

## ORAL PRESENTATIONS

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### 1. THE ELASTIC NETWORK AND TRANSLAMELLAR BRIDGING NETWORK IN THE ANNULUS OF THE INTERVERTEBRAL DISC

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**INTRODUCTION:** The dense elastic network in the annulus of the intervertebral disc appears to play a mechanical role but details of its function are still unknown. Recently, an extensive trans-lamellar bridging network (TLBN) has been identified in the disc annulus. Elastin appears to be one component of the TLBN. The aim of this study was to investigate the organisation of the elastic network of the TLBN under mechanical load in order to provide insight into the role of both the TLBN and the elastic network in healthy and degenerate discs.

**METHODS:** Segments of the annulus from bovine caudal discs were dissected, and subjected to a radial strain. A freezing sledging microtome was then used to obtain 25 - 30 µm thick slices at the oblique angle to give a view of alternating in-plane and cross-sectional lamellae. The elastic network was dual immunostained using specific anti-elastin and anti fibrillin-1 antibodies. A fluorescent microscope in combination with a polarised light filter was used to study the elastic and collagen networks of the annulus and TLBN.

**RESULTS:** A dense elastic network was seen in the TLBN and also observed at the borders of collagen bundle compartments in the lamellae. Under mechanical strain, stretched elastic fibres were seen to run parallel to the direction of loading. In addition, elastic fibres appear to interconnect collagen fibres within lamellae. After discrete mechanical disruption of the lamellae, short arrays of elastic fibres were seen perpendicular to the collagen fibre bundles. We have observed such an elastic fibre structure previously only in degenerate and scoliotic discs.

**DISCUSSION:** Our results demonstrate that the elastic network is an important component in the TLBN, and appears to be linked to and interact with the collagen network. Results strongly support an important mechanical role for the elastic network in disc function.

### 2. DETECTION OF A PROGENITOR/CELLULAR MIGRATION ROUTE IN THE MAMMAL INTERVERTEBRAL DISC. A STUDY IN THREE SPECIES

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**INTRODUCTION:** Disc degeneration is believed to play a major role in patients with chronic lumbar pain. Normal regeneration processes and cell migration within the intervertebral disc (IVD) have been sparsely described and is important for the understanding of pathological processes. Recently, stem cell niches in the IVD region have been identified. The aim of the present study was to investigate cell migration routes and further examine the presence of cartilage progenitor cells in the IVD to gain knowledge about the normal disc regeneration pattern.

**METHODS:** 5-bromo-2-deoxyuridine (BrdU) in vivo labeling was performed in 15 normal rabbits, cell incorporation was visualized by immunohistochemistry after 4, 10, 14, 28 and 56 days providing the cell division pattern and the presence of slow-cycling cells in the disc. IVD tissue from human (n=3)(degenerated), porcine(n=2) and lapine (n=4)(normal) were investigated by immunohistochemistry using antibodies directed towards: Growth and differentiation factor 5 (GDF5) (progenitor marker), SNAIL homolog 1 (Snai1), SNAIL homolog 2 (Slug) (migration markers) and Beta1-integrin (cellular adhesion marker).

**RESULTS:** BrdU positive cells were observed predominantly in early time points in the IVD niche, adjacent to the growth plate, and at later time points mainly in the outer region of the annulus fibrosus (AF), indicating a gradual migration of cells. The presence of the migration markers, Slug and Snai1, and the adhesion protein B1-integrin were found in the same regions. Further, the progenitor marker GDF5, also known to induce migration and differentiation, was detected in cells along this migration route.

**DISCUSSION:** The present results suggest a cellular migration route from the IVD stem cell niche towards the outer region of the AF towards the inner parts of the IVD. These findings may be of importance for understanding of regenerative and growth mechanisms in the IVD and in the perspective of future development of biological treatment strategies.

### 3. IMMUNOLocalIZATION OF HUMAN BONE MORPHOGENETIC PROTEIN 13 IN THE DEVELOPING HUMAN SPINE

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**INTRODUCTION:** Bone morphogenetic protein 13 (BMP13) is a TGF- $\beta$  superfamily member and congenital mutations correlate with vertebral fusions. We postulate that BMP13 has a role in regulating spinal column endochondral ossification in its early development. As molecular processes occurring in development are reiterated in tissue repair, BMP13 may be used for disc regeneration. BMP13 was found to stimulate intervertebral disc (IVD) endplate cells and prevent the effects of annular injury in an animal model. This study aimed to examine the tissue-localised expression of BMP13, its receptors, and key extracellular matrix proteins in the developing human spine to better understand its potential role.

**METHODS:** Twelve human foetal spine specimens with a total of 172 discs, aged 8-19 weeks, were fixed in 10% neutral buffered formalin, 24 hours. Paraffin embedded tissues were cut sagittally and sliced into 4 $\mu$ m sections. Histological examination of haematoxylin-eosin and alcian blue staining was performed. Immunohistochemical staining was conducted to detect BMP13 pro- or active domains, BMP receptor-1A&1B, collagen I/II and aggrecan protein expression.

**RESULTS:** Expression of BMP13 was located in the nucleus pulposus, inner annulus and hypertrophic chondrocytes of developing vertebral bodies in all specimens examined. BMP13 was expressed both inside the cell and in the extracellular matrix, with distribution correlating with BMPRII, collagen II and aggrecan. There was a trend towards reduced expression of BMP13 with increasing endochondral ossification of the foetal column with age and reduced expression in ossified areas.

**DISCUSSION:** To the best of our knowledge this is the first study of BMP13 expression in human foetal spine. It demonstrates that BMP13 is expressed more in the early developing IVD and vertebral bodies. As expression is consistent with its proposed role in cartilage-like tissue formation, the observed trends strengthen the hypothesis that BMP13 has a role in preventing the disc from ossifying.

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### 4. STRUCTURED CO-CULTURE OF STEM CELLS AND DISC CELLS INDUCES MSC DIFFERENTIATION

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**INTRODUCTION:** Mesenchymal stem cells (MSCs) are an attractive component of disc tissue engineering given their ability to differentiate down multiple lineages. However, MSCs require a coordinated set of environmental cues to appropriately differentiate to a chondrogenic or disc-like cell. Our goal is to identify mechanisms involved in MSC differentiation to optimize tissue engineering strategies. We explored the benefits of co-culturing nucleus pulposus cells (NPC) and adult mesenchymal stem cells (MSC) using a 3D system that exploits embryonic processes such as tissue induction and condensation. We have created a novel spherical bi-laminar cell pellet (BCP) where MSC form an inner sphere enclosed within a shell of NPC with a 75:25 ratio respectively. Here we show that signaling interactions between MSC and NPC regulate MSC differentiation and matrix production and greatly enhance therapeutic benefits beyond using MSC alone.

**METHODS:** We have previously shown that the BCP produces 48% more proteoglycan than controls. In this study, the BCP were compared to single cell type controls of 100% MSC and 100% NPC pellets and cultured in growth media for 3 weeks. Pellets were harvested for quantitative RT-PCR and for histology including immunohistochemistry and in situ hybridization.

**RESULTS:** The MSC within the BCP showed statistically significant up-regulation of aggrecan (2-fold), collagen II (675.5-fold), and sox9 (190.3-fold) and a significant down-regulation of MMP13 (2.7-fold) and collagen X (8.2-fold) compared to the controls. These data indicate that in the BCP configuration, NPCs help MSCs differentiate appropriately and synthesize new matrix as a result. As evidenced by histology and immunohistochemistry, after three weeks of culture, MSCs within the BCP secreted and expressed aggrecan whereas the MSC controls did not.

**DISCUSSION:** Taken together, our data demonstrate that structured co-culture can direct MSC differentiation, and that structured communication between MSC and NPC enhances the efficacy of stem-cell-based strategies for nucleus regeneration.

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### 5. THE UP-REGULATION OF INTERVERTEBRAL DISC-CELL MATRIX SYNTHESIS BY PULSED ELECTROMAGNETIC FIELD IS MEDIATED BY BONE MORPHOGENETIC PROTEINS.

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**INTRODUCTION:** Pulsed Electromagnetic Field (PEMF) has been reported to up-regulate matrix synthesis in some cell types through the up-regulation of growth factors. Little is known about PEMF effect on intervertebral disc cells. We carried out an experiment to determine 1) if PEMF could up-regulate intervertebral disc-cell matrix synthesis; and 2) if any up-regulation obtained was through TGF-beta or BMPs.

**METHODS:** The PEMF signal used was similar to that used in the clinical treatment of delayed fracture healing. The cells were treated with and without PEMF for 8 hours per day for 3 days. Quantitative real-time PCR was performed to determine the mRNA expression levels of aggrecan, collagen-2, TGF- $\beta$ 1, BMP-2 and BMP-7. The sGAG synthesis was analyzed by a DMMB method. Western blot analysis was performed to determine the protein levels of TGF- $\beta$ 1, BMP-2 and BMP-7. The recombinant human BMP-2 was used at different doses to evaluate the effect of combining PEMF and BMP-2. To determine if the any action of PEMF was through BMP, specific BMP inhibitor, Noggin, was used at a dose of 100 ng/ml.

**RESULTS:** PEMF up-regulated matrix synthesis by itself, and it also enhanced up-regulation induced by initial stimulation by BMP-2. BMP-7 was markedly up-regulated, BMP-2 was slightly up-regulated and TGF- $\beta$ 1 was not up-regulated by PEMF. While matrix synthesis was up-regulated by PEMF in the absence of Noggin, this effect was cancelled out in the presence of Noggin, confirming that the effect of PEMF was mediated through the BMPs.

**DISCUSSION:** PEMF can not only up-regulate intervertebral disc-cell matrix synthesis by itself but it can also enhance the effect of BMP-2. The effect of PEMF on disc cells is mediated by BMPs, especially BMP-7. Investigation in methods using PEMF as a non-invasive method of treating disc degeneration is warranted.

### 6. THE BIOLOGICAL RESPONSE OF AF CELLS TO DECORIN OVER-EXPRESSION - A POTENTIAL MODEL FOR IVD REPAIR

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**INTRODUCTION:** Contrary to the large proteoglycans (PGs), which are lost during IVD degeneration, the small PG, decorin, accumulates in the degenerated tissue. The aim of this study was to delineate the consequences of decorin accumulation and its potential involvement in IVD repair.

**METHODS:** AF cells were isolated from bovine tails, virally transfected to over-express decorin (WT) or decorin lacking glycosylation (MT). Positively transfected cells were selected and cultured in monolayers. Cells were analyzed for decorin accumulation by western blots, immunofluorescence and ELISA; cellular response to decorin by immunocytochemistry, western blots and RT/PCR; PG content by DMMB; cell motility via an *in vitro* wound assay; and response to TNF- $\alpha$  by western blots and RT/PCR analyses.

**RESULTS:** Decorin expression increased 2-4-fold in the WT and MT cultures. Decorin was shown to bind to the EGF-receptor and activate the ERK signaling pathway, but did not influence cell morphology or viability. Significantly more PG (2-fold) was produced by the WT but not the MT cells. Additionally, large clusters of WT cells but not the MT cells migrated into the artificial wound. WT cells significantly diminished TNF- $\alpha$ -generated NF $\kappa$ B signals (to 16%) and downregulated TNF- $\alpha$  receptor expression (to 31%). MT cells were less effective to counteract TNF- $\alpha$ .

**DISCUSSION:** These results indicate that decorin over-expressed in AF cells can signal back to the cell through the EGF receptor and up-regulate cellular mechanisms that may aid the repair processes in IVD degeneration as demonstrated by the ability of these cells to migrate into the wound area, to increase PG synthesis, and to counteract the deleterious effect of TNF- $\alpha$ . Loss of glycosylation of decorin seems to abrogate these beneficial effects. These data supports our hypothesis that as the disc degenerates, the increased presence of the glycosylated decorin functions to restore the integrity of the IVD.

### 7. SIRT1 ACTIVATES CELL PROLIFERATION ACTIVITY OF HUMAN INTERVERTEBRAL DISC BOTH IN LOW NUTRITIONAL AND CHEMICAL HYPOXIC CONDITIONS

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**INTRODUCTION:** Sirt1, a mammalian homologue of longevity factor Sir2, has been known to increase longevity in mammalian cells. We previously reported that Sirt1 was present in human intervertebral disc (IVD) cells. We hypothesized that Sirt1 might have a positive function in IVD cells that aids their survival in a harsh biological environment. The aim of this study was to investigate the effect of exogenous Sirt1 on the cell proliferation activity of human IVD cells in a low nutritional and hypoxic condition.

**METHODS:** Six human nucleus pulposus (NP) cells were consensually obtained from patients (38-71 year-old) during surgical procedures. After three-days pre-culture, samples were cultured for three days with/without 10 $\mu$ M recombinant Sirt1 in three different conditions to reflect the harsh biological environment: DMEM with 10% FBS for the normal condition (N), with 1% FBS for the low nutritional condition (Ln) and with 10% FBS and 100 $\mu$ M CoCl<sub>2</sub> for the chemical hypoxic condition (Hx). Recombinant Sirt1 was transfected to NP cells using Pro-DeliverIN<sup>TM</sup> with instructions. To estimate transfection efficiency, R-phycoerythrin was used. Cell proliferation activity was measured by the WST-8 assay using Cell Counting Kit-8. The activity of the cells was normalized by the cell number in each well.

**RESULTS:** Immunofluorescent staining revealed that 51.4 % of NP cells were transfected R-phycoerythrin by Pro-DeliverIN<sup>TM</sup>. The cell number significantly decreased both in Ln and Hx conditions with/without Sirt1 treatment. Normalized proliferation activity of NP cells significantly depressed both in Ln and Hx conditions without recombinant Sirt1 treatment, whereas recombinant Sirt1 treatment significantly stimulated normalized proliferation activity in the Ln condition (+60%, p<0.05). The same trend was shown in the Hx condition (+52%, p=0.796).

**DISCUSSION:** Our results demonstrated that Sirt1 significantly stimulated normalized proliferation activity in a harsh biological environment. Exogenous Sirt1 may have the potential to allow NP cells to survive in such an environment.

### 8. HOMING OF MESENCHYMAL STEM CELLS IN STRESSED INTERVERTEBRAL DISCS IN ORGAN CULTURE

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**INTRODUCTION:** It is well known that cells from injured tissues release cytokines and mediators involved in the healing process. One important function of these factors is the recruitment of progenitor cells, which then contribute to tissue repair. In this study we investigated in a whole organ culture whether metabolically and mechanically challenged intervertebral discs (IVDs) release factors that may attract human bone marrow derived mesenchymal stem cells (BMSCs).

**METHODS:** Bovine caudal discs were cultured under “simulated-physiological” or “degenerative” nutrition and loading conditions. For the latter, additionally, one disc/group was stabbed with a 22g needle in the center of the IVD to create a defect. At day 1, 3, 5 and 7 media was collected for chemotaxis analysis. PKH26 (fluorescent dye) labeled human BMSCs were added to the bioreactor chamber hosting the discs and were co-cultured with the IVDs for additional 8 days. After culture, engraftment of BMSCs into the discs was analyzed microscopically and culture media was assessed by Boyden chamber (chemotactic assay).

**RESULTS:** Compared to IVDs cultured under “simulated-physiological” conditions, the number of MSCs that migrated towards the center of the disc was increased 3-4 times in “degenerating” IVDs. Amounts of recruited BMSCs were highest in most stressed discs. Media of “degenerating” discs also demonstrated chemo-attractive activity towards human BMSCs.

**DISCUSSION:** In this study we show in an ex vivo whole IVD organ culture system that “degenerative” conditions may induce the release of factors that promote the recruitment of BMSCs. Since regenerative effects of attracted BMSCs can be envisaged, this finding has implications for therapeutic delivery of BMSCs and endogenous progenitor cell activation.



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### 9. GENE THERAPY EFFECTS ON DISC COLLAGEN HOMEOSTASIS

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**INTRODUCTION:** Gene therapy for intervertebral disc degeneration may offer an effective alternative to traditional treatment modalities through affecting molecular structure of the disc. As candidate therapeutic genes, we examined the utility of Bone Morphogenetic Protein-2 (BMP2), which is anabolic, and Tissue Inhibitor of Metalloproteinase-1 (TIMP1), which is anti-catabolic. We hypothesized that gene therapy utilizing these genes would decelerate intervertebral disc degeneration *in vivo* as assessed by histology, imaging and biomarker profiles specific for collagen.

**METHODS:** Skeletally mature New Zealand White rabbits were divided into groups of control (n=3), punctured (n=4), AAV2-BMP2 (n=4), and AAV2-TIMP1 (n=4). Discs were punctured using a previously validated animal model of disc degeneration and injected with AAV2-BMP2 or AAV2-TIMP1 after three weeks. T2 weighted and T2 mapping MRI of intervertebral discs at times 0, 6 weeks, and 12 weeks were measured. Collagen II breakdown from serum samples at 0, 6, and 12 weeks were analyzed by ELISA using the marker CTX-II. At 12 weeks the intervertebral discs were analyzed histologically by Hematoxylin and Eosin staining.

**RESULTS:** In the punctured group, the T2 weighted MRI index and T2 mapping slope decreased with time compared to control. The BMP2 and TIMP1 treatment groups did not undergo as substantial a decrease in MRI index and slope as the punctured group. Histological analysis of the punctured discs demonstrated homogeneous acellularity consistent with degeneration. The AAV2-BMP2 and AAV2-TIMP1 treated discs maintained their architecture better than punctured discs. The CTX-II increase observed in the punctured animals was blunted by either AAV2-BMP2 or TIMP1 treatment.

**DISCUSSION:** AAV2 vector carrying BMP2 or TIMP1 altered the course of intervertebral disc degeneration *in vivo*. In particular, the T2 mapping and CTX-II results suggest improvement in collagen homeostasis. With improved safety constraints, gene therapy holds promise as an effective alternative for the treatment of intervertebral disc degeneration.

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### 10. DIFFERENTIALLY EXPRESSED GENES IN EARLY AND ADVANCED STAGES OF INTERVERTEBRAL DISC DEGENERATION

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**INTRODUCTION:** Degeneration occurs during normal aging in conjunction with genetic predisposition. The analysis of disc tissues from two distinct levels within one spine showing different degrees of disc generation may shed light on the cellular status at each degeneration stage by a pair-wise comparison. The purpose of this study was to compare the expression of a panel of genes in paired samples with early and advanced disc generation from the same donor and to elucidate the role of each of the genes.

**METHODS:** A total of 10 donor spines specifically exhibiting both grades 2/3 (early stage) and 4/5 (advanced stage) of disc degeneration within the same spine were utilized. Total RNA was isolated from annulus fibrosus (AF) and nucleus pulposus (NP) tissues and q-PCR performed for matrix components, cytokines, matrix-degrading enzymes and growth factors.

**RESULTS:** In the AF, expression levels of aggrecan, col I and col II were significantly lower in the advanced group. The NP showed the same trend, except for the higher expression of col I in the advanced group. Decorin expression was increased as discs degenerated. In the AF, the expression of IL-1 $\beta$ , TNF- $\alpha$ , MMP-3, MMP-2, and ADAMTS4 increased with degeneration. In the NP, IL-1 $\beta$ , IL-6, MMP-3 and ADAMTS4 decreased with degeneration, although TNF- $\alpha$  and MMP-2 increased. The expression of BMP-2 increases with degeneration in both tissues. BMP-7 expression in the AF decreases with degeneration and that in the NP showed a reversed pattern.

**DISCUSSION:** Our data on a comprehensive analysis of genes that contribute to cellular metabolism indicated that levels of expression differ in different stages of disc degeneration. It was interesting to observe that there is a sequential pattern of expression of cytokines as degeneration progresses that may suggest that the proper application of cytokine inhibitors at specific stages of degeneration is required.

### 11. AN ANIMAL STUDY ON THE AETIOLOGY OF VERTEBRAL CHANGES ADJACENT TO THE ENDPLATES IN DISC DEGENERATION

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**INTRODUCTION:** In approximately 30 % of patients with disc degeneration, changes in signal intensity in the vertebral body adjacent to the endplates can be demonstrated in magnetic resonance images.

Since their first description in 1987 controversy has persisted over the causes of these changes, ranging from infection to auto-immune processes and biomechanical factors. The following study was undertaken in animals with the aim of defining the cause of these MRI changes.

**METHOD:** 10 beagle dogs were used in this study. Disc tissue was extracted by nucleotomy from 2 adjacent lumbar discs. One sample was digested by pepsin, and the second was lyophilised. The processed material was inserted in drill holes adjacent to the endplates of vertebra L1, 2, 3. In 4 dogs, one segment with nucleotomy was fixed with plates. In the other 6 dogs, no fixation was used. MRI examinations were performed postoperatively and specimens for histology were harvested at periods between 4 and 92 weeks.

**RESULTS:** In the 12 segments from which disc tissue had been extracted from sites where no fixation had been used, MRI showed vertebral oedema in the bone adjacent to the endplates after 4 weeks. Between 72 to 92 weeks, signs of fatty degeneration were observed adjacent to the endplates. Signal changes were markedly less in the 4 fixed segments. Histologically, sclerosis adjacent to the endplates was found. Sclerosis was less in the fixed segments. No relevant changes were found in the sites where the processed disc material had been inserted.

**DISCUSSION:** These results support the hypothesis that, in segments with degenerative discs, the changes in the vertebral bodies adjacent to the endplates ranging from oedema to sclerosis, are due mainly to mechanically-induced processes. No inflammation was detected in any of the vertebral bodies into which the processed disc tissues had been inserted.

### 12. INTRADISCAL INJECTION OF AUTOLOGOUS PLATELET-RICH PLASMA-SERUM INDUCES THE RESTORATION OF DISC HEIGHT IN THE RABBIT ANULAR NEEDLE PUNCTURE MODEL

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**INTRODUCTION:** Platelet-rich plasma (PRP) is a fraction of plasma, in which several growth factors are concentrated at high level. Recently, the serum isolated from PRP (PRP-serum) has been demonstrated to affect the metabolism of intervertebral disc cells *in vitro*. The purpose of this study was to determine the effects of PRP-serum on the progression of disc degeneration in the rabbit anular needle puncture model.

**METHODS:** Twelve New Zealand white rabbits received an anular puncture in 2 noncontiguous discs to induce disc degeneration. Fresh blood was drawn to isolate autologous PRP and serum. PRP and PPP (platelet poor plasma) were prepared using two centrifugation techniques. After clot formation by adding autologous serum, the PRP- and PPP-serum was isolated from the clotted PRP and PPP by centrifugation. Four weeks after the surgery, either PPP- or PRP-serum was injected into the punctured discs. The discs injected with PBS were used as control. Lateral X-rays of the lumbar spine were taken every two weeks to measure disc height. MRI assessment (T2-quantification) was performed 12 weeks after the initial puncture.

**RESULTS:** The anular puncture induced a consistent disc narrowing within 4 weeks. PRP-serum induced a statistically significant restoration of disc height (12W; % disc height index; PBS: 71%, PPP: 80%, PRP: 90%,  $p < 0.05$  vs. PBS and PPP). In T2-quantification, the mean T2-value of PPP- and PPP-serum-injected discs were significantly higher compared to those of PBS; no significant differences between the PPP- and PRP-serum-injected discs were found.

**DISCUSSION:** We present results showing that the intra-discal injection of PRP-serum is effective for restoring disc height in the rabbit anular puncture model. MRI analysis showed that both PPP- and PRP-serum equally stimulated the T2-value. The results of this showed that the application of autologous PRP-serum is effective for IVD therapy, is safe and immediately available for clinical application.

### 13. MICROSTRUCTURE AND REMODELLING IN MODIC CHANGES

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**INTRODUCTION:** To determine bone microstructure and remodelling of lumbar vertebrae with Modic changes in individuals undergoing spinal surgery.

**METHOD:** Twenty one patients with Modic changes on MRI undergoing surgery with pedicular screws had a transpedicular end plate biopsy taken. A micro-CT scan of the biopsy was carried out for a 3D analysis and Von Kossa and H&E 5-um sections were prepared for tissue-level bone remodelling analysis.

**RESULTS:** All 21 biopsies underwent micro-CT and tissue-level analyses. The average bone volume (BV/TV [%]) was 15.1% for Modic 1 specimens, 16.4% for Modic 2 and 26.6% for Modic 3. The bone volume increase was associated with bone trabecular thickening and increased trabecular number. Structure model index (SMI) values suggested that Modic 3 (SMI = 0.2) samples were more plate like compared with Modic 1 and Modic 2 (SMI = 1.0 both). Tissue-level analysis showed less eroded surface in Modic 3 (4.7%) compared with Modic 1 and 2 (7.5% and 7.7% respectively). There was also more osteoid but reduced resorption surface in Modic 3 (4.5%) compared with Modic 2 (2.5%) and Modic 1 (2.2%).

**DISCUSSION:** This study has shown micro-architectural differences between Modic types. It can be postulated that different Modic types represent different stages of the same pathological process. Modic 3 changes are consistent with a more stable sclerotic phase associated with higher BV/TV due to reduced resorption and more osteoid. Modic 1 changes are the least stable phase with lowest bone volume and osteoid surface.

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### 14. PREVALENCE AND PATTERNS OF DISC DEGENERATION IN THORACIC AND CERVICAL SPINE ASSOCIATED TO LUMBAR DISC DEGENERATION IN A POPULATION WITH AND WITHOUT LOW BACK PAIN - MAGNETIC RESONANCE IMAGING ANALYSIS IN TWO HUNDRED AND NINETY NINE INDIVIDUALS

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**INTRODUCTION:** Lumbar disc degeneration (DD) has been widely investigated but its association with degeneration in cervical and thoracic regions and the exact difference in prevalence between patients and controls in whole spine has not been fully documented.

**METHODS:** Whole spine MRI of 299 individuals (198 patients, 101 controls) was analyzed. Lumbar discs were analyzed for total endplate damage score (TEPS), DD, herniation, annular tears and Modic changes. Thoracic and cervical regions were assessed for the presence of disc degeneration. All the observations were made by two independent observers ( $\kappa=0.9$ ). Hierarchical clustering program was used to group degenerated discs. Binomial logistic regression analysis was used to find the predictors of disc degeneration.

**RESULTS:** Patients and controls were age matched ( $38\pm 9$ ,  $33.5\pm 10$ ,  $p=NS$ ) but only 4.3% of patients had no DD at any level compared to 70% of controls ( $p=0.000$ ). Of the 30 controls who showed any DD, 27 (90.3%) were confined to lower two lumbar segments. In contrast 42 (21.6%) patients had DD extending to the thoracic and cervical spine also ( $p=0.005$ ). Similarly DD involving all lumbar segments was only in 1.4% of controls compared to 10.8% in patients ( $p=0.005$ ). Only 5 discs in controls had a TEPS of 6 or more compared to 172 discs in patients ( $p$ ). Cluster analysis showed that DD of lower lumbar segments have a high tendency of association with lower cervical degeneration and upper lumbar DD had a higher association with thoracic DD.

**DISCUSSION:** Endplate damage rather than annular tear was the primary cause for DD. Patients had a significantly higher incidence of DD and wider distribution in all regions of spine whereas controls had DD restricted to lower two lumbar levels. This could imply a different etiopathogenesis of DD in the two groups.

### 15. QUANTITATIVE ASSESSMENT OF EARLY LUMBAR VERTEBRAL DISC DEGENERATION USING AXIAL T2 MAPPING AND DELAYED GADOLINIUM-ENHANCED MAGNETIC RESONANCE IMAGING

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**INTRODUCTION:** Lumbar vertebral disc degeneration is closely related to decreasing extracellular matrix (ECM) components (water, proteoglycan, and collagen) in both the nucleus pulposus (NP) and annulus fibrosus (AF) in earlier stages. Recently, several studies using delayed gadolinium-enhanced magnetic resonance imaging of cartilage (dGEMRIC) in the relevant literature have shown that sulfated glycosaminoglycan (sGAG), reflecting proteoglycan contents, correlates with the difference of T1 values before and after penetration of Gd-DTPA<sup>2-</sup> ( $\Delta T1$  value). Furthermore, water contents correlate with the T2 value using T2 mapping in MRI analysis. This study was undertaken to confirm the usefulness of the quantitative assessment of the lumbar vertebral disc degeneration using dGEMRIC and T2 mapping to compare biochemical measurements of the ECM component and the  $\Delta T1$  and T2 values.

**METHODS:** This study examined 20 Japanese white rabbits aged 6 months, 1, 2, 3 and 4 years. Their lumbar vertebral discs from L1-2 to L5-6 were imaged using 3.0 T MRI. We measured  $\Delta T1$  and T2 values using dGEMRIC and T2 mapping. Then, lumbar vertebral disc tissues from five consecutive levels were harvested; NP and AF were separated and analyzed biochemically. Statistical analyses were performed using Spearman's rank-correlation coefficient.

**RESULTS:** A significant correlation was found between the  $\Delta T1$  value and sGAG (correlation coefficient of -0.327) for every aged rabbit. The T2 value showed a significant positive correlation with water content (correlation coefficient of 0.705) in every aged rabbit except the 6-month-old animal. No correlation was found between collagen type 1 and type 2 contents in any aged rabbit.

**DISCUSSION:** The  $\Delta T1$  and T2 values correlate significantly with biochemical measurements of ECM component in early degeneration of lumbar vertebral discs. Results suggest that these methods can predict early degenerative changes of ECM components.

### 16. OVERWEIGHT AND UNHEALTHY BEHAVIOUR PREDICT LUMBAR DISC DEGENERATION IN YOUNG MALES

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**INTRODUCTION:** The role of health behaviours in lumbar intervertebral disc degeneration (DD) is largely unknown in younger populations. We evaluated whether overweight, smoking, amount of sitting, and physical activity as proxy measures of health behaviour are associated with lumbar DD in young adults.

**METHODS:** The study population consisted of 558 young adults (325 females and 233 males) who at the age of 21 years underwent magnetic resonance imaging (MRI) using a 1.5-T scanner. Pfirrmann grading was used in the evaluation of lumbar DD and a sum score of DD was calculated. The sum score was categorized into no DD, 1 or at least 2. The data on smoking, sitting time, and physical activity was based on postal surveys, and data of body mass index (BMI) on clinical examinations conducted at 16 and 19 years. The proxies for health behaviour were categorized into high, intermediate and low levels at both time points. The associations of DD (a sum score of at least 2) and the explanatory factors were analysed using multinomial logistic regression.

**RESULTS:** Of the subjects, 295/53 % had no DD, 109/19 % had a sum score of 1, and 154/28 % a sum score of at least 2. Among males, high BMI at 16 and 19 years was associated with having a sum score of DD at least 2 in the multivariate analyses (OR=2.7; CI 1.0-7.4). Moreover, having one risk factor (high BMI, smoking, very low/high level of physical activity or high amount of sitting) or at least 2 risk factors during adolescence was associated with DD (sum score  $\geq 2$ ) among males (OR=2.1; CI 1.0-4.4 and OR=3.4; CI 1.2-9.1, respectively). Only non-significant associations were detected in females.



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**CONCLUSION:** Overweight and unhealthy behaviour predicted lumbar disc degeneration among young males.

### 17. BODY MASS INDEX AND ITS ASSOCIATION WITH DISC DEGENERATION OF THE LUMBAR SPINE IN ADULTS

Dino Samartzis, Jaro Karppinen, Keith DK Luk, Kenneth MC Cheung, Hong Kong

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**INTRODUCTION:** Elevated body mass index (BMI) has been suggested as a risk factor of disc degeneration, but such an association remains questionable. Furthermore, the extent and severity of BMI upon disc degeneration remains speculative. As such, we addressed the association of BMI to the presence, extent, and severity of disc degeneration in adults.

**METHODS:** A cross-sectional analysis was performed of 2,252 individuals (range: 21-88 years) of Southern Chinese origin having undergone sagittal T2-weighted MRIs of the lumbar spine. The presence/extent/severity of disc degeneration as well as additional radiographic and subject demographics were assessed. Asian-modified BMI (kg/m<sup>2</sup>) categories were established.

**RESULTS:** There were 906 males and 1,346 females, with a mean age of 41.4 years. Disc degeneration was noted in 1,598 (71%) subjects. BMI was significantly higher in subjects with disc degeneration (mean: 23.3 kg/m<sup>2</sup>) compared to subjects without disc degeneration (mean: 21.6 kg/m<sup>2</sup>) ( $p < 0.001$ ). Age- and workload severity-adjusted BMI was positively correlated with overall disc degeneration severity ( $r = 0.450$ ,  $p < 0.001$ ), the number of levels of disc degeneration ( $r = 0.365$ ,  $p < 0.001$ ), and the overall disc herniation score ( $r = 0.230$ ,  $p < 0.001$ ). In the adjusted logistic regression model, there was a positive and significant polynomial dose-response between BMI and disc degeneration (underweight, 1; normal, OR: 2.3, 95% CI: 1.57-3.23; overweight, OR: 3.2, 95% CI: 2.20-4.73; obese, OR: 5.3, 95% CI: 3.13-9.05;  $p < 0.001$ )

**DISCUSSION:** Based on the largest population-based study to systematically assess lumbar disc degeneration, our study noted that BMI is associated with the presence of disc degeneration. To our knowledge, our study is the first to note a significantly increasing dose-response between BMI and disc degeneration. Increased extent and severity of disc degeneration was also noted with elevated BMI, in particular overweight and obesity. Future analyses assessing risk factors of disc degeneration should be cognizant of BMI as an influential factor and its effects upon disease.

### **18. PHYSICAL WORKLOAD – A RELEVANT FACTOR FOR DEVELOPING LUMBAR DISC DISEASES (GERMAN SPINE STUDY EPIlift)**

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**INTRODUCTION:** Knowledge on the relationship between diseases of lumbar disc and physical workload is limited. There are open questions in pathogenetics and workload factors. This case-control study explores the dose-response relationship between cumulative work load and lumbar disc diseases, the influence of postures, object handling and whole body vibration.

**METHODS:** In four study regions all patients (25-70 years) with symptomatic lumbar disc herniation (286 males, 278 females) and severe disc narrowing (145 males, 206 females) treated in a hospital or a special orthopaedic and neurosurgical practice were prospectively recruited. Population control subjects (453 males, 448 females) were randomly selected from local registration offices. Participating physicians documented anamnesis, pain data and neurological deficits. On the base of standardized criteria all MRI, CT and X-rays were evaluated by an independent study radiologist. In a detailed semi-standardized interview technical experts documented frequency and duration of manual handling of loads above 5 kg, postures with trunk inclination of 20° and more and other working postures. For each documented activity lumbosacral compressing force was quantified using a biomechanical simulation tool. Quantification of cumulative work load based on several dose models. Odds ratios and 95% confidence intervals were calculated separately for men and woman and for lumbar herniation and disc narrowing. We adjusted for age, region, and social life data.

**RESULTS:** We found a positive dose-response-relationship between cumulative lumbar load and lumbar disc herniation or disc narrowing among men as well as among women. There was an association between whole body vibration and disc narrowing but not with lumbal herniation (analysis only for men).

**DISCUSSION:** Our study results point to an etiologic role of cumulative physical workload in the multifactorial genesis of lumbar disc diseases. In women this association was proven for the first time in an epidemiological study.

### 19. RISK FACTORS FOR LUMBAR INTERVERTEBRAL DISC HEIGHT NARROWING –TEN YEARS RETROSPECTIVE COHORT STUDY-

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**INTRODUCTION:** Disc height narrowing is the most commonly used specific finding to indicate intervertebral disc (IVD) degeneration. To date, reports of cohort study on the changes of disc height is rare. The purpose of this study was (1) to quantitatively evaluate the change of lumbar disc height by radiographic measurement, and (2) to investigate risk factors for the development of disc height narrowing in a population-based retrospective cohort study.

**METHODS:** During ten years from 1997 to 2007 (total six times medical examinations in typical mountain village in Mie, Japan), the inhabitants who participated in the examination more than four times (59 men, 125 women, mean age: 70.1 [61-83]) were subject of this study. Lateral lumbar spine radiographs of each subject were taken, and digitally scanned, and then disc height (L1/2 to L5/S1) was measured. According to the rate of change in the disc height, the subjects were divided into two groups as follow: mildly decreased group (less than 20% decrease) and severely decreased group (more than 20% decrease). The stepwise multiple logistic regression analysis was used to select factors significantly associated with disc height narrowing.

**RESULTS:** Changes in Disc Height: Disc height of each IVD level showed gradual decrease during ten years. The rate of changes in the disc height did not differ significantly among the IVD levels during study period ( $p = 0.78$ ). Factor Analysis: female and treatment history of hypertension were associated with an increase risk of disc height narrowing, whereas BMI and disc height (L5/S1 level) at baseline were associated with a reduction in the risk of disc height narrowing.

**DISCUSSION:** This is the first population-based cohort study that quantitatively evaluated the IVD height for ten years. The results indicate that the female and hypertension are significant risk factors for the development of lumbar disc height narrowing.

### 20. PHENOTYPES AND GENES THAT DISTINGUISH PAINFUL INTERVERTEBRAL DISCS

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**INTRODUCTION:** Disc degeneration is characterized by altered disc structure and biochemical composition (decrease in proteoglycan synthesis and increase in matrix catabolism via upregulated matrix-metalloproteinase activity) that may or may not cause pain. Yet, features that distinguish degenerate/painful from degenerate/painless are not well understood. Here we report a structured approach to compare gene expression patterns from nucleus and annulus surgery samples. We hypothesized that painful discs would fall into one or more of four phenotypes: inflammatory, hypoxic, aberrant wound healing, or innervated. To test this hypothesis, we identified a series of genes historically ascribed to these processes and used logistic regression to determine whether they could predict the appropriate tissue clinical classification.

**METHODS:** Surgery samples were collected and classified in 3 groups: degenerate/painful; degenerate/non-painful; and normal. Sixteen patients were selected based on clinical/radiographic data. RNA was extracted followed by cDNA synthesis, fragmentation and labeling. The expression pattern of the disc tissue was analyzed by Affymetrix gene array. The expression levels of candidate genes belonging to one of 4 phenotypes were quantified and logistic regression procedures performed to define the phenotype and genes most predictive of the clinical characterization.

**RESULTS:** Concerning nucleus pulposus samples, genes included in the hypoxic phenotype (MAPK1, MAPK3, LDHA) had the best correlation ( $R^2=0.48$ ;  $p=0.01$ ). Overall, a combination of hypoxic and innervation (NGF, LDHA, MAPK3) gave the best fit and explained two-thirds of the variance ( $R^2=0.67$ ;  $p=0.001$ ). Looking at the differences between degenerative and painful group combination of inflammatory genes TSG6 and GM-CSF ( $R^2=0.5$ ,  $p=0.01$ ) and innervation genes NGF and PGP9.5 ( $R^2=0.5$ ,  $p=0.01$ ) shows as the best combination.

**DISCUSSION:** Our data suggest that cell behavior in painful discs is distinguished by hypoxic, innervation and inflammatory processes. Next steps involve analyzing annulus data as well exploring associations of a broader set of marker genes reflective of the four phenotypes.

### 21. RISK FACTORS FOR PERSISTENCE OF MULTIPLE MUSCULOSKELETAL PAINS IN ADOLESCENCE: A TWO-YEAR FOLLOW-UP STUDY

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**INTRODUCTION:** Musculoskeletal pain in multiple sites is common already in adolescence, and may lead to subsequent musculoskeletal complaints in adulthood. We examined predictive factors for the persistence of multiple musculoskeletal pains in adolescence over a two-year time span.

**METHODS:** A postal questionnaire was administered to a subsample of the Northern Finland Birth Cohort 1986 (n=1 773) when subjects were aged 16 and 18. The adjusted odds ratios (OR) and 95% confidence intervals (CI) for the possible risk factors of multiple pain were obtained using multinomial logistic regression (a) persistent multiple pain or b) new-onset multiple pain vs. no pain/single pain).

**RESULTS:** A considerable proportion of adolescents reported multiple pains, and the number of pain sites tended to increase during the follow-up. Moreover, multiple pains had a high persistence rate, as 75% of boys and 88% of girls with multiple pains at 16 reported pain in more than one site also at 18. In the multivariate analysis, emotional and behavioral problems (internalizing problems, OR 2.3; externalizing problems, OR 2.2), and high sitting time (OR 1.6) among boys, and internalizing problems (OR 3.7), high physical activity level (OR 1.6), short sleeping time (OR 1.7), and smoking (OR 1.9) among girls were predictive factors for the persistence of multiple pains.

**DISCUSSION:** Multiple musculoskeletal pains appear to have a high tendency to persist in adolescence; both psychosocial factors and lifestyle factors contribute to this vulnerability.

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### 22. CARE SEEKING BEHAVIOUR AND BACK PAIN: ARE BELIEFS ABOUT BACK PAIN ASSOCIATED WITH THE DECISION TO SEEK CARE?

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**INTRODUCTION:** Individuals who seek care for back pain typically report higher pain intensity and functional limitations than those who do not seek care. Whether those seeking care also hold different back pain beliefs is unknown despite the fact educational interventions such as mass media campaigns have aimed to alter health utilization via changing beliefs. We studied the association between beliefs about back pain and the decision to seek care for this condition.

**METHODS:** Descriptive population-based cross-sectional study. Data was collected in two Canadian provinces via computer-assisted telephone interviews with randomly selected participants 18 years of age or older who reported previous back pain. Back pain beliefs were measured using the Back Beliefs Questionnaire, a measure of beliefs regarding the inevitable consequences of future life with back problems. Dependent variables were care-seeking and provider type visited. Additional independent variables included age, gender, province of residence, urban/rural residence, back pain, pain chronicity, pain severity, and coping strategies. Analysis included logistic and multinomial logistic regression.

**RESULTS:** 5986 individuals participated in the survey. 38% of the sample sought care for their last episode of back pain, with medical doctors and doctors of chiropractic the most frequently consulted professionals. Scores on the Back Beliefs Questionnaire did not remain in final multivariable logistic regression models explaining care seeking after controlling for a measure of coping strategies ( $p > 0.05$ ). Associations between back pain beliefs and provider type were also not statistically significant. Increasing age, higher pain severity, reporting non-chronic pain, and passive coping strategies were associated with care seeking.

**DISCUSSION:** Beliefs about back pain were not associated with care seeking after controlling for a measure of coping strategies. Future public health interventions aimed at altering health utilization by changing back pain beliefs will need to consider the complex relationship between beliefs, coping strategies, and care-seeking.

### 23. TRANSVERSUS ABDOMINIS CONTRACTION RATIO DURING ABDOMINAL HOLLOWING: A VALID TOOL TO IDENTIFY PATIENTS WITH CHRONIC LOW BACK PAIN?

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**INTRODUCTION:** Spine stabilisation exercises, in which patients are taught to preferentially activate the transversus abdominus (TrA) during “abdominal hollowing” (AH), are a popular treatment for chronic low back pain (cLBP). The treatment is administered on the assumption that performance in patients with cLBP is suboptimal, despite there being minimal evidence to support this. The present study investigated whether performance during AH differed between cLBP patients and controls to an extent that would render it useful as a diagnostic tool.

**METHODS:** 50 patients with cLBP ( $46.3 \pm 12.5$  y) and 50 healthy controls ( $43.6 \pm 12.7$  y), matched for gender, age, body height and weight, participated in this case-control study. They performed AH in hook-lying (5 times for each body side). Using M-mode ultrasound, thicknesses of TrA, obliquus internus and obliquus externus were determined at rest and during 5s AH. The TrA contraction-ratio (TrA-CR) was calculated as the thickness of TrA contracted/rest. The ability to sustain the contraction steadily was given by the standard deviation (SD) of TrA thickness during the mid-phase of the hold.

**RESULTS:** There were no significant group differences for the absolute muscle thicknesses at rest or during AH, or for the SD of TrA thickness. There was a small but significant group difference of 0.08 (95%CI 0.01, 0.15] for TrA-CR: cLBP  $1.35 \pm 0.16$ , controls  $1.43 \pm 0.25$  ( $p < 0.05$ ). However, Receiver Operator Characteristics (ROC) analysis revealed a poor and non-significant ability of TrA-CR to discriminate between cLBP patients and controls on an individual basis (ROC area under the curve, 0.61 [95%CI 0.49, 0.72],  $p = 0.07$ ).

**CONCLUSIONS:** Whilst a significant difference in group mean values for TrA-CR was observed, it was small and of unlikely clinical relevance. Moreover, TrA-CR showed a poor ability to discriminate between control subjects and cLBP patients on an individual basis. The rationale for prescribing AH exercises in cLBP patients remains obscure.

### 24. EFFECT OF PERIARTICULAR AND INTRAARTICULAR LIDOCAINE INJECTIONS FOR SACROILIAC JOINT PAIN: PROSPECTIVE COMPARATIVE STUDY

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**INTRODUCTION:** The sacroiliac joint (SIJ) can be a source of low back pain. Previous studies indicated that SIJ pain could originate from both the joint capsule and the posterior ligamentous tissues. It has not been clarified as to whether an intraarticular or periarticular injection procedure is more effective for this type of pain. The purpose of this study was to evaluate the effect of two injection procedures prospectively.

**METHODS:** After a pain provocation test, an intraarticular injection of local anesthetic was performed on the first 25 consecutive patients (8 men and 17 women with an average age of 56 years) with SIJ pain and a periarticular injection on another 25 (9 men and 16 women with an average age of 59 years). The periarticular injection was given to one or more sections of the posterior periarticular area of the SIJ and to another section in the extracranial portion. The effect of these injections was assessed using the “restriction of activities of daily life” scoring system from the Japanese Orthopaedic Association.

**RESULTS:** The periarticular injection was effective in all patients, but the intraarticular one was effective in only 9 of 25 patients. An additional periarticular injection was performed in 16 patients who experienced no effect from the initial intraarticular injection and was considered effective in all of them. The injection into the middle of the periarticular area was more effective for SIJ pain. The improvement rate after the periarticular injection was 96%, which was significantly higher than that after the intraarticular injection, which was 62%.

**DISCUSSION:** For patients with SIJ pain, periarticular injection is more effective and easier to perform than the intraarticular injection and especially the injection into the middle of the periarticular area is more effective for SIJ pain than the other areas.



### 25. MULTIDISCIPLINARY REHABILITATION OR SURGERY FOR CHRONIC LOW BACK PAIN – 7 YEAR FOLLOW UP OF A RANDOMISED CONTROLLED TRIAL

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**INTRODUCTION:** The MRC sponsored Spine Stabilisation Trial (SST) was a landmark study of 349 patients with chronic low back pain considered candidates for spinal fusion surgery. It suggested that intensive rehabilitation can produce similar results to spinal fusion at 2 years at about half the cost. However there remained a need to ascertain the longer term outcome of patients managed by the rehabilitation and the surgical strategies

**METHODS:** At 2 years there were 329 subjects remaining in the SST. These subjects were followed for a further 5 years. Subjects were contacted by postal questionnaire and completed the Oswestry Disability Index (primary outcome), SF-36 and Euroqol-5 questionnaire. They also completed a question about whether they had received either surgery or rehabilitation since completion of the original trial intervention that they were allocated. An intention to treat ANCOVA analysis was carried out.

**RESULTS:** At the 7 year follow up 235 (67%) subjects completed the ODI (109 rehab and 126 surgery groups). There was a non significant difference of 2.29 (CI -7.9 – 3.2) between the groups in favour of rehabilitation (rehabilitation mean ODI 32.7 (std error 2.03, 95% CI 28.7-36.7); surgery mean ODI 35 (std error 1.98, 95% CI 31.1-38.9). There were no statistically significant differences in the outcomes for the two intervention strategies for SF-36 and Euroqol. Overall there were only small changes in ODI values between the 2 and 7 year follow up.

**DISCUSSION:** This research suggests that rehabilitation including a cognitive behavioural approach is as beneficial as surgery in the longer term (7 years after randomisation). Whilst subjects in both groups remained moderately disabled, rehabilitation was less invasive and cheaper. It is impossible to rule out the possibility that subjects would have improved without either intervention, but rehabilitation should be seriously considered prior to fusion surgery.

### **26. THE LUMBOSACRAL PLEXUS AND THE TRANSPSOAS APPROACH TO THE INTERVERTEBRAL DISC SPACE: A CADEVARIC STUDY. IS THERE A SAFE ZONE?**

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**BACKGROUND:** The transpsoas surgical approach is gaining in popularity. Post surgical thigh pain, parasthesias, and or weakness have been described.

**METHODS:** Twenty cadaveric lumbar plexus were examined. Needles were placed under flourosopic guidance at the mid coronal plane of the L2-3, L3-4, L4-5 discs prior to dissection. Dissection of the lumbar plexus was then performed. The proximity of the needle to the femoral nerve was observed. Dissection was also performed while a lateral approach retractor was in place.

**RESULTS:** In all specimens the femoral nerve descended at or dorsal to the needle at the midpoint of the L4-5 disc. Fifteen percent of femoral nerves came in contact with the needle in the L4-5 disc. Seventy-five percent of the femoral nerves passed between the needle and the dorsal boundary of the L4-5 disc space. In 25% of the specimens the L2 and L3 contribution to the femoral nerve passed posterior to the L4-5 disc space and joined the L4 root below the L4-5 disc level. Dissection with a lateral retractor in place revealed the lateral femoral cutaneous nerve and the femoral nerve both under significant traction and compression against the L5 transverse process.

**CONCLUSION:** The transpsoas approach to the lumbar spine at the L4-5 interspace may cause a variable degree of compromise to the lateral femoral cutaneous, femoral, and obturator nerve during dilator tube placement and retractor dilation. This may be due to traction at the nerve roots and compression against the L5 transverse process. The “safe zone” which has been described in previous literature may allow for a small access window to the disc, but does not account for anatomic disruption caused by expandable lateral approach retractors. Surgeons should be aware of the L5 spinous process as a posterior boundary against which neural structures may be compressed.

### 27. ADJACENT SEGMENT DEGENERATION OCCURED 3-TIMES MORE 5-YEARS AFTER BILATERAL INSTRUMENTED PLIF THAN UNILATERAL INSTRUMENTED PLIF

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**INTRODUCTION:** Adjacent segment degeneration (ASD) has been considered a potential long-term complication of spinal arthrodesis. However, few studies have analyzed the impact of unilateral or bilateral instrumented lumbar fusion on ASD.

**METHODS:** Sixty patients who underwent L4/5 posterior lumbar interbody fusion (PLIF) for L4 degenerative spondylolisthesis without severe ASD and have more than 5 years of follow-up were subjects of this study. Pedicle screw fixation was performed bilaterally for the first 30 patients (Group-B) and unilaterally for the second 30 patients (Group-U). Two groups were comparable with regard to age and sex. UCLA grading scale was used to evaluate the ASD on radiograph preoperatively, postoperatively, and at the final follow-up.

**RESULTS:** Pain on VAS and walking distance improved significantly ( $P < 0.001$ ) at 5 years follow-up. There was no significant difference between the 2 groups. Patients' satisfaction was as high as 80% in Group-B and 93% in Group-U responded that they would undergo the same procedure again. Radiographically, bony fusion was obtained in 29 patients (97%) in Group-B and 25 patients (83%) in Group-U. In Group-U, 3 patients showed slight screw-loosening at the follow-up without any symptoms. ASD occurred in 50% (15/30 cases) in Group-B, whereas in 17% (5/30 cases) in Group-U. Among them, 8 cases (27%) in Group-B and 1 case (3%) in Group-U had progressed more than 2 levels of degenerative grade. Although two patients in Group-B underwent revision surgery for ASD, no patient needed any additional surgery in Group-U. The severer the change of the degenerative grade was, the worse the patient satisfaction was ( $P < 0.05$ ).

**DISCUSSION:** The clinical results of PLIF with unilateral instrumentation were comparable to bilateral instrumentation. Bilateral instrumentation was superior in terms of fusion rate, but inferior in terms of patients' satisfaction because of the development of ASD.

### 28. SWISS SPINE - NATIONAL MANDATORY REGISTRY FOR LUMBAR TOTAL DISC ARTHROPLASTY: CLINICAL RESULTS OF 593 PATIENTS AND 679 IMPLANTS

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**INTRODUCTION:** The Swiss Ministry of Health has mandated a national registry for lumbar Disc Replacement (TDR). We report on an average of 14-months results.

**METHODS:** In a prospective observational multicenter mode 593 patients (679 implants) were documented. Data collection was performed with EQ-5D, NASS (patient preop, postop) and comorbidity (patient preop) as well as OP- and FU-forms (surgeons). Descriptive statistics and multivariate logistic regressions were performed for a pain relief of  $\geq 18$  points and EQ-5D score improvement of  $\geq 0.25$ .

**RESULTS:** A significant reduction of back (VAS 70-27) and leg pain (VAS 54-19) preoperative to 2-years FU was documented ( $p < 0.001$ ). Quality of life (QoL) improved from 0.33 to 0.79 ( $p < 0.001$ ). At the latest follow-up, the amount of patients that needed pain medication decreased to 34.2% (preop 97.5%). The rates of intraoperative complications for mono- and bisegmental interventions were 4.5% and 5.8% and for postoperative complications 10.9% and 12.8%, respectively. The revision rates were 3.6% and 1.3%.

Preoperative back pain ( $p < 0.001$ ; OR=1.6), preoperative EQ-score ( $p = 0.036$ ; OR=2.4) and number of segments ( $p = 0.036$ ; 2 vs. 1 OR=2.2) had an influence on the postoperative back pain relief. Preoperative leg pain ( $p < 0.001$ ; OR=1.8), preoperative EQ-score ( $p < 0.001$ ; OR=4.9) and number of segments ( $p = 0.036$ ; OR=2.2) had an influence on the postoperative leg pain relief. The preoperative EQ-5D score ( $p < 0.001$ ; OR=0.01) and preoperative leg pain ( $p = 0.028$ ; OR=0.9) had a significant influence on postoperative QoL improvement. Odds ratios were calculated per preoperative unit of 10 VAS-points and 1 EQ-5D point.

**DISCUSSION:** In the short term lumbar TDR appears as a relatively safe and also effective procedure concerning pain reduction and improvement of QoL. Preoperative pain and QoL values significantly influence their own outcome. A two level procedure has a more than two times higher likelihood for a minimum clinically relevant back and leg pain relief than a one level procedure.

## ORAL PRESENTATIONS

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### 29. F.D.A. I.D.E. PROSPECTIVE RANDOMIZED COMPARISON OF THREE LUMBAR ARTIFICIAL DISC REPLACEMENTS (A.D.R.) WITH MINIMUM THREE-YEAR FOLLOW-UP

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**INTRODUCTION:** To establish safety and efficacy between the Maverick™ (M), Charité™ (C), and Kineflex™ (K) A.D.R.'s.

**METHODS:** Follow up on three ADR's performed by two surgeons, at one I.D.E. site were reviewed. There were 25 Maverick, 31 Charité, and 35 Kineflex patients. The majority of A.D.R.'s were performed at L5-S1 vs. L4-L5 (M) 19 to 6, (C) 19 to 12 and (K) 28 to 7. Inclusion/exclusion criteria will be discussed.

**RESULTS:** Re-operations included: (M) 1 infection, (C) 3 implant complications (K) 1 implant complication. These cases will be presented.

ODI results for all groups: Pre-op = (M) 57.6, (C) 63.8, and (K) 61.1; One-year post-op = (M) 16.3, (C) 27.3, and (K) 20.4; Three-year post-op = (M) 14.6 ( $p < 0.001$ )

VAS results for all groups: Pre-op = (M) 74.1, (C) 85, (K) 83.9; One year post-op = (M) 27.9, (C) 31.4, and (K) 27.3; Three-year post-op = (M) 20.5 ( $p < 0.001$ )

F.D.A. clinical success was met in (M) 90%, (C) 83.5%, (K) 90.5% of patients. Patients with a VAS less than 2 occurred in (M) 68%, (C) 29%, (K) 47%. Patients with an ODI less than 10 occurred in (M) 67% (C) 33%, (K) 52%.

Patient satisfaction at three-year follow up was (M) 96%, (C) 84%, and (K) 91%.

**DISCUSSION:** All three ADR's demonstrated safety with a trend to more device related complications with (C) 3 compared to (M) 1 and (K) 1. They all showed efficacy with a statistically significant improvement in ODI and VAS at three year follow-up (p

### **30. FACET JOINT AND ADJACENT LEVEL DEGENERATION FOLLOWING TOTAL LUMBAR DISC REPLACEMENT: A PROSPECTIVE CLINICAL, X-RAY AND MRI INVESTIGATION**

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**INTRODUCTION:** Fusion procedures have been associated with adjacent level degeneration (ALD) and facet joint degeneration (FJD). Whether these negative side effects can be reduced with total lumbar disc replacement (TDR) remains unestablished.

**METHODS:** Clinical outcome scores Visual Analogue Scale (VAS), Oswestry Disability Index (ODI) and patient satisfaction rates were acquired within the framework of an ongoing prospective study with ProDisc II. The mean index-level ROM was established for every patient over the entire postoperative period. Progression of ALD and FJD was evaluated from pre- and postoperative MRI images by 2 independent radiologists.

**RESULTS:** 93 patients with an average FU of 53.4 months (24.1-98.7 months) were included. The overall results showed a significant improvement from preoperative VAS/ODI levels ( $p < 0.0001$ ). The incidence of ALD was 10.2% ( $n = 11/108$  levels). The degenerative changes were mild and occurred late postoperatively (mean 65.2 months, range 37.9-85.6 months). There was no significant correlation between index-level ROM and the occurrence of ALD ( $p > 0.05$ ). Progression of FJD was observed in 20.0% of all facet joints ( $n = 44/220$ ). FJD occurred significantly more often at the lumbosacral junction in comparison to the level above the lumbosacral junction ( $p < 0.02$ ) and was observed more frequently at index-levels than at non-index levels ( $p < 0.001$ ). The degenerative changes were associated with a negative influence on postoperative outcome parameters VAS and ODI ( $p < 0.03$ ) that were already detected early postoperatively. The mean postoperative ROM was significantly lower in patients with FJD in comparison to the remaining cohort ( $p < 0.0001$ ).

**CONCLUSION:** TDR proved to have a beneficial effect with regard to adjacent segment preservation. Progressive index-level facet joint degeneration was observed in a considerable number of patients, particularly at the lumbosacral junction. Lower segmental mobility and less favourable clinical results point to the fact that a particular cohort of patients may predominantly be affected in which TDR shows inferior compatibility with the index-segment's biomechanics.

### 31. COMPARISON OF PATIENT AND SURGEON RATINGS OF GLOBAL OUTCOME 12 MONTHS AFTER SPINAL SURGERY

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**INTRODUCTION:** The contemporary assessment of spine surgical outcome relies primarily on patient-centred reports of symptoms and function. Such measures are considered to reduce bias compared with traditional surgeon-based outcome ratings. This study examined the agreement between patients’ and surgeons’ ratings of outcome 1 year after spine surgery.

**METHODS:** 404 patients (56.6±16.4 y; 259 F, 145 M) and their treating surgeons took part. At baseline and 12-mo post-op, patients completed the Core Outcome Measures Index (COMI), rating pain, function, quality-of-life and disability; at 12 mo post-op, they also rated the global outcome and satisfaction with treatment. Blind to the patient’s evaluation, the surgeon rated the surgical outcome as excellent, good, fair, poor.

**RESULTS:** 76% of patients who were considered by the surgeon to have an excellent/good outcome achieved the minimum clinically important difference (MCID) of a 2.2-point reduction on the COMI. There was a significant correlation between the surgeons’ and patients’ global outcome ratings (Spearman Rho=0.56,  $p<0.0001$ ), and perfect agreement between them in 53.4% cases. Compared with the patients’ rating, senior surgeons “overrated” the outcome in 24.5% cases and “underrated” it in 17.5%; juniors overrated in 7.8% cases and underrated in 43.8% ( $p<0.0001$ , senior v junior surgeons). Surgeon “overrating” occurred significantly more frequently for patients with a poor self-rated outcome. In a multivariate model, the independent variables “senior surgeon” and “patient dissatisfaction” were unique predictors of “overrating” by the surgeon ( $p<0.0001$ ; model adj-R<sup>2</sup> =0.18).

**CONCLUSIONS:** Overall, agreement between surgeon and patient was reasonably good. The majority of patients that were rated as excellent/good by the surgeons had achieved the MCID in the prospectively measured COMI score. Discrepancies in outcome ratings were influenced by surgeon seniority and patient satisfaction. For a balanced view of the surgical result, outcomes should be assessed from the perspectives of both the patient and the surgeon.

### 32. DOES ADVANCED AGE INFLUENCE THE PATIENT-RATED OUTCOME OF FUSION FOR DEGENERATIVE DISC DISEASE?

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**INTRODUCTION:** Advanced age is considered by some to be a contraindication to lumbar arthrodesis, due to the increased risk of complications. Only few studies have examined the influence of age in relation to patient-orientated outcomes and these mostly focused on clinical-trial participants; however, the latter do not always reflect the typical patient seen in everyday practice.

**METHODS:** 129 patients participated, split into two groups: <65 y (N=82) and ≥ 65 y (N=47). The study was nested within the framework of the Eurospine-SSE Spine Tango Registry. Patients were included if they were German/English-speaking, 1-year post-op, had lumbar/lumbosacral degenerative disc disease (DDD), no previous surgery, max 3-level pathology, posterior fusion with autologous bone. The patients completed the Core Outcome Measures Index (COMI;0-10) pre-op and 12 months post-up, and (at 12mo) rated the global outcome of surgery.

**RESULTS:** Baseline low back pain (0-10) was significantly higher in the younger patients ( $6.7 \pm 2.3$  vs  $5.6 \pm 2.8$ , respectively;  $p=0.02$ ), as was the COMI score ( $8.0 \pm 1.5$  vs  $7.1 \pm 1.9$ ;  $p=0.007$ ). Unsurprisingly, ASA comorbidity-score was higher in the older group ( $p=0.001$ ); blood-loss ( $p=0.02$ ) and the % general complications (4.3% vs 0%) were also greater in the elderly. At 12 months, the % good global outcomes (“operation helped a lot/helped”) was similar in the two age-groups: 78.0% for under-65s and 89% for over-65s ( $p=0.11$ ); the reduction in COMI did not differ between the age-groups ( $p=0.34$ ); patient-rated complications were lower in the older (17%) than the younger group (23%) ( $p=0.13$ ).

**CONCLUSIONS:** In view of the increasing life expectancy, the issue of fusion in older patients becomes more and more relevant. Our results suggest that greater age — despite its other consequences during surgery — is not a contraindication to a good patient-centred outcome after fusion. Studies on larger pools of data from surgical registries should serve to clarify the situation further, and in relation to other pathologies/procedures.



### 33. THE UTILITY OF SPINE SURGERY; A COMPARISON OF THE MINIMAL IMPORTANT CHANGE, MIC OF SF-6D AND EQ-5D

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**INTRODUCTION:** SF-36 and EQ-5D are quality of life measures frequently used as outcome measures in back pain research. An indexed version of SF-36, SF-6D now makes it possible to measure the utility of e.g. spine surgery not only with EQ-5D but also with the indexed SF-36 (Brazier 1998). The aim of this study was to determine and compare these measures' MIC, Minimal Clinically Important Change in patients undergoing disc or spinal stenosis surgery.

**METHODS:** All patients undergoing planned spinal surgery during one year were asked to answer SF-36 (revised into SF-6D) and EQ-5D preoperatively and one year postoperatively. An anchor-based method was used to determine MIC. The anchor-based approach used the SF-36' question; "Compared to one year ago, how would you rate your health in general now?" From this question the two answer alternatives; "Somewhat better (or worse) than one year ago" were used as anchors, reflecting a "minimal change", better or worse from just before and one year after surgery.

**RESULTS:** 105 operated patients, 56 with spinal stenosis and 49 with disc surgery were included in the anchor-based MIC calculations. Among the spinal stenosis patients the mean change in utility, MIC, between preop. and postop. was 0.368 using EQ-5D and 0.093 using SF-6D. The corresponding MIC-values for the disc surgery patients were 0.447 using EQ-5D and 0.123 using SF-6D.

**DISCUSSION:** Back pain patients are known to report very low QoL scores. The narrow measuring range of SF-6D, 0.296-1.00, compared to -0.59-1.00 for EQ-5D might suggest that SF-6D is unable to express the typically very low QoL experienced by many back pain patients. In such a way SF-6D might underestimate the utility of an effective back treatment.

The MIC for patients undergoing spine surgery was quite higher than for those with e.g. THR.

## ORAL PRESENTATIONS

### 34. THE INFLUENCE OF SMOKING ON PATIENT OUTCOMES IN THE SPINE PATIENT OUTCOMES RESEARCH TRIAL (SPORT)

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**INTRODUCTION:** Low back pain and cigarette smoking are substantial sources of morbidity and mortality. Treatment of low back pain in smokers has been correlated with poor operative and non-operative outcomes.

**METHODS:** SPORT patients in the degenerative spondylolisthesis (DS) and spinal stenosis (SpS) cohorts were stratified by smoking status into current, former, or never smokers, and analyzed according to treatment received. Longitudinal regression models were used to assess the time-weighted average change in the SF-36 bodily pain (BP), physical function (PF), and Oswestry Disability Index (ODI) primary outcome scores over 4 years follow-up, while controlling for potential confounding covariates.

**RESULTS:** Current smokers were younger in both cohorts, and had significantly ( $p < 0.05$ ) worse baseline functional health status compared with former and never smokers in the SpS cohort. No significant differences in intraoperative or postoperative complication rates were evident in either cohort. Smoking status had no significant effect on outcomes in the DS patients regardless of treatment. The Table shows the time-weighted average change in ODI scores for the SpS cohort over 4 years by smoking status; current smokers showed significantly less improvement with surgery and slightly less improvement with non-operative treatment compared to former and never smokers. As a result, there was no significant benefit of surgery relative to non-operative treatment in this subgroup. The same pattern of results was seen for all the primary outcome measures (BP and PF).

<b>SpS Cohort</b>	<u>ODI score change over 4 years</u>			<i>AUC p-value</i>
	<u>Surgery</u>	<u>Non-operative</u>	<u>Treatment Effect</u>	
Current	-9.0	-7.7	-1.2	<i>0.52</i>
Former	-19.5	-9.8	-9.7	<i>&lt;0.001</i>
Never	-19.9	-10.6	-9.4	<i>&lt;0.001</i>
<i>p-value</i>	<i>&lt;0.001</i>	<i>0.35</i>	<i>&lt;0.001</i>	

**DISCUSSION:** Smoking was associated with significantly worse surgical outcomes in patients with SpS, but not those with DS. Future work should clarify the effect of time since quitting and stratify patients according to level of cigarette consumption.

### 35. POLYMORPHISMS IN GENES ENCODING EXTRACELLULAR MATRIX PROTEINS ARE ASSOCIATED WITH SUSCEPTIBILITY TO LUMBAR DISC HERNIATION

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**INTRODUCTION:** Lumbar disc herniation (LDH) causes sciatica and low back pain that affect activities of daily living of patients and lead to enormous economic burden to the society. Many risk factors of LDH have been proposed, however, its etiology and pathogenesis remain unknown. Extracellular matrix (ECM) plays important roles in the maintenance of integrity and functions of the intervertebral disc (IVD). The aim of the current study is to detect susceptible genes for LDH through case-control association studies on the genes encoding ECM proteins of the IVD.

**METHODS:** Large scale case-control association studies of single nucleotide polymorphisms (SNPs) in DNA obtained from 847 patients with LDH and 896 control subjects without LDH were conducted using the candidate gene approach. All LDH cases had unilateral leg pain of at least 3 months duration and the presence of LDH was verified on preoperative MRI and at surgery. We identified several SNPs that had significant association with LDH and detected genes that include the SNPs and clarified influence of those SNPs on possible pathomechanisms of LDH.

**RESULTS:** A SNP (c.4603C>T; rs1676486) in COL11A1 that encodes alpha1 chain of collagen type XI, which was highly expressed in the healthy IVD, showed significant association with LDH (P=0.000015). The transcript containing the susceptible T-allele degraded faster than that without susceptible allele resulting in decreased expression of COL11A1. Another SNP in THBS2 (IVS10-8C>T; rs9406328) that encodes thrombospondin-2 also showed significant association with LDH (P = 0.0000028). Susceptible allele in this gene increased the skipping rate of exon 11 in mRNA. Exon 11 encodes a protein domain that interacts with MMP2 and 9 and skipping of this exon, therefore, may decrease thrombospondin-2 interaction with MMPs.

**DISCUSSION:** Certain SNPs in COL11A1 and THBS2 may cause functional and morphological changes in the IVD that may lead to the development of LDH.

### 36. TORSION ASSISTS THE DISC HERNIATION PROCESS WHEN COMBINED WITH FLEXION

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**INTRODUCTION:** The role of torsion in the aetiology of lumbar disc herniation is unclear. While torsional movements *in vivo* are small, and are thus unlikely to damage lumbar discs when applied as the sole rotation, torsion may be damaging when combined with flexion. Using mechanical testing followed by micro-CT and microscopy, the current study aimed to determine whether torsion, when combined with flexion, assists the disc herniation process.

**METHODS:** 17 ovine lumbar spines, age 2-5 years, were dissected into L12, L34, and L56 motion segments (posterior elements removed). A hollow injection screw was inserted longitudinally through the inferior vertebra of each segment such that its tip contacted the centre of the nucleus. After being potted in steel rings using dental plaster, each segment was positioned in a posture of 7° flexion either with (n=30) or without (n=21) 2° of applied torsion. While maintained in their designated posture, a viscous radio-opaque gel was injected into the nucleus of each segment using a gradual ramp-and-hold loading regime until failure occurred. Following testing, motion segments were inspected using micro-CT and oblique illumination microscopy in tandem.

**RESULTS:** Motion segments tested with torsion suffered disc failure at a significantly lower applied nuclear pressure ( $p=0.01$ ). While fewer motion segments suffered disc failure in the flexion plus torsion group (32% vs. 65%), an equal proportion in each group (~22%) failed via the formation of a central or mediolateral posterior radial tear involving a systematic annulus-endplate-annulus disruption pattern.

**DISCUSSION:** Torsion markedly reduces the nuclear pressure that some discs can support. Given the morphological similarities between the disc ruptures observed in this study and those seen clinically, small levels of torsion, when combined with flexion, appear to be detrimental the structural integrity of some currently undefined cohort of lumbar intervertebral discs.

### 37. DOES VIBRATION INFLUENCE THE INITIATION OF INTERVERTEBRAL DISC HERNIATION? AN IN-VITRO ANALYSIS TO DETERMINE A CAUSAL RELATIONSHIP

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**INTRODUCTION:** Exposure to vibration has been linked to a higher reporting of low back pain, and in particular disc herniation, via epidemiological studies. However, these studies are unable to determine causal relationships. *In vitro* tissue experimentation assists in determining if certain exposures, for example vibration, actually lead to herniation. The objectives of this study were two-fold. First, this study aimed to determine the effect of exposure to axial vibration on the initiation and progression of disc herniation. Second, this study aimed to determine the effect of both vibration and disc damage on the mechanical properties of individual lamella from the annulus.

**METHODS:** Twenty functional spine units (FSU) were subjected to repetitive flexion-extension (6000 cycles), which has been shown to produce intervertebral disc herniation. While being exposed to the repeated bending profile, ten of these FSUs were statically compressed under 1400N (control group) and the remaining ten were cyclically compressed (1260N-1540N) at a frequency of 5 Hz (vibration group). Post collection, the intervertebral discs were further dissected and individual lamella of the annulus were tested under uniaxial tension to failure in order to assess the mechanical properties.

**RESULTS:** Of the ten control FSUs, four had evidence of herniation initiation while eight of the ten vibrated FSUs showed herniation initiation (chi-square  $p = 0.01$ ). No differences in disc height loss or FSU stiffness were observed between the control and vibrated groups. Further, no differences in mechanical properties were observed between the vibrated and control single lamella.

**CONCLUSION:** This study has confirmed that vibration is a causal mechanical risk factor that significantly increases the occurrence of herniation. Interestingly, vibration in conjunction with repeated flexion-extension does not seem to alter the acute failure mechanical properties of lamella when compared to lamellae only exposed to flexion-extension, suggesting that herniation is a complex injury.

## ORAL PRESENTATIONS

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### **38. EFFECT OF PROGRESSIVE INCREASE IN RADIAL LESION SIZE ON LUMBAR INTERVERTEBRAL DISC BIOMECHANICS DEPENDS ON THE INTEGRITY OF SURROUNDING ANNULAR FIBERS**

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**INTRODUCTION:** Among different phenomena that occur during disc degeneration, annular radial tears are commonly associated with disc herniations. It is hypothesized that change in disc flexibility due to progressive increase in size of radial tear will depend on the integrity of surrounding annular fibers.

**METHODS:** Progression of annular tears was created in a poro-elastic finite element model of L4/5 by modifying material property (from annular ground substance to nucleus material) at two “integrating” points at a time in each annular finite element along the radial direction in the left lateral posterior quadrant. Annular fibers either around the tear region or in the entire vicinity were also removed. Models with radial tears occupying 0.0% to 0.3% of total annulus volume were created and loaded with 1200 N compression combined with moments of 7.5 Nm in all the three principal planes in both directions.

**RESULTS:** Percent increase in range of motion varied from 0% to 0.4 % (for various loading modes) when the annular fibers near the tear region were only removed. A larger increase in range of motion (varying from 0% to 4.0%) was seen when fibers in the entire vicinity of the tear were removed. For example, percent increase in motion under left torsion was 20 times larger when annular fibers in the entire vicinity were removed as compared to removing fibers only around the tear region.

**CONCLUSIONS:** Current study validated the hypothesis that change in disc flexibility due to progressive increase in size of radial tear will depend on the integrity of surrounding annular fibers. The study showed that radial annular incision will propagate much faster if the annular fibers in the vicinity of the tear region (in contrast to fibers near the tear region) are not able to sustain load.

**ACKNOWLEDGEMENT:** NIH AR48152-02

### 39. PATHOMECHANISMS OF SCIATICA IN LUMBAR DISC HERNIATION. EFFECT OF PERIRADICULAR ADHESIVE TISSUE ON ELECTROPHYSIOLOGICAL VALUES BY AN INTRAOPERATIVE STRAIGHT-LEG-RAISING TEST

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**INTRODUCTION:** The straight-leg-raising (SLR) test is one of the most significant signs for making a clinical diagnosis of lumbar disc herniation. A recent study showed that intraradicular blood flow apparently decreased during the SLR test in patients with disc herniation. This study is to investigate the relationships between nerve root movement and the electrophysiological values during an intraoperative SLR test *in vivo*.

**METHODS:** The subjects were 32 patients who underwent microdiscectomy. During the operation, the nerve root motion affected by the hernia was observed during the SLR test. The patients' legs were allowed to hang down to the angle at which sciatica had occurred and the change of nerve root action potentials was measured. After removal of the hernia, a similar procedure was repeated. The periradicular specimens collected during surgery were examined by light and electron microscope.

**RESULTS:** Intraoperative microscopy revealed that the hernia was adherent to the dura mater of the nerve roots in all patients. During the SLR test, the limitation of nerve root movement occurred by periradicular adhesive tissue and amplitude of action potential showed a sharp decrease at the angle that produced sciatica. After removal of the hernia, all the patients showed smooth gliding of the nerve roots during the test and there was no marked decrease of amplitude. Our data suggest that temporary ischemic changes in the nerve root cause transient conduction disturbances. Pathological examination showed that the periradicular tissue consisted of the granulation with vascularization and many inflammatory cell infiltrations.

**CONCLUSION:** The presence of periradicular fibrosis will compound the nerve root pain by fixing the nerve in one position and thus increasing the susceptibility of the nerve root to tension or compression.

### 40. TUBULAR DISCECTOMY VERSUS CONVENTIONAL MICRODISCECTOMY FOR THE TREATMENT OF LUMBAR DISC HERNIATION: TWO YEAR RESULTS OF A DOUBLE-BLINDED RANDOMISED CONTROLLED TRIAL

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**INTRODUCTION:** Conventional microdiscectomy is the most frequently performed surgery for patients with lumbar disc herniation. Transmuscular tubular discectomy has been introduced to increase the rate of recovery, although evidence is lacking. We evaluated the outcome of tubular discectomy compared with conventional microdiscectomy in a double-blinded randomised controlled multicenter trial.

**METHODS:** 328 patients with persistent leg pain (> 8 weeks) due to lumbar disc herniation were randomly assigned to undergo tubular discectomy (167 patients) and conventional microdiscectomy (161 patients). Patients and researchers were kept blinded of the allocated treatment during the follow-up period of 2 years. The main outcome measures were scores from the Roland-Morris Disability Questionnaire for Sciatica (RDQ), visual analogue scale (VAS) for leg pain and back pain, and Likert self rating scale of global perceived recovery. Repeated measurements analyses according to the intention-to-treat principle were used.

**RESULTS:** During follow-up, there were no significant differences between tubular discectomy and conventional microdiscectomy in RDQ scores (between-group mean difference, 0.6; 95% CI, -0.3 to 1.6). Patients treated with tubular discectomy reported more leg pain (between-group mean difference of VAS leg pain, 3.3 mm; 95% CI, 0.2 to 6.3 mm) and more back pain (between-group mean difference of VAS back pain, 3.0 mm; 95% CI, -0.2 to 6.3 mm) as those patients treated with conventional microdiscectomy. At 2 years, 71% of the patients assigned to tubular discectomy documented good recovery versus 77% of the patients assigned to conventional microdiscectomy (odds ratio 0.76; 95% CI, 0.45 to 1.28; P=0.35). The rate of repeated surgery within 2 years after tubular discectomy and conventional microdiscectomy was 15% and 10%, respectively (P=0.22).

**DISCUSSION:** Tubular discectomy and conventional microdiscectomy resulted in similar functional and clinical outcome, although tubular discectomy resulted in less favorable results for leg pain, back pain, and perceived recovery.



## ORAL PRESENTATIONS

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### **41. ANULAR REPAIR AFTER LUMBAR DISCECTOMY: PRELIMINARY OBSERVATIONS FROM AN ONGOING, PROSPECTIVE, RANDOMIZED, CONTROLLED CLINICAL TRIAL**

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**INTRODUCTION:** Repeat surgery may sometimes be performed for recurrent herniation after lumbar discectomy. Repair of the anulus fibrosus has been suggested as a method of reducing the need for secondary surgery. Reoperation rates were compared for patients receiving anular repair versus those that were left unrepaired in an ongoing, prospective, randomized, controlled clinical trial.

**METHODS:** Patients from a fully-enrolled clinical study are being followed up to two years. This study was performed at 34 investigative sites in the United States with 58 surgeons. Randomization of repaired anulus fibrosus (n= 478 pts) versus no repair (n= 250 pts) occurred in a 2:1 schema at the conclusion of the discectomy; anular repair was performed using the Xclose™ Tissue Repair System (Anulex Technologies, Minnetonka MN). At the time of analysis (Oct 1, 2009), the average follow-up was 13.1 +/- 6.4 months (range: 1 month to 30 months). In this preliminary analysis, clinical sites that had enrolled at least twenty patients and had experienced at least one reoperation for recurrent herniation (in either group) were analyzed.

**RESULTS:** Discectomies from ten clinical sites (29%) with twenty-five surgeons (43%) were included in this analysis. Randomization resulted in 320 repaired cases and 165 unrepaired cases, representing 65% of the overall trial enrollment. There was a 7.3% reoperation rate for recurrent reherniation (n= 12) in the unrepaired group versus 4.7% (n= 15) in the repaired group. Therefore the overall treatment effect benefit was 35.6% from the perspective of mitigating secondary surgery for reherniation.

**DISCUSSION:** There is increased awareness for the need for improved outcomes after lumbar discectomy. Specifically, repeat surgery for recurrent herniation remains a concern. Anular repair is one method that can positively affect outcomes by reducing the need for a second surgery.

### 42. SPORT INTERVERTEBRAL DISC HERNIATION: INDICATIONS MATTER MOST

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**INTRODUCTION:** The treatment effect of surgery (TE) may vary with specific patient and disease characteristics. While SPORT demonstrated a significant advantage for discectomy at 4 years for the “average” patient meeting specific inclusion criteria (radiculopathy with neurological findings and corresponding lesion on imaging), we hypothesized that certain subgroups might benefit less from surgery.

**METHODS:** Intervertebral disc herniation (IDH) patients underwent discectomy (n=788) or received exclusively non-operative care (n=404) and were analyzed according to treatment received. Forty 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\*treatment interactions ( $p < 0.1$ ) were simultaneously entered into a multivariate model to select independent TE predictors.

**RESULTS:** All analyzed subgroups improved significantly more with surgery than with non-operative treatment ( $p < 0.05$ ). Joint problems, being single, education beyond high school, reporting an unchanging or improving health trend, age under 42, receiving worker’s compensation, and shorter duration of symptoms predicted smaller TEs. Multivariate analysis demonstrated that joint problems (TE -10.3 vs. -14.6 for patients without joint problems,  $p = 0.012$ ), being single (TE -7.7 vs. -15.8 for married patients,  $p < 0.001$ ), and reporting an unchanging health trend (TE -11.8 vs. -15.9 for patients getting worse,  $p = 0.032$ ) were independent TE modifiers. TEs ranged from -7.2 for single patients with no joint problems and unchanging health to -21.1 for married patients with no joint problems and worsening health.

**DISCUSSION:** SPORT patients met specific inclusion criteria and improved more with surgery than with non-operative treatment in all evaluated subgroups. However, TE varied significantly among subgroups; patients with joint problems, single patients, and those with an unchanging health trend had smaller TEs. The treatment of IDH is “preference sensitive”, so patients meeting the strict inclusion criteria should be offered surgical or non-operative treatment.

## ORAL PRESENTATIONS

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### 43. THE SHORT-TERM RESULTS PREDICT THE LONG-TERM RESULTS IN LDH SURGERY. RESULTS FROM A PROSPECTIVE STUDY OF CONSECUTIVE PATIENTS 15-19 YEARS AFTER SURGERY.

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**INTRODUCTION:** Results after surgery for lumbar disc herniation are generally regarded as favourable; correlation between short-term and long-term results are less thoroughly studied.

The aim of this prospective study was to evaluate relation between short-term and long-term outcome after lumbar disc excision

**METHODS:** In 1986, a prospective study of consecutive patients operated on due to lumbar nerve root compression syndromes was initiated at our department. From this original study, the first 144 patients who underwent surgery due to lumbar disc herniation were identified 15-19 years after surgery and invited to follow-up. 11 were deceased and 133 were available for follow-up investigation. Of these, 128 patients participated (96 percent). Mean patient age at surgery was 41 (15-68) years, and male/female ratio was 56/44. Follow-up investigations, thus, were performed 1, 2 and 15-19 years after surgery. At 1 and 2-years follow-up, all patients graded the result using a 5-grade scale (painfree, significantly improved, improved, unchanged or worse). At long-term follow-up a number of data were collected. Relevant for this presentation are the SF36 form and Oswestry disability index.

**RESULTS:** There was a correlation between 1- and 2-year results and long-term result, Kendall's tau=0.342, p=0,0001. Results are shown in table below.

One-year result, leg pain	ODI 15-19 years after surgery		
	Mean	sd	median
Painfree	11	14	8
Significantly improved	23	23	14
Improved	29	18	34
Unchanged/worse	38	15	39

A similar correlation was noted in the SF-36 form, mainly regarding physical domains.

**DISCUSSION:** In this study, there was a correlation between short-term and long-term results after surgery for lumbar disc herniation. The results obtained one-two years after LDH surgery mainly persist at 15-19 years follow-up.

### **44. THE OUTCOME OF DISCECTOMY FOR LUMBAR HERNIATED DISC IS INFLUENCED BY THE SEVERITY OF CONCOMITANT PRE-OPERATIVE LOW BACK PAIN.**

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**INTRODUCTION:** Discectomy is a common and generally successful treatment for lumbar disc herniation (LDH). However, clinical experience raises some concern that the presence of concomitant low back pain (LBP) may have a negative influence on the overall treatment outcome. This study examined how the relative severity of LBP influences the outcome of decompression surgery for LDH.

**METHODS:** The SSE Spine Tango system was used to acquire the data from 308 patients. Inclusion criteria were LDH, first-time surgery, maximum 1 affected level, and discectomy/sequestrectomy as sole procedure (no fusion/stabilisation). Before and 12 months after surgery, patients completed the multidimensional Core Outcome Measures Index (COMI; includes 0-10 leg/buttock pain (LP) and LBP scales); at 12 months, global outcome was rated on a Likert-scale and dichotomised into “good” and “poor” groups.

**RESULTS:** In the “good” outcome group, mean baseline LP was 2.8 ( $\pm 3.1$ ) points higher than LBP; in the “poor” group, the corresponding value was 1.1 ( $\pm 2.9$ ) ( $p < 0.001$  between groups). There was a low but significant positive correlation between baseline LP-minus-LBP scores and improvement in the multidimensional COMI score after 12-months ( $r = 0.20$ ,  $p = 0.001$ ). Significantly fewer patients with back pain as their “main problem” had a good outcome (69% good) compared with those who reported leg/buttock pain (84% good) as the main problem ( $p = 0.04$ ). In multivariate regression (controlling for age, gender, co-morbidity), baseline LBP intensity was a significant predictor of the 12-month COMI score, and of the global outcome (each  $p < 0.05$ ) (higher LBP, worse outcome).

**CONCLUSIONS:** Overall, patients with more back pain showed significantly worse outcomes after discectomy for LDH. This finding fits with general clinical experience, but has rarely been quantified in the many outcome predictor studies conducted to date. Consideration of the severity of concomitant LBP in LDH may assist in clinical decision-making and in establishing realistic patient expectations before the operation.

## ORAL PRESENTATIONS

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### 45. INFLUENCE OF DEFINITION ON RATES OF SUCCESS FOR LUMBAR DISC HERNIATION

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**INTRODUCTION:** Achieving a “successful outcome” may be the most understandable and clinically relevant outcome for a clinical trial but this approach is limited by a lack of consensus on the “right” definition of success.

**METHODS:** We reanalyzed the one-year results of the Spine Patient Outcomes Research Trial randomized cohort comparing surgery and non-operative treatment for lumbar disc herniation using different criteria for composite definitions of success: 1)  $\geq 15$  points improvement on ODI and  $\geq 10$  points improvement on SF-36 BP; 2) global self-rated “major improvement” and “satisfied” with symptoms; 3) final leg pain bothersomeness score of 0 (no leg pain); 4) #1 and #2 and #3 and no opioids; 5) final leg pain bothersomeness of 0, final SF-36 BP score  $> 80$ , and final ODI score  $< 10$ . The surgery group included all patients having surgery within 3 months of enrollment. In all analyses, repeat spine surgery was considered a failure in the surgery group and cross-over to surgery after 3 months was considered a failure in the non-operative group.

**RESULTS:**

The Table summarizes success rates and the number needed to treat (NNT) to obtain one additional “success” for each definition.

Criteria	Success Definition				
	1	2	3	4	5
% Success with Surgery	78%	64%	43%	33%	27%
% Success with Non-op	43%	32%	25%	14%	8%
Success Difference	35%	32%	18%	19%	19%
NNT (Booststrapped 95% CI)	2.9 (2.29 – 3.85)	3.1 (2.40 – 4.50)	5.6 (3.57 – 12.82)	5.3 (3.64 – 9.85)	5.3 (3.83 – 8.85)

**CONCLUSIONS:** The proportion of patients achieving a successful outcome was highly dependent on the definition of success and even greater variation might be expected if additional criteria such as return to work were incorporated into the definitions. The NNT to achieve one additional success between treatment groups was less sensitive to the definition of success.

### 46. PERSISTENT DISC PROTRUSION AFTER MICRODISCECTOMY: CHANGES OF HERNIA MASS AS SEEN ON POST-OPERATIVE MR IMAGING

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**INTRODUCTION:** We often treat patients with lumbar disk herniation on whom radicular symptoms improve relatively soon after surgery, although postoperative magnetic resonance (MR) imaging shows a mass protruding into the spinal canal from the posterior aspect of the intervertebral disk that compresses the nerve root and dural sac persisting for a long period. In the present study, we observed the changes of the protruding mass and radicular symptoms.

**METHODS:** Thirty-four patients with the diagnosis of lumbar disc herniation who underwent nucleotomy were followed up for more than 2 years. MR imaging was performed before surgery and 3,6,12, and 24 months afterward. MR imaging studies were performed on a 1.5-T permanent magnet (Signa General Electric) using a 12-cm diameter planar circular surface coil operated in the receive mode. We measured the distance between the posterior edge of the intervertebral disk and the top of the mass protruding into the spinal canal before surgery and after surgery, and calculated the reduction rate using MR imaging.

**RESULTS:** Radicular symptoms improved in all patients within 3 months after surgery, although only 36% of the patient showed a significant protruding mass reduction (rate over 75%); but after 2 years, 67% of the residual mass after surgery had disappeared. Thus, clear progressive mass reduction has been demonstrated in the follow up. No clear correlation has been found between the improvement of the symptoms and the presence of a residual mass in the postoperative MR imaging.

**CONCLUSIONS:** This study indicated that there are patients who have a residual mass in the spinal canal even after the improvement of radicular symptoms by surgery for lumbar disc herniation. This should be kept in mind when following up these patients postoperatively.

## ORAL PRESENTATIONS

### 47. LUMBAR DISC HERNIATION IN THE SPINE PATIENT OUTCOMES RESEARCH TRIAL (SPORT): DOES PSYCHOLOGICAL DISTRESS AFFECT TREATMENT OUTCOME?

Anthony Albert MD, Garrett Davis MD, MBA, Kevin Spratt PhD, William Abdu MD, MS, Wenyan Zhao, MS, James N. Weinstein, DO, MSc. Lebanon, NH, USA

**INTRODUCTION:** A generally held clinical impression is that patients with psychological Distress (PD, e.g., Depression, Anxiety, Bi-Polar Disorder) are likely to have poorer treatment outcomes. The literature provides some support for this impression, but the generalizability across patient cohorts and evidence for a causal link between PD and outcome remain controversial.

**METHODS:** Patients with lumbar intervertebral disc herniations (IDH) were studied. Patients with MCS scores  $\leq 35$  were defined as having PD and, otherwise, were classified as not distressed (Non-PD). Longitudinal regression models including baseline covariates were used to control for confounding when evaluating patients' Bodily Pain (BP), Physical Function (PF) and Oswestry Disability Index (ODI) outcomes.

**RESULTS:** The SPORT IDH cohort included 1190 patients: 66% underwent surgery, and 22% reported being depressed at baseline. Change from baseline in PF outcome at 1- and 2-year follow-up for surgical and non-operative PD and Non-PD patients at baseline are summarized below.

Assessment Time	Treatment Received					
	Surgical			Non-Operative		
	PD	Non-PD	p* <	PD	Non-PD	p* <
1-year Follow-up	43.76	44.27	.79	24.50	29.38	.07
2-Year Follow-up	43.89	43.23	.73	24.44	31.47	.01

p\* < The type I error probability associated with the null hypothesis that PD and Non-PD patients, on average, had equivalent outcome change

Surgical patients demonstrated greater average improvement than non-operative patients for all three outcomes,  $p < .0001$ . However, PD patients treated non-operatively demonstrated less improvement than Non-PD patients. In contrast, differences in outcomes in patients with and without PD who underwent surgical intervention were neither statistically significant nor clinically relevant.

**DISCUSSION:** In this IDH patient cohort, surgical outcomes were unrelated to baseline PD, but, for patients treated non-operatively, the average amount of improvement from baseline for PD patients was not as good as for non-PD patients. These results are consistent with the notion that patient non-compliance – mediated by PD – may be a more reasonable explanation for reduced treatment efficacy when treatment requires greater patient participation.

### 48. DOES SMOKING HABIT INFLUENCE THE OUTCOME OF LUMBAR DISCECTOMY?

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**INTRODUCTION:** The literature reports that cigarette smoking has a detrimental effect on the outcome of spinal fusion. This is thought to be due to its deleterious effects on microvascularization. However, there is also epidemiological evidence that smoking is a risk factor for chronic back pain, and it might therefore exert an effect on surgical outcome *per se*, simply as a negative lifestyle factor. This study examined the effects of smoking on the outcome of discectomy, where no bone healing is required.

**METHOD:** Inclusion criteria were: lumbar/lumbosacral disc herniation being treated with discectomy/sequestrectomy, no additional decompressive techniques or fusion/stabilization; German/English-speaking. 282 patients participated; 236 had data on their smoking habits (categorized as non-smoker;  $\leq 5$  cigarettes/day; 6-10/day; 11-15/day; 16-20/day;  $>20$ /day). The patients completed the Core Outcome Measures Index (COMI) at baseline and 3, 12 and 24 months follow-up; at follow-up they also rated the global outcome of surgery.

**RESULTS:** 80/236 (33.9%) patients smoked. Baseline low back pain was significantly higher in smokers than non-smokers ( $5.0 \pm 2.8$  vs  $4.1 \pm 2.8$ , respectively;  $p=0.04$ ). No other baseline differences in COMI outcome domains were observed. The % good global outcomes (“operation helped a lot/helped”) were similar in the smokers and non-smokers at every follow-up: 87.2% vs 85.6%, respectively, at 3 months, ( $p=0.74$ ); 85.2% v 85.0% at 12 months ( $p=0.97$ ); and 87.2% v 85.7% at 24 months ( $p=0.81$ ). There were no significant differences between the groups in the reduction in COMI score at any time-point. The number of cigarettes smoked was unrelated to the change in COMI score.

**CONCLUSION:** The results corroborate the association between smoking and back pain, but indicate that cigarette smoking is not a negative risk factor for the outcome of discectomy. The findings support the notion that the effects previously reported for fusion are indeed related to the specific influence of smoking on bone healing.



### 49. MANAGEMENT OF PEDIATRIC LUMBAR SPONDYLOLYSIS USING MRI SIGNAL CHANGES IN THE ADJACENT PEDICLE

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**INTRODUCTION:** A recent study reported that high signal change (HSC) on T2-MRI in the pedicle adjacent to the pars interarticularis could be an indicator of early spondylolysis. In addition, the HSC-positive pars defects showed significant better bony healing than the HSC-negative pars defects. However, there has been no report on the time course and the duration of HSC. In this study, we prospectively investigated the time course of signal changes in the adjacent pedicle in acute pediatric lumbar spondylolysis.

**METHODS:** We investigated 10 boys and 5 girls with acute lumbar spondylolysis showing HSC in the adjacent pedicle. Their mean age was 15.1 years, ranging from 10 to 17 years. Two patients had multi-level unilateral spondylolysis. Among 15 patients, HSC was found in 22 (12 unilateral, 5 bilateral) pedicles. At the first presentation, the diagnosis of spondylolysis was made based on plain X-ray findings, multi-detector CT, and MRI. Every month from the first presentation, follow-up MRIs were taken. When HSC disappeared, multi-detector CT was taken to confirm bony healing of the pars defect.

**RESULTS and DISCUSSION:** Bony healing of the pars was obtained in 21 out of 22 defects. The bony healing rate was 95.6%. In 19 pedicles of 12 patients, HSC gradually diminished by every month until it disappeared 3 months later, and radiological osseous healing was confirmed by CT in all but one patient. In the 3 remaining pedicles of 3 patients who did not comply with treatment, HSC took more than 4 months to disappear. These results led us to hypothesize that MRI at the third month during follow up can indicate whether the conservative treatment is being successful or not.

### 50. BONY HEALING OF THE PEDIATRIC LUMBAR SPONDYLOLYSIS WITH CONSERVATIVE TREATMENT. – WHICH TYPE OF LYSIS AND HOW LONG?-

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**INTRODUCTION:** The pediatric spondylolysis can be healed osseously when it is treated before it becomes pseudoarthrosis. However, it is unclear what type of defects can be osseously healed, and how long does it take for the osseous healing. In this study, we clarified these issues.

**METHODS:** Total 63 defects were treated in 37 pediatric cases conservatively, aged less than 18. Their mean age was 13.5 y.o. (6- 17 y.o.). There were 25 boys and 12 girls. At the first presentation, their stage was early in 33, progressive in 22, and terminal stage in 8 cases on CT classification. A hard brace was used on the purpose of getting bony healing conservatively (Sairyo et al. ISSLS 2009). CT was taken to confirm the osseous healing. The patients were allowed to return to the original sport activity when the defects get bony union or become pseudoarthrosis.

**RESULTS:** In the early stage of 33 cases, 31 showed bony healing (93.9%) with the conservative treatment. Among the 31 cases showing osseous healing, 83.9% obtained the healing within 3 months. The mean duration for the healing was 3.2 months. In the 22 progressive defects, 10 showed healing (45.5%) at the mean duration of 5.5 months. Among the 10 cases with osseous healing, 7 (70.0 %) required at least 6 months for the healing. None of the 8 terminal defects healed.

**DISCUSSION AND CONCLUSION:** The early stage is a good candidate for the conservative treatment to get bony healing, and usually it heals around 3 months. Only 45% healed in the progressive stage, and it required around 6 months for the healing. Thus, based on this information, one can make a plan of the treatment strategy depending on the patient situation.

### 51. QUALITY OF LIFE AND PHYSICAL FUNCTION FOR PATIENTS FUSED IN SITU AT YOUNG AGE FOR ISTHMIC SPONDYLOLISTHESIS GRADE III–V. A 29 YEAR FOLLOW UP.

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**INTRODUCTION:** The aim of this retrospective clinical study was to evaluate the long-term outcome and quality of life of young patients fused in situ for isthmic spondylolisthesis grade III-V.

**METHODS:** Thirty-five of forty consecutive patients fused in situ for isthmic spondylolisthesis (17 Meyerding grade III, 14 grade IV and 4 grade V) underwent physical examination and were evaluated by validated questionnaires. The mean age at surgery was 15 years (range 9-25) and the mean time to assessment was 29 years (range 23-35). Quality of life was assessed by Short Form-36 and EQ-5D, depression by Zung depression scale (ZDS), physical function by Million score and Oswestry disability index (ODI) and pain by Visual Analogue Scale (VAS). Million score and physical examination data was compared with results from an 8 year follow-up in 1991 for the same patients.

**RESULTS:** The eight domains of SF-36 averaged: Physical Function 88 (range 50-100), Role Physical 89 (range 0-100), Bodily Pain 76 (range 10-100), General Health 79 (range 35-100), Vitality 70 (range 15-100), Social Function 92 (range 50-100), Mental Health 85 (range 40-100) and Role Emotional 93 (range 0-100). EQ-5D index averaged 0.84 (range 0.62-1). ZDS averaged 30 (range 20-52). Million score averaged 28 (range 0-109) and ODI 10 (range 0-34). Mean back pain VAS was 13 (range 0-72) and leg pain VAS 9 (range 0-60). The average Million score was increased by 13 points compared with the 8 year follow-up.

**DISCUSSION:** At long term follow up of patients fused in situ for severe isthmic spondylolisthesis at a young age, quality of life was high and mental health normal. The patients also reported low pain intensity and good physical function which is supported by earlier studies.

### 52. LUMBAR VERTEBRAL GROWTH IS GOVERNED BY 'CHONDRAL GROWTH FORCE RESPONSE CURVE' RATHER THAN 'HUETER-VOLKMANN LAW- A CLINICO-BIOMECHANICAL STUDY OF GROWTH MODULATION CHANGES IN CHILDHOOD SPINAL TUBERCULOSIS.

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**INTRODUCTION:** Hueter-Volkmann's Law (HVL) and Chondral Growth Force Response Curve (CGFRC) are proposed to explain growth modulation (GM) in limbs but have not been validated in spinal growth. We have analysed the forces in a spine FEM to explain the GM changes in Childhood post-tubercular kyphosis (PTK).

**METHODS:** GM changes in vertebrae within the kyphotic curve over 15 years were documented in 63 children with PTK. Defects simulating clinical lesions were created in a validated 3D-FEM and subjected to follower load of 400N with 10Nm flexion moment till collapse and restabilisation was achieved. Stresses at different regions were calculated and correlated to growth changes observed clinically.

**RESULTS:** Clinically different degrees of collapse with significant GM changes were observed in 234 vertebrae in both the primary and secondary curves. In Type A collapse, facet joints were intact and the stress on endplate (EP) was 1MPa. Contrary to HVL, accelerated growth was noted here. With a body destruction of >1.5, the forces in the facet capsules exceeded 30 MPa and the contact stress on the EP increased from 16.6 MPa to 40 MPa leading to growth suppression. In 'Buckling Collapse' where the kyphosis reached almost 160<sup>0</sup>, the EP became almost vertical, devoid of stress. Here again accelerated growth was noticed. Acceleratory growth was found both in tension and in initial phases of compression proving that spinal growth followed principles of CGFRC rather than HVL.

**CONCLUSIONS:** This study is the first in literature to study the biomechanical forces in collapse models of lumbar spine FEM and correlate it with GM changes observed clinically over 15 years in children with PTK. *The finding that spine growth follows CGFRC rather than HVL opens a 'Window of Opportunity' for the spine surgeon to treat spinal deformities by mechanical growth modulation.*

### 53. LYMPHATIC INVOLVEMENT IN VERTEBRAL AND DISC PATHOLOGY

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**OBJECTIVE:** Vascularised cellular fibrous tissue can be found in pathological conditions involving the disc and the vertebra, including primary and metastatic tumours and spinal infection. Whether lymphatic vessels form a component of this stromal tissue is not known as the presence or absence of lymphatics in normal and pathological vertebral tissues is not known. We examined normal and pathological vertebral bone and disc specimens for the presence of lymphatics.

**METHODS:** Immunohistochemistry was used to identify the specific lymphatic endothelial cell markers, podoplanin and LYVE1 in 5 sacrococcygeal chordomas, 4 giant cell tumours, 2 osteoblastomas and 5 breast/5 prostate spinal metastases. 6 cases of discitis/osteomyelitis, twenty disc herniations and 10 normal adult (autopsy-derived) discs and vertebrae.

**RESULTS:** Lymphatic vessels were not found in the nucleus pulposus or annulus fibrosus of intact, non-herniated lumbar and thoracic discs but were present in the surrounding ligaments. LYVE1+/podoplanin + lymphatic vessels were noted in the fibrous tissue of herniated discs. Lymphatic vessels were not seen in infections or primary or secondary tumours that were confined to vertebral bone or disc tissue; however, lymphatics were found in tumours or infections which had extended outside the confines of the bone; lymphatic vessels were frequently noted in surrounding extra-osseous fat and fibrous tissue at the edge of infiltrating tumours.

**CONCLUSION:** Our findings indicate that lymphatic vessels are not present in the normal adult intervertebral disc or vertebral bone but that there is ingrowth of lymphatic vessels into these structures when pathological lesions in disc or bone spread into surrounding soft tissues. Metastatic tumours do not spread to vertebrae via lymphatics and primary malignant bone tumours arising in vertebrae only spread via lymphatics to regional lymph nodes once they have extended into para-spinal soft tissues.

### 54. <sup>18</sup>F-FLUORODEOXYGLUCOSE-PET FOR PATIENTS WITH SUSPECTED SPONDYLITIS SHOWING MODIC CHANGE

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**INTRODUCTION:** Vertebral bone marrow infection may appear as Modic Type 1 signal on magnetic resonance imaging (MRI), so it is difficult to distinguish between common Modic change and infection. <sup>18</sup>F-fluorodeoxyglucose (<sup>18</sup>F-FDG) is known to accumulate at sites of infection, inflammation, and in autoimmune and granulomatous diseases. In the current study, we aimed to examine the utility of <sup>18</sup>F-fluorodeoxyglucose-positron emission tomography (FDG-PET) to diagnose pyogenic spondylitis in patients showing Modic change.

**METHODS:** The protocol for human procedures used in this study was approved by our institution's ethics committee. In prospectively assessment of 312 patients showing low back pain continuing for at least 4weeks, 18 patients were suspected of having pyogenic vertebral osteomyelitis because of their symptoms, biopsy results, blood analysis, X-ray examination, and MRI during a one-year follow up by Group 1 observers (3 spine surgeons). They didn't see the FDG-PET findings. On the other hand, FDG-PET was performed in these patients and Group 2 observers (2 radiologists) evaluated them without any other information. The evaluation by Group 2 was compared with the diagnosis by Group 1.

**RESULTS:** Group 1 Observers ultimately diagnosed 11 patients with pyogenic spondyliti . FDG-PET evaluation by Group 2 showed isotope accumulation in the lumbar spine in 11 patients, and no accumulation in 7 patients. Sensitivity and specificity of Group 2 findings were 100%.

**DISCUSSION:** The sensitivity and specificity in detecting spondylodiscitis infection were very high if FDG-PET was additionally used. In conclusion, FDG-PET is recommended to distinguish between common Modic change and spinal infection.

### **55. PREVALENCE, DETERMINANTS AND ASSOCIATION OF SCHMORL'S NODES OF THE LUMBAR SPINE WITH DISC DEGENERATION: A POPULATION-BASED STUDY OF 2449 INDIVIDUALS (ISSLS Prize Winner)**

Florence P.S. Mok, Dino Samartzis, Jaro Karppinen, Keith D.K. Luk, Daniel Y.T. Fong, and Kenneth M.C. Cheung, Hong Kong, China

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**INTRODUCTION:** Schmorl's nodes (SN) represent intravertebral disc herniation and are commonly seen in the spine. Their reported prevalence and determinants vary, and their association with disc degeneration remains uncertain. Based on the largest, population-based study of intervertebral disc degeneration in Southern Chinese, we attempted to address these issues.

**METHODS:** Sagittal T2-weighted MRIs of the lumbar spine were analyzed in 2,449 volunteers. Two independent observers assessed the images for the presence of SN, and scored for additional radiologic features (e.g. severity of degeneration, presence of disc bulge/extrusion). Subject demographics were assessed by standardized questionnaire.

**RESULTS:** SN were found in 16.4% (n = 401; 219 males, 182 females; mean age = 42.3) of our study population (981 males, 1,468 females; mean age = 40.4), being most common at L1/2 and L2/3 (54.1%). Multivariate logistic regression revealed that males, taller and heavier individuals had an increased likelihood of SN ( $p < 0.005$ ), but SN were independent of age. Overall presence of SN was associated with disc degeneration ( $p < 0.001$ ), and linearly correlated ( $R^2 = 0.97$ ) with increase in severity of degeneration. SN were particularly associated with severe disc degeneration at L1/2 and L2/3 with 22 to 15-fold increased odds, respectively ( $p < 0.0001$ ), but less than 5-fold increased odds ( $p < 0.001$ ) were noted in the lower lumbar spine.

**CONCLUSION:** In a population-based cohort, 16.4% of Southern Chinese subjects had SN at one or more lumbar levels. Males, taller and heavier individuals had increased likelihood of SN. Interestingly, SN were highly associated with severity of disc degeneration.

## ORAL PRESENTATIONS

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### 56. LOADING RATE AFFECTS DISC FAILURE MECHANICS (ISSLS Prize Winner)

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**INTRODUCTION:** The failure mechanics of some bone-ligament-bone constructs vary with the rate of tensile load application. Like many ligaments, recent reports indicate that the mechanical response of the intervertebral disc wall varies with strain-rate. Thus, it is possible that the internal failure mechanics of the disc wall also varies with strain-rate.

**METHODS:** The technique of nuclear pressurization was used to inject a viscous contrast gel into the nuclei of 60 ovine lumbar motion segments until failure occurred. Motion segments were positioned in one of two postures during nuclear pressurization – neutral or flexed 7° – and pressurized using one of two rates – gradual or impulse – resulting in 4 test groups. Following pressurization, the internal failure characteristics of each motion segment was inspected using micro-CT and optical microscopy.

**RESULTS:** *Neutrally positioned discs* subjected to impulse pressurization (n=12) frequently suffered radial tears of the central posterior disc wall that often incorporated tears of the superior cartilagenous endplate adjacent to the transition zone/inner annulus. In contrast, those subjected to gradual pressurization (n=12) suffered diffuse failure of the posterior annulus caused primarily by circumferential gel flow within lamellae. *Flexed discs* subjected to impulse pressurization (n=15) frequently suffered fractures at the cartilagenous/vertebral endplate junction or within a vertebral endplate at the central posterior disc periphery. In contrast, those subjected to gradual pressurization (n=21) commonly suffered annular failure at the disc periphery. This difference was significant (p=0.03).

**DISCUSSION:** The disruption morphologies created using impulse pressurization differed markedly from those created using gradual pressurization for both neutral and flexed discs. As well as showing that the failure mechanics of lumbar discs vary with the rate of internal loading, these results suggest that rapid loading may play a role in the initial development of herniations that involve endplate tears, and in the development of Type-I rim fractures.



## ORAL PRESENTATIONS

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### **57. A STUDY OF EFFECTS OF IN VIVO MECHANICAL FORCES ON HUMAN LUMBAR DISCS WITH SCOLIOTIC DISC AS A BIOLOGICAL MODEL. RESULTS FROM SERIAL POST-CONTRAST DIFFUSION STUDIES, HISTOPATHOLOGY AND BIOCHEMICAL ANALYSIS OF 21 HUMAN LUMBAR SCOLIOTIC DISCS. (ISSLS Prize Winner)**

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**INTRODUCTION:** Mechanical stress is implicated in initiating and accelerating degenerative disc disease. Studies hitherto have not analyzed in-vivo alterations in diffusion under loaded conditions and do not also reflect real life mechanical loading conditions. Scoliotic discs offer a perfect biological model of compressive and tensile stress in a young population without overlapping changes of ageing.

**METHODS:** 21 discs from six patients with adolescent idiopathic scoliosis (AIS) were assessed pre-operatively by serial post contrast MRI and were then harvested during surgery for histological and biochemical evaluation. Results were compared to control discs harvested from tumor surgery and also correlated to Cobb angle, disc wedge angle, disc inclination angle, coronal migration and the level of the discs.

**RESULTS:** Altered diffusion patterns due to end-plate damage (EPD) was universal with site specific breaks in two, double-peak pattern in three, high intensity pattern in 14 and frank contrast leak in two. Cell density was lower on the convex side in both the EP and NP ( $P < 0.05$ ). The percentage of viable cells was comparatively less in the concave side ( $P = 0.000$ ) and also significantly lower at all levels compared to normal ( $P = 0.000$ ). Widespread neovascularization was noted. Changes in water, lactate and glucose content were found to depend on Cobb angle and level of disc. Regression Analysis showed that truncal decompensation and Cobb angle were the primary predictors for changes in cell density, severity of matrix degeneration, calcification changes and water content.

**DISCUSSION:** EPD occurs early and altered nutrition may be the primary mechanism by which mechanical stress induces degeneration. Unlike previous studies, we found histopathological and biochemical alterations to be more severe in caudal discs than at apex, especially in the presence of truncal decompensation. Our findings have important implications in timing and choice of surgery in AIS.

### **58. HISTOPATHOLOGICAL ANALYSIS OF HYPERTROPHIC LIGAMENTUM FLAVUM IN DEGENERATIVE LUMBAR CANAL STENOSIS FOCUS ON THE EXPRESSION OF BMPS SIGNALING COMPONENTS.**

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**INTRODUCTION:** Hypertrophic change of ligamentum flavum (LF) is one of the major causes of canal stenosis in the lumbar spine. However, the mechanism of ligament hypertrophy has not been well elucidated. The purpose of this study was to clarify the mechanism of hypertrophic change of LF by histopathological examination and their relationship with clinical feature such as instability.

**METHODS:** One hundred and thirty two LF specimens surgically harvested from patients with degenerative lumbar canal stenosis (DLCS) and 14 LF specimens from lumbar disc herniation (LDH) used as control were histologically analyzed. Immunohistochemical staining of bone morphogenetic proteins (BMPs) and their receptors were also performed using avidin- Biotin complex (ABC) method or fluorescent method for double staining with cell markers. Clinical data of each patient was reviewed from patients' clinical records. Thickness of LF was measured on axial view of MRI with computer software, and mechanical instability was evaluated on dynamic X-ray.

**RESULT:** Histological examination of degenerated LF showed ruptured elastic fibers with irregular arrangement, reduced elastic component and increased collagen tissue. The cellularity was well correlated with thickness in MRI, and the number of cells in DLCS with instability was significantly higher than that in DLCS without instability. Immunohistochemistry revealed that the BMPs and their receptors were expressed in many kinds of cells even in center of flavum. The average percentage of BMP receptors positive cells was significantly higher in the DLCS with mechanical instability than that in without instability and those in LDH. Sox 9 and Msx2 co-expressed some BMPRs positive cells.

**DISCUSSION:** Histological examination revealed that not only the degeneration of elastic fibers but increase of cell number, especially of chondrocytes, were important changes in hypertrophy of LF. The result of the present study suggested that BMP signaling and mechanical stress play an important role in these changes.

### 59. DIFFUSION MAGNETIC RESONANCE IMAGING OF THE LUMBAR FORAMINAL NERVE ROOT ENTRAPMENT

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**INTRODUCTION:** Diffusion-weighted imaging (DWI) can provide valuable information regarding the microstructure of tissues and quantitative diffusion values. The purpose of this study was to measure apparent diffusion coefficient (ADC) of the lumbar nerve roots in patients with lumbar foraminal stenosis and to investigate the nerve root course using neurography.

**METHODS:** 14 patients (8 male, 6 female, median age 62.0 years) who had unilateral radicular symptoms with lumbar foraminal stenosis were studied. 14 healthy volunteers (7 male, 7 female, median age 55 years) served as controls. DWI was performed using a 1.5-T MRI and diffusion-weighted whole body imaging with a background body signal suppression (DWIBS). Circular regions of interest (ROIs) were placed in the fourth and fifth lumbar nerve roots and sacral nerve root in axial ADC maps and mean ADC values were calculated. The neurography was also used for evaluation of nerve root course. Statistical analyses were performed with Stat View software and a post hoc test was used. A p-value < 0.05 was considered significant.

**RESULTS:** In patients, neurography frequently showed abnormalities such as nerve swelling (100 %) and running transversely (71.5 %). The mean ADC ( $\times 10^{-3}$  mm<sup>2</sup>/s) of proximal nerve roots on the side of entrapment was 1.387 higher than the 1.206 on the intact side and distal spinal nerve ADC on the side of entrapment was 1.507 higher than the 1.154 seen on the intact side (P

**DISCUSSION:** Lumbar foraminal stenosis is a condition in which a nerve root or spinal nerve is entrapped in the narrowed lumbar foramen.

In this study, ADC values in entrapped nerve roots were higher than they were in intact nerve roots, suggesting demyelination and edema by slow compression caused by an increased degree of diffusion. Our study also demonstrated that neurography can accurately localize nerve compression in the foramen.

### **60. NO CORRELATION FOUND BETWEEN PATIENT OUTCOME AND ABNORMAL LUMBAR MRI FINDINGS INDICATING PARASPINAL MUSCLE DAMAGE 5 YEARS AFTER DECOMPRESSIVE UNILATERAL PROCEDURE FOR LUMBAR CANAL STENOSIS**

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**INTRODUCTION:** Previous studies have identified damage in the paraspinal muscle after intraoperative stripping and retraction of back muscles from the lumbar spine. However, whether the changes continue and influence the outcome long after surgery remains unclear.

**METHODS:** The subject of this study was 50 patients who underwent left unilateral approach for bilateral decompression for lumbar spinal stenosis at L4-L5. They completed the self-report questionnaire before surgery and five years after surgery. The status of the back muscles was evaluated from the T1-weighted axial images using Parkkola's method.

**RESULTS:** A significant improvement of leg pain, back-pain, and walking ability as measured by the VAS was noted. There was also significant improvement at 5-year follow-up in disability score (Rolland-Morris) and functional component score of SF12v2. As for back-pain, 10 patients had no pain, 27 patients had occasional minimal pain requiring no medication, 10 patients had moderate pain requiring occasional medications, and three patients had moderate to severe pain at the final follow-up. In 40 patients with back-pain, back-pain was located bilaterally without laterality in 19, dominantly on the left-side in 7, dominantly on the right-side in 7, on the left-side only in 5, and on the right-side only in 2 patients. One patient developed spinal instability at a 5-year follow-up. Assessment of MR images showed degenerations in the left back muscles in 44 patients (85%). Left-sided muscle atrophy at the level of the L5 vertebrae was noted in 48 patients (95%).

**DISCUSSION:** All 50 patients who underwent left unilateral decompressive procedures for lumbar canal stenosis demonstrated degeneration or atrophy of the approach side (left) back muscles 5-years after surgery. However, regarding the location of back-pain, there was no correlation between patient outcome and abnormal lumbar MRI findings of back muscles.

### 61. A 5-YEAR FOLLOW-UP AFTER MICROSCOPIC POSTERIOR DECOMPRESSION FOR LUMBAR CANAL STENOSIS WITH DEGENERATIVE SPONDYLOLISTHESIS

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**INTRODUCTION:** Surgical treatment of lumbar canal stenosis with degenerative spondylolisthesis (LCSDS), either with or without fusion has been extensively discussed. An original technique for performing minimally invasive microscopic decompression, or so-called “semi-circumferential decompression (SCD)” has been used for cases with LCSDS since 1992. The concept of SCD is decompression with the preservation of the facet joints. A surgical microscope, mid-line approach, and an en-bloc flavectomy are the essential technical points of SCD. This paper describes the surgical outcome of SCD over a 5-year period.

**METHODS:** This study included 97 cases with L4 spondylolisthesis who underwent SCD at L4-5 between 1998 and 2002. The mean age at the time of surgery was 68 years old and the mean post-operative follow-up period was 85 months (range 60-108 months).

**RESULTS:** The mean intra-operative blood loss was 34 g, and only 2 minor post-operative complications occurred. The facet joints were preserved in all cases. The pre- and post-operative Japanese Orthopaedic Association (JOA) scores were 8.6 and 12.5, respectively, and the recovery rate (Hirabayashi’s method) was 61%. Additional fusion surgery was performed in one case. The slippage of L4 before the operation and at the final follow-up was 15.9% and 19.0%, respectively. The progression of slippage was not significantly related to their symptoms.

**DISCUSSIONS:** The post-operative results of SCD after more than 5 years were sufficient, even in LCSDS. A biomechanical study has reported that a medial facetectomy did not affect the stability of the lumbar spine, but post-operative instability after a conventional medial facetectomy is common in LCSDS. The preservation of the facet joint is very important to maintain the stability of the lumbar spine. This method of posterior decompression should therefore be discussed more fully, because the surgical results after decompression are very different from those obtained with other methods.

### 62. FACTORS AFFECTING 4-YEAR COST-EFFECTIVENESS OF SURGERY FOR STENOSIS WITH OR WITHOUT DEGENERATIVE SPONDYLOLISTHESIS IN THE SPINE PATIENT OUTCOMES RESEARCH TRIAL (SPORT)

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**BACKGROUND:** The cost-effectiveness of surgery appeared promising over 2 years for patients with stenosis alone (SPS) or with degenerative spondylolisthesis (DS), but longer-term follow-up will better characterize surgery's value. We report SPORT 4-year cost-effectiveness results and examine factors affecting surgery's value.

**METHODS:** Mean cost per quality-adjusted life year (QALY) gained was estimated for surgery vs. non-operative treatment by disease group using pooled data from the SPORT randomized and observational cohorts. Costs, in 2004 US Dollars using Medicare standardized payments, were estimated based on medical resource use and impact on usual activities/work status at 6 weeks, 3, 6, 12, 24, 36 and 48 months. Time-weighted sums of health state values obtained with EQ-5D (US scoring) at each follow-up were used to estimate QALYs. Longitudinal regression analyses according to treatment received controlling for baseline covariates were used to estimate cost/QALY gained with bootstrapped 95% confidence intervals. The impact of higher fee schedules and SF-6D as the effectiveness endpoint were examined in sensitivity analyses.

**RESULTS:** Among 634 SPS participants, 394 (62%) underwent surgery with most involving decompression alone 320/394 (81%). Among 601 DS participants, 368 (61%) underwent surgery with most undergoing fusion 345/368 (94%). Surgery improved health with persistent QALY differences observed through 4 years (SPS QALY gain 0.25; 95%CI: 0.15, 0.34 and DS QALY gain 0.39, 95%CI: 0.30, 0.47). Costs per QALY gained decreased for SPS from \$77,600 at 2 years to \$64,400 (95%CI: \$32,000, \$117,800) at 4 years and in DS from \$115,600 to \$54,500/QALY (95%CI: \$32,000, \$80,700). While higher fee schedules increased costs per QALY gained to approximately \$110,000 for both DS and SPS, using SF-6D to estimate effectiveness had minimal impact on the estimated value of surgery.

**CONCLUSION:** The value of surgery appears more favorable at 4 years than at 2 years but is affected by costing method.

### 63. ONE-YEAR FOLLOW-UP STUDY OF LUMBAR SPINAL CANAL STENOSIS IN LOCAL POPULATION; INFLUENCE ON QOL

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**INTRODUCTION:** Lumbar spinal canal stenosis (LSCS) seems to be common in the elderly. However, there have been few reports on the prevalence and the time course of LSCS in community.

**METHODS:** In this study, 1111 people (390 male and 721 female) agreed to participate and interviewed in 2005 and 2006. The participants comprised approximately 13.4% of the local population. The presence of LSCS was assessed by a validated diagnostic support tool for LSCS (Konno, et al. 2007). Roland-Morris Disability Questionnaire (RDQ) for disease-specific QOL and SF-36 for health-related QOL (HR-QOL) were used.

#### **RESULTS:**

*1. Time course of LSCS:* In 2005, 270 people (24.3%) were judged as LSCS positive and 841 subjects (75.7%) as LSCS negative. In 2006, 116 of 270 subjects (43.0%) in LSCS positive group were still in LSCS positive group and 154 subjects (57.0%) moved to LSCS negative group. On the other hand, 771 of 841 subjects (91.7%) in LSCS negative group were still in LSCS negative group and 70 subjects (8.3%) moved to LSCS positive group.

*2. Change of QOL with time course of LSCS:* Disease –specific QOL in LSCS positive group was much lower than that in LSCS negative group. When subjects moved from positive to negative group, disease-specific QOL improved. Similarly, when subjects moved from negative to positive group, disease-specific QOL worsened.

The change of HR-QOL, especially QOL of physical function was similar to that of disease –specific QOL. When LSCS moved from negative to positive, QOL of physical function worsened, however, QOL of mental health maintained.

**DISCUSSION:** In more than half of LSCS positive subjects, their subjective symptoms improved in community. This indicates that conservative treatment should be considered to the first choice of LSCS treatment in community level. With symptoms in LSCS improving or worsening, disease –specific and health-related QOL improve or worsen.

### 64. SYNOVIAL FACET CYSTS AFTER DECOMPRESSIVE SURGERY FOR LUMBAR SPINAL CANAL STENOSIS

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**INTRODUCTION:** It is known that synovial cysts arise from the facet joints after decompressive lumbar surgery. However, it is not well known about the incidence or the cause of postoperative synovial facet cysts (PSFC). The purpose of this study is to clarify the incidence and radiographic findings of PSFC.

**METHODS:** There were 72 patients who underwent partial facetectomy and flavectomy of the involved level for lumbar spinal canal stenosis. All patients underwent pre and post-operative MRI and CT study. There were 40 male and 32 female and their age ranged from 42 to 85 years (mean 70 years). Follow up period was 6 to 107 months (mean 29.4 months). Cystic lesions demonstrating low signal intensity in T1 weighted and high signal intensity in T2 weighted MRI axial images, which connected with the facet joints were defined as PSFC. Degree of the facet joint degeneration was classified into four categories according to the CT findings as follows; normal, mild, moderate and severe. We also measured %slip, sagittal rotation, intervertebral disc height, Cobb's angle and facet angle on plain radiogram and CT. These measurements were compared between PSFC group (patients with PSFC) and non-PSFC group (patients without PSFC).

**RESULTS:** Fifteen of 72 patients (20.8 %) had PSFC at the operated levels. Degeneration of the facet joints progressed in both groups. There was no statistically significant difference of measurements between PSFC group and non-PSFC group.

**DISCUSSION:** Interestingly, the high incidence of PSFC (20.8%) was observed. Ventral side of the facet joint is covered by the flavum without capsule. Resection of the hypertrophic flavum has to be performed in decompressive surgery. As a result, the facet joint directly connects with spinal canal. As progress of the facet joint degeneration, synovitis deteriorates and hypertrophied synovium may protrude from the facet joint.



### 65. DOES THE DECOMPRESSION SURGERY IMPROVE THE LOW BACK PAIN IN THE DEGENERATIVE LUMBAR SPONDYLOLISTHESIS?

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**INTRODUCTION:** When the physicians plan a surgery for the degenerative lumbar spondylolisthesis (DLS) with low back pain (LBP), it should be a considerable option whether they do decompression alone or add fusions. The sagittal balance of the lumbar spine is thought to be an important factor as well as the slippage itself. The purposes of this study were: 1) to examine whether LBP in the DLS was improved by decompression surgery and 2) to determine the relationship between LBP and sagittal balance in the DLS.

**METHODS:** From 286 DLS patients, 62 cases were subjected to the study by the following criteria. The inclusion criteria were: 1) more than 3 mm of vertebral body slippage, 2) treated by decompression (without fusion). The exclusion criteria were: 1) lumbar scoliosis more than 20°, 2) the past history of lumbar surgery, compression fracture or osteoarthritis of the hip/knee joint. The surgical outcome was evaluated using subjective symptom items of JOA score (9 points of perfect scores) and a visual analog pain scale. The lumbar axis S1 distance (LASD) and lumbar lordosis (L1-L5) were measured as an index of the sagittal balance. Relations among surgical outcomes and radiographic indexes were non-parametrically analyzed (statistical significant level  $p < 0.05$ ).

**RESULTS:** Recovery rate based on JOA score was  $67.2 \pm 23.8\%$ . LBP was improved in 38 of 56 patients (63.3%) by decompression alone. The LASD was significantly decreased after surgery (18.5mm  $\rightarrow$  13.3mm) and showed a negative correlation with the lumbar lordosis. Improving of LBP was significantly correlated with the decrease of the LASD. Leg pain or numbness was not correlated with any radiographic indexes.

**DISCUSSION:** Almost 60% of the DLS patients improved LBP by decompression surgery associated with sagittal balance. Because this study has a limitation due to its retrospective design, a randomized controlled trial should be needed in the future.

### 66. RISK FACTORS FOR RADIOLOGICAL ADJACENT SEGMENT DEGENERATION AFTER LUMBAR FUSION FOR SPONDYLOLISTHESIS

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**INTRODUCTION:** With increase in numbers of spinal fusions performed in recent years, adjacent segment degeneration (ASD) has become a concern. Purpose of this study is to evaluate risk factors of radiological ASD in patients with L4 degenerative spondylolisthesis who underwent either anterior lumbar interbody fusion (ALIF) or posterior lumbar interbody fusion (PLIF).

**METHODS:** Clinical records of 72 patients with L4 degenerative spondylolisthesis treated by single level ALIF (38 patients) or PLIF (34 patients) were reviewed retrospectively. Most ALIF procedures were done before 1995, and PLIF was mostly indicated after 1996. ASD was defined as L3-4 lesion that was not present preoperatively; 1) loss of disc height of more than 20%, 2) listhesis greater than 3 mm on lateral radiographs. Age, sex, operative procedures (ALIF or PLIF), lamina inclination angle, osteophyte formation, pre-existing disc degeneration at L3-4, lordosis angle at fused segment and change in disc height at fused segment were evaluated for potential risk factors related to ASD.

**RESULTS:** ASD was found in 14(19%) patients. Pre-existing disc degeneration ( $p<0.001$ ) and female ( $p<0.01$ ) was significantly associated with ASD, however, age, operative procedures, lamina inclination angle, osteophyte formation, lordosis angle at fused segment and change in disc height at fused segment were not significantly associated with ASD.

**DISCUSSION:** Although many risk factors for ASD have been reported, the actual significance of these risks remains uncertain. Our study demonstrated that pre-existing disc degeneration appear to be a relatively major risk factor of ASD after L4-5 lumbar fusion for degenerative spondylolisthesis and these data might provide useful information about avoidance of additional surgery.

### 67. PROGNOSTIC FACTORS OF REDUCED ACTIVITIES OF DAILY LIVING FOLLOWING OSTEOPOROTIC VERTEBRAL FRACTURES

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**INTRODUCTION:** Reduced Activities of Daily Living (ADL) following osteoporotic vertebral fracture usually is recovered in accordance with bony union of the fracture. In some cases, however, reduced ADL continues for a long time after the fracture. The purpose of this study was to evaluate the prognostic factors indicating reduced ADL following osteoporotic vertebral fractures.

**METHODS:** This was a prospective cohort study that included 385 patients older than 65 years who completed 6 months of follow-up after a fresh fracture. Sixty-eight were men and 317 were women. Age at the time of injury was 76.5 years on average. To evaluate ADL, we used criteria for evaluation of the degree of independence according to the Japanese Long-term Care Insurance system. We defined “reduction of ADL” as one grade reduction in the 6 months after fracture. We analyzed the prognostic factors indicating reduced ADL using univariate and multivariate analysis.

**RESULTS:** Reduction of ADL was observed in 89 patients (23.1%). In the univariate analysis, age greater than 76 years (odds ratio [OR] = 1.04), posterior wall injury (OR=1.81), low bone mineral density (OR = 2.03), and no exercise during the year before the fracture (OR = 2.77) were significantly associated with reduction in ADL. In the multivariate analysis, posterior wall injury (OR = 1.98,  $p = 0.015$ ) was significantly associated with impairment of ADL. Low bone mineral density (OR = 1.85,  $p = 0.071$ ) and no exercise before injury (OR = 1.85,  $p = 0.098$ ) were marginally associated with impairment of ADL.

**DISCUSSION:** Prognostic factors for the impairment of ADL following osteoporotic vertebral fractures were involvement of posterior wall injury of the vertebral body, low bone mineral density, and no regular exercise before the fracture.

### **68. PREEXISTING, AS WELL AS RECENT, VERTEBRAL FRACTURES STRONGLY PREDICT NEW VERTEBRAL FRACTURES: RESULTS FROM A LARGE, INTERNATIONAL RCT IN OSTEOPOROTIC WOMEN.**

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**BACKGROUND:** Vertebral fractures (VF) increase the risk of new vertebral fractures. The relative contribution of recent incident VFs compared to pre-existing VFs on new fractures has not been studied.

**METHODS:** Data from stratum I of the placebo group of the HORIZON Pivotal Fracture Trial; a large international double-blind trial comparing once-yearly zoledronic acid to placebo on fracture risk in post-menopausal, osteoporotic women over three years was used in this analysis. 2677 of 2853 women had yearly lateral radiographs of the spine. New VFs were defined by morphometric analysis. We looked at the ability of baseline vertebral fractures (bLVF) and incident VF in the first year of the trial (VFy1) to predict new VFs in the second and third years of the trial.

**RESULTS:** Among the 2677 women in the placebo group, 245 (9.2%) sustained a new VF in the second or third year of the trial. The risk of a new VF in the second or third year of the trial in subjects without a bLVF was 4.0% and 8.5% in those without VFy1. The risk increased to 12.1% in women with a bLVF and 25.5% in those women who sustained a VFy1. The combined risk with both a bLVF and VFy1 was 29.8%; nearly 7.6-fold greater than those without either risk factor. Both a bLVF and a VFy1 remained independent predictors for future VF when they were both entered in to a logistic regression model (Odds Ratio 3.2 95% CI 2.2-4.5 and OR 3.3, 95% CI 2.0-5.2 respectively). These risks were similar after adjustment for other confounding variables including age, region and BMD.

**CONCLUSIONS:** Historical as well as incident vertebral fractures provide independent predictive information on the risk of new vertebral fractures. This evidence further supports the use of aggressive anti-osteoporotic treatment especially in women with recent vertebral fractures.

### **69. DISCONTINUATION OF WARFARIN 10 DAYS PRIOR TO SURGERY REDUCES BLOOD LOSS TO NORMAL LEVELS IN LUMBAR SURGERY**

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**INTRODUCTION:** Blood loss in lumbar surgery is an established concern. A prior study demonstrated that prior use of anticoagulants, even when stopped, can lead to increased surgical blood loss in lumbar procedures. However, it has not been determined at what point after discontinuation of anticoagulants that blood loss equilibrates to normal levels.

**METHOD:** 330 consecutive patients who underwent lumbar decompression were retrospectively divided into two groups: patients who took warfarin prior to surgery, and a control group with no anticoagulation history. Patients in the warfarin group were reversed prior to surgery in accordance with accepted guidelines (INR<1.5). Records were obtained to determine intraoperative blood loss (EBL), length of hospital stay, postoperative transfusion requirements, and time off of warfarin prior to surgery. Data regarding age, sex, co-morbidities, and number of levels decompressed were also recorded.

**RESULTS:** Linear regression was used to evaluate the effect of pre-operative anticoagulation use on EBL as well as hospital stay. Confounding factors, such as age, sex, race, number of levels decompressed, and number of co-morbidities were corrected for. A pre-operative history of warfarin led to a significant increase in blood loss (200cc/level;  $p=0.01$ ), transfusion requirements (0.21units/level;  $p=0.05$ ), and hospital stay (0.43days/level;  $p=0.02$ ). A logistic reduction in EBL was noted with the number of days in which patients were off of warfarin; EBL was significantly decreased and approached normal expected blood loss in patients who were off warfarin for 10 days preoperatively ( $p=0.02$ ).

**Discussion:** Our results indicate that even with adequate reversal, patients on anticoagulants prior to lumbar surgery have increased blood loss, transfusion requirements, and hospital stay. This is particularly important given the increasing number of anticoagulated patients. Patients who discontinue warfarin at least 10 days prior to lumbar surgery have EBL that approaches expected normal levels for patients who are not anticoagulated.

## ORAL PRESENTATIONS

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### 70. THE VALUE OF MULTIMODAL INTRA-OPERATIVE MONITORING (MIOM) DURING SURGICAL PROCEDURES OF THE LUMBAR SPINE.

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**STUDY DESIGN:** Prospective study.

**OBJECTIVE:** To analyse the specificity and sensitivity of multimodal intra-operative monitoring (MIOM) in predicting neurological deficits after lumbar spine surgery.

**SUMMARY OF BACKGROUND DATA:** Injury of nerve roots and the conus medullaris during surgical procedures of the lumbar spine can cause transient or permanent sensory and motor deficits and/or dysfunction of the bladder and bowel. As a consequence MIOM has become an integral part of complex spine surgery in major spine centres to monitor ascending and descending pathways and give immediate feedback to the surgeon regarding any neurological deficit observed during the operation.

**METHODS:** 1348 patients underwent multimodal intra-operative monitoring (MIOM) during surgical procedures of the lumbar spine between March 2000 and June 2009. Intra-operative motor and somatosensory evoked potentials of multiple index muscles and nerves, combined with continuous EMG were evaluated and compared with postoperative clinical neurological changes.

**RESULTS:** In 326/1348 (24%) surgical procedures the neurophysiologist alerted the surgeon due to significant changes in evoked potentials which could possibly lead to a neurological complication, so that the surgeons could immediately adapt the techniques. A total of 1275 patients presented true negative findings while 9 patients presented false negative and 8 patients false positive findings. 56 patients presented true positive findings where neurological deficit after the operation was predicted intra-operatively. The sensitivity of MIOM applied during lumbar spine surgery was 85% and the specificity 99%.

**Conclusions:** MIOM is an effective method for monitoring the conus medullaris, cauda equina and nerve root function during surgery of the lumbar spine. It has the potential to reduce postoperative surgical complications and hence improve the surgical outcome.

**KEYWORDS:** Spine surgery, Lumbar spine, Intra-operative monitoring, Sensitivity, Specificity, Alert

### 71. THE ROLE OF PREOPERATIVE DVT PROPHYLAXIS IN THROMBOEMBOLIC COMPLICATIONS IN SPINAL SURGERY.

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**INTRODUCTION:** The American College of Chest Physicians recommends only the use of postoperative pharmaceutical deep venous thrombosis (DVT) prophylaxis in spine surgery. The effects of preoperative DVT prophylaxis, specifically with respect to DVT, pulmonary embolism (PE) and spinal epidural haematoma (SEH) rates remains unknown.

**METHODS:** A 5-year retrospective review of all elective spine operations at one major institution was carried out. Patients were separated into 2 groups, based on the presence or absence of preoperative DVT prophylaxis. The DVT, PE and SEH rates were compared between the two groups. The study was adequately powered to detect a halving of the DVT rate.

**RESULTS:** Of the 3870 elective spinal operations conducted between 2004 and 2008, 37% of patients received preoperative DVT prophylaxis as either 5,000 units of unfractionated heparin or 40mg of enoxaparin. Preoperative DVT prophylaxis administration was not found to have a significant effect on DVT or PE rates (relative risk 0.91, 95% CI 0.37 – 2.23,  $p=1.00$ ). There was no apparent significant effect on SEH rates, although the overall incidence of SEH was very low at 0.4% (RR 1.33, CI 0.50 – 3.56,  $p=0.61$ ). The timing of presentation of SEH was usually within three days of surgery, but there were also several cases that presented out to 20 days.

**DISCUSSION:** Administration of preoperative DVT prophylaxis does not influence the rate of clinically relevant postoperative DVT or PE, and probably does not affect SEH rates. Given the cost and human resource burden of its administration, the use of preoperative DVT prophylaxis is not recommended. In light of the continued drive for early discharge, physicians need to be cognizant that late presentation of SEH is possible, and that a vigilance mechanism is required. Patients need to be informed of the signs and symptoms of SEH, and counseled to present immediately should they arise.

## ORAL PRESENTATIONS

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### 72. EFFECTS OF LOCAL ANESTHETIC AND NONIONIC CONTRAST AGENTS ON BOVINE INTERVERTEBRAL DISC CELLS CULTURED IN ALGINATE

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**INTRODUCTION:** Carragee et al. have reported accelerated progression of lumbar intervertebral disc (IVD) degeneration after discography at 10-year follow up. Our working hypothesis is that local anesthetic (Lidocaine, Bupivacaine) or contrast (Iopamidol) agents injected into the disc space during discography result in cytotoxicity. In this study, we compared the cytotoxic effects of a contrast and two anesthetic agents, side by side using 3-D cultured nucleus pulposus (NP) and annulus fibrosus (AF) cells. Studies on the effects of these agents on IVD cells will help guide their usage in future clinical practices.

**METHODS:** Bovine NP and AF cells were isolated and encapsulated in alginate and cultured in media completed with serum and ascorbic acid. After 6 days of culture, the beads were transferred to a 24-well plate and incubated with Saline (0.9%), Lidocaine (1%), Bupivacaine (0.5%) and Iopamidol (61%) diluted with complete media at three different dilutions (1:2, 1:4, and 1:8) for 2-16 hours. Cells were then stained with the Live/dead cell assay (Invitrogen). Live cells (stained green) and dead cells (stained red) were counted under fluorescent microscopy.

**RESULTS:** There was significant cell death when NP and AF cells were incubated with Lidocaine and Bupivacaine diluted at 1:2 or 1:4. However when diluted by 1:8, these anesthetics did not cause significant cell death when compared to the saline control. Various dilutions of Iopamidol were less toxic compared with the anesthetics.

**CONCLUSIONS:** Cell death of 3-D cultured NP and AF occurred when incubated with the two commonly used local anesthetic agents diluted at 1:2 or 1:4. Less cell death occurred when incubated with these anesthetics diluted at 1:8 or with different dilutions of Iopamidol in this short-term culture system. Future studies of the effects of these agents in animal models are indicated in order to more closely predict what happens in patients.



### **73. IOHEXOL, AN IODINATED RADIOPAQUE CONTRAST AGENT, DEMONSTRATES TOXICITY TO RABBIT AND SHEEP NUCLEUS PULPOSUS (NP) CELLS IN VITRO.**

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**INTRODUCTION:** In provocative discography (PD), intervertebral discs are punctured with a spinal needle and pressurized in order to identify painful discs. Recently, Carragee et al (1) reported that PD accelerates progression of disc degeneration and suggested damage from the needle puncture as one possible mechanism. We suggest another source of damage might be exposure to iodinated contrast agent (ICA). In PD, discs are exposed to elemental iodine concentrations up to 350 mgI/ml and ICA may remain for days in the disc. No studies have been published that evaluate the effects of ICA on NP cells. In this study we assess the toxicity of iohexol (an ICA) on NP cells in vitro.

**METHODS:** Rabbit and sheep NP tissues and isolated NP cells were exposed for short (4, 18, 30, 50 and 72 hours) durations at 175 mgI/ml (high concentration) and for long (1 and 3 weeks) durations at 3.5 mgI/ml (low concentration) of iohexol. The effects of iohexol were assessed for: cell viability and proliferation, matrix production, and mechanism of cell death (e.g., apoptosis vs. necrosis).

**RESULTS AND CONCLUSIONS:** Viability of NP cells was significantly diminished by iohexol. Viability decreased with increasing concentration and time of exposure. For example, survival of isolated sheep NP cells exposed to 175 mgI/ml iohexol for 18 hours was 40% of control. Long term exposure (weeks) at low iohexol concentration (3.5 mgI/ml), however, did not significantly diminish NP cell viability or matrix production. Cell death was largely inhibited by apoptosis inhibitors. These results show that short-term, in vitro exposure to iohexol at concentrations similar to that used in PD was toxic to NP cells. Iodinated contrast agents used in PD may impact the long-term health of the disc.

1. Carragee et al., Spine 34; 21:2338-2345

### 74. BUPIVACAINE TOXICITY IN INTERVERTEBRAL DISC TISSUE

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**BACKGROUND:** Bupivacaine is a common amide local anesthetic used in interventional spine procedures. Disc cell exposure to bupivacaine may occur during intradiscal procedures or non-intradiscal procedure as a result of diffusion into disrupted intervertebral discs. We previously demonstrated the in vitro toxicity of bupivacaine to intervertebral disc cells in culture. However, it is possible that the native matrix of the intervertebral disc may protect cells from these effects. The purpose of the current study was to evaluate the cellular response to exposure to bupivacaine in intact intervertebral disc tissue.

**METHODS:** Functional spine units (FSUs) were isolated from the lumbar spines of 10 week old wild-type (C57/B6) mice and subjected to different concentrations of bupivacaine as noted. Cell viability within disc tissue was measured by 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-tetrazolium bromide (MTT) assay as previously described. Matrix protein synthesis was measured by incubating the FSUs with 20  $\mu\text{Ci/ml}$   $^{35}\text{S}$ -sulfate (proteoglycan synthesis) or 10  $\mu\text{Ci/ml}$   $^3\text{H}$ -L-proline (collagen synthesis) in 0.5ml media in a 48 well plate for three days and measuring resultant incorporation of label.

**RESULTS:** Exposure of the intervertebral disc to bupivacaine resulted in a time and concentration dependent effect on cell viability, with approximately 60 % of the resident cells showing evidence of cell death after exposure to 0.5% bupivacaine for one hour. Cell death was noted as early as 15 minutes after exposure. In addition, exposure to bupivacaine resulted in a dose dependent decrease in proteoglycan, total protein, and collagen synthesis in remaining cells.

**CONCLUSIONS:** Even under conditions in which the disc cells are protected by the native matrix, bupivacaine induces cell death and impairs matrix metabolism. This suggests that future in vivo studies are needed to establish the relevance of this finding to clinical practice.

## ORAL PRESENTATIONS

### 75. COMPARISON OF PATIENT AND SURGEON RATINGS OF PAIN AND FUNCTION 12 MONTHS AFTER SPINAL SURGERY FOR DEGENERATIVE DISORDERS.

Grob D, Lattig F, Porchet F, Kleinstueck F, Fekete T, Mutter U, Jeszenszky D, Mannion AF, Spine Center, Schulthess Klinik, Zürich, Switzerland

**INTRODUCTION:** Two of the key domains that should be assessed when examining spine surgical outcomes are pain and function. The present study sought to examine the relationship between patients' and surgeons' assessments of pain and function 12 months after spinal surgery.

**METHODS:** 227 patients with degenerative disease and their treating surgeons (N=7) participated. Pre-op and 12-mo post-op, patients completed the Core Outcome Measures Index (COMI), including 0-10 pain scales and a 5-point function scale; the change in these scores indicated the patient-rated improvement in pain and function. Blind to the patient's evaluation, the surgeon indicated whether the surgical goals for pain and for function had been achieved (3-point scale: yes, partly or no).

**RESULTS:** The magnitude of the patient-rated improvement in pain and function declined progressively in accordance with the surgeons' ratings as to whether the goals had been achieved or not (see Table). For surgeon-rated "goals achieved" (yes or partly) the corresponding patient-rated improvements in pain and function were 20-40% lower for the patients of senior surgeons ( $p < 0.05$ ), indicating that the threshold for improvement corresponding to "goal achieved" was lower for the senior than the junior surgeons.

SURGEON: WERE THE GOALS ACHIEVED?		PATIENT: IMPROVEMENT IN SCORE PRE-OP TO 12 MO	
		PAIN	FUNCTION
YES	Junior-surgeon	5.3±2.5	2.2±1.1
	Senior-surgeon	3.9±2.7	1.7±1.2
PARTLY	Junior-surgeon	3.0±2.7	1.1±1.2
	Senior-surgeon	1.9±3.1	0.7±1.2
NO	Junior-surgeon	0.6±1.6	-0.1±0.5
	Senior-surgeon	1.5±2.1	0.3±0.6

**CONCLUSIONS:** Overall, the surgeon's appraisals of the outcome in relation to pain and function were reflected in corresponding mean changes in patient-rated scores. The differences between senior and junior surgeons confirm previous reports that seniors more commonly than juniors "over-rate" outcome compared with the patient's view. This highlights the potential bias in studies reporting only surgeon-based outcomes and indicates that any benchmarking of performance between centres/surgeons should not be surgeon-based.

## ORAL PRESENTATIONS

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### 76. SURGEONS AGREE TO DISAGREE ON SURGICAL OPTIONS FOR DEGENERATIVE CONDITIONS OF THE CERVICAL AND LUMBAR SPINE

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**INTRODUCTION:** Agreement between spine surgeons on when to operate and what procedure to perform is a subject that has received increasing attention. This is an important question in the field of spine surgery, where “gold standards” that are based on large clinical trials are relatively sparse.

This study was designed to evaluate agreement between spine surgeons regarding treatment options for 6 clinical scenarios involving degenerative conditions of the spine. The purpose was to evaluate whether or not surgeons agree on which cases require operative intervention and what type of surgery should be performed.

**METHODS:** 6 clinical vignettes were presented to 19 spine surgeons and 17 completed the survey (11 at academic institutions and 6 in private practice). Each vignette was accompanied by a series of x-rays and/or MRI's, followed by treatment options in multiple choice format. Two months later the same vignettes were sent out with identical instructions except that they were now told they were treating a close family member.

**RESULTS:** Over 76% of surgeons agreed on whether or not to recommend surgical intervention for the following 4 cases: lumbar degenerative spondylolisthesis with stenosis, cervical herniated nucleus pulposus (HNP), lumbar spondylosis, and lumbar HNP. Two scenarios had approximately 50% surgeon agreement: cervical stenosis and lumbar spondylolysis. However, despite good inter-rater agreement about who needed surgery, there was poor agreement regarding what procedure to perform if surgery was recommended. When repeating the survey in the setting of operating on a family member, only 17 of 96 (17.7%) recommendations were changed.

**DISCUSSION:** Spine surgeons in this survey generally agreed on when to operate but failed to agree on what type of procedures to perform.

## ORAL PRESENTATIONS

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### 77. SURGEON-INDUSTRY CONFLICT OF INTEREST: SURVEY OF NORTH AMERICAN'S OPINIONS REGARDING SURGEONS CONSULTING WITH INDUSTRY

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**INTRODUCTION:** The nature of surgeon-industry conflict of interest (COI) has become a source of considerable interest. Doctors, companies and government leaders have attempted to regulate potential COI without the opinion of the general public. The objectives of this study are to assess the opinions of North Americans on COI issues regarding surgeon-industry consulting relationships and quality of care and to analyze population subgroups for trends.

**METHODS:** A web based survey was administered to sample opinions regarding surgeon-industry consulting and regulation. Validity of hypothetically similar questions was calculated and subgroup analysis was performed for respondent age, sex, education, insurance and patient status.

**RESULTS:** 610/642 surveys had complete data. Our sample population was composed of more females, was older and more educated than a representative cross section of the American population. Most opinions did not differ among subgroups unless weighted to represent the American population census data. About 80% of respondents felt that it was both ethical and beneficial or non-influential for their health care if surgeons were consultants for surgical device companies. Most felt that disclosure of an industry relationship was important. Most people felt that paying surgeons royalties for devices other than those that they directly implant would not affect the quality of their care. Respondents support multidisciplinary surgeon-industry COI regulation and trust doctors and their professional societies the most to head this effort. Respondents trust government officials and company representatives the least with respect to regulation of COI.

**DISCUSSION:** Most respondents did not feel that the quality of their care will be adversely affected by surgeon-industry consulting relationships. The majority distrust government or companies to regulate COI. The development of evidence based treatment recommendations requires the inclusion of patient choice and opinion. We encourage regulatory bodies and especially the U.S. government to follow suit and practice "evidence based government".

## ORAL PRESENTATIONS

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### **78. ASIALO-ERYTHROPOIETIN PROMOTES THE IMPROVEMENT IN PAIN-RELATED BEHAVIOR AND DECREASES THE EXPRESSION OF PHOSPHORYLATED-P38 MAP KINASE AND TUMOR NECROSIS FACTOR-ALPHA IN NUCLEUS PULPOSUS APPLICATION RAT MODEL.**

Nobuyuki Sasaki, MD, Miho Sekiguchi, MD, PhD, Shin-ichi Konno, MD, PhD, Shin-ichi Kikuchi, MD, PhD, Fukushima, Japan

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**INTRODUCTION:** Erythropoietin (EPO) has neuroprotective effects in variety models of nervous injuries. However, EPO is a hematopoietic growth factor, therefore, EPO causes significant side effects. The purpose of this study was to investigate the effects of A-EPO, which is non-hematopoietic derivative EPO, on pain-related behavior, the expression of phosphorylated-p38 (p-p38) mitogen activated kinase (MAPK), and the expression of tumor necrosis factor-alpha (TNF) induced by nucleus pulposus (NP) application on the nerve root.

**METHODS:** Female Sprague-Dawley rats were used (n=149). NP was applied to the left L5 nerve root. Rats were divided into four groups; NP+non-treatment group (no administration), NP+A-EPO group (2680IU/kg A-EPO), NP+EPO group (2680IU/kg EPO), and NP+vehicle group (vehicle). The substances were administrated daily for 2 weeks subcutaneously. The animals were exposed the L5 nerve root and NP was not applied (sham group). Withdrawal thresholds were determined by the von-Frey test for 28 days. The expression of p-p38 and TNF were assessed by immunohistochemical study and immunoblotting analysis. Data were analyzed by unpaired Student t-test and Dunnett t-test (significant level; p

**RESULTS:** In the NP+non-treatment and NP+vehicle groups, the thresholds were decreased significantly for 28 days compared with the sham group (P

**DISCUSSION:** A-EPO has the effects on improvement of pain-related behavior and reducing the expression of p-p38 and TNF. A-EPO might be a potential agent to improve radiculopathy induced by application of NP.

### 79. DIFFERENCES BETWEEN TNF- $\alpha$ RECEPTORS TYPE 1 AND TYPE 2 IN THE MODULATION OF SPINAL GLIAL CELL ACTIVATION AND MECHANICAL ALLODYNIA IN A RAT SCIATIC NERVE INJURY MODEL

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**INTRODUCTION:** Recent research has revealed that activation of spinal glia such as astrocytes and microglia plays an important role in radicular and neuropathic pain. Tumor necrosis factor-alpha (TNF-alpha) is reportedly a modulator for glial activation; however, the precise relationship between TNF-alpha and its two receptors (type 1-p55 and type 2-p75) on glial cells has not been fully delineated. This study investigated changes in pain behavior and spinal glial activation after intrathecal injection of antibodies to each TNF-receptor in a rat sciatic nerve injury model.

**METHODS:** Chronic constriction sciatic nerve injury (CCI: n=60) and sham-operated (n=20) rats were used. Saline or antibodies to p55 or p75 were intrathecally injected at the L5 level into CCI rats (n=20 for each). Mechanical allodynia was examined for two weeks. Spinal cords were removed at days four and seven for immunohistochemical studies of glial fibrillary acidic protein (GFAP, a marker for astrocytes) or ionized calcium-binding adaptor molecule 1 (Iba1, a marker for microglia).

**RESULTS:** Significantly more mechanical allodynia developed in CCI rats compared with sham-operated rats over the two weeks ( $p < 0.01$ ). GFAP-immunoreactive (IR) astrocytes and Iba1-IR microglia numbers significantly increased in the spinal cords of CCI rats ( $p < 0.01$ ). However, injection of antibodies to p55 and p75 significantly reduced pain behavior and decreased the numbers of both glial cell populations ( $p < 0.01$ ). Anti-p55 antibody caused significantly greater reduction in pain behavior compared with anti-p75 antibody ( $p < 0.01$ ) and also significantly suppressed microglial activation more than astrocytic activation ( $p < 0.05$ ).

**DISCUSSION:** These results document that CCI induced pain behavior and up-regulation of spinal cord glial cells. Regarding spinal pain transmission, the TNF-alpha-p55 pathway in microglia played a more important role than the TNF-alpha-p75 pathway in the pathogenesis of peripheral nerve injury pain, suggesting that future studies seeking to clarify neuropathic pain should target TNF-alpha and p55 receptors in microglia.

### **80. DIRECT APPLICATION OF THE TNF-ALPHA INHIBITOR, ETANERCEPT, INTO PUNCTURED INTERVERTEBRAL DISC DECREASES CGRP EXPRESSION IN RAT DRG NEURONS.**

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**INTRODUCTION:** Degeneration of lumbar intervertebral discs is a cause of low back pain. Tumor necrosis factor (TNF)-alpha in the intervertebral disc is a major contributor to discogenic pain. We evaluated effects of TNF-alpha inhibition on calcitonin gene-related peptide (CGRP) expression in dorsal root ganglion (DRG) neurons.

**METHODS:** The neurotracer FluoroGold was applied to the surfaces of L4/5 discs to label their innervating DRG neurons (n = 30). Of 30 rats, 10 were in a non-punctured disc sham surgery control group, whereas the other 20 were in experimental groups in which intervertebral discs were punctured with a 23-gauge needle. Etanercept or saline was applied into the punctured discs (n = 10 each treatment). Fourteen days post-surgery, DRGs from L1 to L6 were harvested, sectioned, and immunostained for CGRP. The proportion of FluoroGold-labeled CGRP-immunoreactive DRG neurons was evaluated in all groups.

**RESULTS:** FluoroGold-labeled neurons innervating the L4/5 disc were distributed throughout L1 to L6 DRGs in all groups. Of the FluoroGold-labeled neurons, the proportion of CGRP-immunoreactive neurons was  $21 \pm 4\%$  in the sham surgery control group,  $32 \pm 7\%$  in the puncture+saline group, and  $23 \pm 4\%$  in the puncture+etanercept group. The proportion of CGRP-immunoreactive neurons was therefore significantly increased in the puncture+saline group compared with the sham control and puncture+etanercept groups ( $P < 0.01$ ).

**DISCUSSION:** In this model, CGRP was upregulated in DRG neurons innervating damaged discs. However, direct intradiscal application of etanercept suppressed CGRP expression in DRG neurons innervating injured discs. This finding may further elucidate the mechanism for the effectiveness of etanercept in the clinical treatment of discogenic low back pain.



### 81. THE EFFECTS OF RISEDRONATE AND EXERCISE ON OSTEOPOROTIC LUMBAR RAT VERTEBRAE AND THEIR SENSORY INNERVATION

Sumihisa Orita, Seiji Ohtori, Takana Koshi, Masaomi Yamashita, Kazuyo Yamauchi, Gen Inoue, Munetaka Suzuki, Yawara Eguch, Hiroto Kamoda, Gen Arai, Tetsuhiro Ishikawa, Masayuki Miyagi, Miyako Suzuki, Tatsuo Morinaga, Kazuhisa Takahashi  
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**INTRODUCTION:** Osteoporotic patients without any vertebral fractures sometimes experience vague low back pain of unknown origin. However the mechanisms of that pain and the effects of osteoporosis treatments are unclear. The present study aimed to investigate those matters in animal experiments. We investigated: (1) sensory innervation of osteoporotic rat vertebrae, (2) effects of osteoporosis treatment on bone mineral densities (BMDs) and the sensory innervation.

**METHODS:** We used 35 weeks old female Sprague Dawley rats in the following experiments. (1) The expression of calcitonin gene-related peptide (CGRP; inflammatory pain marker) -immunoreactive (-ir) or transient receptor potential vanilloid 1 (TRPV1; receptor for capsaicin, activated by acute and chronic inflammation) -ir nerve fibers in vertebrae and dorsal root ganglia (DRGs) innervating L3 vertebrae of rats labeled with neurotracer were examined in control, sham, and ovariectomized (OVX) rats. (2) BMDs and CGRP expression in DRG neurons innervating L3 vertebrae were examined in five groups: sham (treated with saline), OVX (saline), OVX+EXE (treadmill exercise), OVX+RIS (risedronate), and OVX+RIS+EXE (risedronate and exercise).

**RESULTS:** (1) Confocal laser scanning imaging showed the evidence of CGRP-ir or TRPV1-ir nerve fibers in the bone marrow while their numbers were not enough to quantify. CGRP or TRPV1 expression in DRGs was significantly elevated in the OVX group ( $P < 0.05$ ). (2) BMDs significantly improved and the CGRP expression significantly decreased in the risedronate-treated groups ( $P < 0.05$ ), especially the most in the OVX+RIS+EXE group.

**DISCUSSION:** (1) Sensory innervation of osteoporotic rat vertebrae showed increased expression of CGRP and TRPV1 in DRG neurons innervating the vertebrae, which may lead to one of the pathogenesis of osteoporotic pain. (2) Risedronate suppressed CGRP expression and improved BMD, especially together with exercise in vivo. The findings of the present study demonstrated that combined osteoporosis treatments may improve osteoporotic pain state.

### 82. MICROVASCULATURE AND VASOMOTION SYSTEM OF THE LUMBAR DORSAL GANGLIA IN RAT

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**INTRODUCTION:** The dorsal root ganglia (DRG) of the spinal nerve are an important tissue in the mechanism of low-back pain and sciatica. So far, the morphology of vascular system supplying the DRG has been inferred only from microangiogram. However, most of these studies lacked three-dimensional observations and the neurogenic control of intraganglionic blood flow has received little attention in the past. This study is to investigate the changes of vasomotion of intraganglionic microvessels in vivo.

**METHODS:** For three-dimensional observation of intraganglionic vessels, we used scanning electron microscopic (SEM) examination of microvascular corrosion casts in ten Wister rats (250-300g). To investigate the mechanism of vasomotion of the lumbar DRG, we used immunohistochemical methods. The sections were incubated overnight with antisera to tyrosine hydroxylase (TH), aromatic L-aminoacid decarboxylase (ADCC), serotonin (5-HT), cholineacetyl transferase (ChAT), substance P (SP), calcitonin-gene-related peptide (CGRP), vasoactive intestinal peptide (VIP), somatostatin (SOM), neuropeptide Y (NPY), and leucine-enkephalin (ENK). Abidin-biotin complex (ABC) method was used as the immunohistochemical procedure and the sections were observed under the light microscope.

**RESULTS:** The vascular cast of DRG was observed a high density of vessels more than nerve root. Bifurcation or anastomoses of capillaries approximately took place at right angles in a T-shaped pattern. Three types of capillaries may be distinguished, namely: tortuous, straight and beads-like capillaries. Many capillaries had a ring-like and beads-like compression. These compressions in the cast may represent a vascular sphincter in the microvessel. In the immunohistochemical study, TH-, ADCC-, AchE-, SP-, CGRP-, VIP-, SOM- and NPY-positive fibers were seen within the walls of blood vessels in the DRG. And also, SP, CGRP, VIP, SOM, NPY and ENK produced in the primary sensory neurons.

**CONCLUSIONS:** This study revealed the existence of perivascular adrenergic, cholinergic, and peptidergic with a possible role in neurogenic regulation of DRG circulation.

## SPECIAL POSTER PRESENTATIONS

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### SP1. ASSOCIATION BETWEEN LUMBAR SCOLIOSIS AND LEG LENGTH DISCREPANCY ON UNILATERAL HIP OSTEOARTHRITIS

Tadatsugu Morimoto, Katsuhiko Aita, Kenshiro Inatomi, Takao Hotokebuchi, Saga , Japan

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**INTRODUCTION:** The leg length discrepancy (LLD) on unilateral hip osteoarthritis patients (HOA) might cause the occurrence of compensatory lumbar scoliosis (LS) toward the shorter leg (HOA side). However, few papers have investigated the relationship between LS and LLD on HOA. The objective of this study was to analyze the correlation between LS and LLD on unilateral HOA.

**METHODS:** The subjects consisted of 437 patients (40-82 years) treated by total hip arthroplasty due to unilateral HOA. We investigated the LLD and the Cobb angle (maximum or L1-L5) on the erect posture radiographs and assessed the frequency of LS (Cobb angle of more than 5 degrees) (LS rate) and that of the convexity of LS occurring on the HOA side ( $\square$ rate). The patients were classified into four groups according to the degree of LLD: including the under 1cm group (199 patients), 1 cm group (143 patients, over 1 cm and under 2cm), 2 cm group (65 patients, over 2 cm and under 3 cm), over 3 cm group (30 patients). We used the stratum specific likelihood ratio (SSLR) to define the strata with an optimal discriminating power.

**RESULTS:** The LS rate and  $\square$ rate were 40%,26% in all cases. For each stratum, the LS rate was as follows; under 1cm group: 1cm group: 2 cm group: over 3 cm group =35%:40%:43%:70%. In contrast, the  $\square$ rates were as follows; 20%:24%:32%:63%.The frequency of both in the over 3 cm group was significantly higher than that in other groups ( $P<0.01$ ). SSLR was 0.8 (95%CI:0.65-1.0),0.98 (0.75-1.29), 1.12 (0.72-1.76), 3.46 (1.65-7.25) for LS rate, and 0.7 (0.54-0.92) ,0.91 (0.66-1.24) , 1.34 (0.84-2.14) ,4.84 (2.41-9.71) for  $\square$ rate.

**DISCUSSION:** Based on the fact that a 3 cm LLD was found to be a significant factor influencing LS rate and  $\square$ rate, compensating for LS might therefore help to successfully maintain the body balance in unilateral HOA.

## SPECIAL POSTER PRESENTATIONS

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### SP2. LOW BACK PAIN IS ASSOCIATED WITH INCREASED SYMPTOMS IN PERSONS WITH SYMPTOMATIC KNEE OSTEOARTHRITIS

Pradeep Suri, MD; David Morgenroth, MD; David J. Hunter, MBBS, PhD, Boston, MA, USA

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**INTRODUCTION:** The coexistence of low back pain (LBP) in individuals with other musculoskeletal pain may predispose to functional limitations well beyond the situation of isolated joint pain. The objective of this study was to determine the effects of LBP in patients with symptomatic osteoarthritis (OA) of the knee, while adjusting for the effects of other musculoskeletal pain.

**METHODS:** 1443 individuals from the Osteoarthritis Initiative, age 45-79 with symptomatic tibiofemoral knee OA in at least one native knee at baseline, were included in this ancillary study. Participants identified presence of LBP, neck pain, shoulder pain, elbow pain, wrist pain, hand pain, ankle pain, hip pain, knee pain, ankle pain, and foot pain. LBP was defined as pain in the lower back or buttocks during the past 30 days. A knee specific self reported symptom outcome, the Western Ontario McMaster Universities Osteoarthritis Index (WOMAC) was the primary outcome. We examined differences in WOMAC in persons with and without LBP, before and after adjusting for other musculoskeletal symptoms.

**RESULTS:** 57.4% of participants reported LBP. The study sample was 57.1% female, with age  $61.4 \pm 9.1$  years. WOMAC (possible range 0-96) was  $23.4 \pm 17.9$  in participants with LBP, and  $18.0 \pm 15.7$  in participants without ( $p < 0.0001$ ). In multivariate linear regression analysis including LBP and important demographic, medical/psychiatric, anthropometric, and radiographic covariates, LBP was significantly associated with increased knee symptom severity on WOMAC ( $\beta$ [SE]=4.0[0.8]; $p=.0001$ ). However, all other individual pain locations demonstrated similar magnitude and strength associations with WOMAC. In models including all pain locations simultaneously, only LBP ( $\beta$ [SE]=2.3[0.4]; $p=.007$ ), ipsilateral hip pain ( $\beta$ [SE]=1.8[0.9]; $p=.05$ ), and ipsilateral ankle pain ( $\beta$ [SE]=4.9 [1.7]; $p=.003$ ) were significantly associated with WOMAC.

**DISCUSSION:** LBP is significantly associated with higher scores on disease-specific measures for knee OA. The finding of LBP in patients with other musculoskeletal pain complaints may identify patients who can benefit from co-interventions to improve overall outcomes.

## SPECIAL POSTER PRESENTATIONS

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### **SP3. DISC DEGENERATION IN SUBJECTS WITH BILATERAL VERSUS UNILATERAL SPONDYLOLYSIS AT L5.**

Erik Schnaser, Jason Toy, Sheeraz Qureshi, Kasra Ahmandania, Paul Gause, Jason Tinley, Jason Eubanks, and Nicholas Ahn

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**PURPOSE:** Disc degeneration has been shown to be higher in patients with spondylolytic defects secondary to decreased stability across the associated disk space. Although spondylolytic defects are most commonly bilateral at L5, they do occur less frequently unilaterally. This study was performed to determine if unilateral spondylolysis at levels leads to increased disk degeneration when compared to normals and to determine the amount of disk degeneration in unilateral versus bilateral spondylolysis.

**MATERIALS AND METHODS:** An observational study was performed on 121 cadaveric specimens with spondylolysis identified out of 3100 total cadaveric specimens. Twenty two of these specimens had unilateral defects and the remaining specimens had defects that were bilateral. We compared these specimens to 300 normal controls. Disc and facet degeneration was classified by the system of Kettler and Wilke. Linear regression was performed to determine the association between the degree of disk and facet degeneration, and if the spondylolytic defect was bilateral, unilateral or absent, correcting for age, race and sex.

**RESULTS:** A significant increase in disk degeneration was noted in subjects with bilateral pars defects when compared to those subjects with unilateral defects at all ages<60. ( $p=0.01$ ). Specimens with unilateral defects had increased disk degeneration above normals at ages>40 ( $p=0.02$ ).

**CONCLUSIONS:** Unilateral spondylolysis leads to disk degeneration that is above expected when compared to normal controls, but that is slowed when compared to subjects with bilateral pars defects.

## SPECIAL POSTER PRESENTATIONS

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### SP4. A POSSIBLE MECHANISM OF REFERRED LOW BACK MUSCLE PAIN FROM LUMBAR FACET JOINTS

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**INTRODUCTION:** Clinically, the origin of low back pain is unknown. The pain may originate from the lumbar muscles directly or it may be referred pain from the spine. DRG neurons with dichotomizing axons have been reported in several species and are thought to be related to referred pain. However, these neurons, which have dichotomizing axons to the lumbar facet joints and to the lumbar muscle, have not been fully investigated.

**METHODS:** Two kinds of neurotracers [1,1'-dioctadecyl-3,3,3',3'-tetramethyl-indocarbocyanine perchlorate (Dil) and fluoro-gold (FG)] were used in the present double-labeling study. Dil crystals were placed in the right L5/6 facet joint, and FG was applied to right multifidus muscles at the L5 level in 10 rats. Two weeks later, bilateral DRGs from L1 through L6 were harvested, sectioned, and observed under a fluorescence microscope. The number and percentage of all DRG neurons that were Dil-labeled, FG-labeled, or double-labeled were evaluated.

**RESULTS:** Dil-labeled DRG neurons innervating the L5/6 facet joint (5.17% of the total) were distributed from L1 to L6. FG-labeled DRG neurons innervating the lower back muscle (15.9% of the total) were also distributed from L1 to L6. Double-labeled DRG neurons were found from L1 to L6. Approximately 0.95% of all DRG neurons innervating the facet joints had other axons that extended to the lower back muscle.

**DISCUSSION:** This finding provides a possible neuroanatomical explanation for referred low back muscle pain from the lower facet joints. However, these neurons are rare (0.95%); therefore, most low back muscle pain may originate in the back muscle itself. Alternatively, mechanisms of referred pain may be explained by the hypothesis of convergence-projection in the spinal dorsal horn.

### SP5. THE VENTRAL HIPPOCAMPUS – A NOVEL TARGET FOR TREATMENT OF BACK ASSOCIATED PAIN

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**INTRODUCTION:** Nociceptive processing and the development of long-lasting pain involve not only peripheral changes in neuronal excitability, but also changes in the central nervous system. The ventral hippocampus, a brain region located in the temporal lobe, has been implicated in neuronal processing of pain related information as well as pain-related plasticity. Peripheral pain has been reported to reduce c-fos immunoreactivity in the ventral hippocampus, indicating a reduction in neuronal signaling. Changes in neuronal activity in the ventral hippocampus may therefore play an important role in the development and maintenance of low-back pain.

**METHODS:** Rats and mice were subject to application of intervertebral disc material onto the dorsal root ganglion and sham-operated animals were used as controls. Electrophysiological experiments were performed 24 and 72 hours after surgery. Slices of the ventral hippocampus (400 µm thick) were cut and kept in continuously oxygenated buffer solution, to keep the neuronal network intact. The level of neuronal activity was investigated by applying pairs of current pulses (50 ms interval, 20 s between pairs), to evoke release of neurotransmitters.

**RESULTS:** In this disc herniation model, the second pulse gave a larger response than the first pulse in a pair, measured in the ventral hippocampus of rats and mice both at 24 and 72 hours post surgery. In contrast, sham-operated animals showed responses of the same magnitude. A larger response to the second pulse indicates a decrease in glutamate release probability.

**DISCUSSION:** Changes in neuronal activation in the ventral hippocampus were detected using an experimental disc herniation model, indicating this area to be of importance for pain modulation in back associated pain conditions. This finding needs further investigations to determine what signaling pathways are involved in the establishment and maintenance of these changes in neuronal excitability, in order to reverse central changes caused by long-lasting pain.

## SPECIAL POSTER PRESENTATIONS

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### SP6. SURGERY VS. NON-SURGERY FOR TREATMENT OF STRICTLY SELECTED PATIENTS WITH DISCOGENIC LOW BACK PAIN: A SMALL-SIZED RANDOMIZED TRIAL.

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**INTRODUCTION:** Diagnosis of discogenic low back pain (DLBP) without leg pain is difficult and a standard method of therapy has not yet been established. There are equivocal reports of the effectiveness of surgical treatment for DLBP, but the diagnosis therein was unreliable. Therefore, we compared the effectiveness of nonsurgical and surgical therapy (anterior interbody fusion [ABF] and posterolateral fusion with pedicle screws [PLF]) for strictly-selected DLBP patients.

**METHODS:** DLBP without leg pain was strictly diagnosed in 41 LBP patients. The patients suffered from DLBP for an average of 7.5 years and showed disc degeneration only at one level (L4/5 or L5/S1) on MRI, pain provocation on discography, and pain relief by anesthetic discoblock. The 41 patients were divided into 3 groups (conservative treatment, 20 patients; ABF, 15 patients; PLF, 6 patients). Visual analog scale (VAS) score, Japanese Orthopedic Association (JOA) score, and Oswestry Disability Index (ODI) were evaluated before and 2 years after therapy.

**RESULTS:** VAS score, JOA score, and ODI were not significantly different among the three groups before therapy, but were significantly improved in the two surgical groups compared with the conservatively treated group 2 years after treatment ( $P < 0.05$ ). The VAS score and ODI were significantly better in the ABF group than in the PLF group 2 years after treatment ( $P < 0.05$ ).

**DISCUSSION:** If DLBP is strictly diagnosed, surgical therapy is suitable for its treatment. ABF gives good results, but PLF is an option for patients for whom anterior surgery is unsuitable.



## SPECIAL POSTER PRESENTATIONS

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### SP7. IS ILIAC CREST BONE GRAFT STILL THE GOLD STANDARD IN SPINAL FUSION SURGERY? A SURVEY OF SPINE SURGEONS

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**INTRODUCTION:** Numerous studies demonstrate that bone graft substitutes (BGS) may be comparable to iliac crest bone graft (ICBG), without the additional morbidity. However, current literature suggests that ICBG remains the gold standard. This survey evaluates current opinions and uses of ICBG and BGS in spinal fusion surgery.

**METHODS:** A survey was distributed at SRS-2009 and CSRS-2009. It contained multiple-choice and short answer questions evaluating demographics, uses, and opinions of ICBG and bone graft substitutes.

**RESULTS:** Surveys returned: 250 from SRS, 202 from CSRS.  
Orthopaedic surgeons: SRS 95%, 77% CSRS,  
practiced >10yrs: SRS 66%, 55% CSRS,  
perform >100 spine surgeries annually: SRS 73%, 85% CSRS.

Believe they achieve the best fusion rates with:  
ICBG alone-SRS 25%, 34% CSRS,  
ICBG +bone graft substitutes-SRS 11%, 20% CSRS,  
Local bone +bone graft substitutes-SRS 49%, 30% CSRS,  
Bone graft substitutes alone-SRS 3%, 0% CSRS,  
Rate unaffected by graft choice-SRS 12%, 16% CSRS

Expect use of ICBG to remain same/decrease: SRS 92%, 80% CSRS.  
Report problems with ICBG donor site morbidity: SRS 81%, 77% CSRS; this was also the most commonly listed reason for avoiding ICBG use at SRS and CSRS.

Believe ICBG should no longer be the gold standard in anterior cervical fusions: SRS 58%, 56% CSRS ( $p=0.67$ , no significant difference between conferences).  
Believe ICBG should no longer be the gold standard in lumbar fusions: SRS 48%, 50% CSRS ( $p=0.60$ , no significant difference between conferences).

**CONCLUSIONS:** This survey emphasizes the significance of donor site morbidity amongst spine surgeons when selecting bone graft material. It indicates that for the majority of spine surgeons, bone graft substitutes represent an acceptable alternative and that ICBG may no longer be the gold standard in spinal fusion surgery.

## SPECIAL POSTER PRESENTATIONS

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### SP8. DIFFUSION MAGNETIC RESONANCE IMAGING TO DIFFERENTIATE DEGENERATIVE FROM INFECTIOUS ENDPLATE ABNORMALITIES

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**INTRODUCTION:** The purpose of this study was to evaluate the usefulness of Diffusion-weighted imaging (DWI) for the differentiation of degenerative and infectious endplate abnormalities in the lumbar spine using 1.5-tesla magnetic resonance (MR) imaging.

**METHODS:** 16 consecutive patients with endplate abnormalities detected by MR imaging of the lumbar spine and 15 healthy volunteers were enrolled in the study. DWI was performed using a whole body imaging with a background body signal suppression (DWIBS) with b value of 1000 s/mm<sup>2</sup>. Apparent diffusion coefficient (ADC) values of normal and abnormal vertebral bone marrow were calculated.

**RESULTS:** A total of 29 vertebral abnormalities were found in 16 patients. 9 vertebral abnormalities in 5 patients were due to infections and 20 vertebral abnormalities in 11 patients were due to degenerative changes and 7 levels were classified as Modic type1, 7 levels as type2, and 6 levels as type3. DWI showed hyperintensity in all 9 levels with infection, similar to that used in positron emission tomography (PET), but not in the intervertebral spaces of any patients with degenerative disease. Mean ADC ( $\times 10^{-3}$  mm<sup>2</sup>/s) values were 0.453 in normal marrow, 1.067 in infectious marrow, 0.624 in Modic type1, 0.500 in Modic type2, and 0.756 in Modic type3. Mean ADC values of infectious bone marrow were significantly higher than normal and degenerative marrow (p<0.001).

**DISCUSSION:** Spinal infections are now more frequently. Differentiation between degenerative and infectious endplate abnormalities is occasionally difficult. Several studies have reported that PET was sensitive in diagnosing spinal infection. Our findings suggest that DWI is useful for differentiation of degenerative and infectious endplate abnormalities, similar to PET. Moreover MRI is widely used clinically because of the lack of ionizing radiation, low cost and fast imaging time as compared with PET. Therefore, DWI has the potential to be used as a screening tool.

### SP9. METAL ION RELEASE IN PAEDIATRIC SCOLIOSIS INSTRUMENTATION.

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**INTRODUCTION:** Instrumented spinal arthrodesis is performed to correct scoliosis. The long-term consequences of retained implants are unclear. Possible toxic effects of raised metal ion levels have been reported. We investigated serum metal ion levels in posterior instrumented scoliosis patients.

**METHODS:** Scoliosis patients with Isola stainless steel instrumentation between 1998 and 2002 were included (Group 1, n=30, 26 females, 4 males). Patients having post-operative complications, instrumentation removed, revision surgery or additional in situ metal implants were excluded. Serum chromium, molybdenum, iron and ferritin levels were measured. Participants with elevated serum chromium levels underwent erythrocyte chromium analysis (n=11). Comparisons were with two control groups; 1) non-instrumented scoliosis patients (Group 2, n=10) and 2) unaffected volunteers (Group 3, n=10). Control groups underwent serum and erythrocyte analysis.

**RESULTS:** Mean age at surgery was 13.8 years (range 6.6-13.2), mean time from surgery 5.7 years (range 3.4-8.1). Elevated serum chromium levels were demonstrated in 11/30 (37%) Group 1 participants. Elevated serum chromium levels were demonstrated in 0/10 (0%) in Group 2 and 2/10 (20%) in Group 3. There was a statistically significant ( $p=0.001$ ) elevation in serum chromium levels between scoliosis participants with spinal implants and those without.

There was no difference between the three groups for serum molybdenum, iron and ferritin levels. Erythrocyte chromium analysis were considered within the normal range (n=31, 100%).

Stepwise censored regression (Groups 1, 2 and 3, n=50) indicated significant predictors of serum chromium to be spinal implants ( $p=0.001$ ), gender (male versus female,  $p=0.04$ ) and iron grading (low, normal or high,  $p=0.05$ ). Time since surgery did not have a significant correlation with chromium levels ( $p=0.147$ ).

**DISCUSSION:** Raised serum chromium levels were detected in 37 % of instrumented scoliosis patients. This new finding has relatively unknown health implications but is especially concerning with most scoliosis patients being adolescent females with their reproductive years ahead.

## SPECIAL POSTER PRESENTATIONS

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### SP10. RISK FACTOR OF PEDICLE SCREW MISPLACEMENT IN IDIOPATHIC SCOLIOSIS SURGERY USING COMPUTER-ASSISTED TECHNIQUE

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**INTRODUCTION:** The purpose of this study was to analyze of the risk factor of the pedicle screw misplacement in idiopathic scoliosis surgery using computer-assisted technique by comparison of peculiarities of vertebra between that pedicle screw was placed optimally and misplaced.

**METHODS:** Fifteen patients were reviewed. The endosteal width of pedicles and vertebral rotation were measured. Screw placement was graded on: grade A, no perforation; grade B,  $\leq 2$  mm perforation, and grade C,  $>2$  mm perforation.

**RESULTS:** Total 261 screws were placed, 89.6 % were grade A, 7.7 % were grade B, 2.7 % were grade C. Fifty-four pedicles were decided to be impossible to insert. The level of misplaced screws and decided to be impossible to insert were at the right of upper level and at the left of middle level. The endosteal width of pedicles were 2.1 mm in grade A, and 0.9 mm in grade B and C ( $p = 0.02$ ). The ratios of screw to pedicle were 0.78 in grade A, and 0.86 in grade B and C ( $p = 0.01$ ). The angles of vertebral rotation were 6.4 in grade A, and 8.7 in grade B and C ( $p = 0.1$ ).

**DISCUSSION:** The left of the apical region and right of proximal instrumented region were thought to be critical to insert screws even using computer-assisted technique. Ideal screw diameter was around 80 % of narrowest pedicle width to obtain higher strength and avoid perforation. Furthermore, it was proved that insertion of screw into less than 1 mm endosteal pedicle width had much higher risk of perforation.

## SPECIAL POSTER PRESENTATIONS

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### SP11. COMPLICATIONS IN 710 XLIF SURGERIES

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**INTRODUCTION:** The XLIF procedure allows for minimally invasive placement of a large anterior graft, disk height and alignment restoration, and indirect decompression.

**METHODS:** Our single-site consecutive series of 710 XLIF outcomes were reviewed. Surgical and postoperative complications were documented.

**RESULTS:** Patients age 22-89 (average 62 years). Diagnoses included stenosis (51%), spondylolisthesis (15%), DDD (12%), HNP (9%), post-laminectomy instability (6%), and scoliosis (8%). 84% had pre-existing comorbidities; 41% had prior lumbar surgery. 367 (52%) were obese or morbidly obese. 884 levels were treated: 78% single-level; 59% at L4-5. 99.3% included supplemental instrumentation. Hospital stay averaged 1.20 days. 49 complications were reported: (6.9% complication rate): 3 wound (hernia, subcutaneous hematoma, infection); 7 GI (6 ileus, 1 gastric volvulus); 3 renal (1 urinary retention, 1 UTI, 1 peritoneal catheter occlusion); 7 respiratory (4 pneumonia, 2 pulmonary embolism, 1 re-intubation); 7 cardiac (6 atrial fibrillations, 1 MI at 6 wks post-op); 4 neural (3 transient quad weakness, 1 transient anterior tibialis weakness); 12 vertebral body fractures (1 endplate fracture, 1 osteophyte fracture requiring reoperation, 1 subsidence requiring reoperation, 5 compression fractures at an adjacent level requiring vertebroplasty); 1 iatrogenic HNP (requiring laminectomy at 4 wks); 1 hnp at adjacent level (requiring discectomy), 2 sacral fractures (no treatment); and 6 hardware failures. Reoperation rate was 50/710 (7.0%) (7 vertebroplasty, 7 axia LIF, 14 XLIF, 5 PLIF, 1 ALIF, 11 laminectomy, 1 hardware revision, 1 hardware removal, 1 hematoma drainage, 1 stimulator). Average VAS scores, radiographic measures, and fusion scores were not different between the complications group and the total series.

Pretreatment with Decadron was found to significantly reduce neuropraxia,  $P=0.0245$ . Since premedication with Decadron began, no neural complications have been reported.

**DISCUSSION:** XLIF is a safe, effective treatment for multiple thoracolumbar degenerative conditions. XLIF surgery can be performed in many conditions with a low complication rate.

## SPECIAL POSTER PRESENTATIONS

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### SP12. POSTOPERATIVE WOUND COMPLICATIONS ARE INCREASED AFTER LUMBAR SURGERY IN THE SEVERELY AND MORBIDLY OBESE

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**INTRODUCTION:** Postoperative infections in lumbar surgery is an established concern. There is a discrepancy in the literature as to whether obesity predisposes patients to postoperative wound complications as different studies have defined obesity differently and have had widely disparate populations. No studies have been performed to determine the relationship between lumbar wound complications and categories of obesity as defined by the World Health Organization (WHO).

**METHOD:** 276 consecutive patients who underwent lumbar decompression were retrospectively divided after BMI (body mass index) was calculated. Groups were based on definitions established by the WHO: normal (18.5-24.9); overweight (25-29.9), obese (30-34.9), severely obese (35-39.9) and morbidly obese ( $\geq 40$ ). Data regarding age, sex, co-morbidities, and number of levels decompressed were recorded. The presence of postoperative wound complications was recorded and categorized into cases of superficial wound breakdown or seromas, and infections/hematomas requiring surgical intervention.

**RESULTS:** Logistic regression was used to evaluate the effect of BMI and obesity on postoperative wound complications. Confounding factors were corrected for. A significant association of all wound complications with BMI (OR = 1.02,  $p < 0.01$ ) and obesity grade (OR = 1.12,  $p < 0.01$ ) was noted. A significant association of surgical wound infection with BMI (OR=1.01,  $p < 0.01$ ) and obesity grade (1.15,  $p < 0.01$ ) was also noted. However, no significant difference in wound complication or infection in overweight or obese patients vs. normals ( $p=0.37$ ). Patients with a transverse lumbar crease had a markedly increased rate of wound complications including surgical wound infections ( $p < 0.02$ ).

**DISCUSSION:** Our results indicate that patients who are severely or morbidly obese are at dramatic increase in risk for wound complications or infection after lumbar surgery. However, patients who are overweight or only obese (BMI < 35) were not found to have an increase in wound complications or infection above normals.

### SP13. THE ROLE OF NEUROTROPHIC FACTOR IN CULTURED MEDIUM EXTRACTED FROM HUMAN DEGENERATIVE NUCLEUS PULPOSUS AND ANNULUS FIBROSUS TO PROMOTE NERVE GROWTH

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**INTRODUCTION:** Degeneration of the lumbar intervertebral disc is a cause of low back pain, whose pathological mechanism is supposed to be sensory nerve ingrowth into the inner layers of the degenerative discs. NGF is also important for mediating inflammatory pain from discs via the high-affinity NGF receptor, tyrosine receptor kinaseA (TrkA). However, other neurotrophic factor has not yet been clarified in human degenerative discs. The objective of this study is to evaluate the axonal growth using neutralizing antibody of Trk and extracted medium from human degenerative disc cells in vitro.

**METHODS:** The nucleus pulposus (NP) and the annulus fibrosus (AF) of human degenerative discs were harvested from patients with discogenic low back pain. Extracted medium from human degenerative discs and rat DRGs were cultured with the neutralizing antibody of TrkA, TrkB and TrkC. Using immunocytochemistry, we evaluated the promotion of axonal growth from DRG cells in extracted medium from the NP and the AF.

**RESULTS:** The average length of growing axons in the NP medium treated with the neutralizing antibody of TrkA were significantly shorter than the NP only medium, NP with the neutralizing antibody of TrkB and TrkC medium ( $p<0.05$ ). The average length of growing axons in the AF medium treated with the neutralizing antibody of TrkC were significantly shorter than the AF only medium, AF with the neutralizing antibody of TrkA and TrkB medium ( $p<0.05$ ).

**DISCUSSION:** In this study, TrkA was associated with the growing axon in extracted medium from NP, and the same result was observed with TrkC in the medium from AF. These in vitro results indicate that not only TrkA, TrkC was related with nerve ingrowth in human degenerative disc in response to neurotrophin 3 (NT3). Therefore, it is suggested that TrkC-NT3 pathway may play an important role in transmitting discogenic low back pain.

## SPECIAL POSTER PRESENTATIONS

### SP14. DETECTION OF LUMBAR NERVE ROOT INJURY DURING RETRACTION USING TRANSCRANIAL MOTOR EVOKED POTENTIALS (TCMEPS) IN A PORCINE MODEL

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**INTRODUCTION:** Lumbar nerve root injury can occur during spinal surgery and has been reported to be between 20 to 30% following the correction of spinal deformities. Transcranial motor evoked potentials (TcMEPs) is a method to detect nerve root injury. There is minimal data on how TcMEPs change over time following sustained traction and no data has been established to determine how this technique can be used to monitor subtle and progressive injuries in nerve roots. The purpose of the paper was to compare TcMEPs from the L5 nerve root following retraction for ten minutes in a validated porcine model.

**METHODS:** Thirteen female Landrace pigs were used in the study. TcMEPs were recorded at baseline and at minute intervals for 10 minutes during retraction of the L5 nerve root with 1N, 2N or 4N force.

**RESULTS:** A curvilinear change is seen during retraction with 2N( $r^2=0.96$ ) and 4N( $r^2=0.97$ ) over 10 minutes with a greater change being seen during retraction with 4N (Table 1). TcMEP amplitude dropped 58% at 10 minutes following retraction with 2N compared to a 65% drop with 4N for 10 minutes. Statistical difference was found between pre-retraction and post-retraction TcMEP amplitudes within the 4N ( $p<0.0001$ ; CI 0.08) and 2N ( $p<0.0001$ ; CI 0.08) groups. Greater recovery was seen following retraction with 1N and 2N forces compared to 4N and correlated well with change in EMG threshold.

**DISCUSSION:** The data indicate that TcMEPs used frequently during nerve root retraction or spinal manipulation may detect subtle progressive injury in nerve roots. This technique may prevent injury during sustained retraction or spinal manipulation.

Table 1.

RETRACTION FORCE	% Change from Baseline Following Retraction	p value	CI	% Change from Baseline After Recovery	p value
1N	6.00	0.1300	+/- 0	2.00	0.19
2N	58.00	<0.000	+/- 1	17.00	<0.00 001
4N	65.00	<0.000	+/- 1	46.00	<0.00 001



### SP15. INTERACTION OF 5-HYDROXYTRYPTAMINE AND TUMOR NECROSIS FACTOR-ALPHA TO PAIN-RELATED BEHAVIOR BY NUCLEUS PULPOSUS APPLIED ON THE NERVE ROOT IN RATS

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**INTRODUCTION:** Radiculopathy in lumbar disc herniation (LDH) is caused by nerve root inflammation and mechanical compression. 5-hydroxytryptamine (5-HT) and tumor necrosis factor-alpha (TNF) are chemical factors associated with nerve root inflammation. However, it has been unknown when and how much both factors contribute to induce radiculopathy. The purpose of this study was to examine the effects of 5-HT and TNF applied to the nerve root on pain-related behavior and immunohistological changes. In addition, the expression of TNF, TNF receptor 1 (TNFR1), and 5-HT<sub>2A</sub> receptors in Dorsal Root Ganglion (DRG) were evaluated.

**METHODS:** Female Sprague-Dawley rats were divided into six groups: 5-HT group; TNF group; 5-HT + TNF (Combination) group; Nucleus Pulposus (NP) group; Control group (treated with saline); and Naive group. The substances were applied to the left L5 nerve root. Von Frey tests were used for pain-related behavior testing for 28 days. Expressions of activating transcription factor-3 (ATF3) and calcitonin gene-related peptide (CGRP) were evaluated immunohistochemically. Expressions of TNF, TNFR1, and 5-HT<sub>2A</sub> receptors in the left L5 DRG were examined using western blotting. Data were analyzed using Dunnett's test (significance level:  $P < 0.05$ )

**RESULTS:** Mechanical withdrawal thresholds were significantly decreased in the 5-HT, TNF, Combination, and NP groups compared with the Control group ( $P < 0.05$ ). The pain-related behavior and lasted for a shorter period compared with Combination and NP groups. ATF3- and CGRP-immunoreactive DRG neurons were significantly increased only in the early phase in the 5-HT, TNF, Combination, and NP groups ( $P < 0.05$ ). TNF induced 5-HT<sub>2A</sub> receptor expressions in the DRG, while 5-HT induced TNF and TNFR1 expressions.

**CONCLUSION:** The present findings suggest that both 5-HT and TNF induce pain-related behavior and interact with each other to prolong pain-related behavior in rat LDH models.

## SPECIAL POSTER PRESENTATIONS

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### SP16. LONG-LASTING UP-REGULATION OF TNF-ALPHA AND IL-6 IN INJURED INTERVERTEBRAL DISKS INDUCES PAINFUL NEUROPEPTIDES IN DRG NEURONS INNERVATING THE DISKS IN RATS

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**INTRODUCTION:** Various human and animal studies have verified the presence of sensory nerve fibers in intervertebral disks (IVDs) or investigated the behavior of inflammatory cytokines in injured IVDs, but no in vivo study to date has examined the relationship between the two. The purpose of the current study was to elucidate the behavior of sensory dorsal root ganglion (DRG) neurons versus inflammatory cytokines in experimentally-injured IVD disks over an eight-week period in rats.

**METHODS:** Forty-eight female Sprague-Dawley rats were used (disk-injured group: n=24, non-injured group: n=24). In the disk-injured group, L5/6 disks were injured with a 26-gauge needle; simultaneously, the neurotracer fluorogold (FG) was injected into the L5/6 intervertebral disk to detect DRG neurons innervating the IVD. The L5/6 IVD and DRGs from the L1 to L6 levels were resected 1, 2, 4, and 8 weeks after the surgical procedure. TNF-alpha and IL-6 production in the IVD were quantified using enzyme linked immunosorbent assay (ELISA), and the percentage of CGRP (inflammatory pain marker) immunoreactive DRG neurons among all FG-labeled neurons was calculated.

**RESULTS:** At all time points, TNF-alpha and IL-6 levels were significantly higher in the disk-injured group than in the non-injured group, peaking at two weeks (p

**DISCUSSION:** Inflammatory cytokines and inflammatory neuropeptides in DRG neurons innervating the IVDs were significantly and correlatively elevated in the disk-injured group compared with the non-injured group during the first eight weeks following surgery. This observation may help explain persistent diskogenic low back pain in humans.

### **SP17. NOTOCHORDAL CELLS INFLUENCE GENE EXPRESSION OF INFLAMMATORY MEDIATORS OF ANNULUS FIBROSUS CELLS IN PROINFLAMMATORY CYTOKINES STIMULATION.**

Joo Han Kim, Hong Joo Moon, Jung Jae Park, James D Kang, Youn Kwan Park, Seoul, South Korea

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**INTRODUCTION:** Discogenic pain by annular tearing is important initiation step of intractable low back pain. It has been known that notochordal cells in intervertebral disc interact with nucleus pulposus (NP) cells and support the maintenance of disc homeostasis by regulation of matrix production. However, notochordal cells influence has not been studied in annulus fibrosus (AF), main pain generator structure in disc. We hypothesized in this study that notochordal cell can have the capacity to modulate inflammatory mediators secreted by AF cells in stimulation.

**MATERIALS AND METHODS:** Notochord cells and AF cells were isolated from adult New Zealand white rabbits. AF pellet was co-cultured with notochordal cells clusters or cultured in notochordal cells conditioned media(NCCM) for 24 or 48 hrs with/without proinflammatory cytokines ( 1ng/ml, 10ng/ml, 100ng/ml TNF- $\alpha$ , and 0.1ng/ml, 1ng/ml, 10ng/ml IL-1 $\beta$ ). Gene expression in AF pellet was assayed for iNOS, IL-6, and Cox-2 by RT-PCR.

**RESULTS:** AF pellet in notochordal cells clusters significantly expressed the level of Cox-2 and iNOS mRNA compared to AF pellet alone while the gene expressions in AF pellet in NCCM were significantly decreased. AF pellet dose-dependently expressed for Cox-2, iNOS in response with IL-1 $\beta$  stimulation and the concentration of 1ng/ml for 24hrs maximally affect the gene expression in AF pellet. In stimulation of 1ng/ml IL-1 $\beta$ , AF pellet in NCCM significantly decreased the expression of Cox-2 and iNOS except IL-6 while the gene expression of Cox-2 and iNOS were significantly increased in AF pellet co-cultured with notochordal cells clusters.

**CONCLUSION:** We conclude that soluble factors from notochordal cells mitigate the gene expression of inflammatory mediators in stimulated AF, as can be expected after annular injury while interaction AF cells with notochordal cells significantly increased the mRNA expression of inflammatory mediators., suggesting the possibility of notochordal cells usefulness as novel therapeutic approach in symptomatic disc development.

## SPECIAL POSTER PRESENTATIONS

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### SP18. HUMAN UMBILICAL CORD MESENCHYMAL STROMAL CELLS (HUCMSCS) EXHIBIT IMMATURE NUCLEUS PULPOSUS CELL PHENOTYPE IN A LAMININ-RICH PSEUDO-3D CULTURE SYSTEM

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**PURPOSE:** Cell supplementation to the herniated or degenerated intervertebral disc (IVD) is of great interest as a strategy to promote tissue regeneration and inhibit the progression of disc pathology. Recently, mesenchymal stem cells (MSCs) have been studied as a potential cell source for disc tissue regeneration. However, no studies have demonstrated that MSCs can regenerate matrix with unique characteristics matching that of immature nucleus pulposus (NP) cells of the IVD. In prior work, immature NP cells were found to express specific laminin isoforms and laminin-binding receptors that may serve as phenotypic markers for evaluating MSC differentiation to NP-like cells in vitro. The goal of this study is to evaluate a unique NP-like cell phenotype and matrix synthesis for human umbilical cord mesenchymal stromal cells (HUCMSCs) cultured in a laminin-rich pseudo-3D culture system.

**METHODS:** HUCMSCs from Wharton's jelly of umbilical cord were seeded ( $10^6$ /well) on top of Transwell inserts pre-coated with Matrigel<sup>TM</sup>. Cells were cultured in serum-free differentiation media (DEME/F12+ITS) containing 2.5% Matrigel to provide for a pseudo-3D laminin culture system developed previously for epithelial cell culture. Cell morphology, matrix production and the expression of laminin and laminin-receptors were evaluated at day 1, 7 and 21 of culture.

**RESULTS:** Data show that a pseudo-3D culture condition (laminin-1 rich) promotes HUCMSCs differentiation under no serum conditions. Starting at day 1, HUCMSCs demonstrated a cell clustering morphology similar to that of immature NP cells in situ and that observed for primary immature NP cells within the similar laminin-rich culture system (prior study). The expression of laminin and its receptors, integrins  $\alpha 3$ ,  $\alpha 6$ ,  $\beta 4$  and CD239, as well as NP matrix markers (type II collagen and aggrecan) in differentiated cells was confirmed by RT-PCR and immunohistochemistry. In conclusion, HUCMSCs have the potential to regenerate to NP-like cells in a laminin-rich pseudo-3D culture environment.

### SP19. 10 YEAR RADIOGRAPHIC FOLLOW UP OF ACROFLEX LUMBAR DISC REPLACEMENT

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**INTRODUCTION:** Acroflex Total Disc Replacement (TDR) was designed to reproduce the hydro-elastic nature of the normal healthy disc. However fine cut CT scans revealed a high incidence of rubber tears and osteolysis which necessitated revision surgery in 39% of cases. Our aims were to assess the radiological state of retained implants and to compare the incidence of adjacent level degeneration in these cases with those that were revised to a fusion and with our published series of ALIF cases 10 years after surgery.

**METHODS:** 28 subjects with discogenic low back pain who had not responded to at least 6 months of non- surgical treatment underwent TDR. At 10 years all patients were invited to have an MRI scan and for those with the implant still in-situ, a CT scan. CT scans were obtained of 14 implants. 14 patients had an MRI scan, 9 with implant in-situ and 5 revision cases.

**RESULTS:** At a mean of 9 years and 8 months (Range 8.64- 11.47 years) post index procedure, 11 of 28 subjects (39%) had been revised (7 for implant failure with osteolysis). Heterotopic bone formation was present in 85.7% of implants, 50% extensive (equivalent to fusion or pseudarthrosis). 50% of replacement levels showed osteolysis (28.6% severe). 14% of implants showed some subsidence. MRI demonstrated adjacent level degeneration in 66.7% of TDR cases compared with 40% in cases that were revised to fusion and 32% in our published series of ALIF patients assessed at 10 years by MRI.

**CONCLUSION:** TDR with AcroFlex appears not to protect against adjacent level degeneration. 10 years after TDR there is a high incidence of heterotopic new bone equivalent to a fusion or pseudarthrosis. Over ¼ of implants that had not required revision have radiological evidence of severe osteolysis likely to be secondary to particles from elastomer tears.

## SPECIAL POSTER PRESENTATIONS

### SP20. DIRECT COMPARISON OF TWO LUMBAR TOTAL DISC REPLACEMENT DEVICES: RESULTS FROM A PROSPECTIVE, RANDOMIZED, MULTICENTER FDA-REGULATED TRIAL

Richard D. Guyer, Kenneth Pettine, Reginald Q. Knight, Dom Coric, Paul C. McAfee, Charles R. Gordon, Andrew Cappuccino, Rudolph A. Buckley, Pierce Nunley, Fred H. Geisler, Timothy A. Peppers, James R. Rappaport, Carl Laurysen, Plano, TX, USA

**INTRODUCTION:** Randomized trials have reported total disc replacement (TDR) to produce results similar or superior to lumbar fusion. Results for various TDRs appear to be similar, but differences in study design and outcome measures pose challenges in definitively comparing devices. The purpose of this study was to perform a direct comparison of two lumbar TDRs in a prospective, randomized trial.

**METHODS:** TDR was performed in 457 patients from 21 sites (261 subjects in the investigational group (Kineflex Disc; metal-on-metal design, 204 randomized and 57 non-randomized training cases), and 196 in the control group (Charité Artificial Disc; metal with polyethylene core; 190 randomized and 6 non-randomized training cases)). All patients were treated for single-level symptomatic disc degeneration of at least 6 months duration. Success was defined to be at least 25% improvements in Oswestry scores, no re-operation, and no major adverse events.

**RESULTS:** There were no significant differences between the groups when comparing operative time, blood loss, or length of hospital stay. Both groups improved significantly on Oswestry and VAS scores ( $p < 0.01$ ; see table) with no differences between the groups.

	Oswestry		VAS	
	Kineflex	Charite	Kineflex	Charite
Pre-op	59.5	60.2	79.2	78.9
6 wk	37.0	36.5	37.4	32.3
3 mo	27.4	28.2	31.1	27.0
6 mo	24.6	24.7	28.7	28.4
12 mo	23.9	22.2	28.1	24.5
24 mo	23.0	23.0	26.5	26.7

Success rates were similar (75.5% investigational vs. 73.5% control). At 24-month follow-up, 94.1% of the investigational group and 91.9% of controls were satisfied with outcome. Re-operation was performed in 5.4% of the investigational group and 6.6% of controls.

**DISCUSSION:** This prospective, randomized, controlled study comparing two TDRs, the first to the authors' knowledge, found the devices produced very similar clinical outcomes. Both groups improved significantly by 6 weeks post-operative and remained improved throughout follow-up with a high patient satisfaction rate.

## SPECIAL POSTER PRESENTATIONS

### SP21. RADIOGRAPHIC COMPARISON OF TWO LUMBAR TOTAL DISC REPLACEMENT DEVICES: RESULTS FROM A PROSPECTIVE, RANDOMIZED, CONTROLLED MULTICENTER FDA-REGULATED TRIAL

Richard D. Guyer, Kenneth Pettine, Reginald Q. Knight, Dom Coric, Paul C. McAfee, Charles R. Gordon, Andrew Cappuccino, Rudolph A. Buckley, Pierce Nunley, Fred H. Geisler, Timothy A. Peppers, James R. Rappaport, Carl Laurysen, Plano, TX, USA

**INTRODUCTION:** In addition to pain reduction, goals of total disc replacement (TDR) include motion and restoration of disc height at the implanted level. The purpose of this study was to perform a direct comparison of radiographic parameters of two lumbar TDRs in a prospective, randomized study.

**METHODS:** From 21 sites, 457 patients underwent single-level lumbar TDR: 261 subjects in the investigational group (Kineflex), and 196 in the control (Charite). L5-S1 was operated in approximately 75% of both groups. Radiographs were measured at a single lab specializing in radiographic assessments.

**RESULTS:** Operative level ROM decreased at 3 months and then increased to pre-operative value (control) or significantly surpassed pre-operative value (investigational). In both groups, disc height increased significantly by 6 weeks and remained so throughout follow-up (see table).

	ROM (degrees)		Disc height (mm)	
	Kineflex	Charite	Kineflex	Charite
Pre-op	6.3	6.7	7.7	7.8
6 wk	NA	NA	14.8*	15.5*
3 mo	5.0^#	4.5^	14.8*	15.5*
6 mo	6.7#	5.6^	14.8*	15.4*
12 mo	7.0*	6.3	14.7*	15.4*
24 mo	7.9*	6.6	14.7*	15.4*

^significantly less than pre-operative mean; \*significantly greater than pre-operative value; #significantly greater than in other TDR group (p<0.05)

ROM of greater than 4 degrees was associated with a greater success rate (defined as Oswestry improvement >25, no re-operation or device failure). At 24-months, anterior device migration occurred in 0.8% of investigational and 1.2% of control group, and subsidence occurred in 0.4% of investigational group and 0.6% of controls. One implanted level in each group fused.

**DISCUSSION:** Both devices maintained ROM, which decreased and then increased significantly in the investigational group and to pre-operative values in the control. Greater ROM was associated with better outcome. The two devices produced very similar results with respect to disc height. Rates of migration, subsidence, and autofusion were low in both groups.

## SPECIAL POSTER PRESENTATIONS

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### SP22. THE EFFECTS OF MAL-PLACEMENT OF THE INTERVERTEBRAL DISC ALLOGRAFT TRANSPLANT ON THE KINEMATICS OF THE SPINE

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**INTRODUCTION:** In a recent clinical trial of intervertebral disc (IVD) allograft transplantation by Ruan *et al.* (2007), remodelling of the transplanted allograft with reasonable preservation of segmental motion was observed. It is hypothesized that remodelling of a mal-positioned IVD allograft can restore the function and stability of the grafted functional spinal unit.

**METHODS:** 18 male goats (6-12 months, 25-30kg) were randomly assigned into 3 groups: non-operated control group (n=6), centrally-placed allograft treatment group (n=6) and mal-positioned allograft treatment group (n=6). Transplantation of cryopreserved IVD allografts was performed in the lumbar region (L4-L5). In the centrally-placed treatment group, the IVD allografts were placed centred and flush with the vertebral margin. In the mal-positioned group, the allografts were placed anteriorly by 25% of the anterior-posterior length of the allograft. Lateral and flexion/extension radiographs were taken at 4, 12 and 24 weeks post-operatively. Measurement of disc height index (% DHI), range of motion (ROM) and centre of rotation (COR) were made using an image analysis program developed in MATLAB. The results were compared to the non-operated control group using student t-test with  $P < 0.05$  being considered as significant.

**RESULTS:** The % DHI of both groups showed an initial decrease at 4 wks (~80%) but stabilised at 12 wks (~79%) and 24 wks (~80%). No significant differences in the ROM was observed, both the centrally placed and the mal-positioned allograft were able to preserve segmental motion. No significant differences were found in the COR among the groups at different time points with the quality of the motion also preserved.

**CONCLUSION:** Mal-positioned allograft transplantation was compatible with good functional outcome. In contrast to artificial disc replacements, precise positioning of allograft during transplantation is not essential for functional success.



### **SP23. MULTILEVEL LUMBAR DISC ARTHROPLASTY LEADS TO UNFAVORABLE KINEMATICS, HIGH FACET FORCES AND LIFT-OFF PHENOMENA**

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**INTRODUCTION:** Total disc arthroplasty (TDA) has been successfully used for monosegmental treatment in the last few years. However, multi-level TDA led to controversial clinical results. We hypothesize that: (1) the more artificial discs are implanted, the stronger the increases in spinal mobility and facet joint forces; (2) deviations from the optimal implant position lead to strong instabilities.

**METHODS:** A three-dimensional finite element model of the intact L1-L5 human lumbar spine was created. Additionally, models of the L1-L5 region implanted with multiple Charité discs ranging from two to four-levels were created. The models took into account possible misalignments in the antero-posterior direction of the artificial discs. All these models were exposed to an axial compression preload of 500N and pure moments of 7.5Nm in flexion and extension.

**RESULTS:** For central implant positions and the loading case extension, a motion increase of 51% for two implants up to 91% for four implants and a facet force increase of 24% for two implants up to 38% for four implants compared to the intact spine were calculated. In flexion, a motion decrease of 5% for two implants up to 8% for four implants was found. Posteriorly placed implants led to a better representation of the intact spine motion. However, lift-off phenomena between the core and the implant endplates were observed in some extension simulations in which the artificial discs were anteriorly or posteriorly implanted.

**DISCUSSION:** Multilevel TDA leads to significant increase of both spinal mobility and facet joint forces. The more artificial discs are implanted, the stronger these increases can be expected. Implant misplacements lead to unfavorable kinematics, to high facet forces and even to lift-off phenomena. Therefore, multilevel TDA should, if at all, only be performed in appropriate patients with good muscular conditions and by surgeons that can ensure optimal implant positions.

## SPECIAL POSTER PRESENTATIONS

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### SP24. INCREASED INFLAMMATORY MOLECULES IN DEGENERATIVE HUMAN FACET JOINT CAPSULAR TISSUE

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**INTRODUCTION:** Lumbar facet hypertrophy is a potential source of low back pain (LBP). The facet joint capsule (FJC) is richly innervated with nociceptive nerve fibers and mechanoreceptors. The goal of this study is to investigate alterations in inflammatory cytokine expression and neovascularization in the degenerative FJC obtained from patients with chronic LBP and compare these to normal controls. To study functional mechanisms and possible cellular signalling between peripheral spine tissues and sensory neurons, we developed an *ex vivo* organ co-culture system of FJC and rat lumbar dorsal root ganglia (DRG).

**METHODS/RESULTS:** FJC obtained from lumbar surgery and from donors through the Gift of Hope Tissue and Donor Network were studied. Hypertrophic FJC demonstrate increased neovascularization and infiltration of immune cells compared to normal tissues. RT-PCR and western blotting (WB) demonstrate highly upregulated inflammatory cytokines, pain mediators and enzymes in degenerative FJC tissues compared to controls. Ex-vivo co-organ cultures demonstrate increased substance P production in rat DRGs in the presence of hypertrophic FJC compared to normal controls.

**DISCUSSION/CONCLUSIONS:** Our data demonstrates increased neovascularization in human degenerative FJC tissues that are surgically removed from patients with severe LBP, suggesting that highly upregulated angiogenic factors (e.g., VEGF, TNF $\alpha$ , MMPs) may be important in FJ degeneration and LBP. Release of inflammatory cytokines and pain-mediators by DRG is critical in enhancing pain. Our DRG co-culture model demonstrates that degenerative FJC from patients with LBP alter sensory neurons in DRGs as reflected by increased expression of inflammatory pain-molecules (e.g. substance P). Many cytokines possess both inflammatory and angiogenic features, thus potentially playing important roles in facet degeneration. They may serve as a link between musculoskeletal degeneration and neurological stimulation of afferent pain fibers. Determining facet degenerative cascade may significantly contribute to the clinical understanding of low back pain.

## SPECIAL POSTER PRESENTATIONS

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### SP25. LATEST ADVANCES IN THE PRESURGICAL DIAGNOSIS OF LUMBAR LATERAL STENOSIS WITH THE USE OF MAGNETIC RESONANCE MYELOGRAPHY(3D FIESTA)

Tomoyuki Ozawa<sup>1</sup>, Tomoaki Toyone<sup>1</sup>, Atsuya Watanabe<sup>1</sup>, Ryutaro Shiboi<sup>1</sup>, Kunimasa Inada<sup>2</sup>, Yuichi Wada<sup>1</sup>  
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**INTRODUCTION:** Lumbar lateral stenosis (so called foraminal stenosis) is usually diagnosed by MRI and clinical symptoms. With the use of MR myelography (3DFIESTA method), high-resolution images are obtained in thin slices by which we can evaluate foramina in any profile. The purpose of this study was to measure the diagnostic performance of conventional MRI and MR myelography in patients with symptomatic foraminal stenosis.

**METHODS:** From Jan.2008 to Aug.2009, a total of 350 consecutive patients, who underwent conventional MRI (TR/TE 2800~3400/102 ms; slice thickness 4 mm slice gap 5mm) and MR myelography (3D FIESTA method, Fast Imaging Employing Steady State Acquisition TR/TE 5/minimum ms; slice thickness 1.6mm; slice gap 0.8mm) were screened. Of the 350 patients screened, 80 L5/S1 foramina of 40 patients who underwent surgery for lumbar spinal canal and/or foraminal stenosis were included in this study. Two blinded observers evaluated the presence of foraminal stenosis by using conventional MRI and MR myelography and compared their operative findings.

**RESULTS:** Eleven foramina in which foraminotomy were successfully performed were defined as symptomatic. All other foramina (69 foramina) were defined as asymptomatic. Nineteen foraminal stenosis were identified in conventional MRI and fourteen were identified in MR myelography. The sensitivity, specificity, false positive and false negative rates of MR myelography for the diagnosis of symptomatic foraminal stenosis were 100%, 100%, 4.5%, and 0%, respectively. The corresponding values of conventional MRI were 100%, 100%, 11.6% and 0% respectively. The evaluation by MR myelography showed smaller numbers of false positives.

**DISCUSSION:** In conventional MRI, slice widths are comparatively thicker, generating a partial volume effect which could be considered as the reason for the larger numbers of false positives. It could thus be concluded that compared with conventional MRI, the MR myelography affords more specific information for the presurgical diagnosis of symptomatic foraminal stenosis.

## SPECIAL POSTER PRESENTATIONS

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### SP26. VALIDATION OF INDOOR LEVEL WALKING TEST FOR QUANTIFICATION OF NEUROGENIC CLAUDICATION

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**BACKGROUND:** Neurogenic claudication (NC) limits walking in some individuals with lumbar spinal stenosis, and can be quantified using validated motorized treadmill (TMT) protocols. Indoor level walking test (ILWT) has been used as an alternative to TMT to evaluate NC in several studies, but ILWT has not been validated. This study assessed the validity of ILWT for assessing NC by comparing ILWT to TMT and self-reported functional measures.

**METHODS:** 31 adults with MRI evidence of spinal stenosis and NC were studied. Mean age was 69 (S.D.9), and 53% were male. NC symptoms included back pain (81%), radicular pain (81%), paresthesias (61%), weakness (35%), and unsteadiness (45%). All subjects completed the Oswestry Disability Index (ODI), the Swiss Spinal Stenosis Questionnaire (SSQ) along with a walking questionnaire. TMT protocol used a level track. ILWT was performed on a 53 meter rectangular carpeted course (hallways). Walking speeds were self-selected, and maximum testing times were 30 minutes. Testing stopped because of a) NC, or b) fatigue. Tests were performed on the same day and order varied randomly.

**RESULTS:** Poor balance prevented 5 subjects (16%) from performing TMT, with 23 (74%) of the remaining subjects developed NC. All subject could perform ILWT, and 29 (94%) developed NC. Mean walking results were similar between TMT and ILWT for walking time (10.5 vs. 10.1 min.  $P=NS$ ) and distance (480 Vs 555 km,  $P=NS$ ), but walking speeds were faster for ILWT (2.3 vs. 3.4 km/h,  $P<.001$ ). Walking time and distance showed strong correlation between TMT and ILWT ( $r = 0.69$ ,  $P<.001$ ;  $r = 0.83$ ,  $P<.001$ ), and similar correlations with ODI, SSQ and self reported walking abilities. Subjects reported a slight preference for ILWT over TMT.

**DISCUSSION:** ILWT offers valid measurements of walking ability in NC. Participant preference and ease of test indicates that ILWT may have distinct advantages.

### SP27. INTERFERENCE BETWEEN THE EPIDURAL FAT AND LIGAMENTUM FLAVUM CONTRIBUTES TO THE LOAD AND POSITION INDUCED CAUDA CONSTRICTION IN SPINAL STENOSIS

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**INTRODUCTION:** Load and activity induced neurogenic claudication is typical for spinal stenosis. A constriction of the cauda equine ( $< 75 \text{ mm}^2$ ) (Schönström et al 1984) is in most subjects a prerequisite for this claudication. Separately both the epidural fat and the yellow ligament have been shown to contribute to the constriction of the cauda. The aim of this study was to evaluate the interference between the fat and the ligament in load and position induced cauda equine constrictions.

**METHODS:** The lumbar spines in 24 men and women with non specific LBP were examined with MRI; in a supine position with and without an axial loading (+50 % of the body weight) applied through a nonmagnetic loading device. The changes of the cross sectional areas of the flavum, the epidural fat, the dural sac, the spinal canal and also the posterior bulge of the intervertebral disc were determined and compared in the unloaded and loaded spines.

**RESULTS:** The structure showing the largest expansion inwards the spinal canal during axial loading was the ligamentum flavum. On both the L3/L4 and L4/L5 levels flavum contributed to more than 50% of the reduction of the size of the spinal canal. The posterior bulging of the disc when loaded was quite small while the loading caused a statistically significant inward expansion of the epidural fat. This expansion occurred as a consequence of the bulging flavum, compressing and pushing the epidural fat towards the dural sac.

**DISCUSSION:** It is likely that the effects the load induced bulging of the ligamentum flavum (Hansson et al 2009) has on the epidural fat is a consequence of “functional compartments” within the spinal canal formed by the meningo-vertebral ligaments (Geers et al 2003). These “compartments” will allow axial sliding motions but also transversal expansion of the epidural fat.

## SPECIAL POSTER PRESENTATIONS

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### SP28. THERAPEUTIC EFFECTS OF ALFACALCIDOL, RISEDRONATE, AND RALOXIFEN ON THREE-DIMENSIONAL TRABECULAR MICROARCHITECTURE OF CRANIAL VERTEBRAL ENDPLATE IN POSTMENOPAUSAL WOMEN: A PROSPECTIVE RANDOMIZED TRIAL USING A MULTI-DETECTOR-RAW CT IMAGING

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**OBJECTIVE:** Vertebral fractures are the main cause of low back pain and disability among postmenopausal women. It has been reported that vertebral fractures usually affect the cranial endplate because it is thinner and weaker than the caudal endplate. In the present study, we attempted to investigate longitudinal changes in the trabecular microarchitecture of the cranial vertebral endplate during treatments with alfacalcidol, risedronate, and raloxifen.

**METHODS:** The study is a randomized and double-blind trial aimed to assess the improvement of microstructure in the vertebral cranial endplate. Thirty-two postmenopausal women ( $71.6 \pm 6.5$  years old) were randomly assigned to receive either oral administration of daily alfacalcidol (ALF), risedronate plus ALF (RIS), or raloxifen plus ALF (RLX). Their L3 vertebra was scanned using a multi-detector-row CT at the baseline and after 24 months of treatment. Five mm width from the cranial bony surface of the L3 vertebra was extracted and the microstructural parameters were calculated using a 3D image analysis system (TRI/3D-BON; Ratoc System Engineering Co. Ltd. ).

**RESULTS:** RIS and RLX increased trabecular thickness of the endplate, while ALF had no effect on improvement of the trabecular microarchitecture. In addition, RIS increased bone mineral density and decreased structure model index (SMI), suggesting that it maintained a plate-like structure of the trabecular bone. No incidental vertebral fracture of L3 was seen during the study period.

**DISCUSSION:** These results suggest that RIS improves trabecular microarchitecture and mineralization of the endplate. Furthermore, a decrease in SMI observed in the RIS group indicated a beneficial effect on maintaining an ideal plate-like structure of the cancellous bone, supporting the endplate. The findings suggest that RIS may have an effect on the improvement of endplate strength and may lead to decrease in the risk of osteoporotic vertebral fractures.

### SP29. RELATIONSHIP OF NERVE ROOT DISTURBANCE TO LUMBAR SPINAL STENOSIS BASED ON THE OPERATIVE FINDINGS AND CLINICAL SYMPTOMS

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**INTRODUCTION:** Nerve root disturbance (NRD) in lumbar spinal stenosis (LSS) is observed with various degrees. The purpose of this study is to evaluate the clinical significance of NRD in LSS.

**METHODS:** This study included 56 patients with LSS without prior lumbar surgery or disc herniation who had undergone decompression at the L4-5 level under microscopy (mean age 67 years; 29 males, 27 females). NRD was defined based on the operative findings as follows: adherence to the ligamentum flavum, mobility disturbance, and flattening and/or having become hollow by compression. For grading NRD, 1 point was given to each of these conditions. When bilateral nerve roots had the same condition, the more disturbed one was given 2 points, while the other was 1 point. Otherwise, both received 1 point. Thus, the bilateral NRDscores were calculated. Preoperative symptom of each side of the legs was also graded based on subjective symptom, muscle weakness, and sensory disturbance. In the patients exhibiting lateralized leg symptom, bilateral NRDscores were compared. In all patients, factors related to NRD were evaluated. Statistical analysis was performed using Wilcoxon signed-ranks test and a Sperman's rank correlation coefficient ( $P < 0.05$ ).

**RESULTS:** Forty-three patients exhibited lateralization in the degree of leg symptoms, with the dominant side having significantly higher NRDscore than the other ( $P = 0.037$ ). In all patients, the sum of the bilateral NRDscores did not correlate with either the symptom duration or preoperative JOA score ( $P = 0.43$ ,  $P = 0.47$ ), but did correlate with the age at surgery and the recovery rate ( $P = 0.04$ ,  $P = 0.008$ ).

**DISCUSSION:** NRD reflects the degenerative change of neural tissues and aged spine, being useful as a prognosis-predicting factor of LSS. However, further studies are required to elucidate whether or not releasing nerve roots from adhesion is necessary for achieving successful decompression for LSS.

## SPECIAL POSTER PRESENTATIONS

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### SP30. MARKED IMPROVEMENT IN PATIENTS TREATED WITH VERTEBROPLASTY AFTER PAINFUL OSTEOPOROTIC COMPRESSION FRACTURES

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**INTRODUCTION:** Vertebroplasty is a common procedure used to treat painful osteoporotic vertebral compression fractures. Several recent studies report limited reduction in pain and disability after treatment with either vertebroplasty or a sham procedure. Outcomes following vertebroplasty are reported herein.

**METHODS:** A post-hoc analysis of data was conducted on self-reported pain and disability outcomes from patients at one participating site in a multicenter, prospective, randomized clinical trial (RCT). Patients underwent vertebroplasty with either 'Cortoss' or 'PMMA' cements from February 2004 to December 2008. The 'serial self-reported outcome measures,' were compared to pre-treatment values using ANOVA to determine improvement which was defined as decreased pain and increased function.

**RESULTS:** A total of 50 fracture levels were treated in 44 patients (ages ranging 61 to 98 years). Subsequent fractures were observed in 15 (34.9%) patients over the 36 month follow-up period. The average VAS pain was  $6.73 \pm 2.04$  pre-operatively. After treatment, VAS was  $3.82 \pm 2.68$  at 72 hours,  $3.46 \pm 2.74$  at 1 week,  $2.86 \pm 3.00$  at 3 months,  $2.37 \pm 2.94$  at 6 months,  $2.47 \pm 2.78$  at 12 months, and  $3.05 \pm 3.24$  at longest follow-up of 24 to 36 months (*all post-op < pre-op, p < 0.01*). The average ODI score was  $32.08 \pm 8.53$  pre-operatively. After treatment, ODI was  $22.17 \pm 9.71$  at 1 week,  $17.04 \pm 10.65$  at 3 months,  $15.22 \pm 10.92$  at 6 months,  $15.73 \pm 10.65$  at 12 months, and  $16.48 \pm 10.94$  at longest follow-up of 24 to 36 months (*all post-op < pre-op, p < 0.01*). Average improvements were 54.7% less VAS pain and 48.6% less ODI disability.

**DISCUSSION:** Contrary to recent reports of pain improvement of 1.5-2.4%<sup>1</sup> vs. 43%<sup>2</sup>, this study showed 48% to 54% significant improvement in disability and pain as early as 72 hours among patients who had vertebral compression fractures treated with vertebroplasty.

1. Buchbinder, R et. al NEJM 2009
2. Kallmes, DF et. al NEJM 2009



### SP31. SEQUESTERED INTERVERTEBRAL DISCS ARE MAINLY INFILTRATED BY DENDRITIC CELL PRECURSORS: EVIDENCE FROM A PROSPECTIVE STUDY ON PATIENTS UNDERGOING MICRODISCECTOMY

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**INTRODUCTION:** A significant proportion of patients have been reported to suffer from failed back syndrome (FBS). Although an autoimmune response to herniated nucleus pulposus has been suggested to constitute a pathophysiologic mechanism of sciatica there is a lack of evidence examining its relevance for FBS manifestation. Two types of dendritic cell (DC) precursors, termed myeloid (MDCs) and plasmacytoid DCs (PDCs), have been described to be able to initiate an autoimmune response by activating CD4<sup>+</sup>T helper (T<sub>H</sub>) cells after antigen capture. The aim of the present prospective study was to characterize the immune cells infiltrating sequestered discs and relate the type of cells to postoperative outcome.

**METHODS:** Sequestered intervertebral discs from 11 patients were chopped into pieces after surgical removal and digested for 150 minutes. After digestion the tissue clumps were allowed to settle by centrifugation and supernatants removed. Cells in supernatants were counted, stained with specific surface markers of MDCs (CD11c, CD14), PDCs (CD123, CD4) and activated CD4<sup>+</sup>T<sub>H</sub> cells (CD4, CD45RO) and analyzed by FACS. The pain duration and reoperation rate was recorded three months postoperatively.

**RESULTS:** Whereas a significantly higher proportion of cells (21.6%) were identified as PDCs, a minority of cells have been characterized as MDCs (0.31%), indicative of a stronger infiltration of PDCs into the sequestered discs ( $p < 0.05$ ). As compared with PDCs a significant lower proportion of activated CD4<sup>+</sup>T<sub>H</sub> cells infiltrated the sequestered intervertebral discs (6.0%) ( $p < 0.05$ ). The proportion of PDCs was positively correlated with the postoperative pain duration and rate of reoperation.

**DISCUSSION:** The findings of the present study indicates the relevance of the autoimmune hypothesis for the FBS manifestation because discs were mainly infiltrated by PDCs as antigen-presenting cells. Furthermore, patients having a stronger infiltration of PDCs along with CD4<sup>+</sup>T<sub>H</sub> cells into their discs were found to be of higher risk for postoperative reoperation.

## SPECIAL POSTER PRESENTATIONS

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### **SP32. SENESCENT VS. NON-SENESCENT CELLS IN THE HUMAN ANNULUS: LASER CAPTURE MICRODISSECTION AND IN VIVO GENE EXPRESSION WITH MICROARRAY ANALYSIS**

Helen E. Gruber, Gretchen L. Hoelscher, Jane A. Ingram, Natalia Zinchenko, Edward N. Hanley, Jr., Department of Orthopaedic Surgery, Carolinas Medical Center, Charlotte, N.C. U.S.A

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**INTRODUCTION:** Senescent cells are well-recognized in the aging/degenerating human disc. Senescent cells are viable but cannot divide, remain metabolically active and accumulate within the disc over time. Since there are no cell surface markers for senescence which one could use to separate out senescent cells, molecular analysis of senescent cells is challenging.

**METHODS:** Studies were approved by our human subjects Institutional Review Board. We used laser capture microdissection (LCM) to selectively separate and harvest senescent and non-senescent annulus cells in paraffin-embedded tissue, and then compared gene expression patterns with microarray analysis. Eleven human annulus specimens were evaluated; microarray analysis used standard statistical analysis methods.

**RESULTS:** Analysis of gene expression with microarray analysis revealed significant differences in expression levels in senescent cells vs. non-senescent cells: 292 genes were upregulated, and 321 downregulated. Genes with important established relationships to senescence were identified; we found significant upregulation of RB-associated KRAB zinc finger, discoidin, p38, inhibitor of growth family member 5, growth arrest and DNA-inducible (beta), and cyclin-dependent kinase 8. Nitric oxidase synthase 1, and heat shock 70kDa protein 6 were significantly down-regulated in senescent cells. Additional significant differences were also present in genes associated with cell proliferation and matrix formation.

**DISCUSSION:** Using LCM to specifically harvest senescent vs non-senescent cells, we found that a set of recognized genes associated with senescence was significantly upregulated in senescent vs. non-senescent cells in the human annulus. Other genes, including ones involved in cell proliferation, extracellular matrix formation, cell signalling and other cell functions also showed significant modulation in senescent cells. Findings further advance our understanding of senescence in the disc. The aging/degenerating disc undergoes a well-recognized loss of cells; understanding senescent cells is important since their presence further reduces the disc's ability to generate new cells to replace those lost to necrosis or apoptosis.

## SPECIAL POSTER PRESENTATIONS

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### SP33. GENE EXPRESSION DATA SUGGEST MITOCHONDRIAL DYSFUNCTION AS A POTENTIAL UNDERLYING CAUSE OF INTERVERTEBRAL DISC DEGENERATION

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**INTRODUCTION:** Mitochondria are essential for normal energy metabolism since they contain the oxidative phosphorylation system which is the major source of ATP for the cell. A negative mitochondrial contribution, however, occurs when mitochondria are a source of reactive oxygen species which damage critical molecules, promote oxidative stress, and lead to pathology associated with mitochondrial dysfunction. Mitochondrial dysfunction is now recognized to contribute to many conditions, including cardiac failure, diabetes and neurodegenerative diseases, but its role in disc degeneration is unexplored.

**METHODS:** Following human subjects Institutional Review Board approval, disc tissue was utilized for gene expression studies with microarray analyses. Routine statistical methods were employed for expression analyses.

**RESULTS:** Data on gene expression in degenerated grade IV discs were obtained and compared to expression in healthier grade II and III discs. 955 genes were found to be significantly upregulated in the using GeneSifter™ Mitochondrial Ontology analyses. Gene findings showed significant upregulation of the following genes in the more degenerated discs compared to healthier discs: BCL2, p53, mitochondrial ribosomal proteins L48, L2, L3, L33, S15, S18B, S33, S34, and S63, ATP synthase H<sup>+</sup> transporting F0 complex, subunits F2, C2, C3, and E and the F1 epsilon subunit and beta polypeptide complexes of the F1 complex; and cytochrome c oxidase subunits VIIc, Va, Vb, VIIa (all these genes show  $p \leq 0.001$ ).

**DISCUSSION:** Data presented here support a potential underlying role of mitochondrial dysfunction associated with disc degeneration. Implications for these data include the interest in development of therapeutic interventions developed to target mitochondrial dysfunctions. Such treatments may play a role in future biologic therapies for human disc degeneration.

## SPECIAL POSTER PRESENTATIONS

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### SP34. FRAGMENTATION OF HYALURONIC ACID STIMULATES EXPRESSION OF PROINFLAMMATORY CYTOKINES AND MATRIX DEGRADING ENZYMES IN HUMAN INTERVERTEBRAL DISC CELLS

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**INTRODUCTION:** Although current knowledge indicates that there is a correlation between low back pain and intervertebral disc (IVD) degeneration in a certain group of patients, it is still unknown why some degenerated IVDs are symptomatic and others are not. It is thought that maybe the accumulation of specific degradation products can induce a pain response in the IVD, possibly by causing a proinflammatory and catabolic cascade. Therefore, we hypothesized that fragmentation of hyaluronic acid (f-HA) during degeneration can induce the production of proinflammatory cytokines and matrix degrading enzymes in human IVD cells.

**METHODS:** Human IVD cells from 7 donors undergoing spinal surgery were stimulated with different concentrations of f-HA (1, 5, 20, 50  $\mu$ g/ml) with a size of 6-11 disaccharides. After 18 hours, expression of proinflammatory cytokines (TNF- $\alpha$ , IL-1 $\beta$ , IL-6, IL-8) and matrix degrading enzymes (MMP1, MMP2, MMP3, MMP9, MMP13) was analyzed using real-time RT-PCR. Additionally, involvement of Toll-like receptors (TLR) 2,3,4 was investigated on the mRNA level. Changes in gene expression were quantified using the comparative ct-method. Statistics: nonparametric Wilcoxon signed-ranked test,  $p < 0.05$ .

**RESULTS:** At 50  $\mu$ g/ml, f-HA significantly stimulated the expression of IL-1 $\beta$ /-6/-8 as well as of MMP1/3/13; for most genes, a significant stimulation could already be observed at 20  $\mu$ g/ml. No effects could be observed for MMP2/9 and only a trend for TNF- $\alpha$ . We observed involvement of TLR2, but not of TLR3/4.

**DISCUSSION:** Increased levels of f-HA, one of the characteristics in degenerating IVDs, induced levels of major proinflammatory cytokines and matrix degrading enzymes in this *in vitro* study, possibly via the TLR2 pathway. Therefore, it may be possible that *in vivo*, accumulation of f-HA can play a role in the development of discogenic back pain. Induction of matrix degrading enzymes will not only worsen the degenerative status, but may additionally also regulate levels of proinflammatory cytokines.

### SP35. WNT/ $\beta$ CATENIN-MEDIATED REGULATION OF INTERVERTEBRAL DISC CELLS: MODULATION BY BMP SIGNALING

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**INTRODUCTION:** Members of both the Wnt and BMP families of signaling molecules have been implicated in the regulation of skeletal system. However, basic research using intervertebral disc cells (IVDs) in this area is still lacking. Therefore, in this study, we investigated the expression patterns of Wnt proteins in IVDs and examined whether Wnt/ $\beta$ -catenin enhances BMP2 signaling-induced proteoglycan (PG) synthesis.

**MATERIALS AND METHODS:** Sprague-Dawley rats were used. Firstly, we checked the expression of Wnt/ $\beta$ -catenin signal related mRNA and protein expression. Thereafter, Dual-Luciferase reporter assay system was performed. Tcf transcriptional activity was measured in IVDs transfected with the Topflash (Tcf binding site) luciferase reporter plasmid and Fopflash (mutant) reporter plasmid after treatment with or without LiCl and BMP2 stimulation. The effect of BMP signals was assessed through measurement of SBE4-luc (Smad binding element) and mutant plasmid. In addition, in order to determine whether the induction of PG synthesis occurs at reporter assay, we used an Agg-luc plasmid (Aggrecan reporter plasmid).

**RESULTS:** Results of immunohistochemistry analysis for  $\beta$ -catenin demonstrated significantly intense expression of  $\beta$ -catenin in the young rats, compared to old rats. LiCl and BMP2 treatment results in an increased  $\beta$ -catenin mRNA and protein expression. In addition, BMP2 and LiCl pretreatment enhanced Topflash activity, whereas Fopflash failed to increase activity. This induction was strongly up-regulated by BMP2 with LiCl (9.5-fold). LiCl also suppresses the activity of SBE-4 reporter activity. Agg-luc activity increased after the treatment with WT- $\beta$ -catenin expression plasmid. This result was similar to the result for LiCl treatment.

**DISCUSSION:** The results of this study provide the first evidence that Wnt/ $\beta$ -catenin signaling may be part of mechanism leading to disc degeneration. In addition, these data demonstrated that BMP2 up-regulated Wnt/ $\beta$ -catenin mediated Tcf-dependent transcription activity, indicating a possible mechanism through which the BMP2 and Wnt/ $\beta$ -catenin intracellular signaling pathways cooperate to regulate expression of target genes.

## SPECIAL POSTER PRESENTATIONS

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### SP36. OXYGEN METABOLISM OF INTERVERTEBRAL DISC CELLS; COMPARISON BETWEEN CELLS FROM THE BOVINE OUTER ANNULUS AND NUCLEUS PULPOSUS

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**INTRODUCTION:** The intervertebral disc is avascular and its cells use oxygen, but apparently not for oxidative metabolism. The pathways of oxygen usage are still unclear. We examined the effect of culture conditions on oxygen metabolism of cells from the bovine caudal disc nucleus pulposus (NP) and outer annulus (OA). We also analyzed the contribution of mitochondrial and cell-surface oxygen consumption.

**METHODS:** NP and OA cells were either cultured in monolayer and then in alginate beads or in beads only. Activity of enzymes involved in oxidative metabolism was determined by histochemistry. Oxygen consumption and lactate production were measured. Sodium azide & myxothiazol were used for the inhibition of mitochondrial oxygen consumption and diphenylene iodonium was used to inhibit cell-surface oxygen consumption.

**RESULTS:** Oxygen consumption was higher and lactate production was lower in OA than in NP cells for all conditions tested. In freshly isolated NP cells, oxygen consumption appeared mainly to be due to a surface NADPH oxidase. However after culture of NP cells an increase in oxygen consumption through the mitochondrial pathway was detected: an increase in enzyme activity and action of inhibitors confirmed this finding. The mitochondrial pathway activation during monolayer culture was not reversed following a further week of 3D culture. Mitochondrial oxygen consumption was evident in freshly isolated OA cells and in OA cells proliferating in monolayer where they increased their overall oxygen consumption.

**DISCUSSION:** Here we present data on oxygen consumption rates of bovine NP and OA cells. OA cells obtain energy mainly by oxidative metabolism. By contrast NP cells obtain energy by mainly by glycolysis, show little oxidative metabolism and consume oxygen mostly at the cell surface. Major non-reversible changes in energy metabolism of NP cells occur in culture particularly during cell de-differentiation in monolayer with implications for cell culture studies and repair strategies.

## SPECIAL POSTER PRESENTATIONS

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### SP37. ADOLESCENT VOLLEYBALL IS SLIGHTLY PROTECTIVE FOR LOW BACK PAIN AND NOT CORRELATED WITH SPINAL DEFORMITIES : A CONTROLLED CROSS-SECTIONAL SURVEY

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**INTRODUCTION:** A long discussion exists about the possible influence of sport activities on spinal growth and low back pain (LBP) in adolescence, but, with some exception, data are missing. Volleyball is widely practiced by girls in many countries, but we don't know if there is any correlation with spinal deformities and LBP.

**AIM:** Verify prevalence of postural changes, spinal deformities and LBP in girls playing agonistic volleyball compared to normal controls.

**METHODS:** We evaluated 99 girls practicing agonistic volleyball 2-3 times per week in the age range 11-14, and compared them to a normal sample of 91 schoolgirls of the same age range. We proposed a validated questionnaire to collect data on LBP. We collected a series of already validated measurements:

- plumbline distances from kyphosis apex of the C7 and L3 vertebrae
- ATR (Angle of Trunk Rotation) according to Bunnell.

According to previous studies, we considered these normal references:

- ATR: 5°
- C7: 15-55 mm
- L3: 28-70 mm

Statistics: ANOVA;  $\chi^2$  test, with Yates' correction for 2-by-2; Kruskal Wallis test.

**RESULTS:** Compared to normals, volleyball players had the same lifetime prevalence (49.5%) with slightly reduced point prevalence (9% vs 19%) and prevalence in the previous 15 days (33% vs 57%). No differences were noted for medical examinations and X-rays. We did not find more pathological cases in Volleyball players than in controls for the considered parameters:

- ATR:  $3.5 \pm 1.7$  (volleyball) vs  $3.1 \pm 1.5$  (control)
- C7:  $21.6 \pm 9.0$  vs  $20.5 \pm 13.0$
- L3:  $46.0 \pm 11.0$  vs  $44.0 \pm 14.0$ .

**DISCUSSION:** Agonistic volleyball players have suffered less LBP than controls in the last 15 days, even if the lifetime prevalence is the same. We can assume Volleyball to be a moderate protective factor for LBP. Volleyball adolescent players have the same asymmetries without clinically significant differences between groups.

## SPECIAL POSTER PRESENTATIONS

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### SP38. PREDICTORS OF CHRONIC LOW BACK PAIN – WHAT HEALTH PRACTITIONERS SHOULD PAY ATTENTION TO

Melloh M, Rolli Salathé C, Elfering A, Tamcan O, Mannion AF, Boos N, Mueller U, Dunedin, New Zealand

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**INTRODUCTION:** Most people experience acute low back pain (LBP) at least once in their lifetime. Four weeks after the onset of LBP, 90 to 97% of these individuals are pain free but the remainder develop chronic pain symptoms. The aim of this study was to define prognostic variables to identify patients at risk of chronic LBP after acute pain episodes and to develop a short, multidimensional screening tool on recovery obstacles after an acute LBP attack.

**METHODS:** From a large population-based cross-sectional study on norm values for activities of daily living, general health, psychological factors and pain perception, we performed a prospective cohort study investigating 271 patients with acute LBP at baseline and following them up after one year. Mean age of patients was  $49.9 \pm 15.8$  years with an almost equal gender distribution (female: 53.1%). Excluded were patients with chronic LBP at baseline. Outcome measures were self-reported chronic LBP measured by the Chronic Pain Grade Questionnaire (CPG), and activities of daily living, general health, co-morbidities, psychological factors, direct and indirect health care costs, back pain beliefs and working conditions measured by the Standard Evaluation Questionnaire (SEQ). Multilevel regression analysis of predictors of chronic LBP was performed, using a stepwise procedure.

**RESULTS:** Following predictors explained 37% of variance ( $p = .02$ ) and were included in a screening tool for everyday use by health practitioners: pain causes (wear and tear changes), fear-avoidance beliefs (adverse effect of heavy work, inability of doctors to help), co-morbidity factors (dizziness and balance problems, diabetes, shoulder/arm pain), occupational risk factors (heavy lifting) and recently performed imaging studies (CT).

**DISCUSSION:** The inclusion of predictors of chronicity in a screening tool for patients with an acute episode of LBP may assist health practitioners in identifying patients at risk of developing chronic LBP at an early stage.



### P39. WHAT ARE THE RELIABLE RADIOLOGICAL FINDINGS TO PREDICT LUMBAR SEGMENTAL INSTABILITY?

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**INTRODUCTION:** A definition of lumbar segmental instability remains controversial. The purpose of this study was to clarify the reliable radiological findings in the patients who underwent biomechanical evaluation using a novel intraoperative measurement system (IOMS) (ref. *JNS* 2008, *ESJ* 2009).

**METHODS:** One hundred twelve patients (average age: 66.5 years, M/F=56/56) with 58 lumbar degenerative spondylolisthesis and 54 other degenerative diseases were included. Patients with scoliosis, rotational deformity, or history of previous surgeries were excluded. Biomechanical *instability* was determined as a segment with neutral zone (NZ), the most reliable parameter (Panjabi 1982),  $> 2$  mm/N using IOMS. A risk factor analysis to predict *instability* was performed among patient age, sex, diagnosis, X-ray (range of segmental motion, disc height), MRI (Thompson grade, Modic type), and axial CT findings (facet shape, facet opening [FO], vacuum, osteophyte, subchondral erosion, cyst, sclerosis) using a multivariate logistic regression with a forward stepwise procedure ( $P < 0.1$  for entry). Facet shape was classified into four groups: sagittally oriented, frontally oriented, anisotropic, and wrapped type (the lower facet was wrapped by the upper facet). FO was defined as facet surfaces opening parallel  $> 1.5$ mm in width at least one side.

**RESULTS:** The stepwise multivariate regression analysis revealed that FO was the strongest predictor for instability (Odds' ratio=5.6,  $p=0.0145$ ), followed by facet type (2.9), MRI grade (2.6), vacuum (1.8). Wrapped type facet was a resistant factor to *instability*. On the other hand, MRI grade III and existence of vacuum in the facet were risk factors of *instability*. Spondylolisthesis and increased range of motion in flexion-extension X-ray were not predictors.

**DISCUSSION:** In the patients with lumbar degenerative diseases, facet opening in axial CT or MRI is the most reliable finding to predict lumbar segmental instability.

## SPECIAL POSTER PRESENTATIONS

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### SP 40. STAYING AT HOME WITH LOW BACK PAIN: MULTIDIMENSIONAL PREDICTORS OF WORK ABSENTEEISM

Melloh M, Rolli Salathé C, Elfering A, Tamcan O, Mannion AF, Boos N, Mueller U, Dunedin, New Zealand

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**INTRODUCTION:** Most people experience acute low back pain (LBP) at least once in their lifetime. Four weeks after the onset of LBP, 90-97% of these are pain-free. The remaining 3-10% develops chronic LBP with increasing socio-economic costs, e.g. owing to work absenteeism (WA). The aim of this study was to define prognostic variables to identify patients at risk of not returning to work, i.e. WA, and to develop a short, multidimensional screening tool for everyday use by health practitioners.

**METHODS:** From a large population-based cross-sectional study on norm values for activities of daily living, general health, psychological factors and pain perception, we performed a prospective cohort study investigating 312 patients with acute LBP at baseline and following them up after one year. Mean age of patients was  $43.9 \pm 10.6$  years with an almost equal gender distribution (female: 52.2%). Excluded were patients who at baseline were older than 65 years, not in the working process, and received either a disability pension or a pension due to a back injury. Outcome measure were WA, activities of daily living, pain during physical activity, current acute pain episode and a history of LBP. We performed stepwise multiple regression analysis of predictors of WA.

**RESULTS:** Following multidimensional predictors explained 70% of variance ( $p = .04$ ): full-time work and physical activity influenced the development of WA in a positive way, while no education, immobility, negative beliefs about being unable to return to work, negative attitudes about importance of work, restricted social behaviour and recently having undergone CT imaging demonstrated to be risk factors.

**DISCUSSION:** The inclusion of predictors of WA in a screening tool assessing patients with acute LBP provides important information on patients at risk of WA. In order to minimise the socio-economic burden of WA these patients should be identified at an early stage.

## SPECIAL POSTER PRESENTATIONS

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### **SP41. A VALIDATION STUDY OF BRIEF SCALE FOR PSYCHIATRIC PROBLEMS IN ORTHOPAEDIC PATIENTS (BS-POP) FOR PATIENTS WITH CHRONIC LOW BACK PAIN PART 1 (VERIFICATION OF THE RELIABILITY, VALIDITY AND REPRODUCIBILITY)**

Katshuhiro Yoshida, Miho Sekiguchi, Koji Otani, Hirohumi Mashiko, Harumi Shiota, Takahumi Wakita, Shi-ichi Konno, Fukushima, Japan

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**INTRODUCTION:** Psychosocial factors contribute to the exacerbation and prolongation of low back pain (LBP); however, simple methods for evaluating such psychiatric problems are limited. We developed the Brief Scale for Psychiatric Problems in Orthopaedic Patients (BS-POP) (doctor and patient versions), a simple questionnaire enabling evaluation of psychiatric problems in orthopaedic patients. The present study aimed to proactively verify the reliability, validity and reproducibility of the BS-POP with regard to chronic LBP patients.

**METHODS:** Subjects comprised 136 chronic LBP patients (55 males, 81 females; mean age, 61 years) who had suffered from persistent LBP for  $\geq 3$  months. The first test analyzed and verified internal consistency of the BS-POP items through the BS-POP and a questionnaire investigating psychosocial factors. In the second test, 53 patients who displayed no symptom changes after two weeks were asked to complete the BS-POP and VAS in order to verify BS-POP reproducibility. Factor analysis and reliability coefficients for BS-POP items were calculated along with correlation coefficients for the first and second tests.

**RESULTS:** No ceiling or floor effects were generated among the BS-POP question items, and the score distribution had a desirable shape. Factor analysis demonstrated factorial validity of the BS-POP including 1-factor structure. Internal consistency was confirmed by Cronbach's  $\alpha$  reliability coefficient of 0.754. The correlation coefficients for the retests were  $r = 0.920$  (doctor version) and  $r = 0.853$  (patient version), showing reproducibility.

**DISCUSSION:** The present findings demonstrate that the BS-POP possesses factorial validity, internal consistency and reproducibility and is thus a tool that can simply distinguish psychiatric problems of orthopaedic patients. Future study is required regarding criterion-related validity and responsiveness.

## SPECIAL POSTER PRESENTATIONS

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### **SP42. A VALIDATION STUDY OF BRIEF SCALE FOR PSYCHIATRIC PROBLEMS IN ORTHOPAEDIC PATIENTS (BS-POP) FOR PATIENTS WITH CHRONIC LOW BACK PAIN PART 2 (VERIFICATION OF THE CRITERION-RELATED VALIDITY AND RESPONSIVENESS)**

Katshuhiro Yoshida, Miho Sekiguchi, Koji Otani, Hirohumi Mashiko, Harumi Shiota, Takahumi Wakita, Shi-ichi Konno, Fukushima, Japan

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**INTRODUCTION:** We developed the Brief Scale for Psychiatric Problems in Orthopaedic Patients (BS-POP) (doctor and patient versions). A validation study of BS-POP for chronic low back pain (LBP) patients part 1 was demonstrated to verify factorial validity, internal consistency and reproducibility. The present study aimed to proactively verify the criterion-related validity and responsiveness of the BS-POP with regard to chronic LBP patients.

**METHODS:** Subjects comprised 188 chronic LBP patients (78 males, 110 females; mean age, 62 years) who had suffered from persistent LBP for  $\geq 3$  months. During the first test, the BS-POP, Minnesota Multiphasic Personality Inventory (MMPI), Profile of Mood States (POMS), 36-Item Short-Form Health Survey version 2 (SF-36 v2), Roland-Morris Disability Questionnaire (RDQ) and a questionnaire investigating psychosocial factors were conducted. The BS-POP, POMS, SF-36 v2, RDQ and a questionnaire regarding items such as level of treatment satisfaction for the third test were conducted on all patients who had participated in the first test to determine the responsiveness of the BS-POP. The criterion-related validity and responsiveness of the scale were statistically investigated.

**RESULTS:** Criterion-related validity was confirmed through strong association with the SF-36 items of Mental Health (MH), Vitality (VT), and General Health perceptions (GH); the MMPI second (depression) and third (hysteria) scales; and, the POMS D (Depression-Dejection) and F (Fatigue) scales. In comparison with the first test, the total crude scores for BS-POP in the third test were significantly lower for both doctor and patient versions. Moreover, the crude RDQ scores and SF-36 v2 items of physical functioning (PF), bodily pain (BP), MH, VT, GH and RE significantly improved, confirming responsiveness to treatment.

**DISCUSSION:** The present findings indicate that the BS-POP possesses sufficient reliability regarding computational psychology. The BS-POP constitutes a tool enabling orthopaedists themselves to easily identify psychiatric problems in orthopaedic patients.

### SP43. PTH ENHANCES BONE FORMATION IN THE RAT LUMBAR SPINE FUSION MODEL

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**BACKGROUND:** Iliac crest autograft is the graft of choice for spine fusions. Demineralized bone matrix (DBM) has osteoconductive and osteoinductive potential, but rat fusions using DBM have reported variable success with high pseudoarthrosis rates. This study was performed to determine if anabolic properties of PTH could enhance the osteogenic properties of DBM in the lumbar spine fusion setting with a known high risk of pseudoarthrosis.

**MATERIAL AND METHODS:** 12 Adult (4-6 month old) female Sprague-Dawley rats underwent posterior lumbar fusion from L4-5. Rats either received daily injections of 20mcg PTH (n=6) or received no injection (controls) (n=6). The rats were then sacrificed at two (n= 3 PTH and n=3 controls) and four weeks (n= 3 PTH and n=3 controls) for analysis of fusion mass. Fusion mass was assessed with X-ray,  $\mu$ CT, histology, and a palpation technique.

**RESULTS:** PTH rats showed a significant increase in the amount of fusion mass when compared to controls. The mean difference in fusion mass from the  $\mu$ CT and histology at two weeks was 23.2% ( $\text{cm}^3$ ) greater in the PTH treated animals than in the controls (p=0.021). This difference further appreciated at the four week timepoint (p=0.01). More bony fusion was noted on  $\mu$ CT as well as with the palpation technique at two and four weeks (p<0.05).

**CONCLUSION:** In combination with DBM, PTH appears to enhance bone formation and fusion in rat lumbar spine fusions when compared to DBM alone. Thus, in a model known to have high pseudoarthrosis rates, PTH enhanced fusions and may be a useful adjuvant treatment in patients who are at high risk of lumbar pseudoarthrosis. Combination therapies such as PTH and DBM may also help eliminate the use of autograft as well as autograft harvest site morbidity.

## SPECIAL POSTER PRESENTATIONS

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### SP44. EVALUATION OF EARLY TISSUE REACTIONS AFTER LUMBAR INTERTRANSVERSE PROCESS FUSION USING CT IN A RABBIT

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**INTRODUCTION:** To overcome complications of the use of autogenous iliac bone in lumbar posterolateral intertransverse fusion, substitutes for autogenous iliac bone have been developed. Several reports have shown how CT intensity (Hounsfield unit (HU)) can precisely evaluate bone objects in clinical and/or experimental settings. However few studies using CT HU intensity measurement have been performed on early bone genesis after intertransverse process fusion. The purpose of this study was to evaluate tissue reactions such as bone genesis, cartilage genesis and graft materials in the early phase using a clinically available CT scanner.

**METHODS:** Lumbar intertransverse process fusion was performed on 18 rabbits. Four graft materials were used: (1) Autograft bone (n=3); (2) Collagen membrane soaked with recombinant human bone morphogenetic protein-2 (rhBMP-2) (n=5); (3) Granular calcium phosphate (n=5); (4) Granular calcium phosphate coated with rhBMP-2 (n=5). All rabbits were euthanized 3 weeks post-operatively and lumbar spines were removed for CT imaging and histological examination.

**RESULTS:** CT imaging demonstrated that each fusion mass component had the appropriate CT intensity range. CT also showed the different distributions and intensities of bone genesis in the fusion masses between the groups. Each component of tissue reactions was identified successfully in CT images using the CT intensity difference. Using CT color mapping, these observations could be easily visualized, and the results correlated well with histological findings.

**DISCUSSION:** In this study, we have shown that tissue reactions such as bone genesis, cartilage genesis and graft materials can be quantified using CT imaging based on signal intensity (HU) in the early phase of lumbar intertransverse process fusion. The use of CT intensity is an effective approach for observing and comparing early tissue reactions such as newly synthesized bone, newly synthesized cartilage and graft materials after lumbar intertransverse process fusion in a rabbit model.

## SPECIAL POSTER PRESENTATIONS

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### SP45 ASSESSMENT OF THE FACET JOINT DEGENERATION AND TROPHISM COMPARING 360° FUSION AND POSTEROLATERAL FUSION

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**INTRODUCTION:** Facet joint degeneration (FJD) may cause low back pain. The change of FJD and tropism following spinal fusion has not been adequately evaluated. The objective of this study is to evaluate the progression of FJD and facet tropism after spinal fusion using CT scan.

**METHODS:** A total of sixty patients who underwent spinal fusion for lumbar degenerative disease and took minimum 2-year follow-up imaging of CT, were included in this study. Among these patients, 32 patients had undergone minimal anterior lumbar interbody fusion and pedicle screw instrumentation with paraspinous muscle splitting technique (360° fusion), and 28 patients had undergone posterolateral fusion with instrumentation (PLF). The Pathria grade was used to grade the facet joint degeneration and facet tropism was measured preoperatively and at the time of the last follow-up. Wilcoxon signed rank test was used for the statistical analysis.

**RESULTS:** At the fusion levels, both 360° fusion group and PLF group showed the progression of FJD ( $P=0.001$ ,  $P<0.001$  respectively). Between 360° fusion and PLF, there was no significant difference ( $P=0.882$ ) of FJD. No significant change of facet tropism was found in both groups. At the upper adjacent levels of fusion, significant change of FJD was found in only the PLF group ( $P=0.015$ ), not in 360° fusion group ( $P=0.427$ ). Facet tropism did not change in both groups.

**DISCUSSION:** FJD at the fusion level progressed after spinal fusion. At the upper adjacent levels of fusion, only PLF showed the progression of FJD. FJD is one of the factors of postoperative back pain after PLF.

## SPECIAL POSTER PRESENTATIONS

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### SP46. LOW BONE MINERAL DENSITY IS NOT A RISK FOR PSEUDOARTHROSIS AFTER INSTRUMENTED LUMBAR OR LUMBOSACRAL FUSION

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**INTRODUCTION:** Due to the increasing age of society, the population of elderly individuals treated with lumbar surgery has been increasing. Spinal instrumentation can be difficult when considering the existence of osteoporosis in this population. The purpose of this study was to examine the possible association of lumbar or hip BMD and pseudoarthrosis after instrumented lumbar or lumbosacral fusion.

**METHODS:** The study population consisted of 211 patients, 74 males and 137 females, who underwent posterior lumbar or lumbosacral fusion with pedicle screws. Average age at operation was  $68.0 \pm 7.6$  years old. Pseudoarthrosis was diagnosed by dynamic radiography, plain radiography, and CT postoperatively at 1 year post-op. To evaluate the independent effects of BMD levels on the development of pseudoarthrosis after fusion, multivariate logistic regression analysis was performed to obtain odds ratios adjusted for potential confounding effects of age, sex, fusion technique, number of fused segments, existence of lumbosacral fusion, and presence of spinal malalignment.

**RESULTS:** Pseudoarthrosis was found in 23 patients (10.9%). Univariate logistic regression analysis showed that the presence of three or more fused segments (Odds ratio: 2.81,  $P=0.04$ ) was a risk factor of pseudoarthrosis. Multivariate logistic regression analysis was as follows: 1) Lumbar BMD: Odds ratios were 0.838 ( $P=0.84$ ) for lowest BMD of less than 70% and 0.446 ( $P=0.46$ ) for lower BMD from 70% to 80%; 2) Hip BMD: Odds ratios were

**DISCUSSION:** This study proved that low BMD is not a risk factor for pseudoarthrosis after instrumented lumbar or lumbosacral fusion. That is, low BMD is not a cause to avoid instrumented fusion surgery.



## SPECIAL POSTER PRESENTATIONS

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### SP47. DOES PREOPERATIVE DEGENERATION MATTER FOR ADJACENT DISC DEGENERATION?; MINIMUM 5-YEAR MRI FOLLOW-UP

Chang-Hoon Jeon M.D. Ajou University, School of medicine, Nam-Su Chung M.D. Ajou University, School of medicine, Jin-Yeol Yi M.D. Ajou University, School of medicine Do-Young Park M.D. Ajou University, School of medicine, Moon-Soo Park M.D. Hallym University, School of medicine, Republic of Korea

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**INTRODUCTION:** One of the debates in the field of spinal surgery is the essence of adjacent segment degeneration, whether it is complicated by fusion itself or a natural course of spinal degeneration. We conducted a retrospective case-control study to evaluate which grade of degenerated disc is most vulnerable to the progression of adjacent discs degeneration in comparison with lumbar fusion and decompression surgery.

**METHODS:** There were 63 patients in fusion (26 of 360° fusion and 37 of posterolateral fusion) and 32 of decompressive surgery. Inclusion in this study required a minimum 5 years (average  $90.9 \pm 27.5$  months) MRI follow-up. The Pfirrmann classification was used to grade the adjacent disc degeneration with preoperative and follow-up MRI. The changes of each grade were analyzed with Wilcoxon signed rank test.

**RESULTS:** At the upper adjacent levels, 76 % of fusion group and 81% of non-fusion group revealed no progression of disc degeneration. One-grade progression occurred in 14% of fusion and in 12% of non-fusion group. Ten percent of fusion and 7% of non-fusion group showed 2-grade progression. Significant progression of upper adjacent disc degeneration was found in both the fusion group ( $p < 0.05$ ) as well as the non-fusion group ( $p < 0.05$ ). Among the grade-progressed 15 (24%) cases in fusion group, preoperative grade 3 was the most common (47%), followed by grade 1 (27%). In non-fusion group, preoperative grade 1 was the most common (33%). The progression of lower adjacent disc degeneration was not found in both the fusion group ( $p = 0.317$ ) and non-fusion group ( $p = < 0.157$ ).

**DISCUSSION:** Preoperative Pfirrmann grade 3 was the most vulnerable stage for adjacent disc degeneration following spinal fusion, while grade 1 was the most vulnerable for decompressive surgery. In this study, adjacent disc degeneration was noted in both the fusion and non-fusion. These results indicate that adjacent disc degeneration occurs regardless of spinal fusion.

## SPECIAL POSTER PRESENTATIONS

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### **SP48. FUSION STATUS AND CLINICAL OUTCOMES OF INSTRUMENTED TRANSFORAMINAL LUMBAR INTERBODY FUSION WITH LOCAL AUTOGENOUS BONE GRAFT: 2-YEAR RESULTS OF PROSPECTIVE COHORT STUDY.**

Satoshi Kawaguchi<sup>1</sup>, Hiroshi Oguma<sup>2</sup>, Ikuo Yamazaki<sup>2</sup>, Megumu Yamamura<sup>2</sup>, Tomohiro Akatsuka<sup>2</sup>, Shinji Matsuo<sup>2</sup>, Nobuhide Ono<sup>3</sup>, Keiko Horigome<sup>1</sup>, Hideki Yajima<sup>1</sup>, Takashi Oda<sup>1</sup>, Yuichiro Kii<sup>1</sup>

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**INTRODUCTION:** To obviate the morbidity of graft harvest in lumbar fusion surgery, various bone graft alternatives have been proposed. However, these materials such as allogeneous bone and bone-inducing proteins are not preferred or unapproved yet in Japan. Local laminectomy bone serves a minimally invasive graft source. Concerns on the use of local bone are its limited amount and quality. The present study was designed to determine the fusion success of instrumented transforaminal lumbar interbody fusion (TLIF) with local bone graft.

**METHODS:** Between March 2006 and September 2007, 63 patients underwent instrumented TLIF for degenerative lumbar diseases, mostly degenerative spondylolisthesis. Local morselized laminectomy bone and a Titanium interbody cage filled with local bone were inserted into the intervertebral space, and fixed with segmental pedicle screws. Prospective evaluations at 1 year and 2 years postoperatively include Japanese Orthopaedic Association (JOA) score and the fusion status using flexion-extension radiographs and CT scans with sagittal reconstruction.

**RESULTS:** Fifty-three patients completed the evaluation. There are 32 females and 20 males with the average age of 65 years. JOA score was 13.2 +/-3.0 preoperatively, 23.9 +/- 3.3 at 1 year and 24.3 +/- 3.2 at 2 years. Complications were infection in 1 patient, which healed by debridement. Radiographs at 1 year and 2 years showed no instability in all 52 but one patient. In reconstruction CT scans at 1 year, 40 patients showed union of the grafted bone to both endplates (complete union), 7 had union of the grafted bone to either endplate (partial union), and 1 showed nonunion. At 2 years, 49 patients showed complete union and 3 patients showed partial union.

**DISCUSSION:** Instrumented TLIF with local bone graft provided improvement in clinical outcomes, radiographic stability in 51 of 52 patients, and complete union in 94 % of patients at 2 years, supporting the efficacy of this procedure.

## SPECIAL POSTER PRESENTATIONS

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### SP49. P38 MAPK INHIBITION HAS A POSITIVE EFFECT ON HUMAN AND RABBIT INTERVERTEBRAL DISC DEGENERATION.

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**INTRODUCTION:** The intervertebral disc (IVD) expresses cytokines under pathological conditions. Signaling by p38 mitogen activated protein kinase (MAPK) is critical to the catabolic and anti-anabolic action of many cytokines. Our aim was to evaluate the *in vitro* effects of p38 MAPK inhibitor (p38i) on proteoglycan (PG) synthesis by human IVD cells and to determine its *in vivo* effects using a rabbit IVD degeneration model.

**METHODS:** Human nucleus pulposus (NP) and annulus fibrosus (AF) cells were cultured in 1.2% alginate for seven days. After treatment with p38i, PG synthesis and MMP-3 levels were measured.

Eight adolescent New Zealand white rabbits were used for the IVD degeneration study. The experimental disc was injected with p38i and the control disc was injected with phosphate-buffered saline. The rabbits were monitored for one and four weeks after the injections. Total RNA was isolated from AF and NP cells and q-PCR was performed using gene-specific primers for IL-1 $\beta$ , TNF- $\alpha$ , IL-6 and ADAMTS-4,5.

#### RESULTS

**Human IVD cells:** p38i significantly upregulated PG synthesis by NP cells ( $p < 0.05$ ), but did not affect PG synthesis by AF cells. The levels of MMP-3 in conditioned media were significantly suppressed for NP and AF cells ( $p < 0.05$ ).

**Rabbit anular puncture model:** In both the AF and NP, the injection of p38i significantly inhibited the mRNA expression of IL-1 $\beta$ , TNF- $\alpha$  and IL-6 at one and four weeks ( $p < 0.01$ ). The mRNA expression of ADAMTS-4,5 in both tissues was inhibited by the injection of p38i ( $p < 0.01$ ). The effect of p38i on the expression of ADAMTS-4,5 was more apparent in the AF than the NP.

**DISCUSSION:** The inhibition of p38 MAPK in degenerative IVD tissues may have a positive effect on the maintaining the proper balance between anabolism and catabolism. This approach to block p38 MAPK could provide a therapeutic strategy to intervertebral disc degeneration.

## SPECIAL POSTER PRESENTATIONS

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### **SP50. VARIATIONS IN ANULAR DEFECT CHARACTERISTICS IN HERNIATED LUMBAR DISCS: A FEASIBILITY STUDY OF ANULAR REPAIR AND AN ATTEMPT TO CONFIRM CARRAGEE POPULATION DATA ON DEFECT SIZE**

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Murdock, Presbyterian St. Luke's Medical Center, Denver CO, Caroline J. Wong  
Denver Spine

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**INTRODUCTION:** Anular repair has been touted as a method to reduce recurrent disc herniation. Repair technique (suturing, barrier/plugs) depends on defect characteristics. Carragee concluded that larger defects have an increased risk of reherniation/revision surgery. Carragee observed defect size and did not report location (mid annulus, adjacent inferior or superior end plate) nor tissue quality (intact/frayed/calcified). These characteristics have implications for the feasibility of anular repair. Suturing (technically easiest/cheapest) applies only in situations where the tear is mid substance with good adjacent tissue. Defects adjacent to bone require a suture bone anchor (currently none available). Large holes necessitate a technically challenging, expensive barrier reconstruction.

**METHODS:** A prospective, 100 consecutive patient cohort study of herniated lumbar discs. Inclusion/exclusion criteria per Carragee. Location of the anular defect (midsubstance/adjacent to superior or inferior end plate), tissue quality and Carragee Type (fragment/fissure, fragment/defect, fragment/contained, no fragment/contained) were noted.

**RESULTS:** There were 68 males/ 32 females (higher risk for males  $p=0.0003$ ), average age 47. There were 55 right herniations and 45 left. 64% had mid substance defects/good adjacent tissues (suture applicable). Defect adjacent inferior end plate (21%), superior (8%)- bone anchor potentially applicable (29%), thus, total potential repair patients (93%). Repair was not feasible in 7% due to calcification. Carragee categories (% ours/Carragee), Fragment Fissure (27/49), Fragment Defect (2/18), Fragment Contained (60/23), No Fragment Contained (11/8). Significant difference between our cohort vs. Carragee all categories,

**DISCUSSION:** With suture and/or bone anchor techniques, 93% of patients would be candidates for anular reconstruction. The statistically significant variation in all Carragee defect size categories was a surprise. Carragee data on defect size was not confirmed. The true population incidence remains uncertain. This has implications in determining the cost effectiveness of anular repair.

The other key feasibility factor still under investigation is the incidence of reherniation in repaired anular defects.

## SPECIAL POSTER PRESENTATIONS

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### SP51. RELATIONSHIP OF EARLY LUMBAR VERTEBRAL DEGENERATION BETWEEN THE MRI GRADING AND EXTRACELLULAR MATRIX COMPONENTS USING DGEMRIC AND T2 MAPPING

Atsushi Sugawara, Hideki Murakami, Satoshi Yoshida, Ryuhei Kawamura, Ken Yamazaki, Tadashi Shimamura, Morioka, Iwate, Japan

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**INTRODUCTION:** Lumbar vertebral disc degeneration is closely related to decreasing extracellular matrix (ECM) components (water, proteoglycan, and collagen) in both the nucleus pulposus (NP) and annulus fibrosus (AF) in earlier stages. They were correlated the difference of T1 values before and after penetration of Gd-DTPA<sup>2-</sup> ( $\Delta T1$  value) and T2 value measured by two methods of delayed gadolinium-enhanced magnetic resonance imaging of cartilage (dGEMRIC) and T2 mapping. Some classification using magnetic resonance imaging (MRI) has ever reported, the grading system reported by Pfirrmann using sagittal T2WI of MRI was the most suggested in the relevant literature. This study was undertaken to confirm the relationship of early lumbar vertebral degeneration between the grade and extracellular matrix (ECM) components or  $\Delta T1$  and T2 value.

**METHODS:** This study examined 22 Japanese white rabbits aged from 6 months to 4 years old. Their lumbar vertebral discs from L1-2 to L5-6 were imaged using 3.0 T MRI. The images were graded on the basis of Pfirrmann's grading system and measured  $\Delta T1$  and T2 value. Then, their tissues were harvested; NP and AF were separated and biochemical quantitative value of water contents and sulfated glycosaminoglycan (sGAG) contents analyzed respectively. Statistical analyses between their grade and biochemical value or  $\Delta T1$  and T2 value were performed using Bonferroni's multiple comparison.

**RESULTS:** We had a total of 110 samples: grade 1 were 38, grade 2 were 52, and grade 3 were 20. The more discs degenerated, the more sGAG, water content and T2 value in NP decreased and  $\Delta T1$  value increased.

**DISCUSSION:** There were statistically difference in all groups of sGAG, water content and T2 value in grade 1-2 and grade 2-3. Results suggest that these methods can predict early degenerative changes of ECM components.

## SPECIAL POSTER PRESENTATIONS

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### SP52. INTIMATE RELATIONSHIP BETWEEN INSTABILITY AND DEGENERATIVE SIGNS AT L4/5 SEGMENT EXAMINED BY FLEXION-EXTENSION RADIOGRAPHY

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**INTRODUCTION:** Relationships between degenerative signs and segmental instability are still in controversial. The purpose of this study is to examine what types of degenerative signs observed in radiography have relationship with instability.

**METHODS:** Data was obtained for 447 (268 M, 179 F) patients with low back pain and/or sciatica evaluated by neutral and flexion-extension radiography. Relationship between degenerative findings at the L4/5 disc segment and three instability factors: more than >3mm slip in neutral position (SN), >3mm sagittal translation (ST), and >10 degrees segmental angulation (SA), were investigated. Disc height was obtained as a quotient of mean of anterior and posterior disc heights divided by inferior L4 diameter to correct body size. All patients was classified into 3 groups divided by mean (0.232)  $\pm$ 1 standard deviation; high disc height group (68 pts, 44.3 y), medium group (312 pts, 51.3 y), and low group (67 pts, 69.4 y). Other factors examined were sum of the length of anterior osteophytes, presence of vacuum phenomenon and endplate sclerosis.

**RESULTS:** Disc height ratios and mean age of the groups which had SN, ST, and SA factors were 0.18 (63.8 y), 0.23 (59.7 y), and 0.28 (40.1 y), respectively with statistically significant difference. As the disc height decreased, the more significant anterior slip was observed. Mean of angulation in 3 disc height groups were 8.0, 6.4, and 4.2 degrees from high to low, respectively with significant difference. Length of the spur was the largest in ST alone group and appearance of vacuum phenomenon was also predominant in the ST alone group.

**DISCUSSION:** Results showed that three instability factors had intimate relationships with the degenerative findings around the L4/5 disc, especially with disc height and patient age. Furthermore, length of spur formation and presence of vacuum phenomenon thought to be good indicators for the translational instability.

## SPECIAL POSTER PRESENTATIONS

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### SP53. MODIC TYPE I CHANGES PREDICT RAPIDLY PROGRESSING DISC DEGENERATION AT 1-YEAR FOLLOW-UP

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**INTRODUCTION:** Previously an association between Modic type I endplate changes (M1) and chronic low back pain has been noted. The aim of the present study was to evaluate the progression of M1 changes and degenerative disc (DD) changes in the lumbar spine during 1-year follow-up.

**METHODS:** 54 patients (male/female ratio: 9/45, mean age 43.6 yrs, range 24–65yrs) with chronic non-specific LBP, duration at least 3 months, with a “pure” M1 or a mixed lesion (M1/M2 or M1/M3) area comprising at least 5% of the vertebra in a sagittal MR image underwent a 1-year follow-up MRI. Exclusion criteria were: age > 65 yrs, a specific back disorder, neural compression, history of a major spine operation or any spine operation less than 6 months ago. A single endplate was regarded as an observational unit (5 lumbar levels, n=540). Associations between changes in M1 and changes in de-generative disc variables (end-plate lesion: EPL, nucleus pulposus signal intensity: DSI, disc height: DH, disc bulging) were studied by logistic regression analysis.

**RESULTS:** Altogether 110 M1, 81 M2 and 20 M3 were detected at baseline. 53% were pure M1 type lesions and 47% mixed type. Most of (89%) of the M1 were located at L4-L5 and L5-S1 levels. At baseline 4 M1s were detected without an adjacent EPL. At follow-up 38% M1s had converted partly to M2, 4 new M1s had appeared, 5/81 M2s had reconverted to M1. DD changes remained unchanged without M1. DD progressed differently in stable and unstable M1s. An increase of M1 area was associated with decreased DH. In 75/540 endplates the EPL progressed or a new lesion appeared. Both an increase of posterior and anterior disc bulging was associated with decreased DH.

**DISCUSSION:** Even at fairly short 1-year follow-up M1 appear to be linked to rapidly progressing, “pathologic” disc degeneration.

## SPECIAL POSTER PRESENTATIONS

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### SP54. THE ASSOCIATION BETWEEN CIGARETTE SMOKING AND INTERVERTEBRAL DISC DEGENERATION OF THE LUMBAR SPINE

Dino Samartzis, Jaro Karppinen, Keith DK Luk, Kenneth MC Cheung, Hong Kong

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**INTRODUCTION:** Although some studies have noted cigarette smoking to be associated with low back pain, the role of smoking and its association with intervertebral disc degeneration of the lumbar spine in adults remains questionable. As such, we addressed such concerns as part of the largest population-based radiographic study of the lumbar spine in Southern Chinese.

**METHODS:** Sagittal T2-weighted MRIs of the lumbar spine were obtained of 2,542 subjects (range: 21-81 years). Radiographic assessment entailed the presence, extent, and severity of disc degeneration, and the presence of Schmorl's nodes and vertebral body marrow changes. Subject demographics (e.g. body mass index, age, workload, exercise) were also obtained. The presence, duration (years), and amount (cigarettes per day) of smoking was evaluated.

**RESULTS:** The study entailed 60.6% females and 39.4% males. The mean age was 41.7 years. Of all subjects, 72.8% had disc degeneration and 11.9% were smokers. Based on logistic regression modeling, the presence and duration of smoking was not found to be significantly associated with the overall presence of disc degeneration ( $p>0.05$ ). The amount of smoking was significantly associated with disc degeneration involving the mid-lumbar region (adjusted OR: 1.05; 95% CI: 1.02-1.09;  $p=0.003$ ). Based on linear regression modeling, an increase in the amount of smoking was significantly associated with an increase in the number of levels with disc degeneration ( $p<0.001$ ). Overall disc degeneration severity was not significantly associated with any smoking parameter ( $p>0.05$ ).

**CONCLUSIONS:** Based on our study, the amount of cigarette smoking may have a minor influence on lumbar disc degeneration, being primarily associated with disc degeneration of the mid-lumbar region (i.e. L2-L4).



## SPECIAL POSTER PRESENTATIONS

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### SP55. RETURN TO WORK OUTCOMES FOR THOSE WITH AND WITHOUT OBJECTIVE NEUROLOGICAL FINDINGS.

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**INTRODUCTION:** There is a common misconception that early return to work harms the back, particularly for patients with neurological deficits. This study compares the rehabilitation outcomes of two distinct groups of low back pain patients: 1) those with objective neurological findings (irritation or conduction tests) (n=158), and 2) those with normal neurology (n=3103).

**METHODS:** This was a prospective observational cohort study of acute and chronic LBP cases (n=3261) treated non-operatively at 49 spine care rehabilitation clinics in Ontario, Canada and 5 clinics in New Zealand between January 2007 and August 2009.

**RESULTS:** The mean age of the cohort was 40.3 years (SD=11.7, range=18-74) with 58.1% males.

There were no baseline statistical differences between groups for symptom duration, numerical pain rating, gender or work status. At entry, the group with objective findings used significantly more medication, had lower perceived function and were, on average, 4 years older.

At the end of treatment, the objective findings group averaged more time in treatment (15.2 days v. 12.5 days, p

**DISCUSSION:** In spite of slower treatment response, higher medication use and less pain reduction in those with objective findings, at three months the two groups had comparable functional improvements and durable return to work rates.

In conclusion, if the neurological deficit does not directly interfere with job demands, return to work can be an achievable goal even for those with objective neurological findings.

## SPECIAL POSTER PRESENTATIONS

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### **SP56. ANALYSIS OF CHANGE IN SCORES IN COMMONLY USED OUTCOME MEASURES: WHAT CAN WE LEGITIMATELY ASSUME ABOUT THE STABILITY OF INDIVIDUAL PATIENT SCORES BASED ON GROUP MEAN SCORES?**

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**INTRODUCTION:** It has been reported that in lumbar implant trials, there is little change in outcome scores after 6-month follow-up. However, not addressed was whether stability in group mean scores was attributable to each patient's scores remaining stable or if there was compensatory improvement and worsening between patients producing stable group scores. The purpose of this study was to determine the stability of individual patient scores during 24-month follow-up.

**METHODS:** From a database of total disc replacement (TDR) patients and fusion patients with follow-up evaluations conducted at multiple pre-defined time points through 24 months, 195 patients were identified. To determine if there was a significant change (improvement or worsening) in a patient's scores between follow-up periods, the MCID (minimal clinically important difference) value of 15% was applied to Oswestry scores and 1.8 to visual analog scale (VAS) pain scores. These values were also applied to the change between 6 and 24-month scores.

**RESULTS:** Between 6, 12, and 24 month visits, the mean Oswestry scores were stable, not varying more than 2.5 between any two of these periods. Between 6 and 12 months, 80.5% of patients' scores were stable, with 9.7% improving and 9.7% worsening. Between 12 and 24 month, 76.4% of patients had stable scores, with 12.3% improving and 11.3% worsening. However, when tracking patients across these three follow-up periods, only 35.4% had scores that did not improve or worsen significantly between at least two of the follow-up points. The patterns of change were similar for VAS.

**DISCUSSION:** Although mean group scores remain very stable during post-operative follow-up, it is not legitimate to assume each individual patient's scores remain stable, as this occurred in only 35.4% of patients. This suggests stable means scores reported in studies should not necessarily be interpreted as reflecting stable scores for individual patients over time.

## SPECIAL POSTER PRESENTATIONS

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### **SP57. LONG-TERM PSYCHOSOCIAL ADJUSTMENT AND QUALITY OF LIFE FOLLOWING SPINAL CORD INJURY: A COMPARISON OF INJURED PERSONS AND THEIR CAREGIVERS.**

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(b) Department of Spinal Surgery, Royal Adelaide Hospital, University of Adelaide, Australia

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**STUDY DESIGN:** Cross sectional study

**OBJECTIVE:** To examine the long-term psychosocial adjustment and quality of life for both individuals with Spinal Cord Injury (SCI) and their caregivers.

**METHODS:** 114 individuals at least two years post SCI and their caregivers were assessed by administration of the following validated questionnaires: Depression Anxiety and Stress Scales – Short Form (DASS 21), EuroQol 5D (EQ-5D), Satisfaction with Life Scale (SWLS) and Locus of Control and Behaviour Scale (LCB). Medical records were reviewed for all injured persons completing the above questionnaires. Information collected included baseline demographics, mechanism of injury, level and completeness of SCI, American Spinal Injuries Association (ASIA) score, bladder and bowel involvement and whether surgical intervention occurred in the acute setting.

**RESULTS:** 19 individuals from the SCI group and 7 from the caregiver's group opted out of the study. A total of 29 from 114 (25.4%) SCI persons and 16 from a potential of 114 (14.0%) caregivers returned fully-completed questionnaires, despite exhaustive attempts to increase the return rate. Medical records from all 29 SCI persons were examined. Positive relationships were found between the SCI persons and their caregiver on the DASS 21, EQ-5D and SWLS scores. LCB scores positively correlated with the DASS 21 and negatively correlated with EQ-5D and SWLS for both SCI persons and caregiver groups. Level of injury and completeness of lesion predicted quality of life and satisfaction as measured by EQ-5D and SWLS.

**DISCUSSION:** The psychosocial adjustment of individuals with SCI appears to reflect that of their caregiver. While severity of injury did not influence psychosocial adjustment in SCI persons, locus of control was found to have a potential impact on outcomes. Severity of injury did correlate with quality of life and satisfaction with life for SCI persons.

## SPECIAL POSTER PRESENTATIONS

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### SP58. A MULTIDISCIPLINARY FUNCTIONAL RESTORATION PROGRAM FOR PATIENTS WITH CHRONIC BACK PAIN

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<sup>5</sup>Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hong Kong SAR, China

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**INTRODUCTION:** To examine the effectiveness of a multidisciplinary functional restoration program for people with chronic low back pain and to identify the associated factors that can predict the vocational outcomes of the program.

**METHODS:** Sixty-five chronic low back pain subjects who have been off work for  $16.6 \pm 21.4$  months participated in a 12-week multidisciplinary treatment program. Assessment was conducted at the start (baseline), midway, end of the program, and at a 6-month follow-up. Based on their vocational outcomes, the subjects were classified into two groups: the return-to-work group and the not-return-to-work group. Demographic data and baseline measurements were identified and tested as predictors of the program outcome.

**RESULTS:** No significant pain reduction or improvement in psychological performance was demonstrated during the treatment period. Interestingly, significant pain reduction was observed at the 6-month follow-up. The rehabilitation program effectively helped regain physical function and the ability to work. Fifty-two percent of the program participants returned to work after the 6-month follow-up, and showed more improvement in self-perception of disability and physical functions compared to the not-return-to-work group. The pre-program employment status and age of the participants were the most important predictors for the vocational outcomes. The prediction model (consisting of pre-program employment status, duration of absence from work and age) correctly classified 71% and 77% of the program participants who returned or did not return to work, respectively.

**DISCUSSION:** The rehabilitation program was effective in regaining the physical function and the ability to return to work. The pre-program employment status and age of the participants were the most important predictors for the vocational outcomes of the program graduates.

## SPECIAL POSTER PRESENTATIONS

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### SP59. SURGEON-INDUSTRY CONFLICT OF INTEREST: SURVEY OF NORTH AMERICAN OPINIONS REGARDING INDUSTRY SPONSORED RESEARCH

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**INTRODUCTION:** The nature of surgeon-industry conflict of interest (COI) has become a source of considerable interest. As budgets tighten, less research funding is available from government and nonprofit sources, which threatens to stifle innovation. Industry funding as a percentage of total is on the rise but may have greater potential for COI. The objectives of this study are to assess the opinions of North Americans on COI issues regarding industry funded research and to analyze population subgroups for trends.

**METHODS:** A web based survey was administered to sample opinions surgeon-industry consulting and regulation. Validity of hypothetically similar questions was calculated and subgroup analysis was performed for respondent age, sex, education, insurance and patient status.

**RESULTS:** 501/542 surveys had complete data. Our sample population was composed of more females, was older and more educated than a representative cross section of the American population. Questions demonstrated a high degree of validity. Most opinions did not differ among subgroups unless weighted to represent the American population census data. Respondents support multidisciplinary surgeon-industry COI regulation and trust doctors and their professional societies the most to head this effort. Respondents trust government officials and company representatives the least with respect to regulation of COI. Most people think that industry sponsored research can be just as objective and beneficial to patients.

**DISCUSSION:** Most respondents in our study felt that surgeons should be involved in industry sponsored research and that more research, regardless of funding source, will ultimately benefit patients. The majority distrust government or companies to regulate COI. The development of evidence based treatment recommendations requires the inclusion of patient choice and opinion. We encourage regulatory bodies and especially the U.S. government to follow suit and practice "evidence based government".

## SPECIAL POSTER PRESENTATIONS

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### **SP60. SURGEON-INDUSTRY CONFLICT OF INTEREST: SURVEY OF NORTH AMERICAN'S OPINIONS REGARDING INDUSTRY SPONSORED EDUCATIONAL EVENTS AND SURGEON TEACHING**

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**INTRODUCTION:** Surgeons are often reimbursed as faculty for continuing medical education events (CME). Industry often sponsors professional society meetings such as the American Academy of Orthopaedics and other CME events. The nature and extent of surgeon-industry conflict of interest (COI) has become a source of considerable interest. Doctors, companies and government leaders have attempted to regulate potential COI without the opinion of the general public. The objectives of this study are to assess the opinions of North Americans on COI issues regarding CME events and to analyze population subgroups that may form similar opinions.

**METHODS:** A web based survey was administered to sample opinions on reimbursement, disclosure, and funding sources for educational events. Validity of hypothetically similar questions was calculated and subgroup analysis was performed for respondent age, sex, education, insurance and patient status.

**RESULTS:** 501/541 surveys had complete data. Our sample population was composed of more females, was older and more educated than a representative cross section of the American population. There was a high validity content for questions. Most opinions did not differ among subgroups unless weighted to represent the American population census data. Over 90% of respondents felt that industry funding for surgeons tuition and travel for either industry sponsored or professional society CME meetings, would not affect their quality of care. Respondents were also generally in favor of educational conferences for surgeons regardless of funding type. Disclosure of surgeon-industry relationship, appears important to respondents.

**DISCUSSION:** The development of evidence based treatment recommendations requires the inclusion of patient choice and opinion as central components of the process. The vast majority of respondents in our study do not feel that the quality of their care will be diminished due to industry funding of educational events or for surgeon tuition and/or travel expenses.

### **GP1. BOTH ENDOPLASMIC RETICULUM AND MITOCHONDRIA ARE INVOLVED IN DISC CELL APOPTOSIS AND INTERVERTEBRAL DISC DEGENERATION IN RATS**

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**INTRODUCTION:** To investigate whether endoplasmic reticulum (ER) and mitochondria are co-involved in disc cell apoptosis and intervertebral disc degeneration (IVDD) in rats.

**MATERIALS AND METHODS:** Forty-eight rats were used for in vivo experiments. IVDD was characterized by X-ray and histomorphology examination, disc cell apoptosis was detected by TUNEL staining, and the co-involvement of ER and mitochondria in apoptosis was determined by immunohistochemical staining for GRP78, GADD153, caspase-12 and cytochrome C. Additional 8 rats were used for annular cell isolation and culture. After SNP treatment, annular cell apoptosis was observed morphologically and quantified by flow cytometry, the expression of biomarkers of ER stress and mitochondrial dysfunction were analyzed by RT-PCR, fluorescence double labeling and Western blot, and mitochondrial membrane potential was detected by JC-1 staining. Finally, NS3694 and Z-ATAD-FMK were employed to inhibit the formation of apoptosome complex and the activation of caspase-12, respectively, and apoptotic incidence and caspase-9 activity were assayed.

**RESULTS:** Unbalanced dynamic and static forces induced rat lumbar IVDD over time, accompanied by increased disc cell apoptosis and enhanced expression of GRP78, GADD153, caspase-12 and cytochrome C. Annular cell apoptosis induced by SNP was confirmed by morphologic observation and flow cytometry. With increased apoptosis, the expression of GRP78, GADD153 and caspase-12 upregulated, mitochondrial membrane potential decreased, and accumulation of cytochrome C in the cytosol manifested. Furthermore, NS3694 and Z-ATAD-FMK dramatically suppress annular cell apoptosis and caspase-9 activity.

**CONCLUSIONS:** This study demonstrated that disc cell apoptosis mediated simultaneously by ER and mitochondrial play a potent role in IVDD.

## GENERAL POSTERS

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### GP2. NANOPOROUS SILICON PARTICLES (NSP) AS A DELIVERY SYSTEM FOR THE ENHANCEMENT OF SPINAL FUSION

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**OBJECTIVE:** To assess the potential use of Nanoporous Silicon Particles (NSP) as a delivery system for the enhancement of spinal fusion.

**METHODS:** NSP were loaded with bone morphogenetic proteins and coated with different biodegradable polymers to control release and to afford triggering under specific conditions. The in vitro release of drugs was monitored by measuring absorbance at 304nm using a UV-Vis spectrophotometer. Osteoblasts were used for in vitro studies in the presence of drug-loaded NSPs. MTT assay as well as fluorescent and confocal microscopy were performed to characterize the effect of the delivery system on osteoblast activity.

**RESULTS:** We successfully demonstrated the ability (1) to load various g of drug per  $6 \times 10^6$  NSP; (2) to  $\mu$ amounts of BMPs into NSP (1 to 3 create polymer coatings affording a tunable and sustained release of BMPs; (3) to demonstrate significant stimulation of osteoblasts via loaded particles in vitro compared to controls.

**CONCLUSIONS:** We developed a delivery system based on biodegradable, biocompatible NSP loaded with BMPs. The release of drugs is controlled through appropriate tailoring of surface chemistries. Administered to osteoblasts in vitro, this delivery system induced significant osteogenic activity and, when coupled with direct or targeted delivery to bone, shows therapeutic potential for the enhancement of spinal fusion.



### GP3. EFFECT OF ADENO-ASSOCIATED VIRUS-2 MEDIATED HUMAN BMP7 GENE TRANSFER ON CHONDROCYTIC PHENOTYPE OF NUCLEUS PULPOSUS CELL

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**INTRODUCTION:** Nucleus pulposus (NP) cell have an important role to maintain the biomechanics function of spine. However, with getting older, the biological function of NP cell will gradually decrease to induce degenerative disc disease (DDD). Although Ad-hBMP7 vector were confirmed to increase matrix production of NP cell, the disadvantages of adenovirus limited Ad-hBMP7 vector to be applied in clinic. Recombinant adeno-associated virus-2(rAAV2) vector has some empirical advantages, especially application in clinic, to transfer exogenous genes into the cells. There is no report, so far, about rAAV2-hBMP7 transfecting NP cell. This study aims to investigate the effects of human BMP7 transduced by rAAV2 vector on canine nucleus pulposus cells.

**METHODS:** rAAV2-hBMP7 was packaged by infecting the stable cell clone BHK-21 with plasmid pSNAV-BMP7. NP cell of canine transferred BMP7 gene was assessed semi-qualitatively for BMP7 expression (MOI:  $1 \times 10^5$  v.g/cell). At 7 days post-transfection, proliferative ability of NP cells were comparative in the transfection and no-transfection cells. Aggrecan, type I and type II collagen secreted by nucleus pulposus cells were qualitatively accessed at 4, 7 and 14 days post-transfection in two groups.

**RESULTS:** The NP cell transfected by rAAV-hBMP7 vector express human BMP7 at least 14 days. The expressed human BMP7 promote remarkably accumulation of proteoglycans 42% and 77% higher than no-transfection cells at 7 and 14 days post-transfection, and type II collagen 63% and 94% ( $p < 0.05$ ).

**DISCUSSION:** This study demonstrated that AAV might successfully transfer human BMP7 into the canine NP cell. The canine NP cell transfected by rAAV-hBMP7 vector might express human BMP7 at least 14 days. The human BMP-7 expressed can promote remarkably accumulation of proteoglycans and type II collagen of the canine NP cell. These results show that a rAAV2-based gene delivery approach is capable of promoting the biological function of nucleus pulposus.

### GP4. EFFICACY OF INTERSPINOUS PROCESS FUSION WITH RECOMBINANT HUMAN BONE MORPHOGENETIC PROTEIN-2 DELIVERED BY A SYNTHETIC POLYMER AND $\beta$ -TRICALCIUM PHOSPHATE

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**INTRODUCTION:** If interspinous process fusion by use of BMPs is successfully achieved, this method would be one of the less morbid surgical options for treatment of lumbar disorders. In this study, we attempted to achieve an interspinous process fusion and evaluate its efficacy in experimental rabbit models by using a delivery system for recombinant human (rh) BMP-2.

**METHODS:** Japanese white rabbits were divided randomly into 6 groups. To make an implant for the lumbar vertebrae interspinous process fusion,  $\beta$ -TCP granules, polymer gel, and rhBMP-2 (30, 60, or 120  $\mu$ g) were mixed. The implants were placed on the interspinous processes of the rabbits by surgery. The lumbar vertebrae were recovered 8 weeks after surgery. The interspinous process fusion and its efficacy were assessed by radiography, biomechanical testing, intradiscal pressure measurement, and histological procedures.

**RESULTS:** Radiographic images taken at 8 weeks showed calcified shadows between the spinous processes in all animals of the BMP groups, while radiographs of the animals of the BMP 0 group revealed a particulate shadow of  $\beta$ -TCP. Lower magnification views of the coronal sections of the fusion mass in the animals that received rhBMP-2 showed an increase in bone mass and formation of a new bone that bridged the spinous processes. However, in animals that did not receive rhBMP-2, the interspinous process region revealed the presence of fibrous tissue and remnants of  $\beta$ -TCP. The bending moment of the BMP 60 group was significantly greater than that the sham, BMP 0 groups. The intradiscal pressures in the BMP 60 group were significantly decreased than those in the sham, BMP 0 groups

**DISCUSSION:** We achieved solid interspinous process fusion in experimental rabbit models. The efficacy of the interspinous process fusion was indicated by the stabilization of the spinal column and decrease in the intradiscal pressure due to axial compressive loading.

### **GP5. THE ECTOPIC EXPRESSION OF E-CADHERIN UPREGULATES THE EXPRESSION OF COLLAGEN II AND AGGREGAN BY THE BMP PATHWAY IN HUMAN INTERVERTEBRAL DISC CELLS**

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**INTRODUCTION:** E-cadherin is an adhesion molecule that can modulate signal-transduction pathways, and recent studies suggest that BMP activity is partially related to induction of E-cadherin expression. The aim of this study was to investigate the effects of the E-cadherin overexpression using a plasmid expression system on disc matrix macromoleculesynthesis in human intervertebral disc cells.

**METHODS:** Human intervertebral disc cells were grown in DMEM/F12 with 10% FBS. A DNA plasmid vector containing the E-cadherin gene was transfected to overexpress E-cadherin. An empty vector and no treatment groups were used as controls. Real-time PCR was used to quantitate mRNA levels. Western blot and IF were used to quantitate protein levels. DMMB was used to quantitate sulfated glycosaminoglycan (sGAG) content. Data were normalized by cell number and expressed as a ratio to untreated control.

**RESULTS:** Aggrecan and collagen II mRNA levels were upregulated in the E-cadherin transfected disc cells by 2.6 and 2.4 fold respectively ( $p < 0.05$ ). Sulfated-GAG levels were higher in E-cadherin transfected cells by 1.5 fold ( $p < 0.05$ ). E-cadherin transfection upregulated expression of BMP-2 and BMP-7 ( $p < 0.05$ ) mRNA and protein, but not BMP-4, BMP-6 and BMP-12. E-cadherin transfection increased BMP signal transduction as measured by Smad 1-5-8 phosphoralation and nuclear localization. A specific inhibitor of BMP (Noggin) suppressed E-cadherin induced upregulation of aggrecan and collagen II mRNA in the disc cells, indicating BMP dependence.

**DISCUSSION:** We showed that overexpressing E-cadherin, a cell adhesion and signal transduction molecule, significantly stimulated disc-cell matrix production, as well as the anabolic cytokines BMP-2 and BMP-7. Furthermore, we identified the BMP dependence of the stimulatory effect of E-cadherin. E-cadherin is a molecule that may be helpful in understanding the control mechanism of cell-matrix production, and may also be a target molecule that could be manipulated to increase disc-matrix production and potentially treat disc degeneration.

### GP6. LUMBAR INTERBODY FUSION USING HYDROXYAPATITE (HA) GRANULES WITH PLATELET-RICH PLASMA (PRP) IN RATS

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**INTRODUCTION:** Degenerative spondylosis is common in the elderly and often causes lower back pain. If symptoms persist, surgical treatment may be recommended, most commonly spinal fusion with autograft. However, graft site complications such as wound infection or donor site pain occur occasionally and can become troublesome for patients.

Hydroxyapatite (HA) has been used clinically as a bone graft substitute for autogenous bone harvesting, but it does not possess osteoinductive properties. Platelet-rich plasma (PRP) is an autologous source of growth factors and has been shown to enhance bone formation in clinical and experimental studies. The aim of this study was to investigate the ability of PRP to enhance lumbar interbody fusion using HA in rats.

**METHODS:** Sprague-Dawley rats were used as a spinal fusion model. Via a transperitoneal approach, the ventral aspect of the L5–L6 intervertebral disc was exposed. Following discectomy, 0.05g of interconnected ultra-high porous HA granules were applied to the site with platelet-rich plasma (PRP group: n=5) or platelet-poor plasma (PPP group: n=5). Control rats received HA with saline (HA-only group: n=5). Fusion rates and fusion mass areas were evaluated by radiographs and histomorphometric analysis.

**RESULTS:** Radiographic examinations showed that the areas of callus formation were more evident at 45 days and larger at 90 days after surgery in the PRP group than in the other groups ( $p < 0.05$ ). At 90 days, three PRP rats, one PPP rat, and no HA-only rats had achieved fusion, and all five PRP rats group showed complete intervertebral bone formation versus only one PPP rat ( $p < 0.05$ ).

**DISCUSSION:** The study results indicate that HA with PRP promotes bone formation more than HA with PPP or HA only, suggesting the feasibility of using HA with PRP in lieu of autografts in spinal fusion, although further trials are needed.

### GP7. EXPRESSION OF THE TISSUE RENIN-ANGIOTENSIN SYSTEM IN RAT INTERVERTEBRAL DISC -IMPLICATION FOR DISC DEGENERATION-

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**INTRODUCTION:** Angiotensin II (Ang II), the primary effector of the renin-angiotensin system (RAS), is classically known as an endocrine regulator of blood pressure. However, recent studies have shown that locally produced Ang II that is called the “tissue renin-angiotensin system (tRAS), contributed to the process of inflammatory diseases in several types of tissues. The expression of tRAS in intervertebral disc (IVD) is unknown. The purpose of this study was (1) to determine if rat IVD cells express the tRAS, and (2) to examine the effect of tRAS activation on the matrix metabolism, and (3) to examine the effects of a pro-inflammatory cytokine on the expression of tRAS by rat IVD cells.

**METHODS:** Expression analysis: Lumbar IVDs were harvested from rat spines. The IVD cells were isolated by enzyme digestion and were cultured in monolayer. The expression of the tRAS components (angiotensinogen [AGT], angiotensin-converting enzyme [ACE], Ang II type I receptor [AT1] and Ang II type II receptor [AT2]) in IVD cells was analyzed by real-time PCR and immunohistochemistry. Functional analysis: IVD cells were cultured in the presence of Ang II peptide, and the effect of Ang II on matrix synthesis was analyzed by real-time PCR. The expression of tRAS components with/without rhIL-1 $\beta$  stimulation was analyzed by real-time PCR.

**RESULTS:** In rat IVD cells, the expression of each tRAS component (AGT, ACE, AT1 or AT2) was confirmed at the mRNA level by quantitative-PCR and at the protein level by immunohistochemistry. Stimulation of the rat IVD cells with Ang II peptide significantly increased mRNA expression of Type1 and Type2 collagen and Aggrecan. The mRNA expression of each tRAS components was significantly down-regulated by stimulation with rhIL-1 $\beta$ .

**DISCUSSION:** The results of our study suggest that the expression of tRAS, which is controlled by pro-inflammatory cytokines, may contribute to the process of IVD degeneration.

## GENERAL POSTERS

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### GP8. ACTIN-BETA SHOULD NOT BE USED AS AN ENDOGENOUS CONTROL IN REAL-TIME RT-PCR FOR INTERVERTEBRAL DISC RESEARCH UNDER MECHANICAL LOADING STRESS CONDITIONS

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**INTRODUCTION:** Real-time RT-PCR is a reliable and sharply detective method for gene-quantification, and house-keeping genes (HKGs) are necessary as internal references. However, there have been only a few reports describing some of so-called HKGs are not potentially useful in intervertebral disc research. The objective of this study is to investigate the feasibility of HKGs in the disc cells under mechanical loading conditions.

**METHODS:** Forty-eight 12-week-old male Sprague-Dawley rats were equipped with an Ilizarov-type device between the 8<sup>th</sup> and 10<sup>th</sup> coccygeal vertebrae and loaded with static compression at 1.3 MPa for 0, 7, 28, or 56 days. Experimental loaded and unloaded control discs were harvested for radiography, magnetic resonance imaging (MRI), histology, and gene-quantification using real-time RT-PCR: HKGs [ $\beta$ -Actin,  $\beta$ -Glucuronidase,  $\beta$ -2-Microglobulin, Glyceraldehyde-3-phosphate-dehydrogenase (GAPDH), Lactate-dehydrogenase-A (LDH-A)] and extracellular matrix (ECM) genes [aggrecan-1, collagen type 1- $\alpha$ 1, type 2- $\alpha$ 1]. Immunofluorescence for  $\beta$ -Actin and GAPDH were performed.

**RESULTS:** Progressive disc height loss in radiographs, lower nucleus intensities on T2-weighted MRIs, histological degeneration, and ECM gene alterations such as an up-regulation of Col-1 and down-regulations of aggrecan-1 and Col-2 were observed. In the nucleus cells, although HKGs mRNA demonstrated continuous decreases over the loading period,  $\beta$ -Actin was significantly down-regulated compared to  $\beta$ -Glucuronidase ( $P<0.01$ ),  $\beta$ -2-Microglobulin ( $P<0.05$ ), GAPDH ( $P<0.01$ ) at 7 days, and  $\beta$ -Glucuronidase ( $P<0.01$ ) at 28 days. In Immunofluorescence, GAPDH was detected throughout the duration, while  $\beta$ -Actin had disappeared since 28 days.

**DISCUSSION:** We should select the most suitable HKG in experimental tissues and conditions. Accompanying disc degeneration in this validated animal model,  $\beta$ -Actin, a major HKG used in various experiments, demonstrated a drastic suppression from its early-stages at the mRNA and later protein-distributional levels. Mechanical stress might cause cell deformation and alteration of the cytoskeleton, such as  $\beta$ -Actin. Therefore,  $\beta$ -actin should not be used as an endogenous control in mechanical loading stress research using the disc-nucleus cells.

### GP9. PULSED ELECTROMAGNETIC FIELD (PEMF) STIMULATION OF NUCLEUS PULPOSUS CELLS

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**INTRODUCTION:** Histological and biochemical studies have shown that degenerative processes influence disc tissue structure, composition and cellular activity. Current surgical treatments for disc degeneration do not preserve normal disc function, therefore it is desirable to develop alternative treatments to slow or even reverse the degenerative process. Minimally-invasive therapy with pulsed electromagnetic fields (PEMF), as applied already for articular cartilage, may have promise. The aim of this study was to determine the influence of PEMFs on nucleus pulposus (NP) cell proliferation and the synthesis of disc-specific proteins.

**METHODS:** Three monolayer (2D) experiments and two 3D experiments were conducted. Bovine coccygeal NP cells were isolated and cultured directly as 2D monolayers in 6-well plates, or encapsulated first in 3D agarose beads, and exposed to PEMF for up to 14 days, with an exposure interval of 18 h per day. PEMF fields were generated within custom-built chambers employing active and passive coils. The EMF pulses had a duration of approximately 1.2 ms, a flux density of 1.5 mT, and a repetition rate of 2 and 75 Hz, respectively. Outcome measures included cell viability, proliferation, proteoglycan production and the expression of anabolic genes, evaluated via qRT-PCR.

**RESULTS:** Compared to non-exposed controls, the cell proliferation rate and the proteoglycan synthesis increased (+26.1% and +20.4%, respectively) for NP cells exposed to appropriate pulsed electromagnetic fields. No conclusive trends could be identified in gene expression profiles.

**DISCUSSION:** These results correspond to the findings of similar studies performed on chondrocytes, although the magnitude of the effect observed in the present study was substantially lower. PEMF field exposure induced a predominantly mitogenic effect in the NP cells. While the application of PEMF remains an attractive possibility for the non-invasive treatment of disc disorders, the effective field strength and high level of field control required should be critically evaluated.

### GP10. ACTIVATED APOPTOTIC MITOCHONDRIAL PATHWAY IN A RAT TAIL COMPRESSION LOADING-INDUCED DISC DEGENERATION MODEL

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**INTRODUCTION:** Apoptosis has a strong influence on the pathomechanism of intervertebral disc degeneration, a major cause of low back pain. Although two main pathways have been known in apoptosis; the death-inducing signaling complex pathway and the mitochondrial pathway, their participations in disc degeneration have not been fully elucidated. The objective of this study is, using a rat tail compression loading-induced disc degeneration model, to reveal its precise apoptotic pathomechanism.

**METHODS:** Forty-eight 12-week-old male Sprague-Dawley rats were equipped with an Ilizarov-type device between the 8<sup>th</sup> and 10<sup>th</sup> coccygeal vertebrae and loaded with static compression at 1.3 MPa for 0, 7, 28, or 56 days. Experimental loaded and unloaded control discs were harvested for radiography, magnetic resonance imaging (MRI), histology, and gene-quantification using real-time RT-PCR: apoptosis-related genes [Fas, FasL, TNF $\alpha$ , Bad, Bid, Bcl-2, caspase-3, -8, -9] and extracellular matrix (ECM) genes [aggrecan-1, collagen type 1- $\alpha$ 1 (Col-1), type 2- $\alpha$ 1 (Col-2)]. TUNEL-staining and immunohistochemistry for cleaved caspase-3 were performed.

**RESULTS:** Progressive disc height loss in radiographs, lower nucleus intensities on T2-weighted MRIs, histological degeneration, and ECM alterations such as an up-regulation of Col-1 and down-regulations of aggrecan-1 and Col-2 were observed. In the nucleus cells, obviously thicker TUNEL and immunohistochemical staining for cleaved caspase-3 were detected. Gene-quantification demonstrated significant caspase-3 and -9 up-regulations over time, but not -8 despite up-regulated Fas, FasL, and TNF $\alpha$ . Bid and Bcl-2 were significantly up-regulated, while Bad was unchanged.

**DISCUSSION:** Accompanying disc degeneration in this validated animal model, steady progressions of apoptosis, particularly the more activated mitochondrial pathway, were observed from up-regulated caspase-3 and -9 relative to -8. Moreover, relationships among Bad, Bcl-2, and Bid indicated increased apoptosis-promoting sub-family and secondarily counteracted apoptosis-inhibiting sub-family. The elucidation of detailed apoptotic cascade could make a great contribution to understanding the pathomechanism, as well as developing anti-apoptotic therapies for degenerative disc diseases.



### **GP11. EFFECT OF OSTEOGENIC PROTEIN-1 (OP-1) ON PROTEOGLYCAN METABOLISM OF DISC CELLS UNDER LOW OSMOTIC CONDITION AS SEEN IN DEGENERATED DISC**

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**PURPOSE:** The most important problems in disc regeneration medicine are to supply nutrients to cells activated by grafting or growth factors and to maintain a healthy extracellular environment. In this study, we evaluated the influence of osteogenic protein-1 (OP-1, otherwise known as BMP-7) which are involved on the metabolism of proteoglycans by disc cells cultured under low-osmotic conditions.

**METHODS:** Cells were isolated from the nucleus pulposus from caudal discs of 18-24 month bovine. Alginate beads containing disc cells collected from adult bovine (4 million cells/ml) were prepared. Three-dimensional culture was done for 5 days under a low osmotic condition (270 mOsm) or a normal osmotic condition like that of healthy discs (370 mOsm). OP-1 (100ng/ml) was added every day. Cell viability was determined by manual counting using trypan blue. Lactate production rate was measured as an index of cell metabolism. GAG production was assessed by the dimethylmethylene blue (DMB) assay. Rate of sulfate GAG synthesis was measured using a standard <sup>35</sup>S-sulfate radioactive method.

**RESULTS:** Lactate production was decreased by about 30-40% under 270 mOsm compared with that at 370 mOsm, showing that cell metabolism was impaired despite OP-1 being added to cultures. GAG production at 370 mOsm was about 0.05-0.1 mg/ml/day, while it was only about 0.02-0.06 mg/ml/day at 270 mOsm. During culture at 370 mOsm, GAG production was increased about 2-3 times by addition of OP-1, while there was a clear decrease in the response of GAG production to OP-1 at 270 mOsm compared with that seen at 370 mOsm.

**CONCLUSIONS:** Incubation with OP-1 enhances GAG production during culture at a normal osmotic pressure, but cell function is decreased in degenerated discs. Thus, the clinical application of disc regeneration medicine needs to be advanced by providing appropriate physiological conditions with consideration of age-related disc changes.

### GP12. NOVEL TREATMENT OPTIONS FOR DISCOGENIC BACK PAIN: THE RED WINE POLYPHENOL RESVERATROL INHIBITS EXPRESSION OF PROINFLAMMATORY CYTOKINES AND MATRIX DEGRADING ENZYMES IN INTERVERTEBRAL DISC CELLS

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**INTRODUCTION:** As increased levels of proinflammatory cytokines are thought to play an important role in the development of discogenic back pain, agents that would prevent a proinflammatory situation upon injection into the intervertebral disc (IVD) could serve as new minimal-invasive treatment options. Based on the fact that resveratrol, a natural polyphenol found in red wine, was shown to be anti-inflammatory in various cell types, the aim of this study was to analyze whether resveratrol can reduce levels of proinflammatory cytokines and matrix degrading enzymes in IVD cells.

**METHODS:** Expanded human IVD cells from 4 donors were prestimulated with IL-1 $\beta$  (5ng/ml) to increase levels of proinflammatory cytokines and MMPs. After 2 hours, resveratrol (5  $\mu$ M or 50  $\mu$ M) was added; cells were incubated for 18 hours and used for gene expression analysis (real-time RT-PCR). Cells that were preincubated with IL-1 $\beta$  and treated with resveratrol were compared to cells only preincubated with IL-1 $\beta$  or to untreated cells. Differences in mRNA levels of IL-1 $\beta$ , -6, -8 and MMP1, -3, -13 were analyzed using the  $\Delta\Delta$ Ct method and statistically evaluated (One-Way ANOVA,  $p < 0.05$ ).

**RESULTS:** Prestimulation with IL-1 $\beta$  increased expression of all genes compared to untreated control cells. At the higher concentration (50  $\mu$ M), resveratrol was able to reduce these increased levels. Example: IL-6 was increased 38x upon IL-1 $\beta$  stimulation (compared to controls) and significantly reduced by resveratrol to  $\frac{1}{4}$  of the levels seen with IL-1 $\beta$  stimulation. Similar effects could be observed for all other genes ( $p < 0.05$ ).

**DISCUSSION:** In this *in vitro* cell culture study, resveratrol was able to reduce increased levels of proinflammatory cytokines and matrix degrading enzymes that are known to be present in degenerated painful discs. As diffusion patterns in the IVD are unclear, animal studies will be necessary to verify the observed effects *in vivo*. Nevertheless, resveratrol seems to be a possible agent to treat patients with discogenic back pain.

### GP13. PROINFLAMMATORY REACTIONS IN THE INTERVERTEBRAL DISC: INVOLVEMENT OF TOLL-LIKE RECEPTORS

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**INTRODUCTION:** Intervertebral disc (IVD) degeneration is a known cause of back pain, especially if increased levels of proinflammatory cytokines such as IL-1 $\beta$  are present. However, it is not well understood today which pathways and receptors are used in inflammatory reactions in the IVD. As Toll-like receptors (TLRs), which normally recognize molecules derived from microbes, also share homology with the IL-1 receptors, the aim of this study was to investigate whether IL-1 $\beta$  can regulate inflammatory responses via one of the TLRs.

**METHODS:** Human IVD cells were isolated from biopsies of patients undergoing spinal surgery (n=4) and expanded cells were analyzed for basal expression of TLR2/3/4 (untreated control cells) or stimulated with recombinant IL-1 $\beta$  (5ng/ml) or lipopolysaccharide (LPS) (1 $\mu$ g/ml) for 2, 6 or 18 hours before measuring mRNA levels of these TLRs by real-time RT-PCR. Changes in gene expression after stimulation with either IL-1 $\beta$  or LPS were compared to untreated control cells (comparative ct-method, nonparametric Wilcoxon signed-ranked test, p<0.05).

**RESULTS:** All TLRs could be detected in untreated IVD cells. TLR2 expression was already increased at the short time points after treatment with IL-1 $\beta$  and LPS, but the most prominent stimulation could be observed after 18 hours (IL-1 $\beta$ : 7x, LPS: 8x; both p<0.05). In contrast, neither TLR3 nor TLR4 were stimulated by IL-1 $\beta$  or LPS.

**DISCUSSION:** Stimulation with IL-1 $\beta$  leads to an activation of the TLR2 pathway. TLR3/4 are neither regulated by IL-1 $\beta$  nor by LPS, which is uncommon as LPS is the predominant ligand of TLR4 in most cell types. As an activation of TLR2 can lead to a downstream activation of NF $\kappa$ B and thus to a proinflammatory cascade, TLR2 may be a relevant pathway in the painful inflammatory response in human IVDs. Therefore, blocking the TLR2 pathway may present an interesting novel opportunity to treat patients with discogenic back pain.

### GP14. FUNCTIONAL CONSEQUENCES OF SILENCING MMP-2 THROUGH RNAI IN INTERVERTEBRAL DISC CELLS

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**INTRODUCTION:** Intervertebral disc degeneration favors a shift towards primarily catabolic restructuring in the extracellular matrix. Matrix metalloproteinases (MMPs), specifically MMP-2, are thought to play a central role in tissue remodeling. We previously reported using lentivirus to transduce annulus fibrosus (AF) cells with shRNA to knock down MMP-2 expression through RNA interference. This study examined the functional effects of MMP-2 silencing on collagen remodeling by AF cells *in vitro*.

**METHODS:** Rat AF cells were infected with lentiviral shRNA constructs targeting MMP-2. Cells were embedded in type I collagen using custom-made dog-bone molds. Three groups of gels were fabricated: without cells, containing uninfected AF cells, and containing cells infected with MMP-2 virus. Gels were cultured for 1 week, then mechanically tested in tension using hanging weights and a video capture system to analyze deformation, and examined histologically. Cells were also seeded on gelatin films to determine degradation patterns.

**RESULTS:** Collagen gels containing uninfected AF cells significantly decreased in size. Histology revealed denser areas of collagen surrounding these cells. Gels containing infected cells appeared less structured, similar to gels without cells. Gels containing uninfected AF cells possessed higher failure stress, elastic moduli, and viscosity, compared with both acellular gels and infected cells. Gelatin films demonstrated that gelatinases function locally, in the vicinity of AF cells.

**DISCUSSION:** As expected, uninfected AF cells contracted collagen gels, suggesting local reorganization of collagen fibrils. These gels exhibited a higher viscosity than acellular gels and were more mechanically robust. Silencing MMP-2 resulted in little to no gel contraction caused by a compromised ability to remodel collagen. These gels were weaker and deformed more than uninfected cells, possibly due to the random organization of fibrils. It is unclear whether this is a result of compromised collagen turnover, an impaired ability for AF cells to reorganize the matrix, or both.

### **GP15. A P38 MITOGEN-ACTIVATED PROTEIN KINASE INHIBITOR, SCIO-496, INHIBITED THE PRODUCTION AND EXPRESSION OF CYTOKINES AND PAIN-RELATED MOLECULES BY HUMAN INTERVERTEBRAL DISC CELLS**

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**INTRODUCTION:** The metabolism of intervertebral disc (IVD) cells is controlled by cytokines and growth factors through endocrine, paracrine and autocrine mechanisms. Increased levels of proinflammatory cytokines in the IVD have been shown to correlate with pain; such cytokines also stimulate nerve growth factor (NGF) and increase the perception of pain. A downstream signaling molecule, p38 mitogen-activated protein kinase (MAPK), participates in controlling the cellular responses to cytokines and stress. Therefore, blocking cytokine signaling pathways using a p38 MAPK inhibitor (p38i) may reduce the sensation of pain. The present study was to evaluate the effects of p38i on IVD cells to see if it counteracts the expression of cytokines, proteases (ADAMTS4 and ADAMTS5), NGF, cyclooxygenase-2 (COX-2), nitric oxide (NO) and TNF- $\alpha$  Levels.

**MATERIALS AND METHODS:** Primary human nucleus pulposus (NP) and annulus fibrosus (AF) cells isolated from cadaveric IVDs were treated for 24 hrs: 1) control (DMEM/F12); 2) IL-1 $\beta$  (5ng/mL); 3) p38i (SCIO-496, 5 or 10nM/L; [Advanced Technologies and Regenerative Medicine, LLC, MA] or 4) IL-1 $\beta$  (5ng/mL)+p38i (5 and 10nM/L). Total nitrite and TNF- $\alpha$  levels were measured. q-PCR was performed using the gene-specific primers for IL-1 $\beta$ , TNF- $\alpha$ , IL-6, ADAMTS4, ADAMTS5, NGF and COX-2.

**RESULTS:** IL-1 $\beta$  significantly stimulated the production of NO and TNF- $\alpha$ , while p38i significantly inhibited the constitutive production of both. Treatment with IL-1 $\beta$  significantly up-regulated IL-1 $\beta$ , TNF- $\alpha$ , IL-6, ADAMTS4, ADAMTS5, NGF and COX-2 mRNA expression. The addition of p38i (5nM and 10nM) to IL-1-stimulated cultures significantly down-regulated the mRNA levels of these molecules.

**DISCUSSION:** Our results show that p38i, significantly suppressed the IL-1 $\beta$ -induced expression of cytokines, aggrecanases, NGF, COX2, TNF- $\alpha$  and nitrite levels in vitro. The results may suggest that the in vivo use of p38i has a clinical benefit and should be tested to determine if the injection of p38i retards the progression of disc degeneration.

## GENERAL POSTERS

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### GP16. EFFECT OF BONE MORPHOGENETIC PROTEIN-7 ON CHRONIC INTERVERTEBRAL DISC DEGENERATION IN A MATURE RABBIT MODEL

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**INTRODUCTION:** Bone morphogenetic protein-7 (BMP-7) injection into the nucleus pulposus (NP) induces structural and biomechanical recovery of degenerated intervertebral discs (IVDs) in the adolescent rabbit anular puncture model one month after needle puncture. It is important to note that the use of animals with notochordal cells and treatment after acute injury may be limitations. The purpose of this study was to assess if BMP-7 can restore degenerated IVDs during chronic stages of degeneration in a mature rabbit.

**METHODS:** Two non-contiguous discs in 24 2-year-old New Zealand white rabbits were punctured. The percent disc height index (%DHI) was radiographically monitored biweekly and normalized using non-punctured disc DHIs. Twelve weeks later, BMP-7 (100µg) or PBS was injected into the punctured discs. Twelve weeks after injection, animals were sacrificed and imaged with 3T MRI using T1rho and T2 quantification technique. Anulus fibrosus (AF) and NP tissues were separately harvested for biochemical analysis (proteoglycan [PG], DNA). Statistical analyses used two-way ANOVA and Fisher's PLSD.

**RESULTS:** The%DHI and PG content in the AF, was significantly higher in the BMP-7 group than in the PBS group ( $p<0.05$ ). The DHI increase was observed at four weeks after injection. The treatment had a significant effect on MRI T2 values ( $p<0.05$ ). The individual analysis of different lesions revealed significant increases of T2 values in the anterior and posterior AF, which agrees with the increased PG content. Interestingly, no significant increase of T2 values was observed in the NP.

**DISCUSSION:** The increase in disc height and higher T2 values in the AF, observed in the chronic mature rabbit anular puncture model, may indicate that BMP-7 induces the repair of AF tissues. Importantly, the detailed analysis using T2 quantification allowed us to detect changes in the AF in a quantitative manner, indicating the usefulness of these MRI techniques.

### GP17. TNF-ALPHA RESPONSE OF CELLS OF THE INTERVERTEBRAL DISC DEPENDS ON THEIR LOCATION IN THE DISC

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**INTRODUCTION:** TNF- $\alpha$  is one of the cytokines that drives IVD degeneration that is linked to LBP. The purpose of this study was to determine if TNF- $\alpha$  would induce different responses in cells from distinct areas of the IVD.

**METHODS:** Bovine IVD cells from the NP, transition-zone, inner-AF and outer-AF were cultured in monolayers (low-density or high-density) or in the intact disc (ID) and treated with different concentrations of TNF- $\alpha$ . Cellular response was assessed by detecting changes in receptor density, intracellular signaling pathways and gene expression levels triggered by TNF- $\alpha$ .

**RESULTS:** TNF- $\alpha$ -activated NF $\kappa$ B signaling was significantly higher in NP (5-8-fold) than in inner-AF and outer-AF (1.2-1.5-fold) regardless of culture conditions, including the ID culture. Aggrecan and collagen types I and II mRNA levels were down-regulated by 50% in NP but only 20% in outer-AF. MMP-1 expression was up-regulated in NP (5-20-fold) but only 2-3-fold in the outer-AF. NP expressed the most TNF- $\alpha$  receptors and outer-AF the least.

**DISCUSSION:** Independent of the culture conditions, significant differences in sensitivity to TNF- $\alpha$  of the cells from the structurally different compartments of the IVD were found; the outer-AF was particularly resistant, and the NP was particularly sensitive, as demonstrated by their disparity in signaling and gene expression. Thus, the cells preserve their differences whether or not they are isolated from the tissue. Since the NP possessed the most receptors and the outer-AF the least, the response to TNF- $\alpha$  may be regulated by the quantity of its cell surface receptor.

Our findings may be useful to predict which area of the IVD would be the first to develop degeneration. For translational studies, based upon this experimentation, restoration efforts could be developed to target the NP to down-regulate or counteract the deleterious effect of TNF- $\alpha$ .

### GP18. IMBALANCED CATABOLIC RELATIVE TO ANABOLIC GENE ALTERATIONS IN A RAT TAIL COMPRESSION LOADING-INDUCED DISC DEGENERATION MODEL

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**INTRODUCTION:** Biological metabolism has a strong influence on the pathomechanism of intervertebral disc degeneration, a major cause of low back pain; however few animal models are suitable for assessment throughout the degenerative process. The objectives of this study are to assess the validity of a rat tail compression loading-induced disc degeneration model for long-term observations and to reveal comprehensive gene alterations during disc degeneration.

**METHODS:** Forty-eight 12-week-old male Sprague-Dawley rats were equipped with an Ilizarov-type device between the 8<sup>th</sup> and 10<sup>th</sup> coccygeal vertebrae and loaded with static compression at 1.3 MPa for 0, 7, 28, or 56 days. Experimental loaded and unloaded control discs were harvested for radiography, magnetic resonance imaging (MRI), histology, and gene-quantification using real-time RT-PCR: catabolic genes [matrix metalloproteinase (MMP)-1a, -2, -3, -7, -9, -13, a disintegrin and metalloproteinase with thrombospondin motifs (ADAMTS)-4, -5], anabolic genes [tissue inhibitor of metalloproteinases (TIMP)-1, -2, -3], and extracellular matrix (ECM) genes [aggrecan-1, collagen type 1- $\alpha$ 1 (Col-1), type 2- $\alpha$ 1 (Col-2)]. Immunohistochemistry for MMP-3/ADAMTS-4 and TIMP-1/-3 were performed.

**RESULTS:** Progressive disc height loss in radiographs, lower nucleus intensities on T2-weighted MRIs, histological degeneration, and ECM gene alterations such as an up-regulation of Col-1 and down-regulations of aggrecan-1 and Col-2 were detected, firmly validating this rat tail model for disc degeneration research. In the nucleus cells, all MMPs and ADAMTS-4, but not -5 showed significant up-regulations with continuous progressions of increase, while TIMPs were unchanged. Immunohistochemistry demonstrated increased staining for MMP-3/ADAMTS-4 compared to TIMP-1/-3 with time.

**DISCUSSION:** Increased catabolic relative to anabolic gene alterations throughout disc degeneration were observed at both the mRNA and protein-distributional levels, indicating the significant roles of MMPs and aggrecanases. The elucidation of these pathological imbalances using the validated animal model could make a great contribution to investigating the pathomechanism, as well as developing molecular therapies for degenerative disc diseases.



### **GP19. CONTRIBUTION OF RISK FACTORS FOR OVER-STRESS AT ADJACENT SEGMENTS AFTER LUMBAR FUSION: REMOVAL OF POSTERIOR LIGAMENTS, PEDICLE SCREWS, FUSION ITSELF.**

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**INTRODUCTION:** The purpose of this study is to investigate changes of the disc stress and range of motion (ROM) at adjacent segments after lumbar fusion, based on the existence of instrumentation or the preservation of continuity of proximal ligament complex (PLC) using finite element (FE) method.

**METHODS:** In the validated intact lumbar FE model (L2-5), four scenarios such as the preservation of the continuity of PLC with pedicle screws (PpWiP), the preservation of continuity of PLC without pedicle screws (PpWoP), the sacrifice of PLC with pedicle screws (SpWiP), the sacrifice of PLC without pedicle screws (SpWoP), were simulated. Under 4 pure moments (flexion, extension, lateral bending, axial rotation), the ROM and maximal Von mises stress of discs at adjacent segments were analyzed in each scenario.

**RESULTS:** Among 4 scenarios, there was the most increase of ROM at the proximal adjacent segment in the SpWiP. The SpWoP, PpWiP, and PpWop were followed. Under flexion moment, ROM at the proximal adjacent segment was most different between the SpWiP and PpWoP (7.6° and 6.4°, respectively). Similar to the change of ROM, the SpWiP lead to the most increase of maximal von Mises stress of disc (84.5%) at proximal adjacent segments under flexion moment, while the least increase of stress (16.7%) was noted at the corresponding level in the PpWoP.

**DISCUSSION:** The current study suggests that the preservation of the continuity of PLC or the removal of pedicle screws after complete fusion might decrease the stress at adjacent segments, and their combination decrease the stress of adjacent disc much more. Conversely, the combined effect of these risk factors would make the adjacent segments overstressed exceedingly. Furthermore, the preservation of PLC has much more contribution for decrease of stress at adjacent segments than removal of instrumentation.

## GENERAL POSTERS

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### **GP20. A MORPHOLOGICAL ADAPTATION OF THE THORACIC AND LUMBAR VERTEBRAE TO LUMBAR HYPERLORDOSIS IN YOUNG AND ADULT FEMALES**

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The lumbar shape in females is thought to be unique and compensating for lumbar hyperlordosis. Yet, the morphological adaptation of various vertebral parameters in the thoracic and lumbar spine to this unique posture in young and adult females is partially addressed in the literature. The current study aims to investigate the gender association with vertebral shape in the thoracic and lumbar spine as a possible adaptation to lumbar hyperlordosis in young and adult females.

A 3-dimensional digitizer was used to measure the vertebral body sagittal wedging, relative spinous process thickness, and interfacet width at the T1-L5 level. Two hundreds and forty complete, non-pathological skeletons of adults (males and females, White Caucasians and African Americans, age range from 20 to 80 years), and 32 skeletons of young individuals (10 boys and 22 girls with an average age of 11.5 (+/-4.2) years) housed at the Hamman-Todd Human Osteological Collection (Cleveland Museum of Natural History, Cleveland, OH) were assessed. Statistical analysis included Pearson's r and ANOVA following the Kolmogorov-Smirnov test for normal distribution.

The results have indicated that in children, all calculated parameters are not affected by gender. In the adult human skeletons three major results are indicated independent of age and ethnicity: a-VB sagittal wedging in females is significantly less kyphotic than males from T9 to L2 (T11 excluded) with a cumulative mean difference of 8.80; b- females have significantly relatively thinner lumbar (L1-L5) spinous processes and c- relatively wider superior interfacet distance (T9-T10 and L1-L4) than males.

To conclude, the combination of less kyphotic VB wedging in the lower thoracic and upper lumbar vertebrae, relatively greater interspinous space and larger interfacet width in the lumbar spine in females are key architectural elements in the lumbar hyperlordosis in females and may compensate for the bipedal obstetric load during pregnancy.

### GP21. CAN THE EXTRUSION RISK OF INJECTED DISC CELLS BE REDUCED WITH ALBUMIN GEL AS A CELL CARRIER?

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**INTRODUCTION:** New therapeutic approaches utilize autologous intervertebral disc cells as a source for regenerative cell populations to be re-injected into the degenerated nucleus pulposus of patients. One of the drawbacks of this method is the fact that cells are injected as a liquid suspension creating the risk of leakage of cells from the injection site under mechanical loading. To overcome this technical problem, an in situ polymerizing gel based on chemically crosslinking albumin as a cell carrier and hyaluronic acid as a hydrodynamic additive was designed.

**METHODS:** We studied the biomechanical changes of spinal segments after injection of the gel and evaluated the risk of extrusion. 12 lumbar calves segments were tested, 6 treated and 6 controls. We performed flexibility tests in the three principal motion planes, before, after injection, and 100,000 complex load cycles to provoke extrusion.

**RESULTS:** The injection of the gel initially decreased slightly the flexibility in lateral bending but maintained it for flexion/extension and axial rotation compared to the intact segment. The cyclic test caused a successive increase of the flexibility in all motion planes beyond the initial ROM. The disc height showed an initial increase of about 0.25 mm after the gel injection and then a decrease of -1.4 mm due to the dynamic loading. These changes in flexibility as well as in height were the same as in an untreated control group.

Most importantly, however, no extrusion of the polymerizing gel could be noticed over the 100,000 cycles. Finally, macroscopic sections exhibited a decrease of the volume of the implanted gel, probably due to loss of water.

**DISCUSSION:** The results suggested that injection of the new polymerizing gel might be suitable to anchor re-injected autologous intervertebral disc cells or mesenchymal stem cells as a source for regenerative cell populations into the damaged nucleus pulposus.

## GENERAL POSTERS

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### GP22. SURGICAL OUTCOMES OF PLIF FOR ISTHMIC SPONDYLOLISTHESIS

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**OBJECTIVES:** The purpose of this study was to investigate 1) clinical results of PLIF for isthmic spondylolisthesis, 2) influences of preoperative slippage and reduction of slippage/disc height on surgical outcomes as well as postoperative complications.

**METHODS:** We reviewed 76 patients who underwent PLIF with pedicle screws for isthmic spondylolisthesis and were followed for at least 2 years. The average follow-up period was six years. The patients were divided into two groups according to the preoperative slippage. (Group 1: 68 patients who revealed the slippage less than 50%, and Group 2: 8 patients who revealed the slippage more than 50%). Surgical outcome using JOA scoring system and postoperative complications were investigated. As for radiographic evaluations, reduction of slippage/disc height, instrumentation failure, and fusion status were also examined.

**RESULTS:** Clinical results were worse in the elderly populations more than 60 years old and Groups 2 patients. Postoperative neurological deficits were observed in six patients (7.9%), although all cases had fully recovered. No correlation was detected between the preoperative slippage and the occurrence of the postoperative neurological deficits. Postoperative instrumentation failures were observed in five cases and more frequent in Meyerding grade 3-4 groups. The reduction of slippage/disc height did not affect surgical outcomes and the occurrence of the postoperative neurological deficits and instrumentation failures.

**DISCUSSION:** Generally, isthmic spondylolisthesis revealed more slippage and less disc height in compare with degenerative spondylolisthesis. The reduction for isthmic spondylolisthesis has been controversial. In the present study, the reduction of slippage/disc height did not affect surgical outcomes and complications in Meyerding grade 1-2 groups. On the other hands, clinical outcomes were worse in Meyerding grade 3-4 groups by reason of the complications such as pseudoarthrosis and instrumentation failure.

### **GP23. A FRESH LOOK AT THE NUCLEUS/ENDPLATE REGION: MICROMECHANICAL EVIDENCE FOR A HIGHER LEVEL OF STRUCTURAL INTEGRATION**

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**INTRODUCTION:** The nucleus pulposus is commonly viewed as a largely unstructured amorphous gel having little structural integration with the cartilaginous endplates. However our recent work suggests that at least in the ovine lumbar disc there is evidence of structural cohesion both within the core of the nucleus and across the nucleus-endplate junction. This study aims to explore this aspect of cohesion in more detail.

**METHODS:** Frozen motion segments were axially sawn to remove most of the outer annulus, leaving a predominantly vertebra-nucleus-vertebra sample. This composite sample was then loaded in tension whilst carefully ring-severing the remaining annular structures, after which a further 200-500% stretch was obtained. In this extensively stretched state the sample was then chemically fixed and decalcified so that it could be examined microscopically.

**RESULTS:** Even with the annular fibres severed, and thus rendering them non load-bearing, there was a sufficient degree of structural cohesion within the body of the nucleus to transmit some load while undergoing tensile extension  $\sim 2-5x$  that of the intact height of the disc. Microscopic examination revealed fibres inserting into the endplates and extending continuously from endplate to endplate in the central nuclear region.

**DISCUSSION:** The resistance of the vertebra-nucleus-vertebra samples to tension indicates that there is structural cohesion to the nucleus and that it is overly simplistic to describe the nucleus pulposus as a free-flowing gel. Our structural evidence of fibres coursing from the central nucleus into the endplates may help account for the clinical observation that endplate material can be associated with herniated nucleus.

### GP24. ANOMALOUS MICRO-ARCHITECTURAL FEATURES IN ELDERLY VERTEBRAE: MICROCT OBSERVATIONS

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**INTRODUCTION:** Age-related changes to vertebral bone associated with osteoporosis include the loss of bone mineral content and alterations to the three-dimensional micro-architecture, especially in cancellous / trabecular bone. Both have consequences for the load bearing capacity of the vertebra and, therefore, fracture risk. Here we report additional anomalous observations made using high-resolution micro CT imaging.

**METHODS:** Lumbar vertebrae (16) were isolated from 4 male donors, mean age 78 years. Cylindrical bone specimens were isolated by coring endplate-to-endplate through the center of each vertebral body. Specimens were imaged in a micro CT scanner ( $\mu$ CT40, Scanco Medical), with a scan resolution was 10  $\mu$ m. Bone volumetric fraction (BV/TV) was calculated using the standard algorithm of the scanner software. Three-dimensional reconstructions of each specimen were created by automated segmentation of the CT dataset.

**RESULTS:** Bone specimens were osteoporotic, with a low bone volume fraction (0.06 - 0.15). Surprisingly, there was considerable variation in bone volume fraction between specimens from individual donors. Specimens exhibited characteristic osteoporotic architectural changes (e.g. trabecular thinning, increased trabecular spacing, low connectivity). Of particular interest were features we have not previously observed, including: a large degree of micro-callus formation on individual trabeculae, extreme heterogeneity in bone architecture within individual specimens and a sharply-defined "calcification front" delineating regions of normal trabecular architecture from regions completely saturated with mineralized bone.

**DISCUSSION:** While purely observational in nature, and limited to a small sample population, the micro-architectural features described here are intriguing. Increasing micro CT image resolution has allowed the identification of sites of micro-fracture and repair within the vertebral trabeculae. Localized regions of highly sclerotic bone have been observed. Both imply a more complex process of damage and repair, even in the aged bone. Further study is required to elucidate the poorly understood process of bone turnover in osteoporotic vertebrae.

### GP25. ARCHITECTURE OF HUMAN ABDOMINAL WALL MUSCLES: IMPLICATIONS FOR MECHANICAL FUNCTION

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**INTRODUCTION:** Knowledge of muscle architecture defines the structural basis for predicting muscle function. Abdominal muscles greatly affect spine loading, stability, injury prevention and rehabilitation; however, their architectural properties are unknown. The purpose of this study was therefore to quantify the architectural properties of rectus abdominis (RA), external oblique (EO), internal oblique (IO) and transverse abdominis (TrA), and model mechanical function in light of these new data.

**METHODS:** Abdominal muscles from eleven human cadavers were removed intact, separated into regions and micro-dissected for quantification of physiological cross-sectional area (PCSA), fascicle length and sarcomere length. From these data, sarcomere operating length ranges were modeled.

**RESULTS:** IO had the largest PCSA (and thus the largest force generating capacity), followed by EO, TrA and RA, respectively. RA and EO had the longest optimal fascicle lengths, and would thus generate force over the widest range of lengths. Measured sarcomere lengths, in the post-mortem neutral spine posture, were significantly longer in RA and EO ( $3.29 \pm 0.07 \mu\text{m}$  and  $3.18 \pm 0.11 \mu\text{m}$ ) compared to IO and TrA ( $2.61 \pm 0.06 \mu\text{m}$  and  $2.58 \pm 0.05 \mu\text{m}$ ) ( $p < 0.0001$ ). Biomechanical modeling predicted that RA, EO and TrA act at optimal length in the mid-range of lumbar spine flexion, where IO can generate approximately 90% of its maximum force.

**CONCLUSION:** Based on their architectural parameters, functional capabilities of the abdominal muscles were defined and interpreted. IO can generate the largest forces, but over the smallest range of lengths. RA is designed to accommodate the largest length changes, but can generate relatively little force. EO and TrA both play intermediate roles, with EO being able to generate larger forces over a wider range of lengths. Future work will explore the mechanical interactions among these muscles, accounting for neural control strategies, and their relationship to spine health and function.

## GENERAL POSTERS

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### GP26. ASSESSMENT OF SPINAL FUSION STATUS USING BIOMECHANICAL COMPUTED TOMOGRAPHY

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**INTRODUCTION:** Patient-specific finite element analysis of CT scans — aka Biomechanical Computed Tomography, BCT — uses data from clinical CT scans to assess bone strength and stiffness. Using BCT, virtual loading of a fused segment allows the mechanical behavior of the bone and the quality of the fusion to be quantified. This may provide a more objective and clinically useful measure of the success of a spinal fusion than current techniques

**METHODS:** Patients who had undergone multiplanar CT scans following an interbody fusion were identified. Based on a qualitative assessment of the CT, segments were classified as fused (definite bridging bone) or non-fused (no bridging bone). BCT analysis was performed on seven fused and twelve non-fused segments. Finite element models were constructed from a 3D reconstruction of each CT scan. Stiffness, strength, maximum plastic strain, and percent of failed tissue were measured. The outcomes were compared across fused and non-fused groups.

**RESULTS:** The percent of failed bone was the best discriminator of fused from non-fused cases. In particular, all non-fused cases had less than 40% failed tissue (range 15–38%) whereas all fused cases had greater than 40% failed tissue (range 41–54%).

**DISCUSSION:** This preliminary study indicated that BCT correctly classified fused and non-fused segments based on quantification of the percent of failed tissue in response to virtual compression loading of the fusion construct. The non-fused segments appear to fail due to high strains in localized regions near the implant, whereas fused segments are more stable near the implant and fail in a more diffuse pattern (more failed tissue, but less severe strains). BCT may be valuable clinically if it better identifies true non-fused cases when CT produces an uncertain classification. These promising results warrant a more comprehensive study of BCT for assessment of fusion status.



### GP27. INTRADISCAL PRESSURE GENERATION DEPENDS ON LOAD-HISTORY IN RAT CAUDAL DISCS

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**INTRODUCTION:** It is generally accepted that the hydration state of the intervertebral disc is linked with its mechanical function. Load history influences disc hydration and other factors, impacting the disc's behavior for subsequent loads. Using an analytical model we previously showed that load history has a profound effect on the mechanical function of different subregions. Since swelling of the nucleus pulposus (NP) plays a central role in disc mechanics, we sought to elucidate the dependence of intradiscal pressure (IDP) on load history.

**METHODS:** Fresh caudal rat motion segments were mounted onto a materials testing machine, and a custom made Fabry-Perot fiber optic pressure sensor was inserted into the NP. Specimens were preloaded at 0.05 MPa or 0.3 MPa for 1,800 seconds, and then loaded for an additional 0.5 MPa for 900 seconds. These tests were meant to simulate, but not mimic, our previous experiments demonstrating load history dependence under compressive creep loading. Our pressure measurements were compared with analytical results of creep using three models: stretched exponential, Kelvin-type standard solid viscoelastic and the Cassidy fluid transport model.

**RESULTS:** The models showed that load history impacts the disc behavior; a larger preload results a loss in viscoelastic properties. More specifically, the fluid transport model detected large changes in the parameter related to contribution of swelling from the NP. IDP measurements at 0.5 MPa showed 30% lower pressures generated when applied after a higher preload.

**DISCUSSION:** Load history is an important aspect of disc mechanics; the resultant load is not the only determinant in predicting local stresses in the disc. The greater preload decreased disc hydration, leading to a compromised ability for the NP to pressurize. These results could have profound influence on the mechanobiology of NP cells, whose exposure to pressure could be impacted by the load history of the disc.

## GENERAL POSTERS

### GP28. SPINAL INSTRUMENTATION FOLLOWING COMPLETE RESECTION OF THE LAST LUMBAR VERTEBRA: AN IN VITRO BIOMECHANICAL STUDY FOLLOWING L5 SPONDYLECTOMY

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**INTRODUCTION:** Total spondylectomy (TS) remains a preferred treatment for certain tumor lesions. Biomechanically, L5 TS presents the most challenging case scenario for spinal reconstruction. Unfortunately, there is no consensus reported as to the extent of adequate stabilization required after L5 TS. This current biomechanical study was aimed at establishing the optimal extent of instrumentation required following L5 TS.

**METHODS:** Seven L2-S1 cadaveric spines with iliac crest were tested using a 6DOF tester. Following intact testing, L5 TS was performed and expandable cage was used at L4-S1. The following reconstruction techniques were used: 1) L4-S1 bilateral pedicle screws (SP); 2) anterior lumbar plating + SP (ASP); 3) L3-S1 bilateral pedicle screws + iliac screws (MP); 4) anterior lumbar plating + MP (AMP).  $\pm 6$ Nm moments were applied in flexion-extension (FE), lateral bending (LB), and axial rotation (AR). Range of motion (ROM) was recorded at L4-S1. The data was normalized to intact (100%). Statistical analysis was performed using one way ANOVA at  $p < 0.05$ .

**RESULTS:** In FE and LB, all constructs significantly ( $p < 0.05$ ) reduced ROM compared to intact. In AR, ASP and AMP significantly ( $p < 0.05$ ) reduced ROM compared to intact ( $p < 0.05$ ). ASP and AMP significantly ( $p < 0.05$ ) reduced ROM compared to SP in FE and AR ( $p < 0.05$ ). SP-MP and ASP-AMP were statistically comparable ( $p > 0.05$ ) in all loading modes.

	Intact(%)	SP(%)	ASP(%)	MP(%)	AMP(%)
FE	100	38 $\pm$ 12*	21 $\pm$ 12*#	32 $\pm$ 12*	19 $\pm$ 13*#
LB	100	26 $\pm$ 11*	20 $\pm$ 9*	17 $\pm$ 9*	16 $\pm$ 9*
AR	100	107 $\pm$ 46	56 $\pm$ 20*#	81 $\pm$ 24	58 $\pm$ 14*#

**Table 1:** Normalized ROM at L4-S1 (\* vs. Intact, # vs. SP at  $p < 0.05$ )

**DISCUSSION:** Anterior plating significantly increased the stability of circumferential constructs. Adding L3 pedicle screws and iliac screws to the posterior instrumentation did not significantly increase stability. In conclusion, following L5 TS, supplementing of the L4-S1 cage with posterior short segment instrumentation and anterior plate provides sufficient stability. Extending posterior instrumentation does not significantly increase this stability.

### GP29. A BIOMECHANICAL MODEL OF DEGENERATIVE SPONDYLOLISTHESIS: RESULTS OF PURE SHEAR TESTING

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**INTRODUCTION:** At present there is no reported, valid and reproducible model of degenerative spondylolisthesis for biomechanical testing of spinal implants. The purpose of this study was to create a single functional spinal unit (FSU) model that could demonstrate anterolisthesis consistent with low grade degenerative spondylolisthesis under physiologic shear loads.

**METHODS:** Eight fresh-frozen human cadaveric, lumbar FSU's were potted and secured in a custom jig for pure shear testing. The cranial segment was loaded from -50N (posterior) to 250N (anterior) over three cycles for each of five test conditions with a 300N preload. Test conditions addressed known restraints to shear translation and were performed in the same order for all specimens, and included: intact, facet capsulectomy and bilateral 2 mm facet gap, bilateral 4 mm facet gap, nucleotomy, and annular release. Three-dimensional motion was recorded using an optoelectronic camera system.

**RESULTS:** Mean anterior translation at 250N for the five test conditions was 0.7 mm (95% confidence interval 0.4 to 0.9), 1.2 mm (0.9 to 1.6), 1.5 mm (1.1 to 2.0), 1.9 mm (1.4 to 2.4) and 3.1 mm (2.2 to 4.0). The mean maximum anterior translation was significantly different for each test condition with two exceptions. The 4 mm facet gap did not result in a significantly different maximum anterior translation compared to the 2 mm facet gap or the nucleotomy. There were no differences in off-axis motion (lateral or superior-inferior translation, flexion-extension, axial rotation, lateral bending) between the five test conditions.

**CONCLUSION:** Anterior translation consistent with low grade degenerative spondylolisthesis was repeatedly demonstrated under physiologic shear loads using this model. All sequential destabilizations preserved anatomy critical for the application of pedicle screw constructs, interbody devices and interspinous spacers. As such, this model is appropriate for biomechanical testing of implants currently used in the treatment of low grade degenerative spondylolisthesis.

## GENERAL POSTERS

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### GP30. BIOMECHANICAL EVALUATION OF THORACO-LUMBAR BURST FRACTURES TREATED WITH CALCIUM PHOSPHATE: AN IN-VITRO CADAVERIC STUDY

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**INTRODUCTION:** A cadaveric study to evaluate the biomechanical performance of Calcium Phosphate Cement (CaP) with Uni-level (short) and Bi-level (long segment) pedicle screw instrumentation above and below the fractured vertebrae for burst fracture treatment.

**METHODS:** Six T10-L4 cadaveric spines were tested on a 6 degree of freedom spine simulator. Each vertebral body was compressed at 50mm/min in a materials testing machine (MTS, Eden Prairie, MN). However, before compressing minimal osteotomies were created at the anterior cortex of the L1 vertebral body to ensure reproducible fracture at L1. The L1 vertebral body was reinforced with the CaP cement through balloon-assisted bi-pedicular approach. The fracture was then stabilized with bi-pedicle screw (BPS) and rod construct and flexibility was determined. Surgical constructs included: 1) Intact 2) Injured 3) CaP + BPS T12-L2 4) CaP + BPS T11-L3 and 5) CaP Alone. Range of Motion (ROM) was recorded at T12-L2. The data was normalized to Intact (100%). Statistical analysis was performed using t-Test: Two Sample assuming unequal variances ( $p < 0.05$ ).

**RESULTS:** ROM was significantly changed both in FE and LB in all constructs w.r.t Intact. ROM tended to be lesser with CaP + BPS T11-L3 (FE 23%, LB 19%, AR 106%) than for CaP + BPS T12-L2 (FE 48%, LB 55%, AR 123%), but this difference was statistically significant only in FE. The CaP + BPS T11-L3 construct did not significantly reduce motion compared to CaP + BPS T11-L2 (FE 37%, LB 39%, AR 111%) construct. All posterior instrumentation constructs did not reduce motion significantly compared to Intact in AR. CaP alone construct compared to intact did not stabilize the specimen.

**DISCUSSION:** No significant change was found in the biomechanical properties of cadaveric spines with short segment above and below the fractured vertebrae compared to long segment implantation except for FE. Addition of a T-connector may reduce the motion significantly in AR.

### GP31. LUMBAR AND HIP SAGITTAL MOVEMENT: INFLUENCE OF SEX AND AGE

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Assessment of lumbar and hip movement is important for understanding risks, prevention and rehabilitation of low back pain (LBP). It has been suggested that a link between flexion and LBP may be found in the pattern of hip and lumbar coordination/dominance instead of the magnitude of motion. With lumbar dominance a possible risk factor in developing LBP.

The aim is to quantify both magnitude and pattern of lumbar and hip rotation during forward bending in both sexes. Sixty males and 60 females aged 18-50 years of age were recruited. Exclusion criteria were the presence of LBP in the previous 12 months and previous fracture or surgery to the spine, pelvis or lower limb. A 3D Motion Analysis system was used to measure lumbar and hip rotations using surface reflective markers. Participants undertook 5 randomized full flexion and full extension movements.

The results showed that male and female lumbar ROM in flexion decreased between the first and last decade of age,  $-7.4^\circ$  and  $-8.0^\circ$  respectively ( $p < 0.05$ ) but there was no significant difference in hip flexion. Flexion lumbar ROM in males was higher ( $50.3^\circ$ ) than in females ( $39.2^\circ$ ), however hip ROM in males was lower with no significant difference in total ROM between sexes,  $65.2^\circ$  and  $76.9^\circ$  respectively. One year following, 13.3% of female and 22.2% of male respondents experienced LBP. No female with LBP were lumbar dominant and tended to have lower lumbar ROM than their respective age group means. Males with LBP however did show a tendency towards lumbar dominance and higher lumbar ROM than their respective age group means. Consistent across both sexes was an increase in LBP with age. Sex and age differences are apparent in lumbar ROM; notwithstanding the effect of age, the role of lumbar flexion in LBP may vary between males and females.

## GENERAL POSTERS

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### **GP32. USE OF A ROBOT-BASED SEQUENTIAL DISSECTION TECHNIQUE APPLIED IN PORCINE MOTION SEGMENTS TO IDENTIFY WHICH SPINAL TISSUES ARE LOADED DURING THE APPLICATION OF MANUAL THERAPY.**

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**INTRODUCTION:** Manual therapy, a common treatment for low back pain, varies in its therapeutic impact. If the spinal tissues affected by manual therapy could be identified, then clinicians may better recognize those conditions and subjects who respond maximally. Using serial dissection in concert with parallel robotics, it is now possible to use an animal model to determine which spinal tissues are loaded by manual therapy and to what magnitude.

**METHODS:** Spinal manipulation and mobilization were applied to L3 in nine cadaveric pigs and the kinematic response of L3-4 was recorded by optical tracking of indwelling bone pins. The L3-4 segment was then removed and mounted with the cephalad end held stationary and the caudal end mounted to a 6 degree-of-freedom load cell placed in series with the robot. The exact kinematic trajectory experienced by L3-4 in response to both manipulation and mobilization was then replayed by the robot to the isolated segment. Discrete tissues were then removed (interspinous ligament, intertransverse ligaments, facet capsules, facets, disc) and each kinematic pathway replayed. Based on the principle of superposition, the change in force and moment following the removal of a tissue was considered to be the force a moment experienced by that tissue during manipulation or mobilization.

**RESULTS:** All tissues experienced forces and moments as a result of manipulation or mobilization. In both manipulation and mobilization, the tissue experiencing the greatest force and/or moment was the intervertebral disc.

**CONCLUSIONS:** This study is the first to identify which tissues are loaded in response to manual therapy and to what magnitude. The observation that manual therapy loads some tissues significantly more than others may help clinicians better identify when manual therapy is indicated (or contraindicated). Future studies are planned to determine if manual therapy can be altered to target (or avoid) specific spinal tissues.

### GP 33. DELAMINATION OF THE ANULUS: HOW DOES THE ANTERIOR DIFFER FROM THE POSTERIOR IN TERMS OF THE ENERGY REQUIRED TO PROPAGATE DELAMINATION?

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**INTRODUCTION:** Disc herniation is often accompanied by anular delamination. Rarely does the nucleus pulposus (NP) migrate through the anulus fibrosus (AF) linearly, but rather tends to travel via circumferential fissures between the lamellae. As herniation propagates, the NP places stress on the lamellae as well as on the inter-lamellar matrix. These stresses are thought to pry the anular layers apart which allow the NP to occupy the fissure that has formed between lamellae. The mechanical properties of the inter-lamellar matrix are largely unknown; yet this information is vital in validating these hypothesized failure mechanisms and to understand why delamination tends to occur primarily in the posterior region.

**METHODS:** Six human AF samples (three anterior; three posterior), each containing approximately six lamellae, were tested. For each sample, separation between layer three and four was initiated. Samples were then mounted in a material testing apparatus to propagate the separation via a T-peel test. Samples were stretched cyclically at 2mm/sec in increasing increments equal to 1% of original length (jaw-to-jaw) until 30%. Photographs were taken pre and post-test to determine the area of fracture during the peel test. Fracture toughness, the energy to propagate the delamination, was calculated.

**RESULTS:** Fracture area was  $5.68 \pm 3.24 \text{ mm}^2$  for anterior and  $5.23 \pm 1.71 \text{ mm}^2$  for posterior samples ( $p=0.84$ ). The fracture toughness tended to be higher for anterior samples ( $76 \pm 54 \text{ J/m}^2$ ) than posterior samples ( $23 \pm 2 \text{ J/m}^2$ ,  $p=0.17$ ).

**DISCUSSION:** The examined mode of failure is akin to the failure that may occur during herniation progression. As the NP exudes into the AF, it acts to pry anular layers apart resulting in delamination similar to that created during the peel test. Further, the trend of reduced fracture toughness in the posterior may help to explain why delamination is generally observed in the posterior region of the anulus.

## GENERAL POSTERS

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### GP34. THE DIFFERENCE IN SPINE SPECIMEN DXA BMD BETWEEN IN-SITU AND IN-VITRO SCANS

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**INTRODUCTION:** Bone mineral density (BMD) is an important factor in the performance of spinal implants; higher BMD is associated with a stronger bone-implant interface. It is common for *in-vitro* biomechanical studies to carry out dual-energy X-ray absorptiometry (DXA) scans on harvested spine specimens to measure BMD. The purposes of this study were 1) to develop a correction factor between DXA BMD of un-explanted *in-situ* and explanted *in-vitro* spinal specimens, and 2) to assess the application of this correction factor on *in-vitro* BMD values.

**METHODS:** DXA scans were previously carried out on 106 male and 83 female lumbar specimens. Using multiple regressions, the correlation functions between Z-score, BMD and age were determined for male and female groups. The correction factor was developed based on difference in BMD between mean *in-vitro* and population data. Next, *in-situ* DXA scans were carried out on 19 lumbar vertebrae from 4 full cadavers and subsequently after explantation *in-vitro* scans were carried out on these same specimens. The correction factor was applied to these *in-vitro* scan data and the resulting corrected BMD compared with *in-situ* scan values.

**RESULTS:** The mean Z-score of  $-0.7$  (s.d.=1.4) for male and  $-0.3$  (s.d.=1.3) for female specimens were significantly less than zero ( $p<0.001$  and  $p=0.03$  respectively). Mean BMD of these male specimens, as a function of age, was uniformly  $0.06 \text{ g/cm}^2$  lower than the population reference data. The difference between BMD of these female specimens was a function of age. *In-situ* BMDs ( $1.148 \text{ g/cm}^2 \pm 0.221$ ) were higher than *in-vitro* BMDs ( $1.080 \text{ g/cm}^2 \pm 0.141$ ) in repeated scans on specimens ( $p=0.04$ ). Application of the correction factor resulted in corrected *in-vitro* BMD not significantly different from *in-situ* BMD ( $p=0.13$ ).

**DISCUSSION:** *In-vitro* BMD was determined to be lower than *in-situ* BMD. A correction factor when used resulted in more accurate measure of the *in-situ* BMD.



### **GP35. NORMAL AXIAL AND BENDING STIFFNESS OF MOTION SEGMENTS ARE PRESERVED ON IMPLANTATION OF A NOVEL MONO-BLOCK ELASTOMERIC TOTAL DISC REPLACEMENT**

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**INTRODUCTION:** Conventional articulating total disc replacements fail to reproduce the biomechanics of the natural intervertebral disc in terms of progressive resistance to bending, axial stiffness and the ability to load the vertebral endplate uniformly as it deforms under compression. New elastomeric devices, such as CAdisc-L, have the potential to replicate such behaviour.

**HYPOTHESIS:** This study tests the hypothesis that CAdisc-L reproduces the bending and axial stiffness of an intact intervertebral disc and deforms with the vertebral endplate.

**METHODS:** 10 cadaveric human lumbar motion segments were selected using criteria of disc space fitting a Medium 6° CAdisc-L and normal bone mineral density. The segments were tested in pure axial compression and in a physiological relevant combination of bending and compression. CAdisc-L was then implanted and the loading measurements were then repeated. Axial stiffness was determined from a linear fit to the load-deformation data, whilst bending stiffness was calculated from a logarithmic fit to the bending angle-bending moment data.

**RESULTS:** The axial stiffnesses of the intact and implanted segments were  $1970 \pm 130$  N/mm and  $870 \pm 60$  N/mm respectively. Bending stiffness of the intact segments increase from  $4.1$  Nm/° to  $16.4$  Nm/° as bending moment increase from 10 Nm to 40 Nm. The bending stiffness of the implanted segments followed the same pattern of progressively increased stiffness, but was on average 18% less stiff.

**DISCUSSION:** The hypothesis was confirmed, CAdisc-L reproduced the axial and bending stiffness of the intact segment. The CAdisc-L implanted segments whilst less stiff than the intact but fell within the normal range. CAdisc-L must deform into the vertebral body like a natural disc since the stiffness of the implanted segments was lower than the implant alone. The magnitude of bending stiffness and pattern of increasing stiffness with bending moment were similar between the intact and implanted segments.

### GP36. COMPARISON OF THE ACTIVITIES OF THE DEEP TRUNK MUSCLES MEASURED USING INTRAMUSCULAR AND SURFACE ELECTROMYOGRAPHY

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**INTRODUCTION:** Surface electromyography (EMG) has been used for estimating the activity of the deep trunk muscles. However, whether the surface EMG provides an accurate estimation of the activity of the deep trunk muscles remains unknown. The purpose of this study was to compare the surface EMG activity with the intramuscular EMG activity and to investigate the efficacy of surface EMG measurement for the transversus abdominis (TrA) and the multifidus (MF).

**METHODS:** The study participants included 8 healthy men. The activities of the TrA and the MF were measured using intramuscular EMG and surface EMG during the following isometric trunk exercises; Elbow-Toe with contralateral arm and leg lift, Hand-Knee with contralateral arm and leg lift, Back Bridge with single leg lift, Side Bridge with single leg lift and Curl Up. The relationship between the activities measured using intramuscular EMG and surface EMG was examined using the Spearman correlation coefficients and the Bland and Altman plot.

**RESULTS:** The correlation coefficients for the activity of the right TrA, the left TrA, the right MF and the left MF were 0.55, 0.36, 0.67, 0.79, respectively. For the TrA, the mean difference between the activities obtained using intramuscular EMG and surface EMG was not close to zero (right TrA: 8.5 %MVC, left TrA: 10.4 %MVC), and the limits of agreement were greater. On the other hands, the mean difference for the MF was close to zero (right MF, 0.94 %MVC: left MF, 2.5 %MVC).

**DISCUSSION:** The results indicate that the surface EMG did not measure the independent TrA activity, but the combined activities of the TrA and other muscles, most likely internal oblique. In conclusion, there was high correlation for the MF while there was low correlation for the TrA between the activity measured using intramuscular EMG and surface EMG.

### GP37. ANALYSIS OF THE MUSCLE ACTIVITY DURING ACTIVE PELVIC TILTING MOTION

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**INTRODUCTION:** Pelvic tilting is performed to improve lumbopelvic flexibility or for retraining the motor control of local muscles. However, few studies have investigated the activity of local and global muscles during active pelvic tilting. The purpose of this study was to investigate muscle activity during anterior and posterior pelvic tilting motion.

**METHODS:** Twelve healthy males (age,  $22.6 \pm 1.4$  years; height,  $169.9 \pm 5.7$  cm; body mass,  $69.6 \pm 7.6$  kg) participated. Fine-wire electrodes were inserted into the bilateral lumbar multifidus (MF) and transversus abdominis (TrA). Surface electrodes were used to record activity of the bilateral rectus abdominis, external oblique, and erector spinae (ES), and the unilateral right latissimus dorsi, gluteus maximus, semitendinosus, and rectus femoris muscles. The electromyographic activities during anterior and posterior pelvic tilting motion in a standing position were recorded and expressed as a percentage of the maximum voluntary contraction (%MVC) for each muscle.

**RESULTS:** The activity of the bilateral MF (right:  $23.9 \pm 15.9\%$ , left:  $23.9 \pm 15.1\%$ ) and right ES ( $19.0 \pm 13.3\%$ ) was significantly higher than that of the other muscles during anterior pelvic tilting motion. The activity of the left TrA ( $14.8 \pm 16.4\%$ ) was significantly higher than that of the other muscles during posterior pelvic tilting motion.

**DISCUSSION:** The results suggest that the MF is related to anterior pelvic tilting motion. In previous studies, the activity of the MF increased to maintain lumbar lordosis, which is associated with anterior pelvic tilting. The TrA, which was classified as a local muscle, showed higher activity during posterior pelvic tilting motion. We consider that since the TrA is directly attached to the iliac crest, this muscle is related to posterior pelvic tilting motion. This study indicates that local muscles such as the MF and TrA may be related to pelvic tilting motion.

### GP38. THE ANALYSIS OF TRUNK AND LOWER EXTREMITY MUSCULAR ACTIVATION DURING RUGBY SCRUMMAGING

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**INTRODUCTION:** Previous study reported that approximately 45% of rugby union players have a history of low back pain (LBP). In particular, front row players tend to suffer from LBP because of the absorption and transmission of great forces in unsteady scrummaging. This study aimed to demonstrate the characteristics of the activity of trunk and lower extremity muscles during scrummaging.

**METHODS:** Subjects were six healthy males who have played rugby union for over 4 years. The electromyographic activity of the static and pushing phase during scrummaging were recorded as following; fine-wire electrodes for the bilateral transversus abdominus (TrA) and lumbar multifidus (MF), and surface electrodes for the bilateral rectus abdominis (RA), external oblique (EO), and erector spinae (ES) and for the right latissimus dorsi (LD), gluteus maximus (GMA), semitendinosus (ST), and rectus femoris (RF). Electromyographic data was expressed as a percentage of the maximum voluntary contraction (%MVC), and statistically analyzed using ANOVA with Tukey post hoc testing.

**RESULTS:** The activity of the EO, TrA, ES, and MF significantly increased between the static phase and the pushing phase ( $P < 0.05$ ). In particular, the TrA and MF increased from 9.3% to 53.0% and 8.4% to 24.0% respectively. However, there were no significant changes in the RA, LD, RF, ST and GMA.

**DISCUSSION:** It is widely accepted that there are functional disorders of the TrA and MF in LBP patients. The same disorders may be shown in players who have a history of LBP. Therefore exercises for these muscles, which lead to the performance enhancement, are essential. The result of this study indicated that local muscles were activated in unstable scrummaging. In daily life, there are various unstable movements that might cause LBP. To stabilize lumbar spine in the movements, the sufficient activity of local muscles is required through exercises.

### GP39. HYDATID INFESTATION OF THE SPINE - A LONG TERM FOLLOW-UP

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**INTRODUCTION:** Hydatid disease in bone is rare in relation to the infestation of other organs and occurs in bone approximately in 1% of cases of which 50% are spinal. Vertebral hydatidosis is a relatively silent and slowly progressive disease with a latent period of many years. Paraplegia the most serious complication of the disease is attributable to compression of the spinal cord or the cauda equina by the cysts. Posterior surgical decompression was reported to result in a high recurrence rate. The short term results after anterior decompression have been encouraging. Recent advances in imaging, especially magnetic resonance imaging, immunology and improvements in surgical technique have resulted in a better outcome.

**METHODS:** This retrospective study evaluated the long term results of radical anterior and posterior spinal decompression. Eleven patients were treated for spinal hydatid infestation between 1984 and 1996. The mean age was 27yrs and there were two females. The duration of back pain was 4.5 months prior to onset of weakness. All patients had neurological deficit at presentation Frankel B (9) Frankel C (2).

All patients underwent decompression and in two patients who had partial resection of the vertebral body and sacrum respectively developed recurrence. In nine patients radical anterior and posterior procedures were performed. The duration of antihelminthic medication with mebendazole and albendazole varied between 3 to 5 cycles.

**RESULTS:** Neurological recovery was noted in all patients (Frankel E 7, Frankel D 2, Frankel C 2). The mean follow up was 16 yrs (range 12-25yrs) Radical surgical excision of the lesion and antihelminthic medication have reduced the recurrence of spinal hydatidosis.

**DISCUSSION:** Posterior decompression alone has a high recurrence rate and is associated with progressive deformity. MRI is the gold standard in confirming the diagnosed and monitoring the disease at follow up.

### **GP40. SELECTIVE POSTERIOR DECOMPRESSION AND SHORT SEGMENTAL FUSION OF DEGENERATIVE LUMBAR SCOLIOSIS**

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**INTRODUCTION:** Degenerative lumbar scoliosis (DLS) is commonly present in older adult patients with spinal pain. The extent of fusion for degenerative lumbar scoliosis has not yet been determined. The purpose of this study is to analyse the surgical results of short segmental fusion after selective decompression for degenerative lumbar scoliosis.

**METHODS:** 42 patients with DLS complaining of lower extremities pain treated surgically in our hospital from January 2004 to June 2007 were reviewed. 15 males and 27 females, averaged 65.6 years old, were included. The follow-up time ranged from 1 to 3.5 years postoperatively. The selective posterior decompression and short segmental fusion with pedicle screws were employed, and fusion levels were limited within scoliosis curves. The fusion level, blood loss, operation time and perioperative comorbidity and complication were recorded. Preoperative and postoperative Cobb angles, lumbar lordotic angles, VAS and ODI were evaluated, and statistical difference was analysed.

**RESULTS:** The difference between preoperative and follow-up VAS score is statistically significant, and statistical difference also found in ODI score. The statistical difference was not found between preoperative and follow-up Cobb angles, and it was not found in lordotic angle, either. Early complication occurred to 23 percent of patients, including urinary infection, ileus et al. No major complications happened during perioperative period, and no screw failures, compression fracture occurred during the follow-up period.

**DISCUSSION:** Selective posterior decompression and short segmental fusion is an effective way to treat degenerative lumbar scoliosis with main complaint of lower limbs discomforts. The surgical results are related with lumbar canal and foraminal decompression, but not related with change of Cobb angles. The surgical treatment can reduce surgical injuries and leave more mobile levels for degenerated lumbar spine in old patients. Local stability was also preserved in this procedure.

### **GP41. CHANGE OF PELVIC TILT BEFORE AND AFTER GAIT IN PATIENTS WITH LUMBAR DEGENERATIVE KYPHOSIS**

Sang-Bum Kim, Whoan Jeang Kim, M.D., Jong Won Kang, M.D., Sung Il Kang, M.D.,  
Kun Young Park, M.D., Daejon, Korea

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**INTRODUCTION:** Lumbar degenerative kyphosis has dynamic changes which are closely associated with the motion of pelvis. We verify the availability of radiography and gait analysis in order to analyze the changes of pelvic tilt before and after gait in patients with LDK.

**METHODS:** We analyzed 18 lumbar degenerative kyphosis patients who didn't have multiple vertebral compression fractures, past history of spinal surgery or surgery for degenerative arthritis of knee or hip, and obesity which makes a marker error in gait analysis. Pelvic tilt was evaluated statically utilizing radiographs and dynamically utilizing gait analysis. Linear parameters of gait cycle and kinematic datas were obtained in gait analysis.

**RESULTS:** The mean walking velocity was 80.7cm/s, and it decreased largely to 65%, compared with normal value. The cause of decreased walking velocity was decrease of stride length, not decrease of cadence. The mean static pelvic tilt in gait analysis was  $-1.3 \pm 8.0^\circ$ , and there were 8 cases of anterior tilt and 10 cases of posterior tilt. The mean pelvic tilt during gait was  $12.5 \pm 8.2^\circ$ , and there were 17 cases of anterior tilt and 1 case of posterior tilt. It was statistically significant difference (p

**DISCUSSION:** Though there was no statistical significance, we observed anterior pelvic rotation after gait on radiographs. As fatigue of pelvic extensor muscles increases during gait, anterior pelvis tilt increases with statistical significance in gait analysis. Therefore gait analysis is thought to be useful for evaluate the dynamic change of pelvic tilt in patients with LDK.

### **GP42. CURVE PROGRESSION AND DECOMPENSATION AFTER POSTERIOR SHORT-SEGMENT FUSION FOR DEGENERATIVE LUMBAR SCLIOSIS**

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**INTRODUCTION:** Selection of fusion levels remains controversial in the surgical treatment of degenerative lumbar scoliosis. We reviewed radiographic and clinical outcomes of posterior short-segment fusion for degenerative lumbar scoliosis, and analyzed risk factors for postoperative curve progression and decompensation.

**METHODS:** 51 patients who had undergone instrumented posterior short-segment fusion for degenerative lumbar scoliosis were reviewed retrospectively. Number of fusion levels were 1.6 segments on average, and mean follow-up period was 23 months. Radiographic parameters were assessed using standing whole spine radiographs, which included Cobb angle of scoliosis, progression of residual curve, lateral slip and tilt of vertebra proximal to fusion, plumb line deviation, and fusion status. Clinical outcomes were evaluated using JOA score.

**RESULTS:** Mean Cobb angle was 16.1 degrees preoperatively, 9.8 degrees immediately postoperatively, and 15.1 degrees at the final follow-up. Fusion rate was 96%. JOA score was 14/29 before surgery, which improved to 22/29 immediately after surgery and 20/29 at the final follow-up. Residual scoliosis was 8.1 degrees immediately after surgery, and 16.5 degrees at the final follow-up. More than 10 degrees of curve progression were observed in five patients (10%), who showed poor clinical outcomes (JOA score=13/29). Multiple logistic regression analysis demonstrated that anterior deviation of plumb line ( $p=0.03$ , odds ratio=1.05) and lateral tilt of proximal vertebra ( $p=0.07$ , odds ratio=1.33) were related to curve progression. Relative risk for curve progression increased 4.9 times by 30 mm of anterior deviation of plumb line, and 4.1 times by 5 degrees of lateral tilt of proximal vertebra.

**DISCUSSION:** Although degenerative lumbar scoliosis was successfully treated in 90 % by posterior short-segment fusion, larger anterior deviation of plumb line and lateral tilt of proximal vertebra were risk factors for curve progression and decompensation. We recommend that vertebra with more than 10 degrees of lateral tilt should be included into fusion levels.



### GP43. THE ROLE OF POSTERIOR SPINAL FUSION IN HEALED POST-TUBERCULAR LUMBAR KYPHOSIS IN CHILDREN

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**INTRODUCTION:** Lumbar Tubercular kyphosis in children is cosmetically & functionally disabling with a fear of late onset paraplegia. Correction of deformity is difficult and hazardous. We propose posterior-fusion done in highly selective kyphosis resulting in self-correction or prevention of progression, avoiding later surgeries and complications.

**CLINICAL METHODS:** A prospective study of 20 patients over 5 yrs. Selection Criteria:

- a) Healed tuberculosis kyphosis mainly located in upper Lumbar spine.
- b) Progression of kyphosis at serial follow-up
- c) No or > 2 Spine-at-risk signs present. (Rajasekaran, 2001)

Posterior Fusion in situ with autogenous cancellous iliac crest bone grafts and irradiated allografts without instrumentation was done. Kyphosis correction assessed by clinical & radiological improvement in K angle of deformity. Post surgery, Total Body Contact Brace was prescribed for 6 months..

**RESULTS:** 20 lumbar spine cases were evaluated. 16 patients had no Spine-at-risk signs, 4 had <2 Spine-at-risk signs. 19 patients had a progressive increase in kyphotic angle pre-op. Mean follow-up: 5 yrs. Following fusion 75 percent patients showed a self-correction & clinical improvement. 20 % had static angle. Worsening in 1 patient.

**DISCUSSION:** Severe Kyphosis can pose later a risk of cardio-respiratory embarrassment and late-onset paraplegia. 39% children show worsening kyphus (Type IBgroup; Rajasekaran). Posterior fusion with autogenous cancellous chips along with allograft was done in all.

Self-correction is achieved by continued growth of anterior vertebral epiphyseal end-plates causing selective anterior-column growth. The pivot is the posteriorly fused mass and moment of the superior and inferior vertebral arms gives correction. With destruction of end-plates, the posterior-fusion gives complementary global fusion and halts the progression.

It avoids late onset paraplegia and need of highly morbid and complex radical surgeries later.

**CONCLUSION:** Posterior Spinal Fusion is simple, safe, acceptable and less morbid with good results, changing long-term disability of healed post tubercular lumbar kyphosis patients.

### **GP44. SURGICAL MANAGEMENT OF POST TRAUMATIC KYPHOSIS BY SINGLE STAGE ANTERIOR RECONSTRUCTION**

Mohamed M. Mossaad, MD, Ahmed S. Mohamed, MD

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**INTRODUCTION:** Spine trauma is relatively common, and each year approximately 10,000 to 17,000 people in the United States will sustain a spinal cord injury and approximately 150,000 to 160,000 will fracture their spinal column. Posttraumatic spinal deformity is a common potential complication of spinal injury and poses one of the greatest challenges in spinal surgery.

**MATERIALS AND METHODS:** Twelve patients with late post traumatic kyphosis at the thoraco lumbar junction (Ten males and two females), Mean age was 42.7 years (range, 18–58 years), ten were at level of T12 and two patients at level L1,. The average Sagittal plum line was 55 mm positive; the mean local Kyphotic angle was 49.3° range (35° to 60°). Seven patients had no neurological deficit. All were treated with one stage single mini anterior approach using strut bone graft or pyramesh with plate and screws fixation.

**RESULTS:** The average time was 160 minutes, and blood loss was 300 c.c., mean kyphosis angle was reduced to 7.0° range(0°–24°) with a mean 91.7% of correction, only one patient had a hypercorrection of 5° . There was no major complications occurred, and the rate of minor complications occurred was 3%. The fusion occurred in all cases between 3 and 6 months. Kyphosis angles improved significantly after surgery and at last visit.

**DISCUSSION:** The use of minithoractomy approach has favorable advantages over the extensive thoraco-phrenotomy approach..The distraction was the problem to restore the height of the vertebra in the earlier three cases. The rate of complications is lower with the minithoractomy approach. Anterior Decompression and fusion with strut grafting or pyramesh is a feasible option for the correction of post-traumatic Kyphotic deformity, and resolution of pain and other complaints.

### GP 45. RADIOLOGIC ANALYSIS OF POSTOPERATIVE SAGITTAL PLANE CORRECTION IN LUMBAR DEGENERATIVE KYPHOSIS (LDK)

Sang-Bum Kim, Whoan Jeang Kim, M.D., Jong Won Kang, M.D., Sung Il Kang, M.D., Kun Young Park, M.D.#, Daejon, Korea

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**INTRODUCTION:** We radiologically analyzed correction for sagittal imbalance, proximal fusion level to prevent of correction loss and usefulness of iliac screw in LDK.

**METHODS:** We analyzed cause of correction loss among 35 patients who had surgery and were possible for follow-up at least 1 year. All patients had performed gait analysis before operation. Operative techniques were pedicle subtraction osteotomy and fixation to S1. We analyzed degrees of lumbar lordosis for sagittal correction. And we analyzed causes of correction loss into preoperative thoracolumbar kyphosis for proximal fusion range. For analyze of usefulness of iliac screw, they were divided into two groups, -iliac screw (23cases) for patients who fixed without iliac screw and +iliac screw (12cases) for patients who fixed with iliac screw.

**RESULTS:** There were no patient who had marked anterior pelvic tilt. It is important to correct lumbar lordosis over 20° compared with preoperative thoracic kyphosis. There are 10 cases (preoperative thoracolumbar kyphosis  $\geq 10^\circ$ ) and 25 cases (preoperative thoracolumbar kyphosis  $< 10^\circ$ ) in total 35 cases. In 10 cases (preoperative thoracolumbar kyphosis  $\geq 10^\circ$ ), 4 cases that fixed to T10 have no sagittal correction loss and 6 cases that fixed to T11 or T12 have 2 cases of sagittal correction loss. In 25 cases (preoperative thoracolumbar kyphosis  $< 10^\circ$ ), 5 cases that fixed to T10 have no sagittal correction loss and 20 cases that fixed to T11 or T12 have 1 case of sagittal correction loss (P

**DISCUSSION:** It is important to make postoperative lumbar lordosis over 20° compared with preoperative thoracic kyphosis for sagittal imbalance correction. And it is important to decide proximal fixation level according to preoperative thoracolumbar kyphosis and fix with iliac screw.

### GP46. TOBACCO SMOKE EXPOSURE INDUCES DEGENERATIVE CHANGES IN INTERVERTEBRAL DISCS

Nam Vo, Dong Wang, Gwen Sowa, William Witt, Paulo Coelho, Peter Di, Joon Lee, James Kang

**INTRODUCTION:** Epidemiological analyses demonstrate a strong association between cigarette smoking and intervertebral disc degeneration (IDD) and back pain. While these and other existing studies suggest tobacco smoke as a risk factor in IDD, they are limited either to using nicotine or short-term exposure of animal models. Direct effects of tobacco smoke, which contains over 4000 chemicals, on human disc cellular metabolism have not been investigated, and hence the goal of this study.

**METHODS:** Tobacco smoke extract (TSE) was prepared by dissolving particulates from cigarette smoke trapped on a membrane filter (Pallflex filters, VWR) in culture media. Cultures of human annulus fibrosus cells were exposed to various concentrations (0-1 mg/ml) of TSE for 72 hours. Cell viability within disc tissue was measured by 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-tetrazolium bromide (MTT) assay. Gene expression by quantitative RT-PCR and matrix synthesis by incorporation of radioactive labels (<sup>35</sup>S-sulfate for proteoglycan, <sup>3</sup>H-proline for collagen) were performed.

**RESULTS:** TSE induced dramatic morphological changes (cell condensation) and decreased cell viability of in a dose-dependent manner, with the calculated the lethal dose (LD<sub>50</sub>) of 0.8 mg/ml during a 72 hour exposure. Collagen and proteoglycan syntheses were reduced by 20-30% as compared to untreated control at 0.05 mg/ml TSE and 40-50% at 0.5 mg/ml TSE. At 0.5mg/ml, TSE decreased gene expression of aggrecan (40-60%), collagen type 1 (60-80%), TIMP1 and TIMP3 (~50%), while increased the matrix metalloproteinase MMP1 (~60 fold), MMP3 (~5 fold) and ADAMTs4 (~3 fold).

**DISCUSSION:** The vasoconstricting property of nicotine in TSE is thought to cause IDD indirectly by limiting the exchange of metabolites between discs and their surroundings. However, in addition to these potential effects, we showed that TSE has direct detrimental effects on human intervertebral disc cells in vitro by increasing matrix catabolism and decreasing anabolism. This might explain how smoking contributes to IDD.

### **GP47. CLINICAL AND RADIOLOGICAL OUTCOMES OF AN ANTERIOR LUMBAR PLATE FOR LUMBAR INTERBODY FUSION: TWO YEAR RESULTS OF A PROSPECTIVE STUDY**

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**INTRODUCTION:** Anterior lumbar interbody fusion (ALIF) is an accepted surgical treatment for disabling back pain. Low fusion rates with stand alone anterior devices have been a concern and additional posterior fixation has been advocated. This study evaluates supplementary anterior plate fixation as an alternative to posterior instrumentation.

**METHODS:** Consecutive patients considered for ALIF were prospectively recruited. A carbon-fibre cage packed with autogenous bone graft was inserted via a retroperitoneal approach. Additional fixation was obtained with the use of a low profile anterior plate held in place with four locking screws inserted obliquely through the anterior vertebral rims. Peri-operative data, Visual Analogue Scores (VAS), Low Back Outcome Scores (LBOS), Oswestry Disability Index (ODI) and SF-36 data were collected and analysed independently. Radiological assessment by a senior independent radiologist included thin-section CT at 6, 12 and 24 months. Fusion was defined by the presence of bony trabeculae joining the vertebral bodies.

**RESULTS:** Sixty six levels were operated on in 52 patients with a mean age of 46 years (27-64). There were no patients lost to follow-up at 2 years. The mean theatre time was 175 minutes and mean blood loss less than 200ml. Radiographic fusion at one year was 82% and 98% at two years. All mean outcome scores were improved at two years. Two year mean VAS scores decreased from 7.7 to 3.6 ( $p<0.01$ ). Mean LBOS increased from 17.8 to 38.9 ( $p<0.01$ ) and mean ODI scores decreased from 52.0 to 32.0 ( $p<0.01$ ). SF-36 Physical Component Scores (PCS) increased from 34.4 to 50.6 ( $p<0.01$ ). There were no major complications and no patients needed re-operation after the index procedure.

**DISCUSSION:** This technique appears to be a safe and effective method for achieving lumbar interbody fusion over one and two levels. It has the advantage of avoiding the morbidity associated with additional posterior fixation.

## GENERAL POSTERS

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### GP48. DOUBLE KNOCKOUT OF ADAMTS4 AND ADAMTS5 (AGGRECANASE-1&2) MICE ARE NOT PROTECTED FROM SPONTANEOUS AGING-ASSOCIATED INTERVERTEBRAL DISC DEGENERATION

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**PURPOSE:** Mice with a gene deletion for ADAMTS5 (*agg2* -/-), but not ADAMTS4 (*agg1* -/-), have lesser histological evidence of aging-associated intervertebral disc (IVD) degeneration as compared to wild-type controls, primarily observed in the vertebral endplates. This observation suggests that aggrecanase-2, but not aggrecanase-1, may be involved in the development of aging-associated degeneration in the mouse spine. In order to confirm this finding, the current study compared the histopathology and detection of aggrecan degradation products in IVDs from ADAMTS5 and ADAMTS4 double knockout mice (*agg1&2* -/-) against wild-type mice at 11 months of age, when degeneration is generally observed.

**METHODS:** Lumbar spines were harvested from *agg1&2* -/- mice and age-matched wild-type controls (11 mos, n=6 each). Mid-sagittal lumbar spine sections were prepared from the four caudal-most motion segments, and stained with H&E and Safranin O/Fast green. Two blinded graders evaluated sections for characteristic degenerative IVD (0-22, 0=non-degenerate) and endplate (0-18, 0=non-degenerate) changes separately. Differences between wild-type and *agg1&2* -/- motion segment grades were tested by repeated measures ANOVA. Aggrecan degradation fragments cleaved by either aggrecanases or metalloproteinase were analyzed in the IVDs by immunostaining with anti-NITEG and anti-DIPEN (a kind gift from Dr. A Fosang).

**RESULTS:** Average IVD grades were similar for *agg1&2* -/- and wild-type mice at 11 months of age ( $p>0.05$ , ANOVA). Endplate grades were only slightly lower (less degenerated) for the *agg1&2* -/- mice as compared to the wild-types ( $p<0.1$ , ANOVA). In the IVDs, DIPEN positivity was detected at high levels in both *agg1&2* -/- and wild-type mice, while NITEG was mainly detected in wild-type mice only. These findings suggest that neither aggrecanase appears to play a major role in regulating aging-related degeneration in IVD soft tissue, while ample evidence of metalloprotease cleavage products was detected in all sections. Other aggrecan degradation enzymes (i.e. MMPs) may play major roles in mouse IVD degeneration.

### GP49. CHRONIC PSYCHOSOCIAL STRESS LEADS TO INCREASED RATES OF DISC DEGENERATION

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**INTRODUCTION:** Psychosocial factors such as depression and anxiety have been linked to back pain from its inception through the chronic stage. Chronic stress impairs wound healing by interfering with normal cytokine production and fibroblast proliferation via dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis. However, no direct link between stress and disc degeneration has been established. The aim of this study was to investigate the effect of psychosocial stress on disc repair using a rat model.

**METHODS:** Sprague Dawley rats were subjected to predator odorant (trimethylthiazoline, TMT) or no stress for 7 consecutive days for 30 minutes (between 8 am and 11 am during the corticosterone circadian rhythm trough). On day 8, three tail intervertebral discs were injured surgically (single stab) and rats continued to be subjected to TMT stress for another 7 days post-surgically. Blood was collected during the stress period at multiple time points (day 1, 4, 8, and 15) for corticosterone measurements.

**RESULTS:** Corticosterone levels were different between sham and TMT stressed groups. TMT exposed rats had twice the disc height loss after injury than sham rats ( $p < 0.08$ ). There were no statistically significant differences between the non-injured TMT and non-injured sham discs.

**DISCUSSION:** Our data suggest that psychosocial stress has an adverse effect on disc healing. Injured discs in stressed rats tended to have a reduced cell density that was not sufficiently compensated by the increase in matrix synthesis, leading to decreased height. In next steps we will explore the influence of stress on inflammation cascade, but overall this study will provide information to improve preventative techniques and treatments for disc degeneration

## GENERAL POSTERS

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### GP50. PRODUCTION OF A NATURAL DISC SCAFFOLD FOR INTERVERTEBRAL DISC TISSUE ENGINEERING

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**INTRODUCTION:** The physiological properties of the intervertebral disc (IVD) are highly linked to the composition of the extracellular matrix (ECM), of which current synthetic scaffolds lack a natural niche for cell growth. Decellularization helps to remove cellular contents from a tissue whilst minimizing adverse effects on the ECM. This study aims to develop a natural disc scaffold with preserved ECM for disc cell culture by decellularization.

**METHODS:** Bovine caudal discs (18-23 mm in diameter) were harvested. Discs were incubated with 25 mL of phosphate buffer solution containing 0.1% sodium dodecyl sulphate (SDS) and protease inhibitor with constant agitation. Optimum conditions were identified using 4 different protocols which tested the effects of the duration and temperature of washing, frequency of solution replacement and number of snap-freezing cycles during IVD decellularization. Live/Dead staining and the Alamar Blue assay were used for analysing the number of remaining cells and their metabolic activity after treatment.

**RESULTS:** The most effective protocol enabled removal of 69% and 73% cell content from the annulus fibrosus and nucleus pulposus, respectively. Data from Alamar Blue assays suggested that the majority of the cell activity was eliminated.

**DISCUSSION:** Increase of the duration of washing, frequency of solution replacement, and number of snap-freezing cycles, decreased cell viability and facilitated removal of cellular contents. In this study, decellularization was achieved by physical treatment (snap-freezing cycles) and chemical washing (SDS). Our findings imply that formation of intracellular ice crystals during the cycles facilitated the disruption of the cell membrane which allowed disc cell contents to be washed out. SDS buffer has a role in solubilizing cytoplasmic and nuclear membranes which aided in the clearance of cell remnants. Overall, this study shows that varying the frequency of solution change and duration of washing can effectively eliminate the majority of disc cells from the IVD.



## GENERAL POSTERS

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### GP51. IMPROVING PREDICTIONS OF OUTCOMES FOR SURGICAL AND NON-OPERATIVE TREATMENT OF INTERVERTEBRAL DISC HERNIATION (IDH)

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**INTRODUCTION:** The Spine Patient Outcomes Research Trial (SPORT) has demonstrated improved average outcomes for surgical versus nonoperative treatment for IDH. Individual outcomes may depend on baseline patient characteristics.

**METHODS:** Variables for predicting IDH outcomes (Oswestry Disability Index (ODI), SF-36 Physical Function (PF) and Bodily Pain (BP), and Sciatica Bothersomeness were selected from 40 baseline covariates. Stepwise regression analysis was performed to select a parsimonious group of predictors using one-year changes from baseline. Individual linear predicted scores were calculated using the regression coefficients for the selected variables. Indicator variables based on quartile of the predicted scores were included in a longitudinal regression model to evaluate the effects of treatment over time.

**RESULTS:** For BP, the time-weighted outcome average change from baseline for surgical treatment ranged from 25.6 for the lowest predicted quartile to 58.4 for the highest quartile, with nonoperative ranging from 12.7 to 57.4. The estimated time-weighted treatment effect (surgical – nonoperative) ranged from 12.9 for the lowest quartile of improvement to 1.0 for the highest quartile. Multiple degree of freedom tests for these comparisons were all highly statistically significant ( $p < 0.001$ ). Similar results were obtained for PF and ODI. For Sciatica Bothersomeness, the time-weighted average change from baseline for surgical treatment ranged from -14.3 for the lowest quartile to -4.9 for the highest quartile, with nonoperative ranging from -12.1 to -2.6. However, the time-weighted treatment effects did not vary across quartiles (-2.2 to -2.3,  $p = 0.87$ ).

**DISCUSSION:** Depending on initial patient characteristics, wide ranges of outcomes were predicted for surgical and non-operative treatment. The treatment effect tended to diminish with larger predicted improvements for IDH, BP and ODI, but stayed approximately the same for Sciatica Bothersomeness. These results suggest that it is important to use initial patient characteristics to accurately predict individual outcomes for surgical and nonoperative treatment for IDH.

## GENERAL POSTERS

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### GP52. HISTOLOGICAL FEATURES OF THE DEGENERATING INTERVERTEBRAL DISC IN THE GOAT DISC-INJURY MODEL

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**BACKGROUND:** Human disc regeneration therapies have long been sought. Although small animal (rodents, rabbit) models are useful, their intervertebral disc (IVD) dimensions limit the ability to study regeneration strategies requiring the injection of therapeutics or implantation of tissue-engineered constructs. Our aims were to first optimize a minimally invasive, rapidly response (within two months), large animal (goat) model of moderate to severe IVD degeneration and, second, to establish a numeric histological grading scale for injury-induced IVD degeneration in large animals.

**METHODS:** Six adult goats were used with Institutional Animal Care and Use Committee approval. Under general anesthesia, various instruments and techniques were used to create an injury to the right lateral aspect of goat discs at various lumbar levels. Two months post-injury, the goats were euthanized and the spines were harvested for histology. The IVDs were dissected with adjacent endplates, decalcified, and stained using Alcian blue with H&E counterstaining. A numeric grading scale for large animal discs was developed, based on the rabbit histological scale developed by Masuda et al. and histological features of human IVDs described by Boos et al.

**RESULTS:** Injuries produced by a 4.5mm drill bit inserted into IVDs to a depth of 15mm resulted in the highest degree of IVD degeneration and the highest histological scores, both significantly higher than the uninjured controls ( $p=0.0139$ ). Inserting a number 15 blade twice in cruciate fashion or number 10 blade once parallel to the endplate did not result in statistically significant changes in histological scores.

**DISCUSSION:** We have developed a minimally invasive, injury-induced goat model of IVD degeneration and a histological scale to categorize the degree of IVD degeneration in large animals. Among the various injuries inflicted, a 4.5mm drill bit, which disrupts the interchelating annulus fibers, resulted in the most significant histological changes at the two-month time point.

### GP53. IMAGING OF CARTILAGE SURFACE DEGENERATION IN FACET JOINT OSTEOARTHRITIS

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**INTRODUCTION:** Facet joints facilitate and restrict spinal flexion, extension, and axial rotation while limiting antero-posterior sliding between vertebrae. Facet osteoarthritis (OA) has been implicated in over 30% of lower back pain. Gross examination of facets has mapped OA incidence by topographic zone and spinal level, but quantitative topographic analyses are necessary.

Imaging of India ink-staining allows localization and quantification of cartilage fibrillation and erosion. Wear pattern analyses elucidate areas prone to facet OA. Our objective was to quantify facet cartilage surface degeneration in specific topographic zones at each lumbar spinal level using India ink-staining imaging analysis.

**METHODS:** Bilateral facet joints from lumbar levels L1/2-L4/5 were isolated from six cadaveric spines. Apposing surfaces from 42 facet joints were included. Articular surfaces were stained with India ink and digitally imaged using spatial and grayscale intensity-calibration.

A Matlab program divided each surface into five equal zones (superior, inferior, central, medio-ventral, and dorso-lateral). Reflectance scores (RS) were determined, correcting for eburnation. Two-way repeated measures ANOVA assessed the effects of spinal level and topographic zone on RS. Different zones were compared using paired t-tests.

**RESULTS:** RS varied with topographic zones ( $p=0.001$ ); there was a significant interaction between level and surface ( $p<0.05$ ). Except for the dorso-lateral zone, the central zone average RS was significantly lower than all other zones ( $p<0.05$ ). The average latero-dorsal RS was significantly lower than the medio-ventral and inferior zone RS ( $p<0.05$ ). RS of the apposing surfaces of L2/3 ( $p<0.001$ ,  $R^2=0.18$ ) and L3/4 ( $p<0.005$ ,  $R^2=0.147$ ) showed a significant positive correlation.

**DISCUSSION:** Our study revealed maximal surface degeneration in the central zone; this could be due to constant articulation with peripheral zones of apposing surfaces during movement. The correlation of RS of apposing surfaces suggests these areas may be experiencing similar biomechanical stresses. *In-vivo* facet joint kinematic analysis will reveal mechanical causes of degeneration.

## GENERAL POSTERS

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### **GP54. INTERLEUKIN-17 SYNERGIZES WITH IFN $\gamma$ OR TNF $\alpha$ TO PROMOTE INFLAMMATORY MEDIATOR RELEASE AND INTERCELLULAR ADHESION MOLECULE-1 (ICAM-1) EXPRESSION IN HUMAN INTERVERTEBRAL DISC CELLS**

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**PURPOSE:** Interleukin-17 (IL17) is a T helper cell-associated cytokine with documented pro-inflammatory effects. IL17 has been identified in human herniated and degenerated intervertebral disc (IVD) tissues in our prior work. Increased expression for both tumor necrosis factor (TNF $\alpha$ ) and interferon (IFN $\gamma$ ) has also been noted in pathological IVD tissues, both of which may act with IL17 to promote inflammation. Intercellular adhesion molecule-1 (ICAM-1, CD54) may play an important role in IVD pathology by attracting monocyte and leukocyte infiltration. The objective of this study is to determine the ability for IL17, with IFN $\gamma$ , or TNF $\alpha$ , to promote inflammatory cytokine, mediator release and ICAM-1 expression in IVD cells.

**METHODS:** Human IVD cells were isolated from tissues of patients undergoing surgery for IVD pathology. Separate annulus fibrosus (AF) and nucleus pulposus (NP) cells were cultured and treated with: media control, TNF $\alpha$  (25ng/mL), IL17 (10ng/mL), IFN $\gamma$  (200U/mL), or a combination of both IL17 and IFN $\gamma$ , or IL17 and TNF $\alpha$ . After 72 hours, the supernatant was evaluated for release of NO $_x$ , PGE2 and IL6. Cells were labeled with anti-ICAM-1 antibodies and analyzed for the percentage of positively labeled cells and mean fluorescence intensity (MFI) by flow cytometry. One-way ANOVA evaluated treatment group differences.

**RESULTS AND DISCUSSION:** Both human NP and AF cells respond to IL17 and costimulants with increased production of inflammatory mediators (NO $_x$ , PGE2 and IL6) and ICAM-1 expression. These data provide evidence that IL17 can induce an inflammatory phenotype in IVD cells, as demonstrated for multiple other cell types. The observed upregulation of ICAM-1 expression further suggests that IVD cells exposed to IL17 will increase their cell surface expression of molecules that facilitate the migration of monocytes into IVD tissue. Together these findings suggest that the IL17 cytokine may be an important regulator of inflammation in the IVD herniation, degeneration and multiple pathologies.

### **GP55. SMALL INTERFERENCE RNA (SIRNA) OF ADAMTS4 AND ADAMTS5 IN NUCLEUS PULPOSUS CELLS IN VITRO AND EFFECTS OF ADAMTS5 SIRNA IN THE RABBIT ANULAR NEEDLE PUNCTURE MODEL.**

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**INTRODUCTION:** Several investigators have reported the presence of proteolytic enzymes, such as matrix metalloproteinases and the ADAMTS family, in degenerated human discs. Glasson et al. have recently reported that ADAMTS5 knockout mice have significantly reduced cartilage destruction compared with wild-type mice. The purpose of this study was to test our hypothesis that an injection of siRNA for ADAMTS4 or ADAMTS5 into the nucleus pulposus (NP) suppresses disc degeneration.

**METHODS:** Rabbit NP cells were transfected with siRNA oligonucleotide for ADAMTS4, ADAMTS5, or the control. The knock-down rates for the ADAMTS4 and ADAMTS5 genes were assessed with or without interleukin-1 $\beta$  (IL-1b) stimulation in monolayer and alginate bead culture. The in vivo effects of an injection of ADAMTS5 siRNA were tested in the rabbit anular puncture disc degeneration model (16 rabbits; 32 discs: L2/3 and L4/5). siRNA (control: 100 ug or anti-ADAMTS5 oligonucleotide: 100 ug) was injected one week after the initial disc puncture. The outcomes were assessed by radiographic measurements of disc height, MRI (Thompson classification), and Safranin-O staining (histological grade).

**RESULTS:** IL-1b stimulation significantly increased the expression of ADAMTS4 and ADAMTS5 mRNA in NP cells (p

**CONCLUSION:** A single injection of ADAMTS5 siRNA in vivo suppressed the initial progression of disc degeneration, presumably based on its effects to inhibit extracellular matrix fragmentation. Further confirmation on the silencing effects of ADAMTS5 at the mRNA level may be required.

### GP56. STRUCTURED CO-CULTURE OF STEM CELLS AND DISC CELLS PREVENT DEGENERATION IN A RAT MODEL

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**INTRODUCTION:** Intervertebral-disc tissue-engineering with stem cells holds the promise of a minimally-invasive low-back-pain treatment. Previous attempts of injecting mesenchymal stem cells (MSCs) have been met with problems of retention and therapeutic inactivity. This may be due to poor MSC survival and differentiation in the degenerate disc environment. To overcome this, we have created a novel spherical bi-laminar cell pellet (BCP) where MSCs form an inner-sphere enclosed within a shell of Nucleus Pulposus Cells (NPCs) with a 75:25 ratio. In vitro, BCPs have a 48% increase in proteoglycan-synthesis as compared to MSC controls. This study assessed the in vivo therapeutic efficacy of BCPs compared to MSCs, NPCs, and a random mix of MSCs/NPCs.

**METHODS:** To facilitate therapy delivery, rat-tail discs were de-nucleated then treated with one of six therapies: MSCs suspended in fibrin-sealant (FS), NPC/FS, MSC&NPC randomly-mixed in FS, BCP/FS, FS alone, or no treatment. Discs were harvested at 2 and 5-week time-points. We assessed the ability of cell-therapy to prevent the post-nucleotomy degeneration that occurs naturally.

**RESULTS:** At 2weeks, the retention of MSC and NPC was 20-40%lower than the MSC&NPC and the BCP groups (p

**DISCUSSION:** Our data show that the beneficial behaviors previously reported for BCPs in vitro translate to a more effective cell-based treatment in vivo. Future studies will explore the function of BCPs in larger discs that more closely mimic the human situation.

## GENERAL POSTERS

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### **GP57. A DETAILED MICROSCOPIC EXAMINATION OF ALTERATIONS IN NORMAL ANNULAR STRUCTURE INDUCED BY MECHANICAL DESTABILISATION IN AN OVINE MODEL OF DISC DEGENERATION.**

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**INTRODUCTION:** Studies on induced disc degeneration in sheep have demonstrated changes in discal components using histological, biomechanical and biochemical approaches, however changes in disc microstructure have largely remained neglected. In recent years the use of structurally relevant section planes has improved our understanding of disc microstructure, including the presence of significant bridging structures radially linking the lamellae. These translamellar cross-bridges adaptively remodel in response to a changing biomechanical micro-environment. The present study documents such local and distant annular changes induced in response to systematically altering discal biomechanics.

**METHODS:** The macro-structural effect of discal destabilization induced by a controlled annular lesion was examined in serially sectioned 30  $\mu\text{m}$  disc slices from sham and lesion discs. This facilitated a global examination of annular microstructure in its fully hydrated state using a differential interference contrast microscope.

**RESULTS:** Disc degeneration in the mid-inner AF and a spontaneous repair process in the outer AF was evident in lesion discs with increased translamellar bridging contralaterally to the lesion in the mechanically destabilized disc and development of atypical broad bridging elements in the outer lamellae. Structural alterations in lamellar end plate anchorages in destabilized discs included multiple branching and atypical CEP discontinuities.

**DISCUSSION:** The present investigation has offered a glimpse of an annular wall capable of remodeling in response to perturbations in its normal mechanical microenvironment. Translamellar cross bridges undergo adaptations in structure to accommodate altered stresses locally at the annular defect but also distantly in the contralateral AF and, AF-CEP.

### GP58. IMPACT OF SELF-REPORTED MUSCULOSKELETAL PAIN ON HEALTH-RELATED QUALITY OF LIFE AMONG YOUNG ADULTS

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**INTRODUCTION:** The epidemiological studies of musculoskeletal (MS) pains rely on self-reporting. However, validity of the questionnaires in relation to the clinical relevance of such self-reported pains is not fully known. We investigated how self-reported MS pains and health-related quality of life (HRQoL) are associated in young adults.

**METHODS:** The study population consisted of a subgroup of the Northern Finland Birth Cohort 1986 at the age of 19 (n=874), who completed the 15D HRQoL questionnaire (score 0 to 1) and answered questions about six-month period prevalence of musculoskeletal pain in neck, shoulder, low back, and peripheral location.

**RESULTS:** Half of the males and one third of the females reported a 15D score of at least 0.98, and were selected as the reference group in the multinomial logistic regression analysis. Young adults who reported multiple pains had significantly lower 15D scores than those reporting pain in only one location or no pain at all. After adjustments for psychosocial distress, parental occupation, and the young adults' own employment status, the reporting of single musculoskeletal pain (OR 3.3) and multiple pains (ORs up to 12.2) among females, and multiple pains (ORs up to 4.7) among males were associated with a 15D score of 0.94 or less.

**DISCUSSION:** The number of involved sites of self-reported musculoskeletal pain was associated with the level of reduction in HRQoL among young adults.



### GP 59. THE ETIOLOGY OF SUBCHONDRAL BONE CYSTS IN THE LUMBAR FACET JOINT

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**INTRODUCTION:** Subchondral cyst is appeared at the osteoarthritic (OA) joint, and some associations between pain and the cyst at the OA joints were reported. In the lumbar spine, facet OA can induce the low back pain as the facet pain. Furthermore, facet disorder is one of the great issues following the artificial disc replacement. In this report, we clarified the epidemiology of the subchondral cyst of the facet joints.

**METHODS:** Total 160 patients with degenerative disorders were evaluated by CT. Herniated nucleus pulposus (HNP) in 43, lumbar spinal canal stenosis (LCS) in 42 and degenerative spondylolisthesis (SLIP) in 32 were included. These disorders were all found at L4/5. Therefore, subchondral cysts were evaluated at L4/5. For control, 43 patients having disorder at the other level were evaluated. We evaluated the cyst number with reference to age, gender, and BMI as the genetic factor, and with disc height, facet angle, facet osteophyte and joint effusion as the local factor. Relationship between diseases and cyst number was also evaluated.

**RESULTS AND DISCUSSION:** Total cyst mean number in the control, HNP, LCS and SLIP group was 2.5, 3.3, 11.2 and 17.1. The larger cyst (diameter > 2mm) mean number was 0, 0, 0.7 and 2.0. When the osteophyte developed, the cyst number increased. These data indicated that in the degenerated spinal condition, more facet subchondral cysts could be appeared. Also, larger size cysts were also common in the more degenerated condition. The cyst did not show any relationship with genetic factors. Interestingly, the joint having many subchondral cysts showed less joint effusion. Joint inflammation may not be related to the subchondral cysts.

**CONCLUSION:** In the more degenerative condition, the more subchondral cysts were observed. Larger size cysts were also common in the degenerated condition such as degenerative spondylolisthesis.

## GENERAL POSTERS

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### GP60. VASCULAR DISEASE AND FACET JOINT OSTEOARTHRITIS: IS THERE AN ASSOCIATION?

Pradeep Suri, MD; David J. Hunter, MD, PhD; James Rainville, MD; Ali Guermazi, MD; Jeffrey N. Katz, MD

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**INTRODUCTION:** Epidemiologic studies have demonstrated associations between vascular disease and spinal degeneration. We sought to examine whether vascular disease was associated with lumbar spine facet joint osteoarthritis (FJ OA) in a community-based population.

**DESIGN:** 443 participants from the Framingham Heart Study Multi-Detector Computed Tomography (CT) Study were included in this ancillary study. We used a quantitative summary measure of abdominal aortic calcification (AAC) from the parent study as a marker for vascular disease. AAC was categorized into tertiles of 'no' (reference), 'low', and 'high' calcification. FJ OA was evaluated on CT scans using a 4-grade scale. For analytic purposes, FJ OA was dichotomized as moderate FJ OA of at least one joint L2-S1 vs. no moderate FJ OA. We examined the association of AAC and FJ OA using logistic regression before and after adjusting for age, gender and BMI. Furthermore, we examined the effect of including the known cardiovascular risk factors of diabetes, hypertension, hypercholesterolemia, and smoking.

**RESULTS:** Low AAC (OR 3.9 [2.3-6.5]; $p < 0.0001$ ) and high AAC (OR 9.7 [5.2-18.1]; $p < 0.0001$ ) were strongly associated with FJ OA, compared with the reference group. After adjusting for age, gender, and BMI, the association with FJ OA was attenuated for both low AAC (OR 1.9 [1.1-3.4]; $p = 0.03$ ) and high AAC (OR 2.2 [0.96-5.1]; $p = 0.06$ ). The addition of cardiovascular risk factors to the model did not attenuate the relationship between low AAC (OR 2.0 [1.1-3.6]; $p = 0.03$ ) or high AAC (OR 2.6 [1.1-6.3]; $p = 0.04$ ) and FJ OA. BMI and age were also significant correlates with FJ OA in the final model.

**CONCLUSIONS:** Abdominal aortic calcifications are associated with FJ OA in this community-based population, when adjusting for epidemiologic factors associated with spinal degeneration and cardiovascular risk factors. Potentially modifiable risk factors for degeneration unrelated to conventional biomechanical paradigms may exist. This study is limited by a cross-sectional design; longitudinal studies are needed.

## GENERAL POSTERS

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### **GP61. ECONOMIC IMPACT OF MINIMALLY INVASIVE SPINE SURGERY: OPEN V. MIS SPINAL FUSION: COSTS IN THE PERIOPERATIVE PERIOD (FIRST 45 DAYS)**

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**INTRODUCTION:** Improved clinical and radiographic outcomes have been reported of minimally invasive spinal surgery techniques in comparison to traditional open approaches. We seek to determine if fewer complications, reoperations, additional therapies and diagnostics yields a lower overall cost among minimally invasive patients.

**METHODS:** Hospital costs were retrospectively obtained for all our center's two level spinal fusions from 2005-2008. 101 patients had a traditional open procedure, and 109 underwent a minimally invasive fusion. Patients were not randomized; procedure methods were employed sequentially. After our transition to minimally invasive techniques in late 2006, no further open procedures were performed. Costs obtained include surgical procedure and hospitalization, in addition to ensuing hospital costs occurring in the first 45 days postop.

**RESULTS:** Average cost of the original procedure and hospitalization was 6% less expensive in the MIS group overall, despite higher implant costs in the MIS group. When combined with all perioperative costs within the first 45 days after surgery, the average procedure cost reduction was 10%, a savings of \$2,610.11 per procedure.

**DISCUSSION:** Results indicate an overall reduction of costs of MIS two level procedures compared to traditional open approaches. Costs of the surgical procedure and hospitalization are lower in the MIS group. Early numbers indicate that cost savings increase as length of time postop increases. The open group, although with longer follow-up, has demonstrated a significantly higher incidence of reoperation than the MIS group comparatively. Thus, our continued cost evaluation into the intermediate and long-term follow-up period may demonstrate an ever-increasing improvement in overall costs.

### GP62. DOES MENTAL STATUS DETERIORATE FOLLOWING OSTEOPOROTIC VERTEBRAL FRACTURE? : PROSPECTIVE COHORT STUDY

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**INTRODUCTION:** Osteoporotic vertebral fracture (OVF) has a marked influence on activities of daily living and quality of life especially in elderly patients. Some patients might require rest in bed and this rest might induce deterioration of dementia. No previous report has been reported on the status of dementia following OVF. The purpose of this study was to evaluate the status of dementia following OVF and to investigate the factor affecting the deterioration of dementia.

**METHODS:** This was a prospective multicenter cohort study. Three hundreds fifty patients older than 65 years, who completed 6 months of follow-up after a fresh vertebral fracture, were included in this study. To evaluate dementia of the enrolled patients, we used the Mini-Mental State Examination (MMSE) . We defined “deterioration of dementia” as a five-point reduction of MMSE score in 6 months follow-up . Factors potentially affecting deterioration of dementia including age, sex, past vertebral fractures, hospitalization, VAS score of back pain, SF-36, and incidence of non-union following OVF were evaluate d.

**RESULTS:** The mean MMSE score was  $26.4 \pm 4.0$  at the time of enrollment and  $26.5 \pm 4.2$  at 6 months after the fracture. Patients with two or more old fractures had significantly lower MMSE score at the time of enrollment ( $P < 0.05$ ). Deterioration of dementia was observed only in 16 patients (4.6%), who had significantly higher VAS score for back pain at 6 months after the fracture ( $P < 0.05$ ). These patients showed low score of several scales in SF-36 at the time of enrollment ( $P < 0.05$ ). No other factors significantly affected deterioration of dementia.

**DISCUSSION:** Most of the patients following osteoporotic vertebral fracture did not show deterioration of mental status in 6months observation. Small percentage of patients showed the deterioration. Therefore, pain control seems to be absolutely necessary to prevent mental deterioration of patients following osteoporotic vertebral fracture.

### GP63. THE RISK ASSESSMENT OF FALL IN THE PATIENTS WITH LUMBAR SPINAL STENOSIS

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**INTRODUCTION:** The physical impairment in the lumbar spinal stenosis (LSS) such as impaired balance and gait deficit with increased levels of leg and back pain might also lead to increased risk of fall later in the disease process as shown in knee osteoarthritis. Therefore, the purpose of this study is to investigate the risk of fall in the patients with lumbar spinal stenosis (LSS) by comparison with the patients with knee osteoarthritis (KOA), using functional mobility tests.

**METHODS:** The study was an age- and weight-matched case control study consisting of two groups, one group consisting of 40 patients with LSS who are scheduled to undergo spine surgery. (LSS group), the other group consisting of 40 patients with advanced OA at both knees, scheduled to undergo TKA at both knees (KOA group). For both groups, four functional mobility tests such as six meter walk test (SMT), sit-to-stand test (STS), alternative step test (AST), and timed up and go test (TUGT) were performed.

**RESULTS:** There was no difference of demographic data between both groups. In the SMT and STS, the patients in the LSS spent significantly more time performing these tests than the patients in the KOA. (SMT (mean [SD],*P*) in LSS, KOA; 8.70[1.86], 6.01[1.95], *P*<0.001; STS in LSS, KOA; 15.76[1.44], 14.37[2.25], *P*<0.021) In the AST, however, patients in the KOA group presented a statistically worse performance in functional mobility, compared to the LSS group. (LSS, KOA; 15.24[2.07], 23.61[4.51], *P*<0.001) The mean TUGT time was not different between two groups. In the LSS, there was no significant correlation between Oswestry Disability Index score and four functional mobility tests.

**DISCUSSION:** The current study highlights that the patients with symptomatic LSS have the comparable risk of fall to the patients, who had degenerative KOA, based on the results of functional mobility tests.

### GP64. EVALUATION OF BEHAVIOR AND NEUROPEPTIDE MARKERS OF PAIN IN A SIMPLE SCIATIC NERVE INJURY PAIN MODEL IN RATS

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**INTRODUCTION:** Lumbar radicular pain is a common disease. However, its pathomechanisms have not been fully explored. A radicular pain model and a chronic constriction injury model have been established. However, the methods for producing these models are complicated. A sciatic nerve crush model is easy to produce; however, the reliability for evaluating pain behavior has not been examined. The purpose of the current study was to evaluate pain behavior and change in a pain marker in the dorsal root ganglion (DRG) in a simple sciatic nerve crush model.

**METHODS:** In the nerve-injury model, the sciatic nerve was pinched for 4 seconds using forceps (n = 20). Nerves were not injured in the control group (n = 20). Mechanical allodynia was measured for 2 weeks. Immunohistochemistry was used to examine CGRP (neuropeptide marker of pain), ATF-3 (marker for nerve injury), NFkB, and p38 Map kinase (cell signal of pain) expression in L5 DRGs. The proportion of DRG neurons that were immunoreactive (IR) for these markers was evaluated and compared between groups.

**RESULTS:** Mechanical allodynia was found in the pinch group, but not in controls, and persisted for 8 days ( $p < 0.05$ ), however, not found from days 10 to 14 ( $p > 0.05$ ). CGRP, ATF-3, NFkB, and p38 Map kinase expression in L5 DRGs were upregulated in the nerve-injured groups compared with the control group ( $p < 0.01$ ).

**DISCUSSION:** Our results suggest that a simple sciatic nerve crush model produced pain-related behavior. CGRP, ATF-3, NFkB, and p38 Map kinase expression, which are related to pain transmission, were upregulated in the nerve injury model, thus we concluded that this can be used as a model of pain. However, this model only produced pain behavior for up to 8 days and it is therefore not suitable for long-term studies, compared with the chronic constriction injury model.

### GP 65. EFFECT OF LOCALLY ADMINISTERED ETANERCEPT INTO INJURED RAT SCIATIC NERVE

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**INTRODUCTION:** Tumor necrosis factor-alpha (TNF) is a pro-inflammatory cytokine that initiate neuropathic pain. Etanercept, a fusion protein consisting of the TNF receptor II and the constant portion of human IgG, can competitively bind TNF to attenuate neuropathic pain. Locally administered etanercept might minimize potential systemic adverse effects of etanercept administration. However, little is known about the effect of locally administered etanercept on neuropathic pain. In the present study, we evaluated the distribution and the pain-relieving effect of locally administered etanercept into injured rat sciatic nerve.

**METHODS:** Adult female Sprague-Dawley rats (n=52) underwent unilateral sciatic nerve crush. Twenty-four hours after crush injury, the epineurial injections of vehicle or etanercept (0.5mg/kg) were performed. The sham-operated or naive animals were used as control. The distribution of etanercept with or without TNF co-localization in the injured and uninjured nerve (Human IgG and TNF immunohistochemistry, immunofluorescence) was evaluated at 1, 24, 48 and 96 hours after the local application. Binding specificity of etanercept for TNF isoforms was analyzed using immunoblot assay in nerve lysates. In addition, pain-related behaviors were analyzed at 1, 2, 4, 6, 8, 10, 12, 14, 21, 28, 35 and 42 days after crush injury (von Frey test).

**RESULTS:** Locally administered etanercept reached the endoneurium of the injured but not the uninjured nerve 1 hour after the application. Etanercept mainly co-localized with TNF positive Schwann cells and macrophages. Immunoblot analyses for etanercept demonstrated its preferential binding to transmembrane TNF isoforms. Locally administered etanercept therapy inhibited the decrease of the withdrawal thresholds relative to vehicle between 6 and 12 days ( $p < 0.05$ ).

**DISCUSSION:** Locally administered etanercept can reach the endoneurium in the injured nerve and preferably detect transmembrane TNF isoforms in activated Schwann cells and macrophages to modulate neuropathic pain. However, the effective duration of etanercept might be limited with a single acute injection.

## GENERAL POSTERS

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### GP66. MINIMALLY INVASIVE TREATMENT OF RECURRENT DISK HERNIATION VIA XLIF

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**INTRODUCTION:** Recurrent lumbar disk herniation does occur on rare occasion. The XLIF approach provides a minimally disruptive alternative to anterior column access that allows for large graft placement, excellent disk height restoration, and indirect decompression of prolapsed disk tissue, and avoids reoperation through previous posterior surgical scar tissue at L4-5 or above. Results of r-HNP treated minimally invasively using XLIF are presented.

**METHODS:** Of our single-site consecutive series of 710 XLIF patients, 53 were treated for r-HNP. Clinical and radiographic measures were prospectively collected and evaluated to assess surgical details, hospital stay, complications, pain scores, changes in disk height and alignment, and fusion.

**RESULTS:** Ages ranged from 30-86 years (average 56.9years). Comorbidities included CAD (40%), smoking (21%), diabetes (28%), and chronic steroid use (7%). 26 patients (49%) were obese (BMI>30), 7 of those morbidly obese (BMI>38). 65 levels were treated: 38 1-level, 12 2-level, and 1 3-level. All cases included unilateral pedicle screw fixation, save one where a lateral embroidered plate was used. There were no blood transfusions or wound infections. Hospital stay averaged 1.10 days. Complications included 1 ileus, 1 transient tibialis anterior weakness, and 1 quad weakness, all of which resolved without intervention. Average VAS pain scores improved from 8.6 to 1.7 at 12 months follow-up. Average disk height improved from 5.6 to 9.4mm; slip from 3.1 to 0.5mm. At 3 months, 95% showed early signs of fusion (Lenke 1-2); at 6 and 12 months, 100%.

**CONCLUSIONS:** Patients with large disk herniations and significant canal compromise, severe disc degeneration, and instability could be decompressed across the intervertebral space without extensive dorsal exploration of the spinal canal, and, coupled with distraction decompression, marked improvement of symptoms was achieved. Results demonstrate the usefulness and safety of the XLIF technique in treating r-HNP.



### **GP67. CHANGES IN EXPRESSION OF MRNA FOR INTERLEUKIN-8 AND EFFECTS OF INHIBITION OF MICROGLIA IN THE SPINAL DORSAL HORN IN A RAT MODEL OF LUMBAR DISC HERNIATION**

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**INTRODUCTION:** Interleukin-8 (IL-8) is implicated in painful degenerative disc disorders. We here investigated the expression of IL-8 in the spinal cord and dorsal root ganglion (DRG) in relation to pain behavior in a rat model of lumbar disc herniation, and the effects of repertaxin, an inhibitor of IL-8.

**METHODS:** Rats were implanted with autologous nucleus pulposus next to the L5 nerve root; rats were tested for thermal hyperalgesia and mechanical allodynia 2 days before surgery and 1, 5, 10, 20, 30, and 60 days after surgery ; repertaxin was injected intrathecally at L5 level on postoperative day 10 ; rats were tested for mechanical allodynia of the plantar surface of both hindpaw on 1, 5 and 10 days after surgery, and on 0.5h, 1h, 3h, 1, 3, 5 and 10 days after repertaxin injection ; spinal cord sections were studied for expression of mRNA for IL-8 with real-time PCR, or immunostained for the marker for astrocytes glial fibrillary acidic protein (GFAP), the marker for microglia OX42, or the marker for nociceptive-specific cell activation pERK.

**RESULTS:** Thermal hyperalgesia developed on postoperative day 10 and mechanical allodynia developed on postoperative 1 day and persisted for the duration of the experiment. In the spinal dorsal horn, the expression of mRNA for IL-8 was upregulated to reach a maximum on postoperative day 60, and astrocytes and microglia were activated. Intrathecal injection of repertaxin significantly attenuated the mechanical allodynia and microglial activation, as indicated by the decrease of pERK-expressing microglia in the dorsal horn.

**DISCUSSION:** The late upregulation of IL-8 and the attenuation of mechanical allodynia and microglial activation by intrathecal repertaxin suggest that IL-8 is involved in the maintenance of chronic radicular neuropathic pain in lumbar disc herniation.

### **GP68. LONG-TERM ATTENUATION OF HINDPAW PAIN RESPONSE AFTER PULSED RADIOFREQUENCY APPLICATION ON DORSAL ROOT GANGLION IN LUMBAR DISC HERNIATED RAT MODEL**

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**INTRODUCTION:** Pulsed radiofrequency procedure has been used for treatment chronic neuropathic pain conditions without neuronal damage in clinical practice. The purpose of this study is to investigate the long-term effect of pulsed radiofrequency (PRF) on pain-related behavior in a rat model of lumbar disc herniation.

**METHODS:** Lumbar disc herniated rat model was made by implantation of autologous nucleus pulposus on the left L5 spinal nerve root just proximal to the dorsal root ganglion (DRG). Rats were ascertained the development of mechanical allodynia on both hindpaw until 10 days postoperatively (PO) using von Frey hair. PRF was applied on left DRG for 120 seconds with maximum temperature 42°C after 10 days PO. Mechanical allodynia was tested on 8 hour, 1, 3, 10, 20 and 40 days PO after PRF.

**RESULTS:** After once PRF procedure, withdrawal threshold for mechanical stimuli on the ipsilateral hindpaw was increased markedly. Immediate reduction of mechanical allodynia was shown from 1day after PRF procedure and maintained throughout the experimental period.

**DISCUSSION:** Our results demonstrate that mechanical allodynia induced by lumbar disc herniation was reversed by PRF on ipsilateral DRG dramatically and maintained for longer time. The PRF might be a simple and effective procedure to treat radicular pain in lumbar disc herniation.

### **GP69. CHANGES IN EXPRESSION OF SODIUM CHANNELS IN TRKA POSITIVE NEURONS IN THE DORSAL ROOT GANGLION FOLLOWING DISC PUNCTURE. AN EXPERIMENTAL STUDY IN RATS.**

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University of Gothenburg, Gothenburg, Sweden, Fukushima, Japan

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**INTRODUCTION:** Na<sub>v</sub>1.8, an isoform of the voltage-gated sodium channel is predominantly observed in dorsal root ganglion (DRG) sensory neurons associated with pain sensation. Nucleus pulposus has experimentally been found to induce an increase of Na<sub>v</sub>1.8 positive DRG neurons. The purpose of this study was to clarify which neurons express the Na<sub>v</sub>1.8 in DRG exposed to nucleus pulposus using immunohistochemistry.

#### **METHODS**

Adult female Sprague-Dawley rats (200-250g, n=25) were used. The L4/L5 disc was punctured by a 0.4mm injection needle which induced leakage of nucleus pulposus towards the left L4 DRG (disc puncture group, n=10). Exposure of the L4/L5 disc without puncture was performed in the sham group (n=10). There were no surgical interventions in the naive group (n=5). At 1 day and 7 days after surgery, double immunofluorescence staining was performed with anti-Na<sub>v</sub>1.8 antibody in combination with the neuronal markers, IB4, anti-trkA antibody and RT97 (each group, n=5). The percentages of Na<sub>v</sub>1.8 immunoreactive (IR) neurons in each subtype of neurons were calculated using imaging analysis software (NIH ImageJ).

**RESULTS:** Na<sub>v</sub>1.8 was observed in the DRG neurons in all experimental groups, especially in small-sized neurons. At 1 day after surgery, the percentages of Na<sub>v</sub>1.8-IR neurons significantly increased in trkA-IR neurons in the disc puncture group compared with the sham and naive groups (p<0.05). There were no significant differences among three groups in any subtypes 7 days after surgery.

**DISCUSSION:** Leakage of nucleus pulposus from a lumbar disc to the DRG induced a transient increase of Na<sub>v</sub>1.8 neurons in the affected DRG co-localized with trkA, a receptor of nerve growth factor (NGF). Nucleus pulposus might thus contribute to an upregulation of Na<sub>v</sub>1.8 in the DRG through NGF-related mechanisms. The findings in the present study demonstrate a mechanism which may be of importance in the pathophysiology of sciatic pain in lumbar disc herniation.

### GP70. CLINICAL OUTCOME FOLLOWING AGGRESSIVE BILATERAL POSTERIOR DISCECTOMY FOR EXCISION OF CONTAINED LUMBAR DISC HERNIATION

Joo Han Kim, Hong Joo Moon, Jung Jae Park, Jung Keun Suh, Youn Kwan Park

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**INTRODUCTION:** Recently, it has been recommended that contained central disc protrusion with big posterior traction spur should be laboriously removed at the bilateral side. However, usefulness of this strategy is controversial because bilateral approach can evoke more postsurgical back pain and increase the chance to instability compared to unilateral approach. The aim of this study is to evaluate the clinical outcome of patients undergoing aggressive bilateral discectomy compared to standard unilateral microdiscectomy group.

**MATERIALS AND METHODS:** Criteria for performing an aggressive bilateral posterior discectomy were mainly bulging disc with big posterior traction spur and thinning of fibrous ring with or without perforations within the ring. According to these criteria, authors recruited 82 patients who were received aggressive bilateral posterior discectomy by microscopy. The control group (92 patients) was operated in standard unilateral microsurgical discectomy manner during the same time. A detailed analysis of the visual analogue scale (VAS) for pain degree, the Oswestry Disability Index (ODI), and reoperation rate, was performed during more 2 years follow-up.

**RESULTS:** In aggressive bilateral discectomy group, most remarkable radiological features are reshaping of the contours of bulging annulus and widening of spinal canal. Mean VAS and ODI of two groups at 1yr, 2yr and final follow-up were quite similar ( $p>0.05$ ). There were three patients with recurrent radicular symptoms in aggressive bilateral discectomy group, requiring reoperation procedure at two patients (2.4 % of reoperation rate). In control group, there were four recurrences that led to reoperations (4.3 %).

**CONCLUSIONS:** Aggressive bilateral discectomy group revealed similar clinical results with standard unilateral discectomy group. There is a comparable low number of reoperation in aggressive bilateral discectomy group without prominent postoperative back pain. This might be caused by strict patients' selection for aggressive bilateral discectomy according to well-defined criteria, and aggressiveness of disc and spur removal without injury of facet joint.

### GP71. CENTRAL AND PERIPHERAL NERVOUS SYSTEM EFFECTS OF NUCLEUS PULPOSUS EXPOSURE

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**INTRODUCTION:** Disc herniation pain is believed to be caused by both chemical influence of nucleus pulposus (NP) and nerve root compression. Neuronal activity in the thalamus has been demonstrated to increase 20 minutes after NP application onto a dorsal root ganglion (DRG). Here we present data on effects in the thalamus 24 hours after leakage of NP onto the adjacent DRG followed by acute compression.

**METHODS:** On day 1 a lumbar disc puncture was made in 9 Sprague Dawley rats. Sham operated animals (n=8) and naïve rats (n=6) served as controls. Day 2 the L4 DRG was dislocated by inserting a needle into the vertebrae. Neuronal responses in the contralateral ventral posterior lateral thalamic nucleus evoked by electrical stimulation of sciatic A $\delta$  fibres were recorded for 30 minutes. Thereafter NP was applied onto the DRG and recordings continued for 30 minutes. Separate groups of animals were tested for mechanical withdrawal sensitivity on both hindlimb paws using Von Frey hairs (n=7/group).

**RESULTS:** Mechanical dislocation of the DRG resulted in a similar decreased number of evoked responses in both disc puncture, sham and naïve animals to about 70 % of baseline. Application of NP onto the DRG with the needle in situ resulted in increased evoked thalamic responses to only about 80% in all groups. Von Frey tests did not reveal any changes in withdrawal threshold.

**DISCUSSION:** In contrast to previously demonstrated facilitatory acute effects of NP application, no evidence were found for long term changes of increased neuronal activity following prior exposure to NP evaluated by electrophysiology or behavioural tests. The results instead indicate that acute NP effects have worn off after 24 hours. The depression of neuronal responses following mechanical dislocation suggests that it may not contribute to increased pain transmission but counteract the NP effects.

## GENERAL POSTERS

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### GP72. OUTCOMES OF NONSURGICAL TREATMENT OF LUMBAR DISC HERNIATION IN OLDER ADULTS

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**INTRODUCTION:** Increasing rates of laminectomy/discectomy for older adults in the US may be due to a perception that outcomes of non-surgical treatment of lumbar disk herniation (LDH) in older adults are poor as compared to outcomes in younger adults. The objective of this study was to determine whether outcomes of LDH are poor in older adults.

**METHODS:** 154 consecutive individuals with a clinical diagnosis of acute lumbosacral radicular syndrome ( $\leq 12$  weeks) secondary to LDH confirmed by MR imaging were prospectively enrolled. Subjects were assigned to one of two age groups:  $\geq 60$  years or  $< 60$  years. Oswestry Disability Index (ODI), visual analog scale (VAS) for back pain and leg pain, sociodemographic features, clinical features, and herniation characteristics were measured at baseline, 1 month, 3 months, and 6 months. Six month ODI change from baseline was the primary outcome.

**RESULTS:** There were 48 subjects in the older group (mean age  $68.0 \pm 7.9$ ) and 106 subjects in the younger group ( $45.9 \pm 8.7$ ). Older adults had less baseline VAS back pain ( $4.3 \pm 3.3$  vs.  $5.5 \pm 3.2$ ;  $p = .04$ ). Between-group baseline ODI ( $49 \pm 19$  vs.  $53 \pm 22$ ;  $p = .30$ ) and VAS leg pain ( $7.2 \pm 2.2$  vs.  $6.9 \pm 2.5$ ;  $p = .61$ ) were comparable. Multivariate analysis of 6 month change scores adjusting for gender, race, comorbidity, work status, duration of symptoms, and herniation characteristics showed no differences between older and younger groups for ODI improvement (34 vs. 40;  $p = .36$ ) and leg pain improvement ( $4.3$  vs.  $4.2$ ;  $p = .96$ ), but less back pain improvement in older adults ( $1.5$  vs.  $3.7$ ;  $p = .02$ ). There was no difference in back pain improvement when adjusting for older adults' lower baseline back pain ( $2.4$  vs.  $2.8$ ;  $p = 0.46$ ).

**DISCUSSION:** We found no evidence of a poor clinical course with nonsurgical treatment for older adults with acute LDH. Future randomized trials of surgical intervention for LDH should appropriately include older adults to ascertain the relative merits of surgery as compared to conservative care.

### **GP73. FEMORAL NEUROGRAM TO ASSESS THE ANATOMIC COURSE PRIOR TO A TRANSPSOAS SPINAL ACCESS TO THE L4-5 INTERVERTEBRAL DISC SPACE**

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**SUMMARY OF BACKGROUND DATA:** Neurologic symptoms and signs have been reported in up to 30% of patients following a lateral transpsoas approach to the lumbar spine. The femoral nerve as well as other neural structures is at risk when accessing the L4-5 disc space. An L4 neurogram results in contrast spread producing a femoral neurogram. The objective was to predict the course of the femoral nerve across the L4-5 disc space.

**METHODS:** AP and lateral femoral neurograms were reviewed in 100 subjects. The disc space was separated into: Zone 1 = the most ventral 25%, Zone 2 = 25% ventral to mid-coronal line, Zone 3 = 25% dorsal to the mid-coronal line, Zone 4 = the most dorsal 25 %, and Zone P = dorsal to the disc space. Four observers reviewed each fluoroscopic set of images and recorded their interpretation of the femoral neurograms scoring each subject by zone.

**RESULTS:** There were 43 Males and 57 Females, age range 23 to 95 years. The pattern of femoral nerve location is as follows: Males, the femoral nerve was located 4.7% in Zone 2, 32.5% in Zone 3, 53.5% in Zone 4, and 9.3% in Zone 5. For Females, it was located 7.0% in Zone 2, 14% in Zone 3, 54.4% in Zone 4, 24.6% in Zone P. Eighty-two percent of femoral nerves were present in Zone 2, Zone 3, and Zone 4 collectively.

**CONCLUSION:** The femoral nerve trajectory across the L4-5 disc may have an impact on the risk of femoral nerve injury during the transpsoas spinal approach. Femoral neurogram may be a useful tool in the preoperative assessment of patients when considering a transpsoas surgical approach.

## GENERAL POSTERS

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### GP74. THE RELATIONSHIP BETWEEN THE FINDING OF CALCIFICATION OF AORTA AND BOTH THE GRADE OF LUMBAR SPONDYLOSIS AND BONE MINERAL DENSITY

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**INTRODUCTION:** There is an inverse relationship between osteoporosis and lumbar spondylosis. Recent study revealed that arteriosclerosis is related to osteoporosis. In contrast, there were some data showing arteriosclerosis brings about disc degeneration, meaning spondylosis. This study was designed to examine whether the calcification of aorta was related to osteoporosis or lumbar spondylosis.

**MATERIALS AND METHODS:** One hundred fifty-one postmenopausal women who visited our hospital with the complaint of low back problems were subjected to this study. The mean age was  $71.5 \pm 8.0$  years old. Anteroposterior and lateral radiographs of the lumbar spine were obtained. The existence of the calcification of aorta was checked. The severity of lumbar spondylosis was divided into 5 categories using the modified Kellgren and Lawrence score (spondylosis score). BMD s of the lumbar vertebrae, the femoral neck and the distal radius were measured. Then, the relationship between the finding of the calcification of aorta and both the grade of the lumbar spondylosis and BMD s was examined.

**RESULTS:** The spondylosis score was negatively correlated with the BMD of the lumbar vertebrae and the femoral neck ( $p < 0.0001$ ). Sixty-six cases (44 %) had the calcification of aorta (CA group). Twenty-seven cases (44.2%) in CA group had vertebral compression fracture, whereas only 23 cases (28.5%) in non-CA group had the fracture. The difference was statistically significant ( $p = 0.04$ ). The cases with calcification showed lower BMD of the femoral neck ( $p = 0.008$ ) and the distal radius ( $p = 0.02$ ).

**DISCUSSION:** This study clearly indicated that there was relationship between the calcification of aorta and lower BMD at both upper and lower extremity in Japanese elderly women. Further, the cases with the calcification frequently had osteoporotic vertebral fracture in the lumbar spine. Based on these results, it is concluded that the calcification of aorta is related to osteoporosis.



### GP75. RADIOGRAPHIC EVALUATION OF THE INSTABILITY IN DEGENERATIVE LUMBAR SCOLIOSIS (DLS)

Hiroyuki Yasuda, Akira Matsumura, Shinji Takahashi, Tomiya Matsumoto, Sho Dozono, Akinobu Suzuki, Hiromitsu Toyoda, Hidetomi Terai, Nakamura Hiroaki

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**INTRODUCTION:** Evaluation of segmental instability in degenerative lumbar scoliosis (DLS) is essential when we operate. This study aimed to evaluate segmental instability in DLS with radiographic parameters compared with lumbar spinal canal stenosis (LCS).

**METHODS:** Forty patients with DLS (averaged Cobb angle: 17.1 degrees) and 40 patients with LCS were recruited for the study. On standing anteroposterior radiographs, wedging segment ( $>5$  degrees) and non-wedging segment ( $<5$ ) were defined in the DLS and LCS groups, respectively. The ROM of segments was measured on lateral bending films. On standing anteroposterior radiographs, lateral slip (L-slip) were measured, and osteophyte formation were assessed with Nathan's method (Nathan grading). On CT images, joint space discrepancies of facet (JS-discrepancy) were measured.

**RESULT:** There were no significant differences in the ROM between DLS and LCS groups (L2/3: 6.7 vs. 7.9 degrees:  $P=0.43$ , L3/4: 7.0 vs. 6.5 degrees:  $P=0.77$ , and L4/5: 4.7 vs. 6.2 degrees:  $P=0.24$ ). In wedging segments, the reduction of ROM was significantly correlated with Nathan grading ( $R=0.61$ ). L-slip and JS-discrepancy in the DLS group were significantly greater than those in the LCS group (3.8 vs. 1.05 mm:  $P<0.01$ , 1.74 vs. 1.31:  $P<0.01$ ).

**DISCUSSION:** This study showed that the ROM was the same between wedging and non-wedging segments, and that wedging segments had larger lateral slip and joint space discrepancies of the facet. The reduction of ROM was significantly correlated with osteophyte. This indicated that: (1) a vertebral body moved with an inclined axis and (2) greater wedging caused subluxation of the facet joint and led to lateral slip, (3) Hyperdisplasia of osteophyte showed less ROM. Therefore, we speculated that segmental instability in DLS occurred because of asymmetric disc degeneration and led to subluxation of the facet joint or lateral slip and hyperdisplasia of osteophyte repaired segmental instability in DLS.

## GENERAL POSTERS

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### GP76. RELATIONSHIP BETWEEN SAGITTAL INSTABILITY FACTORS AND DISC DEGENERATION EXAMINED BY LUMBAR MRI

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**INTRODUCTION:** Relationship between degenerative findings and instability in lumbar segment is still in controversial. The purpose of this study is to examine the relationships between segmental instability and disc degeneration evaluated by radiography and MRI.

**METHODS:** Data was obtained from 447 (268 M, 179 F, age range 10-86 y, mean: 52.8±19.8 y) patients with low back pain and/or sciatica examined by radiography and MRI simultaneously. The degrees of slip in neutral position (if degree of the slip is positive, relative position of L4 on L5 locate anterior, indicating anterior slip), sagittal translation and angulation at L4/5 segment were obtained as instability factors from neutral and flexion-extension films. MRI was performed using a 1.5 Tesla clinical magnet with sagittal T2-weighted imaging sequence. Disc degeneration in MRI was evaluated using Pfirrmann's criteria (Grade 1 to 5). Relations of instability factors and disc degeneration were examined.

**RESULTS:** Numbers of patients with male/female ratio and mean age of the each degeneration group were 29 (16/13, 23.0) in Grade 1, 37 (25/12, 33.0) in Grade 2, 127 (87/40, 49.6) in Grade 3, 171 (88/83, 60.6) in Grade 4, and 83 (52/31, 61.1) in Grade 5, respectively. As the degeneration progressed, mean degree of the neutral slip was gradually changed from negative to positive, indicating progression of anterior slip with degeneration. Degree of translation was the largest in the Grade 3 group than others but Grade 1. Angulation was the largest in the groups of Grade 1 and 3 with statistically significant difference.

**DISCUSSION:** The above findings indicate that the factors thought to be related to segmental instability well relates with the degrees of disc degeneration. The result that the Grade 3 group had the most excessive angulation and translation might indicate a risky stage of the progressive instability related to low back pain and/or sciatica.

### GP77. LUMBAR SPINOUS PROCESS MORPHOLOGY AND THE INFLUENCE OF AGE

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**INTRODUCTION:** The Lumbar Spinous Processes (LSP) have important anatomical and biomechanical functions. They also influence access to the spinal canal for neural decompressive procedures. There is evidence that various anatomical structures have altered morphology with ageing, and there is anecdotal evidence of changing LSP morphology with age. This study aims to clarify the influence of age on LSP morphology, and on lumbar alignment.

**METHOD:** 200 CT scans of the abdomen were reformatted with bone windows in sagittal and coronal planes allowing precise measurement of LSP dimensions, and Lumbar Lordosis. Observers were blinded to patient demographics. Inter-observer reliability was examined. Data was analysed by an independent statistician.

**RESULTS:** The smallest LSP is at L5. The male LSP is on average 2-3mm higher and 1mm wider than the female LSP. LSP height increases significantly with age at every level in the lumbar spine ( $p < 10^{-5}$  at L2). The LSPs increase in height by 2-5mm between 20-85 years of age ( $p < 10^{-6}$ ), which was as much as 31% at L5 ( $p < 10^{-8}$ ). Width increases proportionally more, by 3-4mm or greater than 50% at each lumbar level ( $p < 10^{-11}$ ). Lumbar lordosis decreases in relation to increasing LSP height ( $p < 10^{-4}$ ) but is independent of increasing LSP width ( $p = 0.2$ ).

**DISCUSSION:** This study demonstrates that the dimensions of the LSP change with age. Increases in LSP height and more impressive increases in width occur with advancing age. This study suggests that loss of lumbar lordosis is correlated with changing LSP morphology. The increased width of the LSP with age influences access to the spinal canal, particularly if midline-preserving approaches are attempted. There is increased bone volume for bone grafting procedures with increasing age. Lordosis reduction may occur not only as a result of disc space narrowing, but also as a consequence of increased LSP dimensions.

## GENERAL POSTERS

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### GP78. 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.

### **GP79. LUMBAR FACET AND INTERFACET SHAPE VARIATION DURING GROWTH IN CHILDREN FROM THE GENERAL POPULATION: A THREE YEARS FOLLOW-UP MRI STUDY.**

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**INTRODUCTION:** The growth of the lumbar facet and interfacet area in children from the general population has rarely been discussed in the literature. This is an important caveat considering the important role these structures play in the development of spinal anomalies. The study aims to characterize lumbar facet and interfacet shape variation during growth.

**MATERIALS AND METHODS:** All lumbar (L1-S1) facet and interfacet widths and transverse orientations were measured twice by the same investigator (YM) from T2-weighted MRIs of 100 healthy children (51 boys and 49 girls) from the general population at the mean age of 12-13 years (t0) and following three years at the mean age of 15-16 years (t1) using the iQ-VIEW system. Statistical analysis included t-tests and Pearson's r following the Kolmogorov-Smirnov test for normal distribution.

**RESULTS:** The superior facet width is correlated with individual's height only in boys at t0 ( $0.56 \leq r \leq 0.66$ ). No significant asymmetry in lumbar facet width and orientation is seen in children independent of gender both at t0 and t1. Lumbar facets have widened significantly only in boys from t0 to t1 (up to 30.8%). Girls at t1, manifest greater superior interfacet width relatively to the superior vertebral body width than boys at L2-L4. No significant difference is indicated in facet orientation of the two sexes at t0 and t1. In boys only, the superior facet rotates significantly from t0 to t1 (up to -100 in the interfacet angle) towards a more sagittal orientation.

**CONCLUSIONS:** The lumbar facet joints in boys continue to develop after the age of 12, whereas facets in girls seem to have reached maturity at that age. Moreover, lumbar facet asymmetry when noted in children can be considered as a deviation from the normal state. Further research should look into what the consequences might be.

## GENERAL POSTERS

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### **GP80. THE SAGITTAL SPINAL ALIGNMENT IN PATIENTS WITH LUMBAR DEGENERATIVE DISEASE. A COMPARATIVE STUDY 193 CASES**

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**INTRODUCTION:** Retrospective analysis of the spino-pelvic alignment in a population of 193 cases with a lumbar degenerative disease and compared to 54 normal control group. Several previous publications reported the analysis of spino-pelvic alignment in the normal and low back pain population. Data suggested that patients with lumbar disease have variations of sagittal alignment such as less lordosis and pelvic shape. The objective of this study was to analyse spino-pelvic parameters including pelvis shape and the correlation and compare these patients with control group of normal volunteers.

**METHODS:** We analysed five different lumbar degenerative disease: disc herniation(DH),n=61; degenerative spondylolisthesis(DSL),n=41; lumbar canal stenosis (LCS), n=35; lumbarlysis (LL), n=20; low back pain, n=36. Spino-pelvic alignment was analysed pre-operatively on full spine radiographs. Spino-pelvic parameters were measured as positioning of C7 plumb line (SVC), lumbar lordotic angle (LLA), sacral slope (SS), pelvic angle (PA) and pelvic morphologic angle (PRS1).

**RESULTS & DISCUSSION:** Concerning the pelvis shape, patients with DD and LL demonstrated to have significant lower PRS1 as  $32.6 \pm 9.0$  and  $32.1 \pm 10.9^\circ$  respectively, than control group ( $37.5 \pm 8.7^\circ$ ). The these five groups (LCS, DS,LL, LDH, LBP) of patients were characterized by significant variations vs control in spino-pelvic alignment: anterior translation of SVA (48.6, 45.2,27.6 vs 2.9mm in LCS, DS, LL) ,loss of LLA( $19.9$  vs  $30^\circ$  in LCS), decrease of SS( $26.6, 29.2$  vs  $35^\circ$  in LCS, DS), increase of SS( $36.4^\circ$  in LL), increase of PA ( $24.6, 28.0$  vs  $17.4^\circ$  in LCS, DS). Measurement of the pelvic morphologic angle and spinal parameters permitted to understand variations of spino-pelvic parameters in a population of patients. Our results suggested that the lower PRS1 could be one of risk factor to occur DS and LL.

### **GP81. MODIFIED MAGNETIC RESONANCE SPECTROSCOPY DIAGNOSIS OF PAINFUL AND NON-PAINFUL LUMBAR INTERVERTEBRAL DISCS**

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Previously reported experiments used 11T HR-MAS Spectroscopy to examine discs removed at surgery. Lactic acid (LA) and proteoglycan (PG), appeared to be quantifiable markers for discogenic pain. The goal of this study is to acquire magnetic resonance spectroscopy (MRS) signatures of the intervertebral disc in vivo (DDD-MRS), and to correlate these with other standard diagnostic measures.

65 discs from 36 total subjects from a single center were included. Thirty-eight discs were from 17 patients with a diagnosis of chronic low back pain, and 27 discs were from 19 asymptomatic volunteers (ASY). All discs were evaluated by single voxel magnetic resonance spectroscopy (SV-MRS). Thirteen discography positive (PD+) discs were used as positive control (PC) discs, and 12 discography negative (PD-) discs plus all the ASY discs were used as negative control (NC) discs.

PD was performed when indicated. A 3.0T GE Signa MRI system and 8-channel spine detector coil were used with the DDD-MRS. Multi-variate regression analyses produced a DDD-MRS diagnostic algorithm using PG, LA, and alanine (AL) MRS region data to calculate a single number for a disc. Positive numbers were MRS+ (painful), and negative values were MRS- (non-painful).

DDD-MRS diagnoses demonstrated a strong correlation with the clinical diagnoses ( $R^2=.89$ ,  $p$

The DDD-MRS diagnostic algorithm developed and evaluated in this study demonstrated high sensitivity for identifying discs with discogenic pain, and a high specificity for identifying non-painful levels. Further prospective, multi-center studies are warranted to confirm these encouraging results.

### GP 82. “SKIPPED” LEVEL DISC DEGENERATION OF THE LUMBAR SPINE, A MRI STUDY OF 1989 INDIVIDUALS

Kenneth M.C. Cheung, Dino Samartzis, Jaro Karppinen, Florence P.S. Mok, Daniel W.H. Ho, Daniel Y.T. Fong, and Keith D.K. Luk

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**INTRODUCTION:** This study describes prevalence and risk factors associated with an unusual pattern of disc degeneration of the lumbar spine which we term “skipped” level disc degeneration (SLDD), in which levels of degenerated discs have intervening non-degenerated level(s).

**METHODS:** As part of a large population-based genetic study in Southern Chinese (N=1,989), subjects had MRI assessments of the whole lumbar spine. Disc degeneration of more than two levels (n=838) were grouped into SLDD (n=174) and non-SLDD (contiguous, multilevel; n=664). Additional radiographic abnormalities and subject demographics were also assessed.

**RESULTS:** SLDD was present in 8.7% of the population, and 20.8% of subjects with multilevel disc degeneration (n=838). SLDD was more prevalent in males (adjusted OR: 1.48; 95% CI: 1.04 to 2.10; p=0.028), and was significantly associated with the presence of Schmorl’s nodes (adjusted OR: 2.72; 95% CI: 1.78 to 4.15; p<0.001). A number of patterns of “skipped” can be identified in which there could be more than one level of intervening non-degenerated discs, or multiple levels of degeneration above and below the non-degenerated level. Disc bulge/extrusion and back injury history were significantly associated with non-SLDD (p<0.05), as was back pain. A greater degree of overall disc degeneration severity was associated with non-SLDD. Other demographics and MRI findings did not significantly differ between groups (p>0.05).

**CONCLUSIONS:** To our knowledge, this is the first study to describe the prevalence and factors associated with SLDD. Our study challenges the “traditional” paradigm for the development of disc degeneration. Although age and biomechanical factors may play a role, the presence of skipped levels would suggest non-mechanical factors or altered mechanics of the lumbar spine plays a role in the development of disc degeneration. Such factors warrant further investigation and may shed light into the cause and mechanism of disc degeneration.



### **GP83. CONE BEAM CT SCAN VS. FLUOROSCOPY: A CADAVERIC STUDY COMPARING ACCURACY, TIME AND RADIATION DOSES.**

Anthony Gibson, Dean Karahalios, Jean-Pierre Mobasser, Eric Potts, Shane Burch, San Francisco, CA, USA

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**INTRODUCTION:** Intra-operative Cone Beam CT Scanning (O-ARM) is currently indicated for complex and MIS spinal procedures. This cadaveric study compared the efficiency, accuracy and radiation dose of O-ARM with conventional fluoroscopy (C-ARM).

**METHODS:** Four participating surgeons operated on eight cadavers without deformity. Instrumentation was placed bilaterally at T1-6 and L5-S1 using open technique and MIS at L3-4. A total of 160 screws were placed, 80 using O-ARM and 80 using C-ARM. Dosimeters were placed on the cadaver and over the surgeon and scrub techs lead. Post-operative CT scans were performed on O-ARM and with a stationary CT scanner. An independent radiologist assessed CT scans for malpositions.

**RESULTS:** Set up time for O-ARM cohort was 592s vs. 297s for C-ARM ( $p$  less than 0.05). The mean time to place screws was 1037s for O-ARM and 1342s for C-ARM (29% difference,  $p=0.06$ ). The mean total time showed no statistical difference (O-ARM= 1629s, C-ARM= 1639s,  $p= 0.96$ ). 5 breaches were identified in O-ARM cohort and 7 in C-ARM. The difference in these rates was not statistically significant ( $\text{Chi}^2=0.63$ ,  $p=0.4$ ). Surgeons received higher radiation doses using C-ARM in lumbar and MIS procedures ( $p$  less than 0.05). No statistical difference was detected in radiation doses for cadavers except in lumbar procedures on lateral dosimeters, O-ARM dose 49.23(+/-14.3) mSv vs. 21.2(+/-9.9) mSv ( $p=0.0001$ ).

**CONCLUSION:** In cadavers without deformity, O-ARM gives lower doses of radiation to the surgeon but higher to the patient, it allows more rapid placement of screws, but slower setup. The two methods showed similar total time and accuracy.

## GENERAL POSTERS

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### GP84. MORPHOLOGICAL STUDY OF LUMBAR FACET JOINT AND THE SAGITTAL ALIGNMENT IN PATIENTS WITH DEGENERATIVE SPONDYLOLISTHESIS

Wuqikun Alimasi, Kenji Endo, Dai Kimura, Hidekazu Suzuki, Hiroto Kobayashi, Hidetoshi Tanaka, Satoshi Tanaka, Kengo Yamamoto

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**INTRODUCTION:** The purpose of the present study was to analyze the morphological character in patients with spondylolisthesis by imaging technique.

**METHODS:** This study is retrospective analysis of the lumbar facet joint in population of 113 cases. The patients with L4 lumbar spondylolisthesis (DS) was in 42 cases, compared to lumbar canal stenosis group (LCS) in 32 cases and the low back pain group (LBP) in 39 cases. In the study, two different planes of facet joint (FJ) (horizontal plane:HP, oblique plane:OP), lamina angle in lateral plane (LP) and lumbar lordotic angle (LLA), pelvic angle (PA) are measured by CT and radiographs.

**RESULTS:** There were less correlation among HP,OP and LP( $r = 0.02 \sim 0.4$ ). The study showed a significant difference between facet orientation and presence of DS as well as difference in facet orientation between individuals with and without DS on HP ( $P < 0.01$ ). Facet orientation is significantly increased in DS versus LBP on OP ( $P < 0.05$ ), but there was no difference on LP. PA is increased in DS, but wasn't a significant difference.

**DISCUSSION:** So far, the two dimensional analysis of facet orientation is few and in this study, we analyzed the correlation of FJ on two planes as well as LP. Patients with DS have on more sagittally orientated FJ than other two groups. These results are in agreement with previously studies, and in the mean while FJ orientation more horizontally on OP. the direction of the force of anterior slip is downward in lumbar vertebra. Regarding to sagittal alignment, the LLA and PA was increased due to the compensation of slipping the vertebra. This finding suggests that sagittal shape of the facet joint is not essential as a factor for the development of the slip. Slipping can influence of the lumbar and pelvic the sagittal alignment of DS.

### GP85. ON-SITE INTRA-OP “SCRAPE CYTOLOGY” OF TRANSPEDICULAR BIOPSY OF VERTEBRAL BODY LESIONS.

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**INTRODUCTION:** Obtaining adequate representative material has been a problem in transpedicular biopsies resulting in inconclusive diagnosis and need to repeat. “Scrape cytology” provides rapid intraoperative confirmation of the adequacy of the material. Present study evaluates the role of scrape cytology in increasing the diagnostic yield of the specimen.

**MATERIALS AND METHODS:** 17 patients with MR proven vertebral body lesions were included (thoracic: 11, lumbar:5 and sacral in one). Scrapings from the surface of biopsy specimen were used to prepare slides. Rapid H&E staining and xylol mountings were used for cytological examination. Additional tissue specimens were obtained if the pathologist reports the tissue as inadequate. All specimens were later submitted to routine histopathological examination and other complimentary tests. For the purpose of analysis, *adequacy* was defined as the percentage of biopsy specimens from which the pathologist can make the diagnosis and *accuracy* as the percentage of biopsy reports that are confirmed either after surgery, open biopsy or response to treatment.

**RESULTS:** The average time taken to report was seven (7+/-2) minutes from the start of scraping to the end of reporting. There were three instances where the initial cytological impression was inadequate. In two of these, additional tissue was obtained; where as in the the other, initial biopsy was performed at a wrong level. The adequacy and accuracy of biopsy without scrape cytology was 88% and 82% respectively where as the accuracy and adequacy were 100% with scrape cytology. There were no complications specific to the procedure.

**CONCLUSIONS:** On-site intra-operative scrape cytology is a rapid and inexpensive technique which complements the transpedicular vertebral biopsy procedure to obtain a highly accurate and adequate tissue specimen with 100% diagnostic yield and completely avoids the need to repeat the biopsy.

## GENERAL POSTERS

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### **GP86. CORRELATION OF EXCESSIVE FACET JOINT FLUID LEVELS WITH SURGICAL OUTCOMES AFTER DECOMPRESSIVE SURGERY WITHOUT FUSION FOR LUMBAR DEGENERATIVE DISEASE.**

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**INTRODUCTION:** Spinal fusion is generally recommended when lumbar spinal instability exists. A correlation between excessive facet joint fluid levels detected on magnetic resonance images and radiological instability has been reported. However, excessive facet fluid levels are occasionally found in cases without radiological instability. This study examined the correlation between facet joint fluid levels and surgical outcomes after decompressive surgery without fusion.

**METHODS:** Seventy-three patients without significant radiological instability who underwent lumbar decompressive surgery ( $\leq$  three levels) were divided into the “fluid-group” and the “no-fluid-group,” by the presence of excessive facet fluid. Severity of pain and numbness (visual analogue scale: VAS), intermittent claudication (IC), subjective surgical outcomes (Odom scale) and disability scores for lumbar spinal disorders (Japanese Orthopaedic Association Back Pain Evaluation Questionnaire: JOABPEQ) were compared pre- and post-operatively.

**RESULTS:** Of the 73 patients, 16 patients had excessive facet joint fluid (21.9%). The mean follow-up period was 16.6 (6-30) months. Pre-operative VAS scores (lower-back pain, leg pain, numbness) were 5.2, 5.4, and 7.5 in the fluid-group, and 5.8, 6.0, and 6.5 in the no-fluid-group, whereas post-operative scores were 2.3, 3.3, and 3.7 in the fluid-group, and 2.7, 2.7, and 2.8 in the no-fluid-group. When comparing the pre- and post-operative states, and post-operative improvements, no significant difference was found between the groups in any of the VAS scores. There were no significant differences in IC, Odom scales, and any of the five subscales of the JOABPEQ scores.

**DISCUSSION:** The present study revealed that excessive facet joint fluid levels did not predict poor surgical outcomes after decompressive surgery without fusion when patients have no radiological instability, suggesting that spinal fusion is not necessary in patients with excessive facet fluid, if they have no radiological instability. Further studies are required to determine the clinical significance of excessive levels of facet joint fluid.

### **GP87. NEW CR IMAGE PROCESSING CONDITION OPTIMIZED FOR IMPROVING THE VISIBILITY OF PREOPERATIVE MARKING IMAGE IN POSTERIOR LUMBAR SPINAL SURGERY**

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**INTRODUCTION:** Sometimes preoperative marking image (=PMI) in posterior lumbar surgery is so obscure that the level diagnosis is difficult. The main cause is patient's condition such as obesity, osteoporosis and malalignment of spinous process. We developed a new image processing condition of CR (Computed Radiography) optimized for improving the visibility of PMI, and examine its usefulness.

**METHODS:** The materials are 100 consecutive PMIs of CR (lateral view of lumbar spine with 18 gauge needle inserted into spinous process as marker) taken from November 2008 to April 2009. Every image was processed under two conditions; the existing default condition (=groupD) and the developed optimized condition (=groupO). The latter is an optimized combination of kinds of image processing. Five doctors graded the 100 processed images (100x5=500) of the two groups into 4 grades by visibility as follows.

**I:** marker invisible

**II:** marker visible / level diagnosis unfeasible

**III:** level diagnosis feasible / contour of spinous process invisible

**IV:** level diagnosis feasible / contour of spinous process visible

**RESULTS:** 500 images were graded **I**101/**II**119/**III**217/**IV**63 in groupD, while **I**0/**II**1/**III**9/**IV**490 in groupO. 97.7% of images which were graded **I**, **II** or **III** in groupD were upgraded to **IV** in groupO.

**DISCUSSION:** Originally CR image is controllable by easy mouse operation on the screen, which is called "windowing". But windowing for PMI does not always produce diagnosable image (often results in too bright or dark image as a whole). On the other hand, our new developed image processing condition, which is an optimized combination of more complicated image processing such as Gradation Processing, Dynamic Range Control and Multi Frequency Processing, can dramatically improve the visibility of PMI regardless of patient's condition. This is useful for reducing surgeon's stress and preventing wrong-level surgery. Such a practical clinical application of CR image processing has not been reported in spinal surgery field.

### GP. 88 LUMBAR FACET JOINT SUBCHONDRAL BONE THICKNESS MEASUREMENT USING MRI

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**INTRODUCTION:** Change in subchondral bone (SCB) microstructure is a sensitive indicator of osteoarthritis (OA) of synovial joints. Few studies have focused on the SCB microstructure of the lumbar facet joints (FJs) and such information can be used to study pathogenesis and progression of the facet OA.

**METHODS:** A total of 1,800 FJs (L1/2-L5/S1, both sides, 90 volunteers, IRB-approved) were scanned with a 1.5T MRI unit. A custom-written C++ bilinear-interpolation, size-conversion algorithm with multi-threshold segmentation technique provided SCB thickness results from the middle axial-slice of each FJ. To validate the technique, an additional 10 cadaveric FJs were scanned both with MRI and microCT. Differences between groups were determined with ANOVA and statistical significance was set at  $p < 0.05$ .

**RESULTS:** The average SCB thickness was  $1.56 \pm 0.37$  mm (mean  $\pm$  SD), and showed significant increases both with age and successive lower spinal levels. In general, the SCB thickness of the superior facet showed large differences with respect to the inferior ones ( $p < 0.01$ ). Women's FJ SCB thickness values were also much smaller than their male counterparts ( $p < 0.05$ ).

**DISCUSSION:** SCB thickening occurs with progression of OA and is reported as a more sensitive indicator of OA compared with joint space width narrowing in various synovial joints. This study is the first to show quantitative measurement of SCB thickness in vivo, usually just diagnosed qualitatively with CT or MRI. The data showed good agreement between the MRI and microCT comparison, thus validating this technique. SCB thickness was greater in men and increased with each successive lower spinal level. These findings may suggest that the SCB thickness increases with loading. Additionally, the superior facet SCB was thicker than the inferior facet regardless of gender, age or spinal level. More studies are needed to relate SCB microstructure, FJ kinematics and spinal loading.

### **GP89. THE USE OF ORTHOGONAL PLAIN RADIOGRAPHS IN DETERMINING THE POSITION OF THORACIC PEDICLE SCREWS: ARE THEY RELIABLE?**

Mr. Naresh Kumar, FRCS(Orth);DM(Orth), Dr. Ni Guo-Xin, MD, PhD, Prof Wong Hee-Kit, MD, National University of Singapore, 5 Lower Kent Ridge Road, Singapore. 119074.

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**BACKGROUND DATA:** Pedicle screws are increasingly being used for internal fixation of the thoracic spine. Surgeons and radiologists are often required to make decisions on the pedicle screw position by plain antero-posterior (AP) and lateral radiographs.

**MATERIALS AND METHODS:** 23 disarticulated fresh adult thoracic vertebrae were used in this study. Pedicle screws were inserted completely within the pedicle; or deliberately violating the lateral or medial cortex of the pedicle. AP and lateral radiographs of each vertebrae were assessed by 2 spine surgeons, 2 spine trainees, and 2 musculoskeletal radiologists in a sequence of AP alone, and AP + lateral views. They were asked to label it as 'out laterally' or 'inside pedicle' or 'out medially'. Their assessments were compared to the actual position of the screws determined by the axial views.

**RESULTS:** For each screw position, trend was found towards slightly better accuracy with availability of AP & lateral views in combination. From either AP alone or AP + lateral views, significantly higher accuracy was found in detecting screws "out laterally" than "inside pedicle" ( $p < 0.01$ ), or "out medially" ( $p < 0.05$ ), respectively. Nearly 30% of screws that were deliberately placed through the medial pedicle wall were not correctly identified. Surgeons have highest accuracy from either AP alone, or AP + lateral views, followed by the spine trainees and radiologists. Radiologists provided more "unsure" answers than surgeons or trainees.

**CONCLUSIONS:** Screws that perforated the lateral cortex were the easiest, and those that were wholly within the pedicle were the most difficult to identify correctly. The use of plain radiographs to detect thoracic pedicle screws placed through the critical medial cortex is unreliable. The positions of thoracic pedicle screws appear to be more accurately detected by AP + lateral, however, the major contribution was from AP views. Surgeon experience is vitally important in the safe placement of thoracic pedicle screws.

## GENERAL POSTERS

### GP90. IN VIVO MEASUREMENT OF LUMBAR VERTEBRAL ENDPLATES 3D SURFACE AREA IN HEALTHY VOLUNTEERS

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**INTRODUCTION:** Measurement of the endplate surface area in healthy subjects provides baseline information to be used for estimation of stress in intervertebral discs, estimation of disc volume and determination of size of spinal implants in addition to anthropological studies. Due to the complex 3D endplate geometry, 3D models are necessary for accurate measurement of the endplate surface area. The objective of this study was to contribute with baseline geometric information from a cohort of healthy volunteers using subject-based 3D CT models.

**METHODS:** L1-S1 3D CT polygon models were analyzed with custom-written Visual C++ software to determine superior and inferior endplate surface areas from CT scans from 56 volunteers (26F, 30M, IRB-approved). The superior vs. inferior areas for each vertebra and the inferior area of cranial vertebra vs. superior area of caudal vertebra for each disc level were compared with paired *t*-tests. Age and level effects were sought with ANOVA. Results are presented as Mean±SD.

**RESULTS:** No differences were found between age groups and gender. The endplate surface-area increased with each successive lower spinal level (Table 1,  $p < 0.001$ ). The superior endplate areas were smaller at L1-L5 ( $p < 0.0001$ ). For the discs, the superior and inferior endplate surface showed uniform areas except at L4/5 (inferior endplate of L4 < superior endplate of L5,  $p < 0.001$ ).

Level/Side	Superior Area (mm <sup>2</sup> )	Inferior Area (mm <sup>2</sup> )
L1	1770.8±452.2	1902.1±382.9
L2	1863.7±448.4	1957.1±330.8
L3	1956.5±407.9	2003.1±372.6
L4	1939.9±299.3	2017.4±307.8
L5	2153.9±355.5	2220.0±329.5
S1	2266.1±363.7	N/A

**Table 1.** Endplate Areas

**DISCUSSION:** Although other anthropological studies report linear dimensions for the vertebrae, this study is the first to measure *in-vivo* surface-areas of the bone surface of the endplates. The results of the present study showed that the disc dimensions increased with each successive lower spinal level; but this increase was primarily due to a larger inferior endplate within each vertebral body.



### GP91. 2D/3D RECONSTRUCTION OF A SCALED LUMBAR VERTEBRAL MODEL FROM A SINGLE FLUOROSCOPIC IMAGE

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**INTRODUCTION:** Accurate three-dimensional (3D) models of lumbar vertebrae can enable image-based 3D kinematic analysis. The common approach to derive 3D models is by direct segmentation of CT or MRI datasets. However, these have the disadvantages that they are expensive, time-consuming and/or induce high-radiation doses to the patient. In this study, we present a technique to automatically reconstruct a scaled 3D lumbar vertebral model from a single two-dimensional (2D) lateral fluoroscopic image.

**METHODS:** Our technique is based on a hybrid 2D/3D deformable registration strategy combining a landmark-to-ray registration with a statistical shape model-based 2D/3D reconstruction scheme. Four cadaveric lumbar spine segments (total twelve lumbar vertebrae) were used to validate the technique. To evaluate the reconstruction accuracy, the surface models reconstructed from the lateral fluoroscopic images were compared to the associated ground truth data derived from a 3D CT-scan reconstruction technique. For each case, a surface-based matching was first used to recover the scale and the rigid transformation between the reconstructed surface model and the ground truth model before the distances between the two discrete surface models were computed.

**RESULTS:** Our technique could successfully reconstruct 3D surface models of all twelve vertebrae. After recovering the scale and the rigid transformation between the reconstructed surface models and the ground truth models, the average error of the 2D/3D surface model reconstruction over the twelve lumbar vertebrae was found to be 0.99 mm.

**DISCUSSION:** An accurate, scaled 3D reconstruction of the lumbar vertebra can be obtained from a single lateral fluoroscopic image using a statistical shape model based 2D/3D reconstruction technique. Future work will focus on applying the reconstructed model for 3D kinematic analysis of lumbar vertebrae, an extension of our previously-reported image-based kinematic analysis. The developed method also has potential applications in surgical planning and navigation.

## GENERAL POSTERS

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### GP92. DO THE DEEP MUSCLES OF THE TRUNK CONTRIBUTE THE STABILITY OF THE LUMBAR SPINE? : EVALUATION BY MR FLUOROSCOPY

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**INTRODUCTION:** Despite the importance of the deep muscles of the trunk for stability of the lumbar spine, few studies have investigated their actual contribution. This study was conducted to clarify if “drawing-in” the abdominal wall, an important action of the transversus abdominis muscle, contributes to the stability of the lumbar spine using MR Fluoroscopy (a method for real-time image reconstruction).

**METHODS:** Subjects were 14 healthy males and 9 healthy females (mean age 29.1 years) in who we could identify the contractions of their bilateral transversus abdominis muscles in MR fluoroscopic images when they were asked to draw in the abdominal wall. They were asked to raise one leg straight with “drawing-in” and without “drawing-in.” Using T1-weighted axial MR fluoroscopic images of the L4/5 intervertebral disc level (the image is updated every four seconds), we measured the rotation angle of the subject's trunk relative to the floor. The differences of the rotation angles of the trunk between “drawing-in” and without “drawing-in” were analyzed using paired-t-test.

**RESULTS:** The mean rotation angles of the trunk to the right side with right leg raising were  $7.6 \pm 2.3^\circ$  without “drawing-in” and  $4.2 \pm 1.8^\circ$  with “drawing-in.” The mean rotation angles of the trunk to the left side with left leg raising were  $9.1 \pm 3.0^\circ$  without “drawing-in” and  $5.6 \pm 3.0^\circ$  with “drawing-in.” The rotation angle of the trunk with one leg raising was decreased significantly by “drawing-in” ( $P < .0001$ ).

**DISCUSSION:** “Drawing-in” was associated with the rotation angles of the trunk. MR fluoroscopy is noninvasive and describes near real time images of the cross-sectional area of the trunk, and is useful to evaluate trunk function. In conclusion, this study suggests that the deep muscles of the trunk contribute to the stability of the lumbar spine.

### **GP93. NEW CONCEPT OF HYPERTROPHY OF THE LIGAMENTUM FLAVUM IN THE LUMBAR SPINAL CANAL STENOSIS -ROLE OF EPILIGAMENT OF THE FLAVUM -**

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**INTRODUCTION:** It has been known that there is the epiligament in the ligament at long bones, which plays an important role in the repairing process from the ligamentous injury, causing scars in the healed ligament. We, pathologically, investigated some kinds of LFs to clarify the pathomechanism of LF hypertrophy in patient with lumbar spinal canal stenosis (LCS) with special reference to the role of epiligament.

**METHODS:** We obtained 3 kinds of LFs: normal, hypertrophied and animal model. For normal control, LF was obtained from 30-year-old fresh cadaveric thoracic spine and young rabbits. We corrected 5 hypertrophied LFs from elderly LCS patients. LF was collected from the lumbar posterior destabilization model (removal of spinous process and supra-spinous ligament). LF was cut sagittally and was stained with Elastica Van Gieson (EVG) and Masson Trichrome (MT) procedure.

**RESULTS:** Basically, normal LF was stained in black color in EVG stain, indicating it contains mostly elastic fibers. However, there are unique layers at the dural and dorsal aspect of LF, which contain mostly collagenous fibers. The layer corresponds to the epiligament of LF. In the all 5 hypertrophied LFs from the elderly LCS patients, dural side is similar to the normal control; however, the dorsal side shows thick collagenous area, which is the enlargement of the collagenous epiligament of dorsal aspect of LF. In the LF of the rat posterior destabilizing model, the pathology of LF shows the similar findings to the hypertrophied LF in the LCS patients. The dorsal part of LF shows the thick collagenous mass, which may be caused by the enlargement of the dorsal collagenous epiligament.

**CONCLUSION:** There is the epiligament of LF. The dorsal collagenous epiligament may enlarge due to mechanical stress with the aging process. The enlargement of the collagenous mass may lead hypertrophy of LF in LCS patients.

## GENERAL POSTERS

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### GP94. TWO YEARS FOLLOW-UP OF PAIN AND DISABILITY IN PATIENTS WITH MODIC TYPE 1 END-PLATE CHANGES

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**INTRODUCTION:** Endplate signal abnormalities, particularly Modic type 1 changes (M1) indicating edema and inflammation, have been suggested to play an important role in the etiopathogenesis of a subgroup of non-specific CLBP patients. Previous studies suggest that as a M1 turns into M2, pain intensity and perceived disability subsides. During follow-up 67 % of M1 lesions decreased or disappeared, 33 % enlarged or remained constant. Clinical symptoms of M1 patients have, however, not been studied in detail in follow-up studies.

**METHODS:** The subjects (n=45) were selected from LBP patients who were sent for the first time for standard lumbar spine MR imaging at a university hospital. The inclusion criteria were chronic nonspecific LBP and a clearly detectable M1 lesion (more than 10% of sagittal vertebral area). In order to exclude other causes of CLBP as far as possible, strict exclusion criteria were used: any specific back disease, even a slight nerve root compression, a recent or major spine operation, or age > 65 years. Intensity of pain and level of disability (ODI) were collected at baseline imaging and two years later.

**RESULTS:** At baseline mean intensity of LBP was 6.6 (median 7.5, range 1-10) and correspondingly the ODI 33.1 (median 31.5, range 8-66). During two years follow-up intensity of pain decreased -40% (=median, range 0-100%) in 34/45 (75.5%) patients and increased +33% (=median, range 11-86%) in 11/45 (24.5%) patients. Correspondingly ODI decreased -50% (=median, range 6-100%) in 33/45 (73.3%) patients and increased +19.5% (=median, range 4-88%) in 12/45 (26.7%) of patients. Twenty six percent (26.7%, 12/45) patients were still after two years severely disabled (ODI more than 40%, range 42-78).

**DISCUSSION:** Although the prognosis of most CLBP patients having a M1 lesion seems to be relatively good even 26% of patients are still severely disabled. Therefore specific intervention methods are urgently needed.

### **GP95. THE EFFECT OF A RADIOGRAPHIC SOLID FUSION FOR SEGMENTAL INSTABILITY ON CLINICAL OUTCOME AFTER MINIMALLY INVASIVE TRANSFORAMINAL LUMBAR INTERBODY FUSION**

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**INTRODUCTION:** The relationship between radiographic fusion and clinical outcome is not perfect. We are aware of no report regarding this subject after minimally invasive TLIF. This study evaluated the correlation between radiographic fusion status and clinical outcome in minimally invasive TLIF.

**METHODS:** We conducted a retrospective case control study by comparing the prospectively collecting data from the consecutive 66 patients who had achieved a solid fusion versus nonunion at least 2 years after minimally invasive TLIF for the treatment of low-grade spondylolytic spondylolisthesis or degenerative segmental instability. Clinical outcome was evaluated using VAS, ODI, and functional scale. The radiographic fusion status was assessed using flexion-extension lateral radiographs and C T scans according to our own criteria. Comparison and correlation analyses were performed to examine the relationship between fusion status and clinical outcome.

**RESULTS:** There were 51 (77%) patients of solid fusion (control) group and 15 patients of nonunion group. The improvement from baseline with regard to VAS scores for back pain and leg pain as well as ODI scores was significant in both groups (all,  $p < 0.0001$ ), with patients in control group reporting significant better improvement of back pain scores than those in nonunion group ( $p = 0.04$ ). Conversely, the improvement of VAS scores for leg pain and ODI scores was comparable between 2 groups. Forty one patients (80%) in control group and 13 (87%) in nonunion group demonstrated an excellent or good result in the final functional scale. The presence of radiographic solid fusion correlated positively with the improvement of VAS scores for back pain ( $r = 0.244$ ,  $p = 0.039$ ).

**CONCLUSIONS:** Following at least 2-years after minimally invasive TLIF, overall successful clinical improvements were noted regardless of the radiographic fusion status. Conversely, patients achieving a radiographic solid fusion for lumbar segmental instability can be expected to have a significantly better improvement from baseline regarding back pain.

## GENERAL POSTERS

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### **GP 96. WHICH LUMBOSACRAL STRUCTURES ARE MORE LIKELY INJURED AFTER MOTOR VEHICLE ACCIDENT, LIFTING INJURY, OR A FALL? A RETROSPECTIVE AUDIT.**

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**INTRODUCTION:** Exploration of precipitating lifting versus non-lifting events in LBP patients would provide a clinical correlate to biomechanical research findings. This study aimed to observe which spinal structure, disc (IDD), facet joint (FJA), or sacroiliac joint (SIJ), is more likely injured after a motor vehicle accident (MVA), lifting injury, or fall.

**METHODS:** Retrospective chart review of consecutive LBP patients. Patients either underwent provocation lumbar discography, dual diagnostic facet joint blocks with local comparative anesthetics, or intra-articular diagnostic SIJ injections according to clinical impression until a diagnosis was achieved. Chi-square analyses were used to identify differences in the percentages of precipitating MVA, lifting, or fall in each diagnostic category of LBP (IDD, FJA, SIJ).

**RESULTS:** 139 cases (34 % male) were included (mean age = 52.7 years, SD = 15.0). MVA was reported in 43 cases (13.2%), lifting in 26 cases (8.0%), and fall in 28 (8.6%). Subjects with a precipitating lifting injury had a significantly greater percentage of IDD (p-value = 0.0019) and significantly lower percentages of FJA (p-value = 0.0393) but similar percentages of SIJ pain (p-value = 0.5425) than those without precipitating lifting injury. Subjects with precipitating MVA did not have different percentages of IDD (p-value = 0.5058), FJA (p-value = 0.8509), or SIJ (p-value = 0.6773) than those without precipitating MVA. Subjects reporting a precipitating fall did not have different percentages of IDD (p-value = 0.3202), FJA (p-value = 0.7069), or SIJ (p-value = 0.3740) than those without precipitating fall.

**DISCUSSION:** The occurrence of IDD was observed more commonly for those with a lifting injury as compared to those without a lifting injury and the occurrence of painful FJA was observed less commonly for those without a lifting injury as compared to those with a lifting injury. Precipitating MVA and falls were not associated with any particular source of low back pain.

### GP97. THE FACTORS FOR THE POSTOPERATIVE LOW BACK PAIN IN LUMBAR DISC HERNIATION

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**INTRODUCTION:** The factors for the postoperative low back pain in lumbar disc herniation have not been clarified. We prospectively investigated the patients who had received microscopic discectomy in order to detect the factors for the postoperative low back pain.

**METHODS:** Forty-one patients who had received microscopic hemilateral discectomy for single intervertebral level to cure the radicular lower limb pain due to lumbar disc herniation were followed for 12 months. Logistic regression analysis was performed to determine the factors associated with low back pain following the operation. The following variables were included in the analysis; age, gender, intervertebral level of the operation, the presence of low back pain before the operation, intervertebral disc degeneration at a concerned level and the edema of the multifidus at an operated side before and 3,6,12 months after the operation. Disc degeneration was graded on MRI by Pfirrmann classification. The edema of the multifidus was evaluated by comparing the signal intensity of the operated side to the opposite side on T2 weighted axial MR images.

**RESULTS:** Age was significantly associated with low back pain at 12 months ( $B=-0.728$ ,  $p=0.015$ ). No association was detected between low back pain at 12 months and the other factors. Low back pain at 3 and 6 months was associated with the presence of low back pain before the operation (3 months;  $B=3.193$ ,  $p=0.003$ , 6 months;  $B=3.889$ ,  $P=0.002$ ).

**DISCUSSION:** The study showed that low back pain at 12 months tends to appear in younger patients. However, no association was detected between low back pain at 12 months and the other factors. The results strongly indicated that postoperative low back pain was not associated with disc degeneration and with muscle changes. Accordingly, it is important that MRI findings should not be overestimated in evaluating low back pain of the patients who received discectomy.

### GP98. NERVE GROWTH FACTOR ANTAGONISM ATTENUATES DISCOGENIC LOW BACK PAIN IN RATS

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**INTRODUCTION:** Local production of nerve growth factor (NGF) is known to cause inflammatory pain. A clinical trial of intravenous anti-NGF antibody administration for knee osteoarthritis induced pain relief with some adverse events such as upper respiratory tract infection. However, the effect of NGF antagonism on discogenic pain is unclear. The present study aimed to investigate how local administration of anti-NGF antibody affects a rat discogenic pain model.

**METHODS:** Twenty-one female Sprague Dawley rats were equally divided into three groups: control, puncture, and anti-NGF. In the latter two groups, the L5–L6 intervertebral disc was injured with repeated puncture, and then neurotracer Fluoro-Gold (FG) and appropriate agents were applied intradiscally: saline for the puncture group and anti-NGF antibody for the anti-NGF group. In the control group only FG was applied into the uninjured disc. Lumbar DRGs were immunostained for the inflammatory pain marker calcitonin related-gene peptide (CGRP). The expression of CGRP and evidence of adverse events were evaluated.

**RESULTS:** FG-labeled DRG neurons were observed dominantly in the L1 and L2 DRGs. The proportion of CGRP-immunoreactive (-ir) DRG neurons in the puncture and anti-NGF groups was elevated compared with the control group, and the expression was significantly lower in the anti-NGF group ( $P < 0.05$ ). The proportion of FG-labeled CGRP-ir DRG neurons innervating the disc showed similar expression. The CGRP expression was significantly ( $P < 0.05$ ) suppressed in the anti-NGF group compared with the puncture group. No evidence of adverse events such as respiratory and discal infection was observed.

**DISCUSSION:** Elevated CGRP expression in DRG neurons innervating injured L5–L6 discs in rats suggests a pathogenesis for discogenic pain. That intradiscal application of anti-NGF antibody induced a decrease in CGRP expression without any adverse event suggests that anti-NGF antibody may safely relieve discogenic pain. This suggests a possible clinical application for discogenic low back pain.



### GP99. P75 NEUROTROPHIN RECEPTOR (P75<sup>NTR</sup>) MODULATES THE NGF SIGNALING PATHWAY RATHER THAN TROPOMYOSIN-RELATED KINASE A (TRKA) IN RAT DISCOGENIC PAIN MODELS

Sumihisa Orita, Maiko Nagata, Manato Horii, Masaomi Yamashita, Kazuyo Yamauchi, Gen Inoue, Munetaka Suzuki, Yawara Eguch, Hiroto Kamoda, Gen Arai, Tetsuhiro Ishikawa, Masayuki Miyagi, Miyako Suzuki, Tatsuo Morinaga, Seiji Ohtori, Kazuhisa Takahashi

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**INTRODUCTION:** Nerve growth factor (NGF) has been reported to cause discogenic pain by inducing abnormal nerve ingrowth into degenerative discs. NGF has two receptors: a high affinity tropomyosin-related kinase A (TrkA) and a low affinity p75 neurotrophin receptor (p75<sup>NTR</sup>). The NGF-TrkA complex has been reported to play a primary role in transmitting inflammatory pain. However, their involvement in discogenic pain is unclear. The present study aimed to investigate the role of these receptors in a rat discogenic low back pain model.

**METHODS:** Twenty-eight female Sprague Dawley rats were equally divided into four groups: control, puncture, anti-TrkA, and anti-p75. In the groups except for the control group, the L5–L6 intervertebral disc was exposed and injured by repeated puncture, and then neurotracer Fluoro-Gold (FG) and appropriate agents were applied: sterilized saline for the puncture group, anti-TrkA antibody for the anti-TrkA group, and anti-p75<sup>NTR</sup> antibody for the anti-p75 group. In the control group only FG was applied into the uninjured disc. Lumbar DRGs were harvested and immunostained for the inflammatory pain marker calcitonin related-gene peptide (CGRP). The expression of CGRP in the DRG neurons was investigated.

**RESULTS:** FG-labeled DRG neurons were observed in all the DRGs with a dominant population in L1 and L2 DRGs. In FG-labeled CGRP-ir DRG neurons innervating discs, CGRP expression was elevated in all the injured-disc groups compared with the control group, while the expression in the two antibody-treated groups was significantly decreased compared with the puncture group ( $P < 0.05$ ). Furthermore, the expression was significantly lower in the anti-p75<sup>NTR</sup> group than in the anti-TrkA group ( $P < 0.05$ ).

**DISCUSSION:** The elevated CGRP expression in the DRGs innervating injured rat discs suggests a pathogenesis for discogenic low back pain. Decreased CGRP expression by p75<sup>NTR</sup> inhibition suggests the possibility of a more crucial role of p75<sup>NTR</sup> than TrkA in discogenic pain pathogenesis.

## GENERAL POSTERS

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### GP100. PREVALENCE OF DISC, FACET JOINT OR SACROILIAC JOINT PAIN IN LOW BACK PAIN PATIENTS UTILIZING AN ALGORITHMIC APPROACH

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**INTRODUCTION:** Prevalence estimates for sources of low back pain (LBP) sampling consecutive subjects regardless of clinical picture indicate 39% for disc (IDD), 15-40% for facet joint arthrosis (FJA), and 13-18% for sacroiliac joint dysfunction (SIJD). Patient age, LBP location, and exam findings implicate certain structures as the source of LBP. This study compared the prevalence estimates of IDD, FJA, and SIJD in subjects diagnosed by implementing an algorithmic approach predicated by best available evidence regarding historical and physical exam features of LBP to previously published prevalence data.

**METHODS:** Retrospective review of consecutive LBP patients having undergone provocation lumbar discography (PLD), diagnostic FJ or SIJ blocks according to clinical impression until a diagnosis was achieved. Midline LBP patients demonstrating centralization underwent PLD; paramidline LBP patients with 3/5 positive SIJ stress maneuvers underwent SIJ blocks; paramidline LBP patients without centralization or SIJ maneuvers underwent FJ blocks. Prevalence rates and 95% confidence intervals (CI) were computed for each diagnostic group and compared to published prevalence estimates.

**RESULTS:** 378 cases from 358 subjects (34.9% male) were reviewed with a mean age of 52.8 years (SD = 15.0) and median duration of LBP of 12 months (IQR = 6 to 24). 208 cases were not included in subsequent calculations because these patients did not undergo definitive diagnostic procedures. 41.8% of cases were IDD (95% CI = 34.6% to 49.3%), 30.6% FJA (95% CI = 24.2% to 37.9%), and 18.2% SIJD (95% CI = 13.2% to 24.7%). The previously reported prevalence data for each diagnostic group falls within our CI's.

**DISCUSSION:** Reported prevalence ranges for SIJD, IDD, and FJA are well within prevalence data collected utilizing an algorithmic approach of best available evidence for predictive value of LBP location and exam findings. Application of an evidence and/or knowledge based approach to diagnosing LBP can yield accurate diagnoses.

## GENERAL POSTERS

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### GP101. WHICH GRADE OF ANNULAR FISSURE IS MORE FREQUENTLY ASSOCIATED WITH LOW BACK PAIN REDUCTION DURING ANALGESIC DISCOGRAPHY?

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**INTRODUCTION:** Lumbar intervertebral discs are common sources of low back pain (LBP) due to annular fissures. Provocation lumbar discography (PLD) has been used to diagnose painful discs. Analgesic discography (AD) has been explored to more accurately diagnose LBP by anesthetizing all grades of annular fissures. This study evaluates which grade of annular tear (III-V) is more frequently associated with LBP reduction during AD.

**METHODS:** Retrospective review of patients with positive PLD at low pressure at 1 or 2 levels and > grade 3 annular tear on post-discography CT. Reproduction of LBP upon injection of 2% xylocaine and pressure upon injection of saline into the painful disc(s) during AD. Subjects demonstrating painful schmorl's node; concordant/partial concordant pain without outer annular disruption; > 2 painful discs during PLD were excluded. Chi-square analysis was performed to detect differences in proportions of subjects having reduction in LBP during AD.

**RESULTS:** 35 discs (17 L5-S1, 17 L4-L5, and 1 L1-L2) underwent PLD & AD in 28 patients (16 males; 57%) with a mean age of 40.4 years (SD = 8.7). Using > 75% reduction in LBP during AD as the reference standard, we observed 33%, 31%, and 54% of grade III, IV, and V fissures, respectively, showing at least 75% reduction in pain. These percentages were compared and not found to be significantly different ( $\chi^2 = 1.7$ ,  $df = 2$ ,  $p\text{-value} = 0.4346$ ). No difference was observed between grades III and IV after being grouped together (31.8%) and grade V (53.9%) tears ( $p\text{-value} = 0.1987$ ).

**CONCLUSIONS:** These findings do not suggest that the grade of annular tear is significantly related to the ability of intradiscal anesthetic to reduce LBP during AD by 75%. Furthermore, these findings may suggest that full-thickness annular tears can be adequately anesthetized similar to grade III and IV annular tears.

### **GP102. CLINICAL AND KINEMATIC EVALUATION OF OSTEOPATHY VS SPECIFIC EXERCISES IN OBESE NON-SPECIFIC CHRONIC LOW BACK PAIN FEMALES PATIENTS: A RANDOMIZED CONTROLLED TRIAL**

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**INTRODUCTION:** In a previous study we demonstrated an increased thoracic stiffness and reduction of thoracic ROM in obese women with chronic low back pain. Osteopathy is recognized as a treatment effective on pain in low back pain aimed at improving ROM, especially useful when associated with an active specific approach with exercises.

The aim of our study was to evaluate the thoracic kinematic pre-post treatment in a group of chronic LBP obese females patients treated with osteopathy and exercises.

**METHODS:** Study design: longitudinal study

Population: 12 obese females (all with BMI > 38 Kg/m<sup>2</sup>) with cLBP have been randomized into 2 groups: Osteopathy + Specific Exercises (OMT; 6 women, Age 32.0±6.63) and Specific Exercises (SE; 6 women, Age 43.83±5.63).

Instrumental measures: kinematic of the thoracic and lumbar spine and pelvis during forward flexion. A VICON 460 A 6 TV was used.

Secondary outcome measures: VAS, Roland Morris Disability Questionnaire (RM) and Oswestry Low Back Pain Disability Questionnaire (OQ).

**RESULTS:** Significant effects on kinematics were reported only for Osteopathy + Specific Exercises, with an improvement of thoracic range of motion (from 34° to 44°, p<0.05 vs 29° to 24°). VAS improved significantly in both groups respectively of 3 point for OMT and 2.4 for SE; RM and OQ improved in both groups but achieved significant values only for the group undergoing Osteopathy + Specific Exercises (OMT: 3.5 and 6; SE 1.5 and 1.5).

**CONCLUSION:** a combined treatment with Osteopathy + Specific Exercises is effective in obese patients with cLBP in improving biomechanical parameters of the thoracic spine, usually stiff in these patients and reducing disability and pain. The former result can be attributed solely to osteopathy, since it was not evident in the other group. Osteopathy seems to provide additional benefit and can be easily associated to other therapeutic approaches.

### GP103. QUANTITATIVE ANALYSIS OF THE EFFECTS OF OBESITY AND LOW BACK PAIN ON GAIT IN FEMALE PATIENTS

Fabio Zaina, Luca Vismara, Veronica Cimolin, Marcello Crivellini, Manuela Galli, Paolo Capodaglio, Stefano Negrini, Milan, Italy

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**INTRODUCTION:** Obesity is associated with various musculoskeletal disorders, including low back pain (LBP). Gait can be also affected in these subjects but no quantitative data are today available.

Aim: to quantify parameters of gait in obese LBP subjects.

**METHODS:** Population: 8 LBP obese female patients, (LBP; age:  $40.5 \pm 10.1$  years; BMI:  $42.39 \pm 5.47$  Kg/m<sup>2</sup>), 10 obese female subjects (OBE; age:  $33.6 \pm 5.2$  years; BMI:  $39.26 \pm 2.39$  Kg/m<sup>2</sup>) and 20 healthy females (CON; age:  $33.4 \pm 9.6$  years; BMI:  $22.8 \pm 3.2$  Kg/m<sup>2</sup>).

Exclusion criteria: secondary LBP, osteoporosis, osteoarthritis or disease precluding physical exercise.

Assessment: 3D-Gait Analysis using an optoelectronic system with 6 cameras (VICON) and two force platforms. Spatio-temporal, kinematic and kinetic parameters were measured to compare groups.

Statistical analysis: Kolmogorov-Smirnov test and post-hoc ( $p < 0.05$ ).

**RESULTS:** LBP showed longer stance duration and reduced step length (63%; 0.33 m) if compared to obese subjects (62%; 0.38) and CON (59%; 0.88;  $p < 0.05$ ). Hip flexion were increased in LBP and OBE with respect to CON ( $46^\circ$  and  $44^\circ$  vs  $27^\circ$ ;  $p < 0.05$ ). LBP group showed reduced knee flexion during swing phase in comparison to obese and CON ( $55^\circ$  vs  $58^\circ$  and  $60^\circ$ ,  $p < 0.05$ ). LBP exhibited plantarflexed position at initial contact and a limited dorsiflexion during stance and swing phase than obese subjects. Both LBP and obese group revealed a limited ankle power generation at push-off if compared to CON; hip exhibited high power generation during stance in both LBP and obese subjects, but LBP subjects revealed higher hip power peak than obese group.

**DISCUSSION:** LBP and obese showed an abnormal gait pattern, more evident in LBP that showed a less stable gait and abnormal strategy at knee and in particular at ankle joint in terms of kinematics. This may be an antalgic strategy, but it's also related to overweight.

### GP104. CLINICAL VALUE OF FINGER FLOOR DISTANCE IN LUMBAR SPINAL DISORDERS

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**INTRODUCTION:** The current study aimed to validate clinical values of anterior- finger floor distance (FFD), lateral-FFD and posterior-FFD as measurement tools of trunk mobility in healthy volunteers and patients with lumbar disc herniation (LDH) or lumbar spinal canal stenosis (LSS).

**METHODS:** Twenty healthy adult volunteers and twenty-one LDH, twenty-eight LSS participated in this study. Mean age was 26 years in healthy volunteers, 55 years in LDH, and 66 years in LSS group. In anterior-FFD measurement, the subjects were ordered to perform maximum flexion with upper limbs perpendicular to the floor. Lateral-FFD was measured in maximum lateral bending with neutral coronal plane. Posterior-FFD was defined as FFD in combination of maximum extension and rotation with upper limbs.

Measurement reproducibility was validated in healthy population, and correlation between FFD and ROM of trunk motion in healthy population and patients with LDH or LSS.

**RESULTS:** High reproducibility was confirmed in anterior- FFD (ICC=0.92), lateral-FFD (ICC=0.86), and posterior-FFD (ICC=0.83) in healthy volunteer group . There was significant correlation between anterior-FFD and flexion ROM ( $r=0.69$ ); lateral- FFD and lateral bending ROM (Right,  $r=0.68$ ; Left,  $r=0.81$ ); posterior- FFD and extension ROM (Right,  $r=0.87$ ; Left,  $r=0.75$ ); posterior-FFD and trunk rotation ROM (Right,  $r=0.87$ ; Left,  $r=0.86$ ).

Anterior- FFD and lateral- FFD was larger in patients with LDH than those with LSS. Posterior- FFD had no difference between LDH and LSS patient groups.

**DISCUSSION:** The current FFD measurement had high reproducibility in any directions. FFD also was correlated to trunk ROM in each motion. The current study demonstrated that anterior-, lateral- and posterior-FFD were valuable measurement tools of trunk mobility. Flexural and lateral bending mobility was decreased in patients with LDH than those with LSS. Extension and rotation mobility had no statistical difference between LDH and LSS.

### GP105. EFFECTS OF INDIVIDUALISED ACUPUNCTURE ON THE QUALITY OF THE LIFE OF PATIENTS WITH CHRONIC NON-SPECIFIC LOW BACK PAIN

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**INTRODUCTION:** For chronic non-specific low back pain (LBP) compared to those receiving usual care, patients receiving simulated acupuncture were more likely to show clinically important improvements in dysfunction and QOL at the end of treatment have been reported. It is also safe and good cost-effectiveness. However, the significance of the specific placement of the acupuncture needles strictly according to the rules of Traditional Chinese Medicine remains unexplained. The purpose of this study is to investigate effects of individualized acupuncture based on each patient's symptoms by evaluating QOL.

**METHODS:** Thirty three patients with LBP lasting 3 month or more (12 males, 21 females average age 55.3 ) were studied. Acupuncture points were decided by patient's pain area and trigger points. Disposable stainless steel needles (0.16 mm in diameter) were used. Patients received up to 6 acupuncture sessions over 4weeks of individualized acupuncture. Data was collected pre- and 4 weeks after the end of treatment. The clinical outcome measure was a SF-36 Health Survey based 8 subscales and Physical Component Score (PCS) , Mental Component Score (MCS).

**RESULTS:** All patients completed follow-up. There were statistically significant improvements in Physical-Functioning 28.8 to 35.8, Bodily-Pain 32.4 to 38.0, Vitality 39.8 to 44.0, Mental-Health 46.8 to 49.9, PCS 26.7 to 31.7 and MCS 46.8 to 49.9 of the SF36 (  $p > 0.05$  ).

**DISCUSSION:** The QOL of patients improved in 4weeks by the acupuncture of this method without regard for the rules of Traditional Chinese Medicine. Especially, individualized acupuncture was effective for MCS. Needle placement based on patient's symptoms may get patients sympathy and feeling of satisfaction and influence improvement of MCS.

### **GP106. LOW BACK PAIN-RELATED QOL AFTER NERVE ROOT BLOCK MAY PREDICT THE PROGNOSIS: AN ANALYSIS USING THE ROLAND-MORRIS DISABILITY QUESTIONNAIRE**

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**INTRODUCTION:** Nerve root block (NRB) is a useful conservative therapy for lumbar radiculopathy. However, it is unknown which kind of NRB affects low back pain-related QOL. The purpose of the current study was to clarify which NRB that may affect low back pain-related QOL using the Roland-Morris Disability Questionnaire (RDQ) and to analyze which RDQ before or after NRB can predict the prognosis for the patients.

**METHODS:** The subjects were 44 cases (18 males and 26 females) of degenerative lumbar spine disease with low back pain and sciatica. Average age was 61.0 years old (26 to 79 years old). There were 34 cases of spinal canal stenosis and ten disc herniations. NRB was performed on the responsible nerve root using 2% lidocaine and steroid. RDQ was measured before and 2 weeks after NRB. The Mann-Whitney test was used for statistical analysis.

**RESULTS:** RDQ before NRB was  $11.8 \pm 7$  and  $11.7 \pm 7$  after NRB. The subjects were divided into two groups: operation group (n=20) and non-operation group (n=24). RDQ values before NRB were  $10.8 \pm 6$  in the non-operation group and  $12.9 \pm 8$  in the operation group. There was no significant difference. However, RDQ values after NRB were  $9.7 \pm 6$  in the non-operation group and  $14.1 \pm 7$  in the operation group. The RDQ value after NRB in the non-operation group was statistically significantly lower compared with RDQ value after NRB in the operation group ( $p=0.016$ ).

**DISCUSSION:** The indication for surgery in the current study was mainly for sciatica. Regarding low back pain-related QOL, the current study showed that NRB did not improve RDQ completely. However, RDQ values 2 weeks after NRB may be useful to predict the prognosis of patients with low back pain and sciatica. NRB may have a role in not only conservative therapy for sciatica but also as a predictor of the prognosis.



## GENERAL POSTERS

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### GP107. EFFECTIVE SPINAL REHABILITATION - AN UNCOMPLICATED EXERCISE APPROACH

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**INTRODUCTION:** Various treatments are utilized to management spinal complaints, often in conjunction with each other. No single treatment approach or combinations has been shown to be clearly superior. The purpose of this study is to describe the findings of a cohort a patients with chronic spinal pain complaints who were managed with a straightforward approach consisting solely of standardized, machine-based exercise.

**METHODS:** A prospective, observational, 1-group, cohort study was conducted with a group of adult patients (n=113) with spinal pain complaints (primarily chronic; who presented for treatment at an outpatient exercise facility between the dates of January 1 and March 31, 2009. Most patients presented with chronic complaints (duration of symptoms: 3.3+/-1.8 years), most had tried other treatments, and all had private insurance with co-payments at each visit. Treatment was carried out by exercise specialists and consisted exclusively of isolated strengthening exercise with equipment for the spinal musculature and other major muscles. The standardized exercise protocol focused on dynamic, progressive resistance exercise with gradual and measurable loading, and was typically administered 2X/week for up to 12 weeks (15.7+/-7.4 sessions).

**RESULTS:** Outcomes, including pain (VAS, 0-10), physical function (Multidimensional Task Ability Profile - MTAP, 0-200), and patient centered outcome (PCO), were assessed at baseline, monthly throughout care, and discharge. At discharge, physical function, pain, and patient-centered outcome improved significantly (p

**DISCUSSION:** This study demonstrates that successful results are achieved in the management of chronic spinal complaints by utilizing a model of minimal treatment consisting solely of protocol-driven exercise therapy. Experimental studies are needed to determine the comparative effectiveness of this and other approaches.

## GENERAL POSTERS

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### GP108. SIGNIFICANCE OF BONY BRIDGES IN THE HEALING PROCESS OF VERTEBRAL BURST FRACTURES IN SENILE OSTEOPOROSIS

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**INTRODUCTION:** Bony bridges were retrospectively investigated regarding the effectiveness in the healing process of osteoporotic vertebral burst fractures based on serial plain roentgenograms and computed tomography images.

**SUBJECTS:** One hundred patients were included in this study (50 to 92 years old). A mean radiological follow up period was 32.8 months (range 2 months to 14 years).

**METHODS:** All patients were classified into three groups. Group A was that bony bridges were formed newly (forty-one patients). Group B was that bony bridges had been already formed before the fracture and grew larger after the injury (six patients). Group C was that bony bridges were not formed (fifty-three patients).

**RESULTS:** Bony bridges grew larger from calluses occurred around the vertebral fractures 2 to 4 weeks after injury in group A. Low back pain on motion when getting up from bed disappeared completely 11 to 593 days (median 50 days) after injury, 76 days after injury in group A, 67.5 days in group B, and 39 days in group C. Low back pain on motion significantly disappeared early in group C.

Twenty-five patients (nineteen patients in group A, one in group B, and five in group C) got into delayed union and suffered from low back pain on motion over three months after injury. Only four patients (two in each group A and C) complained of low back pain on motion one year after injury.

The collapse of anterior wall of the vertebral bodies in group A was significantly larger than that in group C at the first and the latest observation period.

**DISCUSSION:** When the osteoporotic vertebral burst fractures got into delayed union and/or more collapsed, bony bridges were often formed and seemed to help disappearance of low back pain on motion.

### GP109. TECHNICAL DIFFICULTY IN TRANSFORAMINAL EPIDURAL STEROID INJECTION IN FAR-LATERAL HERNIATION OF LUMBAR DISC

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**INTRODUCTION:** Transforaminal epidural steroid injection (TFESI) has been reported to be very effective treatment in radiculopathy or stenotic lesion of lumbar spine. However, there has been a sparse study regarding the efficacy or the result of TFESI in far-lateral herniation of lumbar disc (FHLD). The purpose of this study is to evaluate the efficacy or result of TFESI in the FHLD, compared to the intraspinal herniation of lumbar disc (iHLD).

**METHODS:** Totally 85 patients underwent the TFESI due to radiculopathy caused by FHLD or iHLD. There were 15 and 70 patients in the FHLD and iHLD group, respectively. Successful injection rates were recorded in each group, and patients were evaluated by an independent observer and received questionnaires before the initial injection, at 2 weeks, 2 months and 6 months after the injections. Questionnaires included a visual analog scale (VAS), and Oswestry Disability Index (ODI).

**RESULTS:** In the iHLD group, TFESI were successfully performed in all cases without failure (100%), while TFESI could not be performed in 10 cases of FHLD group due to lancinating leg pain in needle insertion (67%,  $P < 0.05$ ). Both successfully injected 5 cases in the FHLD (33%) and 70 patients (100%) in the iHLD, had successful outcomes, reporting at least 65 % reduction between preinjection and postinjection VAS scores, and at least 50 % reduction between pre and postinjection ODI score.

**DISCUSSION:** In the FHLD, there would be technical difficulty in performing TFESI because of hypersensitive inflammatory nerve root and anatomical alteration of nerve root position, displaced upward and laterally by cephalad and laterally migrated disc. This alteration causes the anatomical landmark, so called “safe triangle” to be collapsed. Therefore, in the FHLD, TFESI need cautious and careful needle insertion not to touch the inflammatory and sensitive nerve root to external stimuli.

## GENERAL POSTERS

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### GP110. CORRELATION BETWEEN FRACTURE HEALING STATUS AND EUROQOL SCORE (EQ-5D) DURING CONSERVATIVE THERAPY FOR OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURES

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**INTRODUCTION:** EQ-5D is a standardized instrument utilized as a measure of health related quality of life outcome. There are few reports investigating the relationship between fracture healing status and EQ-5D after conservative treatment for painful vertebral compression fractures (VCFs).

**METHODS:** Forty consecutive patients (5 male, 35 female, average age: 78) had fresh VCFs due to primary osteoporosis diagnosed by MRI. They were treated in hospital for 2 to 3 weeks by conservative therapy consisting of medication (NSAIDs, Alendronate, Calcitonin) and brace. EQ-5D and questionnaires were collected at pre-fracture (retrospective) and post-fracture at first visit, at discharge and after 12-week conservative therapy. Radiographic evaluation was conducted by flexion-extension X-ray and CT. Pseudoarthrosis was diagnosed when the intervertebral cleft was seen in both X-ray and CT, and there was a motion more than 3-degrees in flexion-extension X-rays. Correlations among fracture healing status, brace compliance, and EuroQOL score were investigated. Final follow-up rate was 85% (34/40).

**RESULTS:** There were 30 patients who could move by themselves (Group A), and other 10 patients who could not even turn over due to severe pain (Group B). EQ-5D at pre-fracture, post-fracture, discharge, and after conservative therapy were 0.9067, 0.5030, 0.7538, and 0.7688 in Group A, 0.7359, -0.0179, 0.5546, and 0.7948 in Group B, respectively. Post-fracture EQ-5D in Group B was significantly lower ( $p < 0.0001$ ). Pseudoarthrosis was found in 6 cases (18%), while the intervertebral cleft was observed in 41% at 12-weeks. All these 6 cases answered as the brace compliance, "almost all day". Average EQ-5D in these 6 cases was 0.2657 at first visit and 0.689 after 12-week therapy, which was significantly lower than that of other fracture healed cases (0.8029,  $p = 0.0001$ ).

**DISCUSSION:** Successful fracture healing rate in this conservative therapy was 82%. Eighteen percent of pseudoarthrosis patients with lower EQ-5D could be candidates for the interventional therapy.

### GP111. EFFECT OF CORTICOSTEROIDS ON CHONDROCYTE OF ZYGAPOPHYSIAL (FACET) JOINT

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**INTRODUCTION:** Facet (zygapophysial) joint injections are commonly administered with steroid for chronic spinal pain in orthopedic treatment. A lot of studies on the effect of facet block in clinical, but many questions on the effect of corticosteroids to the cartilaginous tissue of zygapophysial joint remain unanswered. This study was performed to determine the effects of varying concentrations and exposure times of corticosteroids on the viability and metabolism of zygapophysial chondrocyte *in vitro*.

**METHODS:** Cells were isolated from cartilaginous tissues of 6-10 weeks rabbit facet joints (n= 10) by enzyme digestion, were cultured for 24 hours (5 beads/ml-370mOsm DMEM containing 6% FBS) under 21% oxygen with 1mg/ml and 2mg/ml corticosteroids. These were analyzed in real time, after 1 hour, 12 hours and 24 hours. Cell viability profile was determined by manual counting using trypan blue staining and by confocal microscope LIVE/DEAD assay. Lactate production was measured enzymatically as a marker of energy metabolism and glycosaminoglycan (GAG) accumulation was measured using a DMB assay.

**RESULTS:** After 24 hours, chondrocyte viability was 95% or higher in the control group, while cell viability decreased in a time-and dose-dependent manner in the concentration ranged 1-2mg/ml steroid under the confocal microscope. GAG accumulation/tissue volume decreased of the concentration of steroid increased. However, GAG produced per million cells and the rate of lactate production per live cell was higher for cells cultured at 1 and 2 mg/ml steroid than the control group.

**CONCLUSIONS:** These *in vitro* results cannot be directly extrapolated to the clinical setting, this data suggest caution in prolonged steroid injections to facet joint.

## GENERAL POSTERS

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### GP112. CELL THERAPY WITH HUMAN UMBILICAL CORD BLOOD-DERIVED MESENCHYMAL STEM CELLS FOR INTERVERTEBRAL DISC REPAIR IN CULTURED RABBIT DISC EXPLANTS

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**INTRODUCTION:** Back pain associated with symptomatic disc degeneration is a common clinical condition. Injection of mesenchymal stem cells into the intervertebral disc is an attractive therapy to regenerate the disc and restore function. In this study, we determined the effectiveness of mesenchymal stem cell therapy for repair of the intervertebral disc *in vitro*. Human umbilical cord blood-derived mesenchymal stem cells (hUCB-MSC) were injected into cultured rabbit intervertebral disc explants. Survival of the injected cells and expression of the collagen type II gene were assessed.

**METHODS:** hUCB-MSCs were injected into rabbit whole disc explants, which were maintained in culture for one month. Cell survival was then assessed by fluorescence microscopy and collagen type II expression was assessed by RT-PCR.

**RESULTS:** In this study, hUCB-MSCs have been shown to survive in rabbit explant cultures and to differentiate into cells of the adipogenic, osteogenic, and chondrogenic lineages. Thus, hUCB-MSCs have the same full potential to differentiate into these lineages as mesenchymal stem cells derived from other origins. In addition, these stem cells cultured in micromass stain blue with Alcian blue dye, which suggests that proteoglycan-rich extracellular matrix are produced, further indicating the ability for these cells to differentiate into the chondrocyte lineage. hUCB-MSC achieved long-term survival in the cultured disc explants, and expressed the human collagen type II gene, which indicates that the injected stem cells are differentiating into a chondrocyte-like lineage.

**CONCLUSIONS:** Our study demonstrates the ability of hUCB-MSC to survive and express the human collagen type II gene when transplanted into rabbit intervertebral discs. These data support the potential of a cell therapy approach for disc repair. Further studies of extracellular matrix (e.g., proteoglycan and collagen) accumulation in the organ culture system *in vitro*, and in animal models *in vivo* are indicated as a step towards achieving disc repair in humans.

### **GP113. CAUDAL EPIDURAL INJECTIONS UNDER IMAGE INTENSIFIER GUIDANCE (EPIDUROGRAM) A PROSPECTIVE STUDY USING VALIDATED OUTCOME MEASURES**

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**INTRODUCTION:** The burden of chronic low back pain and sciatica pain on society is enormous in terms of patient suffering, loss of work force and cost to health care providers. There are many studies in the literature relating to efficacy of various routes of administration and medications used in epidural injections. However, there are only very few published prospective studies on caudal epidural injections performed under fluoroscopic guidance with validated outcome measures.

**METHODS:** Between 2007 and 2009, a total of 134 consecutive patients who underwent caudal epidural injections under image intensifier guidance (epidurogram) were prospectively followed -up using validated outcome measures at 6 weeks, 3 months, 6 months and 12 months.

**RESULTS:** We had 129 patients available with one year follow up. 76.2% of patients at 6 weeks, 68% at 3 months, 55% at 6 months and 49% at 1 year had excellent and good subjective rating. The mean Low Back Outcome Score (LBOS), Oswestry Disability Index (ODI) Scores showed statistically significant improvement from initial scores to scores at 6 weeks, 3 months, 6 months and 12 months. Patients with less than two levels of degenerative disc disease, patients with predominant, unilateral leg symptoms, patients with duration of symptoms less than 6 months had a satisfactory outcome. Patients with predominant back symptoms, multi-level degenerative disc disease with bilateral involvement, patients who had previous surgery on lumbosacral spine rated the procedure as fair or poor. The complications rate was minimal and the safety and efficacy was excellent.

**DISCUSSION AND CONCLUSION:** The administration of local steroids into caudal epidural space has been well established procedure in the management of low back pain with or without leg symptoms. Our study along with few other studies of caudal epidural injections done with fluoroscopic guidance indicates improved and predictable outcome and patient satisfaction by this method.

## GENERAL POSTERS

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### **GP 114. EFFECT OF A HIGH EFFICIENCY COGNITIVE BEHAVIOURAL EXERCISES APPROACH TO CHRONIC LOW BACK PAIN: A RETROSPECTIVE CONTROLLED TRIAL WITH LONG TERM FOLLOW UP.**

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**INTRODUCTION:** Cognitive behavioural and exercises approaches that have shown their efficacy in chronic Low Back Pain (cLBP) are usually performed in high costs settings, such as long periods outpatient or inpatient treatments.

**AIM:** Verify the efficacy of an high efficiency cognitive behavioural exercise treatment for cLBP and the influence of starting disability on the final results.

**METHODS:** In a retrospective controlled study with 5 years follow up 76 (34 females) consecutive cLBP patients were included. The patients met an expert and trained physiotherapist 6 times once every 15-30 days: during the 90 minutes sessions the cognitive behavioural treatment was administrated and patients learned specific exercises to be practiced every day at home for 20-30 minutes. The exercises were modified at every session by the therapist according to results obtained. Outcome measures: Roalnd Morris (RM), VAS, Fear avoidance believe questionnaire. We considered patients changed for more than 3 (RM) or 2 (VAS) points. The patients were called telephonically after 5 years to verify the maintenance of results. According to the Italian guidelines, cLBP patients were divided in "High Disability" (HD) for score of RM  $\geq 14$ , and "Low Disability" (LD) if  $< 14$ . Statistical analysis: Mann Whitney, chi-square.

**RESULTS:** 16 patients were HD, 60 LD. The whole population had a median improvement of 3 for RM. For high disability patients the median improvement was 6 vs 2 for Low. Considering the number of changed patients we had 75% improved and 25% stable for HD vs 38.3% and 58.3% (3% worsened) for LD. Also the VAS improved in both populations with better results for HD.

**DISCUSSION:** It is possible to obtain good results in cLBP patients (mainly HD) with a cognitive-behavioural exercises approach, offered by well trained physiotherapis, in only 6 sessions covering 4 to 6 months of treatment.



### GP115. CLASSIFYING PATIENTS WITH LOW BACK PAIN: FACTORS AGGRAVATING OR RELIEVING PATIENT'S SYMPTOM

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**INTRODUCTION:** Not only physical findings and pain patterns, but also other factors aggravating or relieving patient's symptom should be important for classifying the patients with LBP. The purpose of this study was to classify patients with LBP by the factors, and to examine how the classified subgroups related to other patient's findings and background.

**METHODS:** This study consisted of 57 consecutive out patients with LBP. There were 30 men and 27 women with a mean age of 50 years. All the patients completed the questionnaire consisted of 7 questions asking how these factors affect your pain intensity: 1) body movement, 2) sitting, 3) standing, 4) walking, 5) keeping warm, 6) weather change, and 7) diurnal change. Disease specific (Roland-Morris Disability Questionnaire: RMDQ) and generic (Short Form 8: SF-8) measures were also obtained.

**RESULTS:** Sample cluster analysis revealed 3 clusters. Cluster 1 consisted of 19 patients (33%) and had characteristic of aggravating symptoms with physical stress. Cluster 2: 31 patients (54 %), and aggravating symptoms in the morning. Cluster 3: 7 patients (12%), and no factors influence their symptoms. Cluster 1 also had characteristic of male dominant, younger, larger body, and frequent low back history. Cluster 2: female dominant. Cluster 3: less low back history, deskwork, lower RMDQ score and higher score in both SF-8 mental and physical component. There was no difference in duration of symptoms, range of motion, tobacco and alcohol intake and other physical findings.

**DISCUSSION:** Our results showed that the simple seven questionnaires aggravating or relieving symptoms clearly classified the patients with LBP into 3 clusters, and each cluster had different patient's back ground and physical findings. Further studies are needed to confirm how this classification related to usual diagnosis of LBP, and to various conservative treatment responses.

## GENERAL POSTERS

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### GP116. PAIN QUALITY IN PATIENTS WITH BACK SYMPTOMS

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**INTRODUCTION:** Determining the nature of pain is essential in evaluating patients with back pain, and certain types of pain might be useful for reaching clinical diagnosis and selecting appropriate treatment options. The purpose of this study was to classify pain quality in patients with back symptoms, and to examine how the classified subgroups of pain quality related to other patient's findings and background.

**METHODS:** This study consisted of 92 outpatients with back symptoms including leg pain. There were 45 men and 47 women with a mean age of 55 years. All the patients were asked to multiply choose their pain quality using Short Form McGill Pain Questionnaire that consisted of 15 categories of pain. Cluster analysis was applied to classify the pain categories. The findings and backgrounds among classified subgroups were also compared.

**RESULTS:** Cluster analysis revealed 3 clusters. Cluster 1 consisted of 44 patients (48%) and had characteristic pain of heavy (66%), aching (41%), cramping (34%) and gnawing (20%). Cluster 2: 28 patients (30%) and that of shooting (68%) and throbbing (60%). Cluster 3: 20 patients (22%) and that of sharp (65%), stabbing (50%) and tender (25%). Male dominant in cluster 3 (74%) and female dominant in cluster 1 (64%) were observed. In cluster 3, leg pain was frequently occurred (45%) and pain during extension was less (74%). The mean age was also younger in cluster 3 (43 years). There was no difference in duration of symptoms, pain during flexion and pain intensity among the 3 clusters.

**DISCUSSION:** Our results showed that quality of pain in back symptoms were classified into 3 groups, and each group had different patient's background and physical findings. Further studies are needed to confirm how the classified pain quality related to various conservative treatment responses.

### **GP117. EARLY ACTIVE REHABILITATION AFTER SURGERY FOR LUMBAR DISC HERNIATION: A PROSPECTIVE, RANDOMIZED CONTROL TRIAL**

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**INTRODUCTION:** A Japanese clinical guideline for lumbar disc herniation (LDH) recommends that active rehabilitation after herniotomy should be started from 4 to 6 weeks rather than immediately after surgery. However, no randomized controlled trials (RCT) on the effectiveness of postoperative rehabilitation for LDH have ever been reported in Japan.

The aim of study is to prospectively investigate the effectiveness of physiotherapy-based rehabilitation starting immediately after herniotomy.

**METHODS:** LDH patients having been offered herniotomy were consecutively randomized to intervention group and control group. Inclusion criteria were 18-59 years of age, from June 2008 until April 2009, etc. Exclusion criteria were spinal pathologies like spinal stenosis, spondylolisthesis and recurrent LDH, etc. Patients in intervention group received physical agents, strengthening exercise and aerobic exercise in conjunction with ergonomics advices such as simulations of home environments from the 5th day after surgery. As well, those in control group received a traditional rehabilitation program such as physical agents and basic ADL advice. Outcome measures consisted of changes in ratings on the visual analogue scale of symptoms, ROM of the lumbar spine, Oswestry Disability Index, and SF-36v2. Those were assessed at the 5th day after surgery, at discharge and at 2 weeks after discharge, respectively. Those parameters were statistically analyzed between intervention group and control group.

**RESULTS:** Twenty eight and twenty seven patients were allocated to intervention group and control group, respectively. Vitality, Social Functioning and Mental Health of SF-36v2 in intervention group significantly improved than those in control group at 2 weeks after discharge (p

**DISCUSSION:** We conclude that early active rehabilitation after surgery for LDH is a very effective intervention to improve psychological factor in health-related QOL.

## GENERAL POSTERS

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### **GP118. IS THERE ANY VALIDITY OF OUR NEW CLINICAL PATHWAY FOR PATIENTS AFTER LUMBAR DISCECTOMY?**

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**INTRODUCTION:** This study was undertaken to evaluate the validity and effectiveness of our new clinical pathway for patients after lumbar discectomy.

**METHODS:** A series of 335 patients underwent posterior lumbar discectomy for lumbar disc herniation. The first 158 patients (group O: 115 males and 43 females with a mean age of 47.3 years) were applied to the old clinical pathway, and the second 177 patients (group N: 121 males and 56 females with a mean age of 43.5 years) were applied to the new clinical pathway, which was improved on the education for the patients using our original booklet before surgery and on the early ambulation of the patients after surgery. The length of hospitalization after surgery (LOH) of the new clinical pathway was shortened from 5 days to 4 days. We evaluated the LOH of all patients and calculated the rates of the patients who were discharged within the anticipated duration as an index of validity of the clinical pathway. The degree of the patients' satisfaction was also evaluated using the questionnaires. The results were statistically compared using the unpaired t-test and  $\chi^2$  test between the groups O and N. P values less than 0.05 was considered statistically significant.

**RESULTS:** LOH was significantly shorter in group N (4.7 days) than in group O (6.2 days). There were no statistically significant differences concerning the validity of the clinical pathway between group O (53.2%) and group N (55.9%), and concerning the degree of the patients' satisfaction between group O (91.1%) and group N (88.7%).

**DISCUSSION:** These findings suggest that LOH was decreased by our new clinical pathway, however, the validity of the clinical pathway and the degree of the patients' satisfaction were the same in the two groups. Therefore, our new clinical pathway may be useful and be effectively improved.

### **GP119. ARE MIS SPINAL FUSION OUTCOMES PREDICTABLE? FACTORS OF STATISTICALLY SIGNIFICANT OUTCOMES PREDICTABILITY IN MINIMALLY INVASIVE SPINAL FUSIONS**

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**INTRODUCTION:** Predictors of outcomes have been described for traditional open spinal fusions. Herein, we assess if MIS fusion success or reoperation can be predicted based on demographic and outcome factors.

**METHODS:** Clinical and radiographic outcomes from our series of 710 XLIFs were prospectively recorded. A variety of factors were analyzed to determine the statistical significance of effect on success, which we defined as an improvement of at least two points on the VAS pain scale.

**RESULTS :** Preop VAS was a factor in 12 month VAS success. ( $p=0.0283$ ). At 24 months, preop VAS approached significance ( $p=0.0548$ ). Age was a significant factor in success at 12 months ( $p=0.0283$ ); patients achieving success were on average, older. Patients with COPD were less likely to have success at 24 months ( $p=0.0114$ ). Smoking trended towards significance at 12 months ( $p=0.0502$ ) but was not a factor at 24 months. Other aspects were tested and found not to be significant factors in 12 or 24 month outcomes: occurrence of complications or reoperations, prior fusions, and comorbidities like CAD, diabetes, steroid use, and cancer.

Loss of disc height at 6 months postop was found to be a statistically significant predictor of reoperation for residual symptoms. Specifically, greater than 5mm lost from postop to 6 months, or a loss of greater than 50% of surgically gained disc height, is predictive of reoperation ( $p<0.0001$ ). Patients who lose less than 1mm (or less than 10% of disc height) from postop to 6 months require significantly less reoperations ( $p=0.0034$ ).

**CONCLUSION:** The ability to predict long-term MIS fusion outcomes may have considerable impact. Results of the age analysis are significant for relief of pain in the elderly, a challenging group to treat. Also of importance is the potential to prevent reoperation. Technique, implant size, and posterior fixation method may also be factors.

### GP120. THE IMPACT OF PSYCHIATRIC COMORBIDITY ON THE RETURN TO WORK IN PATIENTS UNDERGOING HERNIATED DISC SURGERY

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**INTRODUCTION:** Only few studies investigated predictive factors for return to work (RTW) in patients undergoing herniated disc surgery. Objectives of this study are (1) to examine RTW and ability to work (ATW) rates in patients undergoing herniated disc surgery three months after surgical treatment, (2) to examine whether psychiatric comorbidity is associated with a higher risk for non-return to work (NRTW) and non-ability to work (NATW) respectively in patients undergoing disc surgery, and (3) to investigate which socio-demographic, illness-related, vocational and rehabilitation-related characteristics are associated with RTW and ATW.

**METHODS:** The sample consists of 305 patients aged between 18 and 55 years and taking part in face-to-face interviews during hospital stay. 277 of these patients also participated in a 3-month Follow-up survey via telephone (drop-out rate 9 %). Psychiatric comorbidity was assessed with the Composite International Diagnostic Interview (CIDI-DIA-X). Socio-demographic, illness-related, vocational and rehabilitation-related variables were examined upon their association with RTW and ATW. Calculations were conducted via Chi-Square-tests, independent t-tests and binary logistic regression analyses.

**RESULTS:** 40.1 % of the herniated disc patients in this study were able to RTW three months after surgical treatment, 44.4 % had regained their ATW in this period of time. Psychiatric comorbidity turned out to be an important risk factor for RTW and ATW. Other risk factors seem to be a lower educational qualification, unemployment status, a lower subjective prognosis of gainful employment, a higher number of herniated discs in medical history, cervical disc surgery, and the existence of other chronic diseases, a longer hospital stay and higher pain intensity.

**DISCUSSION:** Identifying a high risk group for RTW and ATW at an early age is important in order to improve rehabilitation effects. The assessment of psychological comorbidity should be linked to specific interventions for this risk group.

### GP121. FEAR-AVOIDANCE BELIEFS AND VIEWS OF LOW BACK PAIN IN ADOLESCENTS – CAN INFORMATION MAKE A CHANGE ?

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**INTRODUCTION:** In adults, the influence of patients' views on the integration of new information has been stressed. This issue is important in adolescents since early prevention is often advocated. We aimed to investigate (1) fear-avoidance beliefs (2) views about LBP and 3) the impact of information in adolescents with or without LBP.

**METHODS:** In a first study, 311 adolescents with (n=177) or without (n=134) LBP responded to the Fear-Avoidance Beliefs Questionnaire (FABQ). Adolescents with LBP were randomized in three groups: group I (n=49) received no information, group II (n=55) received the Back Book, and group III (n=73) received the Back Book and an oral information (30 min) based on the Back Book. Three months later, they responded again to the FABQ. In the second study, a subgroup of 38 adolescents with or without LBP responded to semi-structured interviews investigating their views about LBP (causes, severity, prevention, risk factors).

**RESULTS:** Adolescents with LBP had a significantly higher 'physical activity' (LBP:14.5±1.1 vs NoLBP: 11.08±0.7; p< 0.001). Content analysis of the interviews showed that adolescents with and without LBP considered LBP as a progressive disease, possibly severe and leading to disability. They identified work, including heavy weight lifting and work strain, but also sports as the main causes of LBP.

**CONCLUSION:** Adolescents with LBP hold negative beliefs about physical activity that can be positively improved by information based on a biopsychosocial model.

### **GP122. DEVELOPMENT OF A DOCUMENTATION INSTRUMENT FOR THE CONSERVATIVE TREATMENT OF SPINAL DISORDERS IN THE INTERNATIONAL SPINE REGISTRY SPINE TANGO**

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Spine Tango is the first and only international spine registry in operation to date. It captures all surgical spinal interventions so far, but no comparable structured and comprehensive documentation instrument for conservative treatment procedures for spinal disorders has been developed yet.

We report on the development of such an instrument by using the Delphi consensus method. It was conducted with a group of international experts in the field. We also assessed the usability of this new assessment tool with a prospective feasibility study on 97 out- and inpatients. (69 female, 28 male), mean age 46.9 years (SD 13.0 yrs). 60 patients were experiencing back pain including possible leg pain. At 3 months followup a minimal clinically relevant score decrease was achieved by 63% of patients in the Core Outcome Measures Index (COMI) and by 53% in the Numerical Rating Scale (NRS) for back pain. Mean reduction between pretreatment and followup was 2.9 points in the COMI back ( $p < 0.001$ ). NRS back improved by a mean of 2.5 points, NRS leg by 1.8 points (both  $p < 0.001$ ). 87% of patients were satisfied with the treatment.

The new Spine Tango conservative questionnaire proved useful and suitable for the documentation of pathologies, conservative treatments and outcomes of patients with low back or neck problems. A follow-up questionnaire seemed less important in the predominantly outpatient setting.

With Spine Tango conservative a first step has been taken to develop and implement a complementary system for documentation and evaluation of non-surgical spinal interventions and outcomes within the framework of the international spine registry. It proved useful and feasible in a first pilot study, but it will take the experience of many more cases and therapists to develop a version similarly mature as the surgical instruments of Spine Tango



### GP123. ARE CHANGES IN PAIN AND DISABILITY AFTER A PROGRAMME OF “SPINE STABILISATION EXERCISES” CONTINGENT UPON IMPROVEMENTS IN THE VOLUNTARY ACTIVATION OF TRANSVERSUS ABDOMINIS?

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**INTRODUCTION:** Many studies have shown that spine stabilisation exercises elicit improvements in symptoms/disability in patients with chronic non-specific low back pain (cLBP). However, none have corroborated the intended mechanism of action by examining whether these clinical improvements 1) are greater in patients with “dysfunction” of the muscles targeted by the exercises, or 2) correlate with post-treatment improvements in muscle activation.

**Methods:** Pre and post-therapy, 32 cLBP patients ( $44.0 \pm 12.3$  y) rated their LBP intensity (0-10) and disability (0-24, Roland-Morris; RM); thicknesses of transversus abdominis (TrA), obliquus internus (OI) and obliquus externus (OE) were determined at rest and during “abdominal-hollowing” using M-mode ultrasound. The TrA-contraction ratio (TrA-CR; thickness contracted/rest) and TrA-preferential activation (TrA-PA; TrA proportion of whole TrA+OI+OE thickness when contracted minus same at rest) were determined.

**RESULTS:** RM decreased from  $8.9 \pm 4.7$  to  $6.7 \pm 4.3$ , and average pain, from  $4.7 \pm 1.7$  to  $3.5 \pm 2.3$  (each  $p < 0.01$ ). TrA-CR increased from  $1.35 \pm 0.12$  to  $1.41 \pm 0.17$  ( $p = 0.06$ ) and TrA-PA, from  $0.051 \pm 0.018$  to  $0.056 \pm 0.025$  ( $p = 0.16$ ). There was a non-significant tendency ( $r = -0.31, p = 0.09$ ) for worse baseline TrA-PA to be associated with greater improvements in RM (but not pain). The individual improvements in RM/pain did not correlate significantly with the changes in either TrA-CR or TrA-PA ( $r = -0.06 - 0.20; p > 0.27$ ), though patients achieving a (clinically relevant)  $\geq 30\%$  reduction in RM *tended* to show greater improvement in TrA-PA than did those with  $< 30\%$  reduction ( $0.013 \pm 0.023$  vs  $0.001 \pm 0.022$ , respectively;  $p = 0.16$ ).

**CONCLUSION:** There was some suggestion that patients with worse TrA function benefited more from the treatment. However, a good clinical outcome was not strongly dependent upon corresponding changes in abdominal muscle function. It is hence difficult to attribute the therapeutic results to any specific effects of the exercises on the trunk muscles. Larger groups of patients should be examined to clarify whether stabilisation exercises simultaneously have some sort of “global/general” effect, unrelated to abdominal muscle function.

## GENERAL POSTERS

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### **GP124. XLIF FOR GRADE II SPONDYLOLISTHESIS AT L4-5: THE "WORST CASE" SCENARIO**

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**INTRODUCTION:** The XLIF technique is an MIS alternative to traditional spinal fusion. However, concerns are raised about neural complications with the lateral approach, particularly at the L4-5 level where access is most difficult due to the lumbar plexus. Significant anterolisthesis at this level exacerbates this risk. Outcomes from a series of these "worst case scenario" patients treated with XLIF are reported.

**METHODS:** 54 patients with Grade-II spondylolisthesis at L4-5, w/ and w/o concomitant stenosis, DDD, post-laminectomy instability, HNP, and/or scoliosis, were treated with XLIF. Clinical and radiographic data were reviewed to assess comorbidities, surgery details, hospital stay, complications, pain scores, changes in disk height and alignment, and fusion, and satisfaction scores at 12 months postop.

**RESULTS:** Ages ranged from 25-87 yrs (ave 65.6 yrs). Comorbidities were common (present in 82%). The L4-5 level was accessible in all cases. All cases included supplemental posterior fixation. LOS averaged 1.2 days. Complications included 1 pulmonary embolism requiring anticoagulation, 1 late-term hardware failure (screw fracture at 1 year), and one postop transfusion. No neural deficits were noted.

In 27 patients at 12 months, VAS pain scores improved from 8.5 to 1.7. Average disk height improved from 5.3 mm at pre-op to 10.7mm post-op, with 1.7 mm settling at 12 months. Slip improved from 10.7 mm at pre-op to 3.2mm and was maintained at 12 months. Lenke fusion scores averaged 1.9 at 3 months, 1.4 at 6 months, and 1.2 at 12 months. Eight patients underwent a CT scan at 12 months; all were judged as fused by an independent reviewer. 90% of patients were satisfied with the procedure and would do it again.

**DISCUSSION:** Grade-II spondylolisthesis at L4-5 can be treated successfully with a minimally invasive lateral approach. Results indicate good outcomes, few complications, and high satisfaction even in the most difficult situation. Careful attention to technique is paramount.

### GP125. FACTORS AFFECTED TO CLINICAL OUTCOMES OF DECOMPRESSION SURGERY WITHOUT FUSION FOR DEGENERATIVE LUMBAR SPONDYLOLISTHESIS

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**INTRODUCTION:** The purpose of this study was to prospectively investigate the clinical outcomes of decompression surgery without fusion for degenerative lumbar spondylolisthesis, and to clarify which factors influenced the poor clinical outcomes.

**METHODS:** From 2003 to 2006, all patients, who developed a surgical treatment on degenerative lumbar spondylolisthesis, underwent microendoscopic laminotomy (MEL) surgery at the authors' institute. A total of 113 patients (39 males, 74 females; mean age: 69.2 years) were reviewed prospectively. The slipping grade was 103 patients in grade I and 10 patients in grade II. The mean follow-up period was 24.8 months. The following items were evaluated: Japanese Orthopaedic Association scoring system (JOA score), recovery rate and poor clinical factors. All parameter were analyzed statistically. A probability level of less than 0.05 was considered significant.

**RESULTS:** The average recovery rate of JOA score was  $60.7 \pm 27.4\%$ . The overall results were excellent in 37.2% of the patients, good in 30.1%, fair in 23.0%, and poor in 9.7%, based on JOA score. Five patients underwent additional surgeries with four patients who had spinal fusion performed because of the progressive spinal instability. The vertebral endplate signal changes, posterior opening instability, aging or progressive instability had influences on clinical outcomes. Thirty-eight patients had the endplate signal changes that corresponded to olisthesis. The recovery rate in type III on the Modic classification was significantly lower than in other types. Seventeen patients had the posterior opening instability before surgery on the affected level. The recovery rate was 40.8 %, and the four patients had additional surgeries. However, in the 6/17 patients, the clinical outcomes were excellent.

**CONCLUSIONS:** This observation suggests that the clinical outcomes of MEL surgery without fusion for degenerative lumbar spondylolisthesis were relatively excellent or good. The overlap of vertebral endplate signal changes and posterior opening instability had influences on clinical outcomes.

### **GP126. CLINICAL OUTCOMES OF MINIMALLY INVASIVE TECHNIQUE FOR DIRECT REPAIR OF LUMBAR SPONDYLOLYSIS**

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**INTRODUCTION:** There are various methods of direct repair surgery for lumbar spondylolysis. In the last year ISSLS meeting, we presented our minimally invasive technique for direct repair using percutaneous pedicle screwing system. In this paper, we report the clinical and radiographical outcomes of this procedure.

**METHODS:** We reviewed all 10 patients (8 men, 2 women) of bilateral L5 spondylolysis. Mean age was 32.8 years. Mean postoperative follow-up was 16.1 months. Clinical evaluations were performed using the Japanese Orthopaedic Association (JOA) score and VAS. Radiographical evaluations were performed by measuring intervertebral motion of L5-S1, % slip of L5-S1, and instantaneous axis of rotation (IAR) using the pre- and post-operative lateral dynamic radiographs of lumbar spine.

**RESULTS and DISCUSSION:** The mean JOA score was improved from 15.8 to 26.4 points. The mean VAS also was improved from 75.8 points to 2.5 points. This technique is minimally invasive and could provide good clinical results. Bony fusion was confirmed by multidetector (CT) in 8 patients (80%). Radiographic measurements were performed in 8 patients. Postoperatively, L5-S1 intervertebral motions in 7 patients were decreased, but the motions were preserved in all patients. The L5-S1 slips were decreased in 7 patients. Location of instantaneous axis of rotation (IAR) of L5-S1 had moved posterocaudally in 7 patients. In the literature, IAR of the spondylolytic spine is reported to deviate cranially. Actually, in the present study, in all but one patient, IAR moved postero-caudally after the operation, meaning normalization of IAR occurred after the surgery. Therefore, the direct repair can lead to obtain the normal lumbar kinematics.

**CONCLUSION:** This procedure is minimally invasive and provide good clinical outcome. Biomechanically, a spinal motion segment can be preserved, and the lumbar kinematics can be normalized with reference to IAR.

### GP127. THE EFFECTS OF SPONDYLOLYSIS ON HIP DEGENERATION

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**INTRODUCTION:** The effects of hip disease on lumbar spine degeneration have been established previously. The goal of this study was to examine degenerative lumbar spines and their corresponding hips to determine if lumbar spine pathology leads to accelerated hip pathology.

**METHODS:** Using an osteological collection, 236 specimens without spondylolysis and 88 specimens with L5 spondylolysis were examined as well as their corresponding femora. Degeneration of the L5/S1 junction was evaluated using the Eubanks modification of the Kettler classification of facet joint degeneration. Specific attention was paid to the degree of femoral head arthritis and deformation. Heads were classified as mild, moderate or severe for both arthritis and deformation. The neck-shaft angles of each femur were also measured and recorded. Linear regression analysis was used to analyze the relationship between hip degeneration and the presence of spondylolysis. The analysis was corrected for age, sex, and degeneration at the L5/S1 level.

**RESULTS:** The association of osteoarthritis of the femoral head in the presence of spondylolysis was found to be significant ( $p=0.02$ ). Head deformation in the presence of spondylolysis in subjects age  $> 35$  was also found to be significant ( $p=0.04$ ). The association between head deformation and osteoarthritis of the femoral head was significant ( $p=0.01$ ). No significant association was found between the neck-shaft angle and the presence of spondylolysis.

**DISCUSSION:** The altered spine biomechanics in L5 spondylolysis has a direct effect on accelerating hip degeneration. Patients with lumbar instability should be closely observed for the development of hip degeneration.

## GENERAL POSTERS

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### GP128. PARS REPAIR TECHNIQUE & RATIONALE OF TREATMENT IN ADULTS.

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**BACKGROUND:** Back pain in adult patients with a pars-interarticularis defect may be due to movement at the defect or abnormal inter-segmental movement at the adjacent degenerate disc. We hypothesize that the defect may be the only source of pain in certain adults, even if the MRI scan shows an abnormal disc and spinal fusion may be unnecessary.

**OBJECTIVE:** To form a protocol of management in adults with pars defect and adjacent level disc degeneration. To study the results of primary lysis repair using 'AO Morscher clamp' in patients with 'spondylolysis' or 'Grade 1 'spondylolisthesis'.

**METHODS:** This is a prospective study involving adults with 'spondylolysis' or 'Grade 1 'spondylolisthesis' not responding to conservative management. We developed a protocol to investigate these patients with a lysis block and discography, to offer them appropriate treatment. On this basis fourteen patients were offered a lysis repair and bone grafting using 'Morscher's clamp' & six were offered spinal fusion. Outcome was assessed using Visual Analogue Score (VAS) and Oswestry Disability Index (ODI) done pre-operatively and six months & 2 years post-op.

**RESULTS:** Out of twenty patients (28 to 45 years; 8males and 12 females), fourteen patients underwent primary lysis repair using 'AO Morscher clamp' showing union of pars by 4 months (Follow-up duration of 2 years). Six patients underwent fusion. Mean VAS improved from 7.2 to 1.2 in lysis repair group and 7.8 to 2.4 in the fusion group. Mean ODI improved from 68 % to 24% for the lysis repair group. All patients had full range of spinal movement postop.

**CONCLUSION:** A thorough pre-operative workup of patients with pars defect and adjacent level disc degeneration showed that pain is due to the pars defect in 70% of our cohort. This subgroup of patients could successfully be treated with 'lysis repair' rather than a more morbid procedure –'spinal fusion'.

### **GP129. THE ORIENTATION OF LUMBAR PARS DEFECTS AS A CONSIDERABLY CAUSATIVE FACTOR IN ISTHMIC SPONDYLOLYSIS: BIOMECHANICAL AND THERAPEUTIC IMPLICATIONS**

Hao-ju, Lo; Sai-Wei Yang ; Yang-Hwei Tsuang

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**INTRODUCTION:** Spondylolysis is a fracture of the pars interarticularis and has a high risk of developing spondylolisthesis. There was a wide variation of angle in pars defects in clinical CT scan. We studied the variation in orientation of spondylolytic in different loading conditions and stress variation.

**METHODS:** An experimentally validated three-dimensional non-linear finite element model of the intact L3–S1 segment was used. Spondylolysis was simulated by creating bilateral pars defects with 1.0 mm gap at L5. The angle of pars defect was defined as a line parallel to the posterior cortex of the vertebral body at the lysis level defined the coronal plane, and a second line was drawn tangential to the defect. There are six known angles of pars defect often measured in clinical observation (-15, 0, 15, 30, 45 and 60 degree). Purpose of this study was to analyze the disc stresses at cranial and caudal adjacent level of lumbar spondylolysis in different angles change. A loading of 400 N of axial compression and 10 N·m in six motions of lumbar respectively were imposed on the superior surface of the L3 body. Von Mises stresses in the annulus fibrosus and nucleus pulposus at L4/5 and L5/S disc levels were analyzed.

**RESULTS SECTION:** Spondylolysis increases disc stresses at the affected levels under different angles and it may lead to disc degeneration in measured values. However, the increase in stresses is higher at the affected levels under more horizontal angle of pars defect, when compared to the more vertical angles.

**DISCUSSION:** The variation in the angles of defects in the pars may affect surgical management. However, less consider about the angles of pars defect in biomechanics and the option for treatment. Our results may be beneficial from a biomechanical perspective and provide treatment options under different angles of pars defect.

### GP130. RELATIONSHIPS BETWEEN SPINO-PELVIC PARAMETERS IN PATIENTS WITH LUMBAR CANAL STENOSIS

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**INTRODUCTION:** Several studies have investigated sagittal balance in asymptomatic subjects and patients with spinal disorders. However, there is no study that correlated the shape and orientation parameters of the spine to those of the pelvis in patients with lumbar canal stenosis (LCS) in relation to clinical symptoms.

**METHODS:** This study analyzed 60 asymptomatic adult volunteers and 93 patients with LCS. LCS was classified into two groups according to the presence of neurogenic intermittent claudication; patients of the claudicant group had intermittent claudication of the cauda equina, and those of the nerve root group had no claudication. The following parameters were measured on the lateral whole-spine standing radiographs: sagittal vertical axis (SVA), lumbar lordotic angle (LLA), sacral slope (SS), pelvic alignment angle (PA) and pelvic morphologic angle (PRS1).

**RESULTS:** Significant correlations were found between sacro-pelvic regions and lumbar lordosis in asymptomatic subjects, while there was no correlation between LLA and SVA. There was a significant correlation in both groups of LCS between LLA and SVA, however, the correlations between sacro-pelvic and lumbar regions were lost in the claudicant group.

**DISCUSSION:** Spinal elements provide flexible compensation to maintain posture in asymptomatic young subjects. The relationships between the sacro-pelvic and lumbar region are lost in patients with intermittent claudication, probably because compensation through the lumbar spine and pelvis has reached its limits.



### **GP131. QUALITATIVE GRADING OF SEVERITY OF LUMBAR SPINAL STENOSIS BASED ON MORPHOLOGY OF THE DURAL SAC ON MRI IMAGES.**

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**INTRODUCTION:** Radiological stenosis is assessed commonly by measuring dural sac cross sectional area (DSCA). Great variation is observed though in surfaces recorded between symptomatic and asymptomatic individuals. Our aim was to devise a qualitative grading of lumbar spinal stenosis (LSS), study its reliability and clinical relevance.

**METHODS:** This was a retrospective radiological study on a prospective patient cohort. We describe a seven grade classification based on the morphology of the dural sac as observed on T2 axial MRI images based on the rootlet / cerebrospinal fluid (CSF) ratio. Grades A and B show CSF presence while grades C and D show none at all. The grading was applied to MRIs of 95 subjects divided in three groups: 37 symptomatic LSS surgically treated patients; 31 symptomatic LSS conservatively treated patients (average follow up 2.5 and 3.1 years) and 27 low back pain (LBP) sufferers. DSCA was also digitally measured. We studied intra- and inter-observer reliability, distribution of grades, relation between morphological grading and DSCA, as well relation between grades, DSCA and Oswestry Disability Index (ODI).

**RESULTS:** Average intra-and inter observer agreement were substantial and moderate respectively ( $k = 0.65$ . and  $0.44$ ) whereas they were substantial for physicians working in the study originating unit. Surgical patients had the smallest DSCA. A larger proportion of C and D grades were observed in the surgical group. Surface measurements resulted in over-diagnosis of stenosis in 35 patients and under diagnosis in 12. No relation could be found between stenosis grade or DSCA and baseline ODI or surgical result. Patients with C and D grades were more likely to fail conservative treatment.

**DISCUSSION:** The grading defines stenosis in different subjects than surface measurements alone. Since it mainly considers impingement of neural tissue it might be a more appropriate clinical and research tool than surface measurements alone.

### **GP132. EVALUATION OF OSSIFIED LESIONS IN THE WHOLE SPINE AND SURGICAL RESULTS IN PATIENTS WITH OSSIFICATION OF THE POSTERIOR LONGITUDINAL LIGAMENT**

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**INTRODUCTION:** Ossification of the posterior longitudinal ligament (OPLL) causes narrowing of the spinal canal. OPLL frequently affects the cervical spine, however, it is observed in the lumbar spine. The purpose of this study was to evaluate the spinal stenosis due to OPLL in the lumbar spine.

#### **SUBJECTS AND METHODS**

##### **Study 1- Evaluation of lumbar OPLL in patients with cervical OPLL**

Ninety-two patients with cervical OPLL were included. X-ray and CT in the whole spine were taken. Ossification index (OI) was calculated by the summation of the ossified lesions at the posterior border of vertebral body and intervertebral disc in the cervical, thoracic and lumbar spine.

##### **Study 2- Surgical results in patients with lumbar OPLL**

Twenty surgically treated patients due to lumbar OPLL were included. Clinical features, such as age, gender, symptoms, existence of motor palsy, BMI and general complications were reviewed. Radiological examination was carried out by X-ray, CT and MRI. Pathological examination was also performed. Surgical results were evaluated by the JOA score (full score: 29).

#### **RESULTS**

**Study 1-** Ossified lesions in the lumbar spine were observed in 50 cases (54%). The continuous and mixed types of cervical OPLL frequently had the ossified lesions in the lumbar spine. There were 12 female patients having greater OI, more than 20, which means severe ossification in the spinal canal.

**Study 2 -** Seven patients (35%) were obese and 6 (30%) had a complication of diabetes mellitus. Pathological examination showed that the ossified lesions replaced the enthesis, extended longitudinally to the ligament tissue. JOA score improved from 10.2 to 20.9. One female patient showed a poor recovery.

**DISCUSSION:** This study revealed that more than half cases with cervical OPLL had the ossified lesions in the lumbar spine. OPLL also causes lumbar spinal stenosis. Therefore, whole spinal analysis is recommended in patients with OPLL.

### GP133. DEVELOPMENT AND VALIDATION OF SYMPTOM SCALE OF A LUMBAR SPINAL STENOSIS

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**INTRODUCTION:** Lumbar spinal stenosis (LSS) is a common and well-recognized spinal disorder. In assessing the effectiveness of treatment for LSS, severity of LSS-related symptoms is considered to be one of the most relevant for an outcome. The aim of this study was to develop a reliable and valid instrument to measure symptom severity of the patients with LSS.

**METHODS:** First, in order to derive categories of the LSS-related symptoms, focus group interviews were conducted and the data was analyzed using qualitative method. This analysis extracted ten domains (symptom at rest and in certain posture, difficulty in walking, sleep disturbance, etc) and also created an item pool. One hundred and eighty nine patients from nine hospitals with diagnosis of LSS answered this LSS scale questionnaire. Exploratory factor analysis was conducted to examine the construct validity and Cronbach's alpha coefficient was calculated to test internal consistency. The criterion-related validity used pain, numbness, and walking capacity as external criteria. The test-retest reliability with an interval of 1 to 5 weeks was analyzed in 163 patients.

**RESULTS:** Qualitative study exacted ten domains (symptom at rest and in certain posture, difficulty in walking, sleep disturbance, etc) and also created a pool of 36 items with 5 categories Likert type scale. With factor analysis, items with factor loading less than 0.35 were excluded and 25 items in eight domains were selected. The Cronbach's alpha of these items was 0.929. Coefficient of the test-retest reliability was 0.80. Pain, numbness, and walking capacity were significantly correlated with the score of the LSS symptom scale.

**DISCUSSION:** A 25 item LSS symptom scale was developed and its reliability and validity was confirmed.

## GENERAL POSTERS

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### GP134. A BI-DIMENSIONAL APPROACH TO MEASUREMENT OF PHYSICAL FUNCTION AND ABILITIES

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**INTRODUCTION:** Self-report measures of physical function and ability are becoming more readily accepted as diagnostic and outcome assessment instruments. However, self-report measures are sometimes considered to be inferior to physical performance measures, because the former are "subjective" while the latter are "objective". The juxtaposition of subjective measures against objective measures is artificial; these attributes exist along a bi-dimensional continuum, combining both objective and subjective components, with substantial correlation between the two. The purpose of this study is to compare established self-report and performance measures of ability that are used by orthopedists to assess persons with musculoskeletal injuries.

**METHODS:** 196 healthy adults underwent lift capacity testing (EPIC Lift Capacity test) on a test-retest basis with a one-week interval, followed by online administration of the self-report Multidimensional Task Ability Profile (MTAP). The MTAP has been developed through the use of an item response theory model so that patterns indicating inconsistent responding can be identified statistically.

**RESULTS:** The reliability of the lift capacity test was  $r=0.97$ . The multiple regression equation using age, gender, and MTAP score to predict lift capacity accounted for 67.3% of the variance, with each independent variable making significant contributions to the prediction of lift capacity.

**DISCUSSION:** The marriage of "objective" and "subjective" assessments has been demonstrated to be feasible and potentially useful to orthopedists who are asked to assess physical functional capacity. This bi-dimensional approach fits within the biopsychosocial model in both disability determination and treatment. Self-report measure of ability (MTAP), along with age, and gender, accurately predicts actual lift capacity performance. The use of a self-report measure that is sensitive to inconsistent responding to predict physical performance facilitates cross validation and screening for less than full effort performance. Moreover, serial testing to monitor progress becomes feasible with the use of a valid self-report measure.

### **GP135. THE INFLUENCE OF MIDLINE PRESERVATION (MLP) VS MIDLINE SACRIFICE (MLS) UPON FACET JOINT MORPHOLOGY IN LUMBAR DECOMPRESSIVE SURGERY – A CROSS SECTIONAL ANATOMICAL STUDY.**

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**INTRODUCTION:** There is controversy whether or not the midline should be preserved or sacrificed (MLP vs MLS) during decompression for lumbar spinal stenosis(LSS). MLP is popular as it preserves the posterior tension resisting structures. Equally it is increasingly recognized that the facet joints(FJ), partially resected during decompressive procedures for LSS, resist postoperative spondylolisthesis and instability. This study was performed to examine the effects of MLP or MLS upon FJ morphology.

**METHOD:** MRI scans from 18 patients with LSS (L1/2 to L5/S1) were examined and subjected to theoretical decompression with operative plans that performed decompression via a corridor that either preserved the midline structures via a parasagittal/laminotomy (MLP), or sacrificed the midline structures (MLS) with midline decompression. The lateral margin of the decompression was the medial border of the pedicle. Cross sectional area (CSA) was determined for the FJ before and after decompression with both procedures.

**RESULTS:** The cross sectional area of the FJ prior to surgery was 265, 300, 303, 340, and 324mm<sup>2</sup> at levels L1/2 to L5/S1 respectively. MLS reduced the FJ CSA by 4.7, 9.5, 6.2, 7.2 & 3.9% (L1/2 to L5/S1). MLP reduced the FJ CSA by 38.8, 44.0, 37.6, 32.7 & 23.6%. The differences between the MLP and MLS reductions of FJ CSA were highly significant. Even greater relative reductions were seen with MLP when the CSA of the inferior articular process alone was examined.

**DISCUSSION:** This study demonstrates that preservation of the midline significantly reduces the CSA of the facet joint and in particular the IAP. Biomechanical and clinical evidence suggests that the FJs have a major role in stability of the lumbar spine, and thus well-intentioned determination to preserve the midline structures may have a deleterious effect upon the facet joints responsible for stability of the lumbar spine.

### **GP136. DEVELOPMENT OF A NOVEL PERCUTANEOUSLY INSERTABLE/ REMOVABLE INTERSPINOUS PROCESS SPACER FOR TREATMENT OF LSS PATIENTS: FEASIBILITY STUDY USING PORCINE MODEL**

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**INTRODUCTION:** Symptoms associated with lumbar spinal stenosis (LSS) are posture dependent. Usually extension of the lumbar spine increases epidural pressure leading to provocation of symptoms. Previously a procedure using an interspinous process spacer was developed to prevent segmental extension. We have developed a novel interspinous process spacer, which can be inserted and removed percutaneously. The purpose of this study was to evaluate the feasibility of this novel technique and the effectiveness of the spacer in terms of preventing an increase in epidural pressure.

**MATERIALS & METHODS:** A total of 14 young pigs were used.

**Study 1:** Under general anesthesia and image guidance, the spacers were inserted via a small skin incision. Three month after operation, MRI was taken and all spacers were removed. Blood samples were obtained before and at 3 and 7 days after surgery, and WBC, IL-6, and CRP were evaluated.

**Study 2:** A flexible pressure transducer was inserted into the epidural space at the targeted disc level. Epidural pressure was measured in neutral and at maximum extension with and without spacer insertion.

#### **RESULTS:**

**Study 1:** Percutaneous insertion and removal of the spacer was successful for all animals through small skin incisions. All pigs recovered after surgery without detectable problems. MRI showed minimal damage to the PVM. WBC was increased at 3 days after operation, however up-regulation of IL-6 and CRP was not detected.

**Study 2:** Epidural pressure obviously increased at lumbar extension. Insertion of the spacer did not affect the epidural pressure in neutral, but prevented increases of pressure at lumbar extension.

**DISCUSSION:** Our results demonstrated percutaneous insertion and removal of our novel spacers was possible and safe using simple procedures. Furthermore, the prevention of increases in epidural pressure at lumbar extension could be an important evidence for its clinical usefulness in LSS patients.

### **GP137. LUMBAR DECOMPRESSION FOLLOWED BY COFLEX™ INTERLAMINAR IMPLANT VS. PEDICLE SCREW POSTERIOR LATERAL FUSION FOR TREATMENT OF STENOSIS**

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**INTRODUCTION:** To compare the clinical safety and efficacy of Coflex™ Interlaminar Fixation vs. instrumented fusion following standard decompression for lumbar stenosis.

**METHODS:** A prospective randomized comparison of Coflex vs. fusion from four FDA IDE sites are reported. Randomization was 2:1 Coflex vs. fusion. Every patient underwent one or two level decompression followed by placement of a Coflex Interlaminar implant vs. pedicle screw fixation with posterior lateral bone graft. Inclusion and exclusion criteria will be discussed along with patient demographics. FDA clinical success was based on Improvement of at least 15 points in the ODI at 24 months compared to baseline, no re-operations, revisions, removals or supplemental fixation and no major device-related complications. Follow up was completed at 6 weeks, 3 months, 6 months, and one year with physical exam, SF -12, VAS, ODI, and radiographic analysis.

**RESULTS:** 28 one level surgeries (19 Coflex and 9 Fusion) and 11 two level surgeries (8 Coflex and 3 Fusion). Average pre-op ODI in the Coflex group was 55 (range 40 to 70). Average pre-op ODI in the fusion group was 59 (range 42-72). Post-op ODI in the Coflex group was 10.5 (range 0-40) a 81% improvement. Post-op ODI in the fusion group was 34.8 (range 14-56) a 41% improvement. Pre-op VAS in the Coflex group was 74.2 (range 56-94). Average pre-op VAS in the fusion group was 73.5 (range 64-90). Post-op VAS in the Coflex group was 15.2 (range 0-68) a 80% improvement. Post-op VAS in the fusion group was 34.2 (range 11-66) a 53% improvement.

**DISCUSSION:** Both the Coflex and the fusion groups demonstrated safety with no device related complications and no reoperations or revisions. Both groups showed statistical improvement in ODI and VAS at follow up. The subjects randomized to Coflex demonstrated statistical superiority in all clinical measurements compared to fusion.

## GENERAL POSTERS

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### **GP138. THE INTERSPINOUS LIGAMENT SHOULD BE REMOVED FOR DECOMPRESSION WITH A CASE OF LUMBAR SPINAL CANAL STENOSIS.**

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**INTRODUCTION:** The operative procedure especially for older people suffering from lumbar canal stenosis (LCS) should be simple, less invasive and quick. For that reason we remove the interspinous ligament and decompression is done using the space where the interspinous ligament had existed. The purpose of the study is to determine the efficacy of this procedure retrospectively and to confirm that the interspinous ligament could be removed for the decompression surgery.

**METHODS:** Seventy patients were treated and 63 patients were followed up for more than 4 years. Operative time, blood loss, complications of surgery and further surgery were checked out. During the follow-up period, *JAPANESE ORTHOPAEDIC* Association score and lumbar spine X-ray were evaluated.

**RESULTS:** The average operative time was 51 minutes, average operative time per one level was 32 minutes, and the average blood loss was 57 ml. The recovery rate was excellent in 26, good in 24, fair in 8 and poor in 5 patients. Four of 63 patients (6.3%) needed further surgery and among them only 2 cases (3.2%) needed reoperation because of the instability of the operative levels.

**DISCUSSION:** This procedure is simple, less invasive and quick since the space where the interspinous ligament had existed is used as a working space. Therefore it can be performed for patients with coexisting illness even if they are very old. Many studies have reported less aggressive surgical techniques which minimize the tissue disruption. However, these procedures are more complicated, more time consuming and involve more significant blood loss than the procedure currently we present. We removed the interspinous ligament, yet obvious lumbar spinal instability was not seen until more than 4 years after surgery. In conclusion, the interspinous ligament had better be removed for decompression with a case of LCS.



### **GP139. THE SYNOVITIS OF THE FACET JOINT AT THE RESPONSIBLE INTERVERTEBRAL LEVEL MAY INDUCE CAUDA EQUINA SYNDROME IN LUMBAR SPINAL CANAL STENOSIS.**

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**INTRODUCTION:** It's often to encounter the synovial proliferation induced by the osteoarthritis of the facet joints on surgical approach for lumbar spinal canal stenosis (LSCS). The foregoing research indicated that hydrops of the facet joint might participate in the symptom formation of compressive nerve lesion in LSCS. The purpose of this study was to investigate the significance of the synovitis of the facet joint (SFJ) in LSCS.

**METHODS:** The subjects consisted of 26 patients (mean age 70 years) with LSCS and 8 patients (mean age 69 years) with lumbar spondylosis (SP) as the control. All patient underwent Gd enhanced MRI (1.5T) which could detect the SFJ in LSCS. Relation between the clinical symptoms and the SFJ was analyzed.

**RESULTS:** The distribution of the SFJ on MR image was 0% at L1/2, L2/3, L3/4 and L5/S, 13% at L4/5 in SP and 13% at L1/2, 20% at L2/3, 10% at L3/4, 73% at L4/5, and 7% at L5/S in LSCS. There was a remarkable difference between SP and LSCS. The frequency of the SFJ was in 46% (12/26 levels, 23 in L4/5, 3 in L3/4) for the symptomatic level and in 10% (10/104 levels) for the asymptomatic level. Especially, the SFJ at the symptomatic level was in 73% (8/11 cases) for cauda equina lesion and in 27% (4/15 cases) for radicular lesion. There was a statistical difference between them.

**DISCUSSION:** It has been reported that the synovial fluid of the facet joints include a large amount of the inflammatory cytokines which possible induce the chemical neuritis. This study showed that the SFJ produced in almost all the facet joints at the responsible intervertebral level for the cauda equina lesion. The SFJ plays an important role in the mechanism producing cauda equina lesion in LSCS.

### GP140. DEVELOPMENTAL NARROW SPINAL CANAL IN PATIENTS WITH LUMBAR SPINAL STENOSIS

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**INTRODUCTION:** Coexisted cases of cervical spondylotic myelopathy (CSM) and lumbar spinal stenosis (LSS) were sometimes found. However, there have been few reports regarding cervical spinal stenosis in patients with LSS. The purpose of this study is to evaluate the developmental narrow spinal canal in patients with LSS.

**METHODS:** Two hundred thirty seven patients with LSS (117 males and 120 females, from 35 to 85 years old, an average of 68.7) and 100 cases of cervical sprain as control (50 males and 50 females, from 20 to 85 years old, an average of 41.6) were studied. LSS was diagnosed by characteristic symptoms, physical findings and MRI. Plain lateral cervical radiographs were taken in all cases. A-P diameter of cervical spinal canal and vertebral body from C3 to C6 level were measured, and then a Torg-Pavlov ratio (TPR, canal/body ratio) was calculated. Each measurement was performed three times. Developmental cervical spinal stenosis was recognized by TPR of less than 0.8.

**RESULTS:** Twenty one patients had CSM in this study. There were 114 patients (80 males and 34 females) that showed a TPR of less than 0.8 in 237 patients. Especially this rate was significantly high in male patients (68.4%). In the group of LSS the mean TPR value was 0.76 in males and was 0.85 in females, both significantly lower than those of the control group (0.88 in males and 0.97 in females, both  $p < 0.01$ ).

**DISCUSSION:** This study demonstrated that about 50% of patients with LSS had cervical spinal stenosis. The mean TPR in the group of LSS was also significantly lower than those of the control group. Developmental narrow spinal canal including the cervical spine might be an important factor in the pathogenesis of LSS.

### GP141. LUMBAR SPINAL STENOSIS WITH PERIPHERAL ARTERIAL DISEASE.

Kazuhide Uesugi, Miho Sekiguchi, Shin-ichi Kikuchi, Masahiro Kanayama, Kazuhisa Takahashi, Chiba Kazuhiro, Minoru Doita, Yasumitsu Toribatake, Hiroshi Matsuo, Yukihiro Matsuyama, Seiji yasumura, Kazuo Yonenobu, Sin-ichi Konno, Fukushima, Japan

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**INTRODUCTION:** Neurogenic intermittent claudication (NIC) is a common symptom in patients with lumbar spinal stenosis (LSS). Peripheral arterial disease (PAD) evokes vascular intermittent claudication. Both diseases are prevalent in middle-aged and elderly people. The purpose of this study was to investigate the clinical characteristics of LSS patients with PAD.

**METHODS:** This study performed under the Japanese spine research society initiative. A total of 558 patients (299 males, 259 females) diagnosed with LSS by the clinical diagnostic support tool and MRI at 64 medical facilities were enrolled in this study. History taking, physical examination, blood tests, ankle-brachial index (ABI), the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ), and the Short Form 36 (SF-36) were performed. LSS patients with PAD or ABI below 0.9 were categorized in the LSSPAD group, while LSS patients without PAD were categorized in the control group. Statistical analyses were performed using t tests, Mann-Whitney's U test, and multivariate recurrence analysis. P values less than 0.05 were considered statistically significant.

**RESULTS:** The LSSPAD group included 37 patients (6.6%). Of these, 20 (3.6%) had already been diagnosed with PAD, while 17 (3.0%) were diagnosed with PAD based on the ABI measurements in this study. In the LSSPAD group, the number of elderly patients, the number of males, and the frequency of complication with diabetes, ischemic heart disease and arrhythmia were larger than in the control group (p

**DISCUSSION:** According to the present results, clinicians should consider the prevalence of PAD in NIC patients, particularly in elderly male patients with diabetes and/or ischemic heart disease and/or arrhythmia.

## GENERAL POSTERS

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### GP142. RELATIONSHIP BETWEEN LUMBAR SPINAL STENOSIS AND LIFESTYLE-RELATED DISORDERS.

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**INTRODUCTION:** Lifestyle-related disorders are known to be increasing in middle-aged and elderly people. However, the relationship between lumbar spinal stenosis (LSS) and lifestyle-related diseases has not yet been investigated. The purpose of this study was to examine the relationship between LSS and lifestyle-related disorders.

**METHODS:** Participants were 552 patients (294 males, 258 females) aged over 50 years who were diagnosed with LSS by the clinical diagnostic support tool and MRI at 64 medical facilities. As controls, anonymous data from 1218 males and 1636 females were selected from the National Health and Nutrition Examination Survey in Japan. The LSS and control groups were subdivided based on age (non-elderly, under 70 years old; elderly, 70 years old or over) and sex. Medical histories of hypertension, diabetes mellitus, dyslipidemia and blood sample data [HbA1c, total cholesterol (TC), triglyceride (TG), HDL] were examined. Data were analyzed using chi-square tests and Fisher's exact test. P values less than 0.05 were considered statistically significant.

**RESULTS:** In the non-elderly LSS group, the prevalences of hypertension and diabetes and the frequency of patients with high levels of HbA1c (6.1% or over) were significantly higher than in the control group. In the elderly LSS group, the prevalence of diabetes among females was significantly higher than in the control group (p

**DISCUSSION:** Non-elderly with LSS tend to have more life-style related disorders, such as hypertension and diabetes mellitus, than those without LSS. However, no relationship between dyslipidemia and LSS was observed among our subjects.

## GENERAL POSTERS

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### GP143. RELATIONS BETWEEN DISC DEGENERATION PARAMETERS AND LIGAMENTUM FLAVUM HYPERTROPHY

§ Munns JJ; § An, HS; § Espinoza Orías, AA; § Andersson, GBJ; § Takatori, R, § Inoue, N  
§ Rush University Medical Center, Chicago, IL, USA

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**INTRODUCTION:** Lumbar spinal stenosis constitutes a frequent form of disability in the elderly. Spinal canal narrowing causes nerve impingement, with up to 40% of stenosis attributable to hypertrophy of the soft tissues including the *ligamentum flavum* (LF). The objective of this work was to study LF thickening *in-vivo*. The null hypothesis was that LF thickening is correlated with low back pain (LBP) and effects of disc degeneration (DD).

**METHODS:** A 1.5T MR unit was used to scan axial proton-density slices (L1/2-L5/S1) of 83 volunteers (IRB-approved). Visual-C++ custom-written programs were used for *in-vivo* measurements of LF thickness, disc height and facet joint space width (FJSW) – the latter two derived from CT-scans. Medial, lateral, and mean LF thicknesses ( $t_{med}$ ,  $t_{lateral}$ ,  $t_{mean}$ , respectively) were measured. Data was arranged by age groups (20s-50s, by decade), gender, presence/absence of LBP symptoms, disc height, FJSW and DD grade (Pfarrmann scale). Statistical significance was set at  $p < 0.05$ . ANOVA and *t*-tests were used to compare thickness to DD parameters.

**RESULTS:** LF thickness increased by age (20s<30s<40s<50s) and with each successive lower level from L1/2 to L4/5, then decreased at L5/S1 in all 3 measures. Excluding L5/S1:  $t_{med} > t_{lateral} > t_{mean}$ . By gender,  $t_{mean}^M > t_{mean}^F$  (2.33 mm vs. 2.15 mm,  $p < 0.001$ ).  $t_{lateral}$  showed differences between all age groups except 30s/40s ( $p = 0.74$ ). By LBP symptoms,  $t_{lateral}^{symptomatic} > t_{lateral}^{asymptomatic}$  (3.17 mm vs. 2.91 mm,  $p < 0.009$ ). LF thickness correlated positively only to DD grade and not to the other DD parameters.

**DISCUSSION:** LF thickness increased with age and with level, peaking at the L4/5 level. This work is the first to show the lack of correlation between LF and disc height or FJSW which may cause LF buckling. Conversely, DD grade was confirmed to correlate positively with LF thickening. Mechanical changes associated with DD such as instability may contribute to LF hypertrophy.

## GENERAL POSTERS

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### GP144. LUMBAR FUSION IN OCTOGENARIANS: THE PROMISE OF MINIMALLY INVASIVE SURGERY

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**INTRODUCTION:** Although spinal pathologies are common in the elderly, additional health conditions often preclude operative treatment because anesthesia, blood loss, and recovery are too demanding. Minimally invasive approaches, however, reduce procedure-related morbidity and recovery time. Early results of two lumbar interbody fusion (LIF) procedures – one open (PLIF) and one minimally invasive (XLIF) – were compared in octogenarians to demonstrate the safety of each in this extreme elderly population.

**METHODS:** In our single-site prospective series of XLIF patients, 40 were identified as  $\geq$  age 80 with a minimum of 3 months follow-up. A complete, retrospective review of surgical patients treated in the same practice with traditional open posterior (PLIF) approach found 20  $\geq$  age 80. Comparisons were made between groups to identify differences in morbidity and mortality rates of the two procedures.

**RESULTS:** No clinically significant differences in demographics, diagnoses, or comorbidities were found between groups. Complication rate, blood loss/transfusion rate, and hospital stay were significantly lower in the MIS group ( $p < 0.0001$ ). MIS patients left the hospital an average of 4 days earlier than the open PLIF patients, most discharged home (92.5% XLIF versus 0% PLIF) rather than to skilled nursing facilities. Six deaths occurred in the PLIF follow-up, 3 within 3 months post-op; there was 1 death at 6 months post-op XLIF.

**DISCUSSION:** Surgical treatment need not be withheld based on age; elderly patients can successfully be treated using MIS techniques, and are – in our experience – among the most satisfied with their outcomes, enjoying significant improvements in pain, mobility, and quality of life.

### GP145. SURVIVORSHIP ANALYSIS OF INTERSPINOUS SPACER FOR TREATMENT OF LUMBAR SPINAL STENOSIS AND DISC HERNIATION

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**INTRODUCTION:** Interspinous spacers have been introduced for surgery of degenerative lumbar disc diseases. To date, there has been no study to investigate the survivorship of interspinous spacers.

**METHODS:** Between 2005 and 2009, 150 consecutive patients underwent decompressive surgery and DIAM<sup>®</sup> implantation for primary spinal stenosis or disc herniation. Characteristics of 150 patients (84 male, 66 female) included: mean age, 46.5 years; mean duration of follow-up, 24.2 months; 96 spinal stenosis and 54 disc herniation; 146 one-level (115 L4-5, 31 L5-S1) and 4 two-levels (L4-5 and L5-S1). Revision surgery due to any reasons of DIAM<sup>®</sup> implantation level was defined as failure and used as the end point for determining survivorship. Kaplan-Meier analysis and Cox regression model were used for survivorship of DIAM<sup>®</sup> implantation.

**RESULTS:** Seven patients underwent revision surgery, giving a revision rate of 4.7%. The mean time between primary and revision surgeries was 13.4 months (range, 2-29 months). Cumulative survival rate was predicted to be 92% (8% of revision rate) at 4 years after the operation. Survival rate of DIAM<sup>®</sup> implantation at L4-5 ( $p = 0.002$ ) and one-level ( $p = 0.01$ ) were higher compared with those of DIAM<sup>®</sup> implantation at L5-S1 and two-levels, respectively. However, gender ( $p = 0.16$ ), age ( $p = 0.41$ ), and type of disease ( $p = 0.67$ ) did not significantly affect the survival rate of DIAM<sup>®</sup> implantation. In Cox regression model, DIAM<sup>®</sup> implantation at L5-S1 (HR = 10.3; 95% CI = 1.7 – 63.0;  $p = 0.01$ ) and two-levels (HR = 10.4; 95% CI = 1.2 – 90.2;  $p = 0.04$ ) were correlated with risk of revision surgery.

**DISCUSSION:** The current results suggest that 8% of the patients who has DIAM<sup>®</sup> implantation for primary spinal stenosis or disc herniation undergo revision surgery at the same operation level within 4 years after the operation. Especially, DIAM<sup>®</sup> implantation at L5-S1 and two-levels appear to be risk factors for revision surgery.

## GENERAL POSTERS

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### GP146. SPINAL SURGERY IN PATIENTS WITH END-STAGE RENAL DISEASE UNDERGOING HEMODIALYSIS THERAPY

Sung-Uk Kuh, In-Ho Han, Hyeong-Cheon Park, Dong-Kyu Chin, Keun-Su Kim, Byung-Ho Jin, Young-Sul Yoon, Yong-Eun Cho, Seoul, South Korea

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**INTRODUCTION:** The objectives of our study were to introduce our surgical experiences for end-stage renal disease (ESRD) patients undergoing hemodialysis and discuss the strategic factors which should be considered pre- and postoperatively in spinal surgeries of ESRD patients.

**METHODS:** We retrospectively reviewed 12 patients who underwent spinal surgeries among patients with CRF at our hospital from May 2000 to September 2007. The medical records and radiological findings for these patients were reviewed and combined medical disease, laboratory findings, pre- and postoperative care, clinical outcomes, and complications were investigated.

**RESULTS:** One patient died of pneumonia and sepsis 2 months after fusion surgery. As other postoperative complications, postoperative delirium occurred in 3 patients and terminal ileitis and delayed primary spondylodiscitis on other site occurred in one patient. There was no postoperative wound infection associated with spinal surgery. The preoperative mean VAS score was  $7.8 \pm 0.56$ , which improved to  $2.2 \pm 1.25$  at final follow-up for 11 patients. Among 5 patients underwent fusion surgery, solid bone fusion was achieved in only 3 patients, PLIF with pedicle screw fixation. In 2 patients who underwent PLIF with cage alone, solid fusion was not achieved. In one patient among 2 patients who underwent anterior cervical fusion with plating, solid fusion was achieved. Therefore, overall fusion rate was 57.1% in patients with ESRD undergoing hemodialysis.

**DISCUSSION:** The spinal surgeries in ESRD patient undergoing hemodialysis can be performed with acceptable outcome. However, the complication rate and mortality rate is relatively high and fusion rate is low. Therefore, in order to obtain better outcome, the multiple factor such as combined medical disease, meticulous laboratory correction, and osteoporosis should be carefully considered.



### **GP147. RESTORATION OF VERTEBRAL HEIGHT AND CORRECTION OF KYPHOSIS AFTER KYPHOPLASTY**

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**INTRODUCTION:** Kyphoplasty has been an effective treatment method for osteoporotic compression fracture. In addition, kyphoplasty has absolute benefits for kyphosis correction and vertebral height restoration. It was designed to analyse the three groups by the shape of fractured vertebrae and compare each group with kyphosis correction and vertebral height restoration after kyphoplasty for osteoporotic compression fracture.

**METHODS:** We investigated 40 patients who underwent kyphoplasty for osteoporotic compression fracture during the past 2 years (Oct 2006 - Nov 2008). Preoperative and postoperative radiographs were analyzed by PACS system to quantify kyphosis correction (fractured level and 1 level above and below). Preoperative and postoperative vertebral heights at the fractured levels were also measured and categorized into anterior, middle, and posterior vertebral heights. And then we classify them into v-shaped, flat shaped and wedge shaped fracture and compared these three group with kyphosis correction and vertebral height restoration (ANOVA test) including clinical parameters such as age, sex, treated level, bone mineral density.

**RESULTS:** The mean postoperative anterior vertebral height restoration was 2.63, 2.33, 4.74 in order of flat shaped, V shaped, and wedge shaped. The mean vertebral height restoration were 1.62, 3.99, 4.15 in the middle area and 0.06, 1.27, 1.38 in the posterior area. The mean postoperative kyphosis correction at fractured segment were -5.44, -2.85, -9.27 and the mean postoperative kyphotic angle correction at vertebrae 1 level above and below fractured vertebrae were -2.65, -1.09, -7.02 in order of flat shaped, V shaped, and wedge shaped.

**DISCUSSION:** V-shaped compression fracture has a poor result for kyphosis correction. In case of V-shaped compression fracture, Initial less kyphotic angulations due to relatively preservation of initial collapsed anterior body height might be the one of the reason. But we thought kyphoplasty for V-shaped compression fracture has obvious advantage in middle vertebral height restoration and cement leakage prevention.

## GENERAL POSTERS

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### **GP148. THE OPTIMAL INDICATIONS AND TREATMENT RESULTS OF MINIMALLY INVASIVE TRANSFORAMINAL LUMBAR INTERBODY FUSION**

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**INTRODUCTION:** We are aware of no study that has examined the optimal indications for minimally invasive TLIF. This study evaluated not only if minimally invasive TLIF helps to alleviate symptoms and disabilities with low-grade spondylolytic or degenerative spondylolisthesis, or degenerative segmental instability, but if these could be the optimal indications for minimally invasive TLIF.

**METHODS:** We conducted subgroup analyses by comparing prospectively collected data from consecutive patients who underwent single-level minimally invasive TLIF for treatment of mechanical low-back and radiating pain with following 3 subgroups: (1) grade I/II spondylolytic spondylolisthesis, (2) grade I/II degenerative spondylolisthesis with gross instability, and (3) degenerative segmental instability with lumbar stenosis and/or disc herniation. Clinical outcome was evaluated using VAS, ODI, and functional scale. The radiographic fusion was assessed using flexion-extension lateral radiographs and CT scans.

**RESULTS:** There were 23 patients in group 1, 24 in group 2, and 19 in group 3. The preoperative back pain and leg pain (VAS scores) and disability (ODI scores) were significantly improved at final postoperative follow-up in all of the subgroups ( $p < 0.0001$ ). The groups exhibited equivalent back pain and leg pain and disability preoperatively and at final follow-up. The improvement of back pain and leg pain and disability after surgery was also comparable among 3 subgroups ( $p = 0.28$ ,  $p = 0.58$ ,  $p = 0.22$ ). Furthermore, the subgroups revealed similar distributions of final postoperative symptoms and final functional outcomes. Radiographic solid fusion was similarly rated 73.9% in group 1, 70.8% in group 2, and 89.5% in group 3 ( $p = 0.35$ ). Complications rate was also comparable among 3 subgroups ( $p = 0.66$ ).

**CONCLUSIONS:** The present study could demonstrate the favorable results reported by previous uncontrolled studies that minimally invasive TLIF helps to alleviate similarly each associated symptoms and disabilities from single-level low-grade spondylolisthesis or degenerative segmental instability. Additionally, these indications appear to be optimal for minimally invasive TLIF.

### GP149. IS OUR HEALTH CARE SYSTEM WORKING FOR SPINAL SURGERY PATIENTS?

A Henley, AH McGregor, London, UK

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**INTRODUCTION:** Patients have an important role in evaluating the healthcare; including the treatment they receive as well as the healthcare process. This information can be invaluable in developing a more patient centered approach to health care.

**METHODS:** The FASTER study (Function after spinal treatment, exercise and rehabilitation) aims to evaluate, via a factorial RCT, the benefits of a rehabilitation programme and an education booklet for the postoperative management of patients undergoing discectomy or lateral nerve root decompression, each compared with “usual care”. At the one year review there is an evaluation of each patient’s health care experience and their perceptions of how the system worked for them.

**RESULTS:** To date 201 patients have completed the trial; 60 receiving usual care, 37 an educational booklet, 48 rehabilitation and 56 received both booklet and rehabilitation. The majority (82%) were referred to the consultant through their GP. 40% identified a specific event that led to their pain; of these 48% reported a longstanding pain and 33% noting a sudden injury. 30% waited less than a month for surgery, and 32% 1-3 months. 18% experienced surgical cancellations. The majority of patients felt well informed pre-operatively, had faith in their surgical team and had sufficient time to discuss their condition. Similarly during their operative stay they felt supported and in good hands. When questioned about the health care process as a whole; positive patient comments included: the speed and quality of surgery and the pain relief experienced; whilst negative comments included: lack of information or advice, the delays between diagnosis and management, dissatisfaction with GP care, feeling abandoned, lack of respect from the surgeon, and disappointment with the outcome.

**DISCUSSION:** Whilst aspects of the healthcare process are working well it would appear that there is still dissatisfaction many aspects including outcome, timing and information transfer.

## GENERAL POSTERS

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### GP150. EVALUATION OF AN EDUCATIONAL BOOKLET FOLLOWING SPINAL SURGERY

A Henley, AH McGregor, London, UK

**INTRODUCTION:** The FASTER study (Function after spinal treatment, exercise and rehabilitation) aims to evaluate, via a factorial RCT, the benefits of a rehabilitation programme and an education booklet for the postoperative management of patients undergoing discectomy or lateral nerve root decompression, each compared with “usual care”. The education booklet, “Your back operation, [www.tso.co.uk/bookshop](http://www.tso.co.uk/bookshop), was given to those randomised to the booklet arm at discharge from hospital. The main intention of the booklet is to reduce patient anxiety, encourage a positive approach and exercise and increase confidence, as well as practical advice on self-management.

**METHODS:** Of the 363 subjects recruited 174 were randomised to receive the booklet (81 received only a booklet and 93 rehabilitation and the booklet). At the 3 month review those receiving the booklet were sent a questionnaire containing forced and open questions on readability, content and length.

**RESULTS:** Of the 174 participants randomised to receive the booklet 116 (67%) returned their evaluations (71 booklet only and 45 booklet and rehabilitation). The respondents were very positive with 99% stating that it was easy to read and follow, 89% felt it was the right length whilst 74% found it interesting, and 75% learnt new information although 22% learnt nothing new. 92% would recommend it to a friend and 63% referred to the booklet occasionally. When asked what they learnt from the booklet key responses focused on knowing what to expect, keeping active, getting back to normal and being positive. Whilst 74% rated the booklet as 8/10 or higher, many felt the booklet should include more practical tips, specific exercises and more information on their operation and possible complications.

**DISCUSSION:** Overall the results of this evaluation are promising and it appears that the booklet communicated its key messages effectively; however, its impact on surgical outcome remains to be evaluated.

## GENERAL POSTERS

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### GP151. COST COMPARISON OF TOTAL DISC REPLACEMENT VS. FUSION IN PATIENTS WITH INSURANCE DENIAL FOR DISC REPLACEMENT

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**INTRODUCTION:** New technology must not only be evaluated for outcome but also cost. For total disc replacement (TDR) some comparisons have been made within the confines of rigorous trial protocols, but not with well-matched cohorts outside of a study setting more representative of typical practice. The purpose of this study was to compare hospital costs of TDR to fusion in patients not enrolled in device trials, whose insurance denied payment for TDR.

**METHODS:** Eight patients were identified for whom TDR was recommended, but were denied insurance coverage for it and subsequently underwent fusion. Hospital costs were compared to 8 TDR patients matched to 8 fusion patients based on level(s) operated (exact match), date of surgery (< 25 days between matched procedures), and all at performed at the same hospital. Both groups had five single-level cases and three two-level cases. Seven fusions were combined anterior/posterior procedures. Cost data included total billed and total actually received. Costs were further subclassified and compared by category.

**RESULTS:** The mean total amount billed for fusion was \$98,968.13 vs. \$66,349.25 for TDR ( $p < 0.01$ ). The mean total paid for fusion was \$54,579.13 vs. \$37,123.75 for TDR ( $0.05 < p < 0.08$ ). Costs were similar for nonsterile supplies and recovery room. The only cost significantly greater for TDR was radiology services (\$612.00 vs. \$375.50). Hospital room, pharmacy, sterile supplies, operating room, and anesthesia costs were significantly greater for fusion ( $p < 0.05$ ). There was a trend for greater costs with fusion for intravenous supplies and implants and related supplies ( $0.05 < p < 0.075$ ).

**DISCUSSION:** Although this study had a small sample, denial of TDR and patients electing fusion provided an opportunity to evaluate unusually well matched comparative groups with surgery for same indication, same level(s), same time frame, and same hospital. Both the total amount billed and amount actually paid for fusion were approximately 50% greater than TDR.

### **GP152. THE SURGICAL MANAGEMENT OF DEGENERATIVE LUMBAR SPONDYLOLISTHESIS: A COMPARATIVE STUDY OF OUTCOMES FOLLOWING DECOMPRESSION WITH FUSION AND MICROENDOSCOPIC DECOMPRESSION**

Takato Aihara, Jyuntarou Oouchi, Yasuhumi Saitou, Takahiro Sanada, Kenji Hatakeyama, Naoki Ishigaki, and Tomofumi Ezure, Funabashi Orthopedic Hospital, Chiba, Japan

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**INTRODUCTION:** This study was undertaken to compare the outcomes following decompression with fusion (FU) and microendoscopic decompression (MED) for degenerative lumbar spondylolisthesis (DS).

**METHODS:** Forty-one consecutive patients with DS were treated surgically. The first 17 patients (group FU) underwent FU, and the second 24 patients (group MED) underwent MED. The mean duration of follow-up was 26 months. Clinical outcomes were evaluated using a Japanese Orthopaedic Association Back Pain Evaluation Questionnaire. Degree of improvement (DOI) was calculated by the following formula: postoperative score - preoperative score. Lateral radiographs in neutral position and in maximal flexion and extension were obtained before MED to measure the angle and percentage of slipping. All patients in group MED were classified into two groups based on the radiological measurements: a group whose the measurement was more than the average (M group) and was less than the average (L group). All DOIs were statistically compared using the unpaired t test between the groups FU and MED, and between the M and L groups.

**RESULTS:** DOI in social function was significantly greater in group MED than in group FU ( $P=0.022$ ). Although statistically not significant, DOIs in the other four factors were greater in group MED than in group FU. DOI in low-back pain was significantly greater in L group than in M group concerning the percentage of slipping in neutral position ( $P=0.037$ ). There were no statistically significant differences between the M and L groups in DOIs concerning the angle and percentage of slipping in maximal flexion and extension.

**DISCUSSION:** These findings suggest that there was no influence of the instability before MED to the clinical outcome, and the great percentage of slipping (13-26%) in neutral position could lead to poor improvement in low-back pain after MED, however, MED may lead to a better clinical outcome than FU for DS.

### GP153. PREDICTORS OF SERUM CHROMIUM LEVELS FOLLOWING STAINLESS STEEL POSTERIOR SPINAL INSTRUMENTATION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

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**INTRODUCTION:** Abnormally elevated serum chromium levels have been detected in patients with adolescent idiopathic scoliosis following stainless steel instrumentation. To date, the relationship between serum chromium levels, time of implantation and implant characteristics (including surface area, rod length, numbers of hooks, screws, and cross connectors) have not been studied.

**METHODS:** Prospective cohort study of thirty patients with adolescent idiopathic scoliosis undergoing posterior instrumented spinal arthrodesis using stainless steel Isola implants including cables between 1998 and 2002. Serum chromium levels were measured between October 2006 and June 2007. Post-operative radiographs were used to measure rod lengths, number of hooks, screws, cross-connectors and cables. The surface area of each component and the total surface area for each patient were calculated. Possible associations between serum chromium levels, time of implantation and implant characteristics were investigated.

**RESULTS:** Implant exposure, whether expressed in the form of total metal implant surface area ( $p=0.04$ ), rod length ( $p=0.05$ ), rod surface area ( $p=0.05$ ), or number of metal interfaces ( $p=0.09$ ), was found to be positively associated with serum chromium levels. Multiple stepwise (backward selection) censored regression revealed serum chromium levels increased by 1.0060 for every additional square centimeter of metal surface area ( $p=0.02$ ). This is the first study to identify statistically significant associations between specific spinal implant characteristics (other than corrosion identified by radiographs) and serum chromium levels.

**DISCUSSION:** Metal implant exposure is associated with elevated serum chromium in adolescent idiopathic scoliosis patients with stainless steel posterior spinal implants.

### GP154. LOW BACK PAIN AFTER LUMBAR DISCECTOMY IN PATIENTS SHOWING ENDPLATE MODIC TYPE 1 CHANGE

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**INTRODUCTION:** Lumbar vertebral bone marrow change is divided into Modic types. Some reports indicate that Modic Type 1 is related to low back pain, but the reliability of this assertion is unclear. The current study examines changes in low back pain in patients with lumbar disc herniation and Modic Type 1 change after lumbar discectomy without fusion surgery.

**METHODS:** Forty-five patients with lumbar disc herniation showing normal or Modic Type 1 signals in their bone marrow were selected (mean age 35 years). All patients suffered low back and leg pain due to lumbar disc herniation, and underwent a discectomy without fusion. We evaluated change in low back pain (Visual analogue scale [VAS] score, Japanese Orthopedic Association score (JOAS), and Oswestry Disability Index (ODI)) before, 12, and 24 months after surgery.

**RESULTS:** Twenty-three patients showed Modic Type 1 signals and 22 patients showed normal intensity before surgery. VAS score, JOAS, and ODI were not significantly different between the normal and Modic Type 1 groups. VAS score, JOAS, and ODI improved after surgery in both groups ( $P > 0.05$ ). Low back pain after surgery evaluated from the three scores was not significantly different in the two groups 12 or 24 months after surgery ( $P > 0.05$ ).

**DISCUSSION:** Discectomy improved low back pain in patients suffering from lumbar disc herniation. Patients with or without Modic Type 1 change showed a similar improvement of low back pain score. Low back pain in patients with disc herniation appears to mainly originate from disc or nerve root compression, and decompression surgery without fusion is an option for these patients, even those with Modic Type 1 changes.



### GP155. ADVANTAGES OF THE PARASPINAL APPROACH IN COMPARISON WITH CONVENTIONAL MIDLINE APPROACH FOR S1 PEDICLE SCREW PLACEMENT

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**INTRODUCTION:** To obtain a stronger as well as safer fixation of the S1 pedicle screw (S1PS), medially oriented screw placement is very important. The purpose of this study is to investigate whether the paraspinal approach leads to more medially oriented S1PS placement compared with the midline approach.

**METHODS:** The positions of 32 S1PSs placed by the midline approach (group M) and 34 S1PSs placed by the paraspinal approach (group P) were compared using postoperative CT scan. The location of the bilateral common iliac veins (CIV) in relation to the S1PS tips was also analyzed to evaluate their safety.

**RESULTS:** The mean S1PS angle, S1PS length within the sacral body, and distance from the midline to the S1PS perforation point of the anterior sacral cortex were respectively  $17.1 \pm 6.8^\circ$ ,  $43.2 \pm 5.1$  mm,  $18.9 \pm 4.9$  mm in group M and  $23.7 \pm 6.3^\circ$ ,  $46.5 \pm 4.4$  mm,  $13.9 \pm 7.2$  mm in group P. Statistical differences were found between two groups in these parameters. The mean distance from the midline to the CIV on the left side ( $19.5 \pm 8.3$  mm) was significantly shorter than on the right side ( $23.6 \pm 5.0$  mm). Four left screws in group M actually made contact with the left CIV, while no screw in group P lay adjacent to the CIV.

**DISCUSSION:** In group P, the S1PS were placed with significantly greater medial direction and with longer screws. In addition, they pierced the anterior cortex closer to the midline compared in group M. There is a risk of injury to the left CIV in particular in case of a bicortical S1PS placement in group M. Our results demonstrate that the paraspinal approach may be superior to the midline approach with more medially oriented S1PS placement, which will provide stronger and safer fixation.

## GENERAL POSTERS

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### **GP156. CONTRALATERAL SIDE TRANSIENT NEURALGIA FOLLOWING MICROSCOPIC BILATERAL DECOMPRESSION VIA A UNILATERAL APPROACH FOR LUMBAR CANAL STENOSIS: ITS FREQUENCY AND CLINICAL CHARACTERISTICS**

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**INTRODUCTION:** Following microscopic bilateral decompression via a unilateral approach for lumbar canal stenosis, patients sometimes experience postoperative leg pain on the nonapproach side. This pain is usually transient. The purpose of this study was to evaluate the frequency and clinical characteristics of this unique complication using a prospective cohort study.

**METHODS:** The study participants were 72 consecutive patients who underwent this surgical procedure. The approach side used for the procedure was usually determined by the dominant side of the patients' symptoms. In this study, we prospectively investigated frequency and characteristics of newly developed or increased leg symptoms on the side contra lateral to the surgical approach side after the operation.

**RESULTS:** In spite of permanent neurological complications, transient leg pain occurred in 10 patients (13.9%). In 2 patients (2.8%), the pain was present on the approach side; in 8 patients (11.0%), it was located on the contra lateral side. Characteristics of contra lateral side transient neuralgia were as follows. The patients without postoperative motor weakness improved within 2 weeks but in the patients with postoperative motor weakness, it took several months to improve their neuralgia. Transient neuralgia with motor weakness tended to develop immediately after surgery and neuralgia without motor weakness tended to develop after removal of suction drain. The VAS score for leg pain at one week after the operation was higher in group who developed contra lateral side transient neuralgia than the other patients, but there was no significant difference at other follow-up periods.

**DISCUSSION:** Decompression of the contra lateral side is a technically demanding procedure. Temporal retraction of nerve root, inadequate decompression, and postoperative epidural hematoma in the contra lateral side might be the cause of newly developed buttock or leg pain. Neuralgia on the contra lateral side of the unilateral procedure seemed to be a unique complication of this surgical procedure.

### **GP157. PERCUTANEOUS VERTEBROPLASTY WITH CALCIUM PHOSPHATE CEMENT FOR OSTEOPOROTIC VERTEBRAL FRACTURES: ANALYSIS OF THE POOR CLINICAL OUTCOME**

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**INTRODUCTION:** The purpose of this study is to assess the clinical outcome of vertebroplasty by using calcium phosphate cement (CPC) for osteoporotic vertebral fractures, and to analyze the risk factor for the clinical outcomes.

**METHODS:** We reviewed a consecutive group of patients undergoing CPC-assisted vertebroplasty. A total of 138 patients (103 women) underwent 157 CPC-assisted vertebroplasty procedures. Their mean age at time of surgery was 78 years. The mean duration of follow-up was 12 months (range, 6-26 mo). Outcomes were evaluated by clinically and radiographically. Factor analysis for poor outcome following vertebroplasty was investigated. 1) We defined that patients required any analgesic medication and brace due to back pain or had decreasing of walking ability, or VAS of the back and lower back pain to be more than 20 mm as poor clinical outcome. 2) The poor outcome in radiographic studies was determined by less than 70 % in the kyphosis rate of the vertebral body, pseudoarthrosis, or progression of kyphotic angle to over 20 degree.

**RESULTS:** 1) The patients with poor clinical outcome were 36 cases (26.1%). Logistic regression analysis revealed that poor clinical outcome was associated with female, the low powder/liquid ratio of CPC, and complication. 2) The patients with poor radiographical outcome were 55 cases (39.8%). Poor radiological outcome was significantly associated with the kyphosis rate at the first examination and the injury at thoraco-lumbar level. The patients with poor clinical and radiographical outcomes were 14 cases (10.1%). The complication during and following the procedure was independently associated with these outcomes.

**DISCUSSION:** CPC-assisted vertebroplasty gives a satisfactory outcome in patients with osteoporotic vertebral fractures if these procedures are done in carefully selected patients, and only by using appropriate amount and powder/liquid ratio of injected CPC to avoid the complication.

### **GP158. LONG-TERM FOLLOW-UP STUDY OF VERTEBROPLASTY WITH CALCIUM PHOSPHATE CEMENT FOR OSTEOPOROTIC VERTEBRAL FRACTURES**

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**INTRODUCTION:** The purpose of this study is to assess the long-term clinical outcome of vertebroplasty using calcium phosphate cement (CPC) for osteoporotic vertebral fractures (OVFs).

**METHODS:** We reviewed 106 patients undergoing 123 vertebroplasty procedures using CPC. Twenty-four patients died after less than five years follow-up, and forty-seven patients were lost to follow-up, leaving 35 patients (43 procedures) enrolled in this study. The mean age at time of surgery was 77 years old. The mean duration of follow-up was 6 years (range, 5-8 years). Following repositioning and curettage of the pathological soft tissue of the vertebral body (VB), vertebroplasty using CPC was performed in patients with osteoporotic burst fracture and pseudoarthrosis (procedure A). In situ vertebroplasty was performed in patients with osteoporotic compression fractures (procedure B). Outcomes were evaluated by clinically and radiographically.

**RESULTS:** All patients reported decreased pain from 8.7 to 4.2 in average VAS (cm) immediately after surgery, and pain relief was maintained at the last follow-up in all patients without new OVFs. The walking ability was preserved in 88.6% of patients. The mean preoperative kyphosis rate of the VB was 66.4% in procedure A and 70.5% in procedure B. At the final follow-up visit, those were 73.5% in procedure A and 73.2% in procedure B ( $P=0.0006$  and  $0.1900$ , respectively). Complete bone union was observed in all cases by 6 months after surgery. Complications included asymptomatic leakage of CPC into the spinal canal in 6 cases. There were 10 fractures at an adjacent level.

**DISCUSSION:** Vertebroplasty using CPC gave a satisfactory clinical outcome in elderly patients with OVF at a minimum of five years of follow-up, and was safe. Intra-vertebral procedure prevented from correction loss following vertebroplasty using CPC in patients with osteoporotic burst fracture and pseudoarthrosis.

### **GP159. SURGICAL OUTCOMES AFTER BILATERAL DECOMPRESSION USING A UNILATERAL APPROACH IN LUMBAR DEGENERATIVE DISEASE: IS THIS PROCEDURE ADEQUATE FOR PATIENTS WITH BILATERAL SYMPTOMS?**

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**INTRODUCTION:** Several authors reported favorable surgical results of bilateral decompression through a unilateral approach. If bilateral decompression can't be achieved adequately, patients with bilateral symptoms may have poorer outcome than patients with unilateral symptoms. Therefore, we conducted a comparison study between these patient populations.

**METHODS:** Eighty-four patients who underwent bilateral decompression through a unilateral approach for lumbar degenerative disease were divided into bilateral (n = 56) and unilateral group (n = 28) by the location of pre-operative lower-extremity symptoms. The following were compared between the 2 groups: Surgical outcome (Odom scale), Severity of intermittent claudication (IMC, 0-3: JOA score), pre- and post-operative pain (back-pain, lower-leg pain, and lower-leg numbness evaluated by visual analogue scale: VAS), and pre- and post-operative disability score for lumbar spinal disorders (Japanese Orthopaedic Association Back Pain Evaluation Questionnaire: JOABPEQ). The JOABPEQ consists of 5 subscales such as pain-related disorders, gait disturbance, lumbar spine dysfunction, social life disturbance, and psychological disorders.

**RESULTS:** In bilateral group, 71 % (40/56) had favorable surgical outcome (excellent or good), whereas 68% (19/28) in unilateral group. Although post-operative improvement in pain-related disorders of JOABPEQ was significantly better in unilateral group than bilateral group, no significant difference was observed in postoperative score of pain-related disorders. No significant differences between the groups were found in any of the parameters including IMC, 3 factors of VAS and 5 items of JOABPEQ, except for pain-related disorders. In the bilateral group, 6 patients have significant lower extremity pain on the approach side and 4 patients on the contralateral side after surgery.

**DISCUSSION:** This study has a limitation that we couldn't differentiate the type of nerve involvement, such as nerve root type and cauda equine type. However, our results suggest that this procedure is an effective treatment for patients with lumbar degenerative disease who has bilateral lower-extremity symptoms.

## GENERAL POSTERS

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### **GP160. DYNAMICALLY EVOKED, DISCRETE-THRESHOLD ELECTROMYOGRAPHY (EMG) IN THE EXTREME LATERAL INTERBODY FUSION (XLIF®) APPROACH**

Rodgers, W. B.; Peterson, Mark D.; Tohmeh, Antoine G.; Volcan, Ildemaro J.; Cummings, John T.; Sandhu, Faheem; Yoon, Sangwook; Deviren, Vedat; Taylor, William, Jefferson, City. Missouri, USA

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**INTRODUCTION:** Because the psoas muscle, within which is the lumbar plexus, is traversed during the XLIF approach, appropriate care is needed to avoid nerve injury during surgery and prevent approach-related neural deficit. Dynamically evoked EMG is used routinely to detect neural proximity and location during the XLIF approach, but no studies on its utility have been reported.

**METHODS:** In a prospective, non-randomized, multicenter, IRB-approved clinical study of 102 patients undergoing XLIF at L3-4 and/or L4-5, EMG threshold values from the dilators used in the procedure were recorded at the surface of the psoas muscle, mid-psoas, and on the spine. At each location, the dilators were rotated 360, taking recordings immediately posterior, superior, anterior, and inferior. The rotational position (angle in degrees) of each dilator at which the lowest threshold was found was noted. Pre- and postoperative neurological exams were also recorded to identify new motor deficits.

**RESULTS:** A total of 133 levels were treated at L3-4 (n=24), L4-5 (n=47), and both L3-4 and L4-5 (n=31). Alert-level EMG feedback was given in 55.7% of all cases; 43.6% at L3-4 and 62.9% at L4-5. The relative frequencies of the location of the lowest threshold found for all three dilators combined at each level are summarized. Though nerves were more commonly identified in the posterior margin (63%), there was significant variability in the location of nerves identified. The posterior half of the disc space was targeted in 90% of cases, with no significant neural deficits. Three (2.94%) new postoperative neural motor deficits were identified, all transient.

**CONCLUSIONS:** The ability to identify and report a discrete, real-time EMG threshold during the transpsoas approach helps to avoid nerve injury and contributes to the safety and effectiveness of the XLIF procedure. Additionally, nerve location is variable, thus reinforcing the need for real-time directional and proximity information.

## GENERAL POSTERS

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### **GP161. MINIMALLY INVASIVE LUMBAR FUSION (XLIF) USING A $\beta$ TCP-HA BONE GRAFT SUBSTITUTE (FORMAGRAFT): FUSION RATES OUT TO 1 YEAR**

W.B. Rodgers, MD; Edward J Gerber, PA-C; Jamie Patterson, BS  
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**INTRODUCTION:** Good short-term outcomes after XLIF have been shown. Fusion outcomes have been assumed to meet or exceed those of other interbody fusion procedures due to access for greater disk preparation, large structural implant, and retention of stabilizing ligaments. However, no reports to date have focused specifically on fusion rates associated with XLIF, or on the graft materials used in XLIF. Given the limitations of autograft, many US surgeons use bone morphogenic protein in lumbar fusions. However, issues related to early resorption and hospital costs have fueled continued evaluation of other bone graft substitutes.

**METHODS:** The use of a beta-tricalcium phosphate/hydroxyapatite (FormaGraft) with bone marrow aspirate (BMA) was prospectively studied in 57 consecutive 1- and 2-level XLIF procedures. Radiographic outcomes were evaluated to demonstrate fusion and were compared with clinical results.

**RESULTS:** Patient age ranged from 25-79yrs (average: 55.7yrs). Primary diagnoses included stenosis (31), DDD (12), spondylolisthesis (8), and HNP (6). Comorbid conditions included previous spine surgery (47.4%); smokers (38.6%); diabetes (24.6%); chronic steroid use (10.5%); obesity/morbid obesity (54.4%). 64 levels were treated: 50=1-level, 7=2-level; 1@T8-9, 4@L1-2, 6@L2-3, 16@L3-4, 37@L4-5. Graft included equal amounts by volume FormaGraft and BMA, aspirated from the adjacent vertebral body under lateral exposure. All included supplemental fixation. Hgb change and hospital stay averaged 1.23g and 1.0days. Complications included one iatrogenic HNP requiring secondary decompression. One patient died at 10 months post-op, unrelated to his surgery. Average disk height improved from 6.4mm to 10.9mm, and was maintained at 9.8mm at 12months. Fusion by Lenke score=1 was 92.6% at 12 months. Average VAS pain scores decreased from 9.0 at pre-op to 2.9 at 12 months. 90% expressed satisfaction with their procedures at 12 months, and 95% said they would do it again.

**CONCLUSION:** XLIF has proven to be a safe and effective procedure and now 12-month results using  $\beta$ TCP-HA bone graft substitute confirm fusion, maintenance of improvements, and overall patient satisfaction.

## GENERAL POSTERS

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### GP162. PROSPECTIVE, NON-RANDOMIZED, MULTI-CENTER CLINICAL EVALUATION OF EXTREME LATERAL INTERBODY FUSION (XLIF) IN THE TREATMENT OF ADULT SCOLIOSIS

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**INTRODUCTION:** Surgical intervention in adult scoliosis has traditionally been by large open anterior and/or posterior procedures, with often unacceptable morbidity and risks to elderly comorbid patients. Minimally invasive treatment of adult scoliosis can be achieved with the XLIF approach.

**METHODS:** A prospective, nonrandomized, multicenter IRB-approved evaluation of XLIF in adult scoliosis is ongoing at 17 sites across the US. Clinical and radiographic data is collected prospectively at the pre-op, surgery, post-op, 6-week, 3-month, 6-month, 12-month and 24-month visits for XLIF patients over 45 years of age with degenerative scoliosis of least 10°.

**RESULTS:** One-hundred-seven patients (mean age:68.4 years, range:45-87 years; 72.9% female) with back pain(15.4%), radicular pain(1.9%), or both(82.7%) underwent XLIF procedures at 344 levels from T12-L5 (mean:3.21 levels, range:1-6 levels); with posterior fixation(72.0%), lateral fixation(4.7%), other fixation(4.7%), and standalone (18.7%). Posterior fusion was staged in 16.5%. Additional direct decompression was performed in 47.3 %. The mean operative time was 178minutes/patient or 58minutes/level. Estimated blood loss was a mode of 50-100mL. Mean length of stay was 2.92 days-unstaged (median: 2), 8.13 days-staged (median:8), and 3.82 days-overall (median:3). There were 13 surgical complications in 10 patients. Mean back and leg pain VAS improved from 7.3 and 6.2 to 3.6 and 2.3 at 12 months, respectively. Mean ODI improved from 48.2% to 27.0% at 12 months. SRS-22 scores improved from 2.7 to 4.2 at 12 months. Scoliosis curvature was corrected from 24.3° to 16.0° at 12 months. Lordosis was maintained from pre-op to 12 months.

**CONCLUSIONS:** This is the first prospective, multicenter evaluation of a minimally invasive lateral approach in the treatment of adult scoliosis. Clinical improvement is significant and well-maintained over time. XLIF allows for less invasive surgical treatment of patients who may have been previously considered too high risk for surgery. Longer-term outcomes and maintenance of radiographic correction is forthcoming.



### GP163. CT FUSION ASSESSMENT IN XLIF PATIENTS AT 1 YEAR

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**INTRODUCTION:** XLIF has been shown to result in good short-term outcomes with minimal morbidity. Long-term outcomes have been assumed to mimic those of other interbody fusion procedures. However, no reports to date have focused specifically on fusion rates associated with XLIF.

**METHODS:** From our prospective, nonrandomized single-site consecutive series of 710 XLIF patients, patients reaching 1 year follow-up were asked to undergo a voluntary lumbar spine CT scan. CT scans from 66 patients with 1 year follow-up have been obtained to date, which were reviewed to evaluate fusion, and compared with clinical results and patient satisfaction.

**RESULTS:** Patient age ranged from 34-87yrs (average 61.8yrs). 88 levels were treated: 50 1-levels, 10 2-levels, and 6 3-levels; 16 at L2-3, 32 at L3-4, and 37 at L4-5. Grafting materials included a composite of DBM, local bone graft, and bone marrow aspirate. Twelve surgeries included supplemental unilateral pedicle screw fixation performed in the same surgical position. Average disk height improved from 6.1mm to 9.4mm at one-year follow-up and 100% at 24 months. Signs of fusion by Lenke scores of 1 or 2 were 97% at 6 months and 99% at 12 months. Fusion by CT criteria of >50% area fused was achieved in all but 3 levels (96.8%). Average VAS pain scores decreased from 8.6 at pre-op to 1.7 at 12months with a slight increase to 2.1 at 24 months. At 1yr, 89% of patients were satisfied or very satisfied with their outcomes. The surgeon-reported clinical assessment was good or excellent in 84%.

**CONCLUSION:** XLIF has proven to be a safe and effective procedure. This is the first report specifically highlighting fusion rates of XLIF by CT assessment. High rates of fusion can be reasonably expected using this minimally invasive interbody fusion procedure.

## GENERAL POSTERS

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### **GP164. SAFETY AND THE LEARNING CURVE OF TRANS-SACRAL FUSION (AXIALIF) AT L5-S1: COMPLICATIONS IN THE FIRST 166 SURGERIES OF A SINGLE SURGEON SERIES**

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**INTRODUCTION:** Trans-sacral fusion of L5-S1 has been well described.<sup>1,2</sup> To our knowledge, the early complications during the adoption phase for AxiaLIF have not been reported in detail.

**METHODS:** All AxiaLIF patients were followed to evaluate outcomes. Surgical and postoperative complications were also documented and highlighted here, with respect to type and severity. Preliminary 12 month postoperative data is reported (n=53).

**RESULTS:** 166 patients (62M, 77F; age 55.2 yrs, range 22-88 yrs; BMI 31.1) were treated by a single surgeon (WBR) using the AxiaLIF technique for fusion at L5-S1. 122 procedures were single level; 38 procedures involved concomitant fusion at L4-5 (via XLIF). 99% involved supplemental posterior pedicle screw fixation. OR time averaged 91.4 min (69.1 min for single level procedures and 137.6 min for AxiaLIF-XLIF combinations). Length of stay averaged 27.2 hrs (1.13 days). Hemoglobin change was 1.79 g.

There were 23 complications in the perioperative period: Hardware (1, screw revision at POD 1), graft herniation (3, all required laminotomy), pneumonia (1), wound dehiscence at incision (4, 3 treated with local care, 1 treated with wound VAC), cardiac (1, CHF), urinary retention (1), gastritis (1), ileus (2), delirium (1), infection (1, I&D), transfusion (3), nonunion (2, revised at 10 and 12 mos). There have been 4 reoperations for adjacent segment disease. There were no visceral, vascular, or neurologic complications.

Disk height improved from 4.3 mm preop to 7.7 mm postop; minimal subsidence was noted at 6 mos with some settling at 12mos (disk height 5.5mm). Listhesis was reduced from 4.4 mm preop to 1.2 mm postop with slight settling to 2.1mm at 12 mos. VAS decreased from 8.7 preop to 3.5 at 3 mos and further to 3.1 at 12 mos.

**CONCLUSION:** The adoption phase and learning curve for trans-sacral fusion shows very few complications compared to traditional open techniques.

### GP165. BIOMECHANICAL IMPLANT BEHAVIOR AND EXTRUSION RISK OF AN IN-SITU CURED SILICONE RUBBER NUCLEUS REPLACEMENT IMPLANTED THROUGH A TRANSACRAL APPROACH

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**INTRODUCTION:** Replacement of the nucleus with an implant often requires a large defect in the annulus, which increases the flexibility of a spinal segment and the extrusion risk for the implant. Implantation through a transsacral approach may preserve biomechanically important structures and prevent extrusion. The purpose of this study was to investigate the biomechanical behavior of the transsacrally implanted, in-situ cured, silicone rubber nucleus replacement (PNRTM), which can be implanted after conventional microdiscectomy.

**METHODS:** Six fresh frozen human specimens (L2-S1) were split in two groups: monosegmental L2-3 and bisegmental L4-S1 specimens. In the monosegmental group, microdiscectomy was carried out through interlaminar approach. Transsacral nucleus replacement with an in-situ cured silicone rubber implant in L5-S1 was performed in the bisegmental group. Both groups were exposed to cyclic loading (100-600 N) for 100,000 cycles. Segment flexibility was tested in the intact state, after microdiscectomy, transsacral nucleotomy, implantation and 100,000 cycles of loading under pure bending moments (7.5 Nm) in the three main motion planes. After testing, specimens were dissected and underwent macroscopic investigation.

**RESULTS:** The immediate effect of implantation was a significant segmental stabilization in all planes. In the microdiscectomy group ROM in flexion/extension and lateral bending decreased significantly, but not in axial rotation. In both groups, the cyclic loading caused a destabilizing effect, but was similar to non-treated segments. No expulsion of the silicon core through the posterior defect could be observed in the microdiscectomy group. Macroscopic observation revealed no visible changes of silicon core position.

**DISCUSSION:** Transsacral nucleus replacement with PNRTM silicone implant provided a restoration of the biomechanical behavior of the intact segment. No implant expulsion was observed even with posterior defect in annulus fibrosus and interlaminar approach in microdiscectomy group. This transsacral approach may also serve as a possibility for the use of other nucleus implant technologies.

## GENERAL POSTERS

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### **GP166. RELATIONSHIP BETWEEN ADJACENT SEGMENTAL DEGENERATION AND RANGE OF MOTION OF THE IMPLANT SEGMENT AFTER LUMBAR TDR**

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**INTRODUCTION:** One of the main goals for lumbar TDR is to prevent adjacent segmental degeneration after lumbar fusion. However, there have been several reports that ASD occurred even after lumbar TDR. To evaluate the relationship between ASD and range of motion of the implant segment after lumbar TDR, a retrospective study was conducted.

**METHODS:** From 1999 to 2000, 68 cases of lumbar TDR were performed by one surgeon for lumbar degenerative disorders utilizing SB Charite II. Among them, 44 cases of single level TDR were followed up at least 2 years (2-7, 5.8years). There were 18 male and 26 female with an average age of 42.8 years (36-58). The level of TDR was 3 cases in L3/4, 23 in L4/5 and 18 in L5/S1. There was no degeneration at the adjacent segment preoperatively in all 44 patients. During follow up evaluation, the ROM of implant segment and degenerative changes of adjacent segment was evaluated by standing AP, lateral and flexion-extension X-ray. VAS and ODI was compared for clinical outcome.

**RESULTS:** There were 5 cases (11.4%) with radiographic degenerative changes at the adjacent segment after lumbar TDR. The average ROM of implant segment was  $3.3 \pm 1.2$  degrees for all cases. The ROM was  $2.2 \pm 0.8$  degrees for patients with radiographic ASD and  $4.1 \pm 1.3$  degrees for patients without ASD and there was significant differences between two groups ( $P < 0.05$ ).

**DISCUSSION:** Although there was significant relevance between radiographic ASD and ROM of implanted segment with lumbar TDR, no significant relevance was found regarding the clinical outcome with ASD after lumbar TDR. The limitation of this study is the small number of cases.

### **GP167. PROSPECTIVE RANDOMIZED SERIES COMPARING MAVERICK™ LUMBAR TOTAL DISC REPLACEMENT (TDR) WITH ANTERIOR LUMBAR INTERBODY FUSION (ALIF) WITH FIVE YEAR FOLLOW UP**

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**INTRODUCTION:** Data from a clinical trial with five-year follow-up comparing the Maverick (25 patients) with ALIF (11 patients) was evaluated. All Maverick patients had two-year follow-up and 19 had five-year follow-up. Ten ALIF patients had two-year follow-up and seven had five-year follow-up.

**METHODS:** Patients were randomized 2:1 (Maverick: ALIF). Indications for surgery were similar to lumbar fusion. Inclusion/Exclusion criteria and demographics will be discussed.

**RESULTS:** Maverick pre-op Oswestry Disability Index (ODI) mean was 56; Two years post-op it was 15 for an average improvement of 74% (P  
Maverick pre-op Visual Analog Scale (VAS) mean was 7; Two-year post-op was 2 for an average improvement of 71% (P  
Fourteen of the 19 Maverick patients had an ODI less than 10 and a VAS less than two at five-year follow-up. Clinical success was achieved in 84% of the Maverick patients and 55% of the ALIF patients.  
One Maverick patient required reoperation versus three in the ALIF group. One additional ALIF patient is awaiting posterior fusion.  
Average hospital stay for both groups was 1.6 days.  
Time to unrestricted activity averaged six weeks in the Maverick group and six months in the ALIF group.  
Overall patient satisfaction was 95% for Maverick and 78% for the ALIF.

**DISCUSSION:** These results are similar to those reported by six other IDE sites at two-year follow-up. The combined results of 173 Maverick patients from seven IDE sites indicate statistical superior clinical outcomes compared to ALIF at one-year, and two-year follow-up (P

## GENERAL POSTERS

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### **GP168. INTRA-OPERATIVE CONVERSION OF ATTEMPTED LUMBAR TOTAL DISC REPLACEMENT TO FUSION: INCIDENCE AND CAUSES**

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**INTRODUCTION:** One concern expressed about total disc replacement (TDR) is potential inability to implant these pre-sized devices due to patient anatomy or technical difficulties. The purpose of this study was to analyze the incidence and reasons for intra-operative conversion of TDR to fusion.

**METHODS:** A log of 1070 consecutive lumbar TDR procedures, beginning with 11 surgeons' first case experiences, performed over approximately 10 years was review. All cases of intra-operatively TDR conversion to another procedure were identified and the reasons for such recorded.

**RESULTS:** In 0.47% (5 of 1070) of attempted TDR procedures was intra-operative conversion to a fusion necessary. In no case was surgery aborted completely. A summary of each case follows. In a planned two-level TDR, after successful placement at L5-1, a L4 vertebral body cyst was found. This was removed and circumferential fusion performed at L4-5. In another planned two-level case, while implanting the second device, the first device migrated. Due to poor bone quality, surgery was converted to two-level circumferential fusion. In a third two-level TDR, the inferior L5 endplate was excessively concave and prosthetic endplate could not be seated appropriately. This level was fused and TDR implanted at L4-5. In another patient, L5-1 TDR was attempted; however, the smallest available device was too large to fit appropriately in the disc space and fusion performed. In the remaining patient, during L5-1 TDR placement, posterior vertebral body rim fracture was identified and anterior interbody fusion performed. All five cases were successfully converted to a fusion without incident.

**DISCUSSION:** Intra-operative conversion from TDR to fusion was rarely needed, even in this series including first case experiences for 11 surgeons. When necessary, conversion was accomplished without incident and never was the surgical procedure aborted completely. Careful pre-operative assessment may all but eliminate the need for intra-operative conversion.

## GENERAL POSTERS

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### GP169. PROSPECTIVE EVALUATION OF THE CHARITE™ LUMBAR ARTIFICIAL DISC REPLACEMENT WITH MINIMUM THREE-YEAR FOLLOW UP

Kenneth A. Pettine, M.D., Dr. Christian Schlicht, Loveland, CO, USA

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**INTRODUCTION:** Results of Charite A.D.R. from a completely independent F.D.A. I.D.E. study site were evaluated. The surgeon has no financial ties to Depuy and was not involved in the Charite study.

**METHODS:** Sixty-six single level Charite surgeries at one I.D.E. site were reviewed. Inclusion/Exclusion and demographics will be discussed. Oswestry Disability Index (ODI), Visual Analogue Scale (VAS), patient satisfaction, and flexion/extension radiographs were evaluated pre-op and at 6 weeks, 3 months, 6 months, 12 months, 24 months and 36 months post-op. Clinical success was defined by at least 25% improvement in ODI at 24-months.

**RESULTS:** Operating time average: 104 minutes at L4-L5 and 79 minutes at L5-S1. Average blood loss: 45 cc at both levels. Hospitalization average: 22 hours. Three patients required re-operation.

ODI results: Pre-op = 63.8; twelve months = 27.25; twenty-four months = 20.5 (p

At twelve month follow up 32% of patients had an ODI less than 10. At twenty-four months the percentage increased to 33% and 38% at thirty-six months. Also at twelve months 39% of patients had a VAS of less than two. At twenty-four months the percentage changed to 29%. These patients were considered basically “pain free” with “normal” function.

Clinical success was met in 84% of the patients. Patient satisfaction at two-year follow up was 88% and increased to 92% at three years.

**DISCUSSION:** Charite patients demonstrated clinical efficacy with significant decrease in ODI and VAS (p

## GENERAL POSTERS

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### GP170. SPINE SURGERY AT AN AMBULATORY SURGERY CENTER

Kenneth A. Pettine, M.D., Dr. Christian Schlicht, Loveland, CO, USA

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**INTRODUCTION:** Can spine surgery be safely performed at an ambulatory surgery center (ASC)? This question has important ramifications for providing quality health care at lower costs. Every spine surgery case performed at an ASC from spring 2005 through 2008 (1,030 cases) was prospectively evaluated.

**METHODS:** All cases were evaluated with Oswestries (ODI), neck disability indexes (NDI) and visualanalog scale (VAS) at pre-op, three-month, six-month, one-year and often two-year follow-up. Surgery types included both instrumented (653) and non-instrumented (377) surgeries.

**RESULTS:** In 193 anterior cervical fusion patients, there were no perioperative complications and no unplanned transfers. There was a statistically significant improvement in NDI and VAS values.

In 83 lumbar ADR patients there was one intra-operative vein laceration. One arterial thrombosis and two patients were returned to the OR. There was a statistically significant improvement in ODI and VAS at two-year follow-up.

One patient out of 377 lumbar microdiscectomy and decompression patients was returned to the OR.

All anterior cervical fusions, ADR, and non-instrumented lumbar spine surgeries were released home within 24 hours of their surgery.

Posterior lumbar fusion with pedicle screws, TLIF and, posterolateral fusions were evaluated in 298 patients. Three returned to the OR, five transferred to the hospital, two transferred to a rehab unit, and three had postoperative complications for a complication rate of 4.3%. These patients had an average stay of 48 hours and reported a significant improvement in post-op ODI and VAS.

Outside insurance audits have indicated a 60% cost savings when performing these procedures at an ASC versus a standard hospital setting. Patients reported a 97% satisfaction rate.

**DISCUSSION:** The results of the prospective analysis of 1,030 spine cases at an ASC indicate both instrumented and non-instrumented spine surgeries can be safely performed with efficacy at an ASC.



## GENERAL POSTERS

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### GP171. EXTREME LATERAL INTERBODY FUSION (XLIF) IN THE MORBIDLY OBESE

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**INTRODUCTION:** Minimally invasive procedures are challenging in obese patients whose body habitus may decrease the accessibility of the spine to the instruments necessary to perform these procedures. The XLIF procedure, however, is performed in the lateral decubitus position, minimizing the difficulty of the pannus as it falls away from the exposure.

**METHODS:** In our single-site prospective series of 710 XLIF patients, 367 were identified as obese (BMI>30) and 115 of those were morbidly obese (BMI > 38). Comorbidities, surgical details, hospital stay, complications, pain scores, changes in disk height and alignment, and fusion were assessed.

**RESULTS:** In all our XLIF patients, no surgery could not be successfully completed due to body habitus. The heaviest patient to date weighed 375 lbs (170.4 kgs); the largest BMI was 61.8 (avg 43.6, range 38.0-61.8). Age ranged from 22-78yrs. Comorbidities included smoking (36%), prior spine surgery(39%), diabetes (49%), CAD(52%), COPD(4%). 137 levels were treated in these 115 patients: 97 1-levels, 15 2-levels, 2 3-levels and 1 4-level; the majority at L4-5. All but 2 surgeries included supplemental fixation. There was one transfusion and one infection. Complications included one MI at 6 wks, one atrial fibrillation, pneumonia requiring intubation for 5 days, one other respiratory distress requiring re-intubation, one posterior hardware failure/rod fracture at 6 months, and one fracture of vertebral osteophytes requiring reoperation. Hospital stay averaged 1.28 days. From pre-op to 12 month follow-up: disk height increased an average 2.7mm; slip decreased an average 3.2mm in spondylolisthesis patients; and VAS pain scores decreased from 8.8 preop to 2.4 at 12 mos. Lenke scores were 2.1 at 3 months, 1.6 at 6 months, and 1.3 at 12 months.

**CONCLUSION:** Our results demonstrate the usefulness and safety of the XLIF technique in treating morbidly obese patients minimally invasively. Complications are minimal, procedures timely, and outcomes similar to non-obese patients.

### GP172. HEALTH-RELATED QUALITY OF LIFE IN SURGICALLY TREATED LUMBAR DISC HERNIATION PATIENTS -LONG-TERM FOLLOW-UP

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**INTRODUCTION:** To evaluate success of medical treatments using patients health related quality of life has gained an increased interest the last years. One reason for this is that it allows comparisons between different diagnosis. The aim of the present prospective long-term follow-up study was to investigate improvement of and the influence of preoperative factors on health-related quality of life after lumbar disc herniation surgery.

**METHODS:** One-hundred-seventeen patients surgically treated for lumbar disc herniation were included and evaluated with a self-completion HRQoL instrument (EQ-5D). Follow-up time was 2- and 5-10 years. Baseline data (gender, age and surgical level) and questionnaires about duration of leg pain were obtained preoperatively. The mean age was 39±11 years, 54 (46%) were women, 49 (42%) underwent surgery on L4-L5 level and 68 (58%) on L5-S1 level. 35% of the patients had <6 months duration of leg pain preoperatively, 32% 6-12 months and 33% >12 months respectively. 96 (82%) of the patients answered the EQ-5D questionnaire at the 2-year follow-up and 89 (76%) at the long-term follow-up.

**RESULTS:** The mean EQ-5D score improved significantly preoperatively from 0.12 to 0.69 (2- years) and to 0.74 at the long-term follow-up. Patients <45 year had a lower mean score preoperatively (0.09, n=81), compared to patients ≥ 45 year (0.19, n=36) p=0.003. There were no baselines factors that predicted a better HRQoL during the two follow-ups.

**DISCUSSION:** Most patients who underwent surgery for lumbar disc herniation reported improved HRQoL 2 year after surgery. The improvement seems to be stable even after 5-10 years. Age, gender and duration of symptom which are parameters previously described to predict a better outcome, did not predict a higher improvement in HRQoL. However, the HRQoL for this patient group did not reach the level of the general population at any of the follow-ups.

### **GP173. 10 YEAR FOLLOW UP OF ACROFLEX TOTAL DISC REPLACEMENT:OVERALL FAVOURABLE CLINICAL RESULTS DESPITE HIGH FAILURE RATE**

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**INTRODUCTION:** Acroflex Total Disc Replacement (TDR) was designed to reproduce the hydro-elastic nature of the normal healthy disc. Mechanical testing determined the elastomeric implant should survive for at least 10 years. However, a high rate of early mechanical failure occurred and it was removed from clinical use.

**METHODS:** 28 subjects with discogenic low back pain of at least 6 months duration with failure of non- surgical treatment underwent TDR. The VAS, Oswestry Disability Index (ODI), Low Back Outcome Score (LBOS) and SF-36 were completed for 23 out of 28 patients. All patients were invited to have an MRI scan and for those with the implant still in-situ, a CT scan.

**RESULTS:** At a mean of 9 years and 8 months (Range 8.64- 11.47 years) post index procedure, 11 of 28 subjects (39%) had been revised (7 for implant failure with osteolysis). Outcome data was obtained from 23 patients (9 revised, 14 disc replacement in-situ). For revision cases the mean ODI had improved by 7.5 % to a value of  $41.8 \% \pm 22.6$ . and the mean LBOS had improved by 11.6 to a value of  $29.3 \pm 19.5$ . For the non- revision cases, ODI improved by 21.8% to a value of  $27.5 \% \pm 17.6$  and LBOS by 24.1 to a value of  $41.8 \pm 18.4$ . CT scans at 10 years showed no significant changes in implant integrity and position in comparison to 2 years. MRI revealed a lower incidence of adjacent degeneration in patients converted to fusion.

**CONCLUSION:** This study has demonstrated a less favourable outcome after revision surgery for failed TDR. Despite this the overall functional outcomes for AcroFlex patients were comparable to that reported after ALIF. The AcroFlex experience highlights the importance of reliable pre-clinical mechanical testing and careful pilot studies prior to release of new implants.

## GENERAL POSTERS

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### **GP174. RETROSPECTIVE COMPARATIVE ANALYSIS OF DEGENERATIVE LUMBAR SPONDYLOLISTHESIS TREATED WITH POSTEROLATERAL FUSION (PLF) WITH BONE MORPHOGENIC PROTEIN (BMP) 2 WITH OR WITHOUT ADDITIONAL TRANSFORAMINAL LUMBAR INTERBODY FUSION (TLIF)**

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**INTRODUCTION:** Although the indications and aims of surgical management for Degenerative Spondylolisthesis (DS) are well defined, the surgical approach that should be used is still somewhat controversial. Higher fusion rates associated with the use of BMP may improve the clinical efficacy of PLF potentially making it comparable to TLIF. We aim to evaluate and compare the outcomes of treating DS with surgical decompression and PLF to TLIF with the supplemental use of BMP7 in each group.

**METHODS:** A retrospective study of all patients operated for grade I or II Degenerative Spondylolisthesis between January 2004 and December 2007 by the senior author (RW) was carried out.

The patients were divided into two groups. Group 1 consisted of 27 patients who were treated by decompression and PLF and group 2 consisted of 40 patients treated with decompression and TLIF and PLF. All patients were evaluated clinically (Oswestry disability index) and radiologically (x-rays) pre operatively and at 3 and 6 months follow up. Results were analysed using t test for means and z test for proportions.

**RESULTS:** Use of BMP 7 in every case yielded high fusion rates of 97.5% in PLF and 100% in TLIF/PLF groups.

The improvement in ODI was 37% and 35% at three and six months follow up respectively in PLF group and 52% and 60% at three and six month follow up respectively in the TLIF/PLF group. The difference in improvement between groups was found to be statistically significant at six months follow up ( $p=0.015$ ).

There was no significant difference ( $p=0.34$ , z test) in the overall complication rate (follow up > 2yrs). No significant difference ( $p=0.27$ , z test) seen in adjacent level degeneration requiring treatment between the two groups.

**DISCUSSION:** Although the fusion rates were similar, a significantly better outcome was noticed in the TLIF group.

### **GP175. CLINICAL AND RADIOLOGICAL FUSION RATES FOLLOWING TRANSFORAMINAL LUMBAR INTERBODY FUSION (TLIF) WITH SILICATE SUBSTITUTED CALCIUM-PHOSPHATE BONE GRAFT SUBSTITUTE WITHOUT ICBG FOR THE SURGICAL TREATMENT OF DEGENERATIVE LUMBAR SPINE DISEASE.**

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**INTRODUCTION:** The effectiveness of commercially available ceramic bone graft substitutes may be comparable to iliac crest bone graft (ICBG), without the additional morbidity. This study reviews the one-year clinical and radiographic fusion rates for patients with degenerative disk disease or spondylolisthesis of the lumbar spine who have undergone TLIF utilizing silicate substituted calcium-phosphate bone graft substitute (BGS) (Actifuse™, ApaTech Ltd.).

**METHODS:** This IRB approved study reviewed 25 consecutive patients who underwent decompressive surgery with transforaminal lumbar interbody fusion with instrumentation between April 2007 and June 2008 by a single surgeon (AL). Silicate substituted calcium-phosphate granules mixed with local autograft was placed in the disc space. Medical records were reviewed for demographic and clinical information. Radiographic imaging, SF-36 and Oswestry were completed at each pre- and post-operative visit.

**RESULTS:** Twenty-four patients, mean age 42 years, 42% female, were available for follow-up (avg. 14.4 months). 45% had both DDD and spondylolisthesis, 35% had DDD, 20% spondylolisthesis. 50% had one level fused and 50% had two levels fused. Average VAS, function, and SF-36 PCS improved at 6 months and one year (VAS-7.3 to 4.9 to 4.0, function-2.9 to 3.4 to 3.4, SF-36 PCS-31 to 33 to 38).

18/24 patients had CT scans (avg. 9.6 months), while 6 had flexion extension films. 100% of the CT scans and x-rays demonstrated bridging bone. There were 2 cases of loosening and no cases of pseudarthrosis.

**DISCUSSION:** This study confirms that the use of silicate substituted calcium-phosphate synthetic bone graft substitute mixed with local autograft is an excellent alternative to ICBG for transforaminal interbody fusion. The clinical results at 6 months and one year with respect to VAS, function, SF-36 and Oswestry are highly encouraging. Also, all of the radiologic imaging supports the clinical picture of solid fusion.

## GENERAL POSTERS

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### GP176. HYBRID COMBINED TOTAL DISC REPLACEMENT AND FUSION PROCEDURES IN THE LUMBAR SPINE: CLINICAL AND RADIOGRAPHIC OUTCOME

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**INTRODUCTION:** Traditionally the treatment for painful disc degeneration has been fusion. With multi-level disc disease this may be less desirable due the potential for reduced fusion rates and increased risk of adjacent segment deterioration. While total disc replacement (TDR) is not applicable to all discs, the combination of TDR at some levels and fusion at others, may be a viable alternative. This combined, or hybrid, procedure has been investigated in biomechanical studies; however, there have been no clinical studies reporting specifically on this surgery. The purpose of this study was to determine the clinical and radiographic outcomes of hybrid surgery.

**METHODS:** Data were collected retrospectively from charts and radiographs for the first 50 consecutive patients from one center who, in a single operative setting, underwent lumbar fusion (anterior, posterior, or combined), and TDR. The majority of cases had a TDR at L4-5 and fusion at L5-1. All radiographs were scored by a single evaluator. The mean length of follow-up was 18.0 months.

**RESULTS:** Back and leg pain, assessed by visual analog scales (VAS), as well as Oswestry scores improved significantly (see table, all  $p < 0.01$ ). The mean range of motion of the TDR level was 6.4 degrees.

	Pre-op	Post-op
VAS back pain	7.2	4.4*
VAS leg pain	4.8	3.0*
Oswestry	53.6	36.8*

\* $p < 0.01$

The re-operation rate was 8.0% (two underwent posterior instrumentation removal, one had posterior instrumentation at the TDR level, and the other had TDR removal due to migration).

**CONCLUSION:** Results of this study clinically support the hybrid combination of TDR and fusion as a viable treatment option for patients with symptomatic disc degeneration at more than one level. Prospective randomized studies are needed to determine how well this treatment option compares to either TDR or fusion alone for patients with multi-level disc degeneration.

### **GP177. HOW DOES SPINAL SURGERY AFFECT THE BRAIN'S CONTROL OF THE TRUNK AND LEGS?**

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**INTRODUCTION:** Changes in the central nervous system (CNS) pathways controlling trunk and leg muscles in patients with low back pain and sciatica have been observed this study investigated whether surgery impacts upon these changes.

**METHODS:** Parameters of corticospinal control were examined on 3 occasions in 19 patients prior to, at 6 and 26 weeks following lumbar decompression surgery and in 12 control subjects at the same intervals. Electromyographic activity was recorded from tibialis anterior (TA), soleus (SOL), rectus abdominis (RA), external oblique (EO) and erector spinae (ES) muscles at the T12 & L4 levels in response to transcranial magnetic stimulation of the motor cortex.

**RESULTS:** In the surgical group asymmetries in the size of motor evoked potentials (MEPs) in TA ( $P=0.006$ ) and in the cortical silent periods (cSP) were found between the left and right sides in SOL ( $P=0.010$ ) and ES at L4 ( $P=0.019$ ) prior to surgery. This was not observed at 6 or 26 weeks. Abdominal responses could be evoked in 12 patients and there was a significant reduction in the cSP contralateral to the pain in EO ( $P=0.034$ ) and RA ( $P=0.041$ ) at 6 weeks. These parameters remained stable in controls over time.

**DISCUSSION:** The changes in asymmetry of CNS control are clearly influenced by the surgery. It is of interest that these changes stabilise at 6 weeks; this parallels clinical outcome studies. Current work is ongoing to examine to what extent these changes are related to clinical outcome.

## GENERAL POSTERS

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### **GP178. ANALYSIS OF ADJACENT SEGMENT RE-OPERATION FOLLOWING LUMBAR TOTAL DISC REPLACEMENT**

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**INTRODUCTION:** Arthrodesis has long been used for treating axial back pain. However, development of adjacent segment disease requiring reoperation has become a concern. Lumbar total disc arthroplasty (TDR) has been proposed as a method for addressing back pain and preventing or reducing adjacent segment disease. The purpose of this study was to determine the reoperation rate of at the level adjacent to a level implanted with a TDR and to analyze the pre-operative condition of that segment.

**METHODS:** A consecutive series of 1000 patients from one center, beginning with first case experience, who underwent TDR were reviewed and those who underwent re-operation at the level adjacent to the TDR were analyzed. Pre-TDR radiographs, including plain film flexion/extension X-rays, MRI, and CT were evaluated to assess preexisting pathology. MRI evaluation of the adjacent disc was performed using a classification system of normal, moderate, or severe. CT evaluation of the facet joints was performed using a 0 to 4 grading system (Pathria et al).

**RESULTS:** Twenty one (2.1%) of the 1000 arthroplasty patients underwent reoperation secondary to adjacent segment disease. The mean length of time from TDR to re-operation was 28.3 months. Of the adjacent segments evaluated on pre-operative MRI, 38.8% were normal, 38.8% were moderately diseased, and four 22.2% had evidence of advanced degeneration. Preoperative CT was available for 15 patients with a total of 21 facet levels assessed. Twelve (57%) facet levels were normal (grade 0), seven (33.3%) grade 1, and two (9.5%) grade 2. There were no levels graded 3 or 4 (severe).

**CONCLUSIONS:** The rate of adjacent segment disease requiring reoperation (2.1%) compared favorably to that reported secondary to fusion. Further evaluation of those undergoing reoperation indicated many patients had some indications of degeneration at the reoperated adjacent segment prior to the original arthroplasty procedure.



### GP179. DOES THE FUSION LEVEL INFLUENCE THE OUTCOME OF SINGLE-LEVEL POSTERIOR LUMBAR FUSION FOR DEGENERATIVE DISEASE?

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**INTRODUCTION:** The lumbosacral junction is considered to represent a precarious region of the lumbar spine and it might be expected that the patient-rated outcome of fusion at this level would be worse than that for a single-level fusion higher up the lumbar spine. However, to our knowledge, this has not been investigated in detail before. This study sought to examine the outcome of monosegmental lumbar fusion at L4/5 compared with L5/S1.

**METHODS:** The Eurospine-SSE Spine Tango system was used to acquire the data from 143 patients, operated since 2005 (L4/5 N=82, L5/S1 N=61). Inclusion criteria were first-time surgery, monosegmental lumbar degenerative disease (disc and/or facet joint degeneration, low-grade spondylolisthesis), undergoing lumbar fusion from a posterior approach, and with 12 months' follow-up. Before and 12 months after surgery, patients completed the multidimensional Core Outcome Measures Index (COMI: back and leg pain, function, quality of life, and disability); at 12 months, global outcome was rated on a Likert-scale and dichotomised into "good" and "poor" groups.

**RESULTS:** Similar surgical techniques were used at both levels. At baseline, back pain was slightly but not significantly ( $p=0.12$ ) higher in the L5/S1 group. The groups did not differ significantly in their reduction in back pain, leg pain or COMI score ( $p>0.05$ ) or in the % good global outcome (84% in the L4/5 group, 77% in the L5/S1 group;  $p=0.28$ ); satisfaction was also similar in both groups (91% vs 87% respectively,  $p=0.38$ ).

**CONCLUSION:**

Our hypothesis that fusion of L5/S1 from a posterior approach would be associated with worse outcomes due to its peculiar anatomy was not confirmed. Patients benefited equally well from lumbar fusion regardless of whether it was performed at the L4/5 or L5/S1 level.

### GP180. THE INFLUENCE OF SEGMENTAL SAGITTAL ALIGNMENT ON THE DEVELOPMENT OF ADJACENT SEGMENT DISEASE AFTER SPINAL FUSION SURGERY

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1 These authors contributed equally to this work

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**INTRODUCTION:** The purpose of the study is to report the effect of one and two level lumbar fusion surgery on segmental lordosis across the fused segments, on regional lordosis on the lumbar spine, and on rates of adjacent segment degeneration.

**METHODS:** Retrospective study design of a cohort of patients treated with one or two level lumbar fusions for degenerative pathologies. Radiographs were obtained before surgery, immediate postoperatively and at the last follow-up. Outcome variables were post-operative segmental lordosis at the fused levels, regional lumbar lordosis, radiographic measures of adjacent segment degeneration including disc height, UCLA score, and surluxation.

**RESULTS:** 118 patients with 81 patients with a single level fusion, and 37 patients with 2 level fusion. Group A included 71 patients with posterolateral fusion, and Group B included 47 patients with a circumferential fusion. The follow up averaged 19.8 months, in 71% of patients with follow-up radiographs more than 12 months postoperatively. Lumbar lordosis (T12-S1) of all patients was  $-51.7 \pm 15.6^\circ$  preoperatively,  $-51.3 \pm 15.2^\circ$  postoperatively and  $-55.1 \pm 11.8^\circ$  at follow-up. The increase of lumbar lordosis at follow-up was statistically significant ( $p < 0.05$ ). The highest segmental change occurred proximal to the fused level, with a mean increase of lordosis of  $2.0^\circ$  compared with pre-op. The intervertebral disc at the adjacent segment did not change significantly. The segmental lordosis across the fused level increased by  $1.8^\circ$  (group A) and by  $2.4^\circ$  (group B).

**DISCUSSION:** Sagittal alignment changes after lumbar fusion, and increase in segmental lordosis is more reliable with circumferential arthrodesis. This study demonstrates a measurable reduction in disc height above the fused levels beyond 1 year after surgery. There is no association between degeneration and sagittal balance. Longer follow-up and clinical outcomes including need for revision surgery will lend further insight into the significance of segmental alignment in short lumbar fusions.

### GP181. COMPUTER-ASSISTED SPINAL OSTEOTOMY: A TECHNICAL NOTE AND REPORT OF FOUR CASES

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**INTRODUCTION:** A computer-assisted navigation system provides accurate 3-dimensional (3-D) real-time surgical information during the operation. Although there are many reports on the accuracy and usefulness of a navigation system for pedicle screw placement, there are few reports on the application for spinal osteotomy. The objective of this study is to document the surgical technique and usefulness of computer-assisted surgery for spinal osteotomy.

**MATERIALS AND METHODS:** We report on 4 complex cases including 3 solitary malignant spinal tumors and 1 spinal kyphotic deformity of ankylosing spondylitis, which were treated surgically using a computer-assisted spinal osteotomy. The surgical technique and postoperative clinical and radiological results are presented.

**RESULTS:** 3-D spinal osteotomy under the guidance of a computer-assisted navigation system was performed successfully in the 4 patients. All malignant tumors were resected en bloc, and the spinal deformity was corrected precisely according to the preoperative plan. Pathological analysis confirmed the en bloc resection without tumor exposure in all 3 patients with a spinal tumor.

**DISCUSSION:** Spinal osteotomy is a complex surgery involving the wide resection of a malignant tumor en bloc or correction of a fixed spinal deformity. The problems for conventional spinal osteotomy include the blind maneuver around the spinal cord, nerve root, and major vessels, and the potential for incorrect or insufficient osteotomy, tumor exposure during incorrect osteotomy, insufficient correction of a spinal deformity, and nonunion after the corrective osteotomy. Four complex spinal diseases were treated successfully using spinal osteotomy under the guidance of a computer-assisted navigation system. This navigation system provided real-time anatomical information to the surgeon about the precise location and 3-D orientation during the osteotomy surgery.

## GENERAL POSTERS

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### **GP182. LUMBAR DESTRUCTIVE SPONDYLOARTHROPATHY - RESULTS OF SURGICAL TREATMENTS WITH SIMPLE DECOMPRESSION, RIGID FIXATION, AND FLEXIBLE STABILIZATION**

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**INTRODUCTION:** Dialysis-associated-spondylosis of the lumbar spine is a serious complication of long-term hemodialysis. It causes severe canal stenosis, instability of the spine, and other degenerative changes. Results of spinal flexible stabilization with sublaminar-wiring (GroupS) was compared to simple decompression (GroupD) and ordinary rigid fixation with instrumentation (GroupR).

**METHODS:** This investigation covered GroupD of 8 patients, GroupR of 10, and GroupS of 13. All patients had an operation at Japanese Red Cross Medical Center. Patients were followed up for at least 24 months after surgery, those mean were 86.2(48-128), 32.8(24-45), and 35.5(24-48) months. Mean age were 53.1(33-62), 62.0(56-71), and 60.3(49-77) yrs. Mean duration of hemodialysis were 18.8(12-25), 19.0(9-27), and 18.1(1-29) years at surgery. Symptoms and X-ray findings were investigated before surgery, at one year after surgery, and at the end of the follow-up period. We evaluated symptoms by JOA score without ADL and bladder function.

**RESULTS:** At one year after surgery, those JOA recovery rates of GroupD (71.8%) and GroupR (87.6%) were better than GroupS (44.0%). However, at the end of the follow-up period, GroupD (24.4%) and GroupR (46.1%) became worse than GroupS(53.0%). Observed findings without symptoms were mild spinal instability in 2/8 of GroupD, 2/10 of GroupR and 5/13 of GroupS. There were 3/10 of GroupD and 5/10 of GroupR, because of re-stenosis, instability, and instrument failures. But there was only one case of re-operation of GroupS.

**DISCUSSION:** Surgical treatment for dialysis-associated-spondylosis of the lumbar spine remains controversial. Long-term results of simple decompression are not satisfactory due to advancement of spinal instability. However, rigid fusion with instrumentation is also not satisfactory due to instrumentation failure and additional spinal involvement at adjacent levels. Sublaminar-wiring could stabilize the lumbar spine for patients with Dialysis-associated-spondylosis, resulting in good clinical results. This method has the potential to become the first choice surgical treatment for Dialysis-associated-spondylosis of the lumbar spine.

### GP183. THE CLINICAL STUDY ON THE UNILATERAL PEDICLE SCREW FIXATION IN LUMBAR SPINAL FUSION

Jie ZHAO

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**INTRODUCTION:** Although the technique of bilateral pedicle screw fixation with single or double cages was usually used in the lumbar spinal fusion, the unilateral pedicle screw fixation with single cage was also used. This study is carried out to determine the efficiency and safety of the unilateral pedicle screw fixation with single cage in the lumbar spinal fusion.

**METHODS:** A retrospective study of 60 patients (41 male and 19 female) with the mean age of 67.5 years old (range from 51 to 76 years) who underwent unilateral (n=27) or bilateral (n=33) pedicle screw fixation with single cage in the lumbar interbody fusion from January 2007 to January 2008. Operating time, blood loss, duration of hospital stay, clinical outcomes, fusion rates, complication rates, VAS immediately after the operation and medical expenses were studied and compared.

**RESULTS:** There were no significant differences between the two groups in clinically satisfactory results, fusion rate, and complication rate. Compared with the group of bilateral pedicle screw fixation, there were significant decrease in duration of operating time, duration of hospital stay, blood loss, VAS immediately after the operation and medical expenses in the group of unilateral pedicle screw ( $P < 0.001$ ).

**DISCUSSION:** Unilateral pedicle screw fixation with single cage was as effective as bilateral pedicle screw fixation with single cage in lumbar spinal fusion. It was feasible and effective to employ the unilateral fixation in the lumbar spinal fusion.

## GENERAL POSTERS

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### GP184. COMPARISON OF KYPHOPLASTY AND LORDOPLASTY FOR THE TREATMENT OF OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURE

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**INTRODUCTION:** Kyphoplasty and lordoplasty have been designed to address the kyphotic deformity and help to realign the spine. Restoration of vertebral body height and kyphosis correction is achieved in both procedures. The purpose of this study is to compare restoration of vertebral height, improvement of wedge and kyphotic angle, and the incidence of complications in osteoporotic compression fracture between kyphoplasty and lordoplasty.

**MATERIAL AND METHODS:** Between 2004 and 2009, patients with osteoporotic vertebral compression fractures were treated by kyphoplasty (n = 24) or lordoplasty (n = 12) using PMMA cement, and the results of the two interventions were compared prospectively. Visual analogue scales were used to measure the pain status. Preoperative and postoperative radiographs were analyzed to quantify anterior vertebral height restoration, and wedge and kyphotic angle correction. The presence of cement leakage and adjacent fracture were also examined.

**RESULTS:** All patients in both groups reported significant pain reduction. The anterior heights increased 24.2 percent and 17.5 percent after lordoplasty and kyphoplasty procedures, respectively (p<0.05). The reduction loss of anterior vertebral height was larger for kyphoplasty group (12.8 percent) compared to lordoplasty group (6.3 percent) 3 months after the procedures (p<0.05). The wedge angles decreased significantly after both procedures. Only the wedge angle in lordoplasty maintained the value after 3 months (p<0.05). The kyphotic angular correction was 11.4 and 7.0 degrees after lordoplasty and kyphoplasty procedures, respectively (p<0.05). Kyphotic deformities became worse about similar amount of 5 degrees after 3 months in both groups. There were no statistically significant differences in cement leakage and adjacent fracture. Lordoplasty was cost-effective compared to kyphoplasty by 2.4 times (1525 US \$ vs 3644 US \$).

**CONCLUSION:** Lordoplasty is more useful compared to kyphoplasty in terms of increased anatomic restoration, increased postoperative maintenance and cost-effectiveness.

14-1

### CONVERSION TO HYPERTROPHIC VERTEBRAL PSEUDARTHROSIS FOLLOWING PERCUTANEOUS VERTEBROPLASTY

Satoshi Kawaguchi, Keiko Horigome, Hideki Yajima, Takashi Oda, Yuichiro Kii, Mitsunori Yoshimoto\*, Tsuneo Takebayashi\* Toshihiko Yamashita\*

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**INTRODUCTION:** Vertebral pseudarthrosis is a relatively rare, painful condition characterized by vertebral collapse and intravertebral mobile cleft. A variety of surgical procedures have been reported for the treatment of this condition. Whereas osteosynthesis and fusion surgeries aim at bone union, no studies have so far evaluated the union status of patients following percutaneous vertebroplasty (PVP).

**METHODS:** Between January 2006 and June 2008, 14 patients with vertebral pseudarthrosis were treated with PVP and analyzed for clinical and radiographic outcomes with an average follow-up duration of 22 months. Evaluation methods included back pain (VAS), complications, wedge angle, dynamic mobility, radiographic remodeling including callus and spur formation, and union status. VAS score, wedge angle, and vertebral mobility were determined before surgery, at the final follow-up. The Student t-test was used for statistical analysis and a probability of less than 0.05 was determined as a significant difference.

**RESULTS:** Back pain improved in all 14 patients with a VAS score of 57.8 +/-23.5 mm preoperatively and 14.7 +/-16.4 mm at the final follow-up. Complications included paravertebral cement leakage in 3 patients and fracture of the adjacent vertebra in one patient. The wedge angle decreased from 21.6 +/- 8.3 degrees preoperatively to 13.2 +/- 6.9 degrees at the final follow-up. Callus formation was seen in four patients. Bony spurs were seen in the affected vertebra in preoperative radiographs in all patients, and were further developed to a solidified form during follow up after PVP. Dynamic mobility of the affected vertebrae was 6.9 +/- 2.9 mm preoperatively, which decreased to 1.1 +/- 0.7 degrees at the final follow-up. Nevertheless, only two patients exhibited the dynamic vertebral mobility of 0mm (bone union) at the final follow-up.

**DISCUSSION:** These findings indicate that PVP serves as a dynamic stabilizer for vertebral pseudarthrosis and converts the status of pseudarthrosis from atrophic to hypertrophic.

### **GP186. ENDOSCOPIC VERTEBROPLASTY WITHOUT INSTRUMENTATION FOR INSUFFICIENT BONE UNION WITH NEUROLOGICAL DEFICIT FOLLOWING OSTEOPOROTIC VERTEBRAL FRACTURE**

Akinobu Suzuki, Tadao Tsujio, Masatoshi Hoshino, Hidetomi Terai, Hiromitsu Toyoda Tomiya Matsumoto, Hiroyuki Yasuda, Shinji Takahashi, Hiroaki Nakamura, Osaka, Japan

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**INTRODUCTION:** Insufficient bone union or nonunion following osteoporotic vertebral fracture (OVF) can cause intractable back pain and neurological deficit in elderly patients. Surgical treatment is usually required for patients with neurological deficit. However, invasive surgery is not a preferable option considering the age and comorbidities of elderly patients. We developed a vertebroplasty method that creates a sufficient cavity by carrying out curettage of fibrous and necrotic tissue in the vertebral body under endoscopic observation, followed by injection of calcium phosphate cement (CPC). This facilitates safe treatment, even for insufficient bone union following OVF with posterior wall injury. We report the outcome of endoscopic vertebroplasty for insufficient bone union following OVF with neurological deficit.

**METHODS:** Fifteen vertebrae of 13 patients with severe back pain and neurological deficit from OVF underwent endoscopic vertebroplasty using CPC in our institution from 2003 to 2008. Visual analogue scale of back pain, ambulatory function and neurological function were evaluated at pre- and postoperative selected time points. Sagittal wedging angle (SWA) and percentage vertebral body height (VBH) of the affected vertebra were also evaluated on plain X-rays. The percentage of canal occlusion was evaluated on sagittal CT images.

**RESULTS:** The mean VAS of back pain significantly improved from 76.5 preoperatively to 18.7 postoperatively, and was 27.3 at latest follow-up. Six patients were bedridden before surgery, but all became ambulatory after surgery. The mean percentage of VBH significantly increased and the mean SWA decreased after operation. Although the percentage of canal occlusion was almost unchanged after surgery, neurological improvements were observed in all patients.

**DISCUSSION:** The present study demonstrated that endoscopic vertebroplasty without instrumentation is a treatment option even for patients with neurological deficits resulting from insufficient bone union following OVF. Correction of intravertebral instability, rather than decompression, facilitated neurological improvement.



### GP187. DELAYED-ONSET PARALYSIS AND ITS ANATOMIC CAUSE FOLLOWING OSTEOPOROTIC VERTEBRAL FRACTURE

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**INTRODUCTION:** Delayed-onset paralysis following osteoporotic vertebral fracture has been well recognized. It is generally believed that most of cases are caused by burst fracture. However, carefully following cases, some cases showed delayed-onset paralysis without middle column injury. The purpose of this study was to clarify the anatomic cause of delayed-onset paralysis following osteoporotic vertebral fracture.

**METHODS:** Forty-six patients (male 9, female 37) were assessed. The average age was 70yo. Paralysis was divided for three types; myelopathy (31cases), cauda equina type (2 cases) and radiculopathy (13 cases). Cause of paralysis was considered by image findings including lateral position of roentgenogram (flexion, extension, neutral), CT, MRI and operative findings if operation was performed.

**RESULTS:** Cause of paralysis was mainly divided four types, burst fracture type (28 cases), wedge type (8 cases), flat type (4 cases), hypermobility type (3cases), and others (3 cases). Burst fracture type was judged as vertebral collapse and severe middle column injury. This type showed that neural tissue was compressed by posterior wall of vertebra. Wedge type was judged as no or minimum middle column injury and relatively stable fractured vertebra. This type showed that neural tissue was compressed by both posterior edge of fractured vertebra and posterior elements (flavum and/or facet joint) (Kaji, 1998). Flat type was judged as vertebral collapse but minimum middle column injury. This type showed that neural tissue was compressed by buckling of flavum and facet joint similar to degenerative spinal canal stenosis. Hypermobility type was judged as no or minimum middle column injury and severe unstable fractured vertebra. This type showed that MRI could not detect neural tissue compression.

**DISCUSSION:** There are several types of the anatomic cause of delayed-onset paralysis following osteoporotic vertebral fracture. It seems to be important to assess the anatomic cause for choice of operation procedure.

## GENERAL POSTERS

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### **GP188. TREATMENT OF SPINAL DISCITIS AND VERTEBRAL BODY OSTEOMYELITIS – ARE CURRENT TREATMENT GUIDELINES FOLLOWED?**

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**INTRODUCTION:** Medical management of spinal discitis and vertebral osteomyelitis is based on pathogen specific antibiotic therapy. Current guidelines recommend biopsy and culture prior to initiating antibiotics. Our objective was to evaluate whether current treatment guidelines are being followed.

**METHODS:** We retrospectively reviewed the hospital records at our institution from 2002-2007 of all patients admitted with the diagnosis of discitis or vertebral osteomyelitis (ICD-9 722.90 - 722.93). Exclusion criteria included patients with a spinal fluid collection causing symptomatic neurologic compression and patients with bacteremic sepsis.

**RESULTS:** 39 patients (59 years, 22 Male/ 17 Female) were reviewed. Risk factors were identified in 30 patients (79%), most commonly: diabetes (38%), IVDA (20%), and ESRD (13%). The mean duration of symptoms prior to admission was 27 days (range, 3-120 days). Infection was localized to the cervical (13%), thoracic (15%), and lumbar/sacral regions (72%). Antibiotics were started a mean of 27 hours (range, 0-198 hours) after admission. 14 patients (36%) received antibiotics within 4 hours of admission and 13 patients (33%) received antibiotics prior to obtaining a diagnostic spinal MRI. Biopsy and culture was performed in 20 patients (51%) with 11 (55%) performed after antibiotic administration. Biopsies were not performed in 19 patients (49%), with 14 biopsies not performed secondary to the prior initiation of antibiotics. Overall, 25 patients (64%) were not treated according to treatment guidelines. Specific bacterial pathogens were cultured in 9 biopsies (45%), of which 6 (67%) had antibiotics held until biopsy completion. Biopsies performed after antibiotics identified pathogens in only 3 (27%).

**DISCUSSION:** 25 patients (64 %) treated at our institution for spinal discitis and vertebral osteomyelitis were not treated according to recommended guidelines. Surprisingly, 13 patients (33%) received empiric antibiotics secondary to fever and spine pain without a confirmatory diagnosis of spinal infection. Physician education is imperative regarding the proper management of this disease.

### GP189. EXISTENCE OF PYOGENIC SPONDYLITIS IN MODIC TYPE 1 CHANGE WITHOUT OTHER SIGNS OF INFECTION – 2 YEAR FOLLOW-UP

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**INTRODUCTION:** The relationship of Modic change to pain and inflammation remains unclear. Recently, some authors have reported that Modic type 1 signals are closely related to infection. However, if the patients do not have severe back pain, fever, or an abnormal blood profile, it is difficult to distinguish between common Modic change and infection. The purpose of this study was to examine the prevalence of pyogenic spondylitis in patients who showed Modic type 1 change without other signs of infection.

**METHODS:** Seventy-one patients with Modic type 1 change were evaluated (average age 55; 32 male and 39 female). X-ray and magnetic resonance imaging were performed to investigate low-back and leg pain. Body temperature was measured and blood analysis (including white blood cell count and level of C-reactive protein) was conducted for all patients. All 71 patients with Modic type 1 change but without other signs of infection were followed for 2 years. Low-back pain, X-ray, and blood analyses were performed every 3 months; and magnetic resonance imaging every year.

**RESULTS:** Severe low-back pain or abnormal signs developed in five patients during the follow-up. Pyogenic spondylitis was diagnosed in three patients by symptoms, blood results, and imaging, and confirmed by biopsy. Two of the three patients were diabetic.

**DISCUSSION:** A total of 4.2% of patients with Modic type 1 change, but without other signs of infection were diagnosed as having pyogenic spondylitis during the 2-year follow-up, so it is important to consider this before treating Modic type 1 change.

## GENERAL POSTERS

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### **GP 190. NANOPOROUS SILICON PARTICLES (NSP) AS A CHEMOTHERAPEUTIC DELIVERY SYSTEM FOR THE TREATMENT OF SPINAL METASTASES.**

Chris Loo, Bradley K. Weiner, Ennio Tasciotti, Mauro Ferrari, Harvey Smith, Houston, TX, USA

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**OBJECTIVE:** To assess the potential use of Nanoporous Silicon Particles (NSP) as a chemotherapeutic delivery system for the treatment of spinal metastases.

**METHODS:** NSP were loaded with methotrexate and, separately, with doxyrubicin; and coated with different biodegradable polymers to control release and to afford triggering under specific conditions. The in vitro release of drugs was monitored by measuring absorbance at 304nm using a UV-Vis spectrophotometer. MDA-MB-231 (breast cancer) cells were used for in vitro cytotoxicity studies in the presence of drug-loaded NSPs. MTT assay as well as fluorescent and confocal microscopy were performed to characterize the effect of the delivery system on cancer cell growth.

**RESULTS:** We successfully demonstrated the ability (1) to load various  $\mu\text{g}$  of drug per  $\mu\text{m}^2$  amounts of methotrexate and doxyrubicin into NSP (1 to 3  $6 \times 10^6$  NSP); (2) to create polymer coatings affording a tunable and sustained release of chemotherapeutic drugs; (3) to demonstrate significant cytotoxicity of loaded particles to breast cancer cells in vitro compared to controls.

**CONCLUSIONS:** We developed a delivery system based on biodegradable, biocompatible NSP loaded with methotrexate/ doxyrubicin. The release of drugs is controlled through appropriate tailoring of surface chemistries. Administered to cancer cells in vitro, this delivery system induced significant cytotoxicity and, when coupled with direct or targeted delivery to vertebrae, shows therapeutic potential for the treatment of spinal metastases while minimizing toxic side effects.

### GP191. NANOPOROUS SILICON PARTICLES (NSP) AS A DELIVERY SYSTEM FOR THE TREATMENT OF SPINAL INFECTIONS

Chris Loo, Bradley K. Weiner, Ennio Tasciotti, Mauro Ferrari, Harvey Smith, Houston, TX, USA

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**OBJECTIVE:** To assess the potential use of Nanoporous Silicon Particles (NSP) as a delivery system for the treatment of spinal infections.

**METHODS:** NSP were loaded with cefazolin and, separately, with clindamycin; and coated with different biodegradable polymers to control release and to afford triggering under specific conditions. The in vitro release of drugs was monitored by measuring absorbance at 304nm using a UV-Vis spectrophotometer. Staphylococcus Aureus colonies were used for in vitro cytotoxicity studies in the presence of drug-loaded NSPs. MTT assay as well as fluorescent and confocal microscopy were performed to characterize the effect of the delivery system on bacterial cell growth.

**RESULTS:** We successfully demonstrated the ability (1) to load various g of drug per  $\mu$ amounts of cefazolin and clindamycin into NSP (1 to 3  $6 \times 10^6$  NSP); (2) to create polymer coatings affording a tunable and sustained release of chemotherapeutic drugs; (3) to demonstrate significant cytotoxicity of loaded particles to staph aureus in vitro compared to controls.

**CONCLUSIONS:** We developed a delivery system based on biodegradable, biocompatible NSP loaded with cefazolin / clindamycin. The release of drugs is controlled through appropriate tailoring of surface chemistries. Administered to staph aureus in vitro, this delivery system induced significant bacterial kill and, when coupled with direct or targeted delivery to bone, shows therapeutic potential for the treatment and / or prevention of spinal infections.

## GENERAL POSTERS

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### **GP192. A NOVEL CLASSIFICATION SYSTEM FOR SPINAL INSTABILITY IN NEOPLASTIC DISEASE: AN EVIDENCE BASED APPROACH AND EXPERT CONSENSUS FROM THE SPINE ONCOLOGY STUDY GROUP**

Charles G. Fisher; Christian P. DiPaola; Timothy C. Ryken, Mark H. Bilsky, Timothy R. Kuklo, James S. Harrop, Michael G. Fehlings, Stefano Boriani, Dean Chou, Meic H. Schmidt, David W. Polly, Sigurd H. Berven, Roberto Biagini, Shane Burch, Mark B. Dekutoski, Aruna Ganju, Peter C. Gerszten, Ziya L. Gokaslan, Michael W. Groff, Norbert J. Liebsch, Ehud Mendel, Scott H. Okuno, Shreyaskumar Patel, Laurence D. Rhines, Peter S. Rose, Daniel M. Sciubba, Christopher I. Shaffrey, Narayan Sundaresan, Katsuro Tomita, Peter P. Varga, Luiz R. Vialle, Frank D. Vrionis, Yoshiya Yamada and Daryl R. Fourney, Worcester, Massachusetts, USA

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**INTRODUCTION:** Presently there is a lack of guidelines available to aid in defining the degree of spinal instability in the setting of neoplastic disease. The concept of spinal instability remains important in the clinical decision-making process for patients with spine tumors. The objective of this study is to use an evidence-based medicine process using the best available literature and expert opinion consensus to develop a comprehensive classification system to diagnose neoplastic spinal instability.

**METHODS:** We have integrated the evidence provided by systematic reviews through a modified Delphi technique to generate a consensus of best evidence and expert opinion from the Spine Oncology Study Group (an international group of experts dedicated to the study and care of spine oncology patients) to develop a classification system to define neoplastic spinal instability.

**RESULTS:** A comprehensive classification system based on patient symptoms and radiographic criteria of the spine was developed to aid in predicting spine stability of neoplastic lesions. The classification system includes global spinal location of the tumor, type and presence of pain, bone lesion quality, spinal alignment, extent of vertebral body collapse, and posterolateral spinal element involvement. Qualitative scores were assigned based on relative importance of particular factors gleaned from the literature and refined by expert consensus.

**DISCUSSION:** The Spine Instability Neoplastic Score (SINS) is a comprehensive classification system with content validity that can guide clinicians in identifying when patients with neoplastic disease of the spine may benefit from surgical consultation. It can also aid surgeons in assessing the key components of spinal instability due to neoplasia and may become a prognostic tool for surgical decision making when put in context with other key elements such as neurological symptoms, extent of disease, prognosis, patient health factors, oncologic subtype, and radiosensitivity of the tumor.

### GP193. EPIDEMIOLOGY OF LUMBAR PYOGENIC SPONDYLITIS IN LAST DECADE.

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**INTRODUCTION:** Pyogenic spondylitis was a relatively rare condition before. But recently patients with pyogenic spondylitis have been increasing due to increase of compromised hosts. The purpose of this study is to investigate epidemiology of pyogenic spondylitis in last decade.

**METHODS:** This is a retrospective study of 105 patients who were diagnosed lumbar pyogenic spondylitis. Mean age of the patients at diagnosis was 64 years and mean follow-up period was 33 months. Surgical treatments were performed in 32 patients. The factors we have studied were 1) compromised level 2) comorbidity 3) bacteriology 4) chief complaint on diagnosis 5) paralysis and recovery 6) results of treatment and recurrence.

**RESULTS:** 1) Compromised levels were L1/2-7 patients, 2/3-21 patients, 3/4-22 patients, 4/5-27 patients, 5/S-16 patients, 5/6-3 patients, 6/S-1 patient, multiple (extensive)-8 patients.  
2) 42 patients have comorbidity which revealed diabetes mellitus in 22 patients, chronic hepatitis in 8 patients, auto immune disease (using steroid) in 7 patients, malignancy in 6 patients and chronic renal failure in 5 patients.  
3) Bacterial organism was isolated in 65 patients, which revealed MSSA in 17 patients, MRSA in 11 patients.  
4) Chief complaint on onset was local pain in 76 patients, radicular pain in 18 patients, fever of unknown origin (FUO) in 8 patients and paralysis in 3 patients.  
5) Paralysis was seen in 19 patients and recovery was observed in 12 patients.  
6) 5 patients died before infection had cured. Except these 5 patients, infection was suppressed. Infection had recurred in 4 patients.

**DISCUSSION:** In the current study, 79 % of the patients had subacute or chronic onset and it took more than one month to diagnose in some patients. As pyogenic spondylitis itself can be treated conservatively, early detection and treatment is a key to prevent disastrous sequels.

### GP194. SURGICAL TREATMENT OF SPINAL EXTRADURAL ARACHNOID CYSTS IN THORACOLUMBAR SPINE

Haruki Funao<sup>1</sup>, Masaya Nakamura<sup>1</sup>, Takashi Tsuji<sup>1</sup>, Kota Watanabe<sup>2</sup>, Ken Ishii<sup>1</sup>, Morio Matsumoto<sup>1</sup>, Michihiro Kamata<sup>3</sup>, Yoshiaki Toyama<sup>1</sup>, Kazuhiro Chiba<sup>1</sup>  
Departments of Orthopaedic Surgery<sup>1</sup> and Advanced Therapy for Spine and Spinal Cord Disorders<sup>2</sup>, Keio University and Keiyu Hospital<sup>3</sup>

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**INTRODUCTION:** Because idiopathic spinal extradural arachnoid cyst (SEAC) is rare disease, optimal treatment for SEAC still remains controversial. The purposes of the present study were to retrospectively evaluate surgical results of SEAC, and to clarify the problems associated with treatments for this disease.

**METHODS:** A total of 12 patients with SEAC in thoracolumbar spine (male: 7, female: 5, mean age: 39.7years) who underwent surgery at our hospital during recent 20 years were included in this study. Mean follow-up period was 4.7 years. Total resection of cyst was performed in 8 patients, and closure of dural defect in 4 patients. Surgical outcomes were evaluated with regards to duration of symptoms, size of cysts, and difference in surgical procedures. Statistical analyses were performed using Student's t-test and Mann-Whitney's U test.

**RESULTS:** Neurological recovery was observed in all patients, and there was no recurrence. Poor outcomes were observed in patients with long duration of symptoms (more than 1 year,  $P < 0.01$ ) and large size of cysts (more than 5 vertebrae,  $P < 0.05$ ). Surgical procedures had no significant impact on postoperative neurological recovery. However, there was significant difference in degree of mean postoperative kyphotic angles between patients treated by total resections of cysts ( $9.5^\circ$ ) and those treated by closure of dural defect through selective laminectomy ( $1.3^\circ$ ) ( $P < 0.01$ ).

**DISCUSSION:** Poor outcomes were observed in patients with long duration of symptoms (more than 1 year) and large size of cysts (more than 5 vertebrae). Early surgical intervention, therefore, may provide better clinical outcomes. There was no significant difference in postoperative neurological recovery between patients treated by total resection of cyst and those by simple closure of dural defect. Closure of dural defect through selective laminectomy was as effective as total cyst removal, but less invasive preventing postoperative kyphotic deformity of thoracolumbar spine.



### **GP195. INDICATIONS AND LIMITATIONS OF CONSERVATIVE TREATMENT FOR PYOGENIC SPONDYLITIS IN COMPARISON WITH SURGICAL INTERVENTION (WITH SPECIAL REFERENCE TO LUMBAR LESION)**

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National Hospital Organization Kobe Medical Center, Kobe, Japan.

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**INTRODUCTION:** In treating patients with pyogenic spondylitis (PS), conservative treatment is the first choice, but surgical treatment is required if conservative treatment is ineffective, if there is concomitant paralysis, or development of kyphosis. The purpose of this study was to clarify indications and limitations of conservative treatment for PS by comparing them with those for surgical intervention.

**METHODS:** Seventy four patients who were diagnosed with PS were involved, of whom 50 were having conservative treatment, and 24 surgery. Clinical findings such as duration of disease, affected site, numbers of affected vertebrae, CRP at admission, interval to negative CRP, period of hospitalization, and radiological findings such as presence or absence of epidural abscess and deterioration of kyphosis, were compared between a conservative group and a surgery group.

**RESULTS:** Lumbar lesions comprised 70% of the affected sites in the conservative group but only 25% in the surgery group. There was a significant difference between conservative and surgery groups for duration of disease (1.72 vs 10.1months), CRP at admission ( $4.55 \pm 5.19$  vs  $2.22 \pm 3.08$ mg/dl), and kyphotic angle at follow-up ( $4.86 \pm 5.76^\circ$  vs  $-5.41 \pm 10.03^\circ$ ). There were 13 cases of epidural abscess in the conservative group, 85% occurring at lumbar lesions, but of the 19 cases of epidural abscess found in the surgery group occurrence at lumbar spine was only 21%.

**DISCUSSION:** The present study has demonstrated that for patients with PS whose affected site is lumbar spine and with short disease duration, conservative treatment is indicated. Even if an epidural abscess exists at a lumbar lesion, it is still better to pursue conservative treatment, applying adequate antibiotics during the acute phase. On the other hand, surgery is superior in maintaining alignment, therefore surgery may be indicated in cases with worsening kyphosis.

## GENERAL POSTERS

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### **GP196. SURGICAL SITE INFECTION OF THE SPINE: CONSTRUCTION OF A PREDICTIVE MODEL TO DEFINE NEED FOR SINGLE VERSUS MULTIPLE IRRIGATION AND DEBRIDEMENT**

Christian P. DiPaola, MD ; Davor D. Saravanja , MD; Luca Boriani,MD ; Michael Boyd, MD ; Brian Kwon, MD, PhD ; Scott Paquette , MD; Marcel F. S. Dvorak, MD ; Charles G. Fisher, MD, MHSc , John Street, MD, PhD Worcester, MA, USA

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**INTRODUCTION:** There is very little evidence to guide treatment of patients with spinal surgical site infection (SSI) who require irrigation and debridement (I&D) with respect to need for single or multiple I&D's. The purpose of this study is to build a predictive model which stratifies patients with spinal SSI to determine which patients will go on to need single versus multiple I&D.

**METHODS:** A consecutive series of 128 patients from a tertiary spine center (collected from 1999-2005) who required I&D for spinal SSI, were studied based on data from a prospectively collected outcomes database. Over 30 variables were identified by extensive literature review as possible risk factors for SSI, and tested as possible predictors of risk for multiple I&D. Logistic regression was conducted to assess each variable's predictability by a "bootstrap" statistical method. Logistic regression was applied using outcome of I&D- single or multiple as the "response"

**RESULTS:** 24/128 patients required multiple I&D. Primary spine diagnosis was approximately represented by ¼ trauma, ¼ deformity, ¼ degenerative and ¼ oncology/inflammatory/other. Six predictors: spine location, medical comorbidities, microbiology of the SSI, presence of distant site infection (ie. UTI or bacteremia), presence of instrumentation and bone graft type, proved to be the most reliable predictors of need for multiple I&D. Internal validation of the predictive model yielded area under the curve (AUC) of .84

**DISCUSSION:** Infection factors played an important role in need for multiple I&D. Patients with +MRSA culture or those with distant site infection such as bacteremia with or without UTI or pneumonia, were strong predictors of need for multiple I&D. Presence of instrumentation, location of surgery in the posterior lumbar spine and use of non-autograft bone predicted multiple I&D. Diabetes also proved to be the most significant medical comorbidity for multiple I&D.

### GP197. MICROBIOLOGICAL SPECTRUM OF SIGNIFICANT SPINAL WOUND INFECTIONS

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**INTRODUCTION:** Spinal post-operative wound infections are common, debilitating, and costly to the community. The common microbiological profile of spinal wound infections and their relation to culture results may have significant bearing upon treatment, and the identification of more effective management protocols.

**METHODS:** All consecutive spinal wound infections requiring incision and drainage at our institution in an eight-year period were studied from our ambispective database. Microbiological organisms cultured, distant site infection, number of incisions and drainage required, spinal level affected, use of instrumentation, bacteraemia, and time to first incision and drainage were analysed and assessed for correlations, and effect.

**RESULTS:** 186 post-operative wound infections in 179 patients were identified from eight years of consecutive data in all patients treated at our institution. Only nine (4.8%) cases had negative wound cultures. 155 (83%) cases had gram positive organisms cultured, 46 (24.7%) grew gram negative organisms and 97 (52.2%) had polymicrobial wound infections. MRSA infections were present in 41 (22%) cases. Multiple incisions and drainage were required in 57 (30.6%) cases. Associations for multiple incisions were correlated to polymicrobial infections and distant site infection.

**CONCLUSIONS:** Whilst gram positive organisms are most frequently cultured in spinal wound infections, there is a broad spectrum of causative organisms. Polymicrobial infections and distant site infections can be associated with an increased need of multiple incision and drainage procedures, as are blood cultures that correlate with positive wound cultures. Resistant organisms are present in a significant number of spinal wound infections. Protocols for treatment of spinal wound infection will need to consider these diverse factors to provide early, effective, and economic management.

## GENERAL POSTERS

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### **GP198. POST-OPERATIVE INFECTION TREATMENT SCORE FOR THE SPINE (PITSS): VALIDATION OF A PREDICTIVE MODEL TO DEFINE NEED FOR SINGLE VERSUS MULTIPLE IRRIGATION AND DEBRIDEMENT FOR SPINAL SURGICAL SITE INFECTION**

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**INTRODUCTION:** There is little evidence to guide treatment of patients with spinal surgical site infection (SSI) who require irrigation and debridement (I&D) with respect to need for single or multiple I&D's. The purpose of this study is to externally validate a previously constructed predictive model and design a classification system to decide which patients will need single versus multiple I&D.

**METHODS:** A consecutive series of 34 patients from a tertiary spine center (collected from 2006-2008) who required I&D for spinal SSI, were studied. Data was obtained from a prospectively collected outcomes database. A previously constructed predictive model based on a separate series of 128 patients that identified six predictors: spine location, medical comorbidities, microbiology of the SSI, presence of distant site infection (UTI, bacteremia or pneumonia), presence of instrumentation and bone graft type, proved to be the most reliable predictors of need for multiple I&D. External validation of the model was performed by applying the model to produce predicted probabilities. Receiver Operating Curves (ROC) were constructed and then Area Under the Curve plots (AUC's) were calculated.

**RESULTS:** Validation analysis yielded AUC=0.70, 95% CI = (0.51, 0.89). By setting a probability cutoff of .24 the negative predictive value (NPV) for multiple I&D was .71 and positive predictive value (PPV) was .85. A cutoff of .60 probability yielded a PPV of .98 and NPV of .30.

**DISCUSSION:** The validation of this predictive model proved to be good. Excellent PPV could be obtained at many cutoff points and good NPV was obtained with lower probability cutoff points. This study forms the basis for an evidence based classification system, the Post-operative Infection Treatment Score for the Spine (PITSS) which stratifies patients based on specific spine, patient, infection and surgical factors to assess a low, indeterminate and high risk for multiple I&D in patients with SSI.

### GP199. RISK FACTORS FOR POSTOPERATIVE INFECTION FOLLOWING POSTERIOR LUMBAR INSTRUMENTED FUSION

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Surgical site infection (SSI) is one of the most morbid and costly complications that can occur following surgical procedures. Infection rates vary by procedure type with individual studies indicating that posterior lumbar instrumented fusion as the highest rate. Prior studies have attempted to look at risk factors associated with infection across all spine procedures but were limited due to sample size. This study set out to identify surgical infection rates as well as any unique risk factor for one of the most common spine procedures in the modern era, posterior lumbar instrumented fusion.

The medical records of patients who underwent instrumented lumbar or lumbosacral fusion from January 2000 to December 2006 at a single institution were reviewed. The biostatistics department at our institution completed statistical planning and matching criterion for the control group. All potential risk factors were evaluated for a univariate association with spine infection using independent samples t-tests for continuous variables and chi-square or Fisher's exact tests for categorical variables. Unadjusted odds ratios (OR) and 95% confidence intervals (95% CI) were calculated and presented for discrete variables. A multivariate logistic regression was then used to evaluate the independent associations of each potential explanatory variable.

The overall rate of infection following posterior lumbar instrumented fusion during the five-year period of the study was 2.61% (85 in 3218 operations). Independent risk factors are obesity (adjusted O.R. 6.20 (2.61,14.72; 95% CI) ), presence of a dural tear (adjusted O.R. 3.61 (1.09, 12.00; 95% CI)), diabetes (adjusted O.R. 3.83 (1.42, 10.33; 95% CI)), COPD (adjusted O.R. 6.12 (1.45, 25.92; 95% CI)), and osteoporosis (adjusted O.R. 3.50 (1.14, 10.71)).

Posterior lumbar instrumented fusion historically has had some of the highest rates of infection in spine surgery but this has changed. Unique to posterior lumbar instrumented fusion is the consideration of osteoporosis as an additional risk factor.

### GP200. EPIDERMOID TUMOR OF THE CAUDA EQUINA

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**INTRODUCTION:** The etiology of epidermoid tumor is classified into two groups, acquired and congenital pathogenesis. It is thought that the main cause of acquired epidermoid tumors of the lower spine may be the implantation of epidermal tissue into the subarachnoid space by lumbar puncture, and some epidermoid tumors are congenital caused by abnormal closure of the neural tube.

**METHODS:** We retrospectively studied 7 patients with epidermoid tumor of the cauda equina to investigate the clinical features and surgical outcomes. There were 2 men and 5 female (4-66y.o.), surgical treatments were performed in all the patients under microscope, and mean duration of postoperative follow-up was 114months. (38-207 months)

**RESULTS:** Antecedent lumbar puncture had been performed on 4 patients. A juvenile case was thought to be congenital origin without association with any anomaly such as spina bifida or dermal sinus. All patients complained of pain in lower extremities, and bladder and bowel dysfunction were not so severe. Postoperatively, one patient showed transient retrograde ejaculation, two patients showed sensory deficit around perineal region, and 2 patients, who showed recurrence of the tumor 1 year and 13 years after surgery, showed permanent paralysis on the hemilateral lower extremity after additional surgery for the recurrence of the tumor.

**DISCUSSION:** In our review of English literature, total resection of the tumor was completed in almost all cases, and the reported cases of recurrence of the tumor are very rare. Conversely in our case series, because the tumors were often adhered to neural elements, total resection was usually difficult. However, total resection of the tumor is very important, because patients with epidermoid tumor will be at risk for recurrence. On the other hand, aggressive resection of the tumor adhering to the nervous elements would induce complications related with cauda equina symptom at the high rate after surgery.

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