE supervised by a physical therapist three times weekly between 3 and 6 months, but the Usual care group did not. Primary outcome measure was back muscle strength assessed by measurement of maximal isometric strength. Secondary outcome measures were pain intensity using a visual analogue scale in back and lower extremity (VAS) and functional disability using the 36-item Short-form General Health Survey (SF-36). Data was collected prospectively before surgery, as well as at 3 and 6 months after surgery and analyzed.

**Results:** No adverse effects associated with the LSE occurred. Preoperative mean isometric strength of each group were similar (p=0.582), but after postoperative LSE significant increase was shown in the Exercise group (45.5 %, p = 0.007) and not in the Usual care group (-1.3 %, p = 0.856). In both groups, preoperative lower extremity VAS significantly decreased at postoperative 6 months (p<0.05), and preoperative back VAS also significantly decreased in the Exercise group (p=0.028), but not in the Usual care group (p=0.932). In the SF-36, both physical and mental component scores had significantly improved in the Exercise group (p=0.018 and 0.043, respectively) after the LSE, but not in the usual care group (p>0.05).

**Conclusion:** After 1 or 2 segment lumbar spinal fusion, a clinic-based intensive 12-week LSE did not have any adverse effects and significantly improved patient's back muscle strength, low back pain, and functional ability. A further study is necessary to determine long-term effects of this exercise.

### P366

#### THE EFFECT OF NON-NOXIOUS STIMULATION IN PAIN-RELATED BEHAVIOR INDUCED BY NUCLEUS PULPOSUS APPLIED ON THE NERVE ROOT IN RATS

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**Introduction:** Chronic pain has an impact on psychological and social factors. Stress influences physiological and behavior changes. Non-noxious stimulation induces pain in the patients with allodynia. It is known that repeated stimulus might be memorized and associated with chronicity of pain. The aim of this study was to investigate the effect of non-noxious stimulation on pain-related behaviour after application of nucleus pulposus.

**Methods:** Sprague-Dawley rats (n=48) were used and autologous nucleus pulposus (NP) was applied to the left L5 DRG (NP group). The animals in the sham group were not applied NP (Sham group). And the half of animals in each group was exposed non-noxious stimulation using an artist brush (NP+ST group, Sham+ST group). The left hind-paw was stimulated continuously for 5 minutes daily from next day to 14 days after surgery. The mechanical withdrawal threshold was determined using the von Frey test at 1, 7, 14, 21, 28, 35 and 42 days. Concentrations of plasma corticosterone and natural killer cell activity were measured at 14days after surgery. The statistical analysis was performed by Bonferroni/Dunn test and p value less than 0.05 was considered significant.

**Results:** The mechanical withdrawal threshold in the NP group decreased for 28 days and recovered from day35. The threshold in the NP+ST and Sham+S groups decreased for 42 days. There were no significant differences of the concentration of corticosterone and natural killer cell activity among four groups.

**Discussion:** Systemic stress such as repeated restrain stress effects on duration of pain-related behaviour and corticosterone in plasma according to the reflection of stress. In the present study, the local stimulus using non-noxious stimulation induces chronicity of pain behaviour but not stress in rats.

**Conclusion:** Local repeated stimulus might be associated with the pathway of memory.

### P367

#### CORRELATION OF QUANTITATIVE MRI WITH BIOMECHANICAL AND HISTOLOGICAL CHANGES IN ENZYMATICALLY-DEGENERATED LUMBAR CAPRINE DISCS

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**Aim:** Quantitative MRI may provide valuable information on the matrix status of healthy and degenerating intervertebral discs (IVDs). We have developed a model to culture and load large IVDs in which we can simulate IVD degeneration by injection of chondroitinase ABC (Cabc). The aim of the current study was to investigate whether quantitative MRI mapping correlated with functional biomechanical and histological changes in Cabc-degenerated caprine discs.

**Materials and Methods:** Lumbar IVDs (24 total) dissected from mature goat spines, were cultured in a bioreactor for 21 days receiving either no injection or injection (29G syringe) with 100µL of; PBS, 0.25U/ml Cabc or 0.5U/ml Cabc prior to culture. With a high-field MRI scanner (9T) images were obtained directly after dissection and after culture. T1-, T2-, and T1-rho mapping was used to quantify relaxation time parameters. Changes in

biomechanical properties (IVD height, creep behaviour and stiffness) were quantified during culture. Matrix integrity of IVDs was studied on sections stained with Safranin-O (proteoglycans; PG) and Masson's Trichrome (collagen).

**Results:** All biomechanical properties of IVDs injected with Cabc showed significant and dose-dependent changes during culture. Comparison of histological sections showed a clear loss of PGs in the nucleus of Cabc injected IVDs and some additional staining in the annulus region. Changes observed on T1-, T2 and T1-rho maps between day 0 and day 21 correlated with histological findings. T1-rho values measured in the nucleus showed the same dose-dependent changes to Cabc-injection as observed in the biomechanical data.

**Discussion:** We observed a dose-dependent loss of PGs from the nucleus in lumbar caprine discs injected with Cabc. PG loss was shown to directly influence the IVDs biomechanical properties.

**Conclusion:** Changes in the IVDs matrix and function were correlated to differences in signal intensity of the MRI measurements. The T1-rho sequences was shown to be the most accurate in imaging the degenerative changes.

### P368

#### THE MOST IMPORTANT ISSUES CONCERNING BACK PAIN IN OBESE ADULTS AND HOW TO MANAGE THE PROBLEMS EFFICIENTLY

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**Introduction:** The Lifestyle Intervention Treatment Evaluation (LITE) was a randomized follow-up study for 18 months. The results regarding weight loss, eating behaviour and maintenance and quitting weight loss program has been published earlier.

**Subjects and Methods:** Total 82 (23 males, 59 females), 49+/-9 years of age with mean BMI 35+/-5 kg/m<sup>2</sup>. The relative isometric spinal muscle strength, abdominal and upper limb strength and squats were accomplished. Spinal and cervical ROM and modified Schober were measured. The Oswestry Disability Index and Million Neck and Back Disability index, exercising habits questionnaire and exercise diary were used. Suitable exercises were advised. The recommendations were based on evidence-based guidelines for adult obesity management.

**Results:** 90.1% suffered from musculoskeletal symptoms. 53.1% had symptoms in the cervical or neck-shoulder area and 34.6% in the back. The most common reason to avoid exercise was tiredness after the working day (51.9%) or being busy at work (25.9%) or with the family issues (24.7%). 28.4% experienced poor mobility due the obesity and 13.9% due some other condition. 35.8% were exercising regularly, but only 3.7% 5-7 times per week as was generally recommended. 80% were non-smokers. Higher BMI was connected with poorer results in relative spinal muscle strength, squat and abdominal muscle strength test ( $p=0,001$ ). The better the relative spinal muscle strength was, less pain experience ( $p=0,001$ ) and lower ODI ( $p=0,052$ ). Stronger relative spinal muscle strength was related to better neck ( $p=0,003$ ) and back extension ( $p=0,006$ ) as well as abdominal muscle strength and repeated squat ( $p=0,001$ ). Half of the subjects had cervical ROM within reference values.

**Discussion and Conclusions:** Controlling the musculoskeletal posture and good spinal function with strong spinal muscles and adequate ROM with regular exercises might be one of the key elements of preventing obese related disability. Obesity does not give good muscle strength even if the extra burden is carried continuously. Obesity is related to overall pain experience and may predispose to insufficient cervical ROM and pain in cervical and neck-shoulder area.

### P369

#### A NEW PREDICTIVE INDEX FOR BACK MUSCLE DEGENERATION ASSOCIATED WITH AGING

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**Background:** It is widely accepted that maintaining both lumbar lordosis and paraspinal muscle function is important in the prevention of low back pain. Measurements of the morphology of the lumbar paraspinal muscles using MRI have been an effective method for reflecting the atrophy and fat infiltration of muscles, though it's complicated to perform. We therefore focused on the groove between the left and right lumbar paraspinal muscles as a simple index for evaluation of back muscle degeneration. The purpose of this study was to evaluate the validity of this new index in investigating paraspinal muscle degeneration.

**Methods:** A total of 160 patients by 20 subjects in each decade aged 10 to 80 years of age who had maintained lumbar lordosis over 20 degrees were included, without considering the degree of low back pain. Patients with spinal deformities such as spondylolisthesis or scoliosis were excluded. Body mass index was calculated. Axial T2-weighted MRI was used to measure cross-sectional area (CSA) and fat infiltration of the paraspinal muscle at the intervertebral disc level from L1 to L5. To quantify the depth of the groove between the paraspinal muscles, our own image indicator, the T-back value, equal to the length of the bulge of muscle to the attachment of the spinous process, was also measured. We then determined the correlation between the T-back value and paraspinal muscle degeneration.

**Results:** CSA of paraspinal muscle tended to decrease with age, and in those aged over 60 was significantly decreased compared with that in those younger than 30. Fat infiltration increased with age, most markedly at lower lumbar levels. There was a negative correlation between CSA and fat infiltration at all levels. T-back value significantly decreased with age, and was strongly correlated with CSA at all levels.

**Conclusion:** Our new index, the T-back value, is a simple and practical means of evaluating back muscle degeneration associated with aging.

### P370

#### LEG LENGTH DISCREPANCY IN HEALTHY SUBJECT WITH NO LOW BACK PAIN

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**Introduction/Aim:** Although leg length discrepancy is a common finding among population (0.5-1.5 cm in 32%, >1.5 cm in 4 %), there are conflicting reports about the clinical significance or relationship with low back pain. In this study we aimed to delineate the leg length discrepancy in healthy subjects without low back pain or any disturbance with legs.

**Materials and Methods:** Inclusion criteria: Adult age group, No history of fracture or surgery of legs, No low back pain in last 2 years lasting more than 2 months, any congenital deformity of spine or legs.

**Exclusion criteria:** History of surgery, fracture treatment, any treated or untreated known congenital deformity regarding skeletal system, history of low back pain, or pain in hip, knee or ankle. 87 subjects met the criteria (46 women, 41 men). Subjects were measured with a paper ruler (1mm) three times by two researchers in different periods and arithmetic means were calculated. Measurements were from umbilicus (Um) to medial malleoli (MM), from Anterior Superior Iliac Spine (SIAS) to MM, Trochanter major (Tr) to lateral femoral condyle (LFC), and Tibial



tuberosity (TT) to MM.

**Results:** Leg length discrepancy (SIAS-MM) was detected in 56 subjects (64.3). Pelvic obliquity (discrepancy in Um-MM but not in SIAS-MM) was seen in 6 subjects (6.8%). Mean discrepancy was 0.58 cm (3 cm-0.1 cm). There were significant differences between left and right legs in total, femur or tibia.

**Discussion and Conclusion:** In our study group, leg length discrepancy up to 3 cm with a mean of 0.58cm were seen in 64% and this amount of leg length discrepancy were not causing low back pain or any disturbance with lower extremities

### P371

#### STUDY OF THE EFFICACY OF PARASPINOUS BLOCK IN THE TREATMENT OF THE LOW BACK PAIN

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**Introduction:** Patients with more than three months of back pain are classified as chronic low back pain patients. Prevalence is estimated around 15-30% and are responsible for 75% of total medical costs related to this pathology. Currently there are several types of treatment for chronic nonspecific low back pain, but there is still little knowledge about the mechanisms involved in chronic pain maintenance and amplification. Recently, the development of new diagnostic methods for clinical research on central sensitization provided new insights for better understanding of the pathophysiology of chronic pain. Thus, therapeutic measures aimed to modulate the central nervous system, rather than those that only interfere with inflammatory pathways, may be effective in chronic pain management.

**Purpose:** Overlooking the lack of literature, this study aims to evaluate the analgesic effect of spinal segmental desensitization performed by a paraspinous block in association with a rehabilitation program focused on the treatment of patients with chronic nonspecific low back pain and determine its effect on function and quality of life of these patients.

**Study Design:** This is a prospective, randomized, double-blind, placebo-controlled study.

**Patient Sample:** Forty-five patients diagnosed with chronic nonspecific low back pain.

**Main Outcome Measures:** The improvement in pain, function of the lumbar spine and quality of life was analyzed using the VAS scale, Roland-Morris Disability Questionnaire and SF-36 respectively.

**Methods:** Patients after the initial screening were randomly allocated into two groups. In the first group (A group) patients underwent paraspinous blocks once a week for three consecutive weeks in the levels affected by the pain, they received simple analgesics (acetaminophen up to 2 g/day) and a therapeutic exercises conduct guidance for the lumbar spine. In the second group (B group) patients underwent control intervention. This intervention was performed by placing the tip of a paper clip with a little pressure in the same places where the paraspinous block would be performed, simulating the entry of a needle, also performed once a week for three consecutive weeks. Patients also received simple analgesics and guidance for performing therapeutic exercises of the lumbar spine. Patients were assessed using Roland-Morris Disability Questionnaire, VAS and SF-36 scales. The evaluation times were: before the intervention, 1 week after the last intervention and 3 months after the last intervention.

**Results:** There was an improvement in VAS of group A (paraspinous block) compared to baseline measures at one week and at three months after the intervention ( $p = 0.03$ ), however in group B (placebo) improvement was not observed ( $p = 0.24$ ) (Chart 1). We also observed an improvement in Roland-

Morris Disability Questionnaire of group A (paraspinous block) compared to baseline measures in 1 week after infiltration and 3 months after infiltration ( $p = 0.01$ ) but in group B (placebo) no improvement was observed ( $p = 0.12$ ).

**Conclusions:** Paraspinous block showed improvement in both pain and functional scores of patients with chronic low back pain, which was not different from placebo blocks.

### P372

#### EFFECT OF TREATMENT DOSAGE ON THE THERAPEUTIC EFFICACY OF SPINAL MANIPULATION FOR LOW BACK PAIN: A SYSTEMATIC REVIEW

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**Introduction/Aim:** Outcome heterogeneity has led to discordant conclusions between different systematic reviews of spinal manipulative therapy (SMT). Heterogeneity is potentially due to differences in study methods and quality; however, treatment technique and dosage may also be important. High-velocity low-amplitude (HVLA) techniques constitute the most validated form of SMT and are also mainly administered by chiropractors. **Aim:** To determine if dosage variables (frequency, duration, and number of visits) account for heterogeneity between randomized controlled trials (RCTs) of HVLA-SMT.

**Methods:** *Design.* Systematic review. *Search methods.* Computerized databases were searched up to August 2011. *Selection criteria.* RCTs of low back pain. *Outcome.* Pain intensity, assessed by visual analog scale or other validated measure. *Data extraction.* Two reviewers independently screened abstracts, reviewed full-text articles, extracted data and assessed the quality of relevant studies. *Analysis.* Weighted mean differences were pooled using random effects models. Heterogeneity was assessed using chi-square tests. Meta-regression was used to investigate the effect of dosage variables on outcome heterogeneity.

**Results:** Among 29 relevant RCTs, the pooled effect of HVLA-SMT on mean change in pain intensity was 2.15 mm (95% CI: -0.09 to 4.38) indicating a borderline-to-moderate beneficial effect. Meta-regression involving 14 studies reporting sufficient data showed that duration and number of treatments was significantly associated with heterogeneity. Qualitatively, maximum benefits were associated with 4 weeks of SMT and 6 to 8 visits.

#### Discussion:

This is the first study assessing the effect of dosage variables on study heterogeneity among trials of SMT.

**Conclusion:** Dosage, particularly duration and number of treatments, is associated with improvement in post-treatment pain intensity. Dosage variables should be clearly considered in future RCTs and systematic reviews of SMT.

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### COMPARISON OF MANUAL AND OFFICEPACS-BASED DIGITAL METHODS FOR COBB ANGLE MEASUREMENTS IN PATIENTS WITH SPINAL DEFORMITY

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**Introduction/Aim:** As use of electronic imaging systems such as OFFICEPACS (Merge Healthcare, Chicago, IL) for making and evaluating spinal radiographs increases, reliability of measurements from such systems should be investigated. A few studies have compared manual to digital radiographic measurements in scoliosis patients; however, these involved specialized software not commonly used. The purpose of this study was to investigate the repeatability of Cobb angle measurements in spinal deformity patients using manual and OFFICEPACS methods.

**Methods:** Twenty patients with spinal deformity were randomly selected. Images were deidentified and made available to evaluators in traditional film x-ray format (measure with goniometer) and digitally on the OFFICEPACS system (using the Cobb angle tool). Each of the 5 evaluators were blinded to the others' scores. Repeatability for each method, as well as between methods, was evaluated using intraclass correlation coefficients (ICC). A single-sample t-test was used to determine if the absolute value of differences between sets of intra-evaluator measurements were significantly different from 0 (0 representing perfect agreement).

**Results:** Inter-evaluator ICC was high for both for techniques at 0.963 for computerized and 0.836 for manual. ICC for digital vs. manual measurements ranged from 0.882 to 0.897 for individual evaluators. Mean absolute values of differences between digital and manual measurements for each evaluator were significantly greater than 0, ranging from 2.5 to 5.6 degrees. There was no systematic tendency to consistently score higher (or lower) with either method.

**Discussion:** Inter-evaluator ICCs for both methods were high, with the digital value being slightly greater. Intra-evaluator ICC for the two methods was also high. However, differences between sets of scores were significantly greater than 0 for all evaluators, indicating lack of agreement on specific values.

**Conclusion:** There was high correlation between digital and manual measurements; however, when the same evaluator measured the same image, there was often several degrees difference between digital vs. manual values. This was consistent for all evaluators.

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### A SYSTEMATIC REVIEW ON MULTIDISCIPLINARY TREATMENT FOR CHRONIC LOW BACK PAIN: EFFICACY, UTILITY AND COST-EFFECTIVENESS

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**Introduction:** Although multidisciplinary treatment is well accepted as a treatment option for chronic low back pain (LBP), scientific evidence is inconsistent. So far, reviews focused on efficacy; however, since healthcare providers often refuse to reimburse the costs for multidisciplinary treatment, reviews need to examine cost-effectiveness as well.

**Aim:** This review aimed to investigate the core issues 'efficacy', 'utility' and 'cost-effectiveness' of multidisciplinary treatment for chronic LBP by a systematic review of the literature.

**Materials and Methods:** PubMed, Web of Science, Medline and the Cochrane Library were searched for articles on 'efficacy', 'utility' and 'cost-effectiveness' published between January 1990 and January 2011. Selection criteria included: 1) randomized controlled trials (RCTs) and systematic reviews (SRs), 2) adults with chronic, non-specific LBP, and 3) a clinically relevant outcome like pain, disability, or return to work. The GRADE approach was used to determine the quality of evidence.

**Results:** Nine SRs and three RCTs, prior not included in a SR, met the selection criteria for 'efficacy', one SR and two RCTs for 'cost-effectiveness'. For 'utility', no publication could be identified. Multidisciplinary treatment for chronic LBP was found to be more efficacious in reducing disability and number of sick leave days than usual care or no treatment/ waiting list controls in the long term. Furthermore, there is moderate body of evidence that multidisciplinary treatment is equally efficacious in lessening disability, but more cost-effective than surgery or usual care in reducing costs of treatment and work absenteeism.

**Conclusion:** Multidisciplinary treatment is an efficacious and cost-saving alternative to surgery or usual care for patients with chronic LBP. Furthermore, multidisciplinary treatments help patients to actively cope with difficult health or life situations and are rarely accompanied by complications that require revision surgery. This should be taken into consideration when advising patients with chronic LBP on treatment options available.

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### ASSESSING THORACOLUMBAR KYPHOSIS IN ACHONDROPLASTIC CHILDREN

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**Introduction/Aim:** Achondroplasia is the most common form of human dwarfism with disproportionate short limbs. The spinal canal is narrow throughout due to short pedicles and a small interpediculate distance. This narrowing increases the chance of compression on the spinal cord or cauda equina. Literature claims that achondroplasia is characteristically accompanied by kyphosis at the thoracolumbar junction (TLK). In combination with the narrow spinal canal, this kyphosis can easily result in compression of the medulla. In the developing/maturing spine special attention has to be given to the threat of this deformity. A protocol was designed to avoid thoracolumbar kyphosis in young children and the outcome of the treatment is presented.

**Methods:** In the orthopaedic department of the UMCU a database of 104 achondroplastic children was assembled. Follow up of children treated according to a protocol preventing or treating thoracolumbar scoliosis was performed. Fluoroscopy and clinical features were reported. The angle of the kyphosis was determined using the Cobb method and the radiological signs of achondroplasia were scored.

**Results:** 68% of patients had a thoracolumbar kyphosis. In 14% of these patients kyphosis resolved completely without intervention. 7% of patients had such degree of kyphosis that a brace was prescribed, which resolved the kyphosis. In the other patients the kyphosis was moderate, no brace was prescribed, but in the ongoing follow up, kyphosis was still present.

**Discussion:** Most patients in whom the kyphosis resolved without intervention were at or below the age of 5. In these patients, the angle of the kyphosis was below the mean angle of the total population. This suggests that if thoracolumbar kyphosis persists after a certain age or if the angle of the kyphosis is large, treatment must be considered.

**Conclusion:** Thoracolumbar kyphosis is a serious problem for the achondroplastic patient. The results of this study suggest that giving attention to this problem at a very young age is rewarding.





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### RECURRENT LUMBAR DISC HERNIATIONS IN PATIENTS TREATED NON-OPERATIVELY: 255 PATIENTS FOLLOWED FOR A MINIMUM OF TWO YEARS

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**Introduction:** Recurrent lumbar disc herniations occur at the operative index level. The incidence has been reported to be between 4 and 19%. To date there has been no large-scale analysis of the incidence in the population of patients treated non-operatively for their initial disc herniation.

**Material and Methods:** 255 consecutively identified patients who were treated for lumbar disc herniation, through a non-operative program by the authors at a single institution, were identified by a database search of the medical records.

Patients with MRI documented lumbar disc herniations, with corresponding radicular pain in the nerve distribution of the index disc, and a positive straight leg raise at 60% or less were included in the analysis. Only patients with follow-up of two years or more were included.

The following data was collected and analyzed: Date of initial presentation; Date of initial MRI; History and physical examination findings; Non-operative treatment plan; Date of symptom resolution; Dates of follow-up during the two year period; Date of recurrent symptoms (if present); History and physical examination at re-presentation; Date and findings of follow-up MRI scans; Treatment plan and outcome.

**Results:** Total: 255 patients. Patients with recurrent radicular symptoms who were found to have an MRI documented recurrent HNP at the index level: 1 (0.39%); Patients requiring surgery in the follow up group: 0.

**Discussion:** Recurrent HNP in patients treated for their initial event non-operatively is rare. It would appear that spontaneous resolution does not favor recurrent herniation. The reasons for this phenomenon are unclear, and will require further study. The implications of this finding should be factored in when counseling a patient regarding treatment options.

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### EFFECT OF PREGABALIN FOR PHARMACOLOGICAL TREATMENT-RESISTANT RADICULOPATHY DUE TO LUMBAR SPINAL-CANAL STENOSIS

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**Introduction:** Pharmacological treatments for painful radiculopathy due to lumbar spinal-canal stenosis (LSS) have been mainly administration of NSAIDs or limaprost. However, effect of these treatments sometimes insufficient. Although pregabalin is regarded as first line treatment of neuropathic pain, effect of pregabalin for painful radiculopathy due to LSS has not been precisely evaluated. The objective of this study was to evaluate the effect of pregabalin for medication-resistant radiculopathy due to LSS.

**Methods:** Patients suffering from painful radiculopathy due to pre-diagnosed LSS, who treated by administration of at least 2 weeks celecoxib and 6 weeks limaprost were enrolled. Among them, the patients with insufficient pain alleviation were judged as medication-resistant radiculopathy. The effect of treatment before and 2 weeks after administration of pregabalin was evaluated by VAS (visual analog scale/ before administration = 10 points). VAS under 7 points, 3 points and over 8 points were classified into effective, very effective and not-effective, respectively. Information regarding side effects of administration

of pregabalin was obtained by interviewing patients.

**Results:** A total of 41 patients (mean age 70.9 years old, 16 male and 25 female) were judged as pharmacological treatment-resistant radiculopathy. After 2 weeks treatment by pregabalin, 78.0%, 24.4% and 7.3% of them were classified into effective, very effective and not effective, respectively. Patients over 80 years olds had a tendency to show more side effects than others.

**Discussion:** Our study showed the effectiveness of pregabalin for treatment-resistant radiculopathy due to LSS. This fact may be useful for understanding of the patho-mechanism of painful radiculopathy.

**Conclusion:** Pregabalin is effective for medication-resistant radiculopathy due to LSS.

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### ATTENUATION OF ALLODYNIA BY NEUROTROPIN IN A FACET ARTHRITIS MODEL: ASSOCIATION WITH INHIBITION OF CYTOKINES

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**Introduction/Aim:** Facet joint inflammation has been implicated as a major cause of neuropathic back pain. Neurotrophin® (NTP), a nonprotein extract isolated from inflamed skin of rabbits inoculated with vaccinia virus, is widely used in Japan to treat neuropathic pain. Our specific aim was to determine if allodynia in the rat thrombin-induced facet joint arthritis model can be modified by NTP and to identify NTP-induced changes in gene expression patterns in dorsal root ganglia (DRGs).

**Materials and Methods:** Female Sprague-Dawley rats received an intra-articular injection of bovine thrombin (20U/2µL) to the L4/5 facet joint. Animals received daily injections (1ml/100g BW, sq) of saline (n=12) or NTP (n=12) until sacrifice at 28 days. Tactile allodynia was assessed weekly using the von Frey test. Gene expressions [tumor necrosis factor-α (TNF-α); prostaglandin-endoperoxide synthase2 (PTGS2) and nerve growth factor (NGF)] in DRGs were analyzed by QPCR.

**Results:** In each group, a significant decrease of withdrawal thresholds in the right paw was observed on day 14 (p<0.05) after thrombin injection. Thresholds in the NTP group were significantly higher than those of the Saline group throughout the time course (p<0.05) and at 12, 16 and 20 days (p<0.05). NTP showed significant suppressive effects on TNF-α, PTGS2 and NGF expression in DRGs (p<0.001) at multiple levels, as well as on the contralateral side.

**Discussion:** A significant attenuation of allodynia by systemic NTP application was associated with decreased pro-inflammatory cytokine (TNF-α), and pain marker (PTGS2 and NGF) gene expressions in DRGs. The anti-nociceptive effects of NTP were previously thought to be mediated by enhancing the descending pain inhibitory pathway. Our findings indicate an additional possibility of a direct suppressive mechanism in gene expression at the DRG level for pain reduction in NTP application.

**Conclusion:** An attenuation of allodynia by NTP was associated with molecular changes in DRGs.

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### THE NERVE ROOT SEDIMENTATION SIGN FOR DIAGNOSIS OF LUMBAR SPINAL STENOSIS: RELIABILITY, SENSITIVITY AND SPECIFICITY

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**Introduction:** The nerve root sedimentation sign was recently described as a new diagnostic test for lumbar spinal stenosis (LSS). However the degree to which this sign is sensitive and specific in diagnosis of LSS is unknown.

**Methods:** This study was a retrospective review of MRI images obtained from two studies of LSS. All LSS images were from subjects who were either undergoing surgery for LSS, or who had LSS confirmed clinically (neurogenic claudication) and on imaging by a spine specialist. The other images in the study were from asymptomatic participants, people with mechanical back pain but no LSS and people who were undergoing surgery for vascular disease. Three blinded raters independently assessed the images twice each (2 weeks between readings). A positive sign was defined as the absence of nerve root sedimentation at the level above or below the level of maximum stenosis. For each positive sign, raters also noted whether or not there was room at that level for the nerve roots to sediment.

**Results:** Images from 147 subjects were reviewed (66 LSS, 47 asymptomatic controls, 30 low back pain and 4 vascular disease). Intra-rater reliability for the sign ranged from kappa = 0.847 to 0.972, and inter-rater reliability ranged from 0.616 to 0.689. Sensitivity ranged from 0.500 to 0.614 and specificity from 0.698 to 0.772. The positive predictive value was 0.628. Approximately 10% of those rated as positive signs were thought to have no sedimentation because the canal was too tight at the measured level for sedimentation to occur.

**Conclusion:** Both intra-rater and inter-reliability for the sedimentation sign were high. The sensitivity of the sign was fairly low, correctly identified people with LSS approximately 55% of the time. Specificity was higher, correctly ruling out LSS 74% of the time. Research is warranted to further examine the validity of this sign for diagnosing LSS.

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### THE EFFECT OF LUMBAR BRACING ON BACK MUSCLE AREA IN AMBULATORY ASYMPTOMATIC SUBJECTS

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**Introduction:** A recent survey suggests that a majority of clinicians are reluctant to prescribe lumbar bracing due to a belief that bracing causes spinal muscle atrophy. Compared to atrophy resulting from complete joint immobilization through rigid casting, we hypothesize that non-rigid bracing of the multi-articular spine by itself cannot cause muscle atrophy. Given the above, our objective was to determine the feasibility of an investigation designed to measure changes in muscle area in subjects who wear a brace continuously over a two week period.

**Materials and Methods:** Five asymptomatic subjects volunteered to wear a lumbar brace for two weeks except for sleeping and bathing. Braces were constructed of non-elastic material that could be tightened through drawstrings to increase compression (Quickdraw, Aspen Medical Products, USA). An

onboard datalogger was employed to monitor brace compression. Before and after brace-wearing, axial T1 magnetic resonance imaging was obtained. Five independent raters measured cross-sectional area in visualized muscle groups at the L1, L3 and L5 levels using digitization. Inter-rater reliability was determined by intra-class correlation coefficient (ICC 3,1) while two-week differences in muscle area were assessed by paired t-test (alpha = 0.05). All subjects completed a post-brace survey detailing their experience.

**Results:** Over a two week period of brace wearing, subjects reported no change to their daily activities and minimal discomfort. Datalogger data suggested this technology can be used successfully to assess subject compliance. Inter-rater reliability for measuring muscle area was high before (ICC=0.95) and after brace wearing (0.94). There was no statistically significant change in the muscle cross-sectional area following brace wearing (p>0.05).

**Discussion/Conclusion:** Based on the results of this preliminary study, it is feasible to proceed with a larger study examining the effect of external lumbar bracing on lumbar muscle atrophy in subjects with and without low back pain.

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### LUMBOSACRAL TRANSITIONAL VERTEBRAE INCREASES LUMBAR DEGENERATIVE DISEASE

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**Background:** Lumbosacral transitions typically occur between L5 and S1. This transitional area may be shifted caudad or cephalad, leading to lumbarization or sacralization. Lumbosacral transitional vertebrae (LSTVs) are known to be associated with low back pain. This study aims to characterize the association between LSTV and lumbar degenerative disease (LDD).

**Materials and Methods:** Lumbosacral transitions were assessed for 2991 skeletons in the Hamann-Todd Osteological Collection. LSTV specimens were assessed for lumbar facet/endplate arthrosis and graded from 0 to 4 according to published criteria. Comparison was made to a control group from the collection.

**Results:** Of 2991 spines examined, 339 (11.3%) had evidence of LSTV. Of these, 77 (22.7%) were lumbarizations involving S1 and 262 were sacralizations involving either L5 (125, 36.9%) or an anomalous L6 (137, 40.4%). Facet arthrosis (FA) in LSTV specimens was significantly greater than controls at LSTV level (94% vs 70% (L5/S1) (p<0.05), two levels (90% vs 81% (p<0.05)), three levels (86% vs 75% (p<0.05)), and four levels (83% vs. 64% (p<0.05)) above the transition. The mean grade of FA was greater than controls at the LSTV (2.96 vs 0.87)(p<0.0001) as well as one (1.21 vs. 1.36 (p<0.05)), two (1.35 vs 1.20 (p<0.05)), and four levels (1.04 vs 0.80 (p<0.0001)) above the transition. Degenerative disc disease (DDD) was present in 89% at the LSTV level, 63%, 62%, 57%, and 48% at respective cephalad levels. White race and male gender increased severity of DDD and FA cephalad to LSTV. Gender did not influence prevalence or severity of FA.

**Discussion:** Compared to controls, prevalence and severity of LDD in LSTV specimens is increased. The anomalous transitional vertebrae may alter the biomechanics of normal lumbosacral articulations and change the degenerative cascade throughout the contiguous lumbar spine. Patients with LSTV may be at higher risk for LDD and should be counseled appropriately.

**Conclusion:** LSTV is a common variant and is associated with increased LDD.



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### INCIDENCE AND ASSOCIATION OF SPONDYLOLISTHESIS AND ADOLSCENT IDIOPATHIC SCOLIOSIS (AIS)

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**Introduction/Aim:** The association of spondylolisthesis and AIS has never been thoroughly evaluated. Increasingly, patients needing fusion for AIS may complain of low back pain, and have spondylolisthesis detected on the lateral radiographs. We set out to determine the true prevalence of spondylolisthesis and AIS.

**Materials and Methods:** Using a prospective, multicenter database we analyzed several groups of patients to determine the incidence of spondylolisthesis and AIS. Groups included, I – AIS patients needing fusion (n=1132); II – symptomatic spondylolisthesis requiring fusion (n=66); and III asymptomatic patients with spondylolisthesis (n=149). All preoperative radiographs were evaluated by an independent research nurse who analyzed specifically for the presence of AIS and spondylolisthesis.

**Results:** We found 1132 patients with AIS, of which 1076 had adequate radiographs. For this group (Group I), there were 47 cases with concomitant spondylolisthesis for an incidence (i) of 4.38%. In Group II, we had n=66 patients (only 48 had scoliosis radiographs) with symptomatic spondylolisthesis requiring fusion, we found 14 patients with true scoliosis (i=29.2%), and those with sciatic scoliosis (n=9; i=13.6%). There were 142 patients with adequate x-rays in Group III, with 28 having true scoliosis (i=19.7%) and 13 with sciatic scoliosis (i=9.2%).

**Conclusion:** We personally evaluated every radiograph of 1266 patients using a prospectively collected database. We found the relative prevalence of spondylolisthesis in AIS requiring fusion was 4.38%. The prevalence of scoliosis in symptomatic spondylolisthesis patients requiring arthrodesis surgery was 29.2%. For asymptomatic spondylolisthesis patients, 19.7% of patients had concomitant scoliosis. Due to the high incidence of scoliosis in patients presenting with spondylolisthesis, evaluation for both conditions should be considered.

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### BASELINE MRI CHARACTERISTICS IN ASYMPTOMATIC SUBJECTS AS PREDICTORS FOR FUTURE FIRST-TIME LBP EPISODE

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**Introduction:** Previously, it has been noted that there is no predictive value of MRI findings of degenerative changes of the lumbar spine in asymptomatic individuals in the development of first time episodes of low back pain (LBP). In a population-based cohort, this study addressed if radiographic findings on MRI in asymptomatic individuals are predictive in the development of first-time episodes of LBP and pain severity.

**Methods:** A prospective, radiographic and clinical study was performed of 248 asymptomatic individuals of Southern Chinese origin with no previous history of LBP. All subjects underwent sagittal MRI assessment of the lumbar spine. Assessment of disc degeneration was based on the Schneiderman *et al* radiographic criteria to determine the presence, extent, and severity of disc

degeneration. A summated degenerative disc disease (DDD) score of the lumbar spine was obtained, representing the global severity of disc degeneration. The presence of disc bulge/extrusion, Schmorl's nodes, and Modic changes were also noted. At 2 years minimum follow-up, clinical assessment was performed and subject demographics were noted to identify the development of LBP and functional outcome status (e.g. Oswestry Disability Index).

**Results:** There were 93 males and 155 females with a mean age at MRI of 42.9 years ( $\pm$ SD=7.6, range=21.1-54.6 years). Overall presence of disc degeneration, disc space narrowing, and disc bulge/extrusion was noted in 60.5%, 19.0%, and 34.3% of individuals, respectively. The mean DDD score was 2.2 ( $\pm$ SD=2.9; range=0-12). Schmorl's nodes and Modic changes were noted in 10.5% and 1.2%, respectively. Clinical follow-up was performed at a mean of 4.3 years ( $\pm$ SD=1.9, range=2.2-10.0 years). The incidence rate of first-time LBP episodes on clinical follow-up was 34.7%. The mean age of first-time LBP episode was 44.8 years ( $\pm$ SD=8.5; range=22-57 years). Regression modeling noted that the presence of disc bulge/extrusion (OR: 2.37; 95% CI:1.30-4.32) and increasing DDD score (>7 score OR: 6.90; 95% CI: 1.86-25.52), in particular if segments involved the mid lumbar region, demonstrated significant predictive utility for developing first-time LBP episode. DDD score and disc bulge/extrusion were found predictive to the severity of LBP, greater functional disability, and increased frequency of future LBP episodes ( $p$ <0.05).

**Conclusions:** This large-scale prospective study substantiates that spinal changes are found in asymptomatic subjects on MRI; however, the "global severity" of disc degeneration on initial MRI may be predictive in the development of first-time LBP episodes.

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### QUANTITATIVE EVALUATION AND VISUALIZATION OF LUMBAR FORAMINAL NERVE ROOT ENTRAPMENT USING DIFFUSION TENSOR IMAGING

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**Background:** To visualize the lumbar nerve roots and to measure their fractional anisotropy (FA) in healthy volunteers and patients with lumbar foraminal stenosis using diffusion tensor imaging (DTI) and tractography with 3.0-tesla magnetic resonance (MR) imaging.

**Materials and Methods:** Eight patients with lumbar foraminal stenosis underwent 3.0 T-MRI. In all subjects, DTI was performed with echo-planar imaging at a B value of 800 s/mm<sup>2</sup> and the lumbar nerve roots were visualized with tractography. Mean FA values in the lumbar nerve roots were quantified on DTI images.

**Results:** In all subjects, the lumbar nerve roots were clearly visualized with tractography. In all patients, tractography also showed abnormalities such as tract disruption, nerve narrowing, and indentation in their course through the foramen. The mean FA of proximal nerve roots on the side of entrapment was 0.128  $\pm$  0.036, which is significantly lower than the 0.213  $\pm$  0.042 on the intact side, and the mean FA of the distal spinal nerve roots on the side of entrapment was 0.131  $\pm$  0.014, significantly lower than the 0.242  $\pm$  0.032 seen on the intact side ( $P$  < 0.001).

**Discussion:** The reduction of FA values, indicating that diffusion in the tissue had become more isotropic because of edema, in which fluid is trapped in the tissue. Tractography can provide anatomical information of nerve compression in the foramen, which can help surgical planning.

**Conclusions:** We demonstrated that DTI and tractography of

human lumbar nerves can visualize and quantitatively evaluate lumbar nerve entrapment with foraminal stenosis. We believe that DTI is a potential tool for the diagnosis of lumbar nerve entrapment.

### P386

#### THE ROLE OF SPINAL MANIPULATION AND EPIDURAL STEROID IN THE MANAGEMENT OF COCCYDINIA

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**Introduction/Aim:** Coccydynia a painful coccygeal condition has been a problem diagnosis for a long time. It is a painful condition of the coccyx that is associated with the variety of aetiologies. It is a problem that eluded contemporary management methods.

This study was a prospective review to try and establish the role of spinal epidural manipulation and epidural injection in the management of the coccydynia.

**Materials and Methods:** 46 patients aged 39 men and 67 women were recruited. Of the 25 females 5 of had fracture of coccyx. The patients were then randomly divided into two groups A and B, where A was treated with conventional physiotherapy and hydrotherapy including analgesics, group B was treated differently and there treatment included apart from analgesics physiotherapy and hydrotherapy and spinal manipulations and epidural steroid injection. Both groups were then followed up.

**Results:** The Statistical analysis of the final results demonstrated that 59% out of patients recovered with epidural injection recovered much faster within three weeks with a VAS scale of 9 compared to those without the effect of hydrocortisone who recovered at 6 weeks with VAS Score of 9.

**Discussions:** In summary there was a significant statistical difference  $P < 0.1$ . Observation will stimulate others to look at this modality as form of treatment in recurrent and stubborn cases of coccydynia.

**Conclusion:** This study clearly demonstrates that there is a role for hydrocortisone in cases of recurrent and persistent coccydynia of any course before considering surgery as a final line of treatment. Further research is highly recommended in establishing this promising method of this irksome condition of coccydynia.

### P387

#### SELF REPORTED FUNCTIONAL LIMITATIONS DUE TO LUMBAR STIFFNESS CORRELATE WITH AGE AND SRS-22 SCORES AMONG ASYMPTOMATIC VOLUNTEERS

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**Introduction:** Spine outcomes research has primarily assessed proposed benefits of surgery including impacts of pain, function, and deformity. Validated outcomes tools such as the SRS-22

do not seek information regarding functional limitations due to lumbar stiffness. The LSDI is a validated outcome questionnaire to specifically assess functional impacts of lumbar spine stiffness. Normative data for the LSDI have not been reported.

**Materials and Methods:** The LSDI and SRS-22 were completed by normal adult volunteers. Exclusion criteria included prior spine surgery, back pain, scoliosis, traumatic spine injury, cancer, neurological disease, extremity amputation, or hip or knee surgery. Correlations of LSDI scores with age and SRS-22 subscales were calculated.

**Results:** 177 volunteers completed the LSDI and the SRS-22. Mean age of the cohort was 38.7 years (range 22-73). Mean LSDI scores were 3.4 +/- 6.3 (maximum score = 100). There was a statistically significant correlation between increasing age and LSDI scores ( $r = .30$ ;  $p = .0001$ ), as well as between LSDI scores and SRS-22 pain and function subscales ( $r = .41$ ,  $r = .42$ ;  $p < .0001$  for both).

**Conclusions:** Limitations due to lumbar spine stiffness were low among asymptomatic volunteers. A statistically significant relationship was noted between worsening LSDI scores and advancing age. Correlations between LSDI and SRS-22 pain and function subscales suggest that functional limitations due to lumbar stiffness occur in tandem with limitations from pain. Normative data for the LSDI will complement ongoing functional outcome measurements related to spinal stiffness following spinal arthrodesis.

### P388

#### NAVIGATED TRANSPEDICULAR DRILLING SIGNIFICANTLY REDUCES RADIATION DOSES

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**Introduction:** The purpose of this prospective study was to compare a computer-assisted navigation to a conventional procedure in order to assess if it is possible to reduce radiation exposure while preserving accuracy of screw placement.

**Patients and Methods:** The first „conventional“ group consisted of 30 patients. 1,9 segments of lumbar spine were stabilized on average. Screws were inserted transpedicularly under image intensifier guidance. In the second „navigated“ group of 30 patients, stabilization of 1,8 segments was performed on average. A CT-free fluoroscopic 2D spinal navigation system (VectorVision, Brain LAB, Germany) was used intraoperatively. It combines image-guided surgery with C-arm fluoroscopy. For each surgery (navigated or not), the irradiation duration was recorded. The irradiation duration was collected from the X-ray image intensifier. In both groups the screw positioning accuracy was controlled intra- and postoperatively according to Learch's, Açıkbaş's, and Whitecloud's methods in AP and lateral images.

**Results:** The irradiation duration calculated to one vertebra (two screws) was significantly shorter in the second (navigated) group (3,4 s) than in the first (conventional) group (14,4 s). The mean duration of data registration was 6,0 minutes (range, 3 to 11 minutes). Ratio according to Açıkbaş's calculation method reflecting the accuracy of screw placement was meanly 43,2 % (range, 32 % - 74 %) in the first (conventional) group and 44,1 % (range, 35 % - 76 %) in the second (navigated) group, without statistically significant difference ( $p < 0,05$ ).

**Discussion:** Navigation facilitates the surgical act enabling to acquire the right direction of drilling after obtaining only an AP image and a lateral image at the beginning of the instrumentation for data registration; prolongation of the surgery time is irrelevant.

**Conclusions:** Navigation allows to keep the same accuracy of pedicle screw placement reducing radiation exposure ¼. In multiple level vertebral instrumentations this reduction is more pronounced. In centers where multiple cases of spine instrumentations are done per day the „saving“ of exposure time can amount to hours.



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### RADIOGRAPHIC AND SURGICAL OUTCOME OF PERCUTANEOUS SACROILIAC JOINT FIXATION WITH POROUS PLASMA-COATED TRIANGULAR TITANIUM IMPLANTS: AN INDEPENDENT REVIEW

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**Aim:** Diagnosis and treatment of a dysfunctional sacroiliac joint is challenging and controversial. We reviewed a technique involving percutaneous placement of porous plasma-coated triangular titanium implants across the sacroiliac joint.

The purpose is to independently review the surgical and radiographic results of this procedure.

**Patients and Methods:** We reviewed 31 consecutive patients who underwent the procedure by one orthopaedic surgeon. The reviewers have no relationship with the patients or with the company producing the implants. 31 patients underwent sacroiliac fixation between 10/24/2007 to 10/14/2009, 7 men and 24 women. Mean age was 54.3 years at the time of surgery (34-85). Mean follow-up period was 13.7 months (6-30). 29 of 31 patients had a minimum of 12 months of follow-up. All patients had pain unresponsive to prolonged nonoperative treatment and had complete or near complete pain relief with CT-guided sacroiliac injection. Implants produced by SI-Bone Cupertino, California. After IRB approval, medical charts, plain radiographs, and CT scans were deidentified and randomized. They were reviewed by investigators not involved with the care of the patients to determine the surgical and radiographic outcomes. Radiographic outcome consisted of evaluating osseous ingrowth, bone growth across the SI, and radiographic complications.

**Results:** 27 patients expressed satisfaction, and 4 patients did not. There were no recorded intraoperative complications. Blood loss was negligible. Patients were discharged home on postoperative day one. Patients began walking full weight-bearing by 8-9 weeks (8 patients), 12 weeks (21 patients), and 16 weeks (2 patients). Pain relief was noted to be Complete (16 patients), Excellent (5 patients), Good (9 patients), and Fair (1 patients). There were 4 patients with postoperative complication. These were infected hematoma (2), L5 nerve root irritation by implant (1), and L5-S1 discitis (1). One patient required revision. On 6 mo. postop CT scan, 18/19 patients had radiographic evidence of bone ingrowth and bone into or across the SI joint was evident in 8/19 patients. There also was lucency around at least one implant in 5/19 patients.

**Conclusions:** Preliminary results are promising for the use of this implant for a carefully selected group of patients with disabling SI dysfunction.

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### EFFECTIVENESS OF INTERSPINOUS IMPLANT SURGERY IN PATIENTS WITH INTERMITTENT NEUROGENIC CLAUDICATION: A SYSTEMATIC REVIEW AND META-ANALYSIS

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**Introduction:** Despite an increasing implantation rate of interspinous process decompression (IPD) devices in the treatment of intermittent neurogenic claudication (INC), definitive evidence on the clinical effectiveness of implants is lacking. The

main objective of this review was to perform a metaanalysis of all systematic reviews, randomized clinical trials and prospective cohort series to quantify the effectiveness of IPDs and to evaluate the potential side-effects.

**Methods:** Data from all studies prospectively describing clinical results based on validated outcome scales and reporting complications of treatment of patients with INC with IPD placement. We searched MEDLINE, EMBASE, Web of Science, Cochrane (CENTRAL), CINAHL, Academic Search Premier, Science Direct up to July 2010. Studies describing patients with INC caused by lumbar stenosis, reporting complication rate and reporting based on validated outcome scores, were eligible. Studies with only instrumented IPD results were excluded.

**Results:** Eleven studies eligible studies were identified. Two independently RCTs and eight prospective cohorts were available. In total 563 patients were treated with IPDs. All studies showed improvement in validated outcome scores after six weeks and one year. Pooled data based on the Zurich Claudication Questionnaire of the RCTs were more in favor of IPD treatment compared with conservative treatment (pooled estimate 23.2, SD 18.5-27.8). Statistical heterogeneity after pooled data was low (I-squared 0.0, p=0.930). Overall complication rate was 7%.

**Conclusion:** As the evidence is relatively low and the costs are high, more thorough (cost-) effectiveness studies should be performed before worldwide implementation is introduced.

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### SPINOUS PROCESS SPLITTING OPEN PEDICLE SCREW FUSION REDUCES LOW BACK DISCOMFORT COMPARED TO THE CONVENTIONAL OPEN TECHNIQUE OVER ONE YEAR AFTER LUMBAR SURGERY

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**Background:** The conventional open pedicle screw fusion (PSF) requires an extensive detachment of the paraspinal muscle, which can cause muscle injury and lead to "approach-related morbidity." The spinous process-splitting (SPS) approach for decompression, unilateral laminotomy for bilateral decompression, and the Wiltse approach for pedicle screw insertion are considered to be less invasive to the paraspinal musculature. We investigated whether SPS open PSF combined with the abovementioned techniques attenuates the paraspinal muscle damage and provides better clinical results, including an alleviation in the low back discomfort, compared to conventional open PSF.

**Materials and Methods:** We studied 53 patients who underwent single-level PSF for the treatment of degenerative spondylolisthesis (27 patients underwent SPS open PSF and the other 26 underwent the conventional open PSF). The clinical outcomes were assessed using the Japanese Orthopedic Association (JOA) score, the Roland-Morris disability questionnaire (RDQ), and the visual analog scale (VAS) for low back pain and low back discomfort (heavy feeling or stiffness). Postoperative multifidus (MF) atrophy and T2-weighted signal intensity of the MF were evaluated using MRI. Follow-up examinations were performed at 1 and 3 years after the surgery.

**Results:** The VAS score for low back pain and discomfort in the SPS open PSF group was significantly lower than that in the conventional open PSF group after the surgery. The extent of MF atrophy after SPS open PSF was reduced more significantly than after the conventional open PSF during the follow-up. The MF atrophy ratio was found to correlate significantly with low back discomfort at the 1-year follow-up examination. There was no significant difference in the JOA and RDQ scores and in the change in the T2-signal intensities of the MF between the 2

groups during the follow-up.

**Conclusions:** SPS open PSF was less damaging to the paraspinal muscle and had a significant clinical effect, reducing low back discomfort compared to conventional open PSF over 1 year after surgery.

### P392

#### ACCURACY OF INTRAOPERATIVE CT-BASED NAVIGATION FOR PLACEMENT OF PERCUTANEOUS PEDICLE SCREWS

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**Background:** Previous studies on fluoroscopically-guided percutaneous pedicle screws have demonstrated a cortical breach rate of approximately 25%. The purpose of this study was to evaluate the accuracy of an intraoperative CT-based navigation system for placement of percutaneous pedicle screws in a cadaveric model.

**Materials and Methods:** Two cadaveric specimens were utilized. CT images were obtained using an O-Arm (Medtronic, Memphis, TN) and were coupled to the Stealth navigation system (Medtronic, Memphis, TN). Computer navigation was used for placement of percutaneous pedicle screws. Screws were placed bilaterally from T5-S1 and from T6-S1 respectively. Post insertion CT scans were obtained. Pedicle breach was assessed and classified accordingly (I: none, II: <2 mm, III: 2-4 mm, or IV: >4 mm) along with direction of breach.

**Results:** Thirty thoracic screws were placed with 3 (10%) medial breaches and 17 (56.7%) lateral breaches (all grade III). Out of twenty lumbar there were 0 medial breaches and 2 (10%) lateral breaches (one grade III and one grade IV). Four sacral screws were placed without breaches. The real-time computer-aided navigation tool ("simulated screw") was limited in identifying a pedicle breach. Manipulation of the surgeon's hand or driver could change the orientation of the navigation tool without changing the trajectory of the screw.

**Discussion:** The use of CT-based navigation for placement of percutaneous pedicle screws appears to be safe for the lumbar spine. Thoracic breaches laterally appeared commonly but were not felt to be clinically significant. The 10% rate of medial thoracic breach was cause for concern.

**Conclusions:** Based on the results of this study we cannot recommend the use of CT-guided navigation for placement of thoracic percutaneous pedicle screws. Further study is warranted to define the roles and limits of this technology as factors such as body habitus and pedicle morphology may limit its use in percutaneous spinal surgery.

### P393

#### FUNCTION AFTER SPINAL TREATMENT, EXERCISE AND REHABILITATION (FASTER): AN EXPLORATION OF PATIENT SATISFACTION AND EXPECTATION OF OUTCOME

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**Introduction:** This study explores patient's satisfaction with the outcome of their spinal surgery, and their pre-operative expectations of outcome. It formed a sub-component of a larger randomised controlled trial (FASTER) to determine whether the functional outcome spinal surgery could be improved by a programme of post-operative rehabilitation and/or an educational booklet.

**Methods:** As part of the larger FASTER randomised controlled trial, patients were asked pre-operatively to quantify their expected improvement in pain and health status at 6 weeks, 6 and 12 months following surgery using 100 mm VAS, and to indicate their confidence in achieving this result and also the importance of this recovery to them. Patients were then asked to rate their satisfaction with the outcome of their surgery each post-operative review using 100 mm VAS.

**Results:** Although differences between patients' expectation and achievement were minimal 6 weeks post-operatively, there was a clear discrepancy at 6 months and one year, with patient expectations far exceeding achievement. There were significant correlations between failure to achieve expectations and the importance patients' attached to this recovery at each post-operative assessment, but not with their confidence in achieving this result. Satisfaction levels remained high despite expectations not being met, with discectomy patients being more satisfied than decompression patients.

**Conclusions:** Patients' preoperative expectations of surgical outcome exceed their achievement. The more importance the patient attached to a good outcome the bigger their discrepancy between expectation and achievement. Despite this, satisfaction levels remained high. The impact of unrealistic expectations on outcome remains unclear.

### P394

#### IMPROVEMENT OF BACK PAIN FOLLOWING LUMBAR DECOMPRESSION SURGERY: EVALUATION BY VISUAL ANALOGUE SCALE FOR PATIENTS IN MOTION, STANDING AND SITTING

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**Introduction:** Because the main purpose of lumbar decompression surgery is to decompress neural tissues, improvement of sciatic pain is expected. However, improvement of back pain, relative to that seen for sciatic pain, does not necessarily follow. Recent reports have shown the effectiveness of decompression surgery for back pain. The purpose of this study was to elucidate what types of back pain tend to be relieved by decompression surgery.

**Materials and Methods:** Thirty-eight consecutive patients with lumbar degenerative disease treated by decompression surgery were included. Patients were evaluated pre- and post-operatively, using the Oswestry Disability Index (ODI) for functional pain assessment and a visual analogue scale (VAS) for the subjective assessment of back pain. In addition, we used detailed VAS evaluations for low back pain in three different situations; back pain while in motion, standing, and sitting.

**Results:** Of 38 patients, 25 patients underwent lumbar discectomy for lumbar disc herniation (LDH group), and 13 patients underwent laminectomy for lumbar spinal stenosis (LSS group). None of the patients had significant segmental instability. The mean evaluation scores (pre-operative, post-operative) were the following: ODI; LDH group (55, 15), LSS group (40, 20); VAS score for back pain; LDH group (42, 13); LSS group (53, 19). The mean detailed VAS scores for back pain in three situations (pre- and post-operative) were as follows: LDH group, in motion (53, 13), standing (47, 11), sitting (43, 11); LSS group, in motion (50, 17), standing (62, 18), sitting (48, 17). All the scores, including detailed VAS scores for back pain, improved significantly following decompression surgery; no significant difference was observed in each score between the two groups.

**Conclusions:** All types of back pain evaluated in this study were significantly improved by decompression surgery without fusion. Post-operative improvement of back pain can be expected in patients with lumbar spinal stenosis, as well as patients with lumbar disc herniation.



P395

### ANALYSIS OF THE SURGICAL RESULTS OF LONG, SHORT SEGMENT FIXATION AND FUSION FOR DEGENERATIVE LUMBAR SCOLIOSIS

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**Aim:** To compare surgical results of short segmental fixation and long segmental fixation for degenerative lumbar scoliosis.

**Patients and Methods:** From January, 2004 to June, 2007, 63 patients with DLS were managed in our hospital. 23 males and 40 females were included, and short segmental fixation in 42 patients, long segmental fixation in 21 patients, aged 48 to 78 years old, mean  $63.2 \pm 6.8$  years. Follow up for 2 years to 4.3 years after operation, mean  $2.8 \pm 1.3$  years. Clinical symptoms include mechanical low back pain, neurogenic intermittent claudication, etc. The surgical indications included severe low back pain or lower limb pain affecting daily life, rapid progression of spinal deformity, worsening neurological deficits, significant loss of spinal balance. Short segmental fixation was used in patients without spinal coronal and sagittal imbalance. Long segmental fixation was used in patients with low back pain, accompanied by significant coronal or sagittal trunk imbalance. Cobb angles, lumbar lordosis angle, blood loss, operative time and other indicators were compared. VAS, ODI was used to evaluate the surgical results.

**Results:** Long segmental fixation group have longer operative time, more blood loss than short segmental fixation group. Long segmental fixation group have a better coronal and sagittal correction outcome. The incidences of postoperative complications of long segmental fixation group were significantly higher than short segmental fixation group, but no significant statistical differences were found. Both groups of patients' symptoms improved significantly, VAS and ODI scores were not statistical different between both groups.

**Conclusions:** Surgical fixation levels of degenerative lumbar scoliosis remains in debate. For patients without significant trunk imbalance, lower limb neurological deficits were main presentation of patients, we recommended short segmental fixation. For patients with significant trunk imbalance, we recommended long segmental fixation treatment.

P396

### PROGRESSION OF PROXIMAL ADJACENT DEFORMITY AFTER DECOMPRESSION AND FUSION WITHOUT CORRECTION FOR DEGENERATIVE LUMBAR SCOLIOSIS

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**Background:** Although decompression and fusion without correction of deformity is one of the surgical treatments for degenerative lumbar scoliosis with canal stenosis, progression of proximal adjacent deformity (PAD) after *in situ* fusion is the subject of concern, then, we studied this problem.

**Materials and Methods:** We studied 77 patients with a mean age of 68.7 years who underwent decompression and posterolateral fusion without correction for degenerative lumbar scoliosis with canal stenosis with a mean curve of  $21.8^\circ$  with a minimum follow-up of 1-year. Fifty-seven patients underwent 1-3 segments fusions (short fusion) and 20 patients underwent 4-7 segments fusions (long fusion). Progression of PAD (adjacent curve  $>10^\circ$  or adjacent vertebrae slip  $>5\text{mm}$ ) was analyzed by evaluating upper instrumented vertebrae (UIV) radiographic parameters after surgery, age ( $</>70$  years), and fusion length (short/long).

**Results:** Progression of PAD was found in 14 patients (18.2%).

UIV tilt  $>10^\circ$  was detected in 24 patients (31.2%). Progression of PAD in patients with UIV tilt  $>10^\circ$  was significantly greater than that in patients with UIV tilt  $<10^\circ$  (33.3% vs 11.3%,  $P < 0.05$ ). Progression of PAD in 38 patients with  $<70$  years was higher than that in patients with  $>70$  years (26.3% vs 10.3%). Progression of PAD was equivalent between fusion length groups. UIV tilt  $>10^\circ$  and  $<70$  years were risk factors in progression of PAD in multivariate regression analysis ( $P < 0.05$ ). In short fusion group, progression rate in patients with UIV tilt  $>10^\circ$  compared to patients with UIV tilt  $<10^\circ$ , and in patients with  $<70$  years compared to patients with  $>70$  years were significantly greater (35.0% vs 8.1%,  $P < 0.05$ , 29.6% vs 6.7%,  $P < 0.05$ , respectively). In long fusion group, UIV parameters (tilt/translation/below apex) and age had no relationship with progression of PAD.

**Conclusions:** One third of patients treated with fusion without correction showed UIV tilt  $>10^\circ$  associated with 33.3% progression rate of PAD. In the short fusion group, patients with  $<70$  years demonstrated higher progression rate. Therefore, in the case of short fusion in patients less than 70 years, this procedure is unfavorable.

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### PATHOMECHANISM OF NEUROLOGICAL SYMPTOMS ASSOCIATED WITH OSTEOPORIC VERTEBRAL FRACTURES

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**Introduction:** To select appropriate surgical procedures, pathomechanism of neurological symptoms caused by osteoporotic vertebral fractures is important. The purpose of this study was to investigate the causes of neurological symptoms associated with osteoporotic vertebral fractures.

**Materials and Methods:** A total of 83 patients who underwent surgeries because of neurological symptoms associated with osteoporotic vertebral fractures were reviewed. There were 65 female and 18 male patients with an average age of 74.9 years. Intraoperative findings, neurological and radiographic examinations were reviewed. Neurological symptoms were categorized into myelopathy, cauda equina syndrome, and radiculopathy. Also, causes of neurological symptoms were classified into two types including "Compression" and "Instability". Compression type was defined as neurological symptoms with neural compression on the MRIs, and the symptoms did not improve by preoperative bed rest. Instability type was defined as neurological deficit with slight or no neural compression on the MRIs, and it improved by preoperative bed rest.

**Results:** Fifty-five of 83 patients presented myelopathy. Thirty-three of them (62%) were Compression type. Four patients indicated degenerative canal stenosis at the segment above the fracture, and progressive myelopathy was detected after injury. Twenty patients of myelopathy (38%) were Instability type and all patients showed intravertebral cleft. Thirty of 83 patients presented cauda equina syndrome or radiculopathy. Twenty-seven of them (90%) were Compression type, while 3 cases (10%) were Instability type. Only four patients demonstrated radiculopathy at the neural foramen, and all four cases showed neural compression by the lower endplate fracture.

**Conclusions:** In approximately 40% of myelopathy cases, instability was the main pathology and surgical treatments should be stabilization without decompression. As canal stenosis at the level above the fracture may result in progressive myelopathy, careful follow-up is required during conservative treatments. In 90% of the patients with cauda equina syndrome or radiculopathy, neural compression was the main pathology and stabilization with decompression should be considered. Although not common, foraminal stenosis should be assessed in case of lower end-plate fractures.

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### LONG-TERM CLINICAL OUTCOMES OF SURGERY FOR PATIENTS WITH SCOLIOSIS WITH A MINIMUM 21-YEAR FOLLOW-UP: COMPARISON OF NON-IDIOPATHIC, IDIOPATHIC SCOLIOSIS, AND HEALTHY INDIVIDUALS

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**Introduction:** The purpose of this study was to investigate the long-term clinical outcomes for patients surgically treated for non-idiopathic and idiopathic scoliosis, and to compare them to the age- and body-mass-index-matched healthy subjects.

**Materials and Methods:** Six hundred and two patients were surgically treated for scoliosis from 1968-1988. The Roland-Morris Disability Questionnaire (RDQ), SRS-22 Questionnaire, and our own questionnaire (a survey of marital status) were used for evaluation. Fifty-six (18.5%) of the 303 non-idiopathic scoliosis (Non-IS) patients and eighty (26.8%) of the 299 idiopathic scoliosis (IS) patients answered the questionnaires, and respondents included 111 women and 25 men with a mean age of 47.0 years and a mean follow-up period of 31.1 years (range 21-41 years). Eighty healthy individuals were selected as a control (CTR) group.

**Results:** In Non-IS vs. IS vs. CTR groups, mean RDQ score was 3.4 vs. 2.4 vs. 1.4, respectively; and mean SRS-22 domain scores were 4.0 vs. 4.2 vs. 4.7 for function; 4.3 vs. 4.3 vs. 4.2 for pain; 2.8 vs. 2.9 vs. 3.7 for self-image; and 3.6 vs. 3.8 vs. 3.7 for mental health, respectively. There were no significant difference among 3 groups in pain and mental health of SRS-22. As for RDQ, function and self-image domains of SRS-22, Non-IS group was equivalent to IS group, but their data was significantly inferior to CTR group ( $p < 0.05$ ). The percentage of marriage was significantly low in the Non-IS group compared to other groups (Non-IS: 39.6%, IS: 69.6%, CTR: 88.8%;  $p < 0.001$ ).

**Conclusions:** Low back pain and health-related quality of life were similar in patients surgically treated for non-idiopathic and idiopathic scoliosis. However, the scoliosis patients have significantly lower function and lower self-image than the healthy subjects. The percentage of marriage was lowest in non-idiopathic scoliosis patients.

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### SURGICAL TREATMENT REDUCES RISK OF A FALL IN PATIENTS WITH LUMBAR SPINAL STENOSIS

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**Introduction:** Risk of fall is a major contributing factor for fragility fracture. Risk of fall includes various environmental, medical and neuromuscular conditions. Patients with lumbar spinal stenosis (LSS) showed increased risk of fall compared to those with knee osteoarthritis. But, there is no report to demonstrate the effect of decompressive surgery on risk of fall in patients with LSS.

**Aim:** To demonstrate the effect of decompressive surgery on risk of fall in patients with LSS.

**Patients and Methods:** From June 2011 to September 2011, 34 patients who underwent lumbar spine surgery including decompression and/or fusion procedure for LSS were enrolled prospectively. Walking distance and Oswestry disability index (ODI) were measured preoperatively. Four functional mobility tests were used to evaluate risk of fall, which included Alternative-

Step Test (AST), Six-Meter-Walk Test (SMT), Sit-to-Stand test (STS), and Timed Up and Go test (TUGT).

**Results:** Mean age was 65.3 (51~84) year-old. Mean single walk distance was 104.7 (range 0~400) meter. Mean ODI score was 25.8(9~39) at preoperative and 17.0 (9~29) at postoperative 3 Month ( $p < 0.05$ ). Preoperative mean value of 4 functional tests measure were 15.7±7.9 sec of AST, 9.1±7.3 sec of SMT, 17.5±11.5 sec of STS and 15.4±10.9 sec of TUGT. Re-measured mean value at postoperative 3 months were 10.2±3.7 sec of AST, 6.0±1.3 sec of SMT, 11.6±7.0 sec of STS and 10.4±2.7 sec of TUGT. AST, SMT, STS values were reduced significantly after decompressive surgery. ( $p < 0.05$ ) Reduction ratio of measures of 4 functional mobility tests and ODI score at postoperative 3 month were decreased to the level of 65%~68% from the baseline at preoperative measure.

**Conclusion:** Decompressive surgery renders significant early restoration of risk of fall in the patients with symptomatic LSS.

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### USEFULNESS OF PRONE CROSS-TABLE LATERAL RADIOGRAPHS IN VERTEBRAL COMPRESSION FRACTURES

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**Introduction/Aim:** Some authors proposed the usefulness of supine cross-table lateral radiographs (SuLRs) and recommended it for evaluation of dynamic mobility in vertebral compression fractures (VCFs). However, there are several problems including pain stimulation and poor film quality. Instead, we examined the usefulness of prone cross-table lateral radiographs (PrLRs). The aim of this study is to clarify the usefulness of PrLRs in diagnosis and treatment of VCFs.

**Patients and Methods:** We reviewed 62 VCF patients checked with PrLRs between January 1, 2008 and June 30, 2011. Forty-five cases were acute and 17 cases were chronic in nature. Vertebroplasty or kyphoplasty was done in 49 patients with routine methods. In acute fractures, vertebral wedge angle (VWA), vertebral height (VH) and vertebral height ratios (VHR) were calculated by using preoperative standing, prone lateral and postoperative lateral radiographs. Two variables which were changes in VWA, VH and VHR between 2 preoperative and postoperative radiographs were compared by a paired t-test. In chronic symptomatic fractures, 2 cases were reviewed to illustrate the decision making pathways through PrLRs.

**Results:** Forty-five acute VCF patients were treated by vertebroplasty (36) or kyphoplasty (6). The other 3 patients were reluctant to undergo operations. A paired t-test revealed significant differences between 2 variables described above in all three parameters; VWA ( $p = 0.021$ ), VH ( $p < 0.001$ ) and VHR ( $p < 0.001$ ). Of the 17 cases of chronic VCFs, 7 cases were treated by either vertebroplasty (4) or kyphoplasty (3) due to dynamic mobility or intravertebral clefts. However, 10 cases without such evidences were treated conservatively.

**Discussion:** PrLRs are useful in acute VCFs in that they can predict postoperative vertebral height and wedge angle restoration more precisely. Furthermore, it can be used to predict whether surgical procedures are effective or not in chronic symptomatic VCFs. In conclusion, the authors recommend to examine PrLRs routinely in VCFs.





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### FACTORS ASSOCIATED WITH THE OSWESTRY DISABILITY INDEX SCORE AFTER LUMBAR DISCECTOMY

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**Introduction:** The Oswestry Disability Index (ODI) score six weeks postoperatively has been reported to be an influential factor predicting patients' conditions one year after surgery. The aim of this study was to identify preoperative and early postoperative factors contributing to the ODI score one month after lumbar discectomy, to help with future physiotherapy.

**Materials and Methods:** Ninety-eight patients who were underwent initial discectomy at our hospital included in the present study. Sex, age, hernia level, surgical procedure, smoking, profession, muscle strength, and degree of back pain, leg pain and numbness, ODI score, and ODI sub-scores were evaluated. A stepwise multiple regression analysis was used, with the dependent variable being ODI score one month postoperatively, and independent variables comprising the other factors listed above monitored preoperatively, on resumption of activity, and on discharge (9th postoperative day).

**Results:** Factors contributing to the ODI score one month after discectomy were profession (desk work), back pain before surgery, leg pain on resumption of activity, ODI score, ODI traveling sub-score, and leg pain on discharge. With respect to leg pain on resumption of activity and on discharge, we performed an additional hierarchical multiple regression analysis to search for background factors. The results identified leg numbness as a significant factor on resumption of activity, and leg numbness and back pain as significant factors on discharge ( $p < 0.05$ ).

**Discussion:** In a previous study, we used sub-scores to investigate lumbar disc herniation patients with poor postoperative outcomes, and found that a significantly higher number of such patients complained of difficulty in sitting. Early physiotherapy after discectomy should be important to take into account both residual symptoms, such as leg pain/numbness and back pain, and sitting.

**Conclusions:** Early postoperative physiotherapy should therefore comprise ongoing physical therapy to alleviate residual symptoms, patient education focusing on sitting posture, and exercise.

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### OUTCOME OF SURGERY IN CHRONIC LOW BACK PAIN SUFFERERS WHO FAILED FUNCTIONAL MULTI-DISCIPLINARY REHABILITATION

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**Introduction:** Surgery for low back pain (LBP) is a controversial topic. One randomized controlled trial (RCT) showed superiority of surgery to simple physiotherapy, whereas two more RCTs failed to prove its superiority to functional multidisciplinary rehabilitation (FMR). No studies have been published on surgical results in patients who failed to improve following FMR. The objective of this study was to analyze results of lumbar surgery in a group of LBP patients who failed to improve with FMR and compare their outcome with surgical patients who did not follow such a program.

**Methods:** Forty three patients were operated by a single surgeon for chronic LBP due to degenerative disc disease (36) or isthmic spondylolisthesis (6). Patients with sciatica or neurological abnormalities were excluded. Seventeen patients were operated

having failed to improve with FMR whereas the remaining 26 were operated having failed to improve with physiotherapy of lesser intensity. Oswestry disability index (ODI) pre operatively and at 2 years following surgery was prospectively evaluated. Both a 15 point ODI improvement and a 50% ODI improvement were studied separately. Fisher's exact test was used to compare groups.

**Results:** One transient neurological deficit occurred in one patient of the physiotherapy group. Both groups had an identical pre operative ODI of 52 points ( $t$  test:  $p=0.5$ ). A 15 point ODI improvement was achieved in 47% of the FMR group and in 58% of the physiotherapy group ( $p=0.5$ ). A 50% ODI improvement was observed in 35% and 46% in the FMR and physiotherapy group respectively ( $p=0.5$ ).

**Conclusion:** It is generally accepted that surgery should be considered only in chronic LBP patients who failed initial conservative management. We did not confirm our hypothesis that patients who failed FMR would respond poorly to surgery, compared to patients who failed physiotherapy of lesser intensity. Even though surgical success rates were similar in both FMR and physiotherapy resistant groups, FMR should still be offered as a treatment option in all patients with chronic LBP given evidence from previous studies that it yields better results than physiotherapy alone.

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### VALIDATION OF A DECISION QUALITY INSTRUMENT FOR ASSESSING TREATMENT OF LUMBAR DISC HERNIATIONS

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**Introduction/Aim:** Though growing consensus exists on the importance of engaging and informing patients to improve the quality of medical decisions, few validated instruments measuring decision quality are currently available. Our goal was to evaluate the performance of a new instrument designed to measure decision quality for treatment of lumbar herniated discs.

**Patients and Methods:** The herniated disc decision quality instrument (HD-DQI) was developed with input from clinicians, researchers and patients. The HD-DQI produces two scores each scaled from 0 to 100% with higher scores indicating better quality: (1) a total knowledge score and (2) a concordance score (indicating the percentage of patients who received treatments that matched their goals or concerns). We validated the HD-DQI instrument using data from retrospective and prospective patient surveys and a physician survey using a sample from the AMA master file.

**Results:** The HD-DQI survey was feasible to implement and acceptable to patients, with good response rates and low rates of missing data. The knowledge score discriminated between patients who had seen a decision aid or not (50% vs. 35%,  $p < 0.001$ ) and between providers and patients (67% vs. 42%,  $p < 0.001$ ). The knowledge score also had good retest reliability (intraclass correlation coefficient = 0.85). Most patients (78%) received treatments that matched their goals. Patients who received treatments that matched their goals were less likely to regret the decision compared to those who did not (13% vs. 39%,  $p=0.004$ ).

**Discussion/Conclusion:** The HD-DQI met several criteria for high quality patient reported survey instruments. It can be used to determine the quality of decisions for treatment of lumbar herniated discs. More work is needed to evaluate acceptability for use as part of routine patient care.

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### THE EVALUATION OF A REOPERATION AFTER MICRO-SURGICAL BILATERAL DECOMPRESSION VIA A UNILATERAL APPROACH (MBDU) FOR DEGENERATIVE LUMBAR DISEASE

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**Introduction:** These days, good clinical outcome of a minimally invasive surgical technique for lumbar spine, including microsurgical bilateral decompression via a unilateral approach (MBDU) has been widely recognized. Some authors have reported the clinical results of MBDU for LCS in cases involving instability, such as spondylolisthesis, lumbar degenerative scoliosis and hemodialysis. However, there are few reports about the postoperative complications of MBDU. The purpose of this study is to evaluate the clinical characteristics of cases that required reoperations after MBDU.

**Methods:** Between 1999 and 2011, 833 patients had undergone MBDU for degenerative lumbar disease involving instability, such as spondylolisthesis and lumbar degenerative scoliosis at our institution. These patients (495 men and 338 women) were included in this study. The mean age at surgery was 69.5 years (34-92). We investigated the prevalence of cases that required reoperation and the causes for the second operation.

**Results:** Reoperation after MBDU was needed in 23 cases (2.8%). The mean JOA score of the cases was 11.7 points preoperatively, aggravated to 9.1 points before the second operation, and 14.8 points at the final follow up (recovery ratio: 17.9%). The mean duration of time from the first operation to reoperation was 29 months. Fusion operation was necessary in 17 cases, and re-decompression was operated in 6 cases. The cause of reoperation was the exacerbation of disc degeneration change in 9 cases, intraforaminal stenosis due to an increasing of disc wedging or scoliosis in 8 cases, the development of disc herniation in 4 cases, decompression insufficiency in 1 case and vertebral body fracture in 1 case.

**Discussion:** There is no consensus about the inclusion criteria of MBDU for LCS in cases involving instability or disc degenerative change, such as spondylolisthesis and degenerative scoliosis. It should be cautious to indicate MBDU for cases with degenerative discs, scoliosis, or wedging discs.

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### DOES THE INTRA-OPERATIVE TRANEXAMIC ACID DECREASE OPERATIVE BLOOD LOSS DURING POSTERIOR SPINAL FUSION FOR TREATMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS?

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**Introduction/Aim:** Blood loss associated with spinal surgery is a common potential cause of morbidity and often requires blood transfusion which subject patients to the known risks of blood transfusion including transmission of diseases. Since the 1990s, intra-operative administration of antifibrinolytics has gained popularity. This study assesses the efficacy and safety of TXA, in controlling blood loss during posterior spinal fusion for the idiopathic scoliosis in adolescent.

**Materials and Methods:** A retrospective comparative analysis of 106 consecutive adolescents undergoing posterior spinal fusion procedures at one institution was performed. Patients were analyzed according to treatment group: controls (63) and TXA (43).

There were no significant differences in demographic (gender, age, comorbidities) or surgical traits (surgical time, number of fused vertebrae, pre-operative hematocrit, hemoglobin) between the 2 groups.

**Results:** TXA group had significantly less intra-operative blood loss (613 +/- 195 mL) than the control group (1079 +/- 421 mL; P < 0.001) as well as post-operative blood loss (155 +/- 86 mL and 263 +/- 105 mL; P < 0.001). TXA group received significantly less blood during the surgical procedure than the control group (258 +/- 246 mL and 377 +/- 200 mL; P < 0.001). There were no major intra-operative complications for any of the treatment groups. There were no post-operative cases of MI, DVT, or PE with any of the treatment groups.

**Discussion:** The mechanism of TXA is competitive blockade of the lysine-binding sites of plasminogen, plasmin, and tissue plasminogen activator. The effect of TXA in spine surgery is still controversial. In the present study, TXA treatment group lost significantly less blood and received significantly fewer blood transfusions than the control groups.

**Conclusion:** TXA treatment group lost significantly less blood and received significantly fewer blood transfusions than the control groups without significant differences in intra- and post-operative complications. A multicenter randomized prospective comparative analysis will provide additional information of the efficacy and safety of TXA.

P406

### INCIDENTAL DUROTOMY IN LUMBAR SPINE SURGERY: INCIDENCE AND CLINICAL COURSE

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**Introduction:** An incidental tear of the dural sac and subsequent cerebrospinal fluid (CSF) leak is a well-known risk of lumbar spine surgery. The purpose of this study is to determine the incidence of durotomy, clinical course, and predicting factors of incidental durotomy in lumbar spine surgery.

**Methods:** A retrospective clinical data was obtained from consecutive 149 patients underwent lumbar spine surgery with decompression. We evaluated the incidence of dural tears and clinical course after incidental durotomy among these patients. We also compared the data obtained in patients in whom an incidental durotomy occurred and those in whom no incidental durotomy. Basic demographic information, descriptive findings regarding bleedings, operation times, history of primary surgery, and number of spinal levels underwent decompression were compared between the two groups.

**Results:** Incidental durotomy developed in 17 (11.4%) of 149 patients. In terms of sex, age, descriptive findings regarding bleedings, operation times, history of primary surgery, and number of spinal levels underwent decompression, there were no significant differences between patients with and patients without incidental durotomy; p>0.05, Fisher's test and ANOVA, respectively. The authors were able to repair the tear primarily with suture in 7 patients after incidental durotomy. Postoperative CSF leak from drainage was observed in 9 of 17 patients with incidental durotomy. All of the patients with postoperative CSF leak from drainage were treated without reoperation. One patient with cauda equina impingement at dural sac tear complained of temporary urinary dysfunction.

**Discussion:** In this retrospective study, the incidence of durotomy was 11.4% in 149 patients, and there were no other complications in all but one patient with temporary urinary dysfunction. Patients' sex, age, descriptive findings regarding bleedings, operation times, history of primary surgery, and number of spinal levels underwent decompression were not predict factors of incidental durotomy.



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### CLINICAL OUTCOMES OF SHORT SEGMENTAL TLIF FOR DEGENERATIVE LUMBAR SCLIOSIS (DLS) - DOSE SCLIOTIC WEDGING IN ADJACENT SEGMENT INCREASE AFTER SHORT SEGMENT FUSION FOR DLS?

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**Introduction:** Several reports showed long fusion provided better curve correction and spinal balance than short fusion in DLS, though complications were more substantial in long fusion. The purpose of this study was to assess the clinical results of short segmental TLIF for DLS, and to investigate the postoperative change of scoliotic wedging in upper adjacent segment.

**Methods:** Twenty-six consecutive patients with DLS who underwent short segmental TLIF were retrospectively reviewed with minimum 2-year follow-up. The mean follow-up period was 40 months, and mean age at surgery was 70.1 years. Short segmental TLIF means fused vertebrae exists within the curvature. The clinical outcomes were evaluated by SF-36 and Japanese Orthopaedic Association (JOA) score for low back pain. The following radiographical parameters were assessed before surgery and final follow-up time (FFU) in standing anteroposterior and lateral radiograph: 1) Cobb angle, 2) lumbar lordosis from T12 to S1 (LL), 3) scoliotic wedging angle at upper adjacent segment (AS-SWA), and 4) osteophyte formation at upper adjacent segment with Nathan Grading.

**Results:** The mean numbers of fused segment were 2.1. The mean improvement rate of JOA score were 61.6%. Six domains (Physical Function, Physical Role, Body Pain, Vitality, Social Function, and Emotional Role) in SF-36 significantly improved at FFU. Average Cobb angle and LL changed from 23.3°, and 31.9° before surgery, to 12.7°, and 36.0° at FFU respectively. Average AS-SWA was 5.5° before surgery, and significantly increased to 7.1° at FFU. According to the progress of AS-SWA, we divided into two groups, progress > 5° group (n=6) and progress < 5° group (n=20). Nathan grading is significantly lower (1.6 vs. 2.5; P=0.04), and preoperative AS-SWA is significantly greater (12.4 vs. 5.8°; P=0.002) in progress > 5° group. However, clinical outcomes do not differ between both groups.

**Conclusion:** The current study demonstrated that short segmental TLIF provided the good clinical outcomes for the patients with DLS, and was helpful in correcting scoliotic deformity and lumbar lordosis. Further study is necessary for deciding whether additional fusion is required for the adjacent segment with more than 10° SWA and poor osteophyte formation.

P408

### THE EFFECT OF ALLOGRAFT BONE CAGES IN POSTERIOR LUMBAR MULTILEVEL INTERVERTEBRAL BODY FUSION

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**Introduction/Aim:** Observe the effect of using allograft bone cage in posterior Lumbar multilevel intervertebral body fusion.

**Materials and Methods:** Adults who treated by posterior Lumbar multilevel decompression and intervertebral body fusion were eligible for enrolment in this trial, 40 cases (17 male, 23 female), Age 45 to 72 years old (average of 53.8 ys), randomly divided into two groups, allograft bone cage group (n = 20) altogether 67 levels and the CAPSTONE cage group (n = 20) altogether 70 levels. All patients were given corresponding operation, the strict follow-up, two groups of patients compared with charging

of hospital, operation time, intraoperative bleeding, erythrocyte sedimentation rate (ESR), body temperature, incision reaction and healing of incision, clinical outcome was evaluated with JOA score. Fusion was evaluated with the use of Schulte method.

**Results:** The patient's hospitalized cost in allograft bone cage group was significantly lower than the CAPSTONE group, but the operation time, intraoperative bleeding, erythrocyte sedimentation rate (ESR), body temperature were similar in both groups. In both groups, there were no incision reaction and healing of incision was good; JOA score in 3M, 6M, 1Y showed no significant differences between the two groups; but in allograft bone cage group, JOA score in 2Y is lower than the CAPSTONE group (p < 0.05). According to Schulte fusion evaluation method, there were 5 cases (L5 / S1) and 1 case (L3/4) showing no fusion in allograft bone cage group in 2Y; In CAPSTONE group there was only one case (L5 / S1) suspicious of no fusion.

**Conclusion:** In posterior lumbar multilevel fusion allograft bone cage has no obvious immune rejection and can achieve good fusion effect, but in L5 / S1 level using allograft bone cage should be avoided.

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### PREOPERATIVE ASSESSMENT OF PSYCHIATRIC PROBLEMS IN THE PATIENTS WITH LUMBAR SPINAL STENOSIS BY USING THE BRIEF SCALE FOR PSYCHIATRIC PROBLEMS IN ORTHOPAEDIC PATIENTS (BS-POP): A PROSPECTIVE COHORT STUDY

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**Introduction:** The Brief Scale for Psychiatric Problems in Orthopaedic Patients (BS-POP) (physician's and patient's versions) is a reliable scale for easily and quickly identifying psychiatric problems in orthopedic patients (Yoshida et al., 2011). We prospectively evaluated its efficacy for predicting surgery outcome in lumbar spinal stenosis (LSS) patients at 1-year follow-up.

**Methods:** We divided 178 symptomatic LSS patients who underwent decompressive surgery without fusion into 2 groups: one with patients with psychiatric problems (P group, BS-POP physician's score of  $\geq 11$  or physician's score of  $\geq 10$  and patient's score of  $\geq 15$ ) and the other with patients without psychiatric problems (NP group). Numerical rating scales (NRS, 0–10 points) for low-back pain (LBP), leg pain, and leg numbness and the Roland-Morris disability questionnaire (RDQ) were used for prospective pre- and post-operation (1 year) evaluations. Wilcoxon and chi-square tests were used for statistical analysis.

**Results:** Thirty-four patients had psychiatric problems, whereas 144 had no psychiatric problems. The preoperative scores of LBP, leg pain, leg numbness, and RDQ did not differ significantly between the 2 groups. At follow-up, the P group had higher NRS scores for LBP (4.1  $\pm$  3.1) and leg pain (3.8  $\pm$  3.5) than the NP group (2.0  $\pm$  2.4 and 1.8  $\pm$  2.7; p < 0.0001 and p < 0.0005, respectively). Moreover, the P group had significantly lower RDQ scores (41.6  $\pm$  10.3) than the NP group (47.8  $\pm$  10.2) (p = 0.0024). Leg numbness did not significantly differ between the 2 groups. The P group showed lesser improvement in symptom severity and disability score than the NP group.

**Discussion:** The BS-POP enables early detection of psychiatric problems before surgery. Surgery outcome can be predicted using this scale, which should be included in the preoperative assessment of psychiatric problems in LSS patients.

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### HYPERTENSION AND CARDIOVASCULAR DISEASE ARE ASSOCIATED WITH BLOOD LOSS IN LUMBAR SPINAL SURGERY

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**Introduction:** Comorbid conditions such Hypertension, Diabetes and Heart Disease has been shown to increase the complications and length of stay in patients undergoing lumbar spinal surgery. The purpose of this study was to determine if these conditions lead to increased surgical blood loss and/or transfusion requirements in patients undergoing lumbar spinal surgery.

**Methods:** We retrospectively reviewed the records of 490 consecutive subjects who had undergone lumbar decompression with or without fusion and instrumentation. Patients with underlying coagulopathies or neoplastic disease were excluded from this study. Age, sex, intraoperative blood loss, transfusion requirements, comorbidities, number of levels decompressed, number of levels fused, and use of instrumentation were recorded from patient records. The subjects were split into several groups based on their comorbid conditions and a control group with no comorbidities. Multivariate ANOVAs correcting for the above variables and Chi-square tests, were used to determine differences in blood loss and the need for transfusion in patients with comorbidities.

**Results:** Significant differences in blood loss were seen in patients with Hypertension per decompressed (737cc vs. 812cc,  $p = 0.04$ ), fused (890cc vs. 965cc,  $p = 0.03$ ) and instrumented levels (861cc vs. 977cc,  $p < 0.01$ ). Additionally, patients with Hypertension more likely to need intraoperative transfusion (OR 2.41,  $p = 0.01$ ). In contrast there was no observable difference in patients with comorbid Diabetes or Heart Disease ( $p > 0.05$ ). The total amount of comorbid conditions the patient had also showed increasing blood loss ( $p = 0.01$ ) per instrumented level and need for intraoperative transfusion ( $p < 0.01$ ).

**Discussion and Conclusions:** In this study it was shown that of the comorbid conditions analyzed, Hypertension was found to be significantly associated with blood loss and transfusion requirements regardless of extent of surgery. The number of comorbid conditions was also associated with blood loss and transfusion requirements per levels instrumented. This information may help the surgeon and anesthesiologist appropriately plan for blood requirements during lumbar surgery.

P411

### V-Y VERTEBRAL BODY OSTEOTOMY FOR THE TREATMENT OF FIXED FLEXION DEFORMITY OF THE SPINE

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**Introduction:** Surgical correction of fixed flexion deformity of the lumbar spine has typically utilised either Smith Peterson osteotomy (SPO) or Pedicle Subtraction Osteotomy (PSO). However, the extent of correction possible is constrained by anatomical limitation at the disc or vertebral body. We describe a new, V-Y lumbar osteotomy technique which incorporates features of both open and closing wedge osteotomies in a single vertebral body, increasing the potential correction.

**Aim:** To evaluate the efficacy of V-Y vertebral body osteotomy for the correction of fixed sagittal imbalance and analyse the degree of correction achieved.

**Patients and Methods:** A total of 6 consecutive patients who underwent V-Y vertebral body osteotomy for the management of fixed, sagittal plane deformity of the lumbar spine were included.

The minimum follow-up was 2 years. Radiological analysis included pre- and post-op thoracic kyphosis, lumbar lordosis, sagittal and coronal balance, pelvic incidence and sacral inclination (SI). Clinical outcomes included ODI and SRS23 in all cases.

**Results:** The average correction of lumbar lordosis was 81.2° and sagittal balance improved by a mean 12.6cm. The average correction at the osteotomy site was 44.5° (36°-51°). Mean pre-op SI of 15.2° increased to 30.3° post-operatively. Instrumentation was extended from mid thoracic to the sacrum in 4 cases and to the pelvis in 2 cases. There were no neurovascular complications. All patients recorded improvement in clinical outcome measures and overall satisfaction was high.

**Conclusion:** V-Y vertebral osteotomy is an alternative method to SPO and PSO for the correction of sagittal imbalance of the lumbar spine. The mean correction at the osteotomy site of 44° represents a significant aid to reducing deformity in cases of severe loss of lumbar lordosis and sagittal balance.

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### 10 YEARS FOLLOW UP STUDY OF SMITH-PETERSON VERSUS PEDICLE SUBTRACTION OSTEOTOMY FOR CORRECTION OF LUMBAR SAGITTAL IMBALANCE

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**Introduction:** Smith-Petersen Osteotomy (SPO) and pedicle subtraction Osteotomy (PSO) have been used to correct fixed sagittal deformities. This study is done to compare the results of these two methods. Many papers have described the surgical technique and the results of these two procedures. Our study was performed to compare the results of these two techniques. Our expectations as regards the C7 plum line and lumbar lordosis and blood loss would be identical in the two groups.

**Methods:** Clinical, radiographic, and outcomes assessment comparing these two surgical techniques. Clinical data and the radiographic results were collected prospectively.

Ten patients underwent SPO and were compared with fifteen patients who underwent PSO with follow of 4- 10 years. All the surgeries were performed at one institute between 2000-2010. All patients in both groups were complaining of either flat back or kyphotic spine due to old spinal fusion procedures and had single Osteotomy at one segment. All patients were evaluated by preoperative and postoperative standing radiographs and prospectively collected data.

**Results:** The mean correction of the kyphotic angle at the Osteotomy sites for the SPOs was 8.7 and for the PSO was 13.6. However, the improvement in the Sagittal balance was statistically significantly less with SPOs than with PSO. The mean estimated blood loss for the procedure was 1.45ml in the group with SPOs and 2.65 in the PSO group. The mean Oswestry score improved from 32.4 before surgery to 13.6 after surgery at the last visit in the SPO group. In the PSO group, it improved from 34.3 before surgery to 12.6 at the last visit.

**Conclusion:** When comparing the SPO in Ten patients to PSO in Fifteen patients, the correction in kyphosis was nearly identical. The blood loss was substantially greater with the PSO group ( $p < 0.001$ ).



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**PATIENT EXPECTATIONS, OUTCOMES AND SATISFACTION: RELATED, RELEVANT OR REDUNDANT?**

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**Introduction:** Meeting patient expectations and achieving patient satisfaction are now considered as important as more technical outcome measures such as fusion rate. However, subjective variables are difficult to evaluate and interpret objectively. Their relevance to clinical practice and how to change practice to optimize them is incompletely understood.

**Aims:** This study assessed whether patient expectations had been met and whether they were subjectively satisfied by determining their expectations before lumbar surgery and measuring their clinical outcome after surgery.

**Patients and Methods:** 145 patients undergoing primary, single-level surgery for degenerative lumbar conditions were studied prospectively. Oswestry disability index (odi), back visual analogue scale (vas) and leg vas were assessed pre-operatively and at 6 weeks and 6 months post-surgery. Patients' expectations were measured pre-operatively by asking them to score the level of pain and disability that would be least acceptable for them to undergo surgery and be satisfied. Satisfaction was assessed six weeks post-operatively with a likert scale. Differences in patient expectations between actual and expected improvements were quantified.

**Results:** Most patients had a clinically relevant improvement, but only about half achieved their expectations (table 1).

	6 weeks		6 months	
	AE	MCID	AE	MCID
ODI	37%	66%	50%	77%
Back VAS	51%	72%	59%	76%
Leg VAS	62%	82%	63%	86%

Table 1: Percentage of patients that achieved expectations (AE) and achieved minimal clinically important difference (MCID).

At 6 weeks 75% reported being "very satisfied", 18% "satisfied"; 7% "somewhat satisfied", none were "dissatisfied" or "very dissatisfied". Satisfaction did not correlate with pre-operative pain or disability, or with patient expectation of improvement. Satisfaction correlated with post-operative back pain and to a lesser extent ODI and type of surgery. The 10 patients that were only "somewhat satisfied" fell into the highest quartile of postoperative back pain.

**Conclusion:** Satisfaction correlates with positive outcomes. Patient expectations have little bearing on final outcome and satisfaction. Their value probably lies in identifying patients with unrealistic expectations and counselling them as part of the consent process.

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**CLINICAL CHARACTERISTICS OF RECURRENT LUMBAR DISC HERNIATION AFTER MICROENDOSCOPIC DISCECTOMY - EVALUATION OF 32 CASES**

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**Introduction:** There are few reports which include more than 30 patients with recurrent lumbar disc herniation (rLDH) after microendoscopic discectomy (MED). We evaluated 32 patients with rLDH after MED. We defined rLDH as a recurrent disc herniation at the previously operated disc in patients who experienced a pain free interval of at least one postoperative month. The purpose of this study was to clarify the clinical characteristics of rLDH after MED.

**Materials and Methods:** We investigated 233 patients with LDH who underwent MED. The mean age was 42.6 years old. The mean follow-up period was 22 months. The patients were divided into recurrent and nonrecurrent group and were evaluated clinically.

**Results:** rLDH was observed in 32 among 233 patients (13.7%). Recurrence was observed until one postoperative year in 21 patients (65.6%). We measured sagittal range of motion (sROM) of the herniated disc level using flexed and extended lateral X-ray. Mean preoperative sROM was 9.1 degrees in the recurrent group, while it was 6.7 degrees in the nonrecurrent group. There was statistically significant difference in sROM between these two groups (p<0.01). Modic changes were observed in 10 among 32 patients (31.2%) in the recurrent group, while they were observed in 44 among 201 patients (21.9%) in the nonrecurrent group. This difference was not statistically significant. However, there were 6 patients in whom Modic changes were newly observed at the recurrence. Reoperation was performed only in 5 patients (2.1%). Conservative treatments such as epidural block and NSAIDs were effective in 21 patients (65.6%), and spontaneous resorption of the herniated disc was observed in 13 patients (40.6%) in the recurrent group.

**Discussion and Conclusions:** The results of sROM and Modic changes show that segmental instability could be one of the causes of rLDH. Conservative treatments were effective and spontaneous resorption of the herniated disc was observed in many rLDH patients. These results show that conservative methods are important for treating rLDH.

P415

**BACK MUSCLE ATROPHY FOLLOWING TLIF CAN BE AVOIDED BY A MINIMUM ACCESS METHOD**

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**Introduction:** The purpose of this study is to investigate if minimum access surgery (MAS) can avoid back muscle damage in transforaminal lumbar interbody fusion (TLIF).

**Materials and methods:** Twenty patients with L4 degenerative spondylolisthesis (DSL) (age 65.6y, M/F=6/14) treated by MAS-TLIF (group MAS) were compared to 20 patients with DSL (age, 64 y, M/F=6/14) treated by conventional TLIF (group TLIF). All surgeries were performed by single surgeon, and there was no significant difference in preoperative clinical and radiological findings between the groups. Surgical invasiveness, biochemical parameters, clinical symptom, radiological examinations, and complication were investigated prospectively for 2 years. Morphological change of multifidus muscle was examined using image analysis in MRI-T2 weighted axial images (Tsutsumimoto 2009).

**Results:** Surgical time/blood losses were 121.1(min)/81.8(g) in



MAS and 104.7(min)/220.6(g) in TLIF with significantly less blood loss in MAS ( $p<0.0001$ ). CRP/WBC in postoperative 3 days was 4.2/6338 in MAS and 11.1/7776 in TLIF. Both parameters were significantly lower in MAS ( $p<0.0001$ ). Perioperative complications in MAS were 1 epidural hematoma, while those in TLIF were 1 epidural hematoma, 2 surface infections, and 1 screw malposition. Hospital stay in MAS was shorter than that in TLIF (12.4 vs 14.9 days  $p<0.05$ ). All cases in both groups achieved bony union and there was no difference in clinical improvement between the groups. Multifidus muscle of approach side for interbody fusion in TLIF showed significant atrophic change compared to that in MAS. One lumbar canal stenosis in adjacent level in TLIF was treated surgically.

**Discussion:** The results of operative blood loss and postoperative biochemical parameters showed less invasiveness in MAS. Although both groups showed significant improvement in symptoms with 100 % union, multifidus muscle which is vital in stability of the lumbar spine, inevitably atrophied in TLIF. On the other hand, MAS was able to preserve the back muscle.

**Conclusion:** MAS can realize comparable results with less invasiveness compared to TLIF and can avoid deep back muscle dysfunction.

#### P416

##### SUBSIDENCE OF POLYETHERETHERKETONE CAGE IN MINIMALLY-INVASIVE TRANSFORAMINAL LUMBAR INTERBODY FUSION

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**Introduction/Aim:** The aim of this study was to determine the rate of cage subsidence in minimally-invasive transforaminal lumbar interbody fusion (MITLIF) using polyetheretherketone (PEEK) cage, and to analyze its associated risk factors.

**Materials and Methods:** A total of 104 consecutive patients who had undergone MITLIF using PEEK cage and had a minimum 2- year follow-up were included in this study. Cage subsidence was defined if cage sank into the adjacent vertebral body 2 mm or deeper on the postoperative and serial follow-up lateral radiographs. Age, gender, body mass index, bone mineral density, diagnosis, number of fusion segment, and the quality/quantity of back muscle were considered as demographic variables which may affect the cage subsidence. Level of fusion, size and position of cage, intervertebral angle, and postoperative distraction of the disc height were regarded as cage-related variables. Logistic regression analysis between these independent variables and cage subsidence was conducted.

**Results:** Among 122 inserted cages, the rate of cage subsidence was 14.8% (18 cages). Cage subsidence occurred within  $7.2 \pm 8.5$  (1-25) months after surgery. The Odds ratios for the significant risk factors regarding cage subsidence were 1.950 (95% CI 1.002-4.224) in L5-S1 level, 1.018 (95% CI 1.000-1.066) in cage position.

**Discussions:** In our opinion, there are two reasons for the high risk of cage subsidence in L5-S1 level: first, surgeon's technical tendency or error for the end plate manipulation and cage positioning; and secondly, more applied compression load. Anterior cage positioning as a risk factor also seems to be related with more compression load.

**Conclusions:** The rate of PEEK cage subsidence after MITLIF was considerably low. End plate manipulation and cage insertion in MITLIF did not influenced by small operation window. Cage subsidence was affected by in our series.

#### P417

##### REVISION DISCECTOMY WITH POSTEROLATERAL (PLF) VERSUS TRANSFORAMINAL LUMBAR INTERBODY FUSION (TLIF): A RETROSPECTIVE COMPARATIVE STUDY

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**Introduction:** Revision discectomy and fusion is often performed for recurrent lumbar disc herniations. TLIF is thought to result in increased fusion rates, an advantage over stand-alone instrumented PLF. However, there is a lack of data comparing their outcomes for recurrent herniations. This study compares the clinical and radiographic outcomes of these two fusion methods when performed with revision discectomies.

**Methods:** Records were reviewed for patients who underwent revision discectomy and fusion (PLF or TLIF) between January 2005 and July 2010. Forty patients met inclusion criteria (23 PLF, 17 TLIF). Radiographic, operative, and clinical outcomes were assessed. Fusion status was determined by independent radiographic evaluation. Clinical outcomes were measured using VAS for leg and back pain and ODI. Patients were asked to assess their current pain and to retrospectively give best estimates of their pain prior to surgery.

**Results:** There was a significant association between blood loss, surgery duration, and hospital LOS. TLIFs were significantly longer surgeries (302.5 min) as compared to PLFs (248.0 min) ( $p=0.009$ ). The only clinically significant differences between the groups occurred in magnitude of change from baseline among the ODI domains of sleep ( $p=0.036$ ) and travel ( $p=0.032$ ), favoring TLIF. Among PLF patients, there was significant improvement in VAS back scores ( $p = 0.004$ ) and in ODI scores ( $p = 0.039$ ), and non-significant improvement in VAS leg scores. Among TLIF patients, VAS back and leg scores significantly improved ( $p=0.022$  and  $p=0.039$ , respectively). Radiographic fusion was achieved in 19 (82.6%) PLF patients and 15 (88.2%) TLIF patients (no significant difference).

**Conclusion:** Although a limited study of a small number of patients, these data failed to suggest consistent clinical advantages of one fusion method over another when performed with revision discectomy. A future prospective randomized controlled study may be warranted to more definitively define the roles of these two popular fusion methods.

#### P418

##### THE ROLE OF LOAD ABSORPTION IN LUMBAR ARTHROPLASTY - ELASTOMERIC TOTAL DISC REPLACEMENT 48 MONTHS AFTER SURGERY

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**Purpose:** Lumbar arthroplasty aims maintenance of movement but clinical and biomechanical results have indicated the need of load absorption. This present device is an elastomeric lumbar disc prosthesis which uses compliant polycarbonate polyurethane as its core material and has been designed to have enhanced endurance properties. Clinical and radiological results after 36 months are encouraging for this new lumbar arthroplasty rationale.

**Methods:** Fifteen patients (12 male; 3 female) with DDD underwent anterior disc replacement and prospectively followed. Ten patients received treatment at a single level (L5-S1) while five patients received treatment at two levels (L3-L4/L5-S1, or



L4-L5/L5-S1). Clinical (VAS and ODI) and radiological outcomes were analyzed. All patients were assessed pre-operatively, and at 6 weeks, 3 and 6 months, and annually.

**Results:** Average age was 37.0 years (range 25-54) and an average BMI was 23.7 (range 19.4-28.5). At 48 months follow up evaluation, the VAS back pain and ODI scores improved significantly when compared to baseline. ROM went from a baseline of  $12.0^\circ \pm 6.2^\circ$  to  $13.3^\circ \pm 5.5^\circ$  at 12 mos, and  $11.7^\circ \pm 7.3^\circ$  at 48 mos. No significant facet degeneration was observed. There was one prosthesis removal due excessive motion and consequent pain. One patient experienced intraop vascular damage at L4-L5 that required further surgery to repair. At six month follow up evaluation, one patient experienced retrograde ejaculation which was resolved at 12 months.

**Discussion and Conclusion:** This work reports a 48 month follow-up results of the new elastomeric generation of total disc prostheses. The clinical results for VAS and ODI were superior to other marketed artificial lumbar discs such as Charité and ProDisc-L at the same follow-up timeframes, presenting the same inherent complications related to the anterior surgery access.

#### P419

##### DEVELOPMENT OF A SUPPORT TOOL FOR CLINICAL DIAGNOSIS OF SYMPTOMATIC LUMBAR FORAMINAL STENOSIS

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**Introduction:** Not all cases of lumbar foraminal stenosis (LFS) on MRI are symptomatic. Therefore, establishment of a clinical diagnostic tool for identifying patients with symptomatic LFS is crucial in the clinical setting. The aim of this study was to develop a support tool for clinical diagnosis of LFS.

**Materials and Methods:** Patients with only L5 radiculopathy were prospectively enrolled in this study. Fifty-one patients with intra-canal stenosis only at L4-5 and 49 patients with foraminal stenosis only at L5-S1 were selected from this cohort. To determine the factors related to a high index of clinical suspicion of LFS, 12 items (3 subjective and 3 objective items on the JOA score; Kemp sign; Patrick, Bonnet and Freiberg tests; pain on sitting; and pain when recumbent) were compared between the 2 groups.

**Results:** After factors with a P value < 0.2 on univariate analyses were included in a stepwise multiple logistic regression model, the significant (P < 0.05) predictors of a final diagnosis of LFS were identified as follows: pain when recumbent (P = 0.0009), Bonnet test (P = 0.0271), Freiberg test (P = 0.028) and pain on sitting (P = 0.0309). To develop a diagnostic tool, a scoring system (0-20 points) was formulated on the basis of the contribution ratio of these risk factors. Regarding the contribution ratio, an integer score was assigned to the identified risk factors as follows: pain when recumbent=9 points; Freiberg test=5 points; Bonnet test=3 points; pain on sitting=3 points. The Hosmer-Lemeshow statistic for this scoring system was P = 0.063 and this result confirmed that it was a good model. ROC analysis showed the following results: cut-off value=5 points; area under the ROC curve=0.87435; sensitivity=75.5%; and specificity=82.3%.

**Discussion:** Failure of diagnosis or misdiagnosis of symptomatic LFS is a leading cause of failed back surgery syndrome. However, when a double-crush lesion of the L5 spinal nerve is observed both inside and outside the canal on MRI, it is difficult to differentiate the neural pathology between the two. By using this tool, accurate diagnoses of patients with symptomatic LFS may be possible.

**Conclusion:** The authors believe that use of this tool in the clinical setting will improve the accuracy of diagnosis, thus leading to improved quality of patient care.

#### P420

##### ASYMMETRICAL PEDICLE SUBTRACTION OSTEOTOMY FOR RIGID DEGENERATIVE LUMBAR KYPHOSCOLIOSIS

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**Introduction:** Vertebral wedge osteotomy provides good correction of kyphosis, but has rarely been applied to degenerative lumbar kyphoscoliosis. Our objective was to clarify the safety and efficacy of asymmetrical pedicle subtraction osteotomy (PSO) in the treatment of severe adult lumbar deformities, prospectively.

**Materials and Methods:** A total of 14 patients who had undergone corrective osteotomy were enrolled. The average age at PSO surgery was 67 years (range, 45-76). The minimum follow-up was 2 years. Patient questionnaires were administered prospectively. Radiographic parameters including sagittal and coronal balance were analyzed.

**Results:** Average operative time was 310 minutes (range, 254 to 375 minutes). Average blood loss was 1,090ml (range, 700 to 2,900ml). Mean preoperative lumbar lordosis improved from  $-3^\circ$  to  $42^\circ$  at the final follow-up, and sagittal balance improved from 12cm to 3cm, respectively. Mean lumbar scoliosis improved from  $40^\circ$  to  $12^\circ$ , and coronal offset improved from 3 cm to 1cm, respectively. There was also statistically significant improvement from preoperative to final evaluation in all clinical domains. There were 4 complications; one dural tear, two hook dislodgements at the cephalad side requiring revision instrumentation, and one rod breakage not requiring surgical intervention. Overall, all 14 patients were satisfied with their surgical management and would choose to repeat the procedure.

**Conclusion:** Our data suggests that the surgical procedure of asymmetrical PSO is to correct the scoliosis, to restore the lumbar lordosis by way of convex sided posterolateral wedge osteotomy, and may go a long way toward solving the problems of rigid lumbar degenerative kyphoscoliosis.

#### P421

##### COST-UTILITY ANALYSIS OF ANTERIOR CERVICAL DISCECTOMY AND FUSION VERSUS CERVICAL DISC ARTHROPLASTY

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**Summary:** Anterior cervical discectomy and fusion and cervical arthroplasty have been shown to be effective treatments for cervical disc disease. Fusion provided a slight benefit in terms of QALYs gained at two years over arthroplasty, but at an increased cost. Both treatments were within accepted standards of cost-effectiveness.

**Introduction:** Patients with cervical disc herniations resulting in radiculopathy or myelopathy from single level disease have traditionally been treated with Anterior Cervical Discectomy and Fusion (ACDF) with excellent results. Cervical Disc Arthroplasty (CDA) has been shown to result in similar clinical outcomes. Expert suggestion of reduced adjacent segment degeneration is a promising future result. A Cost-Utility Analysis of these procedures with long-term follow-up has not been previously reported.

**Methods:** We reviewed single institution prospective data from a randomized trial comparing single-level ACDF and CDA in

cervical disc disease. Data collected included demographics, outcome scores (NDI and SF-36), and utility scores. Procedural cost was estimated via medicare reimbursement based on DRG and physician CPT codes. QALYs were calculated at 1 and 2 years after surgery, allowing for cost/QALY assessments.

**Results:** Patients included ACDF (n=10) and CDA (n=18) with no significant difference in demographic data. Both groups showed improvement in NDI. Both groups showed improvement in all domains of SF-36 except general health (GH), which remained stable. ACDF patients recorded significantly higher scores in the mental health (MH) domain at 1 and 2 years ( $p < 0.05$ ). At two years, total QALYs gained were 0.42 and 0.26 for ACDF and CDA respectively. The cost of ACDF was \$16,162, while CDA averaged \$13,187. Cost/QALY was \$38,480 and \$50,719 for ACDF and CDA at 2 years. The incremental cost effectiveness ratio (ICER) of ACDF vs CDA was \$18,593.

**Conclusion:** We confirm the efficacy of ACDF and CDA in the treatment of cervical disc disease. Our results suggest similar clinical outcomes at one and two year follow-up. Both average modalities demonstrate cost-effectiveness. However, the additional QALYs gained by ACDF in this study demonstrate a potentially more cost-effective profile at two years.

P422

#### EVALUATING SYMPTOMATIC LUMBAR DISC DEGENERATION AND ITS TREATMENT IN THE CONTEXT OF OTHER MEDICAL CONDITIONS

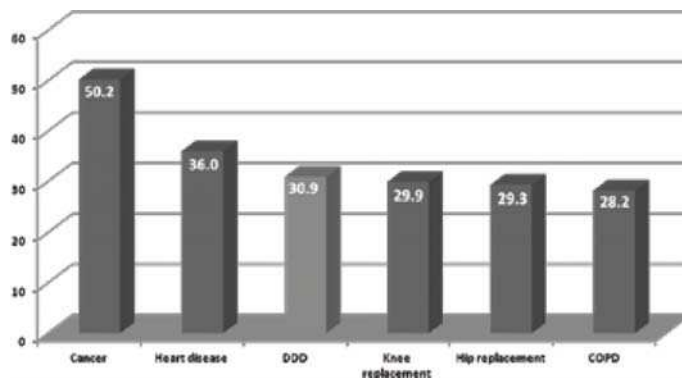
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**Introduction:** The use of health-related quality of life instruments, such as Short Form-36 (SF-36) allows evaluation of spinal diagnoses in the context of other medical conditions. In the current era of changing health economics, this may have important implications for the funding allotted to spine care. The purpose of this study was to compare SF-36 scores in patients with symptomatic degenerative disc disease (DDD) to multiple other non-spine diagnoses as well as the results after treatment.

**Methods:** SF-36 Physical Component Summary (PCS; greater scores indicate better condition) was used in this study. DDD scores came from a prospective total disc replacement trial. SF-36 data were collected from the literature for hip replacement, knee replacement, chronic obstructive pulmonary disease (COPD), cancer, and heart disease. Multiple studies (range 4-12) were combined for each of these conditions to derive a composite comparative value. Only studies with 12 month follow-up were included.

**Results:** DDD patients' mean PCS score was similar to those with: knee replacement, hip replacement, and COPD (see figure). Scores for DDD patients were slightly worse than heart disease patients and worse than for cancer patients. After TDR, the PCS scores improved significantly ( $p < 0.05$ ). The post-TDR score improved to a level similar or better than post-treatment scores for COPD, knee replacement, and heart disease. Hip replacement had greater post-treatment scores.



**Discussion:** The use of general health status questionnaires allows evaluation of spinal diagnoses in the context of various other health conditions.

**Conclusions:** Lumbar DDD was associated with physical debilitation similar to other medical conditions. Spine surgery yielded results comparable to most of the other conditions. Symptomatic lumbar DDD in surgical candidates is a significant health problem and is as debilitating as several other commonly-accepted disease states. Through careful patient evaluation and treatment, their physical condition can be improved in a manner similar to other significant health problems.

P423

#### WORKERS' COMPENSATION VERSUS NON WORKERS' COMPENSATION: PERSONALITY DIFFERENCES

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**Introduction:** Compromised surgical outcomes have been associated with Workers' Compensation (WC) vs. Non-Workers' Compensation (Non-WC) as well as psychological factors. It has not been rigorously investigated whether there are personality or behavioral traits more prevalent in WC patients that may be related to compromised outcome. The purpose of this study was to compare personality profiles of WC vs. Non-WC patients undergoing spine surgery.

**Materials and Methods:** Patients completed a presurgical screening evaluation including an interview with a psychologist and psychological testing. Patients also completed a post-surgical follow-up questionnaire. The study included 36 WC and 129 Non-WC patients.

**Results:** Educational level differed significantly in the two groups with college completed by 35.7% of Non-WC vs. 8.3% of WC patients. Only 1.6% of Non-WC patients did not graduate from high school vs. 13.9% of WC patients. Pre-operatively, WC patients displayed relatively elevated sensitivity to symptoms reflected by higher scores on gastrointestinal problems, head pain, as well as neurological and cognitive complaint scales. WC patients' MMPI-2-RF profiles displayed a greater sense of inefficacy, more behavior-restricting fears, more aggression, and a higher level of aberrant experiences. WC patients also reflected a greater sense of entitlement and demoralization. Post-operatively, WC patients were more fearful, worried, and depressed than Non-WC patients, although the groups did not differ significantly on these measures pre-operatively.

**Discussion:** Psychological factors have been reported to be related to surgical outcome. Compromised surgical outcomes in WC patients may be related to personality/behavioral factors that are more prominent in this population. This study found multiple



such factors when comparing WC vs. Non-WC patients. Further investigation is underway to determine to what extent these factors contribute to the differences in surgical outcome.

**Conclusions:** This study found that WC patients had a lower level of education and had different personality profiles with respect to emotion, self-image, pain sensitivity and reported more physical complaints compared with Non-WC patients.

#### P424

### RELATIONSHIP BETWEEN LOW BACK PAIN AND LUMBAR LORDOSIS AFTER LUMBAR SPINE FUSION

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**Introduction:** To analysis the relationship between low back pain and lumbar lordosis after fusion, a retrospective study was carried out for a group of consecutive patient who have postoperative low back pain and the changes of postoperative lumbar lordosis Cobb angles.

**Materials and Methods:** 42 patients after instrumented lumbar spine fusion ( $\leq 3$  segments) with postoperative low back pain were followed up at 12 months and 24 months postoperatively. All patients were evaluated with standing lumbar AP and lateral X-rays to measure the lumbar lordosis and VAS and Oswestry Disability Index for evaluation of clinical outcome. The change of the lumbar lordosis was calculated according to the baseline of 60 degree for lumbar lordosis. All data were analyzed utilizing SPSS 12 to rule out the relationship been the change of the lumbar lordosis and low back pain.

**Results:** The mean lumbar lordosis was  $40.1^\circ \pm 10.6^\circ$  at 12 months and  $40.8^\circ \pm 10^\circ$  at 24 months follow-up. The mean VAS score was  $29.4 \pm 11.5$  at 12 months and  $27.6 \pm 11.7$  at 24 months follow-up. The mean Oswestry Disability Index scores was  $15.1 \pm 5.4$  at 12 months and  $13.9 \pm 5.2$  at 24 months follow-up. The changes between lumbar lordosis Cobb angle and baseline is  $19.9^\circ \pm 10.6^\circ$  at 12 months and  $19.2^\circ \pm 10.0^\circ$  at 24 follow-up.

**Discussion:** The changes between the lumbar lordosis Cobb angle and baseline has a positive liner correlation not only to VAS scores ( $P < 0.01$ ), but also to ODI scores ( $P < 0.01$ ), at both 12 and 24 months postoperatively.

**Conclusion:** This study shows that there was a positive liner correlation between the degrees of low back pain and loss of lumbar lordosis. The normal lumbar lordosis is worked and should be considered before lumbar fusion operations. One of the most important goals of operation is to restore a normal lumbar lordosis.

#### P425

### CLINICAL CHARACTERISTICS OF ELDERLY PATIENTS WITH LUMBAR SPINAL STENOSIS SURGICALLY IMPROVE PSYCHOLOGICAL IMPAIRMENTS

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**Introduction/Aim:** Psychological impairments are thought to be a risk factor of poor surgical outcomes in lumbar spinal stenosis (LSS). The aim of this study was to clarify the clinical characteristics in elderly patients with LSS, in whom psychological disorders were improved postoperatively.

**Materials and Methods:** Ninety-two elderly patients ( $> 65$  years old) with symptomatic LSS between May 2007 and July 2010 were retrospectively evaluated. Self-rating questionnaire for depression (SRQ-D), visual analog scales (VAS) for low back

pain and leg symptoms, Japanese Orthopaedic Association Back Pain Questionnaire (JOABPEQ) subscales, which consist of pain-related disorders, lumbar spine dysfunction, gait disturbance, social life disturbance and psychological disorders, and patients' satisfaction were evaluated one year postoperatively. Patients, who showed more and less than 10 points improvement of psychological disorders, were divided into the A and B groups, respectively. Data were analyzed and  $P < 0.05$  was considered significant.

**Results:** Follow-up rate was 95%. Thirty-seven and 50 patients were classified into the A and B groups, respectively. There were no differences in age, gender, diagnosis, operation methods, complications and SRQ-D between two groups. VAS for leg symptoms in the A group was statistically higher than those in the B group preoperatively, but not low back pain. Preoperative points of pain-related disorders, lumbar spine dysfunction, and psychological disorders were lower in the A group than the B group ( $P < 0.01$ ). At follow-up, improvement of all subscales and patients' satisfaction were significantly better in the A group than those in the B group.

**Discussion:** Elderly patients with LSS, who improved in psychological disorders postoperatively, had preoperative severe leg symptoms and impairment of QOL. In addition, improvement of psychological disorders was related to that of other JOABPEQ subscales and patients' satisfaction. These results suggest that postoperative improvement of QOL results in recovery of emotional responses to pain.

**Conclusions:** We demonstrated the clinical characteristics of elderly patients with LSS surgically improved psychological disorders.

#### P426

### CLINICAL AND RADIOLOGICAL OUTCOME OF DYNAMIZATION PLIF IN PATIENTS WITH HEMODIALYSIS RELATED SPONDYLOARTHROPATHY

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**Introduction/Aim:** The recent advances in hemodialysis have prolonged the patient's life span and increased the number of the patients suffered from dialysis-related spondyloarthropathy (DRSA) of the lumbar spine. The purpose of this study is to evaluate the clinical and radiological outcome of two different posterior lumbar interbody fusion (PLIF) systems for hemodialysis patients: Conventional PLIF system utilizing normal pedicle screw system, and Dynamization PLIF system which allows cranial pedicle screw connector moving caudally in accordance with reducing of disc height due to subsidence of interbody cages.

**Materials and Methods:** This study included consecutive 34 lumbar DRSA patients who underwent PLIF at our hospital. There were 17 males and 17 females with a mean age of 61.1 years. The mean follow-up period was 30.0 (range 10-64) months. The surgical methods were as follows: Conventional PLIF in 19 cases (PLIF group), and Dynamization PLIF in 15 cases (D-PLIF group). Outcome measures (VAS, ODI, ZCQ) and X-ray findings at the latest follow-up were assessed.

**Results:** In all 34 cases, cage subsidence more than 3mm is observed in 31 cases (91.2%). Local kyphosis more than 4 degrees occurred in 8 cases (25.8%) in the 31 cases with cage subsidence. In the patients with local kyphosis, the mean values of VAS, ODI, ZCQ all showed significant poor results ( $p < 0.05$ : t-test) compared to the results of the patients without local kyphosis. Local kyphosis more than 5 degrees did not occur in patients of D-PLIF group. In D-PLIF group, the mean values of VAS, ODI, ZCQ all showed significantly superior ( $p < 0.05$ : t-test) over the results of PLIF group.

**Discussion:** The result of this study showed that occurrence of

local kyphosis more than 4 degrees was significant risk factors that had adverse effects on postoperative clinical outcome. Dynamization PLIF is considered to be advantageous for the prevention of occurrence of local kyphosis, and an effective procedure for lumbar DRSA patients.

#### P427

### CORRELATION BETWEEN SIGNIFICANT CORTICAL SIGNAL CHANGES ON INTRAOPERATIVE SPINAL CORD MONITORING AND BLOOD PRESSURE DURING LUMBAR SURGERY

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**Introduction/Aim:** The objective of our study is to determine if blood pressures commonly found in controlled hypotension adversely affect cerebral blood flow. Our study was a retrospective and observational study. During lumbar surgery, hypotensive anesthesia to achieve controlled hypotension is requested by many spine surgeons to decrease blood loss and to improve visualization. Naturally, anesthesiologists are resistive to lowering blood pressure due to the risk of cerebral hypoperfusion and possible stroke. These impending adverse events can be monitored in the intraoperative setting with somatosensory evoked potentials (SSEP). With this SSEP data, we can monitor in real time whether blood pressures commonly found in controlled hypotension adversely affect cortical signals and subsequent cerebral blood flow.

**Methods:** Upon obtaining IRB approval, we conducted a chart review of 123 patients who underwent lumbar surgery by one spine surgeon within the last 5 years at one institution. We obtained blood pressure data and recorded significant cortical signal changes in a binary format. We then performed logistic regression analyses between various blood pressure variables and cortical signal changes to identify any significant associations.

**Results:** Twelve out of the 123 patients had significant cortical signal changes. The lowest minimum systolic blood pressure recorded was 55 mmHg and the lowest average mean arterial pressure recorded was 59 mmHg. We found no significant associations between cortical signal changes and these four blood pressure variables (lowest p-value=0.156).

**Discussion/Conclusion:** Hypotensive anesthesia is an effective means of minimizing blood loss and decreasing operative time by allowing better visualization of the surgical field. We already know that cortical signal changes are representative of cerebral hypoperfusion, in the absence of other factors such as surgical manipulation of the spine that can cause cortical signal changes. Our study suggests that there is no significant association between the usual blood pressure variation of lumbar surgery and cortical signal changes.

#### P428

### SINGLE VERSUS MULTIPLE-SCREW SPINO-PELVIC FIXATION IN SCOLIOTIC CURVES WITH PELVIC TILT UNDERGOING LONG POSTERIOR FUSIONS

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**Background:** High rates of iliac screw loosening and even breakage are usually reported, especially in cases where bilateral single-screw constructs are used. Therefore, there is a need for exploring more stable iliac fixation techniques.

**Methods:** A total of 44 patients (average age: 26 years, range: 11-67) operated on by long posterior spinal fusion with pedicle screws and fixation to the pelvis were followed up for more than two years. In 24 cases, one single iliac screw on each side was used. Other 20 cases underwent spino-pelvic fixation with multiple-screw constructs (2 or more screws in each side). Both series were matched in terms of etiology and type of deformity, severity of the main curve, pelvic tilt and fusion levels. The parameters analyzed for comparison were complications rate, lumbosacral fusion rate, lysis around the implants and reoperations rate.

**Results:** Patients with multiple-screw constructs exhibited lower postoperative complications rate and greater pelvic tilt correction. There no case of detachment and radiolucency around implants in this case. However, reintervention because of bar rupture was more frequent in cases with multiple-screw pelvic fixation.

Parameter	Single-screw fixation (n:24)	Multiple-screw construct (n:22)
Duration of surgery (min)	321 (250-410)	302 (253-329)
Curve severity (Cobb)	60° (112-39)	67° (115-45)
Curve correction (%)	68 (41-94)	67 (48-86)
Post-op infections	3	1
Post-op pelvic tilt <10° (%)	42.1	75
Screw radiolucency (n/total)	7	0
Screw detachment	3	0
Bar rupture	1	3
Reinterventions	1	4

**Conclusion:** Spino-pelvic anchorage with 2 or more screws in each iliac wing was more effective than single-screw constructs as to pelvic tilt correction. Implant failure rate was also lower. On the contrary, it seems that higher stable constructs involved a higher rate of lumbosacral non-union leading to bar rupture.

#### P429

### IS FUSION REPLACEMENT HYBRID CONSTRUCT AN OPTION TO FUSION FOR TWO LEVEL LUMBAR DEGENERATIVE DISC DISEASE? A FUNCTIONAL OUTCOME STUDY WITH MINIMUM TWO YEARS FOLLOW UP

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**Introduction:** A FusionReplacementHybrid where one level is replaced and adjacent level fused may be an alternative to two level lumbar fusion. Two concurrent cohorts who either received



FusionReplacementHybrid (Prodisc-L+Synfix+BMP-7)(Group H n=24) or a two level fusion (Group F n=29) were analysed.

**Material and Method:** 31 males and 22 females agreed to surgery from November 2005 to May 2009 for two level disc disease. Patients filled modified NASS and AAOS modern forms preoperatively and at subsequent visits. The primary outcomes were VAS and categorical back pain relief. The secondary outcomes were reduction in pain medication, return to work, improvement in recreational activity or exercises and patient satisfaction. Subjects with at least two interval-points of improvement were defined as responders. Data is presented as mean (±SD) or mean(range), and was analysed as intention-to-treat with RANOVA.

**Results:** Mean age of the patients was 42.4 years (30-64) and 56.6 years (31-76) in GroupH and GroupF respectively. VAS decreased in two years following surgery by 30%(p<0.05) from 7.4(±2.5) to 4.9(±3.3) in GroupH and by 15% (p<0.05) from 9.0 (±1.2) to 7.6 (±1.6) in GroupF. The ratio for responders are shown below

Outcomes	12 months		24 months	
	GroupH	GroupF	GroupH	GroupF
Back pain relief	7(29%)	7(24%)	5(21%)	2(7%)
Pain medication	11(46%)	7(24%)	5(21%)	4(14%)
Return to work	9(38%)	5(17%)	6(25%)**	1(4%)
Recreational activity/ exercise	10(42%)**	4(14%)	6(25%)	4(14%)
Patient satisfaction	11(46%)	10(42%)	8(33%)	9(31%)

**Discussion:** In this retrospective analysis of prospectively collected data, numerous absent data points were observed. Significant reduction in VAS was seen within both groups, however no difference was noted between groups. There was fivefold improvement in return to work at 24 months and threefold in terms of recreational activity/ exercise at 12 months in the GroupH.

**Conclusion:** The level III evidence demonstrated the FusionReplacementHybrid as an option for the recalcitrant two level disc disease. This study will be augmented with an analysis of recent outcome where time from surgery will be the confounding factor.

**P430**

**ANTERIOR LUMBAR INTERBODY FUSION WITH RECOMBINANT HUMAN BONE MORPHOGENETIC PROTEIN-2 AND RETROGRADE EJACULATION: RESULTS FROM A NON-INDUSTRY SPONSORED, SINGLE SURGICAL TEAM**

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**Introduction:** Retrograde ejaculation is a know complication of anterior surgery in the lumbar spine. Concerns have been raised over the variable risk of retrograde ejaculation with respect to the use of recombinant human bone morphogenetic protein-2 (rhBMP-2), in studies with and without a financial relationship with the manufacturer of this product. The aim of this study it to evaluate the rate of retrograde ejaculation in a cohort of patients undergoing anterior lumbar interbody fusion with rhBMP-2 performed by a single surgical team, without financial relationship with the manufacturer of this product. Special attention will also be place on technical issues in our surgical technique.

**Methods:** All male patients who underwent an anterior lumbar interbody fusion, using a retroperitoneal exposure, by the two authors from May 2004 to June 2011 were identified after IRB approval. Patients were excluded if rhBMP-2 was not used, or if the surgical level did not include L4-5 or L5-S1. The risk of

retrograde ejaculation was reviewed preoperatively in with all patients and incidence recorded postoperatively, along with disposition of this complication at final follow-up.

**Results:** One hundred and fifty-two patients were identified. Three patients were excluded because the surgical level was isolated to L3-4, and one excluded because rhBMP-2 was not used. Of the remaining 148 patients, 4 had preoperative erectile dysfunction that mitigated the issue of retrograde ejaculation with their dysfunction unaffected by our intervention. Two remaining patients, ages 67 and 78, had no interest in discussing the retrograde ejaculation preoperatively and out of respect to their wishes, was not discussed post-surgery. One patient was excluded because the retroperitoneal exposure was abandon. Of the remaining 141 patients, there were 2 cases of retrograde ejaculation of which 1 did not recover giving an incidence of 0.7%.

**Conclusion:** These finding indicate that the use of rhBMP-2 in the anterior lumbar interbody region can be used safely with respect to the incidence retrograde ejaculation with a rate that does not exceed that found in patients undergoing similar surgery without rhBMP-2. Given that the authors have no financial relationship with the manufacturer of rhBMP-2, the variability of retrograde ejaculation in studies utilizing rhBMP-2 may be related to technical considerations rather than just the presence or absence of industry relationships.

**P431**

**PERIOPERATIVE INCIDENCE AND MANAGEMENT OF DEEP VEIN THROMBOSIS ASSOCIATED WITH SPINAL SURGERY**

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**Introduction:** Spinal surgery patients are at risk for deep vein thrombosis (DVT). The purpose of this study was to assess incidence and management of DVT during the perioperative period of spinal surgery.

**Methods:** Between December 2006 and January 2011, we retrospectively assessed 209 spinal surgery patients (121 males, 88 females; average age: 64 years-old) who had also received ultrasonography assessments of both lower extremities before and after surgery. The clinical protocol for DVT was the following: 1. When a proximal DVT was found, cardiovascular internal medicine was consulted; 2. When a distal DVT was found pre-operatively, an anticoagulant medication was administered until six hours prior to surgery; and 3. When a new distal DVT was found post-operatively, early post-operative ambulation was prescribed and weekly ultrasonography assessments were performed.

**Results:** 23 patients (11.0%) showed DVT in the perioperative spinal surgery period. 9 patients (4.3%) had a DVT [proximal DVT, 1 (0.5%); distal DVT, 8 (3.8%)] before surgery. In the one case of proximal DVT, an inferior vena cava filter was placed before surgery. 14 patients (6.7%) developed new-onset DVT [proximal DVT, 1 (0.5%); distal DVT, 13 (6.2%)] following spinal surgery. In the one case of new onset proximal DVT after surgery, a pulmonary embolism occurred in association with the proximal DVT; thrombolytic therapy with an inferior vena cava filter was performed. Follow-up ultrasonography assessments showed that DVT disappeared completely in 82.6% of patients with a DVT during the perioperative period.

**Discussion:** 11% of patients who underwent spine surgery had DVT peri-operatively. More than 80% of these DVTs improved with proper perioperative management. The results of this study indicate that DVT assessment using ultrasonography is important for proper management of DVT during the perioperative period of spine surgery.



P432

### HYBRID GRAFTING USING BONE MARROW ASPIRATE COMBINED WITH POROUS $\beta$ -TRICALCIUM PHOSPHATE AND TREPHINE BONE FOR LUMBAR POSTEROLATERAL SPINAL FUSION - A PROSPECTIVE, COMPARATIVE STUDY VERSUS LOCAL BONE GRAFTING

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**Introduction:** Iliac crest bone graft (ICBG) has been traditionally used as the golden standard for lumbar spinal fusion. The significant complication rate associated with harvesting cortico-cancellous ICBG has encouraged development of alternative graft substitutes. We developed a hybrid graft (HBG) of porous  $\beta$ -tricalcium phosphate (TCP) ceramics/percutaneously harvested bone sticks (trephine bone)/autologous bone marrow aspirate (BMA) for lumbar posterolateral fusion (PLF). The aim of this study was to investigate the efficacy of the HBG as a substitute for conventional cortico-cancellous ICBG.

**Materials and Methods:** From September 2005, 64 consecutive patients underwent decompressive laminotomy and one-level instrumented posterolateral fusion (PLF). Each patient in this study had the constructs of the HBG placed on one side of the intertransverse process gutter. An autologous local bone graft (LBG) harvested during decompressive laminotomy was placed on the other side as a control. Radiographic evaluation was performed 6 months, 1 year after surgery and subsequently on an annual basis. The fusion statuses on either side of vertebra were evaluated by independent observers using reconstruction computed tomography.

**Results:** The flexion-extension motion in the dynamic X-rays at the target level decreased over time. Only 1 case (2.3%) exhibited over 5 degrees of angular motion 2 years after surgery. In the evaluation of fusion status, the HBG exhibited a significantly higher fusion rate (71.4%) than that of the LBG (53.7%) 6 months after surgery. At 1 year following surgery, the HBG and LBG sides demonstrated equivalent fusion rates with no significant differences. No significant complications at the donor site were found postoperatively.

**Conclusion:** The HBG promoted posterolateral spinal fusion without significant donor site morbidity. Because of its efficacy and safety, this hybrid construct seems promising as an alternative to conventional iliac bone grafts for lumbar spinal fusion.

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### INFLUENCE OF SHORT FUSION SURGERY FOR LUMBAR LORDOSIS AND SCOLIOSIS IN DEGENERATIVE LUMBAR SCOLIOSIS PATIENTS

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**Introduction:** When the degenerative change in the disc of the lumbar spine induces lumbar scoliotic curvature, the condition is called degenerative lumbar scoliosis (DLS). DLS often accompanies the secondary curvature to compensate the primary curvature. We studied the change of lumbar lordosis and compensated curvature after short fusion surgery for the primary curvature, and risk factors for adjacent segment disease.

**Materials and Methods:** A total of 59 DLS patients, who underwent short fusion surgery, were selected as subjects. Patients were grouped by their fusion methods; fusion surgery for the primary curvature with correction of angle (Group A, n=35); and fusion surgery for the primary curvature without

correction (Group B, n=24). The angles of lumbar scoliosis and the compensated curvature were measured on the antero-posterior radiographs. The changes of lumbar lordosis were also compared regarding adjacent segment disease (ASD).

**Results:** The average scoliotic angle was decreased from  $18 \pm 8^\circ$  to  $11 \pm 6^\circ$  by surgery in Group A ( $p < 0.0001$ ), while there was no difference between the angles before ( $17 \pm 6^\circ$ ) and 1 week after surgery ( $15 \pm 5^\circ$ ) in Group B. The angles of compensated curvature were also decreased from  $12 \pm 8^\circ$  to  $8 \pm 6^\circ$  accompanied with the correction in Group A ( $p < 0.0001$ ), and the decrease were maintained 3 years after surgery. The average lordotic angle was increased after surgery from  $30 \pm 17^\circ$  to  $32 \pm 17^\circ$  in Group A ( $p < 0.05$ ), while there was no difference between the angles before ( $30 \pm 15^\circ$ ) and 1 after surgery ( $30 \pm 18^\circ$ ) in Group B. The average lordotic angle was significantly decreased after surgery in ASD patients.

**Conclusion:** Compensated scoliotic angle was decreased by the correction of primary scoliotic angle. The spontaneous correction of compensated curvature did not trigger ASD. Loss of lordotic angle may trigger ASD after short fusion surgery in DLS.

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### PARAVERTEBRAL MUSCLE ATROPHY INFLUENCES SURGICAL OUTCOMES OF PARTIAL LAMINECTOMY FOR LUMBAR CANAL STENOSIS

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**Introduction:** Many factor analyses have been performed on surgical outcomes of partial laminectomy for lumbar canal stenosis (LCS). Loss of lumbar sagittal and coronal balance is reported as the major factor. We speculate surgical outcomes will be more influenced by muscle capacity of PVM because mobility of lumbar segments is preserved in this procedure. However no data is available, which evaluates PVM as a prognostic factor. We retrospectively evaluated PVM atrophy using signal-noise ratio (SNR) to clarify main factors.

**Patients and Methods:** This retrospective study includes thirty patients (mean age:73.0, male:12,female:18) with LCS without spinal instability, who underwent partial laminectomies at two or more levels. PVM is evaluated by MR T2-images (Signa Excite, 1.5T GE. TR 4000,TE105) using the analysis software attached to MRI viewer to measure the size and SNR of PVM (lumbar multifidus, longissimus and psoas muscles) at L4/5. The relationship between the recovery rate of JOA scores and PVM data was assessed (Spearman rank correlation).

**Results:** Preoperative JOA score was 11.6 and improved to 23.6 at the first year after surgery. The recovery rate was 71.5%. The cross-sectional areas of PVM were  $1776.1 \text{ mm}^2$  in psoas,  $1974.1 \text{ mm}^2$  in longissimus and  $1339.6 \text{ mm}^2$  in multifidus. No correlation was found between the recovery rate and size of the muscles. In contrast, SNR was  $rt.2.594$ ,  $lt.2.376$  in longissimus and  $rt.8.736$ ,  $lt.8.626$  in multifidus muscle, which was higher than in psoas ( $rt.1.468$ ,  $lt.1.203$ ). SNR of longissimus and multifidus muscles was significantly correlated to the recovery rate ( $P < 0.05$ ). L1-S angle, which were previously reported as the important factor, was also correlated to the recovery rate ( $p < 0.05$ ) but Cobb's angle was not (NS).

**Discussion:** Spinal mobility is preserved in partial laminectomy contrast to the instrumentation surgery. PVM is more important after surgery because spinal segments work as motion segments. SNR of PVM will be more accurate than X-ray factors. SNR of PVM will be more accurate than X-ray.

**Conclusion:** We found that the preoperative PVM evaluation would be important for the recovery rate after partial laminectomies as a prognostic factor.



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### SPINO-PELVIC FIXATION WITH THE "T" ILIOSACRAL CONSTRUCT IN NEUROMUSCULAR SPINAL DEFORMITIES- RESULTS IN A PROSPECTIVE COHORT OF 60 PATIENTS

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**Introduction:** Neuromuscular scoliosis often requires a long fusion from the upper thoracic spine to the sacrum or pelvis. We present the results of a prospective series of 60 patients treated for neuromuscular spinal deformities with an original spinopelvic construct using two sacral screws and two iliac screws.

**Materials and Methods:** From November 2007 to May 2010, 60 patients were operated on for neuromuscular scoliosis with long constructs extended to the sacrum with an original iliosacral fixation. Radiographic and functional results were evaluated at a minimum of 18 months follow-up.

**Results:** Mean age was 13.9 years (range, 10.6-19.1 years). Spinal correction was performed by posterior approach with in-situ bending technique using pedicle screws. Anterior release was performed in 6 cases. A special segmental construct was used for pelvic anchorage: two sacral screws and two iliac screws were connected with a horizontal cobalt-chromium rod. Two 90° long-offset connectors were then used to link the pelvic construct to spinal rods. Mean preoperative Cobb angle was 68.9° and pelvic obliquity was 21.2°. Postoperative mean Cobb angle was 28.9° and pelvic obliquity was 3.2°. No significant loss of correction was noted at last follow-up. Twelve patients had early postoperative wound infection. Outcome was favorable in all the cases after local debridement and antibiotics.

**Discussion:** The results obtained in our patients using the "T" iliosacral construct are similar to those obtained with other techniques. At the last follow-up, adequate pelvic obliquity was restored and no loss of correction was noted. The advantage of this technique is a powerful "low profile" construct with a "four-points fixation" in two different planes and three different bones improving earlier mobilization and return to a comfortable sitting position.

**Conclusion:** Despite the high rate of infectious complications in our patients, we stress the importance of treating frontal and sagittal spinal and pelvic imbalance in neuromuscular patients in order to avoid poor sitting posture, thus minimizing skin, respiratory, and/or digestive complications. We think that pelvic fixation with the "T-construct" did provide effective and improved spinal correction and stabilization in these patients, while reducing the need for a postoperative cast or brace.

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### EXPERIENCE OF USING "KARAYAHESIVE" AS HYDROCOLOID WOUND DRESSING FOLLOWING SPINE SURGERY

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**Introduction:** With the change in theory from the conventional dry wound healing to moist wound healing, various wound dressings have released. In view of the mechanism of wound healing, some researchers have proposed the technique of two-day application of dressing materials, based on the fact that the epithelium is completed within approximately two days. In this study, we used Karayahesive, a hydrocolloid dressing material, as a postoperative dressing in the field of spine surgery and examined its clinical utility.

**Materials and Methods:** The subjects of this study were

50 patients who underwent spine surgery and received the treatment with Karayahesive. Subcutaneous suture was done and Karayahesive was used to close the wound. In this treatment, epidermal suture was not carried out. The drain was removed on the second day, and Karayahesive was removed on the third day after surgery. Taking a shower was permitted since the same day. In this manner, the treatment of the wound with Karayahesive was completed.

**Results:** Satisfactory wound healing was achieved in all cases. The patients suffered no complications such as ruptured suture, infection, allergic reaction or keloid/hyperplastic scar.

**Discussion:** The four key advantages of Karayahesive are that it provides a moist environment for promotion of wound healing, transparency, flexibility/tight contact, and absorbability. These advantages mean that: 1) Physicians do not need to do laborious daily changes of gauze dressings. 2) Patients do not feel pain and stress during daily removal of gauze dressings and removal of staples. 3) The wound, which is in the process of forming the epithelium, is not exposed to disinfectants including iodine that interfere with the mechanism of wound healing and its surface does not dry out during application of Karayahesive. The quality of wound healing is improved by introducing this treatment.

**Conclusion:** The Karayahesive wound closure methods has proved to be useful in the treatment after spine surgery.

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### CAN PROVOCATIVE DISCOGRAPHY AFFECT ADJACENT SEGMENT DEGENERATION (ASD) AFTER LUMBAR FUSION?

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**Introduction:** It recently reported that intradiscal procedures during provocative discography damaged the punctured disc and accelerated disc degeneration in lumbar spine. We aimed to assess whether discography affect the acceleration of disc degeneration at the adjacent levels of lumbar fusion.

**Materials and Methods:** A total of 113 discs of 58 patients (ALIF 19, PLF 22, decompression 17) who had undergone a spine surgery for lumbar degenerative disease with preoperative provocative discography were included in this study. Each patients had both preoperative and a minimum of 5-year follow-up MRI. Subject discs were grouped as adjacent discs of fusion (62 discs), and non-fusion controls (51 discs). The progression of the adjacent disc degeneration depending on provocative discography was assessed with preoperative and repeated MRI by three observers, three times each. Logistic regression was conducted to analyze the risk factors for ASD.

**Results:** The mean follow-up duration was 86.0±28.7 months (60~192 months). Demographic variables were homogeneous between the two groups. The progression of disc degeneration was not different between the adjacent levels of fusion (P=0.446) and non-fusion control (P=0.613), regardless of whether concordant pain had been provoked or not. Preoperative diagnosis, type of surgery, gender, age, follow-up duration, and Modic change were not relevant for ASD. Logistic regression revealed that the only significant factor for ASD was the preexisting disc degeneration (OR 2.649, 95% CI 1.607-4.367). Pfirrmann grade 3 was the most vulnerable stage for ASD.

**Discussion:** Pain provocation on discography did not predict the progression of disc degeneration at the adjacent levels of surgery. Constitutional factors such as preexisting disc degeneration should be considered as an etiology of ASD.

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### A SOUND UNDERSTANDING OF THE MORPHOLOGICAL FEATURES OF THE EPIDURAL FIBROUS TISSUE IS THE KEY TO SUCCESSFUL DECOMPRESSION ALONE FOR LUMBAR SPINAL STENOSIS WITH OR WITHOUT THE LISTHESIS

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**Introduction:** Decompression alone for lumbar spinal stenosis (LSS) with or without the listhesis has been performed under microscopy or endoscopy with satisfactory results, which requires precise neural decompression in the limited operative field. The purpose of this prospective observational study was to report the morphological features of the epidural fibrous tissue (EFT) in order to perform successful decompression alone for LSS.

**Materials and Methods:** Ninety-six patients with LSS who had undergone decompression alone at the L4-5 level under microscopy were evaluated with a more than 2 year follow up period. The age at surgery averaged 68.0 years and the recovery rate averaged 69.0% calculated by using the JOA score. With regard to the listhesis grade (%slip), 51 patients had with < 10 % (group A), 30 patients with 10 to 20 % (group B) and 15 patients with  $\geq 20\%$  (group C) without any significant difference in the recovery rate ( $p = 0.93$ ). Noteworthy EFT (n-EFT) was defined as follows: Type 1 obstructs the dural tube expansion and type 2 fixes and compresses the nerve root. The latter was graded in each patient as the nerve root fixation score (NRF score): none = 0, one side = 1 and bilateral = 2. During surgery the morphology of the EFT was observed and recorded. The n-EFT was released from the dura for adequate decompression. The EFT specimens obtained from 21 patients during surgery were examined histologically.

**Results:** The EFT had various morphological features, some of which can cause dural tearing, symptomatic epidural hematoma and scar tissue formation. Type 1 n-EFT was observed in 3 cases, type 2 in 26 cases and a combination of the both in 2 cases, one of which contained generous venous plexus with easy bleeding. The NRF score was: mean  $\pm$  SD =  $0.3 \pm 0.5$  in group A,  $0.4 \pm 0.6$  in B and  $0.9 \pm 0.9$  in C, and group C had a significantly higher score than A and B ( $p < 0.05$ ).

**Conclusion:** Proper management of the EFT with understanding the anatomical features is the key to successful decompression alone for LSS.

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### MODULATION OF BMP-2 ACTIVITY BY A FUNCTIONALIZED CORE/SHELL MICROBEAD DELIVERY SYSTEM IN AN ANIMAL MODEL OF POSTEROLATERAL SPINAL FUSION

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**Introduction:** Although recombinant human bone morphogenetic protein 2 (rhBMP-2) is commonly regarded as the most potent bone inducing molecule, exceedingly large amounts are required for consistency in clinical outcome. This may be due to poor modulation of in vivo release and activity by collagen carriers. Several recent studies have highlighted the importance of heparin and heparan sulfate in the in vivo sequestration and signaling of native BMPs and many other growth factors. In the present study, we hypothesize that the incorporation of heparin would functionalize a relatively "naïve" carrier vehicle and further enhance the osteoinductive activity of rhBMP-2.

**Methods:** Adopting the core-shell polyelectrolyte complexation

methods, we immobilized rhBMP-2 with or without heparin on the surface of multilayered alginate microbeads and evaluated the bioactivity in vitro and in vivo using  $C_2C_{12}$  cells and a rat model of posterolateral spinal fusion respectively.

**Results:** In vitro release kinetics indicates that the microbeads could sustain the release of rhBMP-2 in a variable manner depending on the amount of heparin in the shell. Furthermore, the rhBMP-2 released prolonged the bioactivity of rhBMP-2 in vitro. After six weeks implantation in rats, a significantly higher ( $p < 0.05$ ) bone volume fraction (BV/TV) was observed when rhBMP-2 and heparin were co-delivered from microbeads compared with rhBMP-2 delivered alone from microbeads or from collagen carriers. Whereas bone formation with collagen sponges appeared poorly localized, crossing over the midline to contralateral implants, bone formation with functionalized core/shell microbeads appeared highly localized to each implant site.

**Discussion:** The central influence of carrier vehicles on the potency of BMP-2 is well documented. In the present study, we observed that incorporation of heparin resulted in enhanced bioactivity of rhBMP-2 as well as improved localization of bioactivity. However, excessive soft tissue swelling that resorbed spontaneously was observed with both heparin functionalized core/shell as well as collagen sponges delivery in this study.

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### REPEAT RADIOFREQUENCY NEUROTOMY FOR LUMBAR FACET ARTHRITIS

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**Introduction:** Percutaneous facet joint denervation (neurotomy) using radiofrequency thermal energy is widely used for the non-surgical treatment of chronic low back pain. The usefulness and reliability of repeat percutaneous radiofrequency facet joint thermal denervation (RFJD) is unknown.

**Aim:** To evaluate the effectiveness of repeat RFJD for chronic low back pain.

**Material and Methods:** 57 consecutive patients treated between April 2004 and June 2006 were included in a prospective analysis using VAS (Visual Analogue Score) and the LBOS (Low Back Outcome Score). The median follow up was 14 months. Radiofrequency thermal energy was applied for 90 seconds per joint at a maximum probe tip temperature of 90°C under fluoroscopic control and neuroleptic intravenous sedation. 10 of the 32 patients with a compensation claim had undergone the RFJD twice before against 5 patients in the non-compensable group. All other patients had undergone the procedure more than twice prior to this study.

**Results:** The average LBOS improved as a result of the repeat RFJD from 28.21 to 35.32 correlating with an improvement from the category of poor in function to fair. The improvement in LBOS was more significant in the compensable group. The study revealed a favourable attitude towards repeat RFJD in both compensable and non-compensable groups with 77.2% of patients overall finding the repeat procedure as helpful as the previous one with little difference between the two groups (78.1 vs 76). Pain levels documented by VAS (0-10) showed significant improvement with an overall change in LBOS from 2.37 to 3.58 points correlating with a shift from the VAS pain range of 5 - 6 to a pain range of 3 - 4.

**Conclusions:** This technique of RFJD leads to reliable and satisfactory results when repeated with most patients reporting a high degree of satisfaction with a clinical outcome similar to the initial procedure. The outcomes from multiple repeat RFJD are likely to remain consistent and favourable irrespective of the number of procedures performed.



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### PELVIC FLOOR DYSFUNCTION AFTER TREATMENT IN CAUDA EQUINA SYNDROME DUE TO LUMBAR DISC HERNIATION: A SYSTEMATIC REVIEW

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**Introduction/Aim:** Cauda equina syndrome (CES) is a rare complication of lumbar disc herniation. Even though dysfunction of miction, defaecation and/or sexuality are by definition affected in CES and can be severely disabling, little seems to be known about the outcome with regard to these functions. The objective of this study is to review the literature on outcome of miction, defaecation and sexual function in CES due to lumbar disc herniation.

**Material and Methods:** A literature search was done in Pubmed, Embase and Web of Science using a sensitive search string combination. Reference checking and citation tracking was done on included studies. Using predefined selection criteria, studies were selected and subsequently risk of bias was assessed by two independent reviewers using a validated Cochrane checklist adjusted for this purpose.

**Results:** Fourteen studies were included. The quality of the studies varied, mainly due to selection bias (four studies), attrition bias (two studies) and minor loss-to-follow-up (two studies). In only seven of included studies, both selection bias and any loss-to-follow-up could be excluded. Regarding sexual function, only one study reviewed outcome in all patients that were followed-up. All fourteen studies measured recovery of urinary function, with good outcomes in 35% (range 13-90%). Recovery of bowel function and sexuality were recorded in seven respectively five studies with good outcomes in 39% (range 21-64%) and 43% (range 20-77%) of patients, respectively.

**Discussion:** The great variations in outcome, probably due to differences in terminology in literature, as well as the extent of selection and attrition bias in the included studies, make the reliability of the reported results questionable.

**Conclusion:** The high prevalence of pelvic floor dysfunction in treated CES indicates a substantial problem, attaining minimal attention. Further studies on the outcome of pelvic floor functions in CES are necessary to get a more solid idea about the extent of the problem.

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### IS THE THICKNESS OF THE LIGAMENTUM FLAVUM AFFECTED BY COBB'S ANGLE OR LORDOSIS ANGLE IN NORMAL AND STENOTIC LUMBAR SPINE?

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**Introduction:** Previous studies highlighted factors associated with the thickness of the ligamentum flavum (FL), such as age, disc degeneration, lumbar spinal stenosis (LSS), hypertrophy and buckling, yet with no consideration of effect of Cobb's angle on FL asymmetry or lordosis angle on FL thickness in the lumbar spine. Segmental alignment, particularly in sagittal and coronal planes, results in LF stretched or buckled. We hypothesize that FL thickness is affected by intervertebral angles. This study aims to compare LF thickness between the normal and stenotic lumbar spines with lordosis angle as a co-variable, as well as LF asymmetry between the left and right sides with Cobb's angle.

**Methods:** Anterior, middle and posterior LF thickness on the left and right sides were measured on axial T1-weighted MRI, respectively, at all levels from L2 to S1 for the LSS group (n=78, 59 years old) and the control group (n=49, 42 years old). Lordosis

angles at each level were measured on lateral x-rays, while Cobb's angles at L2-L3 and L3-L4 levels on anterior-posterior x-rays. Difference in LF thickness between groups and sides was analyzed with and without lordosis and Cobb's angles as a co-variable, respectively.

**Results:** Anterior LF thickness was significantly greater in the LSS at all levels except at the L5-S1 level, compared to the control group (P<0.05). There was no significant difference in middle and posterior LF thickness between groups. The aforementioned results didn't change even when lordosis angles were used as a co-variable. Significantly thickness asymmetry was found only in the middle LF of the control group at L2-L3 level (2.86±0.75 mm on the right vs. 3.05±0.82 mm on the left), L4-L5 level (3.42±1.02 mm on the right vs. 3.65±0.89 mm on the left) and L5-S1 level (3.10±1.11 mm on the right vs. 3.36±1.19 mm on the left) (P<0.05). However, such asymmetry disappeared once Cobb's angles were included as a co-variable.

**Discussion:** LF thickness is lordosis-angle-independent and greater in lumbar spine stenosis, especially at the anterior LF. The Cobb's angle may attribute to LF asymmetry.

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### THE ASSOCIATION BETWEEN THE PRESENCE OF RIB ANOMALIES OF THE THORACOLUMBAR JUNCTION AND LUMBOSACRAL TRANSITIONAL VERTEBRAE

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**Introduction:** Several authors have reported rib anomalies of the thoracolumbar junction and lumbosacral transitional vertebrae (LSTV) may coexist. However, few papers have investigated the relationship between these anomalies. The purpose of this investigation was to demonstrate a possible association between these alterations.

**Methods:** Four hundred eleven patients treated by herniotomy for lumbar disk hernias were enrolled in this study. The patients were classified into the following three groups: (1) *Normal group:* Patients without LSTV as a control (84%) (2) *L4/lumbosacral transitional vertebrae (TV) group:* Patients with the sacralization of the 5<sup>th</sup> lumbar vertebrae (7%) (3) *L5/TV group:* Patients with the lumbarization of the sacral vertebrae (9%). Rib anomalies of the thoracolumbar junction were assessed as a 12<sup>th</sup> short rib and lumbar rib at L1 in the thoraco-lumbar spine on the radiographs.

**Results:** A twelfth short rib was observed in 6.4% of subjects in the Normal group, 46% in the L4/TV group, and 2.7% in the L5/TV group. The frequency of the 12<sup>th</sup> short rib in the L4/TV group was significantly higher than in other groups (P<0.05). The lumbar rib was present in 3.2% of subjects in the Normal group, 0% in the L4/TV group, and 32.5% in the L5/TV group. The frequency of the lumbar rib in the L5/TV group was significantly higher than that in the other groups (P<0.05).

**Discussion:** In the current study, the presence of the 12<sup>th</sup> short rib in the L4/TV group and the lumbar rib in the L5/TV group was fairly common. The lumbar spine may develop with a constant count of five by addition and subtraction in the thoracic and the lumbar spine. When LSTV is present, it is difficult to diagnose whether it is L4/TV or L5/TV on lumbar radiographs, and this alteration may contribute to the incorrect identification of the vertebral segment, leading to wrong-level spine surgery and a poor correlation with clinical symptoms. Therefore, all vertebrae should be examined.

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### CAUSES OF LATE REVISION SURGERY AFTER CEMENT AUGMENTATION IN OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURES

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**Objective:** To investigate the cause of the late revision surgery after cement augmentation for osteoporotic vertebral compression fractures (OVCFs)

**Summary of Background Data:** Percutaneous vertebroplasty (PVP) or Kyoplasty (KP) is thought to be effective to treat OVCFs. Many complications related to PVP or KP are simultaneously reported since introduction of the PVP. However, there is paucity of the reports regarding the causes of the late revision surgery after failed PVP or KP.

**Methods:** 49 patients were enrolled, who developed unremitting back pain and/or progressive neurological deficit after certain period of symptoms-free since treated with PVP or KP. Of them, 35 patients underwent late revision surgery. The causes of the late revision surgery were analyzed. 35 patients underwent cement removal and anterior reconstruction. Among 35 patients, 30 patients underwent anterior interbody fusion combined posterior instrumentation. 5 patients underwent anterior reconstruction only.

**Results:** The average time to revision surgery was 15 months (range, 3 to 70 months). Late infection, progressive kyphosis, misdiagnosis, proximal fractures after instrumented lumbar fusions and late neurological involvement were the causes of the late revision surgery. 3 patients had serious complications after revision surgery.

**Conclusion:** PVP or KP is an effective treatment for OVCFs. However, it is not risk or complication-free procedure. This limited cohort of cases shows a glimpse at the failures and offers some thoughts of longevity of PVP or KP. Preoperative evaluation should be thoroughly performed to avoid late failed PVP or KP.

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### SPINOPELVIC ALIGNMENT BETWEEN PEDICLE SUBTRACTION OSTEOTOMY AND ILIAC FIXATION WITHOUT OSTEOTOMY IN DEGENERATIVE LUMBAR KYPHOSIS

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**Objective:** To evaluate changes of the spinopelvic alignment between pedicle subtraction osteotomy (PSO) and iliac fixation without osteotomy in the treatment of degenerative lumbar kyphosis (DLK).

**Summary of Background Data:** The iliac fixation improves the pelvic parameters as well as spinal parameters. However, little is known about the changes of spinopelvic alignment between pedicle subtraction osteotomy (PSO) and iliac fixation in DLK.

**Methods:** DLK patients who had undergone iliac fixation or pedicle subtraction osteotomy (PSO) and had a minimum of 2 years of follow-up were retrospectively selected for groups of PSO (n=29) and iliac fixation (ILF, n=23), respectively. Whole spine anteroposterior and lateral radiographs were reviewed preoperatively, 3-month, 6-month, 12-month and 24-month after surgery. The lumbar lordosis (LL), thoracic kyphosis (TK), T9 offset (T9O) as a spinal parameters and pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT) as a pelvic parameters were measured on a sagittal radiography at each time-point. The sagittal vertical axis (SVA) which was the distance from the anterior superior corner of the sacrum was measured to determine the spinal sagittal balance. Clinical outcomes were

evaluated using back Visual Analogue Scale (VAS), Oswestry Disability Index (ODI) and modified Scoliosis Research Society (SRS).

**Results:** The SS (p<0.0001) and PT (p<0.0001) were significant difference between PSO and ILF. The LL (p=0.385), TK (p=0.186), T9O (p=0.593), PI (p=0.711) and SVA (p=0.900) were not significant difference. The VAS (p=0.513) and ODI (p=0.919) were not significant difference between PSO and ILF. However, there were significant differences of SS, PT, TK at each time points. The SS was only significant difference at each time points of postoperative 3 month, 6month and 1 year (p=0.000, 0.005, 0.012). The PT was only significant difference at each time points of 3 month, 5month and 1 year (p=0.013, 0.049, 0.025). The TK was significant difference at each time points of 3month, 1 year and 2 year (p=0.023, 0.017, 0.001).

**Conclusions:** There were only significant differences of SS and PT between PSO and ILF in pelvic parameters, but there was only significant difference of TK at each time points in the spinal parameters. The ILF group showed a superiority in correction of pelvic orientation. This study showed that ILF group has a better correction on pelvic parameters, compared to PSO.

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### RISK FACTOR ANALYSIS ON THE CAUSE OF REOPERATION IN LUMBAR SURGERY

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**Introduction:** The cause of reoperation following lumbar surgery is not clear. This study aims to investigate risk factors of reoperation following lumbar surgery.

**Materials and Methods:** 873 patients including 450 male and 423 female, mean age 66.7 years-old, underwent lumbar surgery. Additional diagnoses were 315 patients of spondylolisthesis, 69 of spinal deformities, and 77 of multi-operated back (MOB). As to neurological diagnosis, the patients were divided into cauda equine disorder (CE, n=331) or radiculopathy (n=437). Decompressions for 537, fusions 185, decompression/fusions 59, decompression/dynamic-stabilizations (DS) 57, DS 22, and DS/fusions 13 were performed. Under entry factors of age, sex, diagnosis, surgical procedure, number of levels, follow-up duration (FD) and surgeon, multivariate analysis was performed. Furthermore we investigated the reoperation rate of year by Kaplan-Meier's methods.

**Results:** 41 patients underwent reoperations. 15 were spondylolisthesis, 5 deformities, and 7 were MOB. 31 radiculopathy is more affected for reoperation than 10 CE. 1 level and over 4 levels were significant. There was no significant difference by surgical procedures. One surgeon affected to reoperation. Stepwise multivariate analysis revealed that FD (P<0.001) and radiculopathy (P<0.05) as risk factors of reoperation. Odd's ratio of radiculopathy/CE was 2.4 and that of FD was 1.7 per year, respectively. We assumed that important reason why radiculopathy tend to reoperation is the difficulty of evaluation. 16 foraminal stenosis including 6 patients who didn't improve by primary operation had reoperation, and 4 patients with radiculopathy had reoperation for recurrence while only 1 patient with CE had. The reoperation rate was 1.5% for less than 1 year, 2.3% for 1-2 year, 2.4% for 2-3 year and 1.4% for 3-4 year without significant difference. We assumed that the reason is advance of degeneration. From this distribution, the short to middle term reoperation rate is about 2% and it shows the baseline of reoperation.

**Conclusion:** FD and radiculopathy were significant risk factors. Radiculopathy due to foraminal stenosis and natural course of degeneration are considered to contribute to increased risk of reoperation.





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### CORRELATION OF ADULT SPINAL SAGITTAL IMBALANCE AND LIFE QUALITY ASSESSED WITH SF-36

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**Objective:** To evaluate the correlation of spinal sagittal imbalance and life quality.

**Methods:** Radiographic analysis of 48 consecutive symptomatic patients (Males 12, Female 36, 66.2±8.5 yrs) with spinal sagittal imbalance was performed using posteroanterior and lateral standing radiographs. Measurements included C7PL, thoracic kyphosis (TK), thoracolumbar kyphosis (TLK), lumbar lordosis (LL), pelvic tilt (PT), Pelvic incidence (PI), sacral slope (SS) and lumbar-sacral joint angle (LSA). Life quality was assessed with SF-36 questionnaire. Pearman correlation was performed to analysis the correlation.

**Results:** Mean C7PL was 44.7±22.5mm, TK was 26.1±13.1°, TLK was 11.9±10.3°, LL was 23.5±18.2°, PT was 32.1±13.4°, PI was 57.4±10.9°, SS was 22.5±11.5°, LSA was 10.5±7.6°. C7PL had significant correlation with Physical Functioning ( $r=0.428, P<0.01$ ) and General Health ( $r=0.428, P<0.01$ ). PI had significant correlation with Bodily Pain ( $r=-0.374, P<0.01$ ), Vitality ( $r=-0.303, P<0.01$ ), Social Functioning ( $r=-0.309, P<0.01$ ) and Role Emotional ( $r=-0.429, P<0.05$ ). TK had significant correlation with Physical Functioning ( $r=-0.292, P<0.05$ ), General Health ( $r=-0.389, P<0.01$ ). LL had significant correlation with Physical Functioning ( $r=0.428, P<0.01$ ), General Health ( $r=0.340, P<0.05$ ) and Vitality ( $r=0.373, P<0.01$ ). PT had significant correlation with Vitality ( $r=-0.385, P<0.01$ ) and Social Functioning ( $r=-0.417, P<0.05$ ). No significant correlation was shown between TLK, SS, LSA and the SF-36 categories.

**Conclusion:** C7PL, TK, LL, PI and PT are significant parameters correlate to life quality. PI is the most important one that affects bodily pain. TK, LL and C7PL are the main parameters affect general health. PI, PT and LL affect vitality most. Correcting these parameters when treating sagittal imbalance is important to gain better life quality.

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### THE ETIOLOGY OF REOPERATION FOLLOWING LUMBAR SURGERY

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**Introduction:** Although surgical treatment for lumbar spinal stenosis has been advancing year by year, reoperation is sometimes inevitable. The purpose of this study is to investigate the etiology of reoperation following decompression surgery for LS.

**Materials and Methods:** We investigated 873 patients including 450 male and 423 female aged 66.7 in average, underwent lumbar posterior decompression with or without fusion for 4 years. In the follow-up duration, there were 41 reoperations, except for those who had reoperation caused by hematoma or local infection, and we defined them as a reoperation group. We statistically analyzed the diagnoses, including spinal deformities (spondylolisthesis, scoliosis), multi-operated back (MOB), surgical procedures, and number of level. Adding to the analyses, we investigated the second diagnosis for reoperation and the duration from primary to reoperation.

**Results:** There was no significant tendency to reoperation in age, sex, diagnoses. The reoperation rates by surgical procedure were 1.9% in decompression only and 3.2% in fusion with no significant difference. One level operation and over four level operations had a tendency to cause reoperation. The most fre-

quent diagnoses for reoperation were 21 cases of adjacent level disorder including 12 foraminal stenoses. The analysis of the duration showed a two peak distribution and the peaks were 292 days and 829 days.

**Discussions:** The tendency for reoperation is caused by number of levels, not by surgical procedure. It suggested the relation of adjacent disorder. One level operation leaves more untouched levels, resulting in the adjacent lesion. Our results suggest that the adjacent lesion depended more on degeneration but on the adverse effect by the fusion. The second peak of reoperation during the follow-up is considered the effect of degeneration. On the other hand, reoperations within one year are due to the problems of the primary surgery itself.

**Conclusion:** The tendency of reoperation including adjacent disorder is not affected by surgical procedure but by the number of the levels. The causes of reoperations are different between within one year and over one year.

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### RÖNTGENOGRAPHIC PROGRESSION OF DEGENERATIVE LUMBAR SCOLIOSIS AND CLINICAL EVALUATION AFTER SHORT SEGMENT DECOMPRESSION AND FUSION

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**Purpose:** To assess the roentgenographic progression of degenerative lumbar scoliosis after short segment decompression and fusion with instrumentation.

**Methods:** As the main purpose of degenerative scoliosis surgery is the relief of low back pain and leg pain, short segment decompression and fusion with instrumentation were performed in 30 degenerative lumbar scoliosis patients. There were 10 men and 20 women and their ages ranged from 52 to 84 years (mean 67). Selective nerve root infiltration was performed to detect the affected nerve in each patient, and only the affected level was fused during surgery. The numbers of affected level were one (L2), three (L3), fifteen (L4), and fourteen (L5). One level fusion was performed in 17 patients, two levels in 12 patients, and three levels in one patient. Pre- and postoperative Cobb angles and sagittal balance was estimated and clinical result was evaluated using Japanese Orthopedic Association score (JOA-score: full mark is 29 points) in each patient. The average follow-up period was 4.4 years.

**Results:** The average operating time was 5.2h (range 2-8h), and the mean intraoperative blood loss was 270 ml (range 100-680 ml). Pre- and post-operative and follow-up Cobb angle was 19+/-9, 9+/-6, and 10+/-8 degrees respectively. Foraminal diameter of the affected nerve in the frontal plane was estimated using 3D-CT, and they increased significantly from 9.4+/-2.7 mm to 17+/-2.8 mm after surgery. JOA-score improved from 9+/-3 to 25+/-3 points and correction rate was 77+/-13%. All patients showed solid fusion and there was no infection or hardware breakage. In 8 patients, curve progressed due to the adjacent disc degeneration and their postoperative Cobb angle increased from 10+/-4 to 17+/-6 degrees. Two of them needed revision surgeries because of LBP and leg pain. Preoperative scoliosis aggravated rapidly when the preoperative Cobb angle was larger.

**Conclusion:** Cobb angles and clinical results of degenerative lumbar scoliosis were not deteriorated seriously after short segment decompression and fusion. Larger curve magnitude may be the risk factor for the acceleration of scoliosis.

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### ASSESSMENT OF QUALITY OF LIFE AFTER LUMBAR SPINAL SURGERY TO ELDERLY PATIENTS OLDER THAN 75 YEARS

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**Introduction:** There are few reports regarding quality of life (QOL) after lumbar spinal surgeries to elderly patients. The purpose of this study was to evaluate QOL and clinical outcomes of lumbar spinal surgeries in elderly patients.

**Materials and Methods:** Between April 2007 and Jun 2010, 99 patients underwent surgical intervention for lumbar spinal stenosis in our institution. Patients older than 75 years were included in the elderly group (N=30 male=13 female=17), and younger than 75 years were included in the control group (N=69 male=38 female=31). JOA scores, VAS (low back pain, leg pain and leg numbness), QOL were examined before operation and one year after operation. QOL was evaluated by Physical Component Summary (PCS) and Mental Component Summary (MCS) with use of SF36.

**Results:** The average age was 78.5 (75-88) in the elderly group and 66.0 (52-74) in the control group. There was no significant difference between two groups in the improvement ratio of JOA scores and VAS (LBP, leg pain and numbness) at one year after operation. No significant difference was found between two groups in preoperative PCS and MCS (17.1/15.0 and 46.1/49.2). PCS improved a mean of 9.3 points in the elderly group and 15.9 points in the control group, and there was no significant difference between groups ( $p=0.08$ ). Postoperative MCS were 52.1 and 53.5, respectively.

**Discussion:** The Japanese national standard value of PCS in 70's and 60's are 42.6 and 47.6, respectively. In this study, PCS at one year after operation in both groups did not attain the Japanese national standard value. However, clinical results of the lumbar spinal surgeries to elderly patients were satisfactory and postoperative PCS were significantly improved as well as control group.

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### PROPHYLACTIC ANTIBIOTIC ADMINISTRATION IN SPINAL INSTRUMENTATION SURGERY FOR PATIENTS WITH RISK FACTORS FOR SURGICAL SITE INFECTION

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**Background:** Since postoperative surgical site infection (SSI) with multiple drug resistance bacteria including Methicillin-resistant *S. aureus* (MRSA) or Methicillin-resistant *S. epidermidis* (MRSE) can be a devastating complication, we had started administration of teicoplanin (TEICO) as antimicrobial prophylaxis (AMP) for patients with high risk factors for SSI. The purpose of this study was to evaluate the effectiveness of TEICO administration as AMP for patients with high risk factor for SSI in spinal instrumentation surgery.

**Materials and Methods:** 636 consecutive patients who underwent spinal instrumentation surgery at our institution from 2007 to 2010 were included in this study. During 2007-2008, one of the antibiotics from piperacillin, cefazolin and flomoxef was used as AMP in all patients. During 2009-2010, TEICO was used as AMP additionally to the above antibiotics for the patients with

high risk factors for SSI. The high risk factors for SSI in this study were diabetes mellitus, presence of malignant tumor, neurogenic scoliosis, posterior correction and fusion surgery more than five vertebrae in patients aged more than 65 years, and atopic dermatitis.

**Results:** The infection rate in the high risk group was 13.8% (9/65 patients) during 2007-8, and the value significantly decreased to 3.9% (3/77 patients) during 2009-10 ( $p=0.02$ ). While the infection rate in the non-high risk group was 1.3% (3/223 patients) during 2007-8, the value slightly increased to 3.7% (10/271 patients) during 2009-10. Pathogens of SSI were MRSE in 4 patients, MRSA in 3, others in 2, and unknown in 3 during 2007-8, while, during 2009-10, they were MRSE in 7, *S. epidermidis* in 3, and others in 3.

**Discussion:** Since the infection rate of the high risk group significantly decreased from 13.8% during 2007-8 to 3.8% during 2009-10, the administration of TEICO as AMP was effective for prevention of SSI in patients with high risk factors. Though the detections of MRSA decreased after the administration of TEICO as AMP, the increased detections of MRSE would be another noteworthy problem.

**Conclusion:** The administration of TEICO as AMP was effective for prevention of SSI in patients with the high risk factors for SSI in spinal instrumentation surgery.

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### DIFFUSION TENSOR IMAGING: NEW DIAGNOSTIC IMAGING FOR DEGENERATED LUMBAR DISEASE

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**Introduction:** It is difficult to correctly diagnose lumbar degenerated disease with foraminal stenosis using conventional X-ray imaging, CT and MRI. This difficulty can sometimes result in failed back syndrome. Diffusion Tensor Imaging (DTI) was reported as a potential tool for the diagnosis for foraminal stenosis. The purpose of this study is to evaluate the efficacy of DTI for diagnosis of degenerated lumbar disease.

**Patients and Methods:** Twenty-seven patients (20 male, mean age, 68.5 years) with degenerated lumbar disease who underwent 3.0 T MRI and surgical treatment were included. DTI (tractography), fractional anisotropy (FA), and improvement in Japanese Orthopaedic Association (JOA) and visual analog scale (VAS) pain score were investigated.

**Result:** The diagnoses by conventional imaging were lumbar spinal stenosis without foraminal stenosis in 11 cases, with foraminal stenosis in 10 cases, lumbar disc herniation in 3 cases, spodylolisthesis in 2 cases, and discogenic low back pain in one case. We classified the patients into following four groups by the shape of the tractography; disruption, narrowing, tapering and no abnormalities. The mean preoperative JOA and VAS score were 14 and 88, and postoperative score were 21 and 12 respectively. The JOA score was improved by 46%. Tractography of the ipsilateral side showed disruption, narrowing and tapering, and a lower FA compared with the contralateral side. There was no significant correlation between FA and symptoms.

**Discussion:** Although there is no significant correlation between DTI and postsurgical symptoms, DTI has the possibility of detecting lesions of nerve damage, and to be a new diagnostic tool for the degenerated lumbar disease.



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### HISTOLOGICAL EVALUATION OF HUMAN RETRIEVED FRAGMENTED BIORESORBABLE POLYMER IN FAILED LUMBAR INTERBODY FUSIONS

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**Introduction:** The purpose of this study was to evaluate bioresorbability and biocompatibility of polymer cages in clinically failed lumbar interbody fusion cases.

**Materials and Methods:** The fragmented bioresorbable polymer implants were retrieved from 10 cases. Posterior lumbar interbody fusion (PLIF) was performed in 7 cases and transforaminal lumbar interbody fusion (TLIF) was performed in 3 cases. In the primary surgery, the implant was packed with iliac crest autograft alone in 4 cases, local autograft alone in 2 cases, iliac crest autograft combined with platelet rich plasma in 1 case, iliac crest autograft combined with rhBMP-2 in 1 case, cancellous allograft combined with rhBMP-2 in 1 case, and unknown graft in 1 case. The average in vivo duration of these polymers was 11 months (4-16). The indication of implant retrieval was failed fusion (9 cases) and implant migration (1 case). Histological assessment was performed with special reference to bioresorbability and biocompatibility of the polymer, extent of foreign body reaction and inflammation, and bone graft remodeling within the retrieved polymers.

**Results:** Various sizes of fragmented bioresorbable polymer were observed, approximately ranged from 100 microns to 8 millimeters. Most of large fragmented polymers were surrounded by fibrous tissue. Small fragments of polymer were observed as vacuoles in mixoid areas, representing partially dissolved synthetic materials. In 8 cases, these fragmented polymers were not associated with significant foreign body reactions. But in other 2 cases, giant cells and mononuclear macrophages were associated with fragmented polymers, suggesting significant foreign body reaction. These polymers were not associated with new bone formation. Necrotic fragments of bone were present, most likely representing unincorporated bone graft. Neither platelet rich plasma nor rhBMP-2 did not induce extensive bone formation in these cases.

**Conclusions:** Although occasional foreign body reaction was present, our histological evaluation suggests that the fragmented polymers still seem resorbable and biocompatible in most of the cases.

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### THE ASSOCIATION BETWEEN AGE AND THE ORIENTATION OF THE LUMBAR FACET JOINTS, DISC HEIGHT AND DEGENERATIVE SPONDYLOLISTHESIS (DS) IN PATIENTS WITHOUT LOW BACK PAIN

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**Introduction:** The purpose of our study was to determine the association between age and the orientation of the lumbar facet joints, disc height and DS in patients without low back pain.

**Methods:** Four hundred and ninety-nine patients (not orthopedic outpatients) were studied. These patients had undergone abdomen and pelvic computed tomography (CT) scanning in our hospital. All patients were questioned using the RDQ (Roland-Morris Disability Questionnaire) and 249 (169 males and 80 males) with RDQ scores of zero were extracted. They were divided into five groups: those <40 years; group I (19; 12 males, 7

females); 40-49 years, group II (26; 15 males, 11 females); 50-59 years, group III (64; 39 males, 25 females); 60-69 years, group IV (82; 61 males, 21 females); those >70 years, group V (58; 42 males, 16 females). The facet joint angle and disc height at two levels (L4/5 and L5/S1) were measured on axial and sagittal CT scans.

**Results:** With advancing age the facet joint angles were more sagittal on axial view ( $p < .05$ ) and more horizontal on sagittal view ( $p < .05$ ). On the other hand, disc height for the male patients was not significantly different comparing between each of the groups ( $p > .05$ ). Disc height for the female patients increased with advancing age ( $p < .05$ ). Nineteen patients had DS at L4/5 and 10 patients had DS at L5/S1. DS was not significantly correlated to facet joint angle ( $p > .05$ ) or disc height ( $p > .05$ ).

**Conclusion:** The facet joint angles, for both axial and sagittal views, increased with age. There are no correlation between facet joint angle and DS or between disc height and DS.

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### QUANTITATIVE TIME WINDOW DETECTION FOR EARLY-ONSET DISC DEGENERATIVE DISEASE WITH T1 $\rho$ -MR IMAGING TECHNIQUE

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**Introduction:** Biological therapies are promising for regenerating the degenerated intervertebral discs. It is essential to choose an appropriate indication and timing to disc regeneration. The present study was to define the time window of disc degenerative disease with T1 $\rho$ -MR imaging technique for biological regenerative treatments.

**Materials and Methods:** A total of 400 lumbar intervertebral discs of 80 human subjects suffered from low back pain were examined with lumbar spine T1 $\rho$  and T2-weighted MR imaging and quantitative analysis. Six rhesus monkeys randomly underwent either annulus fibrosus puncture or pingyangmycin sub-endplate injection on the L3/4 and L5/6 level, respectively. All animals were examined by X-ray and MRI at pre-operation, post-operation, and followed up for 12 months.

**Results:** The mean T1 $\rho$  values in the nucleus pulposus of 400 human discs from Pfirrmann grade 1 to 5 were 132.73 $\pm$ 24.79ms, 136.00 $\pm$ 31.41 ms, 76.09 $\pm$ 14.23 ms, 60.60 $\pm$ 16.08 ms, and 55.34 $\pm$ 5.39 ms, respectively. The data showed a great T1 $\rho$  value gap existed between Pfirrmann grade 2 and 3 in human subjects; whereas the T1 $\rho$  values on both rhesus disc degenerative models had a rapid decrease and then tended to stabilize. The T1 $\rho$  gap between Pfirrmann grade 2 and 3 in human subjects coincided in the rapid degeneration process in the rhesus disc degenerative models.

**Discussion and Conclusion:** The direct cause of the intervertebral disc degeneration triggers the pathological cascaded degenerative process. Although the degenerative tempos are different, the discs in both the ischemic and stabbed rhesus models in the present study had a rapid degenerative process. The findings demonstrate that the great T1 $\rho$  value gap between Pfirrmann grade 2 and 3 in human subjects which coincided in rapid degenerative stage in rhesus models. This special stage may be presumed as an ideal time window of the biological regeneration of intervertebral disc in the early-onset disc degenerative disease.

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### SPINAL FUSION IN ELDERLY PATIENTS DOES NOT GENERATE EXCESSIVE SECONDARY HEALTH CARE USE AND COSTS

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**Introduction/Aim:** Spinal fusion surgery rates in the elderly are increasing. Cost effectiveness analyses with relatively short length follow-up have been performed. But the long-term effects in terms of health care use are largely unknown. The aim of this study was to describe the long-term consequences of spinal fusion surgery in elderly patients on health care use and costs using a health care system perspective.

**Material and Methods:** 194 patients undergoing spinal fusion between 2001-2005 (70 men, 124 women) with a mean age of 70 years (range 59-88) at surgery were included. Average length of follow-up was 6.2 years (range 0.3-9.0 years). Data on resource utilization and costs were obtained from national registers providing complete coverage of all reimbursed contacts with primary and secondary health care providers. Data was available from 3 years prior fusion surgery until the end of 2009.

**Results:** Secondary sector health care use increased in the year prior to and the first year following surgery. Hereafter it normalized to the level of the background population and was mainly composed of diseases unrelated to the spine. An increase in costs due to secondary health care sector utilization after surgery could not be observed and the level of costs were similar to the background population. In contrast, the use of primary health sector care increased throughout the observation period, with increasing costs, and exceeded that of the background population.

**Conclusion:** Spinal fusion surgery in older patients does not generate excess secondary health care use in the longer term as compared to the background population.

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### THE USE OF A HYBRID DYNAMIC STABILIZATION AND FUSION SYSTEM IN THE LUMBAR SPINE BY USING A NEW SURGICAL PERCUTANEOUS AND MINI-OPEN APPROACH: DOES IT PRESERVE LUMBAR MOTION?

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**Objective:** The study examines whether functional motion is present at one or three years after DSS placement.

**Methods:** In the context of our DSS™ study (1/2008-10/2011) the surgical approach was minimized to a mini open paraspinous intramuscular approach. Only two less invasive paramedian skin incisions are necessary to implant the hybrid components. We reviewed all patients who underwent posterior lumbar instrumentation with the DSS™ system in particular the minimal invasive surgeries. Pre-operative symptoms, Visual Analogue Scale (VAS) pain scores, the Oswestry Disability Index (ODI) score, as well as the resulting flexibility (ROM) for dynamic fused segments and adjacent level above were measured by repeated native imaging and documented. A total of 76 patients underwent dynamic and hybrid dynamic lumbar stabilization. A follow-up was possible for 62 of 76 patients in a cycle of 3, 6, 12, 24 and 36 months post operatively.

**Results:** The average preoperative VAS score was reduced with regard to back pain from 7.4 to a mean postoperative score of 2.9 after 36 months and the leg pain from 4.5 to 1.2. The ODI also improved from 63 to 22. In the period researched so far, 68% of the patients were very satisfied, 28% satisfied and only 4%

somewhat dissatisfied. Patients with a pure dynamic construct demonstrated a decrease in mean for segment flexibility (ROM) at L3/4 (6.6-3.2), L4/5 (5.08-4.1) and L5/S1 (4.36-1.74). Mean ROM for adjacent segments in pure dynamic (5.27-7.0) and hybrid-construct (6.87-8.67) increased moderate.

**Conclusion:** The present study provides first long term information regarding DSS motion preservation system. We conclude that DSS System preserves functional motion sufficient to some degree at the instrumented levels while potentially decreasing the risk of adjacent-segment disease following lumbar arthrodesis. With the new minimal invasive approach collateral muscle damage as well as operative afflictions were minimized and the postoperative outcome showed significant improvements.

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### WHAT ARE THE RISK FACTORS OF PSEUDOARTHROSIS IN PLIF?

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**Objective:** Although reports have been made about the risk factors of developing pseudarthrosis in posterior lumbar interbody fusion (PLIF), none examines the numerous preoperative and perioperative risk factors together. The objective of this study is to determine the risk factors of developing pseudarthrosis in PLIF.

**Subjects and Method:** The subjects consisted of 136 patients (75 males and 61 females) that underwent PLIF as from 2003, and who were followed up for at least four years. The average age was 60.8 years old at the time of surgery and the average observation period 5 years and 10 months. Iliac autografts or local bone grafts were performed using pedicle screws and the Brantigan I/F Cage in all operations. In a year after the surgery, bone union/pseudarthrosis determination was made based on X-ray and CT images. Then, the effects of various preoperative and postoperative factors on bone union/pseudarthrosis were determined by chi-square testing and logistic regression. For statistical analysis, we used the software program SPSS.

**Results:** In a year after the surgery, 124 cases (91.2%) were diagnosed as bone union with 12 cases diagnosed as pseudarthrosis or prolonged bone union (5 cases of pseudarthrosis and 7 cases of prolonged bone union: 8.8%). Single variance analysis identified, as the preoperative risk factors of pseudarthrosis, the age at the time of surgery ( $p < 0.05$ ), degenerative spondylolisthesis ( $p < 0.05$ ), heart disease ( $p < 0.05$ ) and diabetes ( $p < 0.05$ ). As for the perioperative risk factors, the time of surgery ( $p < 0.05$ ), fusion range of two or more vertebral bodies ( $p < 0.05$ ), screw displacement ( $p < 0.05$ ), and dural injury ( $p < 0.05$ ) were significant. Multiple variance analysis using logistic regression determined the odds ratio of developing pseudarthrosis as 10.4 ( $p < 0.05$ ) for screws displacement, 8.1 ( $p < 0.05$ ) for dural injury, 4.7 ( $p < 0.05$ ) for a fusion range of two or more vertebral bodies, 3.6 ( $p < 0.05$ ) for heart disease, and 3.0 ( $p < 0.05$ ) for diabetes.

**Conclusion:** There exist numerous preoperative, perioperative, and postoperative risk factors of developing pseudarthrosis following spinal fusion. In addition to well-known factors, such as screw displacement, vertebral fusion ranges, and diabetes, the result of this study suggests that dural injury and heart disease may also constitute risk factors.



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### SURVIVAL PROGNOSIS FOR PATIENTS WITH NEWLY DETECTED METASTATIC SPINAL TUMORS

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**Introduction:** Several scoring systems to predict survival for patients with spinal metastases were developed by analyzing patients with severe symptoms who died following surgery. Our previous study showed performance status after palliative surgery improved in only half of the patients. To cope with rapidly progressing changes, a survival prognosis at the earlier stage of initial detection of spinal metastases is necessary for consideration of future treatment strategies. The purpose of this study is to investigate prognostic factors for patients with newly detected spinal metastases.

**Materials and Methods:** A total of 268 patients whose spinal metastases were initially detected from 2006 to 2008 with a minimum follow-up of 12 months if alive was analyzed retrospectively. Survival period was calculated from the date of initial detection of spinal metastases to the date of death or final follow-up. Univariate analysis using the Kaplan-Meier log rank statistic and multivariate analysis using Cox proportional hazards model was performed to identify prognostic factors for survival.

**Results:** At the latest follow-up, 192 patients had died, and 76 were alive. The mean survival period from the initial detection of spinal metastases was 15.9 months. By univariate analysis, performance status ( $p < 0.001$ ), primary site of the cancer ( $p < 0.001$ ), and major organ metastases ( $p < 0.001$ ), non-ambulatory ( $p < 0.001$ ), paralysis ( $p = 0.03$ ), and chemotherapy before spinal metastases ( $p = 0.02$ ) were significantly associated with survival period. Multivariate analysis showed that performance status ( $p = 0.01$ , HR=2.0), primary site of the cancer ( $p = 0.002$ , HR=1.6), and major organ metastases ( $p < 0.001$ , HR=3.2) were significantly associated with survival period.

**Discussion:** Until now, there has been no study to examine prognostic factors for the patients with spinal metastases including asymptomatic ones. Our result was almost in agreement with previous ones analyzing severe patients.

**Conclusions:** Performance status, primary site of the cancer, and major organ metastases were correlated with survival period from the initial detection of spinal metastases.

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### SACROILIAC JOINT ARTHRODESIS FOR SEVERE SACROILIAC JOINT PAIN

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**Background:** Most patients with sacroiliac joint (SIJ) pain response to conservative therapies. But in some cases, these therapies fail to manage the pain and only the SIJ arthrodesis would have the possibility to relieve the pain. The purpose of this study is to evaluate the surgical outcome of the SIJ arthrodesis we performed.

**Materials and Methods:** We diagnosed as having SIJ pain when the patient showed all three criteria: 1) lumbo-gluteal pain on one side, 2) positive findings on at least one of the three provocation tests: Gaenslen's test, Patrick's test, modified Newton's test, 3) pain relief more than 70% after the SIJ injection. Patients who had been not adequately responsive to conservative treatments for more than 6 months and been markedly restricted their daily living, were our indication for the SIJ arthrodesis, which included 27 patients. The SIJ arthrodesis was performed through only

anterior approach in 23 patients and combined anterior and posterior approaches in 4. Among them, 21 patients with a minimum 2-year follow up were selected for the present study, including 7 males and 14 females, mean age 48.4 years (24-86). Postoperative follow-up period was averaged 5.4 years (2.6-8.4). Clinical outcomes were assessed according to the MacNab Criteria. Eleven-point postoperative pain score (0-10), Roland-Morris disability questionnaire (RDQ), sitting time on the chair without backrest, walking time, were also evaluated pre-and post-operation.

**Results:** The surgical outcome was excellent in 4, good in 10, fair in 5, poor in 2. Postoperative pain score was averaged 4.2 (0-10). RDQ was improved from 21.5 (17-23) to 7.2 (1-14). Sitting time and walking time was improved from 4.9 minutes (0-20) to 92.5 (10-180), from 9.8 minutes (0-30) to 64.4 (1-180), respectively.

**Conclusions:** The surgical outcome of the SIJ arthrodesis was relatively good and thus it has a possibility of useful optimal method to relieve SIJ pain.

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### INFLUENCE OF TYPE OF INSTRUMENTATION ON SAGITTAL ALIGNMENT AND OUTCOME IN LUMBAR FUSION

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**Introduction:** Posterolateral fusion with posterior instrumentation alone is considered unsuitable for preserving sagittal alignment in a fused segment; additional intervertebral support is regarded as essential. We examined this hypothesis by comparing sagittal alignment and clinical outcome after transforaminal lumbar interbody fusion plus pedicular fixation (TLIF) or translamina screw fixation (TS).

**Methods:** Patients with lumbar degenerative disorders underwent either TLIF (N=36) or TS (N=16). Disc height (DH; % normal), disc angle (DA; degrees), sacral slope angle (SS) and lumbar lordosis (LL) were measured from lateral radiographs preoperatively and at 2mo and 24mo followup (FU). Patient outcome was assessed with the Core Outcome Measures Index preoperatively and up to 24mo post-op.

**Results:** Pre-operatively, there were no significant differences between the groups for DH, DA, SS or LL ( $p > 0.05$ ). In the TLIF group, DH increased from pre-op to 2mo FU (from  $68 \pm 22\%$  to  $87 \pm 18\%$ ;  $p < 0.05$ ), then declined slightly at 24mo FU ( $82 \pm 17\%$ ;  $p < 0.05$ ); in contrast, in the TS group DH showed little change up to 2mo FU ( $67 \pm 23\%$  to  $69 \pm 24\%$ ;  $p = 0.17$ ) but had declined significantly by 24mo FU ( $56 \pm 21\%$ ;  $p < 0.05$ ). DA showed no significant difference over time in either group ( $p > 0.05$ ). The pattern of change in LL did not differ significantly between TS and TLIF groups: there was a significant decrease from pre-op to 2mo FU, then a return to pre-op values at 24 mo FU. The groups did not differ significantly for the improvement in COMI score up to 24mo.

**Discussion:** Disc height was increased more with TLIF than with TS; however the overall alignment of the lumbar spine did not differ between them. Moreover, the group differences in radiographic measures were not accompanied by differences in patient-rated outcome.

**Conclusion:** We conclude that TLIF elicits more pronounced local segmental changes but is not superior to TS in terms of retaining sagittal alignment.

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### CLINICAL OUTCOMES OF PLIF FOR LUMBAR FORAMINAL STENOSIS

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**Introduction:** Various operations for lumbar foraminal stenosis (FS) have been reported. The purpose of this presentation is to investigate the clinical results of posterior lumbar interbody fusion (PLIF) for lumbar FS.

**Patients and Methods:** From 2004 to 2010, PLIF for lumbar FS was performed in 185 patients (104 male, 81 female) with a mean age of 67 years. Mean follow up period was 4 years (1 to 7 years). An interbody cage with local bone graft was inserted at the symptomatic side and followed by posterolateral fusion using pedicle screws. Affected level, operative time, blood loss, fusion rate, and JOA score were investigated. For the patients who had previous lumbar surgery, the possibility of misdiagnosed FS was assessed using MRIs.

**Results:** The affected level was L3-4 in 10 patients, L4-5 in 50, and L5-S1 in 125 patients. Mean operative time and intraoperative blood loss were 122 minutes and 271 ml, respectively. The average JOA score improved from 13.2 points to 25.2 points postoperatively. The fusion rate was 95%. Complications were found in 5 cases such as deep infections in two cases, superficial infection, hematoma, and screw loosening in one case each. Additional surgeries were required in three cases (1.6%) including adjacent segment disease in two cases, and deep wound infection in one. Forty-one cases underwent lumbar surgeries prior to current operation. In 23 of them, lumbar FS might be overlooked at the previous surgery.

**Discussion:** No patients required additional surgeries due to remaining or recurrent radiculopathy. Therefore, PLIF provides and maintains sufficient improvement of radiculopathy due to FS. This is an advantage of PLIF compared to foraminal decompression surgeries reported in the literature. Moreover, the incidence of complications and adjacent segment disease were low and only 1.6 % of the patients required additional surgeries. Therefore, PLIF can be recommended for lumbar FS. The authors would like to emphasize that misdiagnosed FS is still a major cause of failed back surgery syndrome.

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### CLINICAL OUTCOMES OF STAND-ALONE ANTERIOR LUMBAR INTERBODY FUSION

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**Introduction/Aim:** Anterior lumbar interbody fusion (ALIF) without supplemental posterior fixation has been debated. In recent years, new options for interbody fusion implants as well as graft materials have evolved. The purpose of this study was to examine patient outcomes following stand-alone ALIF.

**Material and Methods:** A review of the surgery logs identified 110 patients who had undergone stand-alone ALIF. Only patients with minimum of 12-month follow-up were included. Patients were excluded if any posterior instrumentation was used, the procedure was part of an ALIF/total disc replacement hybrid procedure, or if the ALIF was performed following a previous posterior fusion. The primary diagnosis was symptomatic disc degeneration. Data collected included: gender, age, BMI, operative level(s), blood loss, graft material used, implant type, complications, re-operations, Oswestry and VAS scores. The

majority of cases involved the use of a PEEK fusion cage and BMP or other biologic-based graft material.

**Results:** The mean age was 46.05 years (range: 23 to 79 years) and mean BMI 27.2. Single-level ALIF was performed in 95.0% of cases, with the majority being at L5-S1 (65.0%). The mean blood loss was 62.1 ml. Complications included two intraoperative vascular injuries (both repaired without sequela) and 1 superficial wound infection. There were four re-operations: one posterior fusion to treat a subsided ALIF, two fusion remote from the index level, and one patient received a spinal cord stimulator for pain control. There were significant improvements in the Oswestry and VAS pain scales ( $p < 0.01$ ; see table).

	Pre-Op	Post-Op	Significance
Oswestry	48.1	27.1	$p < 0.01$
Back Pain	7.4	3.1	$p < 0.01$
Leg Pain	5.3	2.3	$p < 0.01$

**Discussion:** There were significant improvements in Oswestry and pain scores following stand-alone ALIF with only one reoperation at the index level.

**Conclusions:** These findings suggest that stand-alone ALIF using current implant and graft options produced significant improvement and may be a viable alternative to using supplemental posterior fixation in the absence of pathology requiring a posterior approach.

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### TUMOR NECROSIS FACTOR- $\alpha$ -IMMUNOREACTIVE CELLS IN NUCLEUS PULPOSUS IN ADOLESCENT PATIENTS WITH LUMBAR DISC HERNIATION

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**Introduction:** TNF is thought to play a crucial role in the radicular pain caused by lumbar disc herniation in adult patients. Adolescent patients show hamstring tightness or painful scoliosis rather than the typical radiculopathy seen in adults. However, the expression of TNF in the nucleus pulposus of adolescent patients with lumbar disc herniation has not been explored.

**Methods:** Five nucleus pulposus from adolescent patients with lumbar disc herniation (age from 12 to 16 year old;  $n = 5$ ) or controls requiring surgery for other back problems (age from 12 to 16 year old;  $n = 4$ ; scoliosis) were harvested during surgery. Nucleus pulposus specimens were immunostained using antibodies to TNF and immunostained cells in the nucleus pulposus were counted. We compared the expression of TNF with pain intensity and existence of hamstring tightness.

**Results:** In patients with lumbar disc herniation, more TNF-immunoreactive cells were seen in the nucleus pulposus in comparison to patients with scoliosis ( $P < 0.01$ ). However, the extent of TNF expression was not related to pain intensity or hamstring tightness.

**Conclusions:** There is a difference in symptoms between adolescent and adult patients with lumbar disc herniation. However, the results suggest that TNF may play a crucial role in adolescent patients with lumbar disc herniation similar to that seen in adult patients. However, the expression of TNF is not correlated with pain intensity or hamstring tightness.



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**PEDICLE SUBTRACTION OSTEOTOMIES: CRITICAL ANALYSIS OF GEOMETRIC PARAMETERS**Mohan V.<sup>1</sup>, Galan T.V.<sup>2</sup>, Klineberg E.O.<sup>1</sup>, Ellwitz J.P.<sup>1</sup>, Roberto R.F.<sup>1</sup>, Gupta M.C.<sup>1</sup><sup>1</sup>Dept. of Orthopaedic Surgery, University of California, Davis, Sacramento; <sup>2</sup>University of Minnesota Medical School, Twin Cities, USA

**Introduction:** Pedicle subtraction osteotomies (PSO) are commonly used to correct sagittal plane deformities. Rose et al. described a computational model to predict a successful overall global balance by summing up postoperative measurements after a PSO: Thoracic Kyphosis + Pelvic Incidence - Lumbar Lordosis  $\leq$  45.

**Methods:** A retrospective review of 29 consecutive patients who underwent a PSO by a single surgeon was performed. Radiographic and statistical analysis of the examined parameters was performed.

**Results:** Lumbar lordosis improved from 19° (SD=18.7, Range=-31° to 48°) to 54° (SD=12.5, Range = 25 to 75°). The C7 plumb line improved from 14.4 cm (SD=6.4, Range = 2 to 24.2) to 6.0cm (SD =5.5, Range = -4.5 to 19.2). Similar to Rose's findings, only the Pelvic Incidence did not have a significant change. Since anterior lumbar interbody fusions (ALIF) and posterior releases were also performed in some cases, the change in lumbar lordosis did not correlate with the PSO angle postoperatively. We found a significant improvement in Pelvic Tilt when an ALIF was performed (-13.7° versus -3.8°; p-value= 0.050) but did not have a significant difference in lumbar lordosis.

**Discussion:** We describe the sum of the pelvic incidence and thoracic kyphosis minus the lumbar lordosis delineated by Rose et al, as the global sagittal sum (GSS). We found a significant correlation between the C7-plumb line and the GSS (p-value= 0.029; R= 0.59). Using linear regression analysis, we developed an equation to estimate the change in the C7-plumb line, or sagittal vertical axis (SVA). Approximately 20% of the change in lumbar lordosis is equal to the change in SVA. Represented mathematically,  $\Delta SVA$  (cm) = -0.204 \*  $\Delta LL$  (°) [SD= 0.0376; p-value = 0.00005; R<sup>2</sup>= 0.63].

**Conclusion:** Our analysis confirmed the formula described by Rose et al. for optimizing sagittal balance, while developing a simple equation to estimate the overall sagittal correction via a pedicle subtraction osteotomy.

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**PREDICTIVE FACTORS OF SURGICAL OUTCOMES INCLUDING PREOPERATIVE TOTAL KNEE REPLACEMENT AND KNEE OSTEOARTHRITIS CONDITION IN PATIENTS WITH DEGENERATIVE LUMBAR CONDITION**

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**Introduction:** There have been many reports on the surgical outcome with numerous prognostic factors in patients with degenerative lumbar conditions and total joint arthroplasty. But there was no report on the surgical outcome in patients undergoing spine surgery including co-existing knee osteoarthritis (KOA) and total knee replacement (TKR) condition.

**Aim:** To demonstrate the effect of KOA and TKR status on surgical outcome in patients with degenerative lumbar conditions.

**Materials and Methods:** The study subjects were 141 female patients (mean age, 67.61 years) who underwent spinal surgery for degenerative lumbar conditions between January 2006 and December 2010. We retrospectively reviewed radiographs of the

initial knee posterior-anterior radiograph to determine the diagnosis of KOA. Depending on the TKR status at spine surgery, we divided subjects into 2 groups: no TKR and preoperative TKR groups. Their result was analyzed as a predictive factor of surgical outcomes. The surgical outcomes were analyzed using Oswestry disability index (ODI) score.

**Results:** The average ODI scores were 25.6±7.4 at preoperative, 16.9±8.9 at postoperative 3 months and 16.5±8.9 at postoperative 1 year. Preoperative ODI scores were only affected significantly by TKR status (p<0.05, multiple regression), which were significantly higher in TKR group. The ODI scores at postoperative 3 months had significantly correlated with preoperative ODI score and fusion level. (p<0.05) At postoperative 1 year, ODI scores were affected by fusion level, preoperative ODI and presence of advanced radiographic KOA (K/L grade III and IV). (p<0.05). Other factors including age, diagnosis, duration of symptom, knee originated symptom presence at surgery, operation name, BMI, co-existing medical illness and bone densitometry did not affect the surgical outcomes.

**Conclusion:** Planned fusion level and preoperative knee condition including osteoarthritis and TKR status at preoperative evaluation predict 1 year surgical outcome in degenerative lumbar conditions.

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**BLADDER BOWEL DISTURBANCE IN PATIENTS WITH LUMBAR SPINAL STENOSIS**

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**Introduction:** Bladder bowel disturbance (BBD) in patients with lumbar spinal stenosis (LSS) is difficult to assess. The purpose of this study is to assess the frequency of BBD in LSS patients and also to evaluate the improvement of BBD after the operation via a self-reported questionnaire.

**Methods:** We analyzed the self-reported questionnaires of LSS patients who underwent an operation from 2008 to 2010. We asked the patients to answer the questionnaires before and after the operation. We asked them whether they had urinary incontinence, fecal incontinence or urge incontinence while walking, urinary disturbances such as urinary frequency, a delay in starting to urinate, feelings of residual urine, and perianal numbness while walking, or perianal numbness during rest. The questionnaire also included the Japanese version of Oswestry Disability Index (ODI) and Zurich Claudication Questionnaire (ZCQ).

**Results:** We obtained 134 and 76 questionnaires before and after the operation, respectively. The mean age at the time of operation was 64.5 years. The mean preoperative ODI and ZCQ severity/function were 33.3 and 2.86/2.06. The mean postoperative ODI and ZCQ severity/function/satisfaction were 29.6 and 2.58/1.94/1.88, respectively. Incontinence or urge incontinence while walking was seen in 41% of the patients, and 47% of them showed a postoperative improvement. Urinary disturbances were seen in 36% of the patients, and 22% of them became asymptomatic. Perianal numbness while walking and during rest was seen in 33% and 16% of the patients, respectively, and 80% and 67% of them, respectively, became asymptomatic. No significant difference was observed in the preoperative ODI and ZCQ between those with BBD and those without, and also in the postoperative ODI and ZCQ between those who improved and those who did not.

**Discussion:** A number of LSS patients who underwent an operation suffered from BBD. The symptoms of BBD could improve by an operation. The outcome scores did not reflect whether the LSS patients had BBD or not, or whether they improved or not.

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### UNPREDICTABLE SPONTANEOUS FUSION AFTER VERTEBROPLASTY AND KYPHOPLASTY IN OSTEOPOROTIC COMPRESSION FRACTURE

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**Introduction:** We found a spontaneous fusion with adjacent vertebrae in osteoporotic compression fractures after percutaneous vertebroplasty (PVP) or kyphoplasty and analyze the radiologic & clinical characteristics retrospectively.

**Materials and Methods:** Between January 2000 and December 2010, 556 patients were treated with PVP or kyphoplasty in osteoporotic compression fracture at our department.

Among them, the spontaneous fused vertebrae were classified two groups. The one is absolute spontaneous fusion group with at least three cortical continuity to adjacent vertebrae, the other is partially fusion group which progressed fusion compared to previous radiologic finding. We reviewed the plain film and analyzed the radiologic characteristics of those patients with duration of fusion, location and extent of fused segments. A clinical characteristics by VAS score compared to our previous report was checked.

**Results:** Fifty for patients (9.7%) had a spontaneous fusion absolutely. And 43 patients (7.7%) were partially fused in plane film. Average duration of the absolute fusion group was 19 months from 3 months to 48 months. Forty-six cases (85%) of absolute fusion patients had occurred with proximal adjacent vertebrae and 7 cases (13%) had proximal with distal adjacent vertebrae. Forty one cases (76%) of spontaneous fusion occurred within 1 segment and 13 cases within multiple segments. The most cases of absolute fusion group were occurred at TL junction (40 patients, 74%). Mean VAS score of absolute fusion group was 2.0 at final follow-up and were analyzed relatively low score compared to mean VAS score of our previous report.

**Conclusion:** After percutaneous vertebroplasty (PVP) or kyphoplasty in osteoporotic compression fracture, unpredictable spontaneous fusion could develop at least 10% rate, especially with proximal vertebra within 1 segment at TL junction. Clinically, patients with spontaneous fusion had a tendency more pain reduction than others.

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### A MULTIFUNCTIONAL NANOSTRUCTURED PLATFORM FOR SUSTAINED RELEASE OF ANALGESICS AND ANTIBIOTICS IN SPINE SURGERY

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**Background:** Current delivery methods for pain medication, local anesthetics, antibiotics, and other medications used in spinal surgery present several limitations due to their route of administration; resulting in potential systemic toxicity and subtherapeutic local levels increasing the risk for such problems as significant pain or infection postoperatively.

**Methods:** Our group developed a hybrid material (gel) consisting of nanoporous silicon (pSi) and poly(lactic-co-glycolic acid) (PLGA) nanoparticles, loaded with antibiotics and analgesics, respectively. The medications were delivered via a bioactive angiogenic gel of platelet-rich plasma (PRP). The material's properties and effectiveness were studied both in vitro and in vivo.

**Results:** This system releases both molecules in a sustained, controlled, long-term fashion; while simultaneously promoting vascularization of the surgical site. Therapeutic analgesics and

antimicrobial agents were released at potent daily dosages for up to seven days by combination of PLGA and pSi particles free or embedded within the PRP gel. When implanted *in vivo* within the surgical field, the composite gel was vascularized and infiltrated with endogenous cells by two weeks while exhibiting no evidence of inflammation or immune response

**Discussion:** Advantages include improved medication efficacy at a lower total drug concentration, decreased risk of systemic toxicity, and - for antibiotics - decreased risk of developing resistance. The nature of the platform allows for a variety of different drugs, molecules, biological factors to be loaded and released by the gel. Moreover, by tuning the chemical and physical properties of each component, it is possible to tailor the release rate of each biomolecule to its desired therapeutic level. This novel technology has the potential to dramatically affect the post-operative management of spine surgery patients with an immediate improvement in post-op pain management, decreased PACU and hospital length of stays, and subsequently decreased hospital and surgical costs. Furthermore, this drug delivery platform technology may eliminate the need for subsequent treatments, repeat dosing, and dramatically improve patient convenience and patient compliance.

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### A PROSPECTIVE RANDOMIZED COMPARATIVE STUDY OF POSTOPERATIVE PAIN CONTROL USING EPIDURAL CATHETER IN PATIENTS UNDERGOING POSTERIOR LUMBAR INTERBODY FUSION

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**Study Design:** A prospective randomized comparative clinical trial for methods of postoperative pain control; IV PCA Vs Epidural PCA.

**Introduction:** Posterior lumbar interbody fusion is associated with high postoperative pain scores and opioid requirement. The objective of this prospective randomized comparative study was to assess the reduction of pain scores and opioid requirements using an intraoperatively placed epidural PCA (0.1% ropivacaine) during the postoperative period.

**Method:** 86 patients undergoing one or two levels posterior lumbar interbody fusion (PLIF) were included in this study. Randomized two groups, epidural group (ED-45 patients) and IV PCA group (IV-41 patients) were divided using random number table. Before wound closure, the tip epidural catheter was placed at one level cephalad to the level of PLIF in only patients of ED group. Additional pain relief was provided using an intravenous PCA pump with fentanyl. Patients were assessed with respect of pain score (visual analog scale:0-10), cumulative opioid requirement, side effects and satisfaction with postoperative pain management

**Results:** Demographic data, level of surgery, time for operation and intra operative bleeding were comparable between two groups. Pain score were assessed as follows (group ED vs. group IV; immediate postoperative status: 2.1±1.5 vs. 7.2±2.1, p=0.01, postoperative 1st day: 2.3±1.9 vs. 6.8±2.3, p=0.02, postoperative 2nd day: 1.9±1.8 vs. 5.4±2.1, p=0.02, postoperative 3rd day: 1.5±1.6 vs. 3.9±1.9, p=0.03, postoperative 4th day: 2.8±2.1 vs. 3.1±1.9, p=0.4.) Less amounts of opioid were required and fewer complications related to opioid were developed in patients of ED group. The complication related to epidural catheter was comparable between two groups. The patient satisfaction about postoperative pain control was higher in ED group.

**Conclusion:** Continuous epidural infusion of ropivacaine results in lower pain scores, opioid consumptions, and higher satisfaction compared with intravenous PCA only. Postoperative pain control using epidural catheter seems to be a higher effective method after posterior lumbar interbody fusion.





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### A STUDY ON RADIATION EXPOSURE OF THE PATIENTS DURING SURGERY USING PERCUTANEOUS PEDICLE SCREWS

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**Introduction:** In surgeries using pedicle screws, surgery with percutaneous pedicle screws may be less-invasive surgery because screws can be inserted without damaging paraspinal muscle. However, the surgery requires radiation exposure to patients, surgeon and other workers in operating room. In this study we investigated radiation exposure of patients in surgery using percutaneous pedicle screws.

**Methods:** Thirty-two consecutive patients (17 males and 15 females, mean age 65.3 years), who underwent posterior lumbar interbody fusion (PLIF) with percutaneous pedicle screws since Jan 2010, were included in this study. All patients underwent PLIF with one interbody-fusion cage and four percutaneous pedicle screws (SEXTANT) under the mobile C-arm fluoroscopy (BV Endura, Philips). Irradiation time and dose (mGy) were recorded. Irradiation dose was automatically calculated using output voltage and electric current of the fluoroscopy.

**Results:** Mean operating time and blood loss during surgery were 250 minutes (range: 209-308) and 190gram (range: 40-260). Mean radiation exposure time was 7.2 minutes (range: 3.3-10.8) and dose was 91.1mGy (range: 43.8-160). No major complications were observed in this series.

**Discussion:** There is little study on radiation exposure of the patients during surgery. There has been no limitation to radiation exposure in medical procedure until now. However, this study showed that radiation exposure of the patients who had undergone PLIF with percutaneous pedicle screws was more than that of abdominal CT scan (10mGy) or coronary angiography (23mGy). Consequently, we must make effort to reduce the time of radiation exposure during surgery.

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### COMPLIANT ARTIFICIAL LUMBAR DISC REPLACEMENT (CADISC-L): IN VIVO IMPLANT STABILITY AND OSSEO-INTEGRATION IN AN ANIMAL MODEL

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**Introduction/Aim:** The cadisc-l is a polyurethane-polycarbonate graduated modulus compliant total disc replacement designed to restore the elastomeric properties of the intervertebral disc. This *in-vivo* study investigates implant stability and osseointegration of this device in an animal model.

**Materials and methods:** Six skeletally-mature male baboons (*papio annubis*) were used for the study. Under general anaesthesia (ga), using a transperitoneal approach, a custom-made cadisc-l device was implanted into the disc space one level above the lumbo-sacral junction in all subjects. Antero-posterior and lateral radiographs were performed under ga post-operatively at specified time intervals up to 6 months. Systematic examination of these radiographs was carried out by an independent radiologist reporting disc height, and any evidence of implant migration or subsidence. Fluorochrome markers which contain molecules that bind to mineralisation fronts, were injected at specified intervals (7, 13, 19 and 25 weeks post-op) to investigate bone remodeling with time. Animals were humanely euthanized six months after the index surgery. Test and control specimens were retrieved, fixed and subjected to histological assessment of the bone-implant-bone interface. Fluorescence microscopy and confocal scanning

laser microscopy were utilized with BioQuant image analysis to determine the bone mineral apposition rates and gross morphology. **Results:** Systematic radiographic evaluation revealed no loss of disc height at the level of surgery or adjacent levels. No evidence of subsidence or implant migration was observed up to 6 months. Heterotopic ossification was observed to varying degrees at the operated level.

Histology demonstrated the primary fixation features of the device had incorporated well with the adjacent vertebral endplates. Fluorochrome distribution revealed active bone remodeling adjacent to the polymeric end-plate with mineral apposition rates of 0.7 – 1.7 microns / day. No evidence of adverse biological responses was noted.

**Conclusions:** Radiographic assessment demonstrated the cadisc-l implant remained stable *in-vivo* with no evidence of migration or subsidence. Histological analysis demonstrated engagement of the primary fixation features. Fluorochrome markers provided evidence of a *positive bone remodelling response* adjacent to the implant.

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### ADJACENT SEGMENT DEGENERATION AFTER LUMBAR DYNAMIC STABILIZATION WITH 2 YEARS MINIMUM FOLLOW UP

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**Introduction/Aim:** There is a controversy over whether lumbar dynamic stabilization accelerates degeneration of adjacent levels. The purpose of our study is to assess the changes of the adjacent and implantation segments after lumbar dynamic stabilization surgery using magnetic resonance imaging (MRI).

**Materials and Methods:** We performed the dynamic stabilization procedure using pedicle screws and a Nitinol spring rod system in patients with grade 1 degenerative lumbar spondylolisthesis, lumbar spondylotic stenosis with segmental instability, or a herniated lumbar disc with segmental instability. Postoperative MRI scans were taken for more than 2 years in all enrolled 25 patients. We compared the findings regarding disc degeneration in the cranial, implantation, and caudal segments between the preoperative period and 2-year-plus postoperative period using T2-weighted sagittal MR images. Also, we investigated the progression of the central and foraminal stenosis of the adjacent cranial and caudal levels.

**Results:** Three of the 25 cranial adjacent discs (12.0%) and 4 of the 25 (16%) caudal adjacent discs demonstrated progression of degeneration after dynamic stabilization. One of the 13 discs in the implantation segment demonstrated progression of degeneration, and 2 of the 13 discs in the implantation segment showed improvement of their disc degeneration (disc rehydration). A total of 5 (10.0%) of the 50 segments (3 cranial and 2 caudal adjacent) showed increased spinal stenosis postoperatively. Among the 5 cases, 3 patients had symptomatic adjacent stenosis.

**Discussion:** Postoperative adjacent segment degeneration developed more frequently in patients who had advanced disc degeneration preoperatively. We suggest that, dynamic stabilization may not have an advantage over fusion surgery in patients with severe preoperative spondylosis; however, patients who are in the early stages of disc degeneration or spondylotic change may benefit significantly from lumbar dynamic stabilization.

**Conclusion:** According to our results, lumbar dynamic stabilization may not prevent adjacent level degeneration completely. Adjacent segment degeneration developed in 9 of the 50 cranial and caudal adjacent segments. However, disc rehydration of the implantation segment occurred in 2 patients.

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### A NEW ANATOMICAL LANDMARK FOR PLACEMENT OF THORACIC PEDICLE SCREW USING FREEHAND METHOD: TRANSVERSE PROCESS RIDGE (TPR)

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**Introduction:** Extended fixation to the thoracic spine is often needed to correct the deformity of the lumbar spine. Thoracic pedicle screws have recently had wide spread use under the circumstance. Methods to aid the surgeon in appropriate screw placement have included the use of intraoperative fluoroscopy and image-guided techniques. However, those techniques need irradiation, high cost, expensive equipment, and prolonged operative time. The purpose of this study was to find an appropriate anatomical landmark and validate it on the freehand pedicle screw placement.

**Materials and Methods:** 1) In vivo 3-D image study: In vivo 3-D vertebral models are created from ten patients with adolescent idiopathic scoliosis by using ZedView, 3-D visualization and measurement software. The position relationship between the pedicle and anatomical landmark was evaluated. 2) Cadaveric study: Seven human cadavers with matched body height were used to insert the thoracic pedicle screws with the freehand technique. After the entire instrumented thoracic spine was harvested, two independent observers determined the screw position directly and radiographically. Statistical analysis was performed using chi-square test.

**Results:** The ridge on the transverse process, Transverse Process Ridge (TPR), was the best indicator for the entry point (EP) of the screws (Matched rate 95.8%), based on the analysis of in vivo 3-D vertebral image. The TPR was consistent with the EP in the pedicle map introduced by Lenke ( $p < 0.05$ ). Fourteen of 168 screws were misplaced in the cadaveric thoracic spines (8.3%). All misplaced screws were located between T5 and T7.

**Discussion:** The current study demonstrated that the TPR was the reliable anatomical landmark for the placement of thoracic pedicle screws by using the freehand technique. The TPR was independent of the spinal pathology such as the deformity and degenerative diseases. The freehand technique could become more reliable and accurate method for the thoracic pedicle screw placement if a surgeon has the excellent knowledge of anatomy in the thoracic spine.

P475

### EFFECTIVENESS OF MIS-TLIF FOR LUMBAR DISC LESION WITH MODIC CHANGES

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**Introduction/Aim:** To assess short- to middle-term clinical outcomes of minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) for patients with severe low back pain caused by intervertebral disc degeneration exhibiting Modic changes on MRI.

**Materials and Methods:** Thirty-five consecutive patients who underwent 1-level MIS-TLIF were included (mean age: 49 years, mean follow-up: 13 months). Severe low back pain and Modic changes on MRI were observed in all patients. Diagnoses were

made by reproducibility of low back pain by discography and, temporary pain relief after intradiscal anesthetic injection and selective nerve block. Peri- and post-operative clinical data including operation time, estimated blood loss and complications were retrospectively reviewed. Surgical outcomes were assessed using Japanese Orthopedic Association Scores for Low Back Pain (JOA score, full mark: 29 points) at preoperative and final follow-up period, recovery rate (RR) of JOA score, Oswestry Disability Index (ODI), and visual analog pain score (VAS) for low back pain.

**Results:** Of 35 patients, Modic type 1, 2, 3 changes were observed in 10, 22, 3 patients, respectively. Mean operation time and estimated blood loss were  $156 \pm 52$  minutes and  $153 \pm 218$  ml. Complications occurred in 2 patients including transient leg pain due to epidural hematoma and superficial wound infection, which resolved conservatively. Average JOA scores improved significantly from  $14.7 \pm 4.1$  to  $27.3 \pm 3.6$  points ( $p < 0.01$ ). RR averaged  $87 \pm 11.3\%$ . There were no statistically significant difference in RRs among patients with Modic type 1, 2, 3 (83.7%, 85.4%, 80.5%, respectively). Significant improvements were obtained in ODI ( $60.4 \pm 15.6\%$  to  $10.8 \pm 7.1\%$ ,  $p < 0.01$ ) and VAS scores for low back pain ( $7.6 \pm 2.0$  to  $0.5 \pm 0.7$ ,  $p < 0.01$ ).

**Discussion:** Although anterior lumbar interbody fusion has been the first line surgical option for low back pain due to lumbar disc lesion, it has several drawbacks including long-time bed rest, large vessel injury and dry ejaculation. This study showed that MIS-TLIF can be a safe and effective alternative for surgical treatment of lumbar disc lesion with any types of Modic changes.

**Conclusion:** Because of less-invasiveness to paraspinous muscles than conventional approach, MIS-TLIF can be a useful surgical option for lumbar disc lesion associated with Modic changes.

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### NEUROLOGICAL FUNCTION AND SURVIVAL OUTCOME OF AARHUS ALGORITHM IN PATIENTS WITH SPINAL SOLITARY PLASMACYTOMA OR MULTIPLE MYELOMA

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**Introduction/Aim:** We conducted a prospective cohort study of 33 patients with Solitary plasmacytoma or myeloma in spine from Aarhus Spinal Tumor Database. Solitary plasmacytoma and multiple myeloma are the most frequent malignant spinal tumors, and they are most frequently localized in the spinal vertebral body. Patients often suffered from severe back pain, pathological fracture, and cord compression. The aim of this study was to describe the neurological status and survival outcome after surgical intervention in patients with spinal solitary plasmacytoma and multiple myeloma based on Aarhus Algorithm.

**Patients and Methods:** This study included 33 patients (19 men, 14 women, mean age of 59 years, range from 30 to 84 years). The solitary plasmacytoma group contained 12 patients; multiple myeloma group contained 21 patients. All the patients underwent surgical treatment after complete diagnostic evaluation during December 1994 to November 2009 at the Aarhus University Hospital in Denmark. All the information was prospectively collected into the Aarhus Spinal Tumor Database.

**Results:** Thirty patients (91%) had local symptoms before operation with mean duration of  $129 \pm 182$  days. Twenty-five patients (82%) had radicular symptoms with mean duration of  $32 \pm 45$  days. Twenty-one of the cases (64%) were identified as Tomita Type 7 (Multiple lesions). Ten patients (30%) were located between Tomita Type 4 to 6 (Extra-compartmental). Thirteen of the cases (39%) had chemotherapy, and 5 Patients (15%) had radiotherapy prior to surgery. Operation duration was  $181 \pm 95$  minutes. Blood loss was  $2271 \pm 1745$  ml. The neurological status



was improved in 14 Patients out of 24 patients (58%), maintained in 16 cases and decreased in 3 patients. At the end of study, 29 patients died. The mean survival duration was 25±20 months (range from 1.4 month to 72 months).

**Conclusion:** The surgical treatment of spinal solitary plasmacytoma and multiple myeloma based on Aarhus Algorithm is an effective method of treatment with respect to neurological function.

#### P477

### INFLUENCE THAT PSYCHIATRIC PROBLEM GIVES TO SURGICAL RESULT OF LUMBAR SPINAL STENOSIS: PRE- AND POSTOPERATIVE ASSESSMENT BY BS-POP AND JOABPEQ

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**Introduction:** As a poor factor of therapeutic results for the lumbar spine surgery, we have a psychiatric problem. We developed the Brief Scale for Psychiatric problems in Orthopaedic Patients (BS-POP) (physician and patient versions), a scale that orthopaedic surgeons can use conveniently for assessing psychiatric problems. The problems of patients with lumbar spine disorders are multifaceted, and the methods for evaluating surgical results for this disease must be similarly multifaceted in taking the standpoint of the patient into consideration. The JOA Back Pain Evaluation Questionnaire (JOABPEQ), is filled out by the patient and evaluates patient-based outcomes. Severity scores are assigned to five parameters: low back pain; lumbar function; walking ability; social life function; and mental health. Accordingly, the JOABPEQ allows multifaceted evaluation of low back pain. The present study aimed to determine it about the effect that the presence of the psychiatric problem in patients of the lumbar spinal stenosis gives in operative results by JOABPEQ.

**Materials and Methods:** The study design is a prospective cohort study. Subjects comprised 115 patients with lumbar spinal stenosis (LSS) who underwent decompression surgery alone and were observed for a postoperative period of 1 year. We conducted psychiatric assessment using BS-POP and classified it in BS-POP normal group (94 pts) and the BS-POP abnormal group (21 pts) preoperatively. We weighed it against JOABPEQ severity score in postoperative one year about a surgical response rate between the two groups if preoperative.

**Results:** 1. JOABPEQ severity score: All postoperative JOABPEQ severity score is low, and, in the BS-POP abnormal group, a psychiatric problem influences surgical results.

2. A surgical response rate: A surgical response rate is low, and, in the BS-POP abnormal group, a psychiatric problem influences a surgical response rate.

**Discussion:** Postoperative JOABPEQ severity score and surgical response rate are low in the patients judged to be abnormal by psychiatric assessment by BS-POP at preoperation. It may be said that the preoperative psychiatric assessment is essential in predicting surgical results of the lumbar spinal stenosis.

**Conclusion:** A psychiatric problem influences patient-based outcomes of lumbar spinal stenosis surgery.

#### P478

### THE PROGNOSTIC ROLE OF MODIC CHANGES FOR LUMBAR DISCECTOMY: A PROSPECTIVE STUDY

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**Introduction/Aim:** There is controversy regarding the prognostic role of Modic changes (MC's) for lumbar discectomy. The aim of this study was to evaluate whether Modic changes affect the results of lumbar discectomy 1 year after surgery.

**Materials and Methods:** The study population consisted of 180 sciatica patients from Northern and Eastern Finland who underwent discectomy. Pain intensity (low back and leg pain) and disability on Oswestry Disability Index (ODI) were evaluated preoperatively and 1 year after surgery. Lumbar MC's on magnetic resonance imaging were classified into: 'No MC', 'Type I' (Type I or I/II) and 'Type II' (Type II, II/III or III). The analyses were performed using the analysis of covariance (ANCOVA) with adjustments for age, gender and disc degeneration (DD) sum score.

**Results:** At baseline, 83 (46%) patients had MC's. Of MC's, 33% were 'Type I'. Patients with MC's were older, more likely female and had a higher degree of DD than patients without MC's. Patients with 'Type I' MC's had smaller improvement in ODI than patients with 'No MC' (P=0.045) or 'Type II' MC's (P=0.037). The improvements in low back and leg pain were similar than in ODI but the differences were not significant.

**Discussion:** 'Type I' MC's indicated a poorer prognosis of lumbar discectomy. The previous contradictory results may be due to smaller study sample sizes.

**Conclusion:** Patients with 'Type I' MC's had smaller disability improvement than patients without MC's or with 'Type II' MC's 1 year after discectomy.

#### P479

### PERCUTANEOUS PLACEMENT OF PEDICLE SCREWS IN OVERWEIGHT AND OBESE PATIENTS

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**Background Context:** In obese patients, placing pedicle screws percutaneously is a particular challenge. As the bulky and thick configuration of obese patients may produce fuzzier fluoroscopic view and longer passage of surgical instruments, the chances of misplacement might increase.

**Purpose:** This study designed to evaluate the effect of patient's body habitus on the incidence of percutaneous pedicle screw misplacements.

**Study design/setting:** A retrospective study with prospectively collecting data.

**Patient sample:** 370 percutaneous pedicle screws for minimally invasive lumbar spinal fusion surgery in 89 consecutive patients.

**Outcome Measures:** The position and direction of screws to pedicle were evaluated using the findings in computed tomography (CT) scan with the following grading method; grade A: completely in the range without pedicle cortex violation, grade

B: pedicle wall violation < 2 mm, grade C: pedicle wall violation 2 to 4 mm, grade D: pedicle wall violation > 4 mm. The direction of violation was grouped as medial, lateral, cranial, and caudal.

**Methods:** Two independent observers retrospectively examined all of the postoperative CT images. All screws were assigned into one of following 3 groups along with patient's body mass index (BMI): 157 screws (38 patients) in normal weight (BMI < 25) group; 124 (29) in overweight (25 ≤ BMI < 30) group; 89 (22) in obese (BMI ≥ 30) group. A pedicle was considered misplaced if the grade was defined as B, C, and D. Multivariate logistic regression analyses was performed to evaluate the association between screw misplacements and BMI.

**Results:** Sixty-two screws (16.8%) were misplaced with the majority of grade B (72.6%, 45/62) and lateral direction (72.6%, 45/62). Twenty-eight screws (22.6%, 28/124) were misplaced in overweight group, 12 (13.5%, 12/89) in obese group, and 22 (14.0%, 22/157) in normal weight group. Two symptomatic pedicle violations were noted with grade D: a caudal violation was found in overweight group, which happened in the third case of surgeon's series; a medial misplacement, which was occurred in the 29th case, was noticed in obese group. There was no statistically significant association of pedicle violations along with patient's BMI (odds ratio [OR] = 1.00, 95% confidence interval [CI] = 0.94 – 1.07, p = 0.99). Moreover, no other factors, such as patient's age, gender, preoperative diagnosis, number of the fused segments, and year of the surgery, had a statistically significant relationship with pedicle violations. On the contrary, pedicle violations observed approximately 5 times more frequently at the level of L3 (47.1%, 8/17) and L4 (28.8%, 36/125) rather than L5 (10.1%, 16/158) and S1 (2.9%, 2/70) (OR = 4.95, 95% CI = 2.62 – 9.33, p < 0.0001).

**Conclusions:** Although symptomatic pedicle violations were noted in the earlier period of surgeon's learning curve and in overweight and obese patients, no statistical evidence could be found between patient's body habitus and percutaneous pedicle screw misplacement. Our data also suggests that greater caution should be taken to avoid pedicle violations especially at L3 and L4.

#### P480

### VERTEBRAL FRACTURES ARE NOT A RISK FACTOR FOR DEGENERATION OF ADJACENT DISCS: A MINIMUM OF 7 YEARS FOLLOW-UP FOLLOWING MOTION PRESERVATION SURGERY FOR THORACOLUMBAR BURST FRACTURES

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**Introduction:** There is an ongoing discussion on the question of whether severe vertebral fractures lead to post-traumatic disc degeneration or not. The purpose of this study was to evaluate whether vertebral fractures are a risk factor for degeneration of adjacent discs.

**Materials and Methods:** Twelve consecutive patients who had thoracolumbar burst fractures and associated incomplete neurologic deficit, operatively treated within 4 days of admission and had their implants removed within one year, were prospectively followed for 7 to 10 years. Following indirect reduction and pedicle screw fixation, transpedicular intracorporeal HA grafting to the fractured vertebrae was performed. Mean operative time was 125 minutes and mean blood loss was 150 g. The neurological function of all 12 patients improved by at least one ASIA grade, with 6 (50%) patients demonstrating complete neurologic recovery. Sagittal alignment was improved from a mean preoperative kyphosis of 16 degrees to -2 degrees (lordosis) by operation, but was found to have slightly deteriorated to 2 degrees at the final

follow-up observation. CT images demonstrated a mean spinal canal narrowing of 60%, 22%, and 11%, respectively. There was no instance of hardware failure. In this study, MRI and X-rays were used to evaluate post-traumatic disc degeneration.

**Results:** From 7 to 10 years after surgery, flexion-extension radiographs revealed that a median range of motion was 10 degrees at the cranial and caudal adjacent segments of the fractured vertebra. On MRI, the shape and intensity of the adjacent discs had changed slightly at the final follow-up in comparison with the preoperative images. With respect to back pain, no patient reported severe pain or needed daily dosages of analgesics at the final follow-up.

**Conclusion:** Posterior indirect reduction, transpedicular HA grafting, and pedicle screw fixation do not require fusion to a segment, thereby preserves thoracolumbar motion without resulting in post-traumatic disc degeneration. This study had a minimum follow-up period of 7 years, and its results may support the fact that vertebral fractures are not a risk factor for degeneration of adjacent discs.

#### P481

### ANALYSIS OF RISK FACTORS FOR PEDICLE SCREW LOOSENING AFTER LUMBAR SURGERY

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**Introduction/Aim:** Pedicle screws have been widely used as anchors in lumbar surgeries. However, the rate of loosening and risk factors for loosening are unclear. The purpose of the present study was to investigate the rate of and risk factors for loosening after lumbar surgery.

**Materials and Methods:** Sixty-four consecutive patients diagnosed with lumbar degenerative disease that underwent lumbar fixation with pedicle screws were evaluated. The average age of patients at the time of surgery was 63.2 ± 12.2 years (range, 24 – 84 years). Revision cases and cases using thoracic or iliac pedicle screws were excluded. Patients underwent posterolateral fusion or transforaminal lumbar interbody fusion. Cases with radiolucent zones greater than 1.5mm after a time period of one to one and a half years after surgery were defined as having loosened screws.

**Results:** 348 pedicle screws were inserted, and 5.4 ± 1.2 screws were inserted per case. 54 screws were diagnosed as loosened, and 23 patients were diagnosed as having more than one loosening. Univariate analysis of possible risk factors for having more than one loosened screw revealed that age (over 65 years) and number of fusion levels were significant factors, while factors related to gender, crosslinks, cages, and mono-segment fusions were not. Logistic regression analysis revealed that the number of fusion levels was the largest risk factor for having more than one loosened screw, with the odds ratio being 2.51 per 1 level fusion.

**Discussion:** Surgeons should recognize that older age groups and multilevel fusion patients are at a higher risk of pedicle screw loosening. Using crosslinks and cages to reinforce pedicle screws did not affect the risk of loosening.

**Conclusions:** 35.9% of 64 cases had loosened pedicle screws, and 15.5% of 348 total pedicle screws were diagnosed as loosened after lumbar surgery. Age and multilevel fusion were significant risk factors for pedicle screw loosening.



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### MAARTENSSAFE, A COMPREHENSIVE ORTHOPAEDIC SURGICAL SAFETY CHECKLIST - IMPLEMENTATION IMPROVES SAFETY AND REDUCES INFECTIONS IN SPINE SURGERY

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**Introduction:** A large number of preventable adverse events are encountered during hospital admission and in particular around surgical procedures. Checklists and continuous measurement on relevant indicators have been shown to be effective in surgery to prevent errors and adverse events.

**Aim:** To prevent adverse events i.e. infections in spinal surgery. **Patients and Method:** Inspired by the WHO Surgical Safety Checklist, the Amsterdam Surpass Checklist and the Dutch Guideline Preoperative Process we developed the multidisciplinary MaartensSafe checklist that accompanies our orthopaedic patients during each step of the orthopaedic surgical pathway and is completed by different members of the team from admission to discharge. Before each transfer (ward > holding > operating room > surgery (time out) > PACU > ward > discharge) a number of essential data is checked, followed by a clearance to proceed or a stop moment to correct missing data or even to cancel surgery. Moreover, along with the implementation of the checklist a software-package for continuous clinical monitoring on the OR was introduced. After successful introduction in knee and hip surgery the tools were implemented in spinal surgery. **Assessment period:** January-October 2011 in patients undergoing a decompression surgery with an implant. **Main indicator:** infection rate.

**Results:** Overall: after introduction during the first 250 procedures 170 stop moments were encountered, diminishing to 1 per 250 after 3500 procedures. Most stop moments occurred in the pre-operative holding. Most frequent cause was incomplete paperwork/patient data. Most impressive was the improvement of antibiotic prophylaxis which should be given 15-60 minutes before surgery (figure 1; spine). During the assessment period 384 patients had spinal surgery with an implant. After introduction, within 2 months the 90% threshold, for correct timing of antibiotic prophylaxis was reached. Comparing the infection rates of first 6 months 2010 (when antibiotic timing was not a stop moment before incision) to 2011 a reduction in infection rate from 5.9% (9 of 159) to 2.5% (5 of 205) is shown, whilst all other parameters remained unchanged (OR team, antibiotic prophylaxis type, patient demographics).

**Conclusions:** The introduction of a surgical safety checklist and continuous measurement on important indicators is feasible in a specialized orthopaedic hospital and produces awareness for patient safety in employees and instant improvement of patient care, including a reduction in deep post-operative infections.

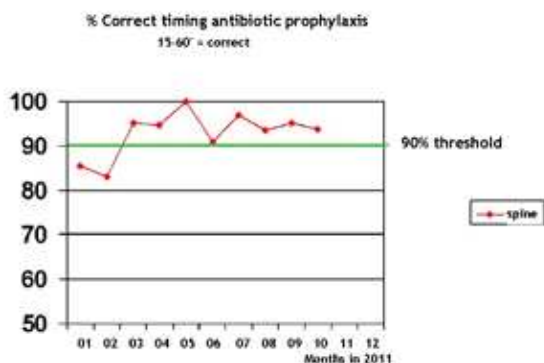


Figure 1. Percentage correct timing antibiotic prophylaxis in patients undergoing spinal surgery.

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### FACET DEGENERATION FOLLOWING LUMBAR DISCECTOMY

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**Introduction:** Because the intervertebral disc relies on pressurization of the nucleus to support loads in the lumbar spine, loss of nucleus due to herniation and the annular defect through which the nucleus extruded may impair the ability of the disc to properly bear loads. The consequent alteration of load sharing patterns may result in overloading of other spinal elements. The purpose of this study was to investigate the condition of the facet joints after lumbar discectomy.

**Materials and Methods:** A total of 137 primary lumbar discectomy patients were enrolled in a prospective, single-arm, multi-national trial. Pre-operative and one year post-operative CTs were reviewed by an independent, blinded radiologist using a four-point scale (0 to 3) to grade facet joint osteoarthritis (Pathria et al, 1987).

**Results:** Matched pre- and post-operative CTs were available for 94 patients. 40/94 (43%) patients exhibited facet degeneration, (defined as a worse facet joint grade) at one year post-op relative to pre-op in at least one of the facets of the index level. Of those exhibiting facet degeneration, 25/40 (62.5%) exhibited mild (grade 1), 14/40 (35%) exhibited moderate (grade 2), and 1/40 (2.5%) exhibited severe degenerative disease (grade 3).

**Discussion:** Evidence of facet degeneration was observed in a substantial percentage of primary discectomy patients at one-year post-op. Continued degeneration may contribute to the persistence of back or leg pain that has been reported in the discectomy population beyond 2 years post-op: 11.5% of patients treated with a conservative discectomy and 28% of patients treated with an aggressive discectomy (Watters and McGirt, 2009). Perhaps contributing to the higher incidence of persistent pain, aggressive discectomies are hypothesized to be more detrimental than limited to the load bearing ability of the intervertebral disc and may therefore result in greater facet joint degradation.

**Conclusion:** 43% of patients receiving a primary discectomy exhibited increased facet degeneration at one year post-op.

P484

### CLINICAL OUTCOMES OF EXTREME LATERAL INTERBODY FUSION (XLIF) IN THE TREATMENT OF DEGENERATIVE CONDITIONS OF THE LUMBAR SPINE

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**Introduction:** Minimally invasive techniques for lumbar spine procedures continue to gain prevalence as both patients and surgeons aim to decrease morbidities associated with conventional, open procedures. The purpose of this study was to examine clinical outcomes of patients treated with the mini-open extreme lateral interbody fusion (XLIF) for degenerative spine conditions at a single institution in Spokane, WA.

**Methods:** 95 patients were treated for degenerative conditions of the lumbar spine with XLIF, and 70 (73.7%) were available at least 12 months postoperative for follow-up through a prospective registry.

Mean age was 60.7 years with a BMI of 29.8 and 52.9% of patients were male. 14.9% of patients were smokers, 19.4%

had diabetes mellitus, 13.6% had coronary artery disease, and 54.3% had prior spine surgery. Mean number of levels treated for lumbar degenerative conditions was 1.5 (range 1-4), most commonly at L4-5 (70.0%). Supplemental internal fixation was used in all but one case.

**Results:** Mean OR time was 93.3 minutes, blood loss (EBL) was 102mL and length of hospital stay (LOS) was 2.8 days. No intraoperative complications were observed. Mild thigh pain and/or weakness occurred in 6 (8.6%) patients, with symptoms resolving without additional intervention. Two (2.9%) patients experienced vertebral body fractures with XLIF and lateral plating in complex indications (ASD, spondylolisthesis) one which was stable and fused without intervention, the other which required reoperation with posterior instrumentation. Both patients had multiple prior, adjacent, instrumented spine surgeries. One (1.4%) patient underwent a second fusion for adjacent segment degeneration at two years postoperative.

All outcome variables were measured preoperatively to last follow-up. VAS back pain improved 62.2% leg pain improved 59.1%, ODI improved 44.8%, and quality of life (SF-36) improved 53.1%. At last follow-up, 95% of patients were "somewhat" or "very" satisfied with their outcome and the same number would undergo the procedure again if their outcome had been known.

**Conclusions:** Carefully selected patients with degenerative conditions of the lumbar spine can be treated safely and effectively with XLIF. Outcome measures are substantially equivalent to reports of conventional approaches for anterior or posterior interbody fusion, with less ORT, EBL, LOS and fewer complications.

#### P485

### A SUCCESSFUL VISUALIZATION OF GROWTH OF PROPIONIBACTERIUM ACNES IN MOUSE INFECTION MODEL BY BIO-IMAGING

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**Introduction/Aim:** Implant-associated infection (IAI) is a serious complication of spinal fusion surgery. Recently, we have reported that *Propionibacterium Acnes* (*P. acnes*), an anaerobic flora, was detected in the intraoperative specimens from 11 of 80 patients underwent the scoliosis surgery even though no symptoms of infection were observed (*Spine* 2011). Other studies showed that *P. acnes* form a bacterial biofilm on the implant, resulting in development of IAI. However, little is known about the kinetics of *P. acnes* *in vivo*. We have visualized *P. acnes* by *in vivo* bio-imaging (BI) to clarify whether it causes the infection in the mice model.

**Materials and Methods:** In the model of osteomyelitis simulating the pyogenic spondylitis, *P. acnes* ( $1 \times 10^6$  CFU) were inoculated into the femur of the BALB/c adult male mouse. Three days after the inoculation, 100ml of fluorescent bacterial detection probe (Caliper) was injected intravenously. The Inflammation probe (Caliper), which enabled tracking of the neutrophils, was also administered to the animals. Then kinetics of *P. acnes* was observed using IVIS® (Caliper).

**Results:** In the osteomyelitis model, the bacterial signal from *P. acnes* was clearly identified in the femur at the next day of the bacterial probe administration and was maintained for approximately 7 days. The signal from neutrophils was also specifically detected around the bacterial signal in the femur of the same animal immediately after injection of the Inflammation probe.

**Discussion:** In the present study, we have successfully cultured

and visualized the growth of living *P. acnes* *in vivo* that were never before possible. We have also proved that *P. acnes* cause the bacterial inflammation and induced the neutrophils by Inflammation probe. To our knowledge, this is the first report showing the visualization of *P. acnes* with bacterial inflammation in the living animal.

**Conclusion:** We report the successful visualization of growth of *P. acnes* in mouse osteomyelitis model by BI. This animal model can be used for experimental spinal infections including IAI to clarify pathophysiology of spinal infection by *P. acnes*.

#### P486

### TWO-YEAR CLINICAL OUTCOMES IN 119 PATIENTS TREATED WITH A MINI-OPEN, 90° LATERAL, RETROPERITONEAL, TRANSPSOAS APPROACH FOR LUMBAR INTERBODY FUSION

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**Background:** Recent trends towards less invasive techniques for lumbar fusion have resulted in the development of several mini-open approaches which utilize conventional surgical techniques through small-incision exposures. The purpose of this study was to report long-term outcomes following extreme lateral interbody fusion (XLIF) for degenerative conditions of the lumbar spine.

**Methods:** Retrospective chart review of a consecutive series of patients treated at a single institution.

119 patients were treated with XLIF between 2006 and 2008 and were followed for at least 24 months. Mean age was 57 years, with 46.2% female. Mean body mass index was 28 and baseline comorbidities included smoking (34.5%), coronary artery disease (13.4%) and prior spine surgery (31.9%). The majority of cases (70.6%) were single-level (range 1-4 levels) from T11-T12 to L4-5. L5-S1 was treated with either a presacral approach or with posterior or anterior lumbar interbody fusion (PLIF, ALIF). Supplemental fixation included pedicle screws (45.5%), anterolateral plating (35.3%), or standalone (19.3%).

**Results:** Significant decreases in mean disability, lower back pain and leg pain were seen at all time points postoperatively (all,  $p < 0.001$ ). Narcotic medication use decreased significantly from 67.2% preoperatively to 34.8% postoperatively ( $p < 0.01$ ). Patient-reported satisfaction was 83.2% overall, 87.0% on relief of pain, and 95% of patients would undergo the surgery again if their outcome was known preoperatively. 87% of patients showed solid fusion at 24-months. Complications occurred in 14 (11.7%) of cases through two-years postoperative with 5% of cases being revised for pseudoarthrosis. XLIF-specific complications included one intra-operative anterior longitudinal ligament rupture, once case of ileus, and two dysesthesias which resolved by 12-months postoperative.

**Conclusion:** The XLIF procedure for interbody fusion, in this series, performed comparably at 24-months postoperatively on reported complications, outcomes, satisfaction and fusion as conventional approaches, with shorter mean operative time and less blood loss.



P487

**PYOGENIC SPONDYLODISCITIS: A RETROSPECTIVE STUDY IN A TERTIARY CARE CENTRE**

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**Introduction:** Infection of the spinal column is rare and often recognized and treated too late. Spondylodiscitis is infection of the intervertebral disc by pathogen with secondary infection of neighboring vertebral bodies. Presentation can be vague and highly variable but usually includes back pain and fever and it is often recognized and treated too late.

**Objective:** To analyze the bacteriology, pathologic entities, complications and results of pyogenic discitis patients treated in a tertiary care referral center (Amrita Institute of Medical Sciences, Kochi) by file review.

**Materials and Methods:** Total of 42 patients were included in the study with the range of age from 15 to 75 years and mean age being 50.33 years, male female ration being. All the cases were confirmed of having pyogenic discitis by pus culture report, histopathological examination. Mean follow-up period was 9.6 months, with a range from 6 to 26 months. Five patients were presented with neurological deficits and 13 patients had other co-morbidities like diabetes mellitus, renal failure, COPE, heart diseases, malignancies.

**Results:** Lumbar spine was the most frequent site of pyogenic discitis (30 cases, 65.21%). The most common bacteria isolated was *S aureus* (21 cases, 45.65%) followed by *E coli* (4 cases, 8.69%), *Klebsella pneumoniae* (4 cases, 8.69). Five cases (10.86%) had previous operation in the spinal level and three (6.52%) cases had history of previous vertebral fractures. Debridement and posterior lumbar interbody fusion (PLIF) was done in 19 cases (41.3%), transforaminal lumbar interbody fusion was done in 8 cases (17.39%), anterior cervical disectomy and fusion was done in 5 cases (10.86%) and ALIF was done in 2 cases (15.21%).

**Conclusion:** Pyogenic Discitis is prevalent in persons associated with other disease often making it difficult to diagnose and treat earlier. Debridement and stabilization with instrumentation is effective and safe in patients who had pyogenic discitis.

P488

**PROGRESSIVE ENHANCED BONE FIXATION WITH NOVEL TITANIUM EXPANDABLE PEDICLE SCREWS IN A SIX-MONTH SHEEP FUSION MODEL**Levy M.M.<sup>1</sup>, Keynan O.<sup>2</sup>, Popper O.<sup>3</sup><sup>1</sup>Dept. of Biomedical Engineering, Technion IIT, Haifa; <sup>2</sup>Dept. of Orthopaedics, Tel Aviv Sourasky Medical Center, Tel-Aviv; <sup>3</sup>QA-Regulatory, Expanding Orthopaedics, Or Akiva, Israel

**Introduction:** Increased stability of pedicle screw constructs is vital to enhance probabilities of spinal fusion, particularly in elderly population, revision cases and patients with compromised bone quality. Evaluation of a new expandable pedicle screw in cadavers showed immediate fixation, due to increased metal-bone surface area with better pullout strength. This in-vivo study was designed to evaluate long term osteointegration and bone ingrowth inside the expandable area using a lumbar spine fusion model on 11 mature Suffolk sheep.

**Materials and Methods:** Expandable Ø5.8 mm screws comprising a threaded section in the pedicle and a 4-wing expandable portion in the vertebral body were compared to standard Ø5.5 mm pedicle screws (control). In each spine 6 screws were inserted through a trans-pedicle approach, one per vertebra, in 3 fusion pairs (1 pair controls and 2 pairs expandable screws) connected with rods, without disc removal or bone graft. Animals were kept up to 180 days. Intermediate time points were

at 35 and 90 days. At the end of each time point, the animals were sacrificed and spines were harvested for removal of screws or histological evaluation. Outcome measures were clinical and radiographic data, specimen's histology and screw removal.

**Results:** Successful deployment of the expandable screws was achieved in all implanted devices using an active mechanism. Histological analysis demonstrated osteointegration of the screw in all surfaces of the expandable portion from the 35-day time point onward. The average amount of bone ingrowth inside the expandable area was elevated with each consecutive time point, showing maturation of bone matrix from woven to lamellar osteonal bone over time. Removal of expandable screws was achieved for all screws due to an active undeployment mechanism allowing retrieval through the pedicle.

**Discussion and Conclusion:** A long-term biological fixation due to incremental osteointegration and bone ingrowth inside the expandable area was demonstrated providing a progressively robust fixation of the screw within the vertebral body. Enhanced initial and long term construct stability using expandable screws may increase the likelihood of fusion. Such characteristics and the ability to undeploy and removal make this new system suitable for clinical use in irregular bone density.

P489

**ANALYSIS OF SAGITTAL PLANE PARAMETERS FOLLOWING DEFORMITY CORRECTION IN SCHEUERMANN KYPHOSIS USING '100% METAL DENSITY' POSTERIOR SEGMENTAL SCREW FIXATION**

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**Introduction:** Scheuermann kyphosis is a common cause of sagittal plane deformity. Patients commonly present with back pain and dissatisfaction with appearance. Diagnosis is established with plain radiographs demonstrating an exaggerated thoracic kyphosis and typical radiographic characteristics. Absolute indications for surgical intervention are rare. The exception is the unusual occurrence of progressive neurological deficit. Thoracic back pain and, to a lesser extent cosmesis, are the usual indications for surgery. A multitude of surgical methods can be employed to correct the deformity. Most commonly, posterior pedicle screw fixation is the preferred method of correction, preceded by anterior release if bending films indicate a stiff curve.

**Aim:** To evaluate the effect on sagittal parameters of corrective surgery for sagittal plane deformity in Scheuermann kyphosis, using posterior segmental-screw fixation

**Patients and Methods:** We evaluated immediate pre-operative and post-operative radiographs of a consecutive series of patients (n=10) treated operatively by the senior author. In each case, treatment comprised posterior-only bilateral pedicle screw fixation at all levels within the area fused creating a 100% metal density construct.

**Results:** The average pre-operative thoracic kyphosis was 68° (range 52°-74°). Lumbar lordosis (LL) was 64° (range 58°-71°). Post-operatively the average thoracic kyphosis improved to 41° (range 31°-51°). Lumbar lordosis reduced to an average of 48° (range 30°-59°). Post-operative sagittal balance was normal in 9 patients; a single patient had 76mm positive sagittal alignment. Pelvic tilt and cervical lordosis remained unchanged. No significant complications were identified.

**Conclusion:** Increased lumbar lordosis is the principal compensatory mechanism in maintaining sagittal balance in Scheuermann's Kyphosis. Pelvic retroversion is not affected in these patients. Following corrective surgery, LL returned to normal in our patients. A good correction is safely achieved with '100% metal density' segmental-screw constructs via posterior-only surgery.

P490

### PEAK EXPIRATORY PRESSURE & BLOOD PRESSURE ARE ASSOCIATED WITH BLOOD LOSS AND TRANSFUSION IN LUMBAR SURGERY

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**Introduction:** Increased intraabdominal pressure is theorized to increased blood loss and need for transfusion in patients undergoing lumbar spinal surgery. The purpose of this study was to determine if data collected during surgery on the peak expiratory pressure (PEEP), which is associated with intraabdominal pressure, will have any effect on blood loss and transfusion requirements. Additional data on the intraoperative blood pressure of the patient was also analyzed.

**Methods:** We retrospectively reviewed the records of 490 consecutive subjects who had undergone lumbar decompression with or without fusion and instrumentation. Patients with underlying coagulopathies or neoplastic disease were excluded from this study. Age, sex, intraoperative blood loss, transfusion requirements, number of levels decompressed, fused and instrumentation were recorded. Average PEEP, systolic blood pressure as well as maximum systolic and mean blood pressures were also recorded. Stepwise linear and log regression was used to determine associations between the airway and blood pressure data and blood loss and transfusion requirements while correcting for the above confounders. ANOVA analysis was used to determine individual comparisons.

**Results:** Linear regression determined that blood loss was positively associated with the intraoperative average systolic ( $p<0.01$ ) and mean blood pressure ( $p<0.01$ ) of the patient. Log regression determined that intraoperative transfusion was positively associated with the average PEEP ( $p<0.01$ ) and the maximum systolic blood pressure ( $p<0.01$ ). ANOVA analysis demonstrated that increased maximum systolic blood pressure was associated with transfusion per decompressed (154 vs 173 mmHg,  $p<0.01$ ), fused (181 vs 200 mmHg,  $p<0.01$ ) and instrumented level (190 vs 211 mmHg,  $p<0.01$ ).

**Discussion and Conclusions:** This study demonstrates that increased PEEP of the patient is associated with increased transfusion requirements in patients undergoing lumbar surgery. Similarly, increased intraoperative blood pressures are associated with increased blood loss and transfusion requirements in these patients. Methods to reduce PEEP and blood pressure may be beneficial in helping patients avoid excessive blood loss and transfusions and the associated complications.

P491

### THE RELIABILITY OF THE THORACOLUMBAR INJURY CLASSIFICATION AND SEVERITY SCORE AMONG ORTHOPEDIC SURGEONS AT DIFFERENT LEVELS OF TRAINING

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**Introduction:** Despite increased use of Thoracolumbar Injury Classification and Severity Score (TLICS), it has not yet gained universal acceptance. The most inexperienced orthopedic surgeon often performs the initial evaluation of a patient with thoracolumbar spine trauma, and relaying reliable information to Staff spine surgeons is imperative for efficient care and initial treatment decision-making. Our objective was to examine the reliability of TLICS between orthopedic physicians from intern to staff level surgeons.

**Methods:** Eight cases of thoracolumbar spine fractures were reviewed and scored using TLICS by eight evaluators: intern ( $n=2$ ), junior level orthopedic resident ( $n=3$ ), senior level resident ( $n=2$ ), spine surgeon ( $n=1$ ). Each participant evaluated the same cases on three different occasions. Statistical analysis with Intraclass Correlation Coefficient (ICC) was calculated assessing the inter- and intra-observer reliability of the TLICS classification.

**Results:** Interobserver reliability yielded moderate to excellent agreement between evaluators in all three rounds of testing. Neurologic injury produced the highest ICC values, ranging from 0.820 to 0.902. Fracture morphology demonstrated the lowest interobserver ICC scores with moderate agreement of 0.449 and 0.423.

Intraobserver ICC scores improved with increasing levels of training. The intern evaluators recorded the lowest intraobserver ICC values, while the staff surgeon scored the highest. Staff surgeon ICC values all ranked above 0.800 for excellent intraobserver agreement. Fracture morphology produced the lowest intraobserver ICC values, ranging 0.586 to 0.683. The total severity score yielded the highest intraobserver ICC values of 0.768 to 0.920 for interns through senior residents.

**Conclusions:** The use of TLICS demonstrated moderate to excellent intra- and inter-observer reliability among all training levels. Clinical knowledge has a direct effect on the reliability and effectiveness of TLICS as demonstrated by improved ICC scores in higher training levels. The results of this study suggest that the TLICS scheme is a reliable way to successfully communicate thoracolumbar injury information.

P492

### THE SEDIMENTATION SIGN FOR THE DIFFERENTIAL DIAGNOSIS OF SPINAL STENOSIS

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**Introduction/Aim:** Recently, a new test using MRI, the sedimentation sign, was introduced to aid in the diagnosis of lumbar spinal stenosis (LSS). It was reported that all patients with LSS with decreased walking ability ( $<200m$ ) and dural sac cross-sectional area (DSCA) less than  $80mm^2$  had a positive sedimentation sign, while 94% of patients with non-specific low back pain and DSCA greater than  $100mm^2$  had a negative sign. The objective of this study was to further evaluate the diagnostic value of the sedimentation sign by evaluating its performance on the differential diagnosis of patients with LSS and other conditions with similar clinical presentation for whom the sign might be used in clinical practice.

**Materials and Methods:** Sixty patients clinically diagnosed with central or combined LSS, 23 with lateral LSS only and 43 with disc herniation with unilateral radiculopathy were included. The sedimentation sign was assessed by two observers who were blinded to clinical diagnosis. Positive sign frequency, sensitivity and specificity were calculated. A sensitivity analysis including only patients with decreased walking ability and DSCA  $<80mm^2$  was also performed.

**Results:** The results demonstrated that 2% of patients with disc herniation, 26% with lateral stenosis and 50% with central/combined stenosis had a positive sedimentation sign. Sensitivity in identifying those with LSS in this clinically relevant sample with back and leg symptoms was 50%; specificity was 89%. The sensitivity increased to 78% when the analysis included only patients with similar characteristics of those from the original study ( $n=18$ ).

**Discussion:** The sedimentation sign was found to have limited differential diagnostic value for those with central LSS and other spinal disorders with similar clinical presentations. The test performed better in a more severely affected group. However,





the diagnosis of LSS is likely to be clearest in this group with severe neurogenic claudication and substantial central canal narrowing, as judged using standard clinical methods.

**Conclusion:** The sedimentation sign is unlikely to provide diagnostic value for LSS above currently used diagnostic practices.

#### P493

### PRE-OPERATIVE ACTIVITY LEVELS DO NOT CORRELATE WITH SELF-REPORTED HRQL SCORES IN PATIENTS WITH DEGENERATIVE LUMBAR CONDITIONS

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**Background:** The CDC and American Heart Association recommend 30 minutes of moderate to vigorous activity (MVPA) at least 5 days per week to improve cardiovascular fitness and reduce overall mortality<sup>1</sup>. Many patients with lumbar spine disorders complain of reduced activity levels due to chronic back pain. Thus, improved activity becomes a desired outcome following surgery.

**Purpose:** To quantify activity levels in a population with lumbar spine disorders using accelerometry. The hypotheses were 1) Patients with lumbar spine disorders have a low level of activity and 2) Activity levels and patient-reported HRQL scores correlate in this population.

**Methods:** Adults with lumbar spine disorders scheduled for surgical treatment were enrolled in this study. Participants wore an accelerometer for 12 hours daily, three consecutive days prior to their scheduled surgery. The Oswestry Disability Index (ODI), the SF-36 Physical Component Summary Score (PCS) and the EuroQual-5D questionnaire (EQ-5D) were collected at enrollment. The average minutes per day spent in MVPA was determined and correlated to each of the outcome scores using the Spearman Rank Correlation coefficient.

**Results:** 81 patients with an average age of 63.8 had complete data. The average time spent in MVPA was 8.6 min/day (Range 0-68.8, SD 17.8, median 3.5). The average ODI, SF-36 PCS, and EQ-5D scores were 46.8, 29.24, and 0.51 respectively. There was no correlation between activity and ODI ( $\rho=-0.19$ ,  $p=0.2$ ), SF-36 ( $\rho=0.072$ ,  $p=0.7$ ), or EQ-5D ( $\rho=0.14$ ,  $p=0.4$ ). 61 patients had a primary diagnosis of lumbar spinal stenosis (LSS) and 20 patients had other degenerative conditions. Patients with LSS participated in less MVPA, 6.5 min/day compared to 17 min/day. This was significant,  $p=0.024$ . There was no significant difference, however, in HRQL scores. When compared by subgroup, there was still no correlation between HRQL scores and MVPA.

**Conclusion:** There was no correlation between HRQL scores and activity levels measured by accelerometry. The majority of this population only achieved 20% of the recommended amount of MVPA. Physical fitness should be addressed prior to surgery and targeted during rehabilitation.

**Disclosure of Research Assistance:** This research was made possible by the OREF Resident Research Grant and the UCSF CTSI Resident Research Grant

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#### P494

### POST-OPERATIVE SENSORY CHANGES FOLLOWING THE MINIMALLY INVASIVE LATERAL RETROPERITONEAL TRANSPSOAS LUMBAR INTERBODY FUSION

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**Introduction:** The lateral retroperitoneal transpsaos minimally invasive lumbar interbody fusion (MIS LIF) is an alternative to traditional open methods for lumbar interbody fusion. The anatomy encountered by the surgeon includes the psoas muscle, which has the lumbar plexus embedded in it. Because of the proximity of the lumbar plexus and its associated motor and sensory nerves, transient post-operative numbness can result.

**Materials and Methods:** This is an IRB-approved retrospective analysis of 71 patients undergoing the XLIF® over a three-year period. All patients had the procedure performed at L1-L5, included constructs ranging from one to four levels. All operations were conducted by a single surgeon.

**Results:** There were 27 males and 44 females. The aggregate rate of sensory deficits was found to be 19.72%. There was a decreasing rate of post-operative numbness for each year with 26.09%, 25%, and 10.71% numbness for 2008, 2009, and 2010, respectively. Sensation was likely to return within the first six months, with lower chances after six months. There was no correlation with construct length. The chance of developing post-operative numbness was increased if the construct included L4/5.

**Discussion:** Post-operative numbness following the MIS LIF can occur. The true rate of occurrence is unclear. Multiple studies by various authors have described the rates of "high complications" inconsistently. The rate of post-operative numbness over a three-year span was found to be comparable to published reports. Interestingly, the rate was lowest during the last year.

**Conclusions:** The rate of post-operative transient numbness has decreased over a three-year period to a rate of 10.71%. This may be related to the learning curve associated with the MIS LIF. In addition, it is important to realize that the inclusion of L4/5 in any construct, long or short, may increase the likelihood of developing a post-operative sensory deficit, most of which is transient.

#### P495

### SUBSIDIENCE OF PEEK INTERVERTEBRAL CAGES IN THE MINIMALLY INVASIVE LATERAL RETROPERITONEAL TRANSPSOAS LUMBAR INTERBODY FUSION

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**Introduction:** PEEK intervertebral cages of different lengths, widths, and heights filled with various allograft types are commonly used as spacers in lumbar fusions. Subsidence is a potential complication. To date, there are no published reports specifically addressing subsidence as it relates to a series of patients undergoing MIS lateral retroperitoneal transpsaos lumbar interbody fusion.

**Materials and Methods:** An IRB-approved, retrospective review of a prospectively collected database was conducted. 140 consecutive patients who underwent this procedure between L1 and L5 over a two-year period were included. All patients had T-scores  $\geq -2.5$ . Post-operative radiographs during routine follow-ups were reviewed for subsidence, defined as any violation of the vertebral endplate.

**Results:** Radiographic subsidence occurred in 14.3% (20/140), while clinical subsidence occurred in 2.1%. Subsidence occurred in 8.8% (21/238) of levels fused. Construct length had a



significant positive correlation with increasing subsidence rates. Subsidence rates decreased progressively with lower levels in the lumbar spine, but had a higher than expected rate at L4/5. Subsidence rates of 14.1% and 1.9% were associated with 18 mm and 22 mm wide cages, respectively. No significant trends were observed with cage lengths. Supplemental lateral plates had a higher rate of subsidence than bilateral pedicle screws. Subsidence occurred at the superior endplate 70% of the time.

**Conclusions:** The use of wider intervertebral cages leads to a significantly lower rate of subsidence, but a longer cage does not necessarily offer a similar advantage. Wide cages are protective against subsidence, and the widest cages should be used whenever feasible for interbody fusion in the lumbar spine to protect indirect compression and promote arthrodesis.

#### P496

### THE EFFECT OF THE MINIMALLY INVASIVE LATERAL RETROPERITONEAL TRANSPSOAS LUMBAR INTERBODY FUSION ON SEGMENTAL AND REGIONAL LUMBAR LORDOSIS

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**Introduction:** Minimally invasive spine surgery is increasingly used to treat multiple spine pathologies. The minimally invasive lateral interbody fusion (MIS LIF) via retroperitoneal transpsaos approach in the lumbar spine can correct coronal Cobb angles, but the effect on sagittal plane correction is unclear. The objective of this study is to radiographically analyze the effect of MIS LIF on the restoration of segmental and regional lumbar lordosis in patients with degenerative spine disease.

**Materials and Methods:** This is a retrospective review of 35 patients with lumbar degenerative disease who underwent MIS LIF without supplemental posterior instrumentation using 10° lordotic interbody cages. Segmental and regional Cobb angles were measured to determine lordosis using preoperative and the most recent postoperative radiographs for comparison for each patient. Mean disc height changes were also measured.

**Results:** The mean follow-up period was 13.3 months. Fifty total levels were fused with a mean of 1.42 levels fused per patient. Mean segmental Cobb angle increased from 11.10° to 13.61° ( $p < 0.001$ ), or 22.6%. L2-3 had the greatest proportional increase in segmental lordosis. Mean regional Cobb angle increased from 52.47° to 53.45° ( $p = 0.392$ ). Mean disc height increased from 6.50 mm to 10.04 mm ( $p < 0.001$ ), or 54.5%. There was also a significant increase at each individual segment.

**Conclusions:** Minimally invasive LIF significantly improves segmental lordosis and disc height in the lumbar spine, but not regional lumbar lordosis. Anterior longitudinal ligament sectioning and/or the addition of a more lordotic implant may be necessary in cases where significant increases in regional lumbar lordosis is desired.

#### P497

### RACIAL DIFFERENCES IN LUMBAR SPINOUS PROCESS ANATOMY RELEVANT TO INTERSPINOUS PROCESS SPACER SURGERY

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**Introduction:** The popularity of interspinous process devices in spinal surgery has been diminished by inconsistent early results and increasing failure rates with longer-term follow-up. Development of first generation implants was likely hampered by a relative paucity of high quality population-based anatomic data regarding the human lumbar spinous process.

**Materials and Methods:** This study utilized 2,955 cadaveric lumbar vertebrae from 591 human lumbar spines at the Hamann-Todd Human Osteological Collection, Cleveland, Ohio. Samples were evenly distributed between ages 20 to 79 years. Each vertebra was photographed and measured digitally. Direct measurements were made with respect to positioning an interspinous process device between adjacent spinous processes and included effective spinous process length, angulation, and spinous process morphology. Height, sex, race and age were also recorded and analyzed.

**Results:** There was significant anatomic variance between African American and Caucasian populations. Average spinous process slope was smaller in the Caucasian population (e.g. L4 14.85°±9.03 vs. 21.10°±7.93  $p < 0.0001$ ), and average spinous process effective length was greater (e.g. L4 20.62±3.41 vs. 19.15±3.93  $p < 0.0001$ ). Differences in spinous process morphology were also noted at the L4 and L5 levels. African-American specimens were more likely to have convex as opposed to straight or concave morphology (87% vs. 74% L4  $p = 0.0002$ , 74% vs. 61% L5  $p = 0.0009$ ).

**Discussion:** This data demonstrates significant racial differences in lumbar spinous process dimensions and morphology that may be directly relevant for interspinous process implant design and performance. Different designs may be better suited to different racial populations.

**Conclusion:** Regarding first generation implants, Caucasian patients may have decreased rates of implant migration and more effective interspinous distraction compared with the African American population due to shallower spinous process slope, larger spinous process length and relatively less convex spinous process morphology.

#### P498

### THE VENTRAL LAMINA AND SUPERIOR FACET RULE: A MORPHOMETRIC ANALYSIS FOR IDEAL THORACIC PEDICLE SCREW START POINT

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**Introduction/Aim:** With the increasing popularity of thoracic pedicle screws, the freehand technique has been espoused to be safe and effective. We set out to define the morphologic relationship of the ventral lamina (VL) to the pedicle for optimal pedicle screw starting point in the thoracic spine.

**Materials and Methods:** 115 thoracic spine vertebral levels



(n=229 pedicles, 1 excluded due to fracture) were evaluated. After the vertebral body was removed, K-wires were inserted retrograde along the four boundaries of the pedicle. Using digital calipers, we measured width of the superior articular facet (SAF) and pedicle at the isthmus, and from the borders of the SAF to the boundaries of the pedicle. We calculated the morphologic relationship of the VL and center of the pedicle (COP), to the SAF.

**Results:** The VL was identifiable in all specimens forming the roof of the spinal canal, and confluent with the medial pedicle wall (MPW). The mean distance from SAF midline to the MPW was  $1.34 \pm 1.25$  mm medial. The MPW was lateral to SAF midline in 34 (14.85%) pedicles, with a mean distance of only  $0.52 \pm 0.51$  mm lateral. The mean distance from SAF midline to COP was  $2.22 \pm 1.49$  mm lateral. The COP was medial to SAF midline in only 11 (4.80%) pedicles.

**Conclusion:** The VL is an anatomically reproducible structure, consistently located medial to the SAF midline (85%). We also found the COP consistently lateral to the SAF midline (95%). Based on these morphologic findings, the starting point for thoracic pedicle screws should be 2-3 mm lateral to the SAF midline ("superior facet rule"), allowing screw placement in the COP, and avoiding penetration into the spinal canal.

#### P499

##### CAMPTOCORMIA (BENT SPINE SYNDROME): A SURGICAL PERSPECTIVE

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**Introduction/Aim:** The objectives of this study are to characterize and define camptocormia from a surgeon's perspective, and to increase awareness of these atypical, rapidly progressive curves resulting in coronal and sagittal plane decompensation.

**Materials and Methods:** We retrospectively reviewed the records of 11 patients with camptocormia treated at UCSF between 2007 and 2011. For each patient, we recorded age, gender, physical exam findings, muscle biopsy results, EMG results, MRI findings, and serum CK levels. Each patient was referred to a neurologist to assist us in establishing the diagnosis of bent spine syndrome.

**Results:** Of our eleven patients thought to have camptocormia, the average age was 67.5 years. There were four males and seven females. All patients had rapidly progressing atypical curves resulting in coronal and sagittal plane decompensation. Three patients had proximal muscle weakness along with paraspinal muscle weakness. Seven patients had paraspinal muscle atrophy on MRI/CT scans, and of the four patients that had a paraspinal muscle EMG, three were positive for a primary myopathy. Of the three patients biopsied, all three were positive for a primary paraspinal muscle myopathy. Seven patients underwent surgical intervention, three requiring revision surgery and one requiring prolonged intubation for respiratory distress post-operatively.

**Discussion:** We define camptocormia as any rapidly progressing atypical curve resulting in coronal and sagittal plane decompensation. The diagnosis can be confirmed with paraspinal muscle atrophy on an MRI/CT scan, as well as an EMG showing a primary myopathy of the paraspinal muscles. These curves are not due to an age related degenerative process.

**Conclusion:** Our recommendation to evaluate these patients from a surgical perspective is to perform a thorough history and physical, perform a muscle biopsy, obtain CK levels, assess for paraspinal muscle atrophy from MRI/CT scans, and to keep a high index of suspicion for an unrecognized cause of rapidly progressive spinal deformities.

#### P500

##### CHANGE IN ACTIVITY ONE YEAR FOLLOWING LUMBAR DECOMPRESSION WITH OR WITHOUT FUSION

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**Purpose:** Lumbar decompression/fusion is one of the most common surgeries performed for adults over the age of 60. Several studies have shown a significant improvement in HRQL following surgery compared; however there have been no studies directly measuring changes in physical activity. The goal of this study was to determine, using objective measures, whether improvement in activity level and duration occurred one year following lumbar decompression with or without fusion. This study also evaluated the correlation between objective and HRQL scores.

**Materials and Methods:** 47 adults undergoing decompression with or without fusion for degenerative conditions of the lumbar spine were enrolled prior to surgery and followed prospectively for one year. Participants wore an accelerometer over the hip for 3-5 consecutive days pre-operatively and at 6 weeks and 52 weeks post-operatively. Average minutes per day spent in moderate to vigorous activity (MVPA; >1950 activity counts per minute) were determined for each time point. EQ-5D, SF-36 and ODI scores at each time point were also captured. The change in activity and HRQL scores were analyzed using paired t-test; correlation between the change in activity and HRQL scores were analyzed using the Spearman Rank Correlation Coefficient.

**Results:** The average age was 63.8 including 26 women and 21 men. Preoperatively the group spent an average of 8.8 minutes per day engaged in MVPA. This improved to 14 minutes per day at one year; the average improvement was 5.1 minutes per day ( $p < 0.05$ ). There was a significant improvement in all HRQL scores; the ODI decreased by 22 points, the EQ-5D increased by 0.25 points, the SF-36 Role Physical Function by 11.3 points and the SF-36 PCS by 11.5 points (all  $p < 0.001$ ). There was no correlation between the change in HRQL scores and the change in MVPA.

**Conclusions:** Following lumbar decompression with or without fusion for degenerative lumbar conditions, there is a significant improvement in both HRQL scores physical activity. However, patients in this study continued to participate low levels of moderate-vigorous physical activity. Improved fitness should be a goal of surgery and a point of education in this patient population.

#### P501

##### ALGORITHM TO DISTINGUISH PLANNED FROM UNPLANNED READMISSION FOR STAGED SPINE FUSION USING ADMINISTRATIVE CLAIMS DATA

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**Introduction:** Administrative databases are an important source of information on healthcare quality. Measuring readmissions from administrative databases is complex and prone to error and overestimation due to non-specific diagnosis and procedure codes. The objective of this study is to develop an algorithm to distinguish planned readmissions for staged spinal fusions from unplanned readmissions based upon administrative claims diagnosis and procedure codes.

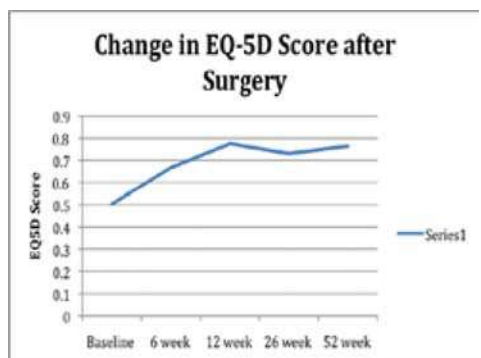
**Materials/Methods:** Retrospective observational study design. ICD-9 diagnosis codes and ICD-9-CM procedure codes at a large spine referral center were collected into a single administrative claims database.

Algorithms with varying complexity were developed to detect planned procedure readmissions and applied to administrative data with a minimum follow-up of 90 days. Concurrent direct medical chart review identifying planned versus unplanned hospital readmissions was used for comparison. All readmissions within one year of the primary procedure were reviewed.

**Results:** 694 patients were included. The rate of planned readmissions was 8.4% at one year. Of 84 algorithms tested, agreement with chart review ranged from 33.6% ( $\kappa=0.09$ ) to 91.1% ( $\kappa=0.80$ ). The most accurate algorithm included time from index procedure, a different surgical approach within 180 days, and excluded cases when the surgical approaches were the same or when a diagnosis code for complication was present.

**Discussion:** The algorithm to distinguish a planned versus unplanned hospital readmission had a 91.1% agreement and kappa statistic of 0.80, confirming excellent agreement. Less specific algorithms significantly overestimate readmission rates when analyzing administrative data.

**Conclusion:** An accurate assessment of readmission rates in spinal deformity surgery requires a distinction between planned readmissions and complications and unplanned readmissions. Administrative datasets are prone to significant error and overestimation of unplanned readmission rates unless a disease-specific algorithm is used for the analysis. The algorithm presented has excellent agreement with direct chart review in identifying planned and unplanned readmissions, and is useful for future administrative database studies in adult deformity.



## P502

### VARIATIONS AND ACCURACY IN READMISSION RATE FOLLOWING SPINE FUSION USING ADMINISTRATIVE CLAIMS DATABASES

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**Introduction:** Large administrative databases are important for measuring variability and quality of care, but these findings depend on the accuracy of coding and inquiry methodology. The objective of this study is to compare readmission rates after spinal fusion for adult deformity as determined by administrative data versus medical chart review.

**Methods:** This retrospective observational study used an administrative database of diagnosis and procedure codes at a large spine referral center. Patients included underwent spine fusion for adult deformity with minimum 90-day follow-up. Chart review confirmed diagnosis, procedure, revision status, fusion length, and 90-day readmission status. Three different algorithms of increasing complexity were developed to analyze administrative data. A low-complexity algorithm counted any inpatient readmission. A medium-complexity algorithm excluded readmissions not associated with spine surgery. A high-complexity algorithm selected only readmissions associated with spine surgery, excluding planned staged procedures. Algorithm readmission rates were compared to chart review.

**Results:** Claims analysis identified 738 patients; 694 had a diagnosis of adult deformity on chart review. Claims data identified 23.6% revision fusions compared to 37.0% on chart review. Claims data identified 21.9% short (2-3 vertebrae), 50.3% medium (4-8 vertebrae), and 27.8% long (>8 vertebrae) spine fusions, compared to 13.1%, 48.0%, and 38.9% by chart review. Chart-review determined readmission rate was 10.4% at 90 days, compared to 16.0%, 15.4%, and 10.4% by the simple, medium, and complex algorithms, respectively, yielding agreement rates of 68.4%, 75.2%, and 91.0%.

**Discussion:** These results have demonstrated wide variation of results using administrative claims data. Simple analysis of claims data overestimated the true readmission rate by over 50%, but it is possible to develop an algorithm that can yield accurate results.

**Conclusions:** Administrative claims data is important in measuring healthcare quality. Accurate interpretation of administrative datasets requires sophisticated and disease-specific algorithms. In the absence of appropriate algorithms, conclusions may significantly underestimate the complexity of procedures and overestimate readmission rates.

## P503

### PRE-OP PSYCHIATRIC DIAGNOSIS PREDICTS OCCURRENCE OF PTSD FOLLOWING ELECTIVE LUMBAR FUSION BETTER THAN EXTENT OF PROCEDURE OR COMPLICATIONS

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**Summary:** Post-Traumatic Stress Disorder (PTSD) is common following lumbar spine fusion. Pre-operative psychiatric disturbance was a stronger predictor of PTSD than spinal diagnosis, extent of surgery, and development of complications. Occurrence of PTSD negatively impacted self-reported clinical outcome scores.

**Background:** PTSD has been demonstrated in surgical patients following trauma, cancer, and organ transplant. No assessments of PTSD among lumbar spine fusion patients have been

performed. We sought to evaluate the impact of pre-operative demographic and peri-operative variable on incidence of post-operative PTSD in patients undergoing lumbar spine fusion.

**Methods:** A prospective analysis of lumbar spine fusion patients was performed using the PTSD Checklist (PCL-C) at pre-operatively, and at 3-, 6-, 9-, and 12-months following surgery. Variables recorded included age, gender, marital and job status, education, psychiatric history, complications, ICU stay, EBL, staging of surgery, and post-op ventilation. Univariate analysis was performed for statistical significance of predictive variables. Clinical outcomes were assessed using ODI and SF-36 scores.

**Results:** 74 patients were enrolled; 26 underwent extended lumbar fusion for spinal deformity. 100% follow-up was obtained at 1 year; because of the short-term effect sought, 2-year follow-up was not sought. PTSD occurred in 22% (16/74) of patients at at least one time point. The only variables statistically associated with PTSD were prior psychiatric history ( $p = 0.02$ ), and positive pre-operative PTSD score on the PCL ( $p=0.01$ ). Occurrence of PTSD post-operatively significantly reduced surgical benefit as measured by ODI ( $p < .0001$ ) and SF-36 summary scores ( $p < .003$  and  $p < .0001$ ).

**Conclusions:** Post-traumatic stress disorder is frequent after lumbar spine fusion surgery. These symptoms appear to be more strongly related to patients' pre-operative psychiatric state than to the extent of surgery or occurrence of complications. Occurrence of PTSD negatively impacted self-reported clinical outcome scores.

#### P504

### CORTICAL WALL THICKNESS IS THE STRONGEST PREDICTOR OF AXIAL LOAD RESISTENCE FOR FEMORAL RING ALLOGRAFT

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**Background:** Structural femoral ring allograft is commonly used in interbody spinal arthrodesis. For optimal clinical function, structural allograft bone must be able to support substantial loads, and fractures of implanted femoral ring allograft have been reported. Limited data currently exist to guide donor screening and tissue processing by allograft tissue banks for factors which affect graft strength.

**Methods:** Fresh frozen human femora were obtained and screened radiographically. Bone mineral density (BMD), donor age, and graft dimensions were recorded for each specimen. Each femur was sectioned into ten 20-millimeter thick specimens. A total of 327 specimens were tested in axial compression at a constant loading rate of 5 millimeters-per-minute. A linear regression model (Pearson correlation, 'r') compared load to failure with BMD, gender-specific donor age, minimum and maximum cortical wall thickness, and minimum and maximum outer ring diameter.

**Results:** The correlations between both minimum and maximum cortical wall thickness and load to failure were statistically significant ( $r=0.73$ ,  $p<0.001$  and  $r=0.74$ ,  $p<0.001$ , respectively). BMD showed a weaker negative correlation with load to failure ( $r=-0.11$ ,  $p=0.05$ ). Correlations between load to failure and minimum outer ring diameter ( $r=0.07$ ,  $p=0.24$ ), maximum outer ring diameter ( $r=-0.04$ ,  $p=0.49$ ), and age ( $r=0.06$ ,  $p=0.31$ ) were not statistically significant. A minimum thickness of 3.5mm reliably gave a graft ultimate strength of 5X physiologic lumbar spine loading.

**Conclusions:** This study found that the minimum and maximum cortical wall thickness of femoral ring allograft is strongly correlated with the axial compressive load to failure of the graft. Other tested parameters did not prove to be effective predictors of resistance to axial loading.

**Clinical relevance:** There is a need for predictive parameters

of strength of femoral ring cortical allograft. Cortical wall thickness may potentially be useful as a screening parameter for compressive strength of structural femoral ring allograft. Minimum or maximum outer ring diameter, BMD, and donor age do not appear to be as useful as screening tools for resistance to axial loading of structural femoral ring allografts.

