O01
CLASSIFICATION CRITERIA FOR LUMBAR RADICULAR PAIN DUE TO DISK HERNIATION
Stephane Genevay M.D. (1) Delphine Courvoisier PhD (2) Kika Konstantinou P.T. Spinal Specialist (3) Francisco M. Kovacs; MD, PhD (4) Marc Marty M.D. (5) Jeffrey N. Katz, MD, MSc. (6) Steven J. Atlas M.D. M.P.H. (7);
(1) Division of rheumatology, University Hospitals of Geneva, Switzerland (2) Epidemiology Department, University Hospitals of Geneva, Switzerland (3) Arthritis Research UK Primary Care Centre, Keele University , UK (4) Scientific Department; Kovacs Foundation; Palma de Mallorca, Spain (5) Department of Rheumatology, Henri-Mondor Hospital, Créteil, France (6) Department of Orthopaedic Surgery and Division of Rheumatology, Immunology and Allergy, Brigham and Women’s Hospital, Harvard Medical, Boston MA, USA (7) General Medicine Division, Massachusetts General Hospital, Harvard Medical, Boston MA, USA

BACKGROUND: Imaging evidence of lumbar disc herniations (DH) may not be associated with symptoms, therefore classification criteria based upon patient symptoms and physical examination findings are required. This study aimed to produce a set of criteria identifying patients with radicular pain (RP) caused by DH.

METHODS: Phase 1: Nineteen spine experts (surgeons and non-surgeons) from 8 countries participated in a Delphi process to rank symptoms and signs which point to DH as the cause of RP. A list of 46 clinical signs and 27 patient-reported symptoms were selected. Phase 2: Twenty different experts from 5 countries recruited patients during office visits[?true] they could classify with high confidence as presenting with either: 1) RP due to DH, 2) neurogenic claudication (NC) due to spinal stenosis, or 3) non-specific low back pain (NSLBP) with non-specific leg pain radiation. Patients completed survey items and specialists documented examination signs. Signs and symptoms present in ≥5 patients were analyzed by using Generalized Estimating Equations (GEE). A score to predict RP due to DH was developed based on the coefficient of the GEE, and used to obtain a ROC curve and the associated area under the curve (AUC).

RESULTS: 209 patients with high confidence in the diagnosis were included, 89 RP due to DH, 63 NC, and 57 NSLBP with non-specific leg pain radiation. Items which predicted RP with a p-value <0.1 included monoradicular pain, leg pain not decreased when sitting, positive straight leg raising test <60°, unilateral motor weakness and asymmetric ankle reflex. The score had an AUC of 0.92, and the cutoff to obtain a specificity of >90% resulted in a sensitivity of 79%.

CONCLUSION: A two-step process produced a set of diagnostic criteria with high specificity and sensitivity for identifying patients with RP caused by DH. Using this set could improve the quality of clinical research in this field by improving homogeneity within groups of patients.

O02
DOES REDUCTION IN LEG PAIN PRECEDE IMPROVEMENT IN DISABILITY AND PHYSICAL FUNCTION AMONG THOSE WITH DEGENERATIVE LUMBAR SPINE DISEASE? ANALYSIS OF DATA FROM THE SPINE PATIENT OUTCOMES RESEARCH TRIAL
Richard L. Skolasky, ScD1,2; Stephen T. Wege
ner2; PhD, Emily A. Scherer, PhD 3; Tor D. Tosteson, ScD3;
1Department of Orthopaedic Surgery and the 2Department of Physical Medicine & Rehabilitation, The Johns Hopkins University School of Medicine, Baltimore, MD 3Department of Community and Family Medicine, The Geisel School of Medicine at Dartmouth

INTRODUCTION: Disability and functional limitations are common presenting symptoms that interfere with an individual’s ability to take part in normal work and recreational activities. It is hypothesized
that interference leads to reduced productivity and social participation that, in turn, leads to diminished quality of life. We examined the temporal relationship between leg pain and disability and physical function during the first twelve months following surgery for degenerative lumbar spinal stenosis (LSS).

METHODS: We analyzed 930 individuals prospectively enrolled in the Spine Patient Outcomes Research Trial (SPORT) who underwent elective surgery for LSS. Leg pain, disability, and physical function were assessed prior to and at 3 and 12 months following surgery. Temporal association between improvements in leg pain and in disability and physical function was assessed using cross-lagged path models. Significance set at P value less than 0.05.

RESULTS: Preoperatively, mean leg pain was 16.2 (standard deviation [SD] 5.2), disability was 54.1% (SD, 20.7%), and physical function was 29.8 (SD, 8.4). In a descriptive analysis of percentage of total change over time in the three measures, reduction in leg pain preceded improvements in disability and physical function during the first year following surgery (Figure 1). Adjusting for patient age and symptom duration, cross-lagged path analysis showed leg pain reduction at 3 months was correlated with disability improvement at 3 months (p = 0.76, p<0.001) and disability at 3 months was predictive of both physical function at 12 months (β = -0.33, p<0.001) and leg pain at 12 months (β=0.22, p<0.001).

DISCUSSION: At 3 months following surgery, patients experience reduction in leg pain and disability. Early improvement in symptoms is associated with improved physical function one year following surgery, although the path analysis also indicates disability at 3 months affecting pain at one year.

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O03

PCR ASSAY OF EXCISED INTERVERTEBRAL DISCS FROM PATIENTS UNDERGOING SINGLE LEVEL PRIMARY LUMBAR MICRO-DISCECTOMY

Todd F. Alamin, MD Nikhil Tendulkar, MD Agnes Ith, BS Ivan Cheng, MD Gaetano Scuderi, MD;
Stanford University School of Medicine

INTRODUCTION: Recent studies have demonstrated a high rate of positive cultures for low virulent organisms in excised HNP samples. These studies have served as the theoretical basis for a pilot trial, and then a prospective randomized trial which demonstrated that systemic treatment with antibiotics may yield improvements in axial back pain. Whether the reported positive cultures in discectomy specimens represent true positives is as yet not proven, and yet important if underlying the basis of therapeutic approaches for chronic low back pain.

METHODS: 45 patients with radiculopathy and MRI findings of HNP underwent microdiscectomy. Excised disc samples were analyzed by PCR assay for the presence of the 16s rRNA gene sequence, which is found in all bacterial species.

RESULTS: All 45 specimens tested negative for the 16s rRNA sequence.

DISCUSSION: With this highly sensitive and specific test, the previous findings of positive culture results in excised disc specimens is called into question. The mech-
anism of the positive results found in the recent randomized trial comparing a course of oral antibiotics to placebo in patients with back pain and type 2 modic change (Albert, Eur Spine Journal 2013), which demonstrated a large, statistically significant effect size in the antibiotic group is further questioned- an underlying infection in this patient group seems unlikely on the basis of these results. An indirect effect of the antibiotics through changes to the microbiome of the intestinal tract seems more likely, with perhaps an effect on an inflammatory response to products of disc breakdown.

O04
MAGNETIC RESONANCE IMAGE FINDINGS IN THE EARLY POST-OPERATIVE PERIOD AFTER MICRO LUMBAR DISCECTOMY
1Kazushi Takayama, 1Teruo Kita, 1Akito Yabu, 1Kazuya Nishino, 1Hideki Sakanaaka, 1Yoshiki Yamano, 2Hiroyuki Nakamura;
1Dept. of Orthopaedic Surgery, Seikeikai Hospital, Osaka, Japan; 2Dept. of Orthopaedic Surgery, Osaka City University Graduate School of Medicine, Osaka, Japan

INTRODUCTION: CT or MRI is frequently performed in the early postoperative period when a symptom persists or is deteriorated after lumbar disc herniation surgery. Especially, MRI is useful for the detection of spinal canal lesions such as residual herniation, recurrent herniation and epidural hematoma. However, since MRI in the normal early postoperative phase can also show subclinical disc bulge and hematoma, the scope of acceptable postoperative change on the MRI in symptomatic patients has not yet been determined. We evaluated the characteristic findings on MRIs obtained within 1week after micro lumbar discectomy.

MATERIALS AND METHODS: This study was conducted on 20 patients who underwent single-level microlumbar discectomy after April 2012; lumbar MRIs were obtained 5 to 7 days after the surgery and at 3 months or later after the surgery. Seventeen patients were male and 3 were female. The mean age at the time of surgery was 50 years (range, 31-75 years). The mean duration of postoperative follow-up was 11 months (3-25 months). The Japan Orthopedic Association (JOA) score was evaluated preoperatively, at 1 week post surgery, and at the latest follow-up. The dural sac area on the T2-weighted axial MR images was measured using an image measurement software (Image J).

RESULTS: Although one patient required another surgery at 3 weeks after the first, the mean JOA score in the subjects increased markedly from 11 prior to the operation to 18 at 1 week post surgery and 24 at the latest follow-up. The mean dural sac area increased from 113% (81%-154%) at 1 week post surgery to 187% (123%-425%) at the latest follow-up.

CONCLUSION: In the MRI obtained at 1 week post surgery, persistent dural sac compression was frequently seen even in patients who showed rapid improvement of the symptoms. Thus, we believe that familiarizing ourselves with the MRI findings in patients with satisfactory symptom improvement may enable more accurate diagnoses to be made in patients with persistent symptoms.
O05
DOES THE HIGH-INTENSITY ZONE (HIZ) OF LUMBAR INTERVERTEBRAL DISCS ALWAYS REPRESENT AN ANNULAR TEAR?
Zhi Shan, Huanhuan Chen, Junhui Liu, Chongyang Wang, Shunwu Fan, Fengdong Zhao;
Department of Orthopaedics, Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University

INTRODUCTION: The initial definition of HIZ simply focused on MRI T2-WI. In fact, when we studied the conventional HIZ, if the characteristics of the same zone on MRI T1-WI were included, we may draw a different conclusion in some cases.

MATERIALS AND METHODS: 73 patients (mean age, 51.4 years; range, 25-80 years) with low back pain and HIZs of the lumbar disc were identified on MRI T2-WI was included in this retrospective study. All cases were divided into two groups according to the characteristics of HIZ: T2-HIZ: the HIZ on MRI T2-WI and low intensity on MRI T1-WI; dual-HIZ group: the HIZ on MRI T2-Weighted-image was found as high intensity on MRI T1-WI as well. All patients also underwent CT scan on the targeted level. Patients meet the surgical criteria underwent discography and/or surgery, and the posterior annulus fibrosus containing the HIZ were harvested for histological analysis.

RESULTS: 39 patients with T2-HIZ, 30 with dual-HIZ, and 4 with both T2-HIZ and dual-HIZ were studied. In discography, 88.6% (31 of 35) patients from T2-HIZ group were positive with annular tear, while no patient (0 of 5) from dual-HIZ group showed annular tear. 15 patients from T2-HIZ group and 13 from dual-HIZ group underwent surgery. Histomorphology examination showed outer annular tears invaded by granulation tissue in T2-HIZ group. In dual-HIZ group, targeted discs had more calcified or ossified lesions in the region of the HIZ in posterior annular on CT scan (94.1% vs. 0%).

DISCUSSION: The High-Intensity Zone on T2-WI which was found as low intensity zone on MRI T1-WI represented an annular tear with granulation tissue, while HIZs on both MRI T2- and T1-WI can represent calcified tissue, possibly from a vertebral endplate or the posterior annulus fibrosus. The conventional concept of HIZ should be modified to T2-HIZ, and definition of HIZ in both T1- and T2-WI should be added. In addition, CT scan was helpful in distinguishing diagnosis.

O06
PROTEOGLYCAN PROFILE AND LEVEL-SPECIFIC IMAGING BIOMARKERS OF LUMBAR DISC DISPLACEMENT
(1) Department of Orthopaedics and Traumatology, The University of Hong Kong, Hong Kong; (2) Department of Diagnostic Radiology, The University of Hong Kong, Hong Kong; (3) CMROI, Department of Radiology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania, USA; (4) Medical Research Center Oulu, University of Oulu and Oulu University Hospital, Oulu, Finland; and (5) RUSH University Medical Center, Chicago, Illinois USA

INTRODUCTION: Controversy exists whether disc displacement is associated with disc degeneration. A decrease in proteoglycan content is synonymous with degenerative disc changes. However, the in vivo proteoglycan concentration of disc displacement is speculative. Signal intensity on traditional T2-weighted (T2W) MRI provides a qualitative snap-shot of disc integrity, but is not reliable and lacks quantification. T1-rho MRI of the discs has been shown to quantitatively represent proteoglycan concentration. The following large-scale imaging study quantitatively addressed the “proteoglycan profile” of lumbar
disc displacement and level-specific cut-off values associated with its development in human subjects.

**METHODS:** 76 volunteers (mean age: 50.6 years; 51.3% males) who underwent T2W and T1-rho MRI of the lumbar spine from L1-S1. The presence and degree of disc displacement (i.e. bulge/protrusion/extrusion) was assessed at each level based on sagittal T2W MRI. T1-rho values were obtained of each disc. Inter- and intra-observer reliability was conducted of all MRI assessments.

**RESULTS:** 380 lumbar discs were assessed. High reliability of imaging measurements was noted. Overall, 50% of the discs had some degree of disc displacement, most prevalent at L4-S1. The median T1-rho values for overall lumbar non-displaced discs was 77.6ms compared to 64.5ms for displaced discs (p<0.001). Significant median level-specific and optimal threshold T1-rho values for non-displaced discs vs. displaced discs were identified.

**DISCUSSION:** This is the first study in humans to quantitatively assess the “proteoglycan profile” of lumbar disc displacement. A decrease in proteoglycan concentration on T1-rho MRI was noted in the presence of disc displacement at all disc levels. Level-specific values have been identified that may have predictive utility at the index or adjacent disc levels as well as aid in the classification, etiology, natural history, and therapeutics of disc displacement.

**O07**

INTEGRATION OF THE CARTILAGE ENDPLATE-INTERVERTEBRAL DISC JUNCTION IN NORMAL AND DEGENERATE HUMAN LUMBAR SPINES

Sharon Owen (1), Kelly Wade (2), Samantha Rodrigues (2), Iain McCall (1), Neil Broom (2), Sally Roberts (1);

(1) Centre for Spinal Studies & ISTM (Keele University), RJAH Orthopaedic Hospital Foundation Trust, Oswestry, Shropshire, SY10 7AG, United Kingdom (2) Department of Chemical and Materials Engineering, University of Auckland, Auckland, New Zealand

**INTRODUCTION:** The extent of integration at the bony and cartilage endplates (CEP) of the vertebrae and intervertebral disc interface greatly influences the structural stability of the spine. In particular, disc herniations have been associated with failure at the endplate region. In ovine spines, the microscopic organisation of these interfaces has been well described, but the human scenario, with its associated degeneration, has received scant attention. This study investigated the mechanism of attachment between the nucleus and annulus and the CEP within normal and degenerate human lumbar spines.

**METHODS:** Following X-ray, CT and MRI, post-mortem lumbar spines were evaluated for degenerative changes using Pfirrmann grading. Motion segments from Grade I (n=2), Grade III (n=6) and Grade IV (n=1) were cut sagittally forming two halves. One half was fixed, decalcified and sectioned to produce three vertebra-disc-vertebra blocks, each containing different regions of the disc (nucleus, anterior and posterior annulus). These were cryosectioned (30μm) for microstructural analysis either along the sagittal or coronal axes (nucleus region) or parallel to exposed lamellar fibre directions (annulus regions). Fully hydrated sections were imaged using differential interference contrast optical microscopy.

**RESULTS:** Structural integration was observed between the CEP and the three regions of the human discs. Nucleus fibre insertions (nodes:* on Figure A) were discernible, but not as regular or penetrating as deeply into the CEP as in ovine spines. Some annular fibres appeared to subdivide on entering the CEP. Loss of integration and structure at the CEP-disc junction
was more apparent with degeneration (Figure B).

**DISCUSSION:** Overall the CEP-disc junction in humans is not as well organised as that found in sheep. The structural continuity seen in the normal CEP-disc junction appears diminished in degenerate discs and may predispose to rupture or herniation.

**O08**

**NUCLEUS PULPOSUS OF BOVINE COCCYGEAL INTERVERTEBRAL DISC CONTAINS PROGENITOR CELLS CAPABLE OF DIFFERENTIATING INTO OSTEOCYTES AND ADIPOCYTES**

Adel Tekari1, Samantha CW Chan1,2, Karin Wuertz3,4, Daisuke Sakai4,5, Lorin M Benneker4,6, Sibylle Grad4,7 & Benjamin Gantenbein1,4;

1 Tissue and Organ Mechanobiology Group, Institute for Surgical Technology & Bioengineering, University of Bern, Switzerland 2 Bioactive materials, EMPA, Swiss Federal Laboratories for Materials Science and Technology, St Gallen, Switzerland 3 Institute for Biomechanics, ETH Zurich, Zurich, Switzerland 4 AOSpine Research Network, Duebendorf, Switzerland 5 Department of Orthopedic Surgery, Tokai University School of Medicine, Isehara, Kanagawa, Japan 6 Department for Orthopaedic Surgery, Insel-spital, University of Bern, Bern, Switzerland 7 AO Research Institute, Davos, Switzerland

**INTRODUCTION:** The intervertebral disc (IVD) has a limited regenerative potential and low back pain represents a leading cause of disability. IVD repair strategies require an appropriate cell source that is able to regenerate the damaged tissue such as progenitor stem cells. Recently, progenitor cells that are positive for the angiopoietin receptor (Tie2) in the nucleus pulposus were identified. Here we isolated primary cells from bovine IVD and sorted bovine nucleus pulposus progenitor cells (NPPC) for the marker Tie2. Furthermore, we demonstrated that Tie2+ expressing cells can differentiate into osteogenic and adipogenic lineages in vitro.

**METHODS:** NP cells were obtained from one year old bovine tails by sequential digestion with pronase for 1 hour and collagenase overnight. Sorted Tie2- and Tie2+ cells were cultured in osteogenic and adipogenic medium for 3 weeks. The formed cell layers from both subpopulations were stained for calcium deposition and fat droplets. Colony forming units were prepared for both cell suspensions in methylcellulose-based medium and formed colonies (> 10 cells) were analyzed macroscopically after 8 days.

**RESULTS:** After 3 weeks of culture, Tie2+ cells were able to differentiate into osteocytes and adipocytes as characterized by calcium deposition and fat droplet formation. By contrast, Tie2- cells generated a weak staining for calcium and no fat droplets were obtained (Figure 1). Sorted Tie2- and Tie2+ subpopulations of cells both formed colonies, however with different morphologies. The colonies formed from Tie2+ cells were spheroid in shape whereas those from Tie2- cells were spread and fibroblastic.

**DISCUSSION:** Our data showed that Tie2+ cells of the nucleus pulposus cells are
progenitor-like cells that are able to differentiate into osteogenic and adipogenic lineages. Sorting of NPPC for Tie2 may represent a promising strategy with the potential to be used in the clinics for treatment of intervertebral disc damage.

O09
TOLL-LIKE RECEPTOR SIGNALING, GRANULOCYTIC DYSREGULATION, AND NEUROGENESIS IN VERTEBRAL BONE MARROW LESIONS
Dudli S, Burch S, Berven S, Deviren V, Lotz JC;
Department of Orthopaedic Surgery University of California San Francisco United States of America

INTRODUCTION: Modic changes (MC) are vertebral bone marrow (BM) lesions adjacent to degenerated discs. MC type 1 (MC1) represent inflammation/fibrosis, while MC2 represent fatty degeneration/fibrosis. Although painful, the pathogenesis is unknown. Cytokines and matrix catabolites draining from the degenerated disc into the BM may play a decisive role.

METHODS: From patients with MC undergoing lumbar fusion, BM aspirate from the MC area and the adjacent disc were collected (MC1: n=3, MC2: n=5). Control disc and BM were collected from a non-MC level. Expression of 46 genes in the disc and BM were analyzed. BM cellularity was analyzed with flow cytometry (CD3/14/19/45), myeloid progenitors (MP) were quantified as colony-forming units (CFU). MC data were normalized to non-MC data. For the BM, gene expression was correlated to cellularity and CFU.

RESULTS: In MC1 discs, genes of Toll-like receptors (TLR), of TLR-signaling (MyD88, TRAF6, IL-23) and of IL-23 down-stream signaling (RORg, RUNX1) were upregulated. Genes related to neurogenesis (NTRK) were upregulated in both the disc and BM. In MC2 discs and BM, inflammatory (NFkB, IFNg, CSF1, TRAF2), matrix- and bone-resorbtent genes (MMP, NFATc1, OSCAR) were down-regulated. MC BM had more MP and showed a shift in the granulocyte (PMN) population from high to low CD45, which correlated with TLR2/6 and IL-23 expression.

DISCUSSION: Results suggest TLR stimulation with IL-23 secretion in MC1 discs. While disc cells could express TLR and IL-23, the upregulation of RUNX1/RORg rather points at immune cells homed to the disc. Indeed, more CFU and a PMN population shift indicate changes in the myeloid lineage. The correlation of the PMN-shift with TLR and IL-23 expression provides a putative pathogenic mechanism: that TLR ligands (e.g. damage-associated molecular pattern) likely cause a myeloid response in MC1, which in the long-term leads to a 'burn-out' situation as seen in MC2. The upregulation of NTRK could explain why MC hurt.

O10
THE ANTI-AGING AGENT RAPAMYCIN MITI-GATES AGE-ASSOCIATED PROTEOGLYCAN MATRIX LOSS IN INTERVERTEBRAL DISCS OF THE NONHUMAN PRIMATE MARMOSET MODEL
Prashanti,Patil(1); Ngo, Kevin(1); Pohl, Pedro(1); Takashi Yurube(1,5); Dong, Qing(1); Cory Ross(2); Tardif, Suzette(2,3); Sowa, Gwendolyn(1,4); Kang, James(1); Vo, Nam(1);
1)Dept Orthopedic Surgery, 4)Physical Medicine and Rehabilitation; University of Pittsburgh, USA. 2)Barshop Institute for Longevity and Aging Studies, University of Texas Health Science Center San Antonio. 3)Southwest National Primate Research Center, Texas Biomedical Research Institute, San Antonio. 5)Department of Orthopedic Surgery Kobe
INTRODUCTION: Decreased nutrition supply is associated with intervertebral disc degeneration (IDD). Aging contributes to IDD, possibly through increased endplate calcification which disrupts disc nutrient diffusion. Nutrient starvation triggers autophagy, primarily through inhibition of an evolutionarily-conserved protein kinase TOR (target of rapamycin), resulting in degradation and recycling of unnecessary or dysfunctional cellular components. Treatment of animal models with rapamycin, a TOR inhibitor, has shown to delay multiple age-related pathologies in different tissues. The goal of this study is to evaluate the efficacy of rapamycin in delaying aging-associated IDD in marmo-sets, a nonhuman primate with a lifespan of 12 yrs.

METHODS: 5 aging marmosets were given rapamycin orally 0.4mg/day daily starting at ~9 yrs of age for 14 months, at the end of which the animals were sacrificed. Four ~10 yr old untreated marmosets were used as control. Disc proteoglycan (PG) content was assessed by safranin-O-histology and quantitative DMMB assay. Levels of disc cellular senescence (p16INK4a) and autophagy (LC3) were determined by Western blot

RESULTS: Disc PG content was higher in rapamycin treated marmosets compared to control. Western analyses revealed increased levels of LC3-II protein, a marker of autophagy, and decreased p16INK4a, a marker of cellular senescence, in discs of rapamycin-treated marmosets compared to untreated controls.

DISCUSSION: Rapamycin treatment ameliorated age-associated disc PG loss and promoted disc autophagy while suppressed cellular senescence in the non-human primate marmoset models. Senescent cells are well-known to produce many matrix-degrading catabolic factors. While more confirmatory experiments are needed, our results suggest that rapamycin might be therapeutic in delaying age-associated IDD by inducing autophagy to respond to nutrient starvation stress and decreasing cellular senescence-related catabolic effects on disc matrix.

Figure 1: Effects of rapamycin treatment on disc matrix proteoglycan. Rapamycin increased marmoset disc PG content as assessed by safranin O/fast green histology (A) and DMMB assay for total GAG of nucleus pulposus and annulus fibrosis tissue (B). Western analysis showed that rapamycin decreased cellular senescence marker p16INK4a (C) and increased autophagy marker LC3-II (D) with actin as loading control.

O11
SUPPRESSIVE EFFECT OF ANTI-INTERLEUKIN-6 RECEPTOR ANTIBODY ON NEUROPATHIC PAIN-RELATED FACTOR IN SCATIC NERVE-INJURED MICE.
Nakayama S, Sainoh T, Yamauchi K, Orita S, Kubota G, Inage K, Sato J, Fujimoto K, Shiga Y, Takahashi K, Ohtori S; Department of Orthopaedic Surgery, Graduate School of Medicine, Chiba University

INTRODUCTION: The pathomechanism of neuropathic pain is associated with inflammatory cytokines such as interleukin-6 (IL-6). The aim of the present study was to evaluate the efficacy of local administration of the anti-IL-6–receptor antibody MR16-1 in a sciatic nerve-injured mouse model by behavior and immunohistology.

METHODS: Right sciatic nerve pinch was
performed in C57BL/6 mice and 3 groups were created: a sham (non-pinched) group, given 10-μL saline locally; a pinch group, given 10-μL saline after nerve pinch; and the MR16-1 group, given 10-μL MR16-1 after nerve pinch. Pain behavior was assessed by gait analysis 1 week after operation. Injured sciatic nerves were then extracted and nerve degeneration and demyelination were evaluated by histopathology. The L4–6 dorsal root ganglia (DRG) were harvested and immunostained for calcitonin gene-related peptide (CGRP) and activating transcription factor 3 (ATF3). Rates of CGRP- and ATF3-immunoreactivity (ir) in DRG neurons from each group were statistically analyzed.

RESULTS: On gait analysis, contact time and pressure of ipsilateral limbs was decreased in pinch mice and improved in MR16-1 mice (p<0.05). Inflammatory cell infiltration, neural cell size change, and denatured demyelination at the distal insult were observed in injured nerves; the insult was mitigated in the MR16-1 group. Pinch group neurons exhibited a significantly higher rate of CGRP-ir vs. the sham group (p<0.01), but there was no difference between sham and MR16-1 mice. Similarly, ATF3-ir was more common in pinch mice than in sham mice (p<0.05), and was suppressed in MR16-1 mice.

DISCUSSION: IL-6 antagonism promoted pain relief and repair of damaged tissue during acute-phase nerve injury. We need to explore more pathomechanism of IL-6 antagonism in the future study, which leads to possible novel treatment for neuropathic pain.

O12
EXPERIMENTAL CHEMONUCLEOLYSIS WITH RECOMBINANT HUMAN MATRIX PROTEINASE-7

1Haro, H; 2Takenouchi, O; 3Kato, T; 4Koyanagi, S; 5Komori, H;

INTRODUCTION: Chemonucleolysis has been proposed as a less invasive technique than surgery for patients with lumbar disc herniation. The purpose of this study was to investigate the effects of recombinant human matrix metalloproteinase 7 (rhMMP-7) in experimental chemonucleolysis in vitro and in vivo and to examine its effects on tissue damage.

METHODS: The effects of rhMMP-7 on the degradation of human herniated discs (HD) were examined by measuring the wet weight in vitro. The correlations between the decrease in wet weight by rhMMP-7 and the conditions associated with HD were also analyzed. The effects of rhMMP-7 on the proteoglycan and water content were respectively examined with alcian blue staining and T2-weighted MRI at 7 days after intradiscal injection in dogs. The distribution of [125I]-labeled rhMMP-7 was investigated by autoradioluminography at 7 days after intradiscal injection in dogs. An epidural injection study with rhMMP-7 was performed to evaluate the effects on the tissue damage around the discs at 1 and 13 weeks after the treatment in dogs. The type 1 and 2 collagen cleavage rates were measured and compared with that of aggrecan in vitro.

RESULTS: Rh MMP-7 concentration-dependently decreased the wet weight of HD in vitro. The decrease in wet weight didn’t significantly correlate with the HD conditions. Intradiscal injection of rhMMP-7 reduced the proteoglycan content and water content, with an increase in the
serum keratan sulfate. Radioactivity of [125I]-labeled rhMMP-7 was detected in the disc, but not in the muscle. Epidural injection of rhMMP-7 had no effect on the injection site or the nerve tissues.

CONCLUSIONS: The effects of rhMMP-7 were not affected by the conditions associated with HD. The epidural injection study suggests that intradiscal injection of rhMMP-7 may not induce tissue damage around the discs because of its distribution and substrate selectivity. Recombinant human MMP-7 may be a novel and promising chemonucleolysis agent.

O13
DEFINING THE CLINICAL SYNDROME OF LUMBAR SPINAL STENOSIS: AN INTERNATIONAL DELPHI STUDY
ISSLS Focus Group: The International Taskforce on Diagnosis and Management of Lumbar Spinal Stenosis: Christy Tomkinc-Lane and Markus Melloh (Co-Chairs), Michele Battié, Brian Freeman, Andrew Haig, Matthew Smuck, Jon Lurie, Lukas Staub, Richard Hu, Luciana Macedo, Kent Stuber, Anne Mannion, Christine Comer, Thomas Barz, Johann Steurer, Constantin Schizas, Dino Samartzis, Jason Cheung, Sangho Ahn, and Kazuhsa Takahashi; Department of Orthopaedic Surgery, School of Medicine, Stanford University, Palo Alto, CA, USA.

INTRODUCTION: Lumbar spinal stenosis (LSS) is a poorly defined clinical syndrome. Criteria for defining a syndrome should be informed by the experience of expert clinicians. The objective of this Delphi study is to reach a consensus among international experts on which factors are most important in diagnosis of LSS.

METHODS: In Phase 1 (Delphi Items) a multidisciplinary team of 12 experts in LSS compiled a list of 14 clinical questions considered to be important in diagnosis of LSS. A consensus meeting of the 18 members of the International Taskforce on the Diagnosis and Management of LSS confirmed these 14 items. An innovative on-line survey was developed that permits specialists to express the value they place on these items, the logical order in which they consider the items, and the level of certainty ascertained from the questions. In Phase 2 (Delphi Study), Round 1, this survey was distributed to all ISSLS members. Following Round 1 completion, an in-person meeting of 9 members of the International Taskforce on Diagnosis and Management of LSS was conducted as a Focus Group Meeting at ISSLS 2013 (Round 2).

RESULTS: 68 individuals from 16 different countries participated in Round 2. The most commonly selected factors were “leg pain while walking”, “flex forward while walking to relieve symptoms”, “sit down or bend forward to relieve pain”, “normal foot pulses”, “relief with rest”, and “lower extremity weakness”. Statistically significant (0.05) change in certainty ceased after 6 questions at 81% certainty. In Round 2 a consensus was reached on a final list of 10 survey items. The final version is presently being distributed to a wider group of experts, with the goal of obtaining 200 responses.

DISCUSSION: This question set will provide one pragmatic criterion for defining LSS that is based on expert opinion, and can be used in both clinical and research settings. Results of the final two rounds of the Delphi study are forthcoming.

O14
RELATIONSHIP BETWEEN BONY SPINAL CANAL STENOSIS AND THE OCCURRENCE OF CLINICAL SYMPTOMS OF LUMBAR SPINAL STENOSIS - THE WAKAYAMA SPINE STUDY
Hiroki Iwashashi1, Noriko Yoshimura2, Hiroshi Hashizume1, Hiroshi Yamada1, Hirioyouki Oka2, Kazunori Shinto1, Yuyu Ishimoto1, Keiji Nagata1, Masatoshi Teraguchi1, Ryohei Kagotani1, Shigeyuki Muraki2, Akihito
DISCUSSION:
The occurrence of clinical symptoms of LSS is not clear. The aim of this study was to investigate the age- and sex-related changes in parameters of bony stenosis of the lumbar spine and the relationship of these changes to clinical symptoms of LSS.

METHODS:
This cross-sectional study included 797 participants (240 men and 557 women; mean age, 63.6 years) of the second follow-up of the Wakayama Spine Study, which used a population-based cohort. Spinal stenosis parameters were measured on axial (upper margin of the pedicle level) T2-weighted MRI. Measurements included the antero-posterior bony spinal canal diameter (APSD) (L2-5). We used a multivariable logistic regression model to investigate the relationship between the occurrence of buttock and leg pains as an objective variable and APSD as an explanatory variable after adjustment for age group, sex, and body mass index category. P-values less than 0.05 were considered as statistically significant.

RESULTS: The APSD (mean±SD, mm) were as follows: L2, 23.1±2.1; L3, 22.7±2.4; L4, 21.6±2.7; L5, 18.8±2.9. The lower lumbar spine had a narrower APSD. The men had significantly wider APSD at the L4 level than the women. The APSD at the L4 level became narrower with age. The multivariate logistic regression model revealed that the APSD at the L4 level was significantly related to the occurrence of buttock and leg pains.

DISCUSSION: This is the first study to report age- and sex-related changes in parameters of bony stenosis of the lumbar spine and their relationship to the occurrence of clinical symptoms of LSS in a population-based cohort. The APSD at the L4 level was significantly related to the occurrence of buttock and leg pains, whereas those at the other levels were not. Other factors (disc degeneration, etc.) are assumed to be related to the occurrence of clinical symptoms of LSS.

O15
THE MECHANISM OF LIGAMENTUM FLAVUM HYPERTROPHY: INTRODUCING ANGI-GENESIS AS A CRITICAL LINK THAT COUPLES MECHANICAL STRESS AND HYPER-
TROPHY
Junseok W. Hur MD1,2, Bum-Joon Kim MD1,3, Jin-Hyun Park BD1, Joo-Han Kim MD PhD1, Youn-Kwan Park MD PhD1, Taek-Hyun Kwon MD PhD1, Hong Joo Moon MD PhD1; 1.Department of Neurosurgery, Korea University Guro Hospital, Seoul, Republic of Korea 2. Department of Neurosurgery, Korea University Anam Hospital, Seoul, Republic of Korea 3. Department of Neurosurgery, Korea University Ansan Hospital, Ansan city, Gyeong-Gi Do, Republic of Korea

INTRODUCTION: Biochemical alterations associated with the mechanical stress have been explored as the initial process in the pathology of ligamentum flavum hypertrophy (LFH), but it still remains poorly understood. Recently, inflammation following mechanical stress and subsequent reactions from ligamentum flavum (LF) cells were implicated to have pathological roles, but the available information is fragmentary. This study aims to investigate our hypothesis that angiogenesis may be a critical link between hypertrophy and a series of stimulation including mechanical stress.

METHODS: LF from 20 lumbar spinal canal stenosis (LSCS) and 16 lumbar disc herniation (LDH) patients were collected during surgery. Patient’s demography and
radiographic data were obtained. The levels of angiogenic factors (VEGF, angiopoietin-1, VCAM, and bFGF) from the LF were investigated by Enzyme linked immunosorbent assay (ELISA). Actual angiogenesis was also quantified by immunohistochemical method using anti-CD34 staining of capillaries. The correlations among clinical factors including radiographic factors, angiogenic factors and angiogenesis were investigated statistically.

**RESULTS:** The LSCS patients were older and exhibited a longer symptom duration, wider segmental motion, and thicker LF. LSCS patients had significantly higher tissue concentrations of VEGF (p<0.001), which were positively correlated with both LF thickness (r = 0.557, p<0.001) and segmental motion (r = 0.586, p<0.001). LSCS patients showed significantly more CD34-positive capillaries than did LDH patients (p = 0.004).

**DISCUSSION:** LSCS patients had higher segmental motion, VEGF concentrations and more CD34-positive capillaries than did LDH patients, indicating that angiogenesis subsequent to mechanical stress may be a critical step within the series of pathological stimulations in LF hypertrophy.

**O16**

**EFFECTIVENESS OF POSTERIOR DECOMPRESSION TECHNIQUES COMPARED WITH CONVENTIONAL LAMINECTOMY FOR LUMBAR STENOSIS, A SYSTEMATIC REVIEW**

Gijsbert M Overdevest, Wilco Jacobs, Carmen Vleggeert-Lankamp, Claudius Thomé, Robert Gunzburg, Wilco Peul; Netherlands, Austria, Belgium

**INTRODUCTION:** The standard surgical treatment of lumbar spinal stenosis (LSS) is a facet preserving laminectomy. New posterior decompression techniques aim to preserve spinal integrity and minimize tissue damage by saving bone and midline structures. The goal of this review is to compare the effectiveness of decompression with laminectomy for the treatment of LSS.

**METHODS:** MEDLINE, EMBASE, Web of Science, CENTRAL, ClinicalTrials.gov, and WHO ICTRP up to June 2014 were searched. We included RCTs comparing conventional facet preserving laminectomy (laminectomy group) with a posterior decompression technique that avoids the removal of posterior midline structures or a technique involving only partial resection of the vertebral arch (decompression...
group). The diagnosis was symptomatic degenerative LSS. Two reviewers selected and assessed risk of bias.

**RESULTS:** Ten RCTs (4 high quality) with 733 patients were included. Decompression techniques were unilateral laminotomy for bilateral decompression in 3 studies, bilateral laminotomy in 4 studies, and split-spinous process laminotomy in 4 studies. Functional disability and leg pain were not different between decompression and laminectomy. Perceived recovery favoured bilateral laminotomy (2 RCTs, n=223, OR 5.7, CI 2.6 to 12.7). Postoperative instability was less for bilateral laminotomy (3 RCTs, n=294, OR 0.10, CI 0.02 to 0.55), but not for unilateral laminotomy (3 RCTs, n=166, OR 0.28, CI 0.07 to 1.15). Low back pain severity was lower after bilateral laminotomy (2 RCTs, n=223, MD -0.51, CI -0.80 to -0.23), and after split-spinous process laminotomy (2 RCTs, n=97, MD -1.07, CI -2.15 to -0.00).

**DISCUSSION:** We found no differences between decompression and laminectomy for functional disability and leg pain. Laminotomy techniques resulted in less iatrogenic instability and all decompression techniques resulted in less postoperative back pain than laminectomy. Long term RESULTS and studies on iatrogenic instability are needed.

**O17**

**NO BENEFIT FROM FUSION IN DECOMPRESSIVE SURGERY FOR LUMBAR SPINAL STENOSIS. 2 YEAR-RESULTS FROM THE SWEDISH SPINAL STENOSIS STUDY, A MULTICENTER RCT OF 233 PATIENTS**

*Peter Försth Thomas Carlsson Karl Michaelsson Bengt Sandén;*  
Orthopedic dept, Uppsala University Hospital and Stockholm Spine Center

**INTRODUCTION:** The role of fusion in surgery for lumbar spinal stenosis (LSS) is a controversy in spine surgery. The aim of this study was to examine if additional fusion improves the outcome after decompression for LSS with or without preoperative degenerative spondylolisthesis (DS).

**METHODS:** From 2006 to 2012, 233 patients aged 50-80 years with spinal stenosis on 1 or 2 adjacent lumbar levels on MRI were enrolled in the study. Randomization was made between decompression with concomitant fusion and decompression only. The material was stratified for the existence of preop DS 73 mm on plain X-ray. 135 of the patients had preop DS (mean 7.2 mm). In addition to patient reported outcome measures an objective walking test (6 min walk test) was performed. Primary outcome measure was ODI. The follow up rate after 2 years was 98%.

**RESULTS:** There was a significant improvement in all outcome measures compared to preoperatively. No differences between the treatments were found in the Zürich Claudication Questionnaire. The walking test revealed a significantly increased walking distance during 6 minutes with no differences between the treatments. The OR to be satisfied with the result after decompression only compared to decompression with concomitant fusion was 1.1(95%CI 0.65-1.87). 13(11%) patients in the decompression group and 17(15%) after decompression and fusion had subsequent lumbar surgery within the follow up period.

**DISCUSSION:** In this multicenter RCT we found no benefit from fusion in decompressive surgery for LSS, regardless of if DS
was present preop or not. DS has been considered as an indication for additional fusion in LSS. Our RESULTS do not support that practice. In this elderly population with one- or two-level LSS, surgery should be limited to the less invasive procedure of decompression.

**O18**

**SHORT-TERM IMPROVEMENTS IN DISABILITY MEDIATE PATIENT SATISFACTION AFTER EPIDURAL CORTICOSTEROID INJECTIONS FOR LUMBAR SPINAL STENOSIS**

Pradeep Suri, Hristina Pashova, Patrick J. Heagerty, Jeffrey G. Jarvik, Judith A. Turner, Zoya Bauer, Thiru Annaswamy, Janna L. Friedly; VA Puget Sound Health Care System, Seattle Epidemiologic Research and Information Center (ERIC), Seattle WA VA Puget Sound Health Care System, Division of Rehabilitation Care Services, Seattle WA Department of Rehabilitation Medicine, University of Washington, Seattle, WA Comparative Effectiveness, Cost and Outcomes Research Center, University of Washington, Seattle, WA Department of Biostatistics, University of Washington, Seattle, WA Department of Radiology, University of Washington, Seattle, WA Department of Health Services, University of Washington, Seattle, WA Department of Psychiatry & Behavioral Sciences, University of Washington, Seattle, WA Department of Physical Medicine and Rehabilitation, Dallas VA Medical Center, Dallas, TX

**INTRODUCTION:** No studies have examined mediators of treatment effects on patient satisfaction in symptomatic lumbar spinal stenosis (LSS). We conducted an analysis of data from a double-blind randomized controlled trial to identify mediators of the effect of lumbar epidural injections of corticosteroid plus lidocaine on patient satisfaction at 6 weeks post-injection, in patients with LSS. We hypothesized that short-term (3-week) change in leg pain would be a significant mediator of satisfaction.

**METHODS:** We used mediation analysis to examine selected variables (adverse events and baseline to 3-week change in leg pain, back pain, disability, depression, and fatigue) as potential mediators of the effect of epidural injections of corticosteroid plus lidocaine on patient satisfaction with treatment. We used the satisfaction items from the Swiss Spinal Stenosis Questionnaire to measure patient satisfaction with the injection procedure at 6 weeks.

**RESULTS:** Among 400 patients randomized to receive epidural injections of corticosteroid plus lidocaine or lidocaine only, 369 had complete data for the satisfaction outcome and potential mediators, and served as the analysis sample. Contrary to expectations, 3-week change in leg pain intensity was not a significant mediator of treatment effects on patient satisfaction. Three-week change in disability (Roland-Morris Disability Questionnaire score) was a significant mediator of the effects of epidural corticosteroid injections on satisfaction at 6 weeks, explaining 48-60% of the treatment effect on satisfaction. Three-week changes in pain intensity in the leg and back together explained very little of the treatment effect on satisfaction beyond the information contributed by disability change alone. Other intermediate variables did not mediate satisfaction.

**DISCUSSION:** These findings support the current approach of examining disability as a primary patient-reported outcome in comparative effectiveness studies of LSS.

**O19**

**POSTOPERATIVE RECOVERY OF PSYCHIATRIC PROBLEMS AND SURGICAL OUTCOMES IN THE PATIENTS WITH LUMBAR SPINAL STENOSIS: A COHORT STUDY USING THE BRIEF SCALE FOR PSYCHIATRIC PROBLEMS IN ORTHOPAEDIC PATIENTS (BS-POP)**

Kinshi Kato; Shoji Yabuki; Koji Otani; Takuya Nikaido; Kazuyuki Watanabe; Shin-ichi Kikuchi; Shin-ichi Konno;
INTRODUCTION: We developed the Brief Scale for Psychiatric Problems in Orthopaedic Patients (BS-POP) as a reliable scale for easily and quickly identifying psychiatric problems in orthopedic patients (Yoshida et al., 2011). However, the efficacy of this scale in predicting surgical outcomes for lumbar spinal stenosis (LSS) patients has yet to be confirmed. The present study evaluated the relationship between surgical treatment outcomes and BS-POP scores in LSS patients at 1-year follow-up.

METHODS: A total of 189 patients (mean age, 67 years) with symptomatic LSS underwent posterior decompression surgery. Patients were divided into two groups according to preoperative BS-POP score and compared prospectively. Numerical rating scale (NRS, 0-10 points) for low-back pain (LBP), leg pain, and leg numbness and the Roland-Morris disability questionnaire (RDQ) were used for prospective pre- and post-operative evaluations.

RESULTS: Psychiatric problems were identified in 41 patients, whereas 148 had no psychiatric problems. Preoperative scores for LBP, leg pain, leg numbness, and RDQ did not differ significantly between groups. By 1 year after surgery, 70% of patients with psychiatric problems preoperatively had improved to show no psychiatric problems. At 1-year follow-up, patients with continued psychiatric problems showed poorer improvement in NRS scores for LBP (4.1 ± 3.1), leg pain (3.8 ± 3.5), leg numbness (3.1 ± 2.5) and RDQ score (41.6±10.3) compared to patients with continued absence of psychiatric problems pre- and postoperatively (2.0 ± 2.4, 1.8 ± 2.7, 2.1 ± 3.1, 47.8± 10.2; p < 0.0001, p < 0.0005, p < 0.0001, p=0.0024 respectively).

DISCUSSION: The BS-POP enables early detection of psychiatric problems before surgery. Surgical outcomes can be predicted using this scale, which should be included in the preoperative assessment of psychiatric problems for LSS patients. However, 70% of preoperative psychiatric problems may be improved by 1 year postoperatively.

O20 SYSTEMATIC LITERATURE REVIEW OF IMAGING FEATURES OF SPINAL DEGENERATION IN ASYMPTOMATIC POPULATIONS

Waleed Brinjikji, Patrick H. Luetmer, Bryan Comstock, Brian W. Bresnahan, Linda E. Chen, Richard A. Deyo, Safwan Halabi, Judith A. Turner, Andrew L. Avins, Kathryn James, John T. Wald, David F. Kallmes, Jeffrey G. Jarvik; Mayo Clinic, Rochester, MN; University of Washington, Seattle, WA; Oregon Health and Science University, Portland, OR; Henry Ford Hospital, Detroit, MI; University of California San Francisco, San Francisco, CA; Division of Research, Kaiser Permanente, Northern California, Oakland, CA

INTRODUCTION: Degenerative changes are common on spine imaging, but often occur among pain-free individuals as well as among those with back pain. Introducing prevalence information about such findings into MRI reports might help optimize clinical responses and promote a more appropriate response by primary care physicians and patients. However, currently available literature-based prevalence estimates vary widely. To help interpret such findings, we performed a systematic review studying the prevalence of imaging evidence of spine degeneration among asymptomatic individuals.

METHODS: We performed a comprehensive review of articles reporting prevalence of imaging findings among asymptomatic individuals. We selected age groupings by decade (20s/30s/40s/50s/60s/70s/80s) to estimate age-specific prevalence. For each imaging finding, we fit a generalized non-linear mixed effects model for the age-
specific prevalence estimate, clustering on study and adjusting for the midpoint of the reported age interval.

RESULTS: Thirty-three articles reporting on 3110 asymptomatic individuals were included in our study. The prevalence of disc degeneration among asymptomatic individuals increased from 37% among 20-year-olds to 96% among 80-year-olds. Disc-bulge prevalence increased from 30% among 20-year-olds to 84% among 80-year-olds. Disc-protrusion prevalence increased from 29% among 20-year-olds to 43% among 80-year-olds. The prevalence of annular fissure increased from 19% among 20-year-olds to 29% among 80-year-olds.

DISCUSSION: Imaging findings of spine degeneration are present in large numbers of asymptomatic individuals. Many imaging-based degenerative features are part of the normal aging process and common among individuals without pain. These imaging findings must be interpreted in the context of the patient’s clinical condition; we speculate that prevalence estimates may aid interpretation.

O21
PESSIMISTIC BACK BELIEFS AND LACK OF EXERCISE: A RISKY COMBINATION FOR FUTURE SHOULDER, NECK, AND BACK PAIN
Achim Elfering1, Urs Mueller2, Cornelia Rolli1, Oezguer Tamcan2, and Anne F. Mannion3;
1 Institute for Psychology, University of Bern 2 Institute for Evaluative Research in Orthopaedic Surgery, University of Bern 3 Spine Center, Schulthess Klinik, Zurich

INTRODUCTION: Beliefs regarding the inevitability of the future as a consequence of having back trouble are known to be associated with pain maintenance and pain-related absenteeism, presenteeism and use of the healthcare system. The aim of this cross-lagged-panel study was to assess the longitudinal validity of the back beliefs questionnaire (BBQ) in predicting future pain in the shoulders, neck, and back.

METHODS: A questionnaire booklet containing questions on demographics, lifestyle, pain, and the BBQ was completed by 2’507 randomly selected individuals who were otherwise participating in a population-based cross-sectional survey of musculoskeletal health. One year later, 1’833 (73%) returned a follow-up questionnaire. Structural equation modelling was used to evaluate associations between baseline BBQ scores and the intensity of pain in the shoulders, neck, and back (in the preceding 4 weeks) at 1-year follow-up, while accounting for pain in these regions at baseline, and to determine whether the models were influenced by the presence of back pain and exercise habits at baseline.

RESULTS: Baseline BBQ scores significantly predicted the intensity of 1-year shoulder, neck, and back pain in individuals who reported having back pain at baseline ($\beta = 0.11$, $p < .05$) but not in those who didn’t ($\beta = 0.02$, $p = .259$). Baseline BBQ also predicted 1-year shoulder, neck, and back pain in those who didn’t exercise ($\beta = 0.15$, $p < .05$) but not in those who did ($\beta = 0.04$, ns). The predictive strength of back beliefs for future shoulder, neck, and back pain intensity was greatest in individuals who both had back pain and did not exercise at baseline ($\beta = 0.29$, $p < .05$).

DISCUSSION: The findings confirm the longitudinal validity of the BBQ. Cognitive behavioural interventions should address pessimistic back beliefs in high-risk groups such as those experiencing back pain who are not regular exercisers.

O22
BENCH-MARKING THE OUTCOME OF LUMBAR SPINE SURGERY USING A SPINE REGISTER DATABASE
Björn Strömqvist1, Peter Fritzell2, Olle Hägg3, Bo Jönsson1, Björn Knutsson4, Bengt Sandén5;
INTRODUCTION: When introducing new techniques and when studying specific lumbar disorders, baseline and outcome data are of a high interest. The Swedish register, Swespine, has existed for 20 years and is generally used within the country since more than 10 years. The prospective design of register makes it suitable for establishing benchmarking of baseline data and outcome.

METHODS: Patient-report outcome measures (PROM) are completed before surgery and at 1, 2 and 5 years post-operatively. In this study we have focused on EQ-5D and Oswestry Disability Index. The study includes more than 45000 patients operated on during a 10-year period for lumbar disorders (disc herniation, spinal stenosis, spondylolisthesis and DDD). Mean values and confidence intervals are presented.

RESULTS: Pronounced reduction of pre-operative quality of life and function were noted for all diagnoses Significant improvements were seen at all follow-up time points. EQ-5D for disc herniation increased from 0.30 to 0.75 postoperatively, spinal stenosis from 0.40 to 0.65, spondylolisthesis from 0.40 to 0.70 and DDD from 0.35 to 0.65. ODI decreased from pre- to postoperatively for disc herniation from 48 (CI 2) to 20 (CI 2), for spinal stenosis from 44 (CI 1) to 27 (CI 2), for spondylolisthesis from 40 (CI 3) to 22 (CI 3) and for DDD from 45 (CI 2) to 24 (CI 3). The results were retained over a five-year postoperative period. The percentage of dissatisfied patients varied from 5 % for disc herniation to 11 % for spinal stenosis.

DISCUSSION: Lumbar spine surgery provides significant improvement of health-related quality of life and function. The results presented may serve as benchmarking data for future studies.

O23

POTENTIALLY MODIFIABLE RISK FACTORS FOR LOW BACK PAIN IN ADULT POPULATION OF THE UNITED STATES

Haiou Yang, PHD Scott Haldeman, DC, MD, PhD; University of California, Irvine, Center for Occupational and Environmental Health University of California, Irvine, Department of Neurology, USA

INTRODUCTION: Low back pain (LBP) is a health problem with profound impact on individuals, business and society. Understanding of behavior-related factors for LBP could be of value for clinicians and policy makers as they are potentially modifiable. The goal of this study was to explore behavior-related factors for LBP in the US adult population, including leisure-time physical activity, sleep deprivation, tobacco use and obesity.

METHODS: The data for this study came from the 2009 to 2012 National Health Interview Survey (NHIS) which is a general health survey conducted in the US. LBP in NHIS was defined as non-specific Low back pain within the past three months. In order to account for the complex sampling design of the NHIS, the Taylor linearized variance estimation method in STATA 12 was used. Risk of LBP was estimated using multivariable logistic regression. The analysis included 122, 345 adults, aged 18 to 85.

RESULTS: Compared with those who were inactive, those who engaged in regular physical at leisure-time (OR 0.83, CI 0.80, 0.86) were less likely to have LBP. Compared with the life-time non-smokers, current regular smokers (OR 1.72, CI 1.63, 1.80) and former smokers (OR 1.35, CI 1.29, 1.40) were more likely to have LBP. Compared with those who had 7-8 hours of sleep, those who slept 3-4 hours (OR 2.85,
CI 2.58, 3.15) and those who slept 5-6 hours per 24 hours (OR 1.50, CI 1.45, 1.56) were more likely to have LBP. Those who were obese (OR 1.44, CI 1.38, 1.50) and those who were overweight (OR 1.14, CI 1.10, 1.19) had a limited increased risk for LBP.

**DISCUSSION:** This study identified a number of behavioral factors associated with LBP in the adult population of the US. Although it is still unclear that they were risk factors, comorbidities or prognostic factors for LBP, the findings of this study have important policy and clinical implications in reducing LBP prevalence and counseling LBP patients. This study also supports future longitudinal research.

**O24**

**EARLY IMAGING IN OLDER ADULTS WITH BACK PAIN IS ASSOCIATED WITH NO IMPROVEMENT IN BACK-RELATED DISABILITY BUT INCREASED RESOURCE UTILIZATION: AN OBSERVATIONAL STUDY**

**JG Jarvik, LS Gold, BA Comstock, PJ Heagerty, SD Rundell, JA Turner, AL Avins, Z Bauer BW Bresnahan, JL Friedly, K James, L Kessler, SS Nedeljkovic, DR Nerenz, X Shi, SD Sullivan, L Chan, JM Schwabl, RA Deyo;**

*Univ of Washington, Seattle; Brigham and Women’s Hospital, Harvard Vanguard Med Assoc, Boston; Henry Ford Hospital, Detroit; Northern California Kaiser-Permanente, Oakland; NIH, Bethesda; Oregon Health and Science Univ, Portland*

**INTRODUCTION:** Most back pain guidelines exempt older adults from imaging constraints. However, early imaging may precipitate unnecessary interventions that do not improve outcomes. Our goal was to compare 12-month function, pain, and resource utilization among older adults who do versus do not receive “early imaging” (within 6 weeks) after a new primary care visit for back pain without radiculopathy.

**METHODS:** We enrolled 5,239 patients 65 years and older with a new primary care visit for back pain with no prior spinal surgery or recent cancer. Our main outcomes were back-related disability measured by the Roland-Morris Disability Questionnaire (RMDQ) at 12 months and cumulative 12-month back-related health-care utilization measured in relative value units (RVUs). We performed propensity score matching of demographic and clinical characteristics, including baseline diagnosis, pain severity, pain duration, functional status, and prior health care utilization.

**RESULTS:** We matched 1,174 patients who had early radiographs and 349 who had early MRI/CT 1:1 to controls without early imaging. The early radiograph and control groups did not differ significantly at baseline: RMDQ (mean [standard deviation] = 10.5[6.0] vs. 10.3[6.3], respectively; P=0.49). At 12 months, the early radiograph group and controls did not differ significantly on the primary disability outcome (RMDQ = 8.54[6.56] vs. 8.74[6.95] respectively; P=0.36), but the mean cumulative RVUs were 30% higher in the early radiograph group than in the control group (Overall RVUs = 71.0[152] vs. 49.1[91.6] respectively; P=0.0004). Of the patients who underwent early imaging, 1/1,630 (0.06%) had a new diagnosis of cancer.

**DISCUSSION:** Older adults undergoing early imaging for back pain do not experience improved patient-reported outcomes but incur greater healthcare resource utilization.

**O25**

**THE ASSOCIATION OF DIFFERENT SPORT ACTIVITIES WITH LUMBAR DISC DEGENERATION AMONG YOUNG FINNISH ADULTS – A SUBSAMPLE OF NORTHERN FINLAND BIRTH COHORT 1986**

**Jani Takatalo, MD, MSc1, Jaro Karppinen, MD, PhD1,2, Joakko Niinimäki, MD, PhD3, Roberto Blanco Sequeiros, MD, PhD3, Simo Näyhä, MD, PhD4, Juha Auvinen, MD, PhD4;**
INTRODUCTION: The role of different kind of sport activities in lumbar intervertebral disc degeneration (DD) is largely unknown in younger populations. We evaluated whether participation in different sport activities is associated with lumbar DD in general population of young adults.

METHODS: The study population consisted of 558 young adults (325 females and 233 males) who at a mean age of 21 years underwent magnetic resonance imaging (1.5-T scanner). Pfirrmann grading was used in the evaluation of lumbar DD and a sum score of DD was calculated for all five and three lowest levels. The sum score was categorized into no DD, 1–2 or at least 3. The data on participating in different sport activities was based on postal surveys at 16, 18 and 19 years and data was categorized into three activity levels for each sport: 1) high level activity (at least twice a week), 2) moderate level activity (2 to 4 times a month), and 3) low level of activity (at most once a month). The associations (OR and 95% CI) of DD with the different sports were analysed using multinomial logistic regression adjusting with body mass index, gender, socioeconomic status and other sport activities.

RESULTS: Of the subjects, 257 (46%) had no DD, 210 (38%) had a sum score of 1–2, and 91 (16%) a sum score of at least 3. Active participation in running and swimming were associated with DD sum score of at least 3 (OR 3.1; CI 1.3–7.0 and 3.0; 1.2–7.3 for all lumbar levels, respectively, and 2.8; 1.1–6.9 and 3.6; 1.4–9.3 for three lowest lumbar levels, respectively). Moreover, active participation in running was associated with DD sum score of 1–2 at all levels and the three lowest levels (OR 2.7; CI 1.4–5.3 and OR 2.2; CI 1.1–4.4, respectively). None of the sport activities had protective effect on lumbar DD.

DISCUSSION: Running and swimming at least two times a week in early adulthood may be linked to lumbar DD.

O26

EFFICACY OF ANTI-RANKL ON THE SENSORY NERVIOUS SYSTEM IN A RAT MODEL OF LUMBAR INTERVERTEBRAL DISC INJURY

Masashi Sato(1), Seiji Ohtori(1), Yoshihiro Sakuma(2), Sumihisa Orita(1), Kazuyo Yamauchi(1), Go Kubota(1), Yasuhiro Oikawa(3), Kazuhide Inagel(1), Takeshi Sainoh(1), Jun Sato(1), Kazuki Fujimoto(1), Yasuhiro Shiga(1), Koki Abe(1), Hiroto Kanamoto(1), Kazuhisa Takahashi(1);
(1) Dept. of Orthopaedic Surgery, Graduate School of Medicine, Chiba University (2) Department of Orthopaedic Surgery, National Hospital Organization, Chiba Medical Center (3) Department of Orthopaedic Surgery, Teikyo University Chiba Medical Center, Chiba, Japan

INTRODUCTION: The pathological mechanisms underlying pain from lumbar-disc degeneration have not been fully elucidated. Nuclear factor-kappa B (NF-kB), RANK (a receptor activator of NF-kB), and RANK ligand (RANKL) are transcriptional regulators of inflammatory cytokines. We have reported that RANKL expression in dorsal root ganglion (DRG) neurons are elevated in a rat intervertebral disc degeneration model. The purpose of this study was to evaluate the effect of anti-RANKL antibody on sensory nerves in injured intervertebral discs.

METHODS: Using a rat model, we labeled DRG neurons innervating L5/6 discs with FluoroGold (FG) neurotracer. Twelve rats underwent intervertebral disc puncture using a 23-gauge needle (puncture group), and 6 rats underwent sham surgery (non-puncture group). The injury group was subdivided into a 10 μl saline infusion group
(puncture + saline group) and a RANKL inhibition group, injected with 10 μl of anti-RANKL antibody (puncture + anti-RANKL group); n = 6 per group. Seven days post-surgery, DRGs from L1 to L6 were harvested, sectioned, and immunostained for CGRP (inflammatory pain marker), and the proportion of CGRP-immunoreactive (ir) DRG neurons of all FG-positive neurons was evaluated.

RESULTS: The ratio of CGRP-ir DRG neurons to total FG-labeled neurons innervating intervertebral discs from L1 to L5 in the puncture + saline group significantly increased (58.5%) compared with the non-puncture group (31.9%; \( p < 0.05 \)). However, application of RANKL antibody into the disc significantly decreased the ratio of CGRP-ir DRG neurons to total FG-labeled neurons after disc puncture (puncture + saline: 58.5%, puncture + RANKL: 42.9%; \( P < 0.05 \)).

DISCUSSION: CGRP expression in disc-innervating DRG neurons increased after disc puncture. However, anti-RANKL antibody suppressed the expression of CGRP in DRG neurons innervating the discs. Anti-RANKL antibody can be a therapeutic target for pain control in patients with lumbar disc degeneration.

O27
THE EFFECTS OF HUMAN UMBILICAL CORD WHARTON’S JELLY CELLS TRANSPLANTATION ON THE INTERVERTEBRAL DISC IN A CANINE DISC DEGENERATION MODEL
Dike Ruan, M.D.1,§, Yan Zhang, M.D.1,2, Hui Tao, M.D.1,3, Tao Gu, M.D.1, Mingyue Zhou, M.D.1, Zhiwei Jia, M.D. 1, Gangqiang Jiang, M.D.1, Chun Chen, M.D.1, Zhihua Han, M.D.1, Cheng Xu, M.D.1, Deli Wang, M.D.1, Qing He, M.D.1;
1 Department of Orthopedic Surgery, Navy General Hospital, Beijing, China. 2 Department of Orthopedic Surgery, Navy Clinical Medical College, The Second Military Medical University, Beijing, China. 3 Department of Spine Surgery, The First Affiliated Hospital of Anhui Medical University, Hefei, Anhui, China.

INTRODUCTION: Current treatment for DDD is usually limited to conservative and invasive care which aims to relieve symptoms but fail to halt the process of IVD degeneration. So, it is of great significance to develop novel technologies to manage IVD degeneration. The aim of this study was to investigate survival and function of Wharton’s jelly cells (WJCs) after transplantation into degenerated canine IVDs.

METHODS: WJCs were isolated and labeled with EGFP. The degeneration of lumbar discs (L4-5/L5-6/L6-7) of 18 mature beagles was induced by aspirating the NP. 4 weeks after the operation, the injured discs were left to be no treatment at L4-5 (DS group), or injected with 0.9% saline at L5-6 (FS group), or transplanted with EGFP-labeled WJCs at L6-7 (TS group). In all animals, the intact disc L3-4 served as control group (CS group). The animals were followed up for 24 weeks after the initial operation.

RESULTS: Our results showed that the transplanted WJCs maintained the disc height and T2-weighted signal intensity compared with discs of DS and FS groups, and promoted the disc matrix formation. By tracking the fate of GFP-tagged WJCs, our results suggested that WJCs could survive up to 20 weeks in the degenerative IVD. Real-time PCR and immunohistochemistry demonstrated that expression of disc matrix genes, aggrecan, type II collagen, and SOX-9, were up-regulated in WJCs-transplanted discs compared to discs of FS and DS groups. Moreover, WJCs-transplanted discs showed a better spinal segmental stability than discs of FS and DS groups.

DISCUSSION: The results of this study indicated that the transplanted WJCs could survive in the canine degenerated IVDs. The transplantation of WJCs into IVDs maintained the disc height, enhanced T2-weighted signal intensity, and promoted the disc matrix formation. Thus, this study suggested that the WJCs could serve as a
valuable cell resource to promote regeneration of IVDs in cell transplantation therapy.

O28
ASSOCIATION AND FUNCTIONAL ANALYSIS OF ADAMTS5 IN LUMBAR DISC DEGENERATION
Yan Li 1, Patrick Kao2, Ming Shum Yip2, Kit Ling Sze2, Amanda Fosang2, Daniel McCulloch2, Kenneth M.C. Cheung3, Dino Samartzis3, Keith D.K. Luk3, Jaro Karppinen5,6, Song Youqiang2, Kathryn Cheah2, Pak C. Sham 1,4, and Danny Chan2*

1. Department of Psychiatry, The University of Hong Kong, Hong Kong, SAR, China 2. Department of Biochemistry, The University of Hong Kong, Hong Kong, SAR, China 3. Department of Orthopaedics and Traumatology, The University of Hong Kong, Hong Kong, SAR, China 4. Centre for Genomic Sciences, The University of Hong Kong, Hong Kong, SAR, China 5. Medical Research Center Oulu, University of Oulu and Oulu University Hospital, Oulu, Finland 6. Finnish Institute of Occupational Health, Health and Work Ability, and Disability Prevention Centre, Oulu, Finland

INTRODUCTION: Lumbar disc degeneration (LDD) is a polygenic disease with heritability up to 77%. A number of candidate genes have been reported to be associated with LDD, including extracellular matrix proteins, matrix degradation enzymes and pro-inflammatory cytokines. Based on our current understanding of disc biology and the degenerative process, we selected 31 new candidate genes with a total of 170 single nucleotide polymorphisms (SNPs) and tested their associations with LDD in a Southern Chinese cohort.

METHODS: Sagittal T2-weighted lumbar MRI was assessed in 2,883 Southern Chinese volunteers. Disc signal intensity loss was scored using the Schneiderman classification. Variant-based association tests were performed. The effects of age, sex, BMI, workload, smoking pack-years were adjusted. Transgenic mice were created for functional validation. Histology and immunostaining were used to assess disc changes in wild type and transgenic mice.

RESULTS: Variant-based association tests showed that a SNP (rs229077) on ADAMTS5 was the most significant (p=0.0029). However, none of the studied SNPs remained significant after Bonferroni correction. Interestingly, ADAMTS5 was significant with Bonferroni correction in a subgroup of subjects older than 40 years (p=8.46E-05). The enhanced activity of ADAMTS5 in disc tissues of transgenic mice showed distinct changes in the nucleus pulposus (NP) consistent with degeneration with an up-regulation of asporin (ASPN).

DISCUSSION: This study confirmed ADAMTS5 as a genetic risk factor for LDD. The age-dependent association suggests an association with late-onset LDD. ADAMTS5 is involved in the degradation of aggrecan, the major proteoglycan in the NP, and the degenerative changes in ADAMTS5 transgenic mice with enhanced activity are consistent with this relationship. The associated increase in ASPN expression suggests a potential link between these two genetic risk factors that potentiate the degenerative process once activated.

O29
CIRCULATING CCL5/RANTES: A POTENTIAL BIOMARKER FOR HUMAN INTERVERTEBRAL DISC DEGENERATION
(1,2) Sibylle Grad, (3) Cora Bow, (2,4) Jaro Karppinen, (2,3) Kenneth MC Cheung, (2,3) Dino Samartzis, (1,2) Mauro Alini;

1) AO Research Institute, Davos, Switzerland; (2) AOspine Research Network, Davos, Switzerland; (3) Department of Orthopaedics and Traumatology, The University of Hong Kong, Hong Kong; and the (4) Medical Research Center Oulu, University of Oulu and Oulu University Hospital, Oulu, Finland

INTRODUCTION: Clinical studies have shown that moderate to severe lumbar
disc degeneration (DD) on MRI increases the risk of developing low back pain and its severity. The pro-inflammatory chemokine CCL5/RANTES is released by degenerative discs and has been associated with discogenic back pain. As such, this study addressed if circulating CCL5/RANTES may be increased in subjects with DD compared to physiological concentrations in individuals with no DD.

**METHODS:** Based on the Hong Kong Disc Degeneration Population-Based Cohort of Southern Chinese, a case-control study was performed. DD profile was based on T2W sagittal MRI. Plasma samples were obtained from peripheral blood of subjects who were noted on MRI to have no DD (Group 1: n=40; DDD score =0) and compared to those with moderate to severe DD (Group 2: n=40; DDD score >5). All cases were matched for age, sex, body mass index (BMI), and workload. Concentrations of CCL5/RANTES were measured using ELISA.

**RESULTS:** Females accounted for 65% in both groups. The mean ages for Group 1 and 2 were, 49.2 years and 49.5 years (p=0.853), respectively. The mean BMIs for Group 1 and 2 were 23.3 kg/m2 and 23.4 kg/m2, respectively (p=0.885). CCL5/RANTES plasma concentrations were significantly increased in Group 2 subjects (mean: 19.8 ng/mL; 95% CI: 14.7-25.0 ng/mL) compared to Group 1 control subjects (mean: 12.8 ng/mL; 95% CI: 10.3-15.2 ng/mL) (p=0.023).

**DISCUSSION:** This is the first study to note that elevated systemic levels of CCL5/RANTES are associated with moderate to severe stages of lumbar DD in humans. The findings suggest that this chemokine may be released from affected discs into the circulation during the degenerative process. Serological tests have several advantages among diagnostic tools; they are non-invasive, simple, convenient, quantitative and reproducible. CCL5/RANTES may therefore be considered as a systemic molecular biomarker for the diagnosis and monitoring of clinically –relevant disc pathology.

**O30 ALLOGENEIC MESENCHYMAL STEM CELLS IMPROVE INDICES OF LUMBAR INTERVERTEBRAL DISC DEGENERATION WITHOUT SITE SPECIFICITY OF INJECTION IN AN OVINE MODEL**

Brian J C Freeman (1,2,3), Mohammad R Zarrinkalam (2,3), Julia S Kuliwaba (2,3), Claire F Jones (2,3), Cindy C Shu (4), Christopher J. Colloca (5), James Melrose (4), Adnan Mula-ibrahimovic (2,3), Stan Gronthos (6), Andrew C W Zannettino (6), Stuart Howell;

1. Department of Spinal Surgery, Royal Adelaide Hospital, Adelaide, Australia. 2. Adelaide Centre for Spinal Research, SA Pathology, Adelaide, Australia. 3. Centre for Orthopaedic and Trauma Research, University of Adelaide, Australia. 4. Kolling Institute of Medical Research, Royal North Shore Hospital, University of Sydney, Sydney, Australia. 5. College of Health Solutions, Arizona State University, Phoenix, Arizona, USA. 6. South Australian Health and Medical Research Institute, Adelaide, Australia. 7. Data Management and Analysis Centre, University of Adelaide, Adelaide.

**INTRODUCTION:** Previous studies assessing the efficacy of stem cell injection into degenerated intervertebral discs (IVD) have reported positive findings. This study utilized an in-vivo ovine model of IVD degeneration to determine if allogeneic mesenchymal stem cells (MSCs) delivered to the NP or the annulus fibrosus (AF) would lead to improved indices of disc health.

**METHODS:** MSCs were obtained from 8-week-old sheep and culture expanded for 4 passages. IVD degeneration was induced by postero-lateral annulotomy at three lumbar levels in eight 2-year-old sheep. Six months later, each degenerated IVD was randomized to one of three treatments: Injection of MSC into i) previously incised
AF (AFI) or ii) into NP (NPI); or iii) no injection (negative control, NC). The superior adjacent (normal) IVD received an injection of phosphate buffered saline only (positive control, PC). Radiographs and magnetic resonance image (MRI) scans were obtained at baseline, 6, 9, and 12 months to determine disc height index (DHI), disc height (DH) and grade of degeneration grade. Discs were harvested at 12 months for biochemical (glycosaminoglycan and hydroxyproline content) and histological analysis (disc degeneration grade).

RESULTS: IVD degeneration was consistently observed at 6 months in the 24 discs that underwent postero-lateral discectomy. This was characterized by reduced DHI, DH and increased disc degeneration grade (Fig a upper). Six months following stem cell injection both DHI and DH had recovered in the NPI and AFI groups. Mean Pfirrmann grade improved from 3.25 to 2.67 in AFI group and from 2.96 to 2.43 in NPI group. Mean histopathological grade improved in both NPI and AFI (Figure b lower) groups compared to NC group. No significant differences were noted in disc biochemistry.

DISCUSSION: In this ovine model, injection of allogeneic MSCs into the AF or the NP of degenerated IVD resulted in significant improvements in disc health (DHI, DH and grade of disc degeneration).

O31 UTE MRI DISC SIGN (UDS): A NOVEL IMAGING BIOMARKER ASSOCIATED WITH SPINE DEGENERATION, PAIN AND DISABILITY

(1) Department of Orthopaedics and Traumatology, The University of Hong Kong, Hong Kong; (2) Department of Diagnostic Radiology, The University of Hong Kong, Hong Kong; (3) CMROI, Department of Radiology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania, USA; (4) Medical Research Center Oulu, University of Oulu and Oulu University Hospital, Oulu, Finland; and (5) RUSH University Medical Center, Chicago, Illinois, USA; (6) Department of Orthopaedics, Xijing Hospital, Fourth Military Medical University, Xi’an, China

INTRODUCTION: Disc degeneration is assessed by T2-weighted (T2W) MRI based on signal intensity. This method however does not consistently correspond to histological and clinical profiles. Ultra-short time-to-echo (UTE) MRI assesses short T2 components (i.e., “invisible” tissue on T2W), and has been primarily used to detect endplate defects. Our group identified a new imaging biomarker on UTE - the “UTE Disc Sign (UDS)” (Fig. 1). This study aims to assess UDS prevalence, association with disc degeneration and other MRI phenotypes as well as pain/disability profiles.

METHODS: 76 Southern Chinese subjects were recruited (51.3% male; mean age: 50.6 years) for T2W, T1-rho and UTE MRI of the lumbar spine (n=380 discs). T2W MRI was used to assess disc degeneration and other phenotypes, and T1-rho MRI was implemented to obtain quantitative proteoglycan disc profiles. UDS was detected on UTE as a hyper- or hypo-intense band across a disc (Fig. 1). Subject demogra-
RESULTS: The UDS was noted in 25% subjects (57.9% males; mean age: 52.6 years). 80% UDS occurred at the lower lumbar levels (L3-S1). 26.3% had multi-level UDS. Subjects with UDS had significantly more disc degeneration, disc displacement, spondylolisthesis, and Modic changes (p<0.001). T1-rho values were lower in UDS discs than non-UDS discs (p=0.022). The majority of UDS could not be detected on T2W MRI. 88% of UDS individuals had LBP. Number of UDS disc levels significantly correlated with worse ODI scores (r=0.303; p=0.013), whereas traditional T2W degenerative grading did not (r=0.234; p=0.057).

DISCUSSION: This is the first study to report “UDS” in humans. UDS is a novel imaging biomarker highly associated with spine degeneration and a negative clinical profile. UDS serves as a new phenotype that broadens our understanding of degenerative disc changes and may have potential clinical utility.

O32

CAN THE CLINICIAN ACCURATELY APPRAISE THE SEVERITY AND IMPACT OF A PATIENT’S BACK PROBLEM DURING THE CLINICAL CONSULTATION?

Zaina F (1), Mutter U (2), Donzelli S (1), Lusini M (1), Kleinstueck FS (2), Minnella S (1), Negrini S (3)(4), Mannion AF (2);

(1) ISICO (Italian Scientific Spine Institute), Milan, Italy (2) Spine Centre, Schulthess Clinic, Zuerich, Switzerland (3) University of Brescia, Italy (4) IRCCS Don Gnocchi, Milan, Italy

INTRODUCTION: The main concerns of patients with back problems are pain and its impact on function and quality of life (Qol). These are subjective phenomena, and should be probed during the clinical consultation so that the physician can ascertain the extent of the problem, its impact on the patient’s life, and hence the most appropriate treatment. This study evaluated the agreement between clinician and patient ratings of the patient’s status on the main domains of the multidimensional Core Outcome Measures index (COMI).

METHODS: This was a two-centre international study involving 5 spine specialists (1 surgeon, 4 physicians) and 108 patients. Prior to the consultation, the patient completed the COMI and returned it to an independent investigator. After the consultation the clinician also completed a COMI, imagining the likely answer given by the patient, based on the preceding discussion and medical history taking. Concordance was assessed by % agreement, Kappa values and Spearman rank correlation coefficients.

RESULTS: Agreement between patient and doctor about the “main problem” (back pain, leg/buttock pain, or neurological disturbance) was 83%, Kappa=0.70 (95%CI 0.58-0.81). Moderate to strong correlations were found between the doctors’ and patients’ COMI-item ratings (back pain, 0.49; leg pain, 0.66; back pain minus leg
pain, 0.74; function, 0.63; symptom-specific well-being, 0.48; QoL, 0.58; all p<0.0001), although the doctors systematically underestimated leg pain (p=0.002) and overestimated symptom-specific well-being (p=0.002).

DISCUSSION: The doctors were able to ascertain the location of the main problem and the differential between back and leg pain with good accuracy, but systematically underestimated the severity of leg pain and the patient’s satisfaction with their current symptom state. More detailed questioning on these domains during the consultation might deliver a better impression of the impact of the back problem on the patient’s daily life.

**O33**

A COMPARISON OF SPINAL MANIPULATION METHODS AND USUAL MEDICAL CARE FOR LOW BACK PAIN: A RANDOMIZED CLINICAL TRIAL

*Michael Schneider *Mitchell Haas *Ronald Glick *Joel Stevans *Doug Landsittel; *Univer-sity of Pittsburgh, Pittsburgh, PA USA ^Uni-versity of Western States, Portland, OR USA

INTRODUCTION: This was a randomized-controlled trial with follow-up to 6 months. Design was a comparative effectiveness trial of: manual-thrust manipulation (MTM) versus mechanical-assisted manipulation (MAM); and manipulation versus usual medical care (UMC). Low back pain (LBP) is one of the most common conditions seen in primary care and physical medicine practice. MTM is a common treatment for LBP. Claims that MAM is an effective alternative to MTM have yet to be substantiated. There is also question about the effectiveness of manipulation in acute and sub-acute LBP, as compared to UMC.

METHODS: 107 adults with onset of LBP within the past 12 weeks were randomized to 1 of 3 treatment groups: MTM; MAM; or UMC. Outcome measures included the Oswestry LBP disability index (0 to 100 scale) and numeric pain rating (0 to 10 scale). Participants in the manipulation groups were treated twice weekly over 4 weeks; subjects in UMC were seen for 3 visits during this time. Outcome measures were captured at baseline, 4 weeks, 3 months and 6 months.

RESULTS: Linear regression showed a statistically significant advantage of MTM at 4 weeks compared to MAM (disability = -8.1, p = .009; pain = -1.4, p = .002) and UMC (disability = -6.5, p = .032; pain = -1.7, p < .001). Responder analysis, defined as 30% and 50% reductions in Oswestry scores revealed a significantly greater proportion of responders at 4 weeks in MTM (76%; 50%) compared to MAM (50%; 16%) and UMC (48%; 39%). Similar between-group results were found for pain: MTM (94%; 76%); MAM (69%; 47%); and UMC (56%; 41%). No statistically significant group differences were found between MAM and UMC, and for any comparison at 3 or 6 months.

CONCLUSIONS: MTM provides greater short-term reductions in self-reported disability and pain scores compared to UMC or MAM.

**O34**

COCCYGETOMY: A PROSPECTIVE, OBSERVATIONAL STUDY OF 98 PATIENTS

Hanley, Edward N, MD (1), Ode, Gabriella E, MD (1), Jackson, J. Benjamin, MD (2), Seymour, Rachel A, PhD (1);

1) Carolinas Medical Center, Department of Orthopaedic Surgery, Charlotte, NC, USA; 2) University of South Carolina, Department of Orthopaedic Surgery, Columbia, SC, USA

INTRODUCTION: Coccydynia is an uncommon and controversial condition. Coccygectomy, although reported as bene-ficial in some case series, has its skeptics. The purpose of this study is to prospectively
evaluate the outcomes of surgical management of chronic coccydynia.

**METHODS:** From 2007-2011, 98 pts underwent coccygectomy for chronic coccydynia. Included pts were over 18 years, had coccygeal pain and abnormality on physical and radiographic evaluation and had failed conservative management. Outcome measures were the Oswestry Disability Index (ODI), Visual Analog Scale (VAS) and the Short Form 36 (SF-36). Secondary analysis compared outcomes and baseline features of pts with successful and failed results at two years. Threshold for success was based on a minimum clinically important difference (MCID) on the ODI of 20 pts. All other subjects, including those lost to follow-up, were classified as failures.

**RESULTS:** Two years following coccygectomy, there was significant improvement in the ODI (22.8 pts) and VAS (38.8 pts) (p<0.0001) and in all 10 components of the SF-36 (p<0.05) [See Table].

<table>
<thead>
<tr>
<th>Comparison of Patient Characteristics and Outcomes of Coccygectomy Successes vs. Failures</th>
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<tr>
<td><strong>Patient Characteristics</strong></td>
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<td>Success Group (n=69)</td>
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<td>Failure Group (n=25)</td>
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<td>Steroid Injection Therapy Prior to Surgery</td>
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**Patient Outcomes**

| ODI ** | Baseline | 36.0 (31.2 - 40.9) | 44.8 (38.9 - 50.7) | * 0.0081 |
| 2 Year  | 8.12 (5.3 - 10.9) | 38.8 (33.2 - 44.3) | NS |
| VAS **  | Baseline | 55.7 (49.1 - 62.3) | 67.5 (60.5 - 74.6) | * 0.0159 |
| 2 Year  | 10.0 (5.0 - 15.0) | 48.6 (38.1 - 59.2) | * <0.0001 |

*Indicates statistically significant difference between groups

**O35**

**SACROILIAC JOINT SCORE AS A SIMPLE CLINICAL DIAGNOSTIC SUPPORT TOOL TO IDENTIFY PATIENTS WITH SACROILIAC JOINT DYSFUNCTION**

Daisuke Kurosawa 1), Eiichi Murakami 1), Hiroshi Ozawa 2), Kimiaki Koga 3), Toyohiko Isu 4), Yasuhiro Chiba 4), Eiji Abe 5), Eiki Unoki 5), Yoshiro Musha 6), Keisuke Ito 6), Shinsuke Kato 7), Toru Yoshida 8), Takuhiro Yamaguchi 9);

1) Department of Orthopaedic Surgery / Low Back Pain and Sacroiliac Joint Center, JCHO Sendai hospital 2) Orthopaedic Surgery, Tohoku University 3) Orthopaedic Surgery, Kikunou hospital, Kagoshima 4) Neurosurgery, Kushiro Rousai hospital 5) Orthopaedic Surgery?Akita Kosei medical center 6) Spine surgery center, Toho University Ohashi Medical center 7) Orthopaedic surgery and Rehabilitation, Tokushima University 8) Orthopaedic Surgery, Yoshida orthopaedic surgery hospital, Nagoya 9) Division of Biostatistics, Tohoku University Graduate School of Medicine

**INTRODUCTION:** Sacroiliac joint (SIJ) pain affects not only the back but also the buttock, groin, and lower extremities and may be difficult to discern from pain secondary to other lumbar disorders. We aimed to develop a simple clinical diagnostic tool that may help spine surgeons distinguish patients with SIJ dysfunction from those with lumbar disorders.
**METHODS:** We evaluated 62 patients with SIJ dysfunction and 59 patients with lumbar disorders (lumbar disc herniation and the lumbar spinal canal stenosis) treated at six hospitals. Patients with SIJ dysfunction were diagnosed definitively based on the achievement of pain relief greater than 70% after periarticular SIJ injection of a local anesthetic under fluoroscopic guidance. Patients with lumbar disorders were diagnosed definitively based on the postoperative improvement assessed by the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire. We investigated the SIJ-related physical characteristics for all patients. A score-based prediction rule for a final diagnosis was developed based on multivariable logistic regression equations of the physical findings.

**RESULTS:** Three items related to patient symptoms (pain involving the posterosuperior iliac spine (PSIS) detected by the one-finger test, groin pain, and pain by sitting) and three items related to the physical examination (modified Newton’s test, tenderness of PSIS, and sacrotuberous ligament) were included in the final scoring system (The SIJ score). An integer score derived from the coefficient and clinical experience was assigned to the identified risk factors (Table). The area under the ROC curve was 0.950. The SIJ score had a sensitivity of 90.3% and a specificity of 86.4%, if the positivity cutoff point was defined as 4. CONCLUSIONS: We developed SIJ score as a simple clinical diagnostic tool. The SIJ score can improve the accuracy of diagnosis, indication of operation for lumbogluteal and lower extremity pain, and the postoperative care.

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<th>Table Sacroiliac joint score</th>
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<tr>
<td>Characteristic</td>
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<td>1. One finger test</td>
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<td>2. Groin Pain</td>
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<td>3. Pain by sitting on the chair</td>
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<td>4. Modified Newton’s test</td>
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<td>5. Tenderness of posterosuperior iliac spine</td>
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<td>6. Tenderness of sacrotuberous ligament</td>
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**O36**

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

Cuellar, JM; Stauff, MP; Herzog, R; Carrino, JA; Baker, G; Carragee, EJ; University of Massachusetts Medical School Study performed at: Stanford University School of Medicine

**INTRODUCTION:** Provocative discography, an invasive diagnostic procedure involving disc puncture with pressurization, is a test for presumptive discogenic pain in the lumbar spine. The clinical validity of this test is unproven. Data from multiple animal studies confirm that disc puncture causes rapid disc degeneration. A recent study confirmed significant radiographic disc degeneration on MRI in human subjects exposed to provocative discography after 10 years. The clinical effect of this disc degeneration after provocative discography is unknown.

**METHODS:** Subjects (n = 75) without current low back pain problems were recruited to participate in a study of provocative discography at the L3 – S1 discs. A closely matched control cohort was simultaneously recruited to undergo a similar evaluation except for discography injections. Subjects were followed by serial protocol evaluations at 1, 2, 5 and 10 years after enrollment. Interval and cumulative adverse lumbar spine events were recorded. The primary outcomes were lumbar
O37
MONTHLY FLUCTUATIONS OF SURGICAL SITE INFECTIONS FOLLOWING ELECTIVE SPINAL SURGERY: A RETROSPECTIVE ANALYSIS USING THE JAPANESE DIAGNOSIS PROCEDURE COMBINATION DATABASE
Junichi Ohya, Hirotaka Chikuda, Yasushi Oshima, Yuki Taniguchi, Yoshitaka Matsubayashi, Yoh Kumano, Kentaro Hayakawa, Masayoshi Fukushima, Takeshi Oichi, Sakaie Tanaka;
Department of Orthopaedic Surgery, Faculty of Medicine, The University of Tokyo

INTRODUCTION: Little has been known about the effects of seasonality on surgical site infections (SSI) following spinal surgery. This study investigated the fluctuations of SSI following spinal surgery throughout the year.

METHODS: We abstracted data for patients who underwent elective spinal surgery from the Diagnosis Procedure Combination database, a nationwide administrative inpatient database in Japan. The age, sex, smoking status, body mass index (BMI), use of dialysis, diabetes mellitus, surgical site, surgical procedure, blood transfusion, duration of anesthesia and the month when spinal surgery was performed were extracted. SSI requiring surgical intervention was the primary outcome.

RESULTS: A total of 62,136 patients (36,887 males and 25,249 females; mean age, 64.6 years) were identified. The most common procedure was decompression surgery (31,184 patients; 50.2%), followed by fusion surgery (19,740; 31.8%), discectomy (9,223; 14.8%) and resection of a spinal cord tumor (1,989; 3.2%). The overall incidence of SSI requiring surgical intervention was 0.64% (396 of 62,136 cases) during hospitalization. The SSI rate was highest in May (0.80%) and lowest in December (0.44%). A multivariate analysis showed that SSI were associated with the BMI, smoking status, DM, blood transfusion, prolonged anesthesia, site of surgery, surgical procedure and the month of the year. Spinal surgeries performed in May (OR, 1.75; 95% confidence interval (CI), 1.03–2.99; p = 0.04), July (OR, 1.72; 95%CI, 1.02–2.88; p = 0.04) and September (OR, 1.84; 95%CI, 1.06–3.18; p = 0.03) had a higher risk of SSI compared with those in December.

DISCUSSION: This study revealed seasonal trends in SSI following spinal surgery. May and the summer months were associated with increased SSI, suggesting that SSI can be reduced by avoiding complex surgery in “high-risk” months. We believe that the findings of this study provide useful information regarding the risk of SSI following spinal surgery.

O38
THE EFFECT OF VANCOMYCIN POWDER ON BONE HEALING IN A RAT SPINAL ARTHRODESIS MODEL
Marco C. Mendoza MD, Kevin Sonn MD, Abhishek S. Kannan BS, Sharath Bellary MD, Sean M. Mitchell BS, Gurmit Singh BS, Christian Park BS, Chawon Yun PhD, Jonghwa Yun, Anjan
INTRODUCTION: Surgical site infections (SSIs) after spinal surgery occur in 1-10% of patients. Such complications are devastating to patients and the healthcare system. Staphylococcus aureus is the most common organism responsible for SSIs, and vancomycin powder has the potential to serve as a simple, cost-effective solution to the problem. Although in vitro studies suggest that vancomycin is cytotoxic to differentiating osteoblasts, the effect of vancomycin powder application on the rates of spinal arthrodesis has not been properly evaluated.

METHODS: Thirty-six female rats underwent a posterolateral lumbar spinal fusion at the L4 and L5 vertebrae. Fusion was elicited via implantation of an absorbable collagen sponge containing 3 mg rhBMP-2. Rats were divided into three groups: no vancomycin (control), standard dose vancomycin, and high dose vancomycin, which was applied to the fusion bed. Spines were harvested and evaluated at 8 weeks postoperative using radiographs, fusion scoring, microCT, and histologic analysis.

RESULTS: Qualitative radiographs demonstrated equivalent bridging bone formation in all groups. No significant differences in fusion scores were seen in the standard-dose (2.25) or high-dose (2.13) treatment groups relative to untreated control animals (1.78) (Figure 1-A). Similarly, fusion rates were not significantly different between vancomycin-treated animals (100% for both groups) and control animals (92%) (Figure 1-B). Quantification of new bone formation via microCT imaging revealed no significant differences in the volume of newly regenarated bone among groups (Figure 1-C).

DISCUSSION: This study demonstrates that vancomycin powder does not inhibit fusion rates at an equivalent wt% dose to what is routinely used by surgeons. Moreover, bone formation and fusion rates were not reduced even after administration of a vancomycin dose that is ten-fold higher than which is typically administered clinically.
with incidental durotomy, as well as total hospital charges and costs, as well as length of stay.

RESULTS: A total of 17,232 cases were identified, of which 801 had an incidental durotomy (rate 4.65%). The rate of dural tears in teaching hospitals (5.09%) was significantly higher compared to non-teaching hospitals (4.19%) [p=0.006]. Multivariate regression analysis revealed that the odds-ratio getting a dural tear increased by 2% with each year of increasing age. Durotomy was associated with a 1.40-day increase in hospital stay, $10,885 increase in total hospital charges, and a $3,873 increase in estimated total costs [compared to no durotomy group with p<0.0001]. While durotomy was associated with increased neurological complication, length of stay was the main driver of cost, deep vein thrombosis/pulmonary embolus, and cardiac complications.

DISCUSSION: Durotomy during short level posterior lumbar fusion is associated with significant increased cost and length of stay. Length of stay was an independent driver of cost and complications suggesting that better durotomy closure and early mobilization might ameliorate the disadvantages of a durotomy.

O40

EFFECT OF OBESITY ON COMPLICATIONS OF SPINAL SURGERY RELATED TO MECHANICAL FACTORS INCLUDING RE-OPERATION RATE AND ADJACENT SEGMENT DISEASE.

Michael A. Flippin, MD(1); Jason Chen, MA(1); Jessica Harris, MS, RD(1); Donald C Fisthian, MD(1); Samuel R. Ward, PhD, PT(3); Sara P. Gombatto, PhD, PT(2);

1-Kaiser Permanente of Southern California, San Diego, CA 2-San Diego State University, San Diego, CA 3-University of California San Diego, San Diego, CA

INTRODUCTION: Obesity has been identified as a factor that negatively influences surgical outcomes, however, its impact on outcomes after lumbar spine surgery is debated. The purpose of this study is to examine the influence of Body Mass Index (BMI) on the relative risk of mechanical complications after spinal surgery-including re-operation rate and adjacent segment disease.

METHODS: A retrospective cohort study was conducted using a spine registry from a large integrated healthcare organization. All instrumented lumbar spine surgical cases were identified (1/2009-9/2013), excluding cases of infection and trauma. The effect of BMI (30,25-29,<25 kg/m2) on reoperations and adjacent segment disease-related reoperations was examined. Logistic regression was used to estimate the odds ratios (OR) and 95% confidence intervals (CI), and age, gender, diabetes status, smoking status, admitting diagnosis, and surgical approach were included as covariates.

RESULTS: Among the 8,118 cases (61.3±12.9y, 42.3% male), 24% had a BMI<25, 38% 25-30, and 37% >30 kg/m2, mean follow-up time was 2.1±1.4y, and 11.1% of cases were lost to follow-up. After adjusting for covariates, patients with obesity were more likely to require reoperation than patients with BMI <25 (Fig1, P=0.019). Reoperation rate for obese patients (BMI>30) was 9.9%, compared to 8.7% for patients with normal weight (BMI<25). Reoperation rate due to ASD specifically was higher for obese patients (3.2%), than patients with normal weight (BMI <25) (2.9%), but this did not achieve statistical significance (Fig1, P=0.089). Of re-operation cases due to ASD, re-operation was required within 2 years in 70.8% of obese patients versus 58.9% for patients with BMI<25.

DISCUSSION: Obesity (BMI>30) is a risk factor for reoperation after lumbar spine
surgery. Future research should consider the risks associated with different distributions of body mass, and measure other health-related, surgical, pain and functional outcomes.

**O41**

**PROSPECTIVE MULTICENTER SURVEILLANCE AND RISK FACTOR ANALYSIS OF DEEP SURGICAL SITE INFECTIONS AFTER LUMBAR LAMINECTOMY AND/OR HERNIOTOMY IN ADULTS**

Satoshi Ogihara 1), Takashi Yamazaki 2), Toru Maruyama 3), Hiroyuki Oka 4), Hirohiko Inanami 5), Kota Miyoshi 6), Seiichi Azuma 7), Taka shi Yamada 8), Hirotaka Chikuda 9), Motoaki Murakami 10), Naohiro Kawamura 11), Kiyohumi Yamakawa 12), Yasushi Oshima 9; 1)Department of Orthopaedic Surgery, Sagamihara National Hospital, Kanagawa, Japan 2)Department of Orthopaedic Surgery, Musashino Red Cross Hospital, Tokyo, Japan 3)Department of Orthopaedic Surgery, Saitama Medical Center, Saitama Medical University, Saitama, Japan 4)Department of Joint Disease Research, 22nd Century Medical and Research Center, the University of Tokyo, Tokyo, Japan 5)Department of Orthopaedic Surgery, Iwai Orthopaedic Hospital, Tokyo, Japan 6)Department of Orthopaedic Surgery, Yokohama Rosai Hospital, Kanagawa, Japan 7)Department of Orthopaedic Surgery, Saitama Red Cross Hospital, Saitama, Japan 8)Department of Orthopaedic Surgery, NTT Kanto Hospital, Tokyo, Japan 9)Department of Orthopaedic Surgery, Faculty of Medicine, University of Tokyo, Tokyo, Japan 10)Department of Orthopaedic Surgery, Toranomon Hospital, Tokyo, Japan 11)Department of Spine and Orthopaedic Surgery, Japanese Red Cross Medical Center, Tokyo, Japan 12)Department of Orthopaedic Surgery and Musculoskeletal Oncology, Tokyo Metropolitan Komagome Hospital, Tokyo, Japan 13)Department of Orthopaedic Surgery, Sanraku Hospital, Tokyo, Japan

**INTRODUCTION:** Surgical site infection (SSI) is a serious and significant complication after spinal surgery, and it is associated with high morbidity rates, high healthcare costs, and poor patient outcomes. The accurate identification of risk factors is essential for developing strategies to prevent devastating infections. The purpose of this study was to identify independent risk factors for SSI in adults undergoing posterior lumbar spinal decompression surgery using a prospective, multicenter, surveillance research method.

**METHODS:** From July 2010 to June 2013, we performed a prospective surveillance study in adult patients who had developed SSI after undergoing lumbar laminectomy and/or herniectomy at 12 participating hospitals. Patients who underwent lumbar fusion surgery were excluded. Detailed preoperative and operative patient characteristics were prospectively recorded using a standardized data collection form. Identification of SSI was based on the Centers for Disease Control and Prevention definition. Data were analyzed using multi-variable regression analysis with P <0.05 set as the significance level.

**RESULTS:** A total of 2,622 consecutive adult patients were enrolled, of whom 23 (0.88%) developed postoperative surgical site infections (8 superficial and 15 deep SSI). Multivariate regression analysis indicated 3 independent factors: long operative time (P = 0.039) was a statistically significant independent risk factor for developing SSI, while surgery using endoscopes (P = 0.036) and surgery using bioclean rooms (P = 0.049) were statistically significant independent protective factors against developing SSI.

**DISCUSSION:** Long operative time was an independent risk factor, and surgery using endoscopes and surgery using bioclean rooms were independent protective fac-
tors for SSI after lumbar laminectomy and/or herniotomy in adult patients. Identification of these correlating factors for SSI could be used to develop protocols to decrease the risk of SSI.

O42
CHARACTERISTICS OF OSTEOPOROTIC BACK PAIN WITHOUT FRACTURE
Department Orthopedic Surgery, Graduate School of Medicine, Chiba University

INTRODUCTION: Back pain sometimes affects patients with osteoporosis even if there is no obvious fracture, but its nature and mechanism are unknown. Animal models have shown that inflammatory cytokines lead to osteoclast differentiation and sensory nerve sensitivity. Bisphosphonates generally suppress activation of osteoclasts, and result in pain relief. The purpose of this study was to clarify the reasons for back pain by examining the effect of minodronic acid in a multi-center study.

METHODS: Eighty-three patients with low back pain associated with osteoporosis but without lower extremity symptoms were evaluated. Patients were administered 50mg per month orally minodronic acid hydrate for 6 months. The therapeutic effect was measured initially and after one month by serum TRACP-5b, a marker of osteoclast activity. Bone mineral density (BMD) was measured initially and after 4 or 6 months by DXA. A Numerical Rating Scale (NRS) was used to assess back pain in motion and at rest, and pain DETECT, a tool used to determine pain caused by inflammation or neuropathy was used to evaluate pain quality initially and after 1 month and 4 or 6 months.

RESULTS: TRACP-5b was reduced significantly after 1 month (499.7 → 309.4) (P<0.05), but BMD did not improve after 6 months (P>0.05). After 6 months, there was no significant improvement in back pain assessed by NRS at rest, but there was a significant improvement in back pain during movement (P<0.05). Pre-treatment assessment using pain DETECT indicated that 86.3% of the pain was from inflammation, 3.8% was neuropathic pain, and 10% was of mixed type. There was no significant change in these values after 6 months (P>0.05).

DISCUSSION: This study revealed that osteoporotic pain was mostly caused by inflammation. BMD did not change, but bone turnover was suppressed by minodronic acid. Reduced back pain during movement may suggest that inflammation associated with osteoclast activity sensitizes sensory nerves in bone.

O43
WHAT MRI FINDINGS PREDICT PSEUDARTHROSIS OF OSTEOPOROTIC VERTEBRAL FRACTURE? – A MULTICENTER PROSPECTIVE COHORT STUDY BETWEEN 2012 AND 2014
Shinji Takahashi 1, Masatoshi Hoshino 1, Hiromitsu Toyoda 1, Tadao Tsuji, Kazumichi Iseki, Kazushi Takayama, Ryuchi Sasaoka, Hiroyuki Yasuda, Fumiaki Kanematsu, Hiroshi Kohno, Ryuchi Nagayama, Hiroaki Nakamura;
1 Osaka city university, 2 Shiraniwa hospital, 3 Satou hospital, 4 Seikeikai hospital, 5 Yodogawa Christian hospital, 6 Osaka tetsudou hospital, 7 Saiseikai Nakatsu hospital, 8 Ishikiri Seiki hospital, 9 Saiseikai Senri hospital

INTRODUCTION: Osteoporotic vertebral fracture (OVF) causes significant pain and disability in elderly population. In particular, patients with pseudarthrosis of OVF often needs surgical treatments. However, it generally takes more than 6 months to make a diagnosis of pseudarthrosis. Few papers reported the predictive factors by magnetic resonance imaging (MRI), although the factors showed insufficient
accuracy. Our purpose was to evaluate the predictive value of MRI findings for pseudarthrosis in patients with OVF.

METHODS: This was a prospective cohort study in which 11 hospitals participated. Patients who were older than 65 years and developed OVF within 2 weeks were enrolled. Temporal MRI and x-rays were taken at enrollment, 1st month, 3rd month, 6th month and 12th month. Pseudarthrosis was diagnosed if MRI showed fluid or gas filled cleft and fractured vertebral showed mobility in x-rays between supine and standing erect position after 6th month. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for prediction of pseudarthrosis were calculated.

RESULTS: Fifty-six patients were followed-up more than 6 months and 25 patients of those completed the 12 months follow-up. Fifteen patients (27%) had pseudarthrosis. The natural course of OVF were shown in figure. The MRI findings which showed highest accuracy for predicting pseudarthrosis were confined high intensity or diffuse low intensity in T2 weighted-image (WI) at 3rd month. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were 87%, 95%, 87% and 95%, respectively.

DISCUSSION: Confined high intensity and diffuse low intensity in T2WI at 3rd month was able to predict pseudarthrosis in OVF with high accuracy. This can be easily introduced into clinical practice to determine the way of treatments for OVF.

O44

EFFECT OF TERIPARATIDE ON SUBSEQUENT VERTEBRAL FRACTURE FOLLOWING LONG INSTRUMENTED FUSION SURGERY FOR OSTEOPOROTIC VERTEBRAL COLLAPSE

Keishi Maruo, Toshiya Tachibana, Shinichi Inoue, Fumihiro Arizumi, Shinichi Yoshiya;

Department of Orthopaedic Surgery, Hyogo College of Medicine

INTRODUCTION: Vertebroplasty (VP) or kyphoplasty have been reported as effective treatments for persistent painful osteoporotic vertebral compression fractures though these procedures increase the risk of new vertebral fracture. Vertebroplasty with posterior spinal fusion (PSF) often requires osteoporotic vertebral collapse (OVC) with neurological deficits. Teriparatide has been reported to decrease the risk of new vertebral fracture. The objective of this study was to assess the incidence and effect of teriparatide on subsequent vertebral fracture following long instrumented fusion surgery for OVC.

METHODS: A total of 47 patients who underwent VP with PSF (> 3 levels) for OVC were included. The mean age was 76 years (range: 58-88) with 20 males. The mean follow-up period was 23 months (range: 12-59). The types of surgery included VP with PSF in 36 cases, other type in 11 cases. The average of fused vertebrae was 4.9 (range: 3-7). Teriparatide was used in 19 patients. The occurrence of subsequent vertebral fracture was estimated by Kaplan-Meier analyses. Risk factors were evaluated using a Cox proportional hazards model.

RESULTS: The overall occurrence of subsequent vertebral fracture was 21% at 1 year and 32% at 2 years. The median time of vertebral fracture from index surgery was 4 months. A higher rate of subsequent vertebral fracture was observed with the non-teriparatide group. There was no significant difference in age, fused levels, presence of prevalent fracture, or correction loss between with and without teriparatide administration. The occurrence of subsequent vertebral fracture was lower in the teriparatide group (P=0.031). Cox proportional hazard model revealed use of teriparatide is only a protective factor of
subsequent vertebral fracture after surgery for OVC (Hazard ratio 0.281, P=0.047).  
**DISCUSSION:** Teriparatide significantly reduced the occurrence of subsequent vertebral fracture after instrumented fusion surgery for OVC.

**O45**

**WHAT DO PATIENTS CONSIDER TO BE AN ACCEPTABLE LEVEL OF PAIN TO LIVE WITH AFTER SURGERY FOR LUMBAR DEGENERATIVE DISORDERS?**  
*Fekete TF, Kleinstueck FS, Porchet F, Haschtmann D, Jeszenszky D, Mannion AF; Spine Center, Schulthess Klinik, Zuerich, Switzerland*

**INTRODUCTION:** The “minimal clinically important change score” is often used as a marker of treatment success but its achievement is dependent on the patient’s starting point, and it does not indicate whether a satisfactory state is ultimately reached. An alternative approach concerns reporting the % of patients whose symptoms have reduced to a level that they could live with. We evaluated the acceptable level of pain in patients operated on for painful degenerative lumbar disorders.  
**METHODS:** Data from consecutive patients in our Spine Outcomes Registry undergoing first-time surgery for disc herniation (DH; N=772), spinal stenosis (SS; N=558) and degenerative spondylolisthesis (DS; N=316) were analysed. 12 mo postoperatively, patients completed 0-10 scales for back and leg pain and a question “if you had to spend the rest of your life with the symptoms you have now, how would you feel about it?”, with a 5-point response scale from “very satisfied” to “very dissatisfied”. This was dichotomised and used as the external criterion in receiver operating characteristics (ROC) analysis to derive the cut-off score for pain indicating being at least “somewhat satisfied”.  

**RESULTS:** 90% patients returned a 12-mo questionnaire of which 55.6% (DH), 43.4% (SS) and 53.2% (DS) reported being at least somewhat satisfied with their symptom state. The areas under the curve for the ROC were 0.88-0.91, indicating a good ability of the pain score to discriminate between being in a satisfactory state or not. The cut-off indicating a satisfactory symptom state was ≤22 points for DH (sensitivity 78%, specificity 89%), ≤23 points for SS (sens 83%, spec 80%) and ≤23 points DS (sens 85%, spec 80%).  
**CONCLUSION:** Most spine interventions decrease pain but rarely do they totally eliminate it. Reporting of the % patients achieving a pain score equivalent to the “acceptable symptom state” may represent a more stringent target for denoting surgical success in the treatment of painful spinal disorders.

**O46**

**A COMPARATIVE EFFECTIVENESS STUDY OF MINI-OPEN VERSUS OPEN TRANSFORAMINAL INTERBODY FUSION FOR LUMBAR DEGENERATIVE DISORDERS**  
*Kleinstück FS, Haschtmann D, Fekete TF, Jeszenszky D, Mannion AF; Spine Center, Schulthess Klinik, Zuerich, Switzerland*

**INTRODUCTION:** Mini-open transforaminal lumbar interbody fusion (mTLIF) through a Wiltse approach is a less invasive modification of the conventional open TLIF (cTLIF). Previous comparative studies of mTLIF and cTLIF have been beset with design flaws, such as low sample size, non-systematic data collection, selection bias, and confounding. We addressed the issue by analysing prospectively collected data from consecutive patients in our local database within the framework of Eurospine’s Spine Tango Registry.  
**METHODS:** Patients undergoing mTLIF for 1-2 level degenerative disorders from
2011-2014 were compared with historical controls (cTLIF, same surgeons) from 2005-2011. Medical history, surgical procedures, and complication rates were recorded systematically using Spine Tango surgery forms (98% completion rate). Patients completed the Core Outcome Measures Index (COMI) before and at 3 mo (98% follow-up) and 12 mo (95%) after surgery. Multiple regression was used to evaluate the effect of treatment group, whilst adjusting for age, gender, ASA, number of levels, prior surgery and decompression.

RESULTS: 154 patients were identified: 101 cTLIF (age 59±13y; 41% M) and 53 mTLIF (age 57±13y; 45% M). mTLIF was associated with lower blood loss (by mean 380 ml; p<0.0001) and a shorter stay (by mean 3.5 days; p<0.0001). Operation time tended to be shorter (by mean 0.14 hr; p=0.28) for mTLIF. General medical complications tended to be lower in the mTLIF than the cTLIF group (4% and 13%, respectively; p=0.13). There were no significant group differences in COMI scores at either 3mo (p=0.11) or 12mo follow-up (p=0.23).

DISCUSSION: Our study confirms the previously reported surgical benefits of mTLIF in a consecutive series with systematic, prospective, and almost complete data collection. mTLIF enjoys the advantages of a less invasive approach, complemented by comparable patient outcomes to cTLIF, suggesting it is a valid alternative to the conventional open approach.

O47
BONE UNION RATE OF PLIF USING LOCAL BONE GRAFT IN LONG TERM BISPHOSPHONATES USERS
Si Young Park, Seung Woo Suh, Jae Young Hong, Jae Hyuck Yang, Hyun Min Lee; Department of Orthopaedic Surgery, Korea University College of Medicine

INTRODUCTION: Bisphosphonates are the most popular drugs for treatment of postmenopausal osteoporosis. However, long-term use of bisphosphonates (BPs) may cause several complications such as atypical fracture of hip, osteonecrosis of jaw and delayed fracture healing. PLIF is a typical surgical technique for treatment of degenerative spinal disorders. Long-term use of BPs may also inhibit spinal fusion process after PLIF. We compared bony union rates of long-term BPs users and non-users after undergoing PLIF.

METHODS: The subject were 95 postmenopausal women whose course could be observed for at least 2 years after surgery. Single interbody PLIF was done using local bone graft from laminectomy. Participants were divided into two groups; there were 62 patients in long-term BPs users group and 33 in non-users group. Serum C-terminal cross linking telopeptide levels were checked for bone resorption marker which could be extremely decreased in long-term BPs users. Bone fusion rates were calculated, 2 years after the surgery using plain radiographs and computed tomographic scans. Clinical outcomes were measured using ODI and VAS.

RESULTS: Serum CTX level was extremely decreased in long-term BPs user group (p<0.05). However, fusion rates turned out to be 82% in long-term BPs users group and 87% in non-users group (p>0.05, not significant). There was no significant difference between two groups in ODI and VAS.

DISCUSSION: At the two-year postoperative follow-up, there was no significant difference in bone fusion rate between two groups. Long-term BPs users showed fusion rates greater than 80% and clinical outcome improvement that were compatible to those in non-users. No significant effect was found after long-term BPs use on fusion rate of PLIF.
O48
SURGICAL TREATMENT OF ADULT SPINAL DEFORMITY RESULTS IN VASTLY SUPERIOR BACK AND LEG PAIN IMPROVEMENT COMPARED TO NON OP TREATMENT: ANALYSIS OF 421 PATIENTS WITH 2-YEAR FOLLOW-UP

Sibel D Deviren, Justin K. Scheer BS1, Justin S. Smith MD PhD2, Aaron J. Clark MD, PhD3, Virginie Lafage PhD4, Han Jo Kim MD5, John D. Rolston MD3, Robert Eastlack MD6, Robert A. Hart MD7, Themistocles S. Protopsaltis MD4, Michael P. Kelly MD8, Khaled Kebaish MD9, Munish Gupta MD10, Eric Klineberg MD10, Richard Hostin MD11, Christopher I. Shaffrey MD2, Frank Schwab MD4, Christopher P. Ames MD3, and the International Spine Study Group (ISSG);

1Department of Neurological Surgery, Northwestern University Feinberg School of Medicine, Chicago, IL, USA
2Department of Neurosurgery, University of Virginia Health System, Charlottesville, VA, USA
3Department of Neurological Surgery, University of California, San Francisco, San Francisco, CA, USA
4Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases, New York, NY, USA
5Department of Orthopaedic Surgery, Hospital for Special Surgery, New York, NY, USA
6Scripps Clinic, San Diego, CA, USA
7Department of Orthopaedic Surgery, Oregon Health & Science University, Portland, OR, USA
8Department of Orthopaedic Surgery, Washington University, St. Louis MO, USA
9Department of Orthopaedic Surgery, Johns Hopkins University, Baltimore, MD, USA
10Department of Orthopaedic Surgery, University of California, Davis, Sacramento, CA, USA
11Department of Orthopaedic Surgery, Baylor Scoliosis Center, Plano, TX, USA

INTRODUCTION: Back and leg pain is the primary concern of adult spinal deformity (ASD) patients and are also a predictors to seek operative management. The purpose was characterize back and leg pain improvement or deterioration after operative management of ASD surgery based on pain severity groups.

METHODS: Retrospective review of a prospective multicenter ASD database. Inclusion criteria: age >18 years and ASD. Back and leg pain numerical rating scales (NRS), Oswestry disability index (ODI), physical component of the short form-36 (PCS), minimal clinically important difference (MCID) and substantial clinical benefit (SCB) were assessed. Patients were divided into non-operative (NONop) and operative cohorts (OP) as well as by the surgical procedure type, SRS-Schwab deformity class, pre-operative pain severity, and patient satisfaction.

RESULTS: 421 patients (235 OP, 186 NONop). OP was 6.2x more likely to improve in back pain and 3.0x more likely to improve in leg pain compared with NONop. NONop was more likely to have back and leg pain remain the same or worsen. New post-operative leg pain: 37.0% at 6wks and 33.3% at 2-years. Patients with severe (NRS 7-10) pre-operative back/leg have 21.0%/32.8% being pain free at 2-years, respectively. More patients with decompression had improvement in leg pain and reached MCID. Osteotomies improved back pain but were associated with higher incidence of new leg pain. SRS-Schwab coronal curve TypeN was least likely to improve in back pain. TypeD was least likely to improve in leg pain and more likely to have worsening or new leg pain. Patients with higher back/leg pain severity have larger improvements and are more likely to reach MCID/SCB. Back pain contributes to ODI and PCS improvements and more to patient satisfaction than leg pain.

CONCLUSION: Our results provide a valuable reference for pre-operative patient counseling regarding patient expectations for back and leg pain improvements from surgical intervention of ASD.
O49
CIRCUMFERENTIAL FUSION FOR THORACOLUMBAR ADULT DEFORMITY SURGERY: COMPARISON OF MIS LATERAL INTERBODY FUSION WITH OPEN OR PERCUTANEOUS PEDICLE SCREW FIXATION
Alexander A. Theologis, MD (1); Stacie Nguyen, MPH (2); Greg Mundis Jr., MD (2); Behrooz Akbarnia, MD (2); Robert K. Eastlack, MD (2); Michael Wang, MD (3); Praveen V. Mummaneni, MD (4); Juan Uribe, MD (5); David Okonkwo, MD, PhD (6); Neel Anand, MD (7);
(1) Department of Orthopaedic Surgery, University of California - San Francisco (UCSF), San Francisco, CA. (2) San Diego Center for Spinal Disorders, La Jolla, CA. (3) Department of Neurological Surgery, University of Miami Miller School of Medicine, Miami, FL. (4) Department of Neurologic Surgery, UCSF, San Francisco, CA (5) Department of Neurosurgery and Brain Repair, University of South Florida, Tampa, FL. (6) Department of Neurological Surgery, University of Pittsburgh, Pittsburgh, PA. (7) Cedars-Sinai Medical Center, Los Angeles, CA. (8) Department of Neurosurgery, University of Michigan, Ann Arbor, MI. (9) Department of Neurosurgery, University of Virginia Medical Center, Charlottesville, VA. (10) Department of Neurosurgical Surgery, Rush University Neurosurgery, Chicago, IL. (11) Department of Orthopedic Surgery, Rocky Mountain Hospital for Children, Denver, CO. (12) New York University Hospital for Joint Diseases, New York, NY. (13) Department of Orthopedic Surgery, University of Kansas School of Medicine, Wichita, KS. (14) Department of Orthopedic Surgery, University of Oregon Health Sciences Center; Portland, OR.

INTRODUCTION: Minimally invasive surgery (MIS) is gaining popularity in adult spinal deformity (ASD) surgery. The purpose of this study is to compare ASD patients who underwent circumferential fusions with open versus percutaneous pedicle screw instrumentation.

METHODS: Retrospective review of a multi-center database. Inclusion criteria: LIF via a MIS approach, posterior instrumentation, and minimum 2-year follow-up. The cohort was sub-divided into 2 groups based on type posterior pedicle screw instrumentation—open (“hybrid”) and percutaneous (“cMIS”). Exclusion criteria: 3-column osteotomies, stand-alone LIF, and posterior-only instrumentation. Operative, radiographic, and clinical outcomes were analyzed pre-operatively and 2-years post-operatively.

RESULTS: Of 190 consecutive patients, 155 met inclusion criteria (hybrid–65; cMIS-90). There were significant improvements in Cobb angles, lumbar lordosis, lumbopelvic mismatch, ODI, and VAS back and leg pain scores (p<0.05). cMIS had significantly less EBL (536±532 vs. 1199±946cc, p<0.01), shorter operative times (440±190 vs. 627±246mins, p<0.01), smaller pre-operative Cobb angles (36.90±14.30 vs. 43.90±16.90, p=0.01), fewer minor complications (15.6% vs. 32.3%, p<0.01), overall complications (33.3% vs. 53.8%, p<0.01), minor radiographic complications (0% vs. 9.2%, p=0.01), and lower ODI scores (28.3±21.0 vs. 37.2±19.1, p<0.01) at 2 years follow-up. No statistical differences were found between groups in regards to demographics, pre-operative ODI, and pre- and post-operative radiographic parameters and VAS back/leg scores.

CONCLUSIONS: Circumferential fusion with MIS LIF and posterior instrumentation is effective for pain relief and radiographic deformity correction in well-balanced, symptomatic thoracolumbar deformities. Compared to open posterior instrumentation, percutaneous posterior fixation results in fewer complications, less blood loss, shorter operative times, and better disability outcomes 2-years post-op.

O50
IS THE CORE OUTCOME MEASURES INDEX (COMI) AS RESPONSIVE AS THE SRS-22 FOR THE ASSESSMENT OF OUTCOME IN ADULT SPINAL DEFORMITY?
INTRODUCTION: The Core Outcome Measures Index (COMI) is a brief instrument for assessing the main outcomes of importance to back patients (pain, function, symptom-specific well-being, quality of life, disability). However, in specific pathologies, it might be expected to be less responsive than a disease-specific instrument. In patients with adult spinal deformity, we compared the performance of COMI with the widely accepted SRS-22 questionnaire.

METHODS: At baseline and 12 mo after nonoperative (N=97) and operative (N=49) treatment, 146 patients (123 F, 23 M) completed the following: COMI, SRS-22, Oswestry Disability Index (ODI) and SF-36 PCS. At 12 mo, patients also indicated on a 15-point Likert-scale how their back problem had changed relative to one year ago (=external criterion for treatment success).

RESULTS: Baseline values for the COMI showed significant (p<0.0001) correlations with SRS-22 subtotal (r=-0.86), ODI (r=0.85), and SF-36 PCS (r=-0.81) scores. The correlations between the external criterion of treatment success and change scores (baseline to 12 mo) for the different instruments were as follows: COMI, r=0.52; SRS-22 subtotal score, r=-0.50; ODI, r=0.50; SF-36 PCS, r=-0.34 (each p <0.0001). The SRS-22 satisfaction subscale at 12 mo FU showed a slightly higher correlation with the change score for COMI (r=0.47) than for SRS-22 subtotal score (r=-0.35), ODI (r=0.37) or SF36 PCS scores (r=-0.35) (each p <0.01).

CONCLUSION: COMI scores correlated strongly with the scores on the SRS-22, suggesting good construct validity. With either “change in back problem” or the SRS-22 "satisfaction with treatment results" serving as external criteria, COMI showed similar external responsiveness to SRS-22. The COMI seems to be well able to detect important change in adult spinal deformity. It has the added benefit of facilitating outcome comparisons with other spinal pathologies (useful in Spine registries) and reducing the response burden for the patient.

O51

SPINO-PELVIC SAGITTAL MALALIGNMENT DETERMINED BY A NEW SLOT-SCANNING X-RAY IMAGER (EOS) HAS A POSITIVE RELATIONSHIP WITH ODI SCORE

Kazuhiro Hasegawa, Masashi Okamoto, Keiji Ishii, Haruka Shimoda, Masatoshi Ono, Takao Homma;
Niigata Spine Surgery Center, Niigata, Japan

PURPOSE: HRQOL declines with increasing sagittal vertical axis (SVA) which is measured in conventional standing X-ray. A true whole body alignment is, however, unknown in the x-ray measurement. We introduced a new slot-scanning X-ray Imager (EOS) to define the true 3D standing alignment of whole body. The purpose of this study is to clarify a relationship between the global spinal alignment determined by EOS and ODI score.

METHODS: 136 volunteers (mean age: 39.5 years (20 ~ 69), M/F=34/102) who have no history of spinal diseases were enrolled. Following ODI questionnaire, x-ray parameters (T1/T12 kyphosis, LL, SS, PT, PI, and SVA) were measured using EOS. The radiographs were made from the center of acoustic meati (CAM) to the feet with
standing on a force plate to determine a gravity line (GL), then a distance between CAM to GL was measured in the sagittal plane (CAM-GL) (Fig.1). The subjects were divided into 5 generations: 20’s (n=30), 30’s (n=43), 40’s (n=35), 50’s (n=20), and 60’s (n=8) and all parameters were compared among the generations. Relationships among ODI and X-ray parameters were also analyzed.

RESULTS: Mean ODI scores (%) in each age groups were 4.1 (20’s), 4.5 (30’s), 5.7 (40’s), 6.1 (50’s), and 8.0 (60’s). There was no significant difference among age groups in LL, SS, PI, and CAM-GL. On the other hand, T1/T12 kyphosis, PT, and SVA showed a tendency of greater value with higher generation. ODI has a positive relationship with SAV and PT (Fig.1).

DISCUSSION: CAM-GL was not different among age groups, suggesting that the standing balance was compensated even in advanced age groups. The spino-pelvic alignment evaluated by SVA and PT was, however, deteriorated with age and these parameters had a positive relationship with ODI. This suggests that not only disc degeneration but spinal sagittal malalignment may affect low back symptom.

INTRODUCTION: Radiological normative values of sagittal spinopelvic alignment are only one aspect of multifaceted etiology of adult spinal deformity (ASD), and clinical features of ASD have not been well-documented. Purpose of this study was to investigate longitudinal radiological changes and clinical features of common ASD.

METHODS: A final total of 289 female subjects were recruited from population register and followed for a mean 12.3 years. Upright entire spine radiographs were used to evaluate sagittal spinopelvic parameters including lumbar lordosis (LL), pelvic incidence (PI), and percent slip of each vertebra. Clinical evaluations included range of motion (ROM) by active back extension (BET), trunk flexor and extensor muscle strength using isometric device, and change in trunk inclination angle (dTIA) using surface markers.

RESULTS: Subjects’ mean age (standard deviation; SD) was 56.9 (10.0) years at baseline and 68.5 (9.2) years at the final follow-up. Degenerative spondylolisthesis (DS) was defined as more than 5% of percent slip, and 32 subjects (12.5%) developed de novo DS at the final follow-up. Degenerative kyphosis (DK) was defined as LL of less than 1SD (<24.4°) or dTIA of more than 1SD (>8.0°). Among 159 subjects with full clinical data at the final follow-up, DK was found in 26 subjects (12.6%). Trunk flexor muscle was significantly weaker in DS (normal 282.5N, DS 245.5N, p=0.0219), while extensor muscle (normal 478.1N, DK 405.6N, p=0.0405) and BET (normal 12.2cm, DK 6.9cm, p<0.0001) were significantly smaller in DK. PI showed signi-
significant difference between DS and DK (DS 58.6°, DK 51.5°, p=0.0138).

DISCUSSION: Current study substantiated that the development of DS was associated with large PI and reduced trunk flexor muscle, supposedly due to reduced capacity of maintaining pelvic retroversion. DK was associated with reduced extensor muscle strength and ROM. Different treatment strategy should be elaborated for different types of ASD.

O53

PATIENT AND SURGEON RADIATION EXPOSURE DURING SPINAL INSTRUMENTATION USING INTRAOPERATIVE CT-BASED NAVIGATION

Daniel Mendelsohn, Jason Strelzow, Juliet Batke, Marcel Dvorak, Charles Fisher, John Street;
Combined Neurosurgical and Orthopedic Spine Program, Vancouver General Hospital
Department of Orthopedics and Neurosurgery, University of British Columbia

INTRODUCTION: Intraoperative imaging modalities such as x-rays, fluoroscopy and CT emit ionizing radiation exposing the surgical team and patient to radiation. The amount of radiation emitted to the patient and the surgeon, when performing surgeries using intraoperative CT-based spine navigation were compared. The impact of intraoperative CT (iCT) on the use of intraoperative x-rays and postoperative x-rays and CTs was investigated.

METHODS: An ambispective review of surgical cases using iCT at a single centre over one year was performed. Intraoperative x-ray, fluoro and CT dosages were standardized to effective doses. The number of peri-operative imaging investigations was compared with a matched cohort of surgical cases involving only intraoperative x-rays and fluoroscopy. A literature review was performed to compare radiation exposure to historical values for fluoroscopic-guided instrumentation.

RESULTS: Seventy-three navigated cases involving an average of 5.44 levels of instrumentation were reviewed. Thoracic and lumbar spine instrumentations were associated with the highest radiation emission from all modalities (CT, X-ray, fluoroscopy) compared to cervical cases (TL: 6.40 mSv vs. C: 2.33 mSv). On average, the patient was exposed to 8.7 times more radiation than the surgical team. CT navigation increased radiation exposure to the patient by 2.8 times and decreased radiation exposure to the surgical team by 2.5 times compared to conventional fluoroscopy operations. The average radiation exposure to the patient was 5.69 mSv, a value less than a single routine lumbar CT scan. CT navigation did not reduce the number of postoperative x-rays or CT scans obtained.

CONCLUSIONS: Intraoperative CT navigation improves the accuracy of spine instrumentation with acceptable patient radiation exposure, and reduced surgical team exposure. Surgeons should be aware of the radiation exposure implications to both the patient and the surgical team when using iCT navigation.

O54 - ISSLS PRIZE WINNING PAPER
A DETAILED EXAMINATION OF THE ELASTIC NETWORK LEADS TO A NEW UNDERSTANDING OF ANNULUS FIBROUS ORGANISATION

Jing Yu, PhD(1); Meredith L. Schollum, PhD(2); Kelly R. Wade, PhD(2); Neil D. Broom, PhD(2);
Jill P.G. Urban, PhD(1);
STUDY DESIGN: Investigation of the elastic network in disc annulus and its function

OBJECTIVE: To investigate the involvement of the elastic network in the structural interconnectivity of the annulus and to examine its possible mechanical role.

SUMMARY OF BACKGROUND DATA: The lamellae of the disc are now known to consist of bundles of collagen fibres organised into compartments. There is strong interconnectivity between adjacent compartments and between adjacent lamellae, possibly aided by a trans-lamellar bridging network, containing blood vessels. An elastic network exists across the disc annulus and is particularly dense between the lamellae, and forms crossing bridges within the lamellae.

METHODS: Blocks of annulus taken from bovine caudal discs were studied in either their unloaded or radially stretched state then fixed and sectioned, and their structure analysed optically using immunohistochemistry.

RESULTS: An elastic network enclosed the collagen compartments, connecting the compartments with each other and with the elastic network of adjacent lamellae, forming an integrated network across the annulus, linking it together. Stretching experiments demonstrated the mechanical interconnectivities of the elastic fibres and the collagen compartments.

CONCLUSION: The annulus can be viewed as a modular structure organised into compartments of collagen bundles enclosed by an elastic sheath. The elastic network of these sheaths is interconnected mechanically across the entire annulus. This organisation is also seen in the modular structure of tendon and muscle. The results provide a new understanding of annulus structure and its interconnectivity, and contribute to fundamental structural information for disc tissue engineering and mechanical modelling.

KEY WORDS: Elastic fibres, microfibrils, disc annulus integrity.

O55 - ISSLS PRIZE WINNING PAPER
CYCLIC LOADING-INDUCED CONVECTION ENHANCES NET TRANSPORT INTO THE INTERVERTEBRAL DISC

Sarah E. Gullbrand, PhD[1]; Joshua Peterson, BS[1]; Jenna Ahlborn[1]; Rosemarie Mastropolo, BS[1]; Arun Fricker, BS[1]; Timothy T. Roberts, MD[2]; Mostafa Abousayed, MD[2]; James P. Lawrence, MD, MBA[2]; Joseph C. Glennon, VMD[3]; Eric H. Ledet, PhD[1];

INTRODUCTION: Intervertebral disc (IVD) nutrition correlates with homeostasis. Diminished small molecule transport can initiate or exacerbate degeneration. Because of the role of transport in disc homeostasis, strategies for enhancing it have potential to arrest or even reverse degeneration. Forced convection (bulk flow) is a potential mechanism to enhance small molecule transport. However, the role convection plays in transport is controversial. The purpose of this study was to establish whether forced convection can augment diffusion in healthy and degenerative discs in vivo.

METHODS: To measure the effects of convection + diffusion compared to diffusion alone, 21 skeletally mature New Zealand white rabbits with healthy or degenerated IVDs were subjected to cyclic in vivo loading (0.5 cycles/sec, 200N) at a single lumbar spinal level (L45) for either 2.5 minutes, 5 minutes or 10 minutes using a custom external loading apparatus. Animals were administered a small molecule contrast agent prior to loading to quantify transport via post-contrast enhanced MRI. Loaded levels were compared to an
unloaded control levels (diffusion alone).

RESULTS: In both healthy and degenerative IVDs, low rate cyclic loading enhanced small molecule uptake and clearance in the NP relative to diffusion alone. As shown in Figure 1, transport kinetics were accelerated by convection more in degenerative than healthy discs. Net transport into the NP was maximally enhanced by a mean 16.8% and 12.6% in healthy and degenerative discs, respectively.

DISCUSSION: We have shown for the first time that loading-induced convection enhances small molecule transport in both degenerative and healthy discs. Increases in transport achieved in this study (12-15%) may be significant enough to reverse the reduction in transport measured in human degenerative discs. As a regenerative strategy, convection may be a means to restore transport in degenerative IVDs to levels of normal healthy discs.

O56 - ISSLS PRIZE WINNING PAPER
VERTEBRAL ENDPLATE (MODIC) CHANGE IS AN INDEPENDENT RISK FACTOR FOR EPISODES OF SEVERE AND DISABLING LOW BACK PAIN
Juhani Määttä 1, Sam Wadge 2, Alex MacGregor 2, Jaro Karppinen 1, 3, Frances M K Williams 2;
1 Medical Research Center Oulu, University of Oulu and Oulu University Hospital, Finland
2 Department of Twin Research and Genetic Epidemiology, King’s College London, London, UK
3 Finnish Institute of Occupational Health, Health and Work Ability, and Disability Prevention Center, Oulu, Finland

INTRODUCTION: Modic change (MC) describes vertebral endplate and bone marrow lesions visible on magnetic resonance imaging (MRI). MC has been associated with disc degeneration (DD). It remains unclear whether MC causes LBP independently or through association with DD. Moreover, association of MC with severe, disabling LBP is uncertain. The objective was to assess the relationship between MC and severe, disabling LBP, features of intervertebral DD and incident MC during 10-year follow-up among a sample of the British population (TwinsUK).

METHODS: Volunteers were recruited from the TwinsUK register to MRI and interview between 1996 and 2000 with a subset attending for follow-up a decade later. MC, DD (evaluated by loss of disc height and signal intensity, presence of disc bulge and anterior osteophytes) and Schmorl’s nodes (SN) were determined on T2-weighted lumbar MR scans.

RESULTS: Complete data were available for 823 subjects at baseline and 429 at follow-up. Mean age at baseline was 54.0 years (range 32-70) with 96% females. The prevalence of MC was 32.2% at baseline and 48.7% at follow-up. Subjects with MC were older (p<0.001) and more overweight (BMI: p=0.026). At baseline (and follow-up), more subjects reporting severe LBP demonstrated MC (35.0% vs. 16.4%, respectively, p<0.001 and 35.1% vs. 20.0%, respectively, p<0.001). In multivariable analyses, MC was associated with episodes of severe, disabling LBP (OR 1.58; 95% CI 1.04-2.41) independently of age, BMI, DD and SN at baseline. Loss of disc height and disc signal intensity were independently associated with prevalent MC at baseline, and disc height and disc bulge with incident MC during follow-up.

DISCUSSION: MC is an independent risk factor for episodes of severe and disabling
LBP in middle-aged women. Our results give also an insight of more precise factors of DD affecting development of MC. These observations support further work aimed at identifying the precise histology underlying MC.

O57
INFLUENCE OF PAIN SENSITIVITY ON SURGICAL OUTCOMES AFTER LUMBAR SPINE SURGERY IN PATIENTS WITH LUMBAR SPINAL STENOSIS
Ho-Joong Kim, MD1, Jeong-Ik Lee, MD1, Kyoung-Tak Kang, MS2, Bong-Soon Chang, MD3, Choon-Ki Lee, MD3, Ruth Ruscheweyh, MD4, Sung Shik Kang, MD5, Jin S. Yeom, MD1;
1Spine Center and Department of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Bun-dang Hospital, 166 Gumiro, Bundang-gu, Sung-nam, 463-707, Republic of Korea 2Department of Mechanical Engineering, Yonsei University, 134 Shinchon-dong, Seodaemun-gu, Seoul, Republic of Korea 3Department of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Hos-pital, 101 Daehangno, Jongno-gu, Seoul, 110-744, Republic of Korea 4Department of Neuro-logy, University of Munich, Marchioninistr. 15, 81377 Munich, Germany. 5Department of Orthopaedic Surgery, Pusan National University, School of Medicine and Pusan National University Yangsan Hospital, Yangsan, Korea

INTRODUCTION: No previous study has investigated the relationship between the surgical outcomes for lumbar spinal stenosis (LSS) and pain sensitivity questionnaire (PSQ) scores. Therefore, We aimed to assess the influence of pain sensitivity on surgical outcomes after lumbar spine surgery in patients with LSS.

METHODS: The study included 171 patients who were scheduled to undergo spine surgery for LSS. Based on their PSQ scores, patients were assigned to either a low (PSQ score < 6.5, n = 87) or high PSQ group (PSQ score ≥ 6.5, n = 84). The primary outcome

was the Oswestry Disability Index (ODI) at 12 months after surgery.

RESULTS: The ODI at 12 months after surgery was significantly lower in the low PSQ group than in the high PSQ group. Twelve months after surgery, the mean ODI scores (95% confidence interval [CI]) in the low and high PSQ groups were 21.1 (16.8–25.5) and 29.6 (25.0–34.1), respectively. The difference (95% CI) in the ODI between the 2 groups was 3.2 (-14.7 to -2.2) (P = 0.009). There were significant differences in the secondary endpoints, including the ODI and visual analogue scale (VAS) scores for back and leg pain, in the follow-up assessments over a 12-month period after surgery, between the 2 groups (PSQ group; P < 0.001 for the ODI, VAS score for back pain, and VAS score for leg pain). However, the patterns of changes of the ODI and VAS scores for back pain and leg pain in the follow-up assessments over a 12-month period were not significantly different
(interaction between the PSQ group and follow-up assessment time; \( P = 0.757, 0.126, \) and 0.950, respectively).

**DISCUSSION:** Patients with high pain sensitivity may display less improvement in back pain, leg pain, and disability after surgery for LSS as compared to patients with low pain sensitivity. Furthermore, the PSQ can be used to predict surgical outcomes after spine surgery for LSS.

**O58**

**POSTEROLATERAL LUMBAR ARTHRODESIS WITH AND WITHOUT INTERBODY ARTHRODESIS FOR L4-5 DEGENERATIVE SPONDYLOLISTHESIS: A COMPARATIVE VALUE ANALYSIS**

Michael B Gottschalk MD Ajay Premkumar BS
Kyle Sweeney MD Scott D Boden MD John Heller MD S Tim Yoon MD PHD John Rhee MD;
Emory University, The Emory Spine Center

**INTRODUCTION:** The addition of an interbody arthrodesis (IBA) to a posterolateral arthrodesis (PLA) has become increasingly popular over the past two decades, yet the potential added value for the patient has not been carefully defined. The authors hypothesized that the addition of IBA to PLA in the setting of L4-5 degenerative spondylolisthesis (DS) will produce added value while incurring minimal additional costs.

**METHODS:** Patients undergoing single level arthrodesis with either PLA alone or PLA+IBA for L4-5 DS from 2004-2012 were identified from our institution’s prospective database. Exclusion criteria included multilevel arthrodesis, spinal stenosis requiring decompression at or above L2-3, previous L4-5 spinal fusion, spondylolisthesis of greater than 33% of the vertebral body, and use of minimally invasive surgery.

**RESULTS:** 179 patients with an average follow up of 38.7 months met inclusion criteria with 68 having undergone PLA alone and 111 having undergone PLA+IBA. The study was powered to detect smaller differences than the accepted minimal clinically important differences (MCID) for each outcome measure; however, no statistical differences were noted in ODI, SF-36, or fusion rates at 6 months and at over 3 years despite the PLA cohort being significantly older with more medical comorbidities. The addition of IBA did improve lordosis/sagittal balance by 1.5 degrees when compared to the PLA cohort (\( p=0.04 \)). When Costs/QALYs were calculated and normalized for length of stay (LOS), the PLA+IBA cohort demonstrated increased Costs/QALYs at every time point except the extremes of LOS (\( p=0.01 \)).

**DISCUSSION:** This single center review of open surgical treatment of L4-5 DS demonstrated that the addition of IBA to PLA added cost while not producing superior results in fusion rates, ODI, and SF-36 when compared to PLA alone. On the basis of this data we cannot recommend routine addition of IBA to PLA in patients being treated surgically for symptomatic DS.

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**O59**

**INTERRELATION BETWEEN SURGICAL TREATMENT OUTCOMES AND PSYCHIATRIC PROBLEMS IN LUMBAR SPINAL STENOSIS PATIENTS: A 2-YEAR COHORT STUDY USING BRIEF SCALE FOR PSYCHIATRIC PROBLEMS IN ORTHOPAEDIC PATIENTS (BS-POP)**

Kazuyuki Watanabe, Koji Otani, Takuya Nikaido, Kinshi Kato, Shoji Yabuki, Shin-ichi Kikuchi, Shin-ichi Konno;
Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine
INTRODUCTION: Brief scale for psychiatric problems in orthopaedic patients (BS-POP) is a originally developed questionnaire to evaluate psychosocial problems in orthopaedic patients such as depression and personality disorder (Yoshida et al. J Orthop Sci, 2011;16:7-13). The purpose of this study was to clarify the relationship between preoperative BS-POP and surgical outcomes in lumbar spinal stenosis (LSS).

METHODS: One hundred and one patients with LSS were included in this study. All patients received decompression surgery without fusion. Follow up period was 2 years. The outcomes were evaluated by numerical rating scales (NRS:0-10) of low back pain, leg pain, leg numbness, satisfaction rate, and Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ). The BS-POP has the physician version (Figure) (score range:8-24) and the patient version (score range: 10-30). In both versions, the higher the total score, the more severe the psychiatric problem. A patient with ≥11 physician version points or ≥10 physician version points and ≥15 patient version points is considered to have psychiatric problems. Objectives were divided into two groups according to preoperative BS-POP and compared prospectively.

RESULTS: Fourteen patients showed abnormal BS-POP and 87 patients showed normal BS-POP preoperatively. In preoperative JOABPEQ, the patients with abnormal BS-POP showed significantly lower score in low back pain, lumbar function, and mental health compared with the patients with normal BS-POP (p<0.05). 2 years after surgery, the patients with abnormal BS-POP showed significantly higher NRS for leg pain, lower satisfaction rate, and lower scores of JOABPEQ in low back pain, lumbar function, and mental health compared with the patients with normal BS-POP (p<0.05)

DISCUSSION: The result of this study showed that preoperative abnormal BS-POP related to poor surgical outcomes for LSS 2 years after surgery, BS-POP may predict surgical outcomes for LSS.

O60
A PROSPECTIVE, RANDOMIZED, MULTI-CENTER STUDY COMPARING TWO INTERSPINOUS DEVICES FOR THE TREATMENT OF LUMBAR STENOSIS

Scott L. Blumenthal, MD, W. Daniel Bradley, MD, Donna D. Ohnmeiss, DrMed;
Texas Back Institute and the Texas Back Institute Research Foundation; Plano, Texas

INTRODUCTION: After failure of nonoperative care for lumbar spinal stenosis, surgical alternatives are generally decompression, fusion, and interspinous devices. In recent years, many interspinous implants have been introduced with good results for appropriately selected patients. The purpose of this study was to compare clinical outcomes of two interspinous devices.

METHODS: Data were collected under a Food and Drug Administration regulated trial. Primary selection criteria were stenosis at 1 or 2 levels confirmed by imaging, symptom relief in flexion, failed nonoperative care, and no significant spinal instability. After randomization, 190 patients received the Superion (Vertiflex; Investigational group) and 201 received the X-STOP (Medtronic; Control group). Outcome measures used included the Zurich
Claudication Questionnaire (ZCQ), Oswestry Disability Index (ODI), and visual analog scales (VAS) separately assessing back and leg pain. In both groups, 24 month follow-up rates were greater than 94%, and 36 mo is near completion.

RESULTS: In both groups, ODI, back pain and leg pain VAS symptom severity and physical function scales of the ZCQ, all improved significantly (approximately 50%) as early as 6 weeks after surgery and maintained throughout follow-up (Figure 1). Reoperation rates were not significantly different in the 2 groups (20.0% Investigational vs. 14.4% Control). Radiographic analysis found no device disassembly or collapse. Both devices increased foraminal height, slightly greater in Control group. But also noted in the Control group was decreased anterior disc space height (“levering effect”). There were no significant differences in occurrence of adverse events in the two groups.

DISCUSSION: Both devices produced statistically significant improvement by 6 weeks after surgery which was maintained through 24-month follow-up. This prospective study indicates that interspinous devices can produce good outcomes in appropriately selected patients.

INTRODUCTION: Lumbar spinal stenosis (LSS) is one of the most common spinal disorders. Consensus on the best surgical treatment approach is lacking; the most appropriate treatment likely differs, depending on the patient’s presenting signs, symptoms, age and comorbidity state. We compared patient, treatment and outcome characteristics of the most frequent surgical treatments for LSS, based on data from the Spine Tango registry, screened 6.11.14.

METHODS: Inclusion criteria were LSS with no concomitant degenerative spondylolisthesis or previous surgery, with at least one surgical and one patient-rated (COMI) follow-up between 3–27 mo postoperatively. This resulted in 2005 patients from 30 hospitals and 7 countries. Average follow-up time was 14.5 mo. A subgroup analysis was performed using generalized linear modeling for continuous and Chi-square test for categorical variables.

RESULTS: Out of 2005 patients, 1952 (97.4%) were treated either by decompression alone (Deco; n=1291; 64.4%), decompression with instrumented fusion (IF; n=461; 23.0%) or decompression with posterior dynamic stabilization (PDS; n=200; 10.0%). Other treatments were used in 2.6% of the cases. Treatment groups differed significantly regarding their proportions of females, treated segments,
degenerative disc disease, disc herniation, other additional pathology, extent of lesion, duration of nonsurgical treatment, morbidity, and back and leg pain at baseline (p<0.038). Only patient age and baseline COMI score were similar for each group (p>0.06). Postoperative back and leg pain and COMI score, as well as their change, differed significantly among the groups in favor of PDS and IF (p<0.004) (Fig. 1).

**DISCUSSION:** Different treatment approaches appear to be used for differing patients. This limits the comparability of treatments in observational/registry studies. Stringent measures should be taken to control statistically for differences in patient selection, to avoid biased analyses and conclusions.

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**O62**  
**RISK FACTORS OF RESIDUAL LOW BACK PAIN ASSOCIATED WITH LUMBAR SPINAL STENOSIS FOLLOWING DECOMPRESSION SURGERY**  
Hiroshi Yamada1, Munehito Yoshida1, Hiroshi Hashizume1, Akihito Minamide1, Yukihiro Nakagawa1, Hiteto Nishi1, Hiroshi Iwaski1, Syunji Tsutsui1, Motohiro Okada1, Shinichi Nakao1, Sae Okada1, Hiroyuki Oka2;  
1. Department of Orthopaedic surgery, Wakayama Medical University, Wakayama, Japan. 2. Department of Medical research and Management for Musculoskeletal pain, 22nd Century Medical & Research Center, Faculty of Medicine, The University of Tokyo, Tokyo, Japan.

**INTRODUCTION:** Improvement of radicular leg symptoms and walking distance is guaranteed for lumbar spinal stenosis (LSS) patients treated with decompression surgery, while improvement of low back pain (LBP) is not always secure. Therefore, to figure out risk factors of residual LBP is needed to make surgical indication of spinal fusion more clear. The aim of this study is to clarify risk factors of residual LBP associated with LSS after decompression surgery.

**METHODS:** 121 LSS patients with preoperative 0-100mm VAS score of greater than 40mm for LBP were prospectively enrolled. They completed VAS score for LBP at 1 year postoperatively and were divided into two groups (free LBP and residual LBP groups) in accordance with the postoperative VAS score. Free LBP was defined as score of 0–25 mm and residual LBP was defined as score of 26-100 mm on the VAS. We used a multivariate logistic regression model to investigate the association between the residual LBP and predictive factors.

**RESULTS:** In a 1-year follow-up of patients who responded to this survey, 60 patients (49.6%) had the residual LBP. The multivariate logistic regression model revealed that the preoperative VAS for LBP(odds
ratio[OR]=1.03;95% confidence interval [CI], 1.00-1.06) and the presence of Modic type 1 changes (OR=5.64;95% CI,1.06-45.1) were significantly associated with the residual LBP in a 1-year follow-up.

**DISCUSSION:** When we discuss the need of additional spinal fusion for LBP associated with LSS, various abnormal imaging factors become the point of issues. However, X-rays and CT abnormalities were not correlated with residual LBP after decompression surgery in this study. Whereas only Modic type 1 change on MRI was strongly correlated with residual LBP. Many studies have demonstrated similar relationship between Modic type I change and LBP. Therefore, Modic type I change may become a risk of residual LBP after decompression surgery in LSS patients with LBP. In such cases, spinal fusion should be considered.

**O63**

**STRESS ENHANCES GAIT DISTURBANCE INDUCED BY LUMBAR FACETECTOMY IN THE RAT**

+1Fukui D., 2Matsumoto T., 2Naiki M., 3Masuda K., 1Kawakami M;
1. Spine Care Center, Wakayama Medical University Kihoku Hospital, Wakayama, Japan
2. Institute of Bio-Active Science, Nippon Zoki Pharmaceutical Co. Ltd., Hyogo, Japan
3. Department of Orthopaedic Surgery, School of Medicine, University of California, San Diego, CA

**INTRODUCTION:** Although psychological factors are assumed to be the primary cause of stress-related back pain, there have been no reports of stress-enhanced back pain in an animal model. We have developed a rat model that showed evidence of delayed gait abnormality induced by lumbar facetectomy. The purpose of this study was to examine the effects of SART (specific alternation of rhythm in temperature) stress on gait abnormality induced by lumbar facetectomy in rats.

**METHODS:** Sixty SD rats were divided into six groups. In the Sham group (n=20), only exposure of bilateral facet joints at the L4-5 level was performed. In the Experimental group (Exp group, n=20), rats underwent bilateral L4-5 facetectomy. Naive un-operated rats served as controls (n=20). Each group was divided into SART-stressed and non-SART-stressed subgroups. The CatWalk method was used to analyze gait up to 7 weeks postoperatively (PO). The parameters obtained from each group were compared statistically.

**RESULTS:** At 7 weeks PO, in the non-SART-stressed subgroup, the average speed was significantly decreased while step cycle and stand time were significantly increased in the Exp group, compared with other groups (p<0.05). In SART-stressed subgroups, the duty cycle and the swing time were significantly increased in the Exp group (p<0.01), in addition to other significant parameter changes seen in SART subgroup.

**DISCUSSION:** We demonstrated, for the first time, that SART stress enhanced the gait abnormalities after lumbar facetectomy that were previously shown to be associated with delayed instability and disc degeneration in the rat. It has been reported that SART stress induces hypersensitivity due to dysfunction of the descending pathway and sympathoadrenal system. This hypersensitivity might have affected the severity of abnormal gait in this model. Collectively, these results suggest that stress plays an important role in mechanisms of back pain associated with structural changes of the lumbar spine.

**O64**

**LESIONS IN THE INTERVERTEBRAL DISC AND HERNIATIONS CAN BE INDUCED UNDER COMPLEX LOADING CONDITIONS AND DETECTED WITH ULTRA HIGHFIELD MRI @ 11.7 T**
INTRODUCTION: The cause of disc herniation in not well understood yet. It is assumed that heavy lifting and extreme postures can cause small injuries starting in the inner annulus. Such injuries are accumulated over years until its structure is weakened and finally a single loading event leads to a sudden failure of the last few intact lamellae. However, failure may also start from the outside close to the endplate working its way into the disc until nucleus material can be extruded through this channel. The goal of this study is to provoke such disc failure due to repetitive loading to elucidate the mechanism of disc failure.

METHODS: Six sheep segments (L3-4, L5-6) were loaded under various combined loading conditions (5-18° flexion-extension, 3-12° lateral bending, 0-10° axial rotation, 500-800 N axial compression, up to 1200 loading cycles, 1 Hz) in a newly developed dynamic six-degree-of-freedom disc loading simulator. Before and after testing the discs were examined in a μMRI (11.7 Tesla). A three dimensional reconstruction was performed to visualize the internal disc lesions.

RESULTS: Typical failure patterns and herniations could be provoked with complex asymmetrical loading protocols. Lateral reversed loading protocol lead to similar mirror-inverted lesions. A delamination could be detected between the nucleus and posterior annulus on the ipsi-lateral side of rotation and ruptures on the anterior-lateral side. These rupture result-

Hans-Joachim Wilke1, Nikolaus Berger-Roscher1, Sebastian Mail1e, Volker Rasche2,3, Annette Kienle4;

1 Institute of Orthopaedic Research and Biomechanics, Ulm University, Ulm, Germany 2 Department of Internal Medicine II, University Hospital Ulm, Ulm, Germany 3 Small Animal MRI, Medical Faculty, Ulm University, Ulm, Germany 4 SpineServ GmbH & Co. KG, Ulm, Germany

INTRODUCTION: Brain stimulation techniques including transcranial direct current stimulation (tDCS) have shown promise in decreasing post-operative hydromorphone usage after ERCP and total knee arthroplasty. No published study has examined the effect of tDCS following spine surgery.

METHODS: Twenty seven patients who underwent lumbar spinal fusion surgery completed this study. Immediately after surgery, participants were randomly assig-
ned to receive 20 minutes of real or sham tDCS (2 mA, anode placed over the superior motor cortex (corresponding to the low-back/trunk area) and cathode over the right dorsolateral prefrontal cortex). Patient-controlled hydromorphone pump usage was tracked throughout each participant’s post-operative hospital stay. VAS pain scale and Hydromorphone usage were recorded.

**RESULTS:** The mean age of the sample was 59.4 years (SD=2.1), and 15% were African American (85% Caucasian). Participants who received real tDCS used a mean of 12.82mg (SD=10.27) of hydromorphone and subjects receiving sham tDCS used a mean of 16.35mg (SD=12.73) suggesting that tDCS was associated with a 22% reduction in PCA usage. The effect of tDCS (real versus sham) on the slope of the cumulative PCA hydromorphone curve was significant ($F(238,2879)=5.06$, $p<.001$).

**DISCUSSION:** These preliminary findings indicate that tDCS may have the potential to decrease post-operative hydromorphone usage among lumbar spinal fusion patients.

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**O66**

**THE ASSOCIATION OF MODIC CHANGES AND DISABLING LOW BACK PAIN: A LARGE-SCALE, POPULATION-BASED STUDY**

(1) Juhani Määttä, (1,2,3) Jaro Karppinen, (4) Cora Bow, (4) Keith DK Luk, (4) Kenneth MC Cheung, (4) Dino Samartzis;

(1) Medical Research Center Oulu, University of Oulu and Oulu University Hospital, Oulu, Finland (2) Finnish Institute of Occupational Health, Health and Work Ability (3) Disability Prevention Center, Oulu, Finland (4) Department of Orthopaedics and Traumatology, The University of Hong Kong, Hong Kong, SAR, China

**INTRODUCTION:** Modic changes (MC) are vertebral bone marrow changes adjacent to the endplates as noted on MRI. The association of specific MC type with low back pain (LBP) remains inconclusive, largely attributed to small sample sizes with limited phenotype assessment. Recently, the MC phenotype has been thoroughly defined. In relation to disabling LBP, various aspects of the topography and morphology of MC have not been properly assessed. As such, this study evaluated the relationship of disabling LBP with lumbar MC based on an extensive phenotype profile of these changes in a large, population-based study.

**METHODS:** This was a cross-sectional study of Southern Chinese based on the Hong Kong Disc Degeneration Cohort Study. Disabling LBP was defined as LBP lasting ≥30 days during the past year and a VAS severest pain intensity of at least 6/10. Significant disability was regarded as an Oswestry Disability Index (ODI) score ≥20. Axial T1- and sagittal T2-weighted lumbar MRIs were used to assess the MC phenotype, disc degeneration (DD) and bulge/extrusion (B/E), and Schmorl’s nodes (SN). Subject demographics were also assessed.

**RESULTS:** There were 1,151 subjects (63% females; mean age: 57 years). The prevalence of MC was 24.7% (7.0% Type I; 17.7%
Type II). Subjects with MC were older (p=0.003), had more disabling LBP (p=0.008), higher ODI (p=0.001) and DD sum score (<0.001). There were no significant differences of LBP or ODI between lumbar regions. In multivariable analyses, MC were associated with LBP among males (adjusted OR: 2.07; 95% CI: 1.01-4.25) but not females. The associations strengthened when excluding anterior and mid MC in the anteroposterior dimension, whereby the association of MC with ODI was significant (adjusted OR: 2.08; 95% CI: 1.00-4.30).

DISCUSSION: This is the largest study to assess specific MC phenotypes with pain/disability profiles. We noted that MC variants were associated with disabling LBP, primarily among males but not females.

O67
ASSOCIATIONS BETWEEN TYPES OF MODIC CHANGES IN THE LUMBAR AND LOWER BACK PAIN IN A LARGE COHORT IN JAPAN: THE WAKAYAMA SPINE STUDY
Masatoshi Teraguchi 1, Noriko Yoshimura 2, Hiroshi Hashizume 1, Shigeyuki Muraki 2, Hiroshi Yamada1, Hiroyuki Oka 3, Akihito Minamide 1, Hiroyuki Nakagawa 1, Yuyu Ishimoto1, Keiji Nagata1, Ryohi Kagotani 1, Sakae Tanaka 4, Hiroshi Kawaguchi 5, Kozo Nakamura 6, Toru Akune 6, Munehito Yoshida 1;
1. Department of Orthopaedic surgery, Wakayama Medical University, Wakayama, Japan. 2. Department of Joint Disease Research, 22nd Century Medical & Research Center, Faculty of Medicine, The University of Tokyo, Tokyo, Japan. 3. Department of Medical research and Management for Musculoskeletal pain, 22nd Century Medical & Research Center, Faculty of Medicine, The University of Tokyo, Tokyo, Japan. 4. Department of Orthopaedic surgery, Faculty of Medicine, The University of Tokyo. 5. Japan Community Healthcare Organization Tokyo Shinjuku Medical Center 6. Rehabilitation Services Bureau, National Rehabilitation Center for Persons with Disabilities, Tokorozawa City, Saitama, Japan.

INTRODUCTION: The results of many studies regarding Modic changes with lower back pain (LBP) are controversial. This is because most of these studies have been performed in selected groups of patients. The purpose of this study was to examine the association between Modic changes and LBP in a large population-based cohort.

METHODS: Of the 952 subjects who participated in the second Wakayama Spine Study, 820 subjects (men, 249; women, 571; mean age, 63.3 y) were included in this study. The degree of end-plate changes as measured by MRI were classified on the basis of the Modic classification system. The definition of LBP was continuous back pain for at least 48 hours in the past month. The prevalence of Modic change types in the lumbar region was assessed. Multiple logistic regression analysis was conducted to determine the association between types of Modic changes and LBP in comparison to subjects without radiographic changes, after adjusting for age, body mass index, and gender.

RESULTS: The prevalence of type 2 Modic changes was highest (type 1, 10.7%; type 2, 31.7%; and type 3, 2.9%). Type 1 Modic changes were significantly associated with LBP (odds ratio (OR) 1.97, 95% confidence interval [CI] 1.2-3.2, p=0.007); however, type 2 and 3 Modic changes were not significantly associated with LBP (type 2: OR 1.37, 95% CI 0.9-1.9, p=0.08; type 3: OR 2.39, 95% CI 0.9-5.72, p=0.05).

DISCUSSION: Type 1 Modic changes in the lumbar region are significantly associated with LBP whereas other Modic change types are not. To the best of our knowledge, this is the first large population-based study on the association between Modic changes and LBP. However, this study is cross-sectional in design, and
therefore, investigations into Modic changes and LBP are ongoing.

**O68**

ASSOCIATION OF VERTEBRAL BONE MARROW EDEMA WITH LOW BACK PAIN IN DEGENERATIVE LUMBAR SCOLIOSIS IN THE ELDERLY: A CROSS-SECTIONAL OBSERVATIONAL STUDY

Toshio Nakamae, Yoshinori Fujimoto, Kiyotaka Yamada, Osami Suzuki, Takashi Hashimoto, Masaki Matsuura, Taiki Morisako, Kjell Olmarker;

JA Hiroshima General Hospital, Hiroshima, Japan. Muskuloskeletal Research, Department of Medical chemistry and Cellbiology, Institute of Biomedicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden.

**INTRODUCTION:** The underlying pathophysiology of low back pain (LBP) in degenerative lumbar scoliosis (DLS) is unclear. The objective of this study was to examine if bone marrow edema (BME) adjacent to the vertebral endplate on magnetic resonance imaging (MRI) was associated with LBP in elderly DLS patients.

**METHODS:** This study is a cross-sectional observational study. One hundred and twenty DLS patients over 65 years were enrolled. Of these patients, 64 with LBP were allocated to LBP group, and 56 without LBP to control group. DLS was defined as de novo DLS with a Cobb’s angle > 10°, developing after bone maturation without previous history of scoliosis. Lumbar radiography, computed tomography (CT), MRI, and tender point examination in the lumbar spine were performed in all patients. On MRI, coronal gadolinium-contrasted T1- or T2-weighed fat-saturated images were used to score the size of BME. The prevalence of BME in LBP group and in control group was compared. The radiographic and MRI findings were evaluated by two spine specialists. The intra- and inter-reader kappa value was 0.80 (p<0.001) and 0.79 (p<0.001).

**RESULTS:** The two groups were similar at baseline data of clinical characteristics. BME was found in 62 of 64 (96.9%) patients with LBP compared with 21 of 56 (37.5%) patients with no LBP (P< 0.001). BME located more frequently on the concave side than on the convex side of scoliosis (P< 0.001). Among patients in LBP group, BME score was associated with LBP severity (r = 0.724; P< 0.001). Lumbar tenderness was found in 52 (81.3%) patients in LBP group compared with 4 (7.1%) patients in control group (P< 0.001).

**DISCUSSION:** BME on MRI was closely associated with the presence and severity of LBP in the elderly DLS patients. In DLS patients, the biomechanical stress loaded on the vertebral endplate at the concave side of scoliosis might be the causes of LBP.

**O69**

A NOVEL PATHWAY ASSOCIATED WITH LUMBAR DISC DEGENERATION: A GENOME-WIDE ASSOCIATION STUDY

Yan Li 1, Dino Samartzis2, Desmond Campbell1,3, Stacey Cherny1,3, Kenneth M.C. Cheung2, Keith D.K. Luk2, Jaro Karppinen4,5, Song Youqiang6, Kathryn Cheah6, Pak C. Sham 1,3, and Danny Chan6*;

1. Department of Psychiatry, The University of Hong Kong, Hong Kong, SAR, China 2. Department of Orthopaedics and Trauma-
INTRODUCTION: Lumbar disc degeneration (LDD) is a major cause of low back pain, and reported to have up to 77% heritability. However, genetic association studies using the candidate gene approach have identified only a few genes. Genome-wide association studies (GWAS) are preferable for the identification of novel genetic risk factors for LDD on MRI. Utilizing a new etiological classification scheme of LDD on MRI, we addressed LDD using GWAS.

METHODS: Sagittal T2-weighted lumbar MRI was assessed in 2,113 Southern Chinese volunteers (mean age, 43.6 years; range, 15.0 to 65.5 years; 59.4% females). The lower lumbar score (LLS), consisting of disc signal intensity loss, disc bulges or extrusions, and high-intensity zones at L3/4, L4/5 and L5/S1, represented the degenerative disc changes. The upper lumbar score, including SL, DB at L1/2 and L2/3 and endplate changes at all five levels, represented the developmental changes. 814,285 SNPs were genotyped using Illumina HumanOmniZhongHua-8 BeadChip. Both variant- and set-based association tests were performed. Subject demographics and lifestyle/environmental factors were considered in the analyses.

RESULTS: Set-based association tests identified the integrin pathway with marginal statistical significance in LLS (FDR p=0.065). Nine genes in this pathway were significant with p <0.05. The “integrin pathway” has interactions with the “extracellular matrix pathway”, which included key extracellular matrix components of discs.

DISCUSSION: This is the first genome-wide association study of LDD on MRI in a Southern Chinese cohort. While the sample size is still relatively small to detect genome-wide significant variants; set-based association analysis is one approach to enhance statistical power. Our study has identified the integrin pathway with candidate genes in relation to LDD, providing the foundation to conduct future functional analyses.

O70
AGE, PRO-INFLAMMATORY GENE POLYMORPHISMS AND FUSION ARE ASSOCIATED WITH ADJACENT SEGMENT DISC DEGENERATION IN PATIENTS TREATED FOR CHRONIC LOW BACK PAIN.
Ahmad Omair 1, Anne F Mannion 2, Gunnar Leivseth 3, Jeremy Fairbank 4, Marit Holden 5, Benedicte A Lie 6, Olle Hägg 7, Peter Fritzell 8, Jens I Brox 9;
1 Department of Orthopaedics, Oslo University Hospital-Rikshospitalet, Oslo, Norway. 2 Department of Research and Development, Spine Center Division, Schulthess Klinik, Zürich, Switzerland. 3 Department of Clinical Medicine, Neuromuscular Diseases Research Group, University of Tromsø, Norway 4 Nuffield Orthopaedic Centre, University of Oxford, Oxford, United Kingdom. 5 Norwegian Computing Centre, Blindern, Oslo, Norway. 6 Department of Medical Genetics, University of Oslo and Oslo University Hospital-Ullevål, Oslo, Norway. 7 Spine Center Göteborg, Gothenburg, Sweden. 8 Neuro-orthopedic center, Länssjukhuset Ryhov, Jönköping, Sweden. 9 Department of Physical Medicine and Rehabilitation, Oslo University Hospital, University of Oslo, Oslo, Norway.

INTRODUCTION: Does lumbar fusion lead to accelerated adjacent segment disc degeneration (ASDD) or is it explained by genetics and aging? The influence of genetics on ASDD remains to be explored. This study assesses whether the disc space height adjacent to a fused segment is
associated with candidate gene single nucleotide polymorphisms (SNPs).

**METHODS:** European patients with low back pain from 4 RCTs (N=208 had fusion; 77, non-operative treatment) underwent standing plain radiography and genetic analyses at 13±4 years follow-up. Disc space height was measured using a validated computer-assisted distortion compensated roentgen analysis technique and reported in standard deviations from age and gender adjusted normal values. Genetic association analyses included 34 SNPs in 25 genes relevant to disc degeneration. Analyses were adjusted for age, gender, smoking, duration of follow-up, and treatment group.

**RESULTS:** Decreased disc space height at the adjacent level was associated with age (β= -0.05, p< < 0.001) and two SNPs (rs1420106 and rs917997) from the IL18RAP gene (β= -0.34, p= 0.04 and β= -0.35, p= 0.04, respectively); together, these explained 11% of the variance. Fusion was also significantly associated with decreased disc space height (β= -0.50, p< < 0.008), explaining a further 2-3% variance. Rs20544 from the MMP-9 gene was associated with greater disc space height (β= 0.35, p= 0.04) and, together with age and fusion, explained 14% of variance. No associations were observed for the haplotypes tested. At the 2 levels above the adjacent segment, two SNPs from IL6 gene were associated with greater disc space height and SNPs from IL18RAP, COX2 and CILP genes with lower height.

**DISCUSSION:** Age was the most significant determinant of disc space height; genetic factors, specifically inflammatory genes, and fusion explained a statistically significant but small proportion of the variance. Gene-environment interactions may be important to consider in future studies.

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**O71**

**SEVERITY OF ADJACENT DISC DISEASE DUE TO LOWER LUMBAR DISC DEGENERATION IS EQUALLY IMPORTANT AS THOSE DUE TO LUMBAR FUSION**

**Raghu N Natarajan and Gunnar BJ Andersson; Rush University Medical Center, Chicago, IL, USA**

**INTRODUCTION:** Adjacent segment disc disease (ASDD) may be produced either by degenerated discs or fusion. Aim of the current study is to understand and compare how either fusion or degeneration of L4/5 and/or L5/S1 accelerates the progression of ASDD in a lumbar spine.

**METHODS:** Fifteen poro-elastic finite element models representing either fusion or degeneration (Thompsons Grades 2 to 5) at either L4/L5 or L5/S1 or at L4/S1 were created. The motions of L1 with respect to S1 in all the three principal directions were obtained from a normal spine model for a 400 N compression with moment of 7.5 Nm and applied to the lumbar spine models with fused or degenerated disc/s. Change in motions at all levels due to either fusion or degeneration were calculated.

**RESULTS:** Increase in adjacent segment motions due to degenerated discs were more than 50% of those produced by fused discs. Fusion at L4/L5 produced an increase in adjacent disc motion of 30% to 50%, degenerative disc at L4/L5 produced an increase of 15% to 40% (Figure). Two level fusion (50% to 80%) or two level disc degeneration (15% to 40%) produced the largest increase in adjacent segment motions as compared to single level fusion (25% to 50%) or degeneration (10% to 35%). Fusion or degenerated disc at L4/L5 produced larger increase in adjacent segment motion (30% to 50%) then those produced due to fusion or degeneration at L5/S1 (15% to 25%).
CONCLUSIONS: Increase in adjacent disc motions due to degenerated discs were more than 50% of those produced by fusion showing disc degeneration is equally important while considering ASDD. Fusion or degeneration at L4/L5 level and not L5/S1 level caused larger increase in adjacent segment motions leading to the conclusion that developing ASDD is greater with L4/L5 degeneration or fusion. As expected two level fusion/degneration produced larger increase in adjacent segment motions leading to the conclusion that occurance of ASDD is higher with multilevel fusion or degeneration.

![Graph showing change in adjacent segment motion](image)

O72

COMPARATIVE STUDY OF ADJACENT SEGMENT DISEASE BETWEEN TLIF AND MICROSCOPIC BILATERAL DECOMPRESSION VIA UNILATERAL APPROACH IN L4 SPONDYLOLISTHESIS: A MINIMUM 5-YEAR FOLLOW-UP.

Ohyama S, Matsumura A, Kato M, Namikawa T, Nakamura H;
Department of Orthopaedic Surgery, Osaka City General Hospital. Department of Orthopaedic Surgery, Osaka City University Hospital.

INTRODUCTION: Several authors have written about the adjacent segment disease (ASD) after fusion surgery. However, there still remains little known regarding the ASD after fusion surgery compared with microscopic bilateral decompression via unilateral approach (MBDU). The purpose of this study is to compare the incidence of ASD between TLIF and MBDU.

METHODS: Fifty four patients with L4 spondylolisthesis who underwent TLIF (n=28) or MBDU (n=26) in L4/5 were enrolled with a minimum 5-year follow-up. We measured the following radiographic parameters in L3/4 PreO and FFU; (1) %slip, (2) changes of slip (Δslip), (3) segmental lordotic angle (SLA), (4) disc arc (DA), and (5) disc height (DH). We also evaluated the progression of facet degeneration on CT, and disc degradation and spinal stenosis on MRI. Clinical outcomes were assessed with JOA score PreO and FFU. Statistical analysis was conducted using ANOVA and a P value of <0.05 was considered to be significant.

RESULTS: Radiographic parameters of TLIF group (PreO/FFU) were following; (1) %slip: 2.2/6.0%, (2) Δslip: 0.93/1.26mm, (3) SLA: 8.0/9.8°, (4) DA: 8.7/7.8°, (5) DH: 7.5/7.5mm. Those data of MBDU group (PreO/FFU) showed; (1) %slip: 2.3/3.1%, (2) Δslip: 0.96/1.00mm, (3) SLA: 6.9/8.°, (4) DA: 7.8/7.8°, (5) DH: 6.8/6.3mm. The comparative analysis between the two groups showed DH at FFU was significantly different (p=0.04).The progression of facet degeneration were detected 20% in TLIF group and 20% in MBDU group in CT. MRI showed disc degeneration and spinal stenosis was observed 13% and 27% in TLIF group, and 20% and 20% in MBDU group, respectively. These data were not significantly different. The mean improvement rate of JOA score were calculated to 60.3% in TLIF group and 56.6% in MBDU group.

DISCUSSION: This study showed the incidence of ASD in TLIF and MBDU were equivalent. Therefore, the incidence of ASD after one level fusion is thought to be same as decompression surgery with a minimum 5-year follow-up.
O73
PREVENTION OF ACUTE PROXIMAL JUNCTIONAL FRACTURES AFTER LONG THORACOLUMBAR POSTERIOR FUSIONS USING TWO-LEVEL CEMENT AUGMENTATION AT THE UPPER INSTRUMENTED VERTEBRA AND THE VERTEBRA ONE LEVEL PROXIMAL TO THE UPPER INSTRUMENTED VERTEBRA
Alexander A. Theologis, MD (1); Shane Burch, MD (1);
Department of Orthopaedic Surgery, University of California – San Francisco, San Francisco, CA

INTRODUCTION: Prevention of acute proximal junctional failure (PJF) due to fractures after long thoracolumbar fusions is critical, as they may result in neurologic injury. Cement augmentation of the construct’s proximal vertebrae is postulated to decrease proximal junctional failure, although clinical reports are limited. The purpose of this study is to compare patients who underwent posterior fusion from the thoracolumbar (TL)-junction to the pelvis with and without 2-level cement augmentation at the proximal extent of the construct.

METHODS: Patients who underwent posterior fusion from the TL-junction to the pelvis with a minimum 6 months of follow-up were retrospectively studied. Intra-operative data, re-operation rate for acute proximal junctional fractures, deformity radiographic parameters, and clinical outcome scores were compared between patients who did and did not undergo 2-level cement augmentation at the most proximal instrumented vertebra (UIV) and UIV+1.

RESULTS: Fifty-one patients [female: 29; male: 22; average age: 65 years (33-82 years)] met inclusion criteria. Thirty-two patients [female: 19; male: 13; average age: 63 years (33-82 years)] did not include 2-level cement augmentation, while 19 patients [female: 10; male: 9; average age: 68 years (55-79 years)] included 2-level cement augmentation at UIV and UIV+1. Compared to those without 2-level cement, patients with 2-level cement had significantly fewer revisions for PJF caused by fractures (0% vs. 19%), significantly better post-operative functional outcome scores [EQ VAS 74 ± 23 vs. 63 ± 16 (p=0.04); EQ-5D 0.65 ± 0.22 vs. 0.53 ± 0.22 (p=0.04)], significantly less post-operative disability (ODI 32 ± 17 vs. 46 ± 17) (p<0.01), and shorter average radiographic follow-up (14 ± 8 months vs. 23 ± 16 months) (p=0.01).

DISCUSSION: Two-level cement augmentation (UIV, UIV+1) in posterior fusions from the TL-junction to the pelvis is an effective method to prevent acute proximal junctional fractures.

O74
FUNCTIONAL ASSESSMENT OF LOCAL VERSUS DISTAL TRANSPLANTATION OF HUMAN NEURAL STEM CELLS FOLLOWING CHRONIC SPINAL CORD INJURY
Ivan Cheng, Michael Githens, Allison Rao, Tyler Johnston, Kali Tileston, Nima Salari, Michael Stauff, R. Lane Smith; Stanford University

INTRODUCTION: Previous studies have demonstrated functional recovery of rats with spinal cord contusions after transplantation of neural stem cells adjacent to the site of acute injury.

METHODS: 4 groups of Long-Evans hooded rats were identified: 2 experimental and 2 control. All subjects underwent a laminectomy at the T10 level. A moderate spinal cord contusion at the T10 level was incurred by use of the Multicenter Animal Spinal Cord Injury Study Impactor. Experimental subjects received a subdural injection of human neural stem cells (hNSCs) adjacent to the site of injury or an intrathecal injection of hNSCs through a separate lamino-
tomy made in the mid-lumbar spine distal to the site of injury 4 weeks after injury. Control subjects received an injection of control media alone. Subjects were assessed following injury and then weekly for 10 weeks using the BBB Locomotor Rating Score.

RESULTS: 24 subjects underwent spinal cord injury and injection, 6 in each group (local cells, local media, distal cells, distal media). A statistically significant functional improvement in subjects that received hNSCs injected distally to the site of injury was observed when compared to control (p=0.030). There was no significant difference between subjects that received hNSCs locally compared to control (p=0.350).

DISCUSSION: The transplantation of hNSCs into the contused spinal cord of a rat led to significant functional recovery of the spinal cord when injected distally but not locally to the site of chronic spinal cord injury. Discussion: Patients may be able to receive a potentially therapeutic injection of hNSCs through a traditional lumbar puncture in the chronic phase after their injury. Acknowledgments: We would like to thank StemEdica for the use of their human neural stem cells and Alex Sox-Harris, PhD for his assistance with the statistical analysis in this study.

O75
PROGNOSIS IN SURGICAL MANAGEMENT OF SYMPTOMATIC SPINAL METASTASIS - PROSPECTIVE COHORT STUDY OF SURGICAL OUTCOME
1. Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine 2. Division of Rehabilitation Medicine, Kobe University Graduate School of Medicine 3. Department of Rehabilitation Science, Kobe University Graduate School of Medicine in Hyogo Rehabilitation Center

INTRODUCTION: Spinal metastasis is a growing problem in patients with cancer. Previously the authors reported spinal surgery for spinal metastasis improved performance status and activity of daily living. The aim of study was to elucidate the effect of spinal surgery on the prognosis of patients with spinal metastasis.

MATERIALS AND METHODS: A prospective cohort study on the prognosis in spinal metastasis was performed. A consecutive cohort of 94 patients with spinal metastasis, who met the surgical indication with intractable pain or progressive neurologic deficit, was studied. Sixty-five patients (Group S) desired the spinal surgery. Twenty-nine patients (Group C) wished the conservative treatment. All patients received radiation and chemotherapy if indicated. Statistical analysis of survival time and univariate analysis were performed by the Kaplan-Meier method and the log-rank test. Multivariate analysis used the Cox proportional hazards model for variables that had been identified as significant by univariate analysis.

RESULTS: Median survival time (MST) of Group C and Group S after the day of study enrollment was 86 days and 236 days, respectively. Long-rank test revealed survival rate of Group S was statistically longer
than Group C. Postoperative chemotherapy was significantly administered to more patients in Group S than Group C. Multivariate analysis indicated the postoperative chemotherapy in Group S as a significant prognostic factor. MST of Group S in the absence of postoperative chemotherapy was 155 days, and it in the presence of postoperative chemotherapy was 462 days. The statistical significance was recognized between them.

**DISCUSSION:** The results of this study had demonstrated that spinal surgery for symptomatic patients with spinal metastasis could extend the prognosis. Improving the general condition through surgery, as a result, the adaptation of chemotherapy was expanded and thought to have led to an improved prognosis.

**O76**

**IMPROVED PATIENT SELECTION BY STRATIFIED SURGICAL INTERVENTION: AARHUS SPINAL METASTASES ALGORITHM**

Miao Wang, MD, PhD*, Cody Eric Bünger, MD, DMSc*, Haisheng Li, MD, PhD*, Ming Sun, MD PhD*, Peter Helmig, MD, PhD*, Gilava Borhani-Khominani, MS*, Chun Sen Wu, MD, PhD†, Ebbe Stender Hansen, MD, DMSc*, David Choi, FRCS, PhD, Kristian Hoey, MD*;

*Department of Orthopaedic E, Aarhus University Hospital NBG, Denmark † Section for Epidemiology, Department of Public Health, Aarhus University, Denmark ‡Department of Neurosurgery, the National Hospital for Neurology and Neurosurgery, UK

**INTRODUCTION:** Choosing the best surgical treatment for patients with spinal metastases remains a significant challenge for spine surgeons. There is currently no gold standard for surgical treatments. This study was to evaluate the clinical outcome of stratified surgical interventions based on the Aarhus Spinal Metastases Algorithm (ASMA), which combines life expectancy and the anatomic classification of patients with spinal metastases to inform surgical decision-making.

**METHODS:** A consecutive series of 515 spinal metastatic patients who underwent surgical treatment from 1992 to 2012 in Aarhus University Hospital were included prospectively and analyzed in detail retrospectively. Surgeons evaluated and classified patients into five surgical groups preoperatively by using the revised Tokuhashi score and the Tomita anatomical classification. Survival time after surgery was determined for all patients. Neurological function was assessed using the Frankel score preoperatively and postoperatively. Complete outcomes data were retrieved in 97.5% of this cohort.

**RESULTS:** The median survival times in the five surgical groups determined by the ASMA were: 2.1m, 5.1m, 12.1m, 26.0m, and 36.0months. The 30-day mortality rate was 7.5%. Postoperative neurological function was maintained or improved in 469 patients (92.3%). Overall re-operation rate was 13.5%, commonly due to postoperative hematoma and new limb weakness.

**DISCUSSION:** Reconstruction surgery achieved the longest survival in the patient group that was recommended by ASMA. High-complication- and reoperation rate was observed in patients who underwent aggressive surgery (e.g. vertebrectomy) that ASMA did not recommended. Surgical intervention based on ASMA recommendations minimized complications and improved survival in our study. The ASMA provided a useful tool to evaluate patient preoperatively and select optimal surgical treatment that tailored to each patient.

**O77**

**COST-UTILITY OF SURGICAL TREATMENT FOR PATIENTS WITH SPINAL METASTASIS**

Miyazaki, S1; Kakutani, K1; Sakai, Y2; Maeno, K1; Takada, T1; Yurube, T1; Kurakawa, T1; Terashima, Y1; Ezima, Y3; Kawamoto, T1; Hara,
INTRODUCTION: Because of a worldwide increase in the incidence of cancer and a longer life expectancy of patients with cancer, a rise in the incidence of bone metastasis has been observed. The authors had reported the improvement of performance status and activity of daily living after spinal surgery for spinal metastasis, however, the economic value of this surgery remains poorly understood. The aim of the study was to elucidate the cost-utility of surgical treatment for patients with spinal metastasis.

METHODS: A consecutive cohort of 47 patients with spinal metastasis from 2008 to 2013, who met the surgical indication, was studied. Thirty-one patients (surgery group), who desired surgery, underwent spinal surgery with laminectomy and posterior fusion. Sixteen patients (conservative group), who did not desire surgery, underwent adjuvant therapy. EuroQol 5D (EQ-5D) and relevant cost were measured at 1, 3, 6 and 12 months after the day of study enrollment. Health state values was obtained by Japanese EQ-5D scoring and quality-adjusted life year (QALY) gained were calculated for each group. Cost-utility was expressed as the incremental cost-utility ratio (ICUR). Costs were converted into U.S dollars using the rate 1$=110 yen.

RESULTS: Survival rate at one year was 54% in surgery group and 18% in conservative group. Improvement of health state value using EQ-5D was exhibited in 30 patients (97%) with surgery group and 3 patients (18%) with conservative group. The mean QALY gained was 0.43 in surgery group and 0.02 in conservative group. The mean total cost per patient in the surgery group was $20621 compared with $5691 in conservative group. The ICUR using 1year follow up date was $36557/QALY.

DISCUSSION: In the orthopaedic surgery, the ICUR less than$50,000/QALY per quality-adjusted life year was considered the acceptable cost-effectiveness. Our results indicated, for the first time, surgical treatment for metastatic spinal tumor could be cost-effective.
37.4% (n=173) attended some, while only 13% (n=60) had +30 rehabilitative visits. Those attending non-operative therapy 1-30 times within six months presurgery had a statistically significant improvement in health-related quality of life score from baseline (M=52.03, SD=22.3) to follow up (M=70.8, SD=17.7) compared to those who did not attend any presurgical care (baseline: M=51.7, SD=20.5; follow up M=64.5, SD=20.7, p=0.018). For Oswestry score, there was a trend towards improvement for those attending non-operative therapy +30 times (baseline: M=52.6, SD=16.3; follow-up: M=34.5, SD=18.9) compared to no presurgical care (baseline: M=51.9, SD=16.3; follow up M=38.7, SD=19.3, p=0.085). No other significant differences were found.

**DISCUSSION:** Failure of non-operative care does not appear to be a common prerequisite for elective thoracolumbar surgery. Presurgical non-operative care was under-utilized; approximately half the patients did not attend any therapy at all. Presurgical non-operative intervention improved postsurgical health-related quality of life, with an additional trend toward decreasing disability. Only after consistent referral to structured and exhaustive non-operative therapy can the role of non-operative treatment in complimenting surgical outcomes be validly determined.

**O79**

**OUTCOME OF DECOMPRESSION WITH AND WITHOUT FUSION IN SPINAL STENOSIS WITH DEGENERATIVE SPONDYLOLISTHESIS IN RELATION TO OPERATIVE PAIN PATTERN - A REGISTER STUDY OF 1,624 PATIENTS**

Sigmundsson FG Strömqvist B Jönsson B;
Department of Orthopedic Surgery, Lund University, Skane University Hospital, Malmö, Sweden

**INTRODUCTION:** Patients with spinal stenosis with concomitant degenerative spondylolisthesis (DS) and predominance of back pain have been shown to have inferior outcome after surgery. The purpose was to study if adding spinal fusion to the decompression in DS impacts outcome in patients with predominant back pain (back pain VAS< leg pain VAS) compared to predominant leg pain (back pain VAS< leg pain VAS).

**METHODS:** The Swedish Spine Register was used and included 1,624 patients operated for DS at the L4-L5 level. Outcome measures included the visual analogue scale (VAS) for pain, the Euroqol-5 (EQ-5D) and the physical and mental component summaries of the Short-form 36 and the Oswestry disability index to estimate function. Inclusion criterion was single level DS operated on with either decompression only (D) or decompression and instrumented posterolateral fusion (DF). Based on preoperative leg and back pain scores, the patients were assigned to one of two groups: Leg pain predominance or back pain predominance. The patients completed the outcome protocol at 1 and 2 year follow-up. Statistical analysis was performed using linear regression adjusting for multiple potential confounders.

**RESULTS:** Patients with predominant leg pain reported a 7.9 mm more improvement on the VAS for back pain with fusion, compared to decompression only (95%CI: 0.7-15.2), p=0.03. Despite more change in the fused group, the reported back pain levels remained similar in the decompressed only versus decompressed and fused at the 1 year follow-up (28 vs. 24, p=0.77). The patients with predominant back pain benefited from adding fusion in terms of back pain 7.1 (95%CI: 0.3-13.9, p=0.04), leg pain 8.8 (95%CI: 2.15.7, p=0.01), the ODI 5.7 (95%CI: 1.6-9.9, p=0.006) and the EQ-5D 0.09 (95%CI: 1.7-0.02, p=0.02) at the 1 year follow-up as the
DISCUSSION: Patients with predominant back pain operated with DF report better outcomes in terms of pain, function and HRQoL than patients with only decompression. Although these differences are significant on a group level they may fail to reach minimal clinical significant difference. Patients with predominant leg pain report significantly more improvement in terms of back pain with DF compared to D but due to baseline differences in preoperative BP these improvements may not be explained by the added fusion per se. At the two year follow-up no significant differences were observed between the D and DF patients in either the PB or PL groups but greater loss to follow-up in the DF groups could potentially bias these findings.

O80
LONG-TERM OUTCOME OF SURGERY FOR LUMBAR DEGENERATIVE SPONDYLOLISTHESIS IN A PROSPECTIVE RANDOMIZED CLINICAL TRIAL
Tsuyoshi Kato, Toshitaka Yoshii, Hiroyuki Inose, Takashi Hirai, Tsuyoshi Yamada, Kenichiro Sakai, Yoshiyasu Arai, Atsushi Okawa;
Tokyo Medical and Dental University, Dept. of Orthopaedic Surgery

INTRODUCTION: To investigate the necessity and efficacy of stabilization or fixation after posterior decompression for lumbar degenerative spondylolisthesis (LDS), we have been conducting a multi-center prospective randomized clinical trial (RCT) approved by the IRB of our hospital. We have previously reported short-term outcome; here, we report long-term (≥5 years) surgical outcome.

METHODS: Subjects were patients indicated for decompression for central canal stenosis or lateral recess stenosis at the L4/5 due to LDS. After providing informed consent, patients were divided into three groups: decompression only (D group); decompression + Graf stabilization (G group); and decompression + posterolateral fusion (P group). A prospective comparative study of JOA scores, VAS, SF36 results, and Xp and CT findings was performed at pre- and postoperative findings years 2 and 5, and at final.

RESULTS: We followed 45 patients of those 15, 14, and 16 patients were in the D, G, and P groups, respectively. Mean observation period was 79.0, 80.4, and 80.7 months, respectively (overall about 7 years). Preoperative (final) JOA scores were respectively D:14.7 (24.1), G:16.5 (25.3), and P:17.3 (25.2). Re-operation was performed in only 1 patient (D group) who had foraminal stenosis. In the D group, we found a trend a gradual worse in JOA and VAS scores related to low back pain, as well as fusion at the intervertebral joint on CT images in 12 patients (80%). A gradual narrowing of the disc space at L3/4 was observed in all groups, and L4/5 spinal fusion was also prevalent in the G group. At the final follow-up, stabilization of the intervertebral joint was observed in all groups.

DISCUSSION: In this RCT evaluating surgical procedures for LDS, no significant difference by group was observed in surgical outcome or imaging findings at ≥7 years after surgery as well as at 2 years, suggesting the efficacy of fenestration alone. We plan to elucidate preoperative prognostic factors.
O81
PREDICTORS OF RETURN TO WORK STATUS FOLLOWING LUMBAR FUSION SURGERY AMONG WORKERS’ COMPENSATION SUBJECTS WITH SPONDYLOLISTHESIS

Anderson JT, Duff RJ, Ahn UM, Ahn NU;
University Hospitals Case Medical Center Department of Orthopaedics, Case Western Reserve University School of Medicine, University of Minnesota - Twin Cities, New Hampshire NeuroSpine Institute, University Hospitals Case Medical Center Department of Orthopaedics

INTRODUCTION: Lumbar fusion surgery for spondylolisthesis tends to have more consistent and superior outcomes than fusion for discogenic low back pain. Studies show that U.S. workers compensation (WC) subjects tend to have worse clinical outcomes following fusion than the general population. We evaluated a cohort of WC subjects who underwent posterior, anterior, or 360 degree lumbar fusion for spondylolisthesis to identify predictors of return to work (RTW) status.

METHODS: We included 544 subjects from the Ohio Bureau of Workers’ Compensation (BWC) that underwent fusion for spondylolisthesis between 1993-2013. Subjects were considered returned to work if they made a sustained return within 2 years of fusion and maintained this for more than 6 months of the following year. We utilized a multivariate logistic regression analysis, while correcting for a number of relevant covariates, to identify independent preoperative predictors of postoperative RTW status.

RESULTS: 32.2% (175/544) of all subjects met RTW criteria after fusion. Clinically diagnosed depression was the strongest negative predictor of RTW status (p=0.007; OR=0.01). Of the 26 subjects with preoperative depression, 0 returned to work. Other significant negative predictors included preoperative lumbar discography (p=0.042; OR 0.44) and chronic preoperative opioid analgesia (p=0.001; OR 0.33). The ability to remain working within the same week as fusion was a strong positive predictor (p=0.001; OR 4.28). No other covariates significantly impacted RTW status. After fusion, subjects utilized opioid analgesics for 511.5 days, were absent from work 863.5 days, developed failed back syndrome at a 7.4% rate, and were associated with $70,959.2 in medical costs.

DISCUSSION: Preoperative depression was the strongest predictor of RTW status. Psychological screening and, if necessary, treatment may be beneficial. We hope that our study provides insight into which WC patients may be more challenging postoperatively.

O82
INCREASING RATE OF SURGICAL MANAGEMENT OF ADULT SPINAL DEFORMITY IN PATIENTS OVER SIXTY

David C Sing, Jeremy D Shaw, Lionel N Metz, Ryan Khanna, Shane Burch, Sigurd H. Berven; University of California, San Francisco

INTRODUCTION: Adult spinal deformity (ASD) has been increasingly recognized as a major source of morbidity in patients over sixty years of age. The economic burden of non-operative management for ASD is elusive and likely underestimated. Though patient reported outcomes suggest that surgical treatment of ASD may be superior to non-operative treatment in selected patients, surgical utilization trends remain unclear. The purpose of this study was to assess changes in utilization and cost of treatment for ASD in patients over 60 from 2004 to 2011 and assess the bearing of age, region, and complications on these trends.

METHODS: Data were obtained from the Nationwide Inpatient Sample between 2004 and 2011. Analysis included patients over age 60 with a spinal deformity
diagnosis treated with a multi-level spinal fusion (>3 levels fused) determined by ICD-9-CM diagnosis and procedure codes. Population-based utilization rates were calculated from US census data. Hospital charges were assessed by procedure year, age, and by presence of a perioperative complication.

RESULTS: A total of 84,302 adult patients underwent multilevel deformity surgery from 2004-2011. The annual number of >3 level spinal fusions for ASD in patients over age 60 increased 2.5 fold from 6,571 to 16,526 (p<0.01). Utilization rates in patients 65-69 years old experienced the greatest growth, increasing by 184% from 1,589 cases in 2004 to 4,514 cases in 2011 (p<0.01). Average hospital charges increased 108% from $90,557 in 2007 to $188,727 in 2011 (p<0.01), and were highest in the West.

DISCUSSION: The rate of surgical management of ASD increased from 2004-2011, exceeding growth of the 60+ age demographic during the same period. The 65-69 year old age group demonstrated the largest increase in utilization, though growth was demonstrated in all age demographics. Hospital charges consistently increased from 2004 to 2011, and were impacted both by patient age and presence of complications.
SP01
RISK FACTORS FOR INCIDENTAL DUROTOMY DURING POSTERIOR SPINE SURGERY FOR DEGENERATIVE DISEASES IN ADULTS: A PROSPECTIVE MULTICENTER STUDY
Hisatoshi Ishikura 1, Satoshi Ogihara 1, Takashi Yamazaki 2, Toru Maruyama 3, Hiroyuki Oka 4, Hirohiko Inanami 5, Kota Miyoshi 6, Seiichi Azuma 7, Takashi Yamada 8, Motoaki Murakami 9, Naohiro Kawamura 10, Hirotaka Chikuda 11, Yasushi Oshima 11, Kiyohumi Yamawata 12, Jiro Morii 13,
1 Department of Orthopaedic Surgery, Sagamihara National Hospital, Kanagawa, Japan
2 Department of Orthopaedic Surgery, Musashino Red Cross Hospital, Tokyo, Japan
3 Department of Ortho-paedic Surgery, Saitama Medical Center, Saitama Medical University, Saitama, Japan
4 Department of Joint Disease Research, 22nd Century Medical and Research Center, the University of Tokyo, Tokyo, Japan
5 Department of Orthopaedic Surgery, Iwai Otho Hospital, Tokyo, Japan
6 Department of Orthopaedic Surgery, Yokohama Rosai Hospital, Kanagawa, Japan
7 Department of Ortho-paedic Surgery, Saitama Red Cross Hospital, Saitama, Japan
8 Department of Orthopaedic Surgery, NTT Kanto Hospital, Tokyo, Japan
9 Department of Orthopaedic Surgery, Toranomon Hospital, Tokyo, Japan
10 Department of Spine and Orthopaedic Surgery, Japanese Red Cross Medical Center, Tokyo, Japan
11 Department of Orthopaedic Surgery, Faculty of Medicine, University of Tokyo, Tokyo, Japan
12 Department of Orthopaedic Surgery and Musculo-skeletal Oncology, Tokyo Metropolitan Komagome Hospital, Tokyo, Japan
13 Department of Orthopaedic Surgery, Sanraku Hospital, Tokyo, Japan

INTRODUCTION: Incidental durotomy (ID), a common intraoperative complication of spine surgery, may lead to persistent cerebrospinal fluid leakage that may cause serious complications such as pseudo-meningocele formation and intracranial hemorrhage. Several studies reported that ID contributes to high health-care costs and poor patient outcomes. The purpose of this study is to clarify the independent risk factors for ID during posterior open spine surgery for degenerative diseases in adults.

METHODS: From July 2010 to June 2013, we conducted a prospective surveillance study in adults (≥20 years old) undergoing posterior open spine surgery in 12 Japanese hospitals. We researched potential risk factors: age, gender, body mass index, American Society of Anesthesiologists physical status classification, diabetes, hemodialysis, smoking, steroid intake, anatomical location of the surgery, the type of operative procedure, use of instrumentation, and past surgical history in the operated area. The clinical data were collected using a standardized form. Multivariate logistic regression analysis was performed to identify the risk factors. P<0.05 was statistically significant.

RESULTS: A total of 4753 consecutive adult patients were enrolled (2873 male, 1880 female, mean age 66.5 years). The total incidence of ID after surgery was 8.3% (396 cases). The results of the analysis suggest that lumbar surgery (P<0.001, odds ratio [OR]=2.28, 95% confidence interval [CI]: 1.61-3.25), posterior spinal osteotomy (P<0.001, OR=2.26, 95%CI: 1.11-4.59), revision surgery (P<0.001, OR=1.94, 95%CI: 1.50-2.53), posterior lumbar interbody fusion (P=0.001, OR=1.49, 95%CI: 1.19-1.88), and female gender (P=0.024, OR=1.28, 95%CI: 1.61-3.25) are independent risk factors for ID during posterior spine surgery.

DISCUSSION: We identified 5 independent risk factors for ID. The results contribute to making surgeons aware of the risk factors for ID and improving informed consent for spine surgery patients.

SP02
INCIDENCE, PATHOLOGIES AND RISK FACTORS FOR REVISIONAL SPINAL FUSION AFTER POSTERIOR LUMBAR DECOMPRESSION
Takamasa Watanabe, Masahiro Kanayama, Fumihiro Oha, Akira Iwata, Shingo Onda, Kahoru Tashiro, Tomoyuki Hashimoto Norimasa Iwasaki*;
Spine Center, Hakodate Central General Hospital * Department of Orthopaedic Surgery, Hokkaido University

INTRODUCTION: We investigated the incidence, pathologies and risk factors for additional spinal fusion at the index level after posterior lumbar decompression.

METHODS: 96 patients who underwent a posterior lumbar decompression (161 segments) were reviewed retrospectively with a minimum 2-year follow-up. They were 50 men and 46 women with a mean age of 69 years. 53 segments (33%) had a vertebral slip preoperatively; a mean slip was 3.7mm (2.0-7.7) anteriorly and 4.1mm (2.0-6.7) posteriorly. Incidence and pathologies for revisional fusion were examined. For risk factor analysis, we reviewed preoperative radiographic parameters including vertebral slip (>2mm), intervertebral hypermobility (>10 degrees), sagittally-oriented facet tropism (<30 degrees of facet angle in CT), and foraminal stenosis (MRI assessment by 3 independent observers).

RESULTS: Revisional fusion was performed at 14 segments in 11 patients (11.5%). The pathologies were progression of vertebral slip in 6 patients, disc herniation in 3, foraminal stenosis and facet synovial cyst in one each. All 161 segments were divided into revision level (n=14) and non-revision level (n=147). The percentages of pre-existing vertebral slip were 64% vs 30% (P=0.015). Hypermobility, facet tropism, and foraminal stenosis were observed in 36% vs 21% (P=0.312), 33% vs 39% (P=0.767), 31% vs 15% (P=0.232), respectively. Multivariable analysis showed that vertebral slip (P=0.008) and foraminal stenosis (P=0.036) were the risk factors of revisional fusion.

DISCUSSION: The current study showed that pre-existing vertebral slip and foraminal stenosis are the risk factors for revisional fusion. These factors should be assessed preoperatively to decide whether or not to fuse the segment. As hypermobility and facet tropism were not revealed as risk factors, surgeons could preserve sagittal facet joints without vertebral slip.

SP03
PREDICTORS OF CHRONIC OPIOID ANALGESIA AFTER LUMBAR FUSION AMONG 1407 WORKERS’ COMPENSATION SUBJECTS WITH DEGENERATIVE DISC DISEASE

Anderson JT, Duff RJ, Ahn UM, Ahn NU;
University Hospitals Case Medical Center Department of Orthopaedics, Case Western Reserve University School of Medicine, University of Minnesota - Twin Cities, New Hampshire NeuroSpine Institute, University Hospitals Case Medical Center Department of Orthopaedics

INTRODUCTION: U.S. workers’ compensation (WC) subjects tend to have worse clinical outcomes following fusion than the general population. Few studies have evaluated lumbar fusion outcomes within this population. We evaluated a large cohort of WC subjects who underwent fusion for degenerative disc disease (DDD) and discogenic low back pain (LBP) to identify risk factors for chronic postoperative opioid analgesia requirement.

METHODS: We identified 1407 subjects from the Ohio Bureau of Workers’ Compensation (BWC) that underwent anterior, posterior, or 360 degree discogenic lumbar fusion between 1993-2010 using ICD-9 and CPT codes. Our primary outcome was chronic postoperative opioid analgesia, defined as being supplied with narcotic pain medications for greater than 1 year. We utilized a multivariate logistic regression analysis to identify independent predictors of chronic postoperative opioid analgesia.

RESULTS: The best predictor of chronic postoperative opioid analgesia was chronic preoperative opioid analgesia (p=0.001, OR
INTRODUCTION: Lumbar fusion surgery performed for degenerative disc disease (DDD) and discogenic low back pain (LBP) is associated with variable clinical outcomes. Studies have shown that U.S. workers’ compensation (WC) subjects tend to have worse clinical outcomes following fusion than the general population. We evaluated a cohort of WC subjects who underwent posterior, anterior, or 360 degree lumbar fusion for DDD and discogenic LBP to identify predictors of RTW status.

METHODS: We included 1407 subjects from the Ohio Bureau of Workers’ Compensation (BWC) that underwent discogenic fusion between 1993-2010. Subjects were considered returned to work if they made a stable return within 2 years of fusion and maintained this for more than 6 months of the following year. We utilized a multivariate logistic regression analysis, while correcting for a number of relevant covariates, to identify independent preoperative predictors of postoperative RTW status.

RESULTS: 369 (26.2%) of all subjects met our RTW criteria after fusion. Clinically diagnosed depression was the strongest negative predictor of RTW status (p=0.001, OR 0.34). Other negative predictors included preoperative lumbar discography (p=0.047, OR 0.77), age older greater than 50 (p=0.005, OR 0.63), and prescription opioid analgesic use for more than 1 year preoperatively (p=0.001, OR 0.55). The ability to remain working within the same week as fusion was a positive predictor (p=0.001, OR 2.17). Type of fusion was a significant predictor (p=0.047). Subjects who underwent standalone posterior interbody fusion met our RTW criteria at the highest rate (36.0%, 68/189), while only 21.7% (23/106) anterior interbody lumbar fusion subjects and 23.8% (159/668) posterolateral lumbar fusion plus PLIF subjects met RTW criteria.

DISCUSSION: Comorbid depression before fusion was the strongest predictor of RTW status. Stabilization of psychological comorbidity before lumbar fusion may greatly improve outcomes within a WC setting.
**SP05**

**HOW DOES OBESITY AFFECT EARLY COMPLICATIONS IN PATIENTS UNDERGOING REVISION SPINE SURGERY?**

John K. Yue, David C. Sing, Shane Burch;
Department of Orthopaedic Surgery, University of California, San Francisco, San Francisco, CA, USA

**INTRODUCTION:** Patients undergoing revision spine surgery, including removal of instrumentation or revision of fusion site, often have higher rates of early complications. The purpose of this study is to examine the association between obesity level and 30 day post-operative complication rates in patients undergoing revision spine surgery.

**METHODS:** Data were analyzed from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database from 2005-12. Patients undergoing removal of anterior/posterior instrumentation, reinsertion of spinal device, or exploration of fusion were included. WHO body mass index (BMI, kg/m²) categories were used to classify patients into three groups: Non-Obese (18.5-29.9), Obese Class I (Obese-I, 30-34.9), and Obese Class II/III (Obese-II/III, ≥35). Patients underweight or moribund on American Society of Anesthesiologists (ASA) classification were excluded.

**RESULTS:** Of 2722 patients in the analysis, 56.8% were Non-Obese, 23% Obese-I, 20.2% Obese-II/III. Non-Obese patients were associated with lower cardiovascular (44.6% vs. 69.3%, 70.4%, p<0.001) and respiratory comorbidities (8.6% vs. 12%, 15.3%, p<0.001). Diabetes increased with obesity (8.3%, 18.2%, 31.5%, p<0.001). ASA scores increased with obesity (p<0.001). Univariable logistic regression was performed, and predictors significant (defined as p<0.05) for post-operative complication were included in the multivariable model. Age >80 (OR 2.20, [1.26-3.82]), ASA 4 (OR 4.72 [1.28-17.42]), Obese-II/III (OR 1.54 [1.07-2.22]), and history of sepsis (OR 3.94, [2.13-7.29]) were identified as significant risk factors for complication.

**DISCUSSION:** BMI ≥35, ASA 4, age >80, and history of sepsis are significant predictors for early post-operative complications within 30 days of revision spine surgery. Although obesity may not contraindicate revision spine surgery, its status as a risk factor warrants further study to reduce acute complications and improve outcomes.

**SP06**

**LARGE INCREASE IN BLOOD PRESSURE AFTER EXTUBATION INCREASE THE RISK OF SPINAL EPIDURAL HEMATOMA AFTER LUMBAR SURGERY**

Kentaro Yamada, Yuichiro Abe, Yasushi Yanagibashi, Takahiko Hyakumachi, Shigenobu Satoh;
Department of Orthopaedic surgery, Wajokai Eniwa Hospital

**INTRODUCTION:** Postoperative spinal epidural hematoma (SEH) is rare, but a potentially devastating complication of spinal surgery. Previous studies that reported risk factors for postoperative SEH all identified a multilevel procedure as a risk factor, but the other risk factors for SEH remain
unclear. The purpose of this matched case control study was to clarify risk factors for symptomatic SEH after lumbar surgery, other than multilevel procedure.

**METHODS:** A total of 28 patients (12 men and 16 women, median age 71 years old) have undergone evacuation surgery due to SEH after lumbar surgery at our institution since 1998. Three controls per case were selected. Each control had undergone a procedure with the same number of decompression levels, and under the same surgeon within 1 year of the procedure. The univariate analyses were performed on the patient’s background, preoperative coagulabilities, and perioperative status between SEH cases and controls. The multiple logistic regression analysis was used to obtain adjusted odds ratio (aOR) and 95% confidence intervals (CI).

**RESULTS:** The incidence of postoperative SHE that needed surgical evacuation was 0.39% of 7210 lumbar surgeries within the same period. Ten patients underwent evacuation of SEH due to severe paralysis, and 18 patients underwent due to intolerable leg pain. The univariate analyses identified age, body mass index, and ≥50 mmHg increase in systolic blood pressure after extubation as significant difference (p <0.05). The multivariate analysis including potential confounders noted ≥50 mmHg increase in systolic blood pressure after extubation (aOR 3.67, CI 1.28-10.5) as risk factors for SEH after lumbar surgery.

**DISCUSSION:** This study identified a≥50 mmHg increase in systolic blood pressure after extubation as risk factors for SEH after lumbar surgery. Appropriate blood pressure control during surgery, especially at the end of surgery, is important for the prevention of postoperative SEH.

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**SP07**

**QUANTITATIVE ANALYSIS OF LONG-TERM EFFICACY OF CELL THERAPY FOR INTERVERTEBRAL DISC REPAIR**

1,2Weiyong Gu, 1Qiaoqiao Zhu, 2Xin Gao, 3,4H. Thomas Temple, 3Mark D. Brown; 1Dept. of Biomedical Engineering 2Dept. of Mechanical & Aerospace Engineering 3Dept. of Orthopaedics 4University of Miami Tissue Bank University of Miami, Coral Gables, FL

**INTRODUCTION:** Cell therapies have been proposed for the repair of degenerated intervertebral disc (IVD). However the long-term effects of the treatment are unknown. The objective of this study was to quantitatively analyze the long-term efficacy of cell therapy approaches for IVD repair.

**METHODS:** A finite element method was used to investigate the repair process in the disc for: cell implantation (Case 1), increasing the anabolic process (Case 2), and inhibiting the catabolic process (Case 3). In Case 1, the cell density in the NP region within the degenerated disc was increased to 8000 cells/mm3 (100% increase above normal value, i.e., 4000 cells/mm3) to simulate cell implantation. In Case 2, the GAG synthesis rate was increased by 100% to simulate the increased anabolic process. In Case 3, the GAG degradation rate was reduced by 50% to simulate the reduced catabolic activity. For comparison purposes, a case where no treatment was administered was simulated as a control. All cases were simulated in a degenerated disc with normal nutrition supply.

**RESULTS:** The results of normalized water content (Fig. 1) after 10 years of treatment were presented. The water content in the NP was significantly improved for Case 1. For Case 2, the water content in the degenerated region showed no improvement. For Case 3, the decrease in water content was smaller than that in Control case.
DISCUSSION: The treatment with cell density increase (Case 1) is very effective for disc repair with a normal nutritional supply. Results for Case 2 suggest that this approach may not be effective in the regions with low viable cell density. Inhibiting the catabolic processes in the disc (Case 3) can effectively slow down the degenerative process. This study simulated and predicted long-term efficacies of the three cell therapy approaches for disc repair. The findings in this study can be used to develop and optimize the treatment strategy for disc repair.

SP08
NUCLEUS PULPOSUS CELLS INHIBIT OSTEOGENESIS OF MESENCHYMAL STEM CELLS
Samantha CW Chan1,2 Lorin M Benneker3, Paul Heini4 & Benjamin Gantenbein1;
1 Tissue and Organ Mechano Biology, Institute for Surgical Technology and Biomechanics, University of Bern, Bern, Switzerland 2 Bioactive materials, EMPA, Swiss Federal Laboratories for Materials Science and Technolog, St. Gallen, Switzerland 3 Orthopaedic Department, University Hospital, Bern, Switzerland 4 Sonnenhof Clinic, Bern, Switzerland

INTRODUCTION: Clinical observations indicate that the presence of nucleus pulposus (NP) cells and tissues hinders the rate of ossification of the disc. The underlying mechanism is unknown. We hypothesized that BMP-antagonists are constantly secreted by the disc tissue and potentially hindering the ossification process. Noggin, gremlin and chordin have been identified as the major BMP-antagonists.

METHODS: We isolated and amplified primary human Mesenchymal stem cells (hMSCs) from the bone marrow (N = 8) and isolated primary nucleus pulposus (NPC) and annulus fibrosus cells (AFC) (N = 8) (ethically approved). Cells were expanded up to passage 3 for co-culture experiments. IVD cells were then seeded in ~30 μl 1.2% alginate beads with a cell density of 4M/mL. For co-culture MSCs were expanded in 12-well plates in monolayer and either kept in 1: control medium, 2: osteogenic medium + alginate control, 3: osteogenic + NPC, 4: osteogenic + AFC; the alginate beads were added separated by culture inserts (0.4 μm pore size, high pore density, polyethylene terephthalate, Becton, Dickinson and Company). Relative gene expression of major bone-related genes was quantified on day 21, Alkaline Phosphatase (ALP) Assay and Alizarin Red Staining was performed on day 7, 14 and 21.

RESULTS: Osteogenesis of MSCs was hindered as indicated by a reduced alizarin red staining in the presence of NPC cells. No such inhibition was observed if co-cultured with alginate only (not shown) or less pronounced in presence of AFC (Fig. 1). This result was confirmed at the RNA and the protein level (Fig. 2). Presence of NPC reduced ALP activity.

DISCUSSION: We could demonstrate that NP cells secrete yet unidentified factors that prevent osteogenesis in MSCs.
Further, experiments will look into specific role of noggin and grelin and other BMP inhibitors with respect to IVD factor release to improve fusion outcome. Acknowledgements: This study was supported by the Lindenhof Foundation.

SP09
LINK PROTEIN N-TERMINAL PEPTIDE (LPP) USES THE BMP-RECEPTOR TO INCREASE CARTILAGE PRODUCTION BY INTERVERTEBRAL DISC CELLS
Zili Wang, M. Neale Weitzmann, Sreedhara Sangadala, William C. Hutton, and S. Tim Yoon; Emory University Atlanta VAMC

INTRODUCTION: LPP is a proteolytic fragment of the link protein. LPP can stimulate cartilage production by intervertebral disc cells. Unlike BMP, LPP has little osteogenic effect. The mechanism of action of LPP is not understood.

METHODS: Rabbit and human nucleus pulposus cells were treated with LPP and compared to negative controls. Confocal microscopy was used to localize LPP and BMP-Receptors. Western blots and co-precipitation experiments were performed to determine whether LPP binds to BMP receptors. Gene silencing experiments with siRNA were performed to ablate BMP-RI and BMP-RII to determine whether both chains of the BMP-Receptor are necessary for LPP activity. The effect of LPP on BMP Receptor mediators (Smad 1,5,8) was assessed. The effect of selectively blocking Smad 1, 5, 8 pathways with Dorsomorphin was tested. Protein-protein binding was modeled on in silico protein docking software (SwarmDock) to identify a potential LPP binding domain on the BMP-RII molecule.

RESULTS: Confocal microscopy shows that LPP co-localizes with BMP-RII on the cell membrane. Co-precipitation and Western blots show that LPP-Biotin conjugates with BMP-RII, but not BMP-RI. Gene silencing of either BMP-RI or BMP-RII with siRNA reduces LPP-mediated upregulation of the disc matrix macromolecules aggrecan and collagen II. The phosphorylated forms of Smad 1, 5, 8 (BMP-RI mediators) were up-regulated in cells treated with LPP. Blocking the Smad 1, 5, 8 pathways with Dorsomorphin blocked the effect of LPP on disc cells. In silico modeling indicates a LPP docking site on the extracellular domain on the BMP-RII (figure 1).

DISCUSSION: The mechanism of action of LPP depends on direct binding to BMP-RII and requires both BMP-Receptors I and II and Smad 1, 5, 8 pathways. This is a first description of a small peptide binding BMP-RII to induce a biological function. Knowledge of this mechanism could be helpful in the development of drugs that could simulate cartilage production.

SP10
DYNAMIC IMAGING DEMONSTRATES THE EFFECT OF PULSED ELECTROMAGNETIC FIELDS (PEMF) TREATMENT ON IL-6 TRANSCRIPTION IN BOVINE NUCLEUS PULPOSUS CELLS
Tang, Xinyan 1; Coughlin, Dezba 1; Waldorff, Erik 2; Ryaby, James 2; Alliston, Tamara 1; Lotz, Jeffrey 1;
1 Department of Orthopaedic Surgery, University of California San Francisco, San Francisco, CA, United States; 2 Orthofix Inc., Lewisville, Texas, United States.

INTRODUCTION: Application of pulsed electromagnetic fields (PEMF) in orthopaedics has been shown to provide clinical
benefits. However, little is known about the disease-modifying mechanism of PEMF, and the ideal PEMF dose. Our previous study revealed that PEMF inhibited IL-6 gene expression in human annulus fibrosus cells. The objective of this study was to use a GFP-tagged MS2 reporter system to visualize and quantify dynamic changes of IL-6 mRNA transcription in response to inflammation and PEMF stimulation. This dynamic data will help optimize the PEMF dosing conditions for clinical treatments.

**METHODS:** Nucleus pulposus cells were isolated from bovine tail discs. Vectors were prepared by cloning MS2-GFP and IL-6 promoter-MS2x24 fragments into backbone PminiTol2 (Addgene) respectively. In this system, the fluorescing signal is amplified through GFP tethering to specific mRNA driven by the IL-6 promoter, rapidly forming bright nuclear GFP particles upon IL-6 mRNA induction. Co-transfection was performed with electroporation. After 2 hours of IL-1α treatment (10ng/ml, Sigma), cells were treated with or without PEMF for 4hr (Orthofix Inc.). Dynamic confocal imaging was used to observe fluorescence particles. Particle number and intensity were analyzed over 6.5hr with Imaris software (n=5).

**RESULTS:** After co-transfection, NP cells exhibited enriched GFP in their nucleus. IL-1α triggered IL-6 expression quickly by increasing GFP particle number and intensity within the first 30min; however, this promoting effect was significantly reduced by PEMF treatment compared to IL-1α treatment alone (Figure 1).

**DISCUSSION:** The novel GFP-MS2 reporter system was successfully used to visualize the dynamic PEMF inhibitory effects on IL-6 mRNA transcription within 4 hrs of dosing, helping optimize the PEMF dosing treatment. The data will provide a promising tool to monitor the dynamic gene expression of interesting genes associated with pathological or therapeutic process.
vating L5/6 discs with FluoroGold neurotracer (n=12). Rats were divided into three groups (n=4/group): an anti-VEGF group (that underwent L5/6 intervertebral disc puncture using a 23-gauge needle and 30μg pegaptanib sodium, a VEGF165 aptamer, injection into the disc); a control group (disc puncture and 10μl saline solution injection to disc); and a sham-surgery group (non-puncture group). One day and seven days after surgery, DRGs from the L1 to L6 levels were harvested, sectioned, and immunostained for CGRP to detect CGRP levels and distribution.

RESULTS: The percentage of CGRP-positive cells in the FG-positive rats was lower in the anti-VEGF group (48.8% and 58.2%) than in the control group (55.2% and 71.6%) both one day and seven days after puncture, respectively, reaching statistical significance (p<0.05). The percentage was also higher in the control group than the sham group (41.0% and 51.6%) both one day and seven days after puncture, respectively, also statistically significant (p<0.05).

DISCUSSION: The percentage of CGRP-positive cells in the FG-positive rat was lower in the anti-VEGF group than in the control group both one day and seven days after puncture. VEGF may be a therapeutic target for pain control in patients with discogenic low back pain.

SP12

PROTECTIVE EFFECTS OF RAPAMYCIN AGAINST INTERVERTEBRAL DISC CELLULAR APOPTOSIS, SENESCENCE, AND EXTRA-CELLULAR MATRIX DEGRADATION ARE LINKED TO AKT PHOSPHORYLATION AS WELL AS TO AUTOPHAGY INDUCTION

Takashi Yurube (1,2), Thomas P. Lozito (1), Robert A. Hartman (3), Pedro H. I. Pohl (1), Zhang Zhongying (1,2), Kotaro Nishida (2), Masahiro Kurosaka (2), Nam V. Vo (1), Gwendolyn A. Sowa (1,3), James D. Kang (1);

(1) Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, PA (2) Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, Kobe, Japan (3) Department of Physical Medicine & Rehabilitation, University of Pittsburgh, Pittsburgh, PA

INTRODUCTION: Autophagy is an important stress-response cell survival mechanism by which cells break down and recycle damaged components. However, roles of autophagy in disc cells and matrix remain unclear. Our objective was to elucidate effects of an autophagy inducer rapamycin (Rap), compared to of an autophagy inhibitor 3-methyadenine (3-MA), and to provide insight into potential biological disc therapy.

METHODS: Rabbit annulus fibrosus cells were cultured with 10 ng/ml interleukin (IL)-1α with Rap or 3-MA. 1) To clarify drug toxicity, cell viability was measured. 2) To assess autophagy, autophagic flux and mTOR signaling were monitored by imaging cytometry and Western blotting. 3) To analyze cell fate, apoptosis and senescence were evaluated. 4) To examine matrix metabolism, catabolic and anti-catabolic molecule expression and aggrecan degradation were investigated.

RESULTS: 1) Based on optimal cell viability, 100 nM Rap and 2.5 mM 3-MA were selected for the remainder of experiments. 2) Longitudinal observation revealed Rap increased but 3-MA decreased autophagy markers, LC3 puncta number and LC3-II expression, at 6–24 h; but, 3-MA increased them at 48 h. A negatively correlated marker, p62/SQSTM1 expression, decreased over time by both agents. In mTOR pathway, while Rap decreased mTOR and p70/S6K but increased Akt phosphorylation, 3-MA decreased all these phosphorylation. 3) IL-1α increased apoptotic cleaved PARP and senescent p16/INK4A. Rap reduced but 3-MA elevated apoptosis and senescence. 4) IL-1α increased active MMP-3 and MMP-13, TIMP-1, and MMP-cleaved aggrecan fragments. Rap decrea-
sed active MMPs and aggrecan fragments and further increased TIMP-1. 3-MA induced opposite changes.

**DISCUSSION:** Incomplete autophagy inhibition by 3-MA is consistent with other reports. Nevertheless, Rap and 3-MA showed contrasting effects. Rap is a promising drug to treat disc disease. Beneficial effects of Rap may result from activation of Akt as well as of autophagy.

**SP13**

**SAGITTL FLAT BACK ALIGNMENT IS COMMON IN YOUNG PATIENTS WITH SYMPTOMATIC LUMBAR DISC HERNIATION**

Olof Thoreson MD1, Peter Kovac MD2, Klas Halldin MD, PhD1, Pall Jonasson MD1, Helena Brisby MD, PhD1 and Adad Baranto MD, PhD1; 1Department of Orthopaedics, Institute of Clinical Sciences at Sahlgrenska Academy, University of Gothenburg and Sahlgrenska University Hospital, Gothenburg, Sweden. 2Department of Radiology, Institute of Clinical Sciences at Sahlgrenska Academy, University of Gothenburg and Sahlgrenska University Hospital, Gothenburg, Sweden.

**INTRODUCTION:** Recent studies suggest a correlation between spinal sagittal alignment and different types of lumbar pathologies due to different load patterns on the lumbar spine. The main purpose of this study was to investigate the pre-operative horizontal spinal sagittal alignment in young patients (<25 years) undergoing lumbar disc herniation surgery.

**METHODS:** Fifty-three consecutive patients (mean age 18.1 (range 12 to 24) years; 58% boys) undergoing surgery for a lumbar disc herniation was included in the study. Preoperative MRI (n=51) and CT (n=2) examinations were used to classify lumbar types according to four sagittal spinal alignment types (a long thoracic kyphosis (type 1), a flat back (type 2), a normal spine (type 3) and an increased thoracic kyphosis (type 4)). Classification of lumbar types was performed independently by three spine surgeons. In a subgroup of the patients (n=8) the classification by supine MRI was compared to classification by standing X-ray.

**RESULTS:** The distribution of operated levels was L3-L4 2% (1 patient), L4-L5 47% (25 patients), L5-S1 42% (22 patients) and L4-L5+S1 9% (5 patients). The distribution of lumbar curve types based on MRI/CT was; type 1: 17% (9 patients), type 2: 62% (33 patients), type 3: 17% (9 patients) and type 4: 4% (2 patients). There was no difference in the grading of spinal alignment type between MRI and X-ray examinations in the subgroup of 8 patients.

**DISCUSSION:** A majority of the young patients (62%) that underwent surgery due to herniated disc in the lumbar spine was classified as having a type 2 spine, indicating having a flat back. The classification performed in supine MRI agreed well with classification in standing x-rays. Future studies are needed to increase the knowledge about spino-pelvic sagittal alignment and the correlation to spinal pathologies.

**SP14**

**TARGETED THERAPY OF LOW BACK PAIN ASSOCIATED WITH DE NOVO DEGENERATIVE LUMBAR SCOLIOSIS IN THE ELDERLY: PROSPECTIVE OBSERVATION COHORT STUDY**

Kiyotaka Yamada1, Yoshinori Fujimoto1, Toshio Nakamae1, Takashi Hashimoto1, Osami suzuki1, Masaki Matsuura1, Taiki Morisako1, Kjell Olmarker2;
**INTRODUCTION:** The cause of low back pain (LBP) in degenerative lumbar scoliosis (DLS) is controversial. We speculate that bone marrow edema (BME) frequently found in the endplates at the concave side of scoliosis on MRI is strongly associated with LBP. We developed a novel operative therapy, termed percutaneous transpedicular intervertebral vacuum PMMA injection (PIPI), for LBP with BME in elderly DLS patients. The aim of this study is to report 2-year outcomes of PIPI as a treatment for LBP in the elderly patients with DLS.

**METHODS:** We included de novo DLS patients aged 65 years and over who had LBP (VAS >50) at least 6 months with intervertebral vacuum phenomenon and BME defined on fat saturated T2-weighted or gadolinium-enhanced T1-weighted MRI. 119 patients underwent PIPI (PIPI group) and 61 patients received nonoperative treatment (control group). PIPI was performed under general anesthesia. A 14-gauge bone needle was inserted into the intervertebral vacuum through percutaneous and transpedicular approach. After vacuumography, opacified PMMA was injected into the intervertebral vacuum cavity. The outcomes were evaluated using Visual analog scale (VAS) for LBP, and the Oswestry Disability Index (ODI). BME was evaluated with MRI as an objective measurement.

**RESULTS:** In PIPI group, the mean VAS and ODI scores were 82.9±15.3 and 53.0±16.3 at the baseline. These scores were significantly improved at 1 month after PIPI (28.8±22.9, 31.2±18.1), and maintained for 2 years (30.0±25.4, 32.3±18.0). In control group, the mean VAS and ODI scores were 70.3±15.2, 49.7±16.1 at the baseline. These were not improved for 2 years (66.5±18.6, 47.0±15.1). BME was reduced from 6 month after PIPI, and gradually disappeared for 2 years in PIPI group. However, BME was not reduced in control group.

**DISCUSSION:** LBP was improved immediately after PIPI compared with nonoperative treatments. PIPI could be a novel targeted therapy for LBP associated with de novo DLS in the elderly.

**SP15**

**THE PROGNOSIS OF L5 RADICULOPATHY AFTER REDUCTION AND INSTRUMENTED FUSION OF ADULT ISTHMIC HIGH-GRADE LUMBOSACRAL SPONDYLOLISTHESIS AND THE ROLE OF MULTIMODAL INTRAOPERATIVE NEUROMONITORING (MIOM)**

Ralph T. Schär MD1, Martin Sutter MD2, Anne F. Mannion PhD3, Andreas Eggspüler MD3, Dezső Jeszenszky, MD, PhD1, Tamas Fekete MD1, Frank Kleinstück MD1, Daniel Haschtmann MD1;
1. Spine Center, 2. Department of Neurology, 3. Department of Research and Development, Schulthess Clinic, Zurich, Switzerland

**INTRODUCTION:** Iatrogenic L5 nerve root injury is a common complication of reduction of isthmic high-grade spondylolisthesis (HGS). However, the clinical presentation and prognosis as well as its impact on patient-rated outcome have never been analysed systematically and the role of multimodal intraoperative neuromonitoring (MIOM) is largely unknown.

**METHODS:** Clinical and radiographic data from consecutive patients who underwent reduction and instrumented fusion of HGS between 2005–2013 were analysed. The multidimensional Core Outcome Measures Index (COMI) was completed before and after surgery. MIOM with transcranial MEP and continuous EMG of index muscles was carried out.

**RESULTS:** 17 patients (13f, 4m) with a radiographic follow-up of 23 (3 to 83)
months were included. Mean (±SD) age was 26.3 (±9.2) years. L5-S1 slip was 72% (±21%), which was reduced to 19% (±13%). After 1 year COMI improved from 6.7±1.7 to 3.7±3.1, leg pain from 5.2±3.1 to 2.3±3 and back pain from 6.2±1.9 to 3.4±2.6. In 5 patients (29%) an incomplete L5 motor deficit occurred: 2 with 3/5 paresis or worse, 3 with 4/5. 4 patients fully recovered after 3 months, 1 patient was lost to follow-up. In 15 procedures 25 intraoperative MIOM alerts were recorded. Based on intraoperative recovery of the signals, MIOM theoretically predicted 1 new neurological deficit and 15 patients without deficits and related to the final outcome has a sensitivity and specificity of 100%. However, with respect to 29% early and (mostly) transient neurological deficits, the sensitivity was only 20%.

DISCUSSION: Reduction and instrumented fusion of HGS showed a satisfactory outcome. The rate of transient L5 palsy was relatively high. However, all followed patients fully recovered after 3 months. MIOM alerts occurred in 88% of the procedures and thereby possibly limited the prevalence of relevant neurological deficits to 5.9%. Intraoperative recovery of deteriorating MIOM signals cannot predict transient neurological deficits.

**SP16**

**INFLUENCE OF SPINOPELVIC ALIGNMENT ON THE RESIDUAL LOW BACK PAIN AFTER LUMBAR SPINAL FUSION.**

1. Spine Center, Hakodate Central General Hospital Kahoru Tashiro, Masahiro Kanayama, Akira Iwata, Shingo Onda, Takamasa Watanebe, Tomoyuki Hashimoto 2. Department of Orthopaedic Surgery, Juntendo University Kazuo Kaneko; Spine Center, Hakodate Central General Hospital

**INTRODUCTION:** The aim of this study is to investigate the effect of spinopelvic alignment on the residual low back pain after PLIF/TLIF.

**METHODS:** 217 patients who had undergone PLIF/TLIF were reviewed retrospectively after six postoperative months. They were 69 males and 148 females with a mean age of 68 years. Patients with long fusion (>4 segments), postoperative infections, pseudarthrosis, or subsequent vertebral fractures were excluded. Residual low back pain (LBP) was defined as those who needed pain-killers for LBP for more than three postoperative months. There were 50 patients with residual LBP (Group A) and 167 patients without LBP (Group B). Radiographic assessment was performed using upright whole spine radiographs at three weeks after surgery. Parameters included sacral slope (SS), pelvic tilt (PT), pelvic incidence (PI), lumbar lordosis (LL), lordosis at the fusion level (LF), and anterior deviation of sagittal vertical axis (SVA).

**RESULTS:** Anterior deviation of SVA was significantly larger in Group A than Group B (5.9 vs. 4.1 cm, p=0.001). There were no statistical differences in SS (30.5 vs. 30.1 degrees), PT (24.2 vs. 21.5 degrees), PI (54.7 vs. 51.6 degrees), LL (38.7 vs. 40.1 degrees), and LF (13.7 vs. 12.9 degrees).

**DISCUSSION:** Residual low back pain after lumbar spinal fusion was reported to range from 37 to 66%. Potential risks included sagittal imbalance, pseudarthrosis, postoperative infection, subsequent vertebral fracture, proximal junctional kyphosis. The current study demonstrated that larger anterior deviation of SVA at early postoperative period was a risk factor for residual low back pain after lumbar spinal fusion.

**SP17**

**PREOPERATIVE FIBRINOGEN PLASMA CONCENTRATION BUT NOT FACTOR XIII ACTIVITY PREDICTS BLEEDING IN LUMBAR SPINAL FUSION PATIENTS**

Carling M1,2, Jeppsson A3, Ericsson B1,2, Brisby, H1,2;
INTRODUCTION: Low preoperative concentration of fibrinogen in plasma is a relatively good predictor for excessive bleeding in patients undergoing idiopathic scoliosis surgery (1). Furthermore, plasma activity of factor XIII has been suggested to be a potential predictive biomarker of excessive bleeding in different surgical patients. The aim of the present study was to investigate if preoperative fibrinogen concentration and/or factor XIII activity are useful clinical predictors for excessive blood loss and transfusion requirements in patients undergoing lumbar fusion surgery.

METHODS/MATERIALS: Fifty-two consecutive patients (mean age 62 ±12 years, 52% women) undergoing instrumented lumbar fusion surgery were included in a prospective observational study. Fibrinogen concentration and factor XIII activity was measured before surgery and related to bleeding volume and transfusions of allogeneic blood products.

RESULTS: Mean operating time was 247±78 min. Mean preoperative fibrinogen concentration was 3.0±0.8 g/L and factor XIII activity 1.06±0.23 kIE/L. Median bleeding volume was 1690 (25th and 75th percentile 1715-2530) mL. Red blood cell transfusion rate during hospital stay was 67% (35/52). Patients with fibrinogen concentration ≤2.5 g/L had significantly larger total bleeding volume than patients with>2.5 g/L (2430 (1245-3162) vs 1390 (935-2107) mL, p=0.029. The proportion of patients bleeding >2000 mL was significantly higher in patients with fibrinogen concentration ≤2.5 g/L (61 vs 32%, p=0.046). No associations between factor XIII activity and bleeding, or between fibrinogen concentration or FXIII activity and transfusion rate, were observed.

CONCLUSIONS: The prevalence of large bleeding and red blood cell transfusion is high in lumbar fusion surgery. A preoperative fibrinogen concentration ≤2.5g/L is associated with an increased bleeding risk.


SP18
PARASPINAL MUSCLES AND SAGITTAL SPINOPELVIC ALIGNMENT IN PATIENTS WITH DEGENERATIVE SPONDYLOLISTHESIS
Sibel Demir-Deviren, MD1, Emel E Ozcan-Eksi, MD1, Murat Pekmezci, MD1, Irem Kapucu, BS2, Murat Eksi, MD1, Bobby Tay, MD1, Sigurd Berven, MD1, Shane Burch, MD1, Vedat Deviren, MD1;
1 University of California San Francisco, San Francisco, CA, US 2 Koç University, Istanbul, Turkey

INTRODUCTION: Sagittal spinopelvic misalignment (SSM) causes worse clinical outcomes in degenerative spinal disorders. Patients with degenerative spondylolisthesis (DS) have high pelvic incidence (PI), unless lumbar lordosis (LL) is increased, SSM is unavoidable. We hypothesize that patients with more atrophied and fatty infiltrated paraspinal muscles could not compensate SSM and have surgery. We compared paraspinal muscles, spinopelvic alignment and their relationships in patients with DS who chose to have surgery with those who did not.

METHODS: This is a retrospective study on prospectively collected data. One hundred four patients (mean age: 63.06±14.33) were included based on the exclusion criteria: BMI>40 kg/m2, DM, isthmic
spondylolisthesis, Modic 1 DDD, scoliosis, osteoporosis, metastatic cancer, neuro-muscular disorders, previous spine surgery. Facet joint widening, functional cross-sectional area (fCSA), percentage atrophy and fatty infiltration of multifidus, erector spinae, and psoas muscles were measured on lumbar spine MRIs with OsiriX®. PI, LL, sacral slope (SS) and pelvic tilt (PT) were measured to evaluate sagittal spinopelvic alignment on lateral lumbar spine X-rays with Surgimap®.

RESULTS: The groups were similar in age, facet joint widening and spinopelvic parameters. However, the surgical group had significantly higher BMI (p<0.031), more fatty infiltration and bigger paraspinous muscles than the nonsurgical group (p<0.025). LL increased as surgical patients had bigger multifidus, less atrophied erector spinae and less fatty infiltrated psoas (r=0.27-0.33).

DISCUSSION: Patients with higher BMI and more fatty infiltration in paraspinous muscles were more likely to have surgery. Patients with atrophy and fatty infiltration in multifidus and erector spinae muscles could not increase LL and compensate SSM.

### SP19

**HIGH-DOSE ACETAMINOPHEN HAS NEITHER ANALGESIC NOR ANTI-INFLAMMATORY ADVANTAGE OVER LOXOPROFEN SODIUM HYDRATE FOR THE ACUTE PAIN AFTER SPINE SURGERY**

Yukitaka Nagamoto Hidekazu Tobimatsu Hirayuki Aono;
Department of Orthopaedic Surgery, Osaka National Hospital

**INTRODUCTION:** Although non-steroidal antiinflammatory drugs (NSAIDs) are one of the most commonly prescribed drugs for the acute pain after spine surgery, the use of NSAIDs is frequently limited by gastrointestinal side effects and renal failure. Since Health, Labour and Welfare Ministry of Japan approved an increase in the maximum dose of acetaminophen (AC) in 2011, high-dose AC attracts increasing attention because of its effectiveness and safety. The purpose of our study is to elucidate the analgesic and anti-inflammatory effect of high-dose AC compared with loxoprofen sodium hydrate (LX).

**MATERIALS AND METHODS:** 256 patients who underwent spinal surgery were included. From August 2012 to June 2013, 107 patients (1-level PLIF (1PLIF): 37, fenestration adjacent to PLIF (PLIF+Fn): 14, fenestration (Fn): 29, and cervical laminoplasty (LP): 27) were treated with LX 180mg/d (LX group) and from June 2013 to May 2014, 149 patients (1PLIF: 45, Fn+PLIF: 26, Fn: 48, and LP: 30) were treated with AC 2400mg/d (AC group) for postoperative pain. The pain was evaluated with a numerical rating scale (NRS) at postoperative day 1-7. Liver enzymes, C-reactive protein (CRP), and estimated glomerular filtration rate (eGFR) were assessed at baseline, day 0, 1, 3, 5, 7 and 14. NRS and the blood tests were compared between 2 groups. There is no significant difference between groups in age, sex and surgical procedure.

**RESULTS:** NRS on day 1-7, CRP on day 3-14, and AST on day 3-14 of AC group were significant higher than those of LX group. ALT and eGFR showed no significant difference among groups. Within each surgical procedure, NRS and CRP of AC group were
also higher than those of LX group but the difference was not significant.

**DISCUSSION AND CONCLUSION:** High-dose AC has neither analgesic nor anti-inflammatory advantage over LX for the acute pain after spine surgery. We elucidated the difference of anti-inflammatory effect on the surgical invasion between NSAIDs and AC for the first time.

**SP20**

**MINIMALLY INVASIVE TRANSFORAMINAL LUMBAR INTERBODY FUSION: META-ANALYSES OF THE FUSION RATES. WHAT IS THE OPTIMAL GRAFT MATERIAL?**

Avelino Parajón 1, Marjan Aliimi 1, Paul Christos 2, Jose M. Torres-Campa 1, Rodrigo Navarro-Ramirez 1, Yu Moriguchi 1, Roger Härtl 1;
1 Weill Cornell Brain and Spine Center, Department of Neurological Surgery, Weill Cornell Medical College, New York-Presbyterian Hospital, New York, NY 2 Department of Statistics, Weill Cornell Medical College, New York, NY

**INTRODUCTION:** It has previously been shown that Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS TLIF) has similar fusion rates and complication rates compared to open TLIF surgery. Different graft materials are being used for fusion. No previous studies have compared the fusion rates of different graft materials. The aim of the current study was comparison of the fusion rate between different graft materials, via meta-analysis of the published literature.

**METHODS:** A Medline search was performed to identify the studies reporting fusion rates of MIS TLIF using different graft materials. A database was created including patient demographics, per-operative data, type of graft material, clinical outcome, and the fusion rate. Groups were defined based on the type of graft utilized. Meta-analysis of the fusion rate was performed using the StatsDirect statistical software.

**RESULTS:** Forty series with 1320 patients were included. Significant clinical improvement was observed in all studies. Fusion rates were high, regardless of the type of the graft, ranging from 92% to 99%. Comparison of all rhBMP series with all non-rhBMP series showed fusion rates of 96.6% vs. 92.5%, respectively. Iliac bone graft alone compared to non- iliac bone graft showed fusion rates of 92.8% and 92.4%, respectively. The lowest fusion rate was observed with isolated use of autologous local bone (91.7%). Yet, addition of rhBMP to local bone increased the fusion rate up to 95% and addition of non-rhBMP grafts to the local bone increased it up to 93%. The median complication rate was 8.82%.

**DISCUSSION:** Utilization of rhBMP for MIS TLIF resulted in higher fusion rates. Isolated use of local bone resulted in the lowest. Given the potential complications of iliac bone harvesting and rhBMP, the decision on the type of graft material should be made for each patient separately. When rhBMP used, efforts should be made to use the lowest possible amount.

<table>
<thead>
<tr>
<th>Group</th>
<th>Graft</th>
<th>Fusion rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>With BMP</td>
<td>96.6</td>
</tr>
<tr>
<td>B1</td>
<td>Without BMP</td>
<td>92.5</td>
</tr>
<tr>
<td>A2</td>
<td>Only Autologous local bone, With BMP</td>
<td>95.3</td>
</tr>
<tr>
<td>B2</td>
<td>Only Autologous local bone, Without BMP</td>
<td>91.7</td>
</tr>
<tr>
<td>A3</td>
<td>Other non-human bone substitutes, With BMP</td>
<td>99.1</td>
</tr>
<tr>
<td>B3</td>
<td>Other non-human bone substitutes, Without BMP</td>
<td>93.1</td>
</tr>
<tr>
<td>B4</td>
<td>Iliac crest, Without BMP</td>
<td>92.8</td>
</tr>
<tr>
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<td>Non-Iliac crest, Without BMP</td>
<td>92.4</td>
</tr>
<tr>
<td>A5</td>
<td>12 months follow-up, With BMP</td>
<td>98.7</td>
</tr>
<tr>
<td>B5</td>
<td>12 months follow-up, Without BMP</td>
<td>93.6</td>
</tr>
<tr>
<td>A6</td>
<td>24 months follow-up, With BMP</td>
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<tr>
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<td>24 months follow-up, Without BMP</td>
<td>94.3</td>
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</tbody>
</table>

**SP21**

**FACTORS ASSOCIATED WITH IMPROVEMENT OF SPINAL SAGITTAL ALIGNMENT AFTER MICROENDOSCOPIC LAMINOTOMY IN PATIENTS WITH LUMBAR SPINAL CANAL STENOSIS.**

Sho Dohzono, MD PhD, Hiromitsu Toyoda, MD PhD, Akinobu Suzuki, MD PhD, Masatoshi
INTRODUCTION: Patients with lumbar spinal canal stenosis (LSS) present a forward-bending posture during walking. However, there is little knowledge about the improvement of forward-bending posture after surgery. The purpose of this study was to identify the sagittal spinal alignment and objective findings in LSS patients.

METHODS: We reviewed 61 patients with LSS who underwent microendoscopic laminotomy (MEL) and the pre- and post-operative clinical data and radiographic parameters, such as JOA score, VAS (LBP, leg pain and numbness), symptom duration, sagittal vertical axis (SVA), lumbar lordosis (LL), sacral slope (SS), pelvic tilt (PT), pelvic incidence (PI) were evaluated. On axial T2-weighted MRI, the cross sectional area (CSA) and the percentage of fat infiltration (%FI) of paravertebral muscle (PVM) before surgery were calculated. About the patients with preoperative SVA > 40mm (N=30), the correlation was calculated between improvement of SVA and preoperative clinical data or radiographic parameters.

RESULTS: The mean SVA value decreased from 45.5mm before surgery to 36.7mm at latest follow-up (P=0.082). The LL angle was significantly increased from 25.6° to 28.0° at latest follow-up (P<0.05). There were no significant differences between pre- and post-operation in SS, PT, PI, and PI-LL. The improvement of SVA value showed an correlation with preoperative LL (r = -0.388) and PI-LL (r = 0.543). Step-wise multiple regression analysis showed that preoperative PI-LL (beta = 0.615, p<0.01) and symptom duration (beta=-0.399, p<0.05) were independently associated with the improvement of SVA. CSA and %FI of PVM were not related to the improvement of SVA.

DISCUSSION: High value of PI-LL means the sagittal imbalance according to the SRS-Schwab classification. In the current study, high value of PI-LL was related to the good improvement of SVA. So we speculate that high value of PI-LL in LSS patients was due to the abnormal posture to avoid neurological symptom.

SP22
EXTERNAL COMPARISONS OF A TREATMENT OUTCOMES CALCULATOR FOR SURGICAL AND NONSURGICAL TREATMENT OF DISC HERNIATION
1EA Scherer, 2J Lurie, 3S Atlas, 4WC Jacobs, 4W Peul, 5K Spratt, 5W Zhao, 6J Weinstein, 1TD Tosteson;
1Department of Community and Family Medicine, 2Department of Medicine, Geisel School of Medicine at Dartmouth, Hanover, NH, USA 3Department of Primary Care, Massachusetts General Hospital, Boston, MA, USA 4Department of Neurosurgery, Leiden University Medical Center, The Hague, The Netherlands 5The Department of Orthopaedics, Geisel School of Medicine at Dartmouth, Hanover, NH, USA 6Dartmouth-Hitchcock Medical Center, Lebanon, NH, USA

INTRODUCTION: An outcomes prediction calculator was developed using longitudinal regression coefficients derived from the Spine Patient Outcomes Research Trial (SPORT). The calculator provides predicted longitudinal physical function (SF-36 PF) for surgical and non-surgical treatment given user-entered baseline PF and prognostic information. We compared the calculator predictions to data from two independent studies: The Dutch Sciatica Trial and the Maine Lumbar Spine Study.

METHODS: Using the adjusting covariates available in both the external validation datasets and the calculator model, the calculator regression coefficients were
applied to all observations in the external datasets. Predicted values were compared to observed PF scores. Estimates and confidence intervals of bias (observed minus predicted) and root mean square error were obtained using 1000 bootstrap samples from each dataset.

RESULTS: For the Dutch dataset, mean prediction bias for 1 year PF was 4.4 (95% CI 0.9, 7.9) and 12.7 (95% CI 8.5, 16.6) for surgical and non-surgical groups, respectively, indicating observed scores higher than calculator-predicted scores. Participants in the Dutch trial were, on average, of similar age and gender proportions, but had lower BMI (mean (SD) 25.7 (5.6)) and greater PF (mean (SD) 34.2 (19.2)) at baseline than those in the SPORT dataset (mean (SD) BMI=28.0 (5.6), mean (SD) PF=37.8 (25.6)). For the U.S. dataset, mean bias for 1 year PF was -6.2 (95% CI -8.9, -3.5) and -6.0 (95% CI -9.2, -2.9) for surgical and non-surgical groups, respectively, indicating predictions higher than observed. This population was similar in age and baseline PF.

DISCUSSION: Predictions based on the SPORT data showed systematic biases in opposite directions in the other studies, but these were only ½ to ¾ of the total error including random variations. Population characteristics and variation in treatment protocols may affect the interpretation of predictions based on a single study.

SP23
THE IMPACT OF NEW POLICY RESTRICTION ON INDICATIONS FOR LUMBAR FUSION SURGERY
Brook I. Martin, PhD MPH Richard A. Deyo, MD MPH Jon D. Lurie, MD MS Anna N.A. Tosteson, ScD Timothy Carey, MD Sohail K. Mirza, MD MPH;
The Dartmouth Institute for Health Policy and Clinical Practice Department of Orthopaedic Surgery at Department-Hitchcock Medical Center

INTRODUCTION: Use of lumbar fusion for certain indications is under scrutiny for overuse, driving policy changes to curb harms and costs associated with this procedure. A dominant insurer (Blue Cross Blue Shield of North Carolina) restricted coverage of lumbar fusion for disc herniation (HNP) and degenerative disc disease (DDD) in 2011. We used NC’s State Inpatient Database (2005-2012) to examine population-based trends in lumbar fusion operations before and after this policy change.

METHODS: We applied a validated claims-based categorization of surgical indications to measure monthly rates and volume of inpatient lumbar fusion surgery by insurance type. Admissions for trauma, spinal fracture, congenital anomaly, cancer, cauda equina syndrome, and osteomyelitis were excluded. We used regression models for time series to test for significant changes in the use of fusion surgery before and after the policy change.

RESULTS: Rate (p=0.006) and volume (p=0.002) of lumbar fusion for two indications restricted by the new policy – HNP and DDD – decreased significantly following the policy implementation. The change in the rate of fusion per 100,000 residents was most pronounced for patients under age 65 years: increasing from 86.7 (95%CI 84.1–89.3) in 2005 to 91.1 (95%CI 88.6–93.5) in 2010, followed by a sharp decline to 73.0 (95%CI 70.8–75.2) two years after the policy restriction. Fusion among commercially insured patients dropped below that of publicly insured patients following the policy change. Decreases in HNP and DDD as indications were not accompanied by significant increases for other indications.

DISCUSSION: Use of lumbar fusion surgery for HNP and DDD declined sharply following a major insurer’s policy restriction, without corresponding increases in the
rates for other surgical indications. Diagnosis-based restrictions had its intended effect of making the use of fusion operations more concordant with trustworthy clinical guidelines.

SP24
ECONOMIC EVALUATION OF INTRAOPERATIVE CT BASED NAVIGATION FOR THE PLACEMENT OF SPINAL PIEDIC SCREWS: A PATIENT-LEVEL COST EFFECTIVENESS ANALYSIS
Dea N, Fisher CG, Batke J, Street J; University of British Columbia

INTRODUCTION: Pedicle screws are routinely used in contemporary spinal surgery and screw misplacement is correlated with potential adverse events. An economic evaluation looked at misplaced screws leading to reoperation secondary to neurological deficits or biomechanical concerns.

METHODS: Patient-level cost-effectiveness analysis from the hospital perspective used prospectively collected data from a single center to determine the value of a navigation system coupled with intra-operative 3D imaging (O-arm and StealthStation, Medtronic, TN) in adult spinal surgery. A consecutive series of patients treated using computer-assisted surgery (treatment group) were compared to a matched historical cohort treated with conventional methods (control group). The primary effectiveness measure was the number of reoperations for misplaced screws.

RESULTS: 5132 pedicle screws were inserted in 502 patients, 2682 screws in 253 patients in the treatment group and 2450 screws in 249 patients in the control group. Accuracy rates were 95.2% for the treatment group and 86.9% for the control group. Two patients (0.8%) in the treatment group required revision surgery (within same admission) compared to 15 patients (6%) in the control group (9 same admission and 6 within one year). Costs of the different alternatives were based on the annuitization of capital expenditures method. Using this methodology, an incremental cost effectiveness ratio of $15,961/reoperation avoided was calculated for the treatment group. Based on a reoperation cost of $12,618, if a center performs more than 254 instrumented spinal procedures per year, this new technology might be cost-saving.

DISCUSSION: Computer-assisted spinal surgery may reduce reoperation rates and has cost-effectiveness implications. High technology acquisition and maintenance costs can be offset by equally high reoperation costs. Cost-effectiveness analysis showed that this technology might be economically justified for high-volume centers.

SP25
ANALYSIS OF INTERNET INFORMATION ON LATERAL LUMBAR INTERBODY FUSION
Rebekah Belayneh, Addisu Mesfin MD; Howard University College of Medicine and University of Rochester School of Medicine and Dentistry

INTRODUCTION: The Internet is a common resource for health and medical information. Previous studies have shown the Internet’s shortcomings in presenting comprehensive information regarding surgical procedures. Lateral lumbar interbody fusion (LLIF) is a surgical technique
that is being increasingly used. The purpose of this study is to examine information on the Internet about LLIF and determine the comprehensiveness of the information.

**METHODS:** The top 35 websites providing information on the “lateral lumbar interbody fusion” from four search engines were identified. 140 websites were evaluated. Each website was categorized based on authorship (academic, private, medical industry, insurance company, other). We analyzed patient inclusion and exclusion criteria, surgical and non-surgical treatment alternatives, benefits and risks, industry-sponsored and peer-reviewed literature, description and diagram of procedure, author contact information, and date of last update.

**RESULTS:** 78 unique websites were identified. 46.2% of websites were authored by a private medical group, 26.9% by an academic medical group, and 5.1% by biomedical industry. 68% of websites reported indications and 24.4% reported contraindications. Benefits of LLIF were reported in 69.2% of websites. 36% of websites reported complications of LLIF. 50% and 7.7% of websites discussed alternative surgical and non-surgical options, respectively. 21.8% of websites contained references to peer-reviewed literature and 32.1% contained industry-sponsored literature.

**DISCUSSION:** Overall, the quality of information regarding LLIF on the Internet is poor. The majority (46.2%) of Internet information on LLIF is provided by private medical groups. Only 36% of websites discuss potential complications of LLIF and most of the cited literature (32%) is from the biomedical industry. Spine surgeons and spine societies can assist in improving the quality of the information on the Internet regarding LLIF.

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**SP26**

**ASSESSMENT OF INTERVERTEBRAL DISC DEGENERATION BASED ON QUANTITATIVE MAGNETIC RESONANCE IMAGING ANALYSIS IN A DOG MODEL**

*Chun Chen, Zhiwei Jia, Zhihua Han, Tao Gu, Wei Li, Deli Wang, Qin He, Dike Ruan; Department of Orthopedic Surgery, Navy General Hospital*

**INTRODUCTION:** Low back pain is correlated with the cartilage endplate (CEP) damage and subchondral bone resorption (namely, CEP zone) which have been implicated in intervertebral disc degeneration (IVDD). Previous studies have evaluated the potential of quantitative MRI (such as T2 relaxation Time and magnetization transfer Ratio (MTR) as a diagnostic tool of disc degeneration. To investigate the sensitivity of quantitative MRI methods in early disc degeneration, using an experimental dog intervertebral disc injury model, and to investigate their sensitivity in depicting biochemically and histologically controlled degenerative changes in the disc.

**METHODS:** Twelve juvenile dogs underwent experimental 3 times annular stab incisions. The animals underwent repeated 3.0 T MRI for one week interval in first month and were sacrificed 4, 8 and 12 weeks after operation. Presence of degenerative changes was controlled with biochemical and histological analysis.

**RESULTS:** Both T2 and MTR values changed for CEPZ, NP, and AF tissues within 12 weeks. T2 values decreased significantly in the NP, AF, and CEPZ separately at pre-operation, 4, 8, and 12 weeks when compared each time (P<0.05). No significantly differences between 8 and 4 weeks or 12 weeks or pre-operation in CEPZ in MTR but vice versa for AF. Biochemical and histological analysis showed changes consistent with early degeneration.

**DISCUSSION:** This study aimed to evaluate correlation of IVD of biochemical changes
and T2 relaxation times and MTR. However, these changes in CEPZ more early and sensibility detected by T2 values. We demonstrated that two quantitative MRI of biochemical content changes in degenerated discs are correlated, indicating a complementary relationship between physiological and biochemical alterations correlated to IVDD. To better reveal subtle molecular alterations and thus further our understanding of IVDD progression, the two complementary strategies are necessary.

SP27

DIOXIN EXPOSURE INHIBITS OSTEOGENIC DIFFERENTIATION AND IMPAIRS BONE HEALING IN A RAT SPINE FUSION MODEL

Marco Mendoza, Chawon Yun, Sean Mitchell, Abhishek Kannan, Kevin Sonn, Sharath Bellary, Jonghwa Yun, Sohaib Hashmi, John Nelson, Michael Nickoli, Jason Ghodasra, Christian Park, Amaruta Ashketar, Anjan Ghosh, Akshay Jain, Stuart Stack, Wellington Hsu, Erin;
Northwestern University Department of Orthopaedic Surgery

INTRODUCTION: Smoking inhibits bone healing and leads to increased rates of pseudoarthrosis. We found previously that dioxin, a toxic constituent of cigarette smoke that activates the Aryl hydrocarbon receptor (Ahr) pathway, inhibits spinal fusion in a rat posterolateral fusion (PLF) model. We hypothesized that prolonged cessation of dioxin exposure would alleviate this effect in vivo, and that co-treatment of bone marrow stromal cells (BMSC) with Ahr antagonists in vitro would counteract the inhibitory effects of dioxin on osteogenic differentiation.

METHODS: Rats were treated with dioxin or vehicle for 6 weeks, followed by PLF across the L4-L5 transverse processes using rhBMP-2/absorbable collagen sponge. A third treatment group also received dioxin injections, followed by cessation of treatment for 4 half-lives prior to PLF procedure. After euthanasia at 4 weeks post-op, spines were evaluated using radiographs, microCT, and fusion scoring via manual palpation. To determine whether Ahr antagonists mitigate the effects of dioxin on osteogenic differentiation, BMSC were harvested from rats and treated with vehicle, dioxin, or dioxin+antagonists, followed by quantitation of ALP activity, cell migration rate, and mineralization capacity.

RESULTS: Cessation of dioxin exposure reversed its negative affects on fusion rates (100% vs 80%, control vs dioxin-recovery groups, p=0.20), but not fusion scores (1.75 vs 0.97; p<0.01). In vitro, co-treatment with Ahr antagonists rescued the inhibitory effect of dioxin on ALP activity, cell migration rate, and mineralization.

CONCLUSION: Since cessation of dioxin exposure facilitated a partial recovery of
bone healing capacity, our data suggest that the Ahr pathway is a therapeutic target to combat the effects of dioxin on bone. Future studies will quantify the capacity of Ahr antagonists to protect against dioxin action in vivo, with the ultimate goal of identifying a therapeutic approach to improve bone healing in smokers.

**SP28**

**COMPARATIVE STUDY OF THE EFFICACY OF LIMAPROST AND PREGABALIN AS SINGLE AGENTS AND IN COMBINATION FOR THE TREATMENT OF LUMBAR SPINAL STENOSIS: A PROSPECTIVE, DOUBLE BLIND, RANDOMIZED CONTROLLED NON-INFERIORITY TRIAL**

Ho-Joong Kim, MD1, Jin Hyok Kim, MD2, Ye Soo Park, MD3, Suk Kyung Soo, MD4, Jae Hyup Lee, MD5, Moon Soo Park, MD6, Seong-Hwan Moon, MD4;

1Spine Center and Department of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Bundang Hospital, 166 Gumiro, Bundang-gu, Sungnam, 463-707, Republic of Korea
2Department of Orthopaedic Surgery, Inje University Sanggye Paik Hospital, 1342, Dongil-ro, Nowon-gu, Seoul, Korea
3Department of Orthopaedic Surgery, Hanyang University Medical Center, 153, Gyeongchun-ro, Guri-si, Gyeonggi-do, Korea
4Department of Orthopaedic Surgery, Yongin University College of Medicine, 134 Shinchondon, Seodaemunku, Seoul, Korea
5Department of Orthopaedic Surgery, Seoul National University College of Medicine and SMG - SNU Boramae Medical Center, 20, Boramae-ro 5-gil, Dongjak-gu, Seoul, Korea
6Department of Orthopaedic Surgery, Medical College of Hallym University, 22, Gwanpyeong-ro 170beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, Korea

**INTRODUCTION:** The aim of this study was to compare the effects of limaprost and pregabalin as single agents and in combination for the treatment of lumbar spinal stenosis (LSS).

**METHODS:** The present study was a prospective, double-blind, double-dummy, randomized controlled trial designed to determine the efficacy of limaprost in persons with degenerative LSS in 3 different treatment groups: limaprost alone medication, pregabalin alone medication, and the combined medication of limaprost and pregabalin through 1:1:1 allocation. The primary outcome was the baseline adjusted-Oswestry Disability Index (ODI) score at 8 weeks after treatment. The non-inferior margin of the ODI was set at δ = 10 points.

**RESULTS:** The baseline-adjusted ODI score at 8 weeks after treatment in the limaprost group was not inferior to those in the pregabalin and limaprost + pregabalin groups. The mean baseline adjusted-ODI scores (95% CI) in the limaprost and pregabalin groups were 29.9 (27.2-32.6) and 26.5 (23.8-29.2), respectively, with a difference of 3.39 (-1.28 to 8.06) between the groups. The mean baseline adjusted-ODI scores (95% CI) in the limaprost group and limaprost + pregabalin group were 29.9 (27.2-32.6) and 29.0 (26.3-31.7), respectively, with a difference of 0.85 (-3.80 to 5.50). The overall changes of the baseline-adjusted ODI scores, visual analog pain scale (VAS) scores for leg pain, the European Quality of Life–5 dimensions (EQ-5D), and initial claudication distance (ICD) during the follow-up assessments over a 8-week period were not different among the 3 groups. The baseline-adjusted ODI scores and VAS scores for leg pain decreased significantly over time after treatment in all 3 groups. The baseline-adjusted EQ-5D score and ICD also increased significantly over time after treatment in all 3 groups.

**DISCUSSION:** The efficacy of limaprost for LSS was not inferior compared to that of pregabalin or the combination of limaprost + pregabalin in terms of disability.
SP29
METASTATIC SPINE TUMOUR SURGERY: A COMPARATIVE STUDY OF MINIMALLY INVASIVE APPROACH USING PERCUTANEOUS PEDICLE SCREWS FIXATION VERSUS OPEN APPROACH
Naresh Kumar, Pang Hung Wu, Aye Sandar Zaw, Rishi Malhotra, Milindu Makandura, Gabriel Liu, Joseph Thambiah, Hee-Kit Wong; National University Health System

INTRODUCTION: Minimally invasive surgery (MIS) has shown encouraging results for early wound healing, reduced intra-operative blood loss, and shortened hospital stay in management of degenerative spine diseases. Such surgical strategies in metastatic spine disease (MSD) are highly desirable in reducing surgical morbidity and enabling earlier initiation of oncological treatment. However, previous studies conducted were case series; none comparing the outcomes between MIS and open approaches. We aimed to investigate and compare the outcomes of open and MIS approach in patients with MSD, who underwent posterior spinal stabilization and/or decompression.

METHODS: We prospectively analyzed data on patients undergoing surgery for MSD in our institution. We included 22 patients who underwent posterior surgery using MIS and 22 patients using open approach. Preoperative, intraoperative and postoperative data were collected for direct comparison of the two approaches. Generalized Linear Model was exploited to estimate the effect of MIS on outcomes, adjusting potential confounders. All patients were followed up for a minimum period of three months from time of surgery until the end of study period or till their demise.

RESULTS: All patients showed improvement in pain and neurological status. Independent ambulation was observed within 3 months of surgery in 88% in MIS group as compared to 64% in open group. There was a significant reduction in the amount of blood loss and time to initiate radiotherapy from index surgery in MIS group. Operative time, duration of hospital stay and time to initiate chemotherapy were also favourable in MIS group though the difference was not statistically significant.

DISCUSSION: MIS in MSD have shown promising results for patients suffering from clinically significant MSD. The intro-
duction of MIS can be a game-changer in treatment of MSD due to less perioperative morbidity and allowing earlier radiotherapy and/or chemotherapy.

**SP30**

**SAFETY OF INTRAOPERATIVE CELL SALVAGE IN METASTATIC SPINE TUMOUR SURGERY**

Naresh Kumar Aye Sandar Zaw Qasim Ahmed Victor Lee Raymond Goy Hee-Kit Wong; National University Health System

**INTRODUCTION:** Intraoperative blood loss is one of the major problems faced during metastatic spine tumour surgery (MSTS). Presently, this is replenished by allogeneic blood transfusion, placing severe strain on limited blood resource world over. We feel that this problem can be addressed by introducing use of salvaged blood in MSTS. We conducted a prospective observational study to evaluate the feasibility of using intraoperative cell salvage (IOCS) in combination with leucocyte depletion filter (LDF) in eliminating tumour cells from blood salvaged during MSTS.

**METHODS:** Forty consecutive patients with known primary epithelial tumour, who underwent MSTS at our institution, were recruited. Blood samples were collected at three different stages during surgery: stage A) from operative field prior to IOCS processing, stage B) after IOCS processing and stage C) after IOCS-LDF processing. Three separate 15 ml samples (5ml each) were taken at each stage. Samples were examined by cell block technique using immunohistochemical monoclonal antibodies to identify tumour cells of epithelial origin.

**RESULTS:** Malignant cells of epithelial origin were detected in the samples taken from stage A, i.e. the operative field prior to IOCS processing in 16 out of 40 patients and in the samples from stage B, i.e. the transfusion bag post-cell saver processing in 4 out of 40 patients. No viable malignant cells were detectable in any of the blood samples taken from stage C where the salvaged blood was filtered with LDF.

**DISCUSSION:** The findings of our study were consistent with previous studies on the use of IOCS-LDF in cancer surgeries; showing filtered salvaged blood was devoid of tumour cells and hence safe for transfusion. The findings support the notion that IOCS-LDF combination works effectively in eliminating tumour cells from salvaged blood so it can be applied successfully in spine tumour surgery and further be extended to the whole musculoskeletal tumour surgery.

**SP31**

**AN ANATOMICAL STUDY OF MIDDLE CLUNEAL NERVE ENTRAPMENT**

Tomoyuki Konno, MD1, Hiroshi Kuniya, MD1, Tomoyuki Saito, MD1, Yoichi Aota, MD2, Nei Kyoku, MD3, Shougo Hayashi, MD3, Shinichi Kawada, PhD3, Masahiro Itoh, MD3;

Department of Orthopaedic Surgery, Yokohama City University Graduate School of Medicine, Yokohama, Kanagawa, Japan; 2Yokohama stoke and brain center, Yokohama, Kanagawa, Japan, 3Department of Anatomy, Tokyo Medical University, Shinjyuku, Tokyo, Japan

**PURPOSE:** In view of the paucity of literature, we performed anatomical study of middle cluneal nerve (MCN) around long posterior sacroiliac ligament (LPSL), with the objective of providing an accurate anatomical basis for clinical conditions involving the nerve entrapment.

**METHODS:** A total of 32 sides of the pelvis from 16 cadavers (12 female, 4 male), for educations and/or research, were studied for gross anatomical dissection. The age cadavers at their death were 77-101 years with a mean of 88 years. Branches of MCN were identified under or over gluteus maximus fascia in the caudal side of PSIS and traced laterally as far as their finest
ramification. Special attention was paid to the relationship between MCN and LPSL. Distance from the branch of MCN to the PSIS and to the midline, and the diameter of the MCN were measured by using a digital caliper (Mitsutoyo Corp. Japan).

RESULTS: MCN was identified in 23 specimens and not identified in 9 specimens. Of 23, 13 specimens (56%) had MCNs traversing superiorly to LPSL and 10 (44%) traversed between superficial and deep layers of LPSL. Of 10 branches penetrating LPSL, 5 had obvious constriction under the ligament (Figure). The average cephalocaudal distance from the PSIS to the MCN penetrating LPSL was 24.5 mm (9-36 mm). That from midline was 37.3 mm (23-50 mm). The width of MCN branch was thin with an average 1.7mm (0.7-3.2mm) measured at traversing LPSL.

DISCUSSION: Previous anatomical studies showed that MCNs passes through or underneath LPSL, suggesting irritation under the ligament as a potential cause of low back pain and peripartrum pelvic pain. This paper is the first anatomical report showing obvious entrapment of the penetrating MCNs within or under the ligament.

SP32
THE INFLUENCE OF SPINAL DEFORMITY ON ACETABULAR ORIENTATION IN TOTAL HIP ARTHROPLASTY
Duy Phan Ran Schwarzkopf S. Samuel Bederman;
Department of Orthopaedic Surgery University of California, Irvine

INTRODUCTION: The interaction between the lumbosacral spine and the pelvis is complicated by preexisting pathology and positional change. Our study examines the influence of spinal deformity on positioning of total hip arthroplasty (THA). A guideline is provided to assist in pre-operative planning and improved communication between hip and spine subspecialists.

METHODS: A comprehensive literature review was conducted investigating the relationship at the spinopelvic junction. Topics examined included acetabular anteversion (AA) with spinal imbalance and rigidity, hip functional range of motion with positional change, and hip functional range of motion after THA. Information that was consistently sourced was used to create schematic and visual recommendations.

RESULTS: Sagittal imbalance of the lumbar spine influences AA during THA. Preoperatively, patients needing THA can be screened with sitting and standing lumbar radiographs into four categories based on flexibility and sagittal balance of the spine: flexible/balanced, flexible/unbalanced, rigid/balanced, and rigid/unbalanced. Patients in the flexible/balanced category should have AA during THA in the standard safe zone of 5 to 25 degrees. Patients with spinal rigidity will require adjustment of AA to limit impingement and dislocation. Patients with spinal imbalance, whether rigid or flexible, may be addressed by spinal realignment or alternatively may require adjustment of AA to accommodate for compensatory pelvic retroversion.

DISCUSSION: Patients can be preoperatively screened into different categories based on lumbosacral balance and flexibility. Acetabular cup placement can be optimized based on the type and significance of coexisting spinal deformity to increase hip functional range of motion. Spinal realignment should be considered primarily for unbalanced patients prior to THA to ensure ideal placement of the acetabular cup.

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<th>Unbalanced</th>
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<td>Cup anteversion from 5 to 25 degrees</td>
<td>Hip surgery followed by THA</td>
<td>Cup anteversion from 15 to 25 degrees</td>
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<td>Hypotric – decrease cup anteversion</td>
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SP33
IN VIVO EVIDENCE THAT TASK-SPECIFIC MODIFICATIONS OF TRUNK MUSCLE ACTIVITY PROTECT PAINFUL SPINES
Arnold Wong, Greg Kawchuk, Eric Parent, Christopher Huang; University of Alberta

INTRODUCTION: Low back pain (LBP) is thought to cause task-specific facilitation/inhibition of trunk muscle activity with the goal of protecting the spine. Unfortunately, no human trial has tested this premise. This study examined the temporal effects of experimentally induced LBP on within-subject trunk muscle activity during passive and active tasks.

METHODS: Nine healthy subjects received injections into the L3/4 and L4/5 inter-spinous ligaments on two separate occasions. Injections were randomized between 0.3ml isotonic saline (0.9%) and hypertonic saline (5% NaCl). Before, immediately after, and 25-minute after injection, subjects received mechanical indentation at the L3 spinous process to quantify spinal stiffness, and performed an arm lift to activate trunk muscles. Surface electromyography (EMG) of six trunk muscles was collected concurrently during indentation and arm lifts. Lumbar multifidus contraction thickness ratios were also measured by ultrasound imaging during arm lifts. Pain intensity was measured by a numeric rating scale. Separate repeated measures ANOVAs were used to analyze the changes in measured variables.

RESULTS: Hypertonic saline injections caused significant transient increases in LBP compared to isotonic injections. Hypertonic injections also temporarily elevated spinal stiffness and trunk muscle EMG during indentation (p < 0.05). Conversely, hypertonic injections transiently reduced multifidus thickness ratios (p < 0.01) and had no effect on trunk muscle EMG during arm lifts. Isotonic injections did not alter spinal stiffness or muscle function.

DISCUSSION: These data support the widely held premise that trunk muscles are selectively activated to limit movement in painful spines. In this model of experimentally induced pain, trunk muscles increased activity to resist a passive, pain provoking stimulus while during active voluntary movements, deep trunk muscles were inhibited to minimize spinal movement.

SP34
VERTEBRAL ENDPLATE DEFECTS AND DISC DEGENERATION
Uruj Zehra MD, Luke Flower BSc, Kate Rabson-Brown PhD*, Michael A. Adams PhD, Patricia Dolan PhD;
Centre for Comparative and Clinical Anatomy, University of Bristol, Bristol, U.K.
*School of Archaeology and Anthropology, University of Bristol, Bristol, U.K.

INTRODUCTION: Vertebral endplates comprise a thin layer of hyaline cartilage loosely bonded to a plate of perforated cortical bone. Physical disruption to an endplate causes an immediate decompression of the adjacent intervertebral disc, and this can lead to disc degeneration, in humans and animals. We investigated naturally-occurring endplate defects in cadaveric spines in order to identify which characteristics are most closely associated with disc decompression, and degeneration.

METHODS: 40 motion segments (T8-9 to L4-5) were dissected from 23 cadavers aged 48-98 yrs. Intradiscal stresses were measured, under 1kN compression, by pulling a pressure transducer along the disc’s mid-saggital diameter. Specimens were further dissected for micro-CT scanning at a resolution of 35µm. ‘Defects’ had well-defined margins in three planes, and combined some discontinuity in the original plane of the endplate with appa-
rent new bone formation within the vertebral body (Fig1). Their volume and average X-sectional area (in the transverse plane) were calculated. Disc degeneration was assessed macroscopically on a scale 0-48.

RESULTS: Defects were observed in 24/40 specimens (35/80 endplates). 25/35 involved thoracic levels. 74% involved the central-posterior endplate. Average volume and area were 68 mm3 and 39 mm2, respectively. Disc degeneration score increased significantly with defect volume (R2=0.18), and area (R2=0.15). Nucleus pressure in the adjacent disc was inversely correlated to degeneration score (R2=0.70 P<0.001) and defect area (R2=0.20 P=0.008).

DISCUSSION: Endplate defects are common, and large defects are associated with severe disc degeneration and decompression. Disc degeneration involves low nucleus pressure, and so is unlikely to cause such endplate defects. On the contrary, endplate defects arising from compressive overload could lead to disc decompression and degeneration. Large shallow defects appear to have more mechanical influence than deep focal defects.

SP35
RADIOGRAPHIC FEATURES OF LUMBO-PELVIC CONTOUR IN SIT-TO-STAND MOTION IN THE ELDERLY
Hidekazu Suzuki, Kenji Endo, Hirosuke Nishimura, Hidetoshi Tanaka, Takaaki Shishido and Kengo Yamamoto

Department of Orthopedic Surgery, Tokyo Medical University

INTRODUCTION: Differences in spino-pelvic alignment between young adults and elderly people could affect the intensity of low back pain in different situations. Sagittal spinal alignment is usually analyzed in standing position, however, for understanding of symptoms associated with postural changes, it must be analyzed in various position. The purpose of this study was to investigate the relationship between lumbar and pelvic segment in sit-to-stand (STS) in the young adult and the elderly.

METHODS: The study subjects were 50 healthy adult volunteers (mean age, 28.7) and 33 elderly persons (mean age, 75.4). The following parameters were measured on the lateral radiographs at standing upright (St up) or anteflexed (St ant) and seated upright (Si up) or anteflexed (Si ant) on a chair: lumbar lordotic angle (L1L5), sacral slope (SS), pelvic tilt (PT) and pelvic incidence (PI).

RESULTS: The measurements of spino-pelvic parameters in STS (Si up, Si ant, St ant, St up) were as follows: young adults, L1L5 (7.9, -4.4, 3.1, 31.9), PT(31.5, 26.5, 11.9, 7.7), the elderly, L1L5 (12.5, 0.6, 6.2, 17.8), PT(31.2, 30.4, 13.9, 23.6). The change of L1L5 was positively correlated with PI in young adults but not in the elderly. As regards L1-5 and L5-S ROM, L4-5 and segment have wide range in STS (before seat off, after seat off): young adult, L1-5 (12.3, 36.3), L5-S (2.4, 8.4), the elderly, L1-5 (11.9, 17.2), L5-S (0.6, 4.8).

DISCUSSION: Lumbar lordosis was decreased in sitting and temporarily more decreased and then increased in STS. Pelvis was retroverted in sitting position and gradually anteverted in standing in young adults. In the elderly, however, pelvis was temporarily anteverted after seat off and retroverted in standing upright. It suggests that less lumbo-pelvic mobility in the
elderly was compensated by hip joint motion in STS. From these results, hip ROM exercise is very important for high PI young patients with multiple lumbosacral fusion or elderly patients in STS.

**SP36**
PARASPINAL MUSCLE ASYMMETRY AND FAT INFILTRATION IN PATIENTS WITH SYMPTOMATIC DISC HERNIATION
Maryse Fortin, PhD CAT(C); Áron Lazáry, MD, PhD; Peter Paul Varga, MD; Michele C. Battié, PhD; Common Spinal Disorders Research Group, Faculty of Rehabilitation Medicine University of Alberta, Edmonton, Canada

**INTRODUCTION:** Studies have revealed level and side-specific multifidus atrophy, asymmetry and fatty infiltration in relation to symptoms and localized disc pathology. However, results are inconsistent and it is still unclear whether selective multifidus atrophy is an indicator of a disc lesion or other clinically relevant lumbar pathologies. Therefore, the purpose of this study was to 1) investigate asymmetry in size and composition of the multifidus and erector spinae in patients with posterolateral disc herniation and concordant radicular symptoms, and 2) determine whether symptom duration is associated with degree of asymmetry.

**METHODS:** Thirty-three patients diagnosed with posterolateral disc herniation at L4-L5 verified on imaging and concordant leg pain were included. Multifidus and erector spinae cross-sectional area (CSA), functional cross-sectional area (FCSA, fat-free area), signal intensity and ratio of FCSA to total CSA were measured bilaterally from T2-weighted axial magnetic resonance imaging (MRI) at L3-L4, L4-L5, L5-S1 and S1 levels.

**RESULTS:** No side-to-side differences in multifidus CSA, FCSA, and ratio of FCSA/CSA reached statistical significance at any spinal level. The multifidus signal intensity at L5-S1 was significantly greater (more fatty infiltration) on the side of the disc herniation. The erector spinae FCSA (lean muscle mass) at L5-S1 was found to be significantly smaller on the side of the herniation and the ratio of FCSA/CSA was smaller (more fatty infiltration) on the side of the herniation at L4-L5 and L5-S1. The degree of muscle asymmetry was not associated with symptoms duration.

**DISCUSSION:** Our findings do not support the model of localized multifidus wasting ipsilateral to, and at the spinal levels below, the disc herniation. Instead, variations in muscle composition were observed, with greater fat infiltration on the side and at spinal levels adjacent to the disc herniation.

**SP37**
A MORPHOMETRIC STUDY OF L4-L5 LUMBAR SPINE IN L4 SPONDYLOLISTHESIS: ANALYSIS OF FEASIBILITY OF THE OBLIQUE LATERAL INTERBODY FUSION APPROACH
Hori Y, Hoshino M, Mandai K, Tsujio T, Seki M, Ando Y, Iwakiri K, Kobayashi A, Nakamura H; Orthopedic department of Shironiwa Hospital, Orthopedic department of Osaka-City University Hospital

**INTRODUCTION:** The minimally invasive procedure of Oblique Lateral Interbody Fusion (OLIF) is being increasingly used to achieve lumbar interbody fusion. However, this approach is problematic in some
patients because of the particular anatomical features of their psoas muscles and major blood vessels. The aims of this study were to ascertain the frequency of these problematic features in patients with L4 spondylolisthesis and to determine their predictors.

METHODS: Preoperative axial MRIs of consecutive 100 L4 spondylolisthesis patients were assessed. The distances between (1) anterior border of disc and psoas muscle (positive values indicate psoas anterior to disc); (2) aorta and psoas muscle; (3) anterior border of disc and attachment of psoas muscle; and (4) anterior border of disc and posterior border of inferior vena cava were measured at the L4/5 disc level (Figure). Problematic anatomy was defined as psoas muscle projecting >10 mm anteriorly or <10 mm between psoas and aorta. Predictors of these physical characteristics were identified by multivariate analysis.

RESULTS: The mean distances described above were (1) 2.3±6.8 mm; (2) 16.7±7.3 mm; (3) 9.3±3.5 mm, and (4) 6.4±3.0 mm, respectively. No significant predictor of the psoas projecting >10 mm anteriorly was identified in the 19 patients with this characteristic. Male sex was a significant predictor of psoas <10 mm from the aorta in the 14 patients with this characteristic (odds ratio; 2.62, P<0.05). Taken together, 29/100 patients had these problematic anatomical features. Additionally, the inferior vena cava was posterior to the attachment of the psoas in 18 patients.

DISCUSSION: The identified anatomical features made an oblique lateral approach problematic in 29% of cases. It is important to ensure that OLIF is feasible by assessing preoperative MRIs, especially in male patients. Additionally, in 18% of cases, special care is required to avoid inferior vena cava injury while inserting the cage.

SP38
INFLUENCE OF LUMBAR SPINAL STENOSIS ON THE SAGITTAL IMBALANCE OF THE WHOLE SPINE
Hashimoto K, Miyamoto H, Ikeda T, Akagi M; Dept. of Orthopaedic Surgery., Kindai University Faculty of Medicine

INTRODUCTION: Based on the classification of adult spinal deformity, sagittal vertical axis (SVA) exceeding 40mm can cause disability of the patients. Whereas, lumbar lordosis (LL) of lumbar spinal stenosis (LSS) patients decreases because of antalgic effect, therefore their sagittal alignment seems off-balance. The purpose of this study was to investigate the characteristics of sagittal imbalance due to LSS.

METHODS: Fifty-one LSS patients (male 26, female 25, a mean of 71.4 years old) were enrolled. Epidural analgesic injection was performed for removing the antalgic effect. Spinopelvic lateral radiographs in standing position were taken, and SVA, thoracic kyphosis (TK), and LL were measured before and after the injection. We divided the patients into two groups; non-structural type (SVA<40mm) and structural type (SVA≥40mm) after the injection. Surgery was performed when conservative treatment failed. As clinical evaluation, visual analog scale (VAS) was applied. They were prospectively followed up until a year after surgery.
RESULTS: VAS was improved in all patients from 7.2 to 2.3 after epidural injection. Thirty-eight cases were classified as non-structural, and 13 as structural. In non-structural type, improved SVA was more associated with LL compared to TK. Forty-two% of non-structural type underwent surgery (9 decompression and 7 fusions), and 77% of structural type did surgery (2 decompression, 7 fusions, and 1 correction surgery). Sagittal alignment was maintained at the follow-up in all cases (Figure).

DISCUSSIONS: The present study has indicated that sagittal imbalance due to LSS contains non-, and structural types. For treating non-structural type, decompression or short fusion surgery is sufficient. On the other hand, structural type may require longer fusion, however, the case required correction surgery was only one in this series because the complaint of sagittal imbalance remained although other symptoms relieved by epidural injection.

INTRODUCTION: In recent years, an increasing amount of research into the rates, mechanisms and treatment strategies for PJK have seen publication. Despite the widespread interest of the scientific community, formal, widely accepted indications for revision surgery have yet to be established.

METHODS: A retrospective chart review of all adult spine patients undergoing segmental posterior instrumen-ented fusion from the sacrum to at least L1 in a specialized spine care center between 2003 and 2011 was conducted through an electronic database.

RESULTS: A total of 539 consecutive patients were identified. After exclusion criteria application, 464 patients were included into the study and 215 (46.3%) developed PJK. Twenty-five PJK patients were excluded for either having less than six months of documented follow-up or due to post-operative surgical site infection, leaving 190. Fifty-four patients with PJK (28.4%) required revision surgery, while 136 (71.6%) had not undergone revision. Significant differences between the two groups were observed with respect to time to onset of PJK, post-op, final SVA and SVA progression, final PJA, PJA progression, fracture to the UIV or UIV+1, and listhesis of the UIV+1 over the UIV. The odds ratio for revision surgery in the presence of fracture to the UIV or UIV+1 was 4.3 (p=0.002), while that for spondylolisthesis of the UIV+1 on the UIV

SP39
RADIOGRAPHIC PARAMETERS ASSOCIATED WITH REVISION SURGERY FOR PROXIMAL JUNCTIONAL KYPHOSIS IN ADULT SPINAL DEFORMITY
Murat Şakir Ekşi(A), Fred Nicholls(A), Murat Pekmezci(A), Barış Kadir Gün(B), Gokhan Demirkiran(C), Sigurd Berven(A), Shane Burch(A), Dean Chou(D), Praveen Mumma-

neni(D), Bobby Tay(A), Christopher Ames(D), Vedat Deviren(A);
A) Department Of Orthopedic Surgery, University Of California, San Francisco, California, USA B) Touro University, College Of Osteopathic Medicine, Vallejo, California, USA C) Department Of Orthopedic Surgery, Hacettepe University School Of Medicine, Ankara, Turkey D) Department Of Neurosurgery, University Of California, San Francisco, California, USA
was 7.7 (p=0.015) and the presence of screw pullout was 2.7 (p=0.021). Each millimeter increase in final SVA yielded increased odds of 0.014 towards revision (p=0.001), while each additional month passing prior to development of PJK increased the odds of revision by 0.04 (p=0.02).

**DISCUSSION:** While further investigation is still required into the effectiveness of PJK prevention strategies, our case series indicates that the presence of radiographically apparent proximal junctional failure (PJF), along with positive sagittal balance are the most important factors in predicting the need for revision surgery.

**SP40**

**THE SIX-MINUTE WALK TEST FOR PATIENTS WITH LUMBAR SPINAL STENOSIS**

Imoo. Y1, Mamizuka. N2, Kubota. Y1, Suzuki. H3 Hirano. A2, Fujie. K4, Hashimoto. K4, Nakata. Y4, Sakane. M4, Yamazaki. M4; 1Department of Rehabilitation, University of Tsukuba, Mito Clinical Education and Training Center, Mito Kyodo General Hospital 2Department of Orthopaedic Surgery, University of Tsukuba, Mito Clinical Education and Training Center, Mito Kyodo General Hospital 3Department of Health and Sports Science, University of Juntendo 4Faculty of Medicine, University of Tsukuba

**INTRODUCTION:** Impairment of ambulation is a crucial component of some impairments for lumbar spinal stenosis (LSS). The 6-minute walk test (6MWT) has been validated as a laboratory walking test and is increasingly recognized as a meaningful outcome measure in patients with peripheral arterial disease. However, the 6MWT has not been validated for the patients with LSS. In this study, we evaluated the criterion-related validity of 6MWT by examining a correlation with a self-report questionnaire.

**METHODS:** Subjects following rehabilitation after the surgery of LSS (Sex: male/female 28/47, Age: 71±8 y.o) completed Zurich Claudication Questionnaire (ZCQ) and performed the 6MWT before the surgery and three months after the surgery. Correlation with ZCQ subscales (symptom severity and physical function) was examined to evaluate the criterion-related validity of the 6MWT.

**RESULTS:** There were significant improvements in ZCQ score (p<0.001) and parameters (distance and walk speed) of the 6MWT (p<0.001) after the surgery. Before the surgery, the parameters of the 6MWT correlated weakly with the symptom severity scale (distance: r=0.27, p=0.018, walk speed: r=-0.29, p=0.012), and with the physical function scale (distance: r=-0.38, p=0.001, walk speed: r=-0.36, p=0.001).

**DISCUSSION:** It was reported ZCQ has the validity and the reliability for the evaluation of the patients with LSS. In this study, there were weak relationships between ZCQ subscales and the parameters of the 6MWT both before and after the surgery. Therefore, 6MWT has the certain criterion-related validity in the walking ability evaluation of patients with LSS. Furthermore, the 6MWT may evaluate different walking performance from physical function scale of ZCQ.

**SP41**

**IMPROVEMENT IN LOW BACK PAIN ASSOCIATED WITH LUMBAR SPINAL CANAL STENOSIS FOLLOWING SPINAL MICROENDOSCOPIC SURGERY**

Hiroshi Yamada1, Munehito Yoshida1, Hiroshi Hashizume1, Akihito Minamide1, Yukihiro Nakagawa1, Hideto Nishi1, Hiroshi Iwasaki1,
INTRODUCTION: The aim of surgery in patients with lumbar spinal canal stenosis (LSCS) is to improve radicular leg symptoms and walking distance. However, recent studies reported the possibility of improvement in low back pain (LBP) following decompression surgery. The aim of this study is to quantify the improvement in LBP associated with LSCS following spinal microendoscopic surgery.

METHODS: Consecutive 121 LSCS patients with LBP of preoperative 40-100mm on the Visual Analogue Score (VAS) score were prospectively enrolled in this study. They completed Oswestry Disability Index questionnaire (ODI) and VAS for LBP, preoperatively and 1 year postoperatively. Pre- and postoperative scores were compared using the paired Student’s T test. A p value of <0.05 was considered to be significant. The distribution of patients who acquired the minimum clinically important difference (MCID) and acceptable status for LBP after surgery were also investigated. MCID and acceptable status for LBP improvement on the VAS was defined as 20 mm reduction from baseline values and score of 0–25 mm on the VAS, respectively.

RESULTS: There was a significant reduction in mean LBP from a baseline of 70.0±17.6mm to 30.1±28.5mm at 1 year postoperatively (p<0.0001). Mean ODI were also significantly improved from 45.2±15.2% to 26.2±21.4% at 1 year (p<0.0001). 95 patients (78.5%) acquired 20 mm reduction from baseline values of VAS for LBP and 61 patients (50.4%) demonstrated 0–25 mm on the VAS for LBP after surgery.

DISCUSSION: This study reports statistically significant improvement of LBP after LSCS decompression surgery with the use of spinal microendoscope. The percentage of no change or deterioration of LBP after surgery was very small. Although spinal fusion has still been a last resort for the treatment of LBP, the indication of spinal fusion for the LSCS patients with LBP should be limited.

INTRODUCTION: Low back pain (LBP) is one of the common symptoms in lumbar spinal stenosis (LSS). The purpose of this study was to investigate the influence of preoperative LBP on surgical outcomes of decompression for LSS.

METHODS: One hundred and eighty-seven patients with lumbar spinal stenosis were included in this study. All patients received decompression surgery without fusion. Follow up period was 1 year. The outcomes were measured by numerical rating scales (NRS:0-10) for low back pain, leg pain, leg numbness, satisfaction rate, Roland-Morris disability questionnaire (RDQ) and Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ). Objectives were divided into two groups according to preoperative NRS for LBP; ≤2 were LBP(-) group and ≥3 were LBP(+) group. Statistical analysis was performed by chi-square test and Wilcoxon test. A p-
value less than 0.05 was considered significant.

**RESULTS:** There were 133 patients in LBP (+) group and 54 patients in LBP (-) group. NRS for LBP was 6.0±2.0 in LBP (+) group and 0.4±0.8 in LBP (-) group, NRS for leg pain was 5.2±3.3 in LBP (+) group and 3.2±3.7 in LBP (-) group, the RDQ score was 12.6±5.2 in LBP (+) group and 9.1±5.3 in LBP (-) group and there was significant difference between 2 groups (p<0.05). In preoperative JOABPEQ, the score of low back pain was 34.5±30.3 in LBP (+) group and 57.9±34.7 in LBP (-) group, the score of lumbar function was 48.4±28.7 in LBP (+) and 59.2±28.2 in LBP (-) group, and significant differences were observed between 2 groups (p<0.05). One year after surgery, there were no significant differences between 2 groups in NRS for LBP, leg pain, and leg numbness, satisfaction rate, RDQ score and JOABPEQ scores 1 year after surgery.

**DISCUSSION:** The results of this study suggested that there were no influences of preoperative LBP on 1 year surgical outcomes of decompression for LSS. Decompression surgery was effective for not only leg symptoms but also LBP in LSS.

**SP43**

**SPINOPELVIC PARAMETERS AND RELIABILITY BETWEEN IMAGING MODALITIES: 36-INCH-LONG CASSETTE VS. DEDICATED LUMBAR LATERAL RADIOGRAPHS**

*Ivan Cheng, James Woodall; Stanford University*

**INTRODUCTION:** Classically spinopelvic parameters are measured on 36-inch-long cassette radiographs, since sagittal vertical axis is commonly measured and used in conjunction with the other parameters. There is no data comparing measurement of these parameters on the classic 36-inch-long cassette versus dedicated lumbar lateral radiographs.

**METHODS:** Our institutional database was queried for patients that underwent both 36-inch-long cassette radiographs and standard lumbar radiographs within a 3-month period. Spinopelvic parameters were measured and recorded for each image by two spine surgeons independently. The measurements were repeated 3 weeks later to measure inter- and intra-rater reliability. Data was collected for lumbar lordosis (LL), pelvic incidence (PI), sacral slope (SS) and pelvic tilt (PT). Inter and intra-rater reliabilities were calculated for each modality and t-tests were used to compare the modalities.

**RESULTS:** Data was collected for 14 sets of radiographs at two separate time points. Lumbar lordosis was the most reliable measurement with intra-rater reliability across both imaging methods ranging from 0.945-0.976 and inter-rater reliability across the same methods from 0.909-0.977. Paired t-test did not find a significant difference between methods for either rater. Pelvic incidence was similarly reliable across methods with intra-rater scores from 0.879-0.962 and inter-rater scores from 0.876-0.97. Scores for pelvic tilt respectively were 0.862-0.904 and 0.889-0.947. The measurement of sacral slope trended in a less in a less reliable fashion with intra-rater scores from 0.729-0.903 and inter-rater from 0.695-0.905.

**DISCUSSION:** Spinopelvic parameters can be reliably measured on either 36-inch-long cassette radiographs or standard lumbar radiographs. The only parameter that had reliability statistics fall below the “high-reliability” threshold of 0.7 was sacral slope.

**SP44**

**RADIOGRAPHIC CHANGES IN THE PARAVERTEbral MUSCLES OF THE LUMBAR SPINE ASSOCIATED WITH THE C7 SAGITTAL VERTICAL AXIS: THE WAKAYAMA SPINE STUDY**
INTRODUCTION: Forward shift of the sagittal vertical axis (SVA) is a radiographic predictor of low back pain. Muscles degeneration around the spinal column may be related to sagittal imbalance, but the exact mechanism is still unknown. We elucidated the relationship between radiographic changes in paravertebral muscles (PVM) of the lumbar spine and C7 SVA in a general population.

METHODS: This cross-sectional study of an established population-based cohort in Japan included 952 subjects who had participated in the second survey of the Wakayama Spine Study; of these, 794 (male, 239; female, 555; age, 63.6 ± 13.1 years) underwent whole-spine sagittal X-ray while standing and lumbar spine magnetic resonance imaging (MRI). The C7 SVA (mm) on the X-ray was measured and the percentage of fatty degeneration in the PVM at the L1 and L5 upper end-plate levels on axial MRI was calculated. Representative parameter values according to age and sex were observed. The relationship between fatty degeneration of the PVM and C7 SVA was determined using a multiple regression analysis, after adjusting for age, sex, and body mass index. P-values less than 0.05 were considered as statistically significant.

RESULTS: The C7 SVA significantly increased with age in both sexes. The percentage of fatty degeneration in the PVM increased with age in both sexes (Table). Multiple regression analysis revealed that fatty degeneration of the PVM at the L1 level was significantly associated with forward shift of the C7 SVA (partial regression coefficient, 2.47), whereas that at the L5 level was not.

DISCUSSION: Information on the implications of PVM findings from lumbar spine axial MRI is scarce. This is the first study to show a significant relationship between lumbar PVM degeneration and SVA in a general population, although it is limited by a cross-sectional design and lack of information on vertebral body fracture.

<table>
<thead>
<tr>
<th>Table. Age- and sex-related changes in the C7 SVA and fatty degenerated area of the spinous muscles.</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td>C7 SVA (mm)</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Fatty degenerated area</td>
</tr>
<tr>
<td>PVM at L1 level (%)</td>
</tr>
<tr>
<td>PVM at L5 level (%)</td>
</tr>
<tr>
<td>SVA, sagittal vertical axis; PVM, paravertebral muscle; Data are showning Mean ± SD.</td>
</tr>
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</table>

SP45

TOEI STUDY - CUTOFF VALUES OF SPINOPELVIC SAGITTAL PARAMETERS CAUSING QOL DETERIORATION IN HIGH AGE VOLUNTEERS

Daisuke Togawa, Tatsuya Yasuda, Tomohiko Hasegawa, Yu Yamato, Sho Kobayashi, Shin Oe, Tomohiro Banno, Hideyuki Arima, Koichiro Iide, Yu Watanabe, Tomohiro Yamada, Keiichi Nakai, Hironobu Hoshino, Yuhihiro Matsuyama; Department of Orthopaedic Surgery, Hamamatsu University School of Medicine, Shizuoka, Japan.

INTRODUCTION: Purpose of this study was to investigate cutoff values of sagittal spinopelvic parameters causing QOL deterioration evaluated by 3 different health related QOL (HRQOL) questionnaires in high age volunteers. METHODS: High volunteers with age over 50 living in Toei town of Aichi prefecture in Japan were participated. Three different HRQOL questionnaires (Oswestry Disability Index (ODI), EuroQOL (EQ5D), and the 25-question Geriatric Locomotive Function Scale (Locomo25)) were obtained and
standing total spine and pelvic X-rays were taken from all participants. Radiographic parameters were measured by computer software twice and averaged. Using 3 sagittal modifiers (Pelvic Incidence minus Lumbar Lordosis (PI-LL), Sagittal Vertical Axis (SVA), Pelvic Tilt (PT)) of SRS Schwab Classification, cutoff values causing QOL deterioration were investigated. ODI 40%, EQ5D 0.45, and Locomo25 score 32 were set up as QOL deterioration.

RESULTS: Volunteers with previous surgeries (spine, hip, and knee), poor quality X-rays, and transitional vertebrae were excluded. Total 656 volunteers (263 male, 393 female, average age 73) were investigated. Intra- and interclass correlation coefficients in every parameters were all over 0.9 (excellent). Three sagittal modifiers and 3 HRQOL questionnaires were all significantly correlated each other. To reach ODI 40%, PI-LL was 20 degrees, SVA was 91mm, and PT was 24 degrees. To reach EQ5D 0.45, PI-LL was 18 degrees, SVA was 85mm, and PT was 24 degrees. To reach Locomo25 score 32, PI-LL was 19 degrees, SVA was 92mm, and PT was 24 degrees. By correlation analyses under significance level less than 1%, SVA and HRQOLS had the highest correlation coefficients among 3 sagittal modifiers (vs ODI: 0.40, vs. EQ5D: -0.32, Locomo25: 0.44).

<table>
<thead>
<tr>
<th>3 Sagittal Modifiers</th>
<th>60% or under</th>
<th>70%</th>
<th>80% or over</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI-LL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>++ &gt;20</td>
<td>7.29</td>
<td>13.29</td>
<td>0.862</td>
</tr>
<tr>
<td>+ 10-20</td>
<td>5.32</td>
<td>7.62</td>
<td>0.901</td>
</tr>
<tr>
<td>0 within 10</td>
<td>5.11</td>
<td>7.69</td>
<td>0.903</td>
</tr>
<tr>
<td>SVA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>++ &gt;9.5</td>
<td>14.43</td>
<td>26.14</td>
<td>0.762</td>
</tr>
<tr>
<td>+ 4-9.5</td>
<td>3.98</td>
<td>6.53</td>
<td>0.904</td>
</tr>
<tr>
<td>0 &lt;4cm</td>
<td>5.48</td>
<td>8.04</td>
<td>0.903</td>
</tr>
<tr>
<td>PT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>++ &gt;30</td>
<td>8.00</td>
<td>16.00</td>
<td>0.881</td>
</tr>
<tr>
<td>+ 20-30</td>
<td>8.37</td>
<td>10.71</td>
<td>0.844</td>
</tr>
<tr>
<td>0 &lt;20</td>
<td>4.57</td>
<td>7.54</td>
<td>0.912</td>
</tr>
</tbody>
</table>

DISCUSSION: This high age volunteer study with large sample size showed that elderly population might be able to tolerate moderate sagittal spinopelvic mal-alignment compared to younger population.

SP46
ASSOCIATION OF OBESITY WITH INCREASE IN BACK AND LEG PAIN IN PATIENTS WITH SPINAL CONDITIONS: A STUDY OF 2,636 PATIENTS
Anand H Segar (1,2,3), Jeremy Fairbank (1,2), Jill Urban (3), Andy Judge (1);

INTRODUCTION: The 2010 Global Burden of Diseases Study found low back pain (BP) to be the leading cause of disability worldwide and placed an urgent call to understand further the predictors. This is important since patients with back and leg pain present to surgeons, rheumatologists and physiotherapists daily. The aim of this study was to identify the relationship between obesity, quantified by body mass index (BMI), and both back and leg pain in spinal patients.

METHODS: The Genodisc Study was a large prospective study of patients presenting to tertiary spinal units which recruited 2636 patients between 2008 and 2013. Patients scored both back and leg pain in the range 0-10. Multivariate linear regression was used to model the relationship between BMI and pain. Potential confounders included in the model were: age, Zung Depression score, episodes of sport, gender, disability benefit, family history, previous surgery, smoking status, work type, clinical diagnosis and relevant comorbidities. Back and leg pain were modelled separately.

RESULTS: The study included 54% women with a mean age of 50.9 years and BMI of
27.2kg/m². In our fully adjusted model, a 5-point increase in BMI was associated with an increase in back (0.15 units [95% CI 0.04, 0.27]) and leg (0.22 units [95% CI 0.10, 0.33]) pain scores. Female gender, heavy workload, rheumatoid arthritis, previous spine surgery, smoking and depression were associated with greater pain scores.

**DISCUSSION:** In this large cross section of spine patients presenting to tertiary European centres, obesity, as measured by increased body mass index, was associated with increased back and leg pain. Given this association, weight loss could be a strategy for modulating back and leg pain but this requires further investigation with an interventional study.

**SP47**

**OBESITY IS ASSOCIATED WITH A CLINICAL DIAGNOSIS OF LUMBAR SPINE STENOSIS BUT NOT LUMBAR DISC HERNIATION OR DEGENERATIVE SPONDYLOLISTHESIS**

Anand H Segar (1,2,3), Jeremy Fairbank (1,2), Jill Urban (3), Andy Judge (1);
1-Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Science, University of Oxford, Oxford, UK
2-Nuffield Orthopaedic Centre, Oxford University Hospitals NHS, Oxford, UK
3-Department of Physiology Anatomy and Genetics, University of Oxford, Oxford, UK

**INTRODUCTION:** Clarifying a clinical phenotype is important as it provides a deeper understanding of patients and will help to guide further research and treatment modalities. The aim of this study was to identify predictors of the clinical diagnosis of lumbar disc herniation (LDH), lumbar spine stenosis (LSS), degenerative spondylolisthesis (DS) and non-specific back pain (NSBP), with a focus on obesity.

**METHODS:** Patients were recruited as part of the pan-European Genodisc study. In total, 2636 patients were enrolled across six tertiary spine centres. At presentation, patients were seen by the treating surgeon and using all available clinical information, placed into one or more of the diagnostic categories LDH, LSS, DS and NSBP. Patients can exhibit clinical features of more than one category and were categorised accordingly. Multivariate logistic regression was used to model the relationship between the diagnoses and BMI. Given the comprehensive data, we were able to correct for multiple clinical confounders.

**RESULTS:** LDH was the most common diagnosis followed by LSS, DS and finally, NSBP. There was considerable overlap between these four categories. Of those with LDH, 20% shared a diagnosis of LSS (see figure). In the multivariate analysis, there was no relationship between BMI and a diagnosis of LDH (1.01 [95% CI 0.93, 1.11]). Age which was the strongest negative predictor of LDH. Both BMI (OR 1.21 [95% CI 1.10, 1.33]) and age (OR 2.04 [95% CI 1.88, 2.21]) were associated with increased odds of LSS. The relationship between BMI and DS or NSBP was not significant. Smoking was positively associated with LSS and LDH.

**DISCUSSION:** This analysis presents a pragmatic approach to understanding phenotypic features of common spinal diagnoses. There was considerable overlap in diagnosis, indicating that patients have complex presentation patterns. We also defined other strong associations that may inform clinical understanding of patients and guide further research.
SP48

OBESITY IS ASSOCIATED WITH INTERVERTEBRAL DISC DEGENERATION, DISC HERNIATION AND SPINAL STENOSIS ON MRI: AN EPIDEMIOLOGICAL STUDY OF 1,684 PATIENTS

Anand H Segar (1,2,3), Andy Judge (1), Jeremy Fairbank (1,2), Jill Urban (3), Iain McCall (4) for the Genodisc Consortium;

1-Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Science, University of Oxford, Oxford, UK 2-Nuffield Orthopaedic Centre, Oxford University Hospitals NHS, Oxford, UK 3-Department of Physiology Anatomy and Genetics, University of Oxford, Oxford, UK 4-Spinal Studies & ISTM (Keele University), Robert Jones & Agnes Hunt Orthopaedic Hospital, Oswestry, UK

INTRODUCTION: Low back pain has been associated with both disc degeneration and obesity, suggesting that the pain associated with increased body mass index (BMI) is partly mediated by degeneration. Here we examine the relationships between BMI and intervertebral disc degeneration (DD), disc herniation (DH) and spinal stenosis (SS), using a large prospectively recruited heterogeneous patient population.

METHODS: Patients were recruited from tertiary spine centres in 4 EU countries. An experienced radiologist scored magnetic resonance images (MRI) for DD (Pfirrmann grading system), any DH or any SS. Multivariate linear and logistic regression analyses were used to model the relationship between these variables and BMI. Given the comprehensive data collection, we were able to adjust for both patient and MRI defined confounders.

RESULTS: The analysis included 1684 patients with a mean age of 51 years and BMI of 27.2kg/m2. There was a strong positive linear relationship between age and DD (r=0.66). In the fully adjusted model, a 10-year increase in age and a 5kg/m2 increase in BMI were associated with a 0.31 and 0.04 unit increase in degeneration, respectively. Age (OR 1.23 [CI 1.06,1.43]) and BMI (OR 2.60 [CI 2.28,2.96]) were also positively associated with the presence of SS. For DH presence, age was a negative predictor (OR 0.70 CI 0.64,0.76) but BMI (OR 1.19 [CI 1.07,1.33]) showed a strong positive association. BMI was the strongest predictor of all three MRI features when the upper lumbar spine was considered separately.

DISCUSSION: Higher BMI was associated with more DD but the small coefficient suggests limited clinical relevance. For DH and SS, BMI is a more clinically meaningful predictor. The upper lumbar discs appear more sensitive to increased BMI, supporting the upper lumbar spine phenotype described by others. We now need to understand how obesity predisposes to DH and SS and if weight loss can help prevent these conditions.

SP49

DOES LUMBAR INTERVERTEBRAL DISC DEGENERATION AFFECT PSOAS MAJOR MUSCLES?

1Teruo Kita, 1Kazushi Takayama, 2Hiroaki Nakamura, 3Fumiaki Kanematsu, 3Toshiya Yasunami, 1Hideki Ueyama, 1Kazuya Nishino, 1Akito Yabu, 1Hideki Sakanaka, 1Yoshiki Yamano;

1Dept. of Orthopaedic Surgery, Seikeikai Hospital, Osaka, Japan; 2Dept. of Orthopaedic Surgery, Osaka City University Graduate School of Medicine, Osaka, Japan; 3Dept. of Orthopaedic Surgery, Saiseikai Nakatsu Hospital, Osaka, Japan

INTRODUCTION: From our previous MRI study, we reported that the cross-sectional areas (CSAs) of the paraspinal muscles and psoas major muscles decrease comparably with age, although the percent area of fat (%) fat) increases to a much greater degree in the paraspinal muscles. There was no difference in the degree of atrophy of the psoas major muscles between patients with and without paraspinal atrophy. In this study, we evaluated whether
degeneration of the disc close to the psoas major muscles might affect the CSA and % fat of this muscle.

METHODS: This study was conducted in 240 patients aged 60 years or over (80 males; 160 females; mean age, 73 years) in whom atrophy of the psoas major muscles had been evaluated based on the presence/absence of paraspinal atrophy in plain lumbar MRI. Using an image measurement software, the CSA and % fat of the psoas major muscles at the L2/3 to L4/5 level were measured on T2-weighted transverse MR images, and the degree of lumbar lordosis (L1 to S1) was measured on sagittal MR images. The severity of the disc degeneration at the L2/3 to L4/5 levels was assessed using the Pfirrmann grading system (Grade I to V, a higher grade indicating more severe degeneration), and the association between the severity of the disc degeneration and the CSA/% fat of the psoas major muscles was evaluated.

<table>
<thead>
<tr>
<th>No. of cases</th>
<th>CSA (mm²)</th>
<th>% fat (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>level</td>
<td>grade I</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>L3/4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>L4/5</td>
<td>0</td>
</tr>
<tr>
<td>CSAs (mm²)</td>
<td>L2/3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>L3/4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>L4/5</td>
<td>0</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION: Our results were shown in a table. No significant difference was noted among the values in any of the patients. While both disc degeneration and atrophy of the psoas major muscles advance with age, atrophy of the psoas major muscles appears to be scarcely affected by the severity of disc degeneration in patients aged 60 years and over, suggesting that disc degeneration and muscle atrophy advance independently. We previously reported that atrophy of the psoas major muscles was associated with the age, sex and BMI of the patient. This study showed that disc degeneration scarcely affects the CSA and % fat of the psoas major muscles.

SP50
ASSOCIATIONS OF SERUM BIOMARKERS WITH IMPROVEMENT IN PAIN SCORES IN SUBJECTS WITH AXIAL LOW BACK PAIN UNDERGOING SPINAL PROCEDURES
Wan Huang MD, PhD, Subashan Perera, PhD, Prakash Jayabalana MD, PhD, Katie Tremont BS, J Paolo Coelho MS, Jennifer Chamberlin, BS, Megan Cortazzo, MD, Debra Weiner, MD, Nam Vo PhD, James Kang MD, Gwendolyn Sowa MD, PhD, University of Pittsburgh School of Medicine

INTRODUCTION: Despite the frequency of interventional procedures performed for axial low back pain, selection criteria remain unclear and outcomes suboptimal. Serum biomarkers represent a potential opportunity to predict response to treatment.

METHODS: Consecutive patients were recruited from an academic medical center. All had consented for either epidural steroid injection (ESI, n=48) or medial branch block without steroid (MBB, n=45) as part of routine clinical care. Eligible subjects had axial low back pain without radiation into the lower extremities, red flags, oral steroids, uncontrolled psychiatric illness, or systemic inflammatory conditions. Serum blood samples taken immediately prior to the procedure were assayed by ELISA for NPY, E-selectin, RANTES, CS846, CTXII, and serotonin. Responders were defined as improvement in pain score of 2 points or more on a 0-10 numeric pain rating scale. Additional clinical data were collected on demographics, disability, function, previous treatments and treatment expectations. Wilcoxon Rank Sum Test was used for comparison of continuous variables, and Fisher’s exact test for categorical variables.
**RESULTS**: Response rates were 78% and 48% for MBB and ESI, respectively. Among subjects undergoing MBB, responders had greater baseline RANTES levels than non-responders (p=0.04). Among subjects undergoing ESI, responders had lower baseline CS846 levels (p=0.04), greater frequency of past exercise (p=0.04), and greater percentage expecting relief (p=0.04) than non-responders. No other associations were observed with other clinical variables.

**DISCUSSION**: These data identify candidate serum biomarkers that may have utility for patient selection for spinal procedures. Because clinical decision making for interventional management for axial low back pain is even more challenging than for radiculopathy, these represent important biomarkers for use in future prospective studies to assess and validate their predictive ability.

**SP51**

**WHAT DOES THE PFIRRMANN CLASSIFICATION EVALUATE ON THE DEGENERATED INTERVERTEBRAL DISC?**

Jun Sato(1), Yasuhiro Oikawa(2), Yawara Eguchi(3), Sumihisa Orita(1), Kazuyo Yamauchi (1), Go Kubota (1), Kazuhide Inage (1), Takeshi Sainoh (1), Kazuki Fujimoto (1), Yasuhiro Shiga (1), Abe Kouki (1), Hiroto Kanamoto(1), Kazuhisa Takahashi(1), Seiji Ohtori; (1)Department of Orthopaedic Surgery, Graduate School of Medicine Chiba University, Japan (2)Department of Orthopaedic Surgery, Teikyo University Chiba Medical Center, Chiba, Japan (3)Department of Orthopaedic Surgery, Shimoshizu National Hospital, Japan

**INTRODUCTION**: The Pfirrmann classification using MRI is a tool used to evaluate degeneration of intervertebral discs (IVDs). Diffusion tensor imaging (DTI) and diffusion tensor tractography (DTT) are neuroimaging tools for visualizing highly anisotropic tissues. Recently, DTI has been used to evaluate degenerated IVDs. The aim of this study was to obtain evidence on the efficacy of DTI and DTT to quantitatively evaluate degenerated IVDs.

**METHODS**: A total of 59 discs from L2-3 to L5-S were evaluated in the patients. The Pfirrmann classification on conventional MRI, fractional anisotropy (FA) value, apparent diffusion coefficient (ADC), and morphological classification on DTT were evaluated. The IVD was divided into 3 layers in a concentric manner from the center, defined as 1, 2, 3, 4, or 5 in order from the anterior of the intervertebral disc. The FA and ADC values were measured at each layer (e.g., FA1, FA2, FA3 etc.). DTT was classified into three types (ring, donut, or disk type), assuming degeneration progressed in this order.

**RESULTS**: A strong correlation (R=0.779) was observed between the Pfirrmann classification and morphological classification on DTT. In all the layers, the Pfirrmann classification correlated to a greater degree with the FA value than with the ADC value. The strongest correlation for the FA and ADC values in all the layers was the FA3 value (R=0.603). The FA value of the outer layer of IVD (areas 1 and 5) did not show a significant correlation (R=0.038 and R=0.111).

**DISCUSSION**: This study showed that shape on DTT correlated with the Pfirrmann classification, and that DTT of discs describes the IVD degeneration process. Like the Pfirrmann classification, FA3 is likely to indicate degeneration of the intervertebral disc nucleus. Measurement of the FA3 value may be a more objective evaluation of disc degeneration.
SP52
CORE OUTCOME MEASURE INDEX FOR LOW BACK PATIENTS: DO WE MISS ANXIETY AND DEPRESSION?
C. Cedraschi (1); M Marty (2); D. S. Courvoisier (3); V. Foltz (4); G. Mahieu (5); C. Demoulin (6); A. Gierasimowicz Fontana (7); M. Norberg (8); P. de Goumoens (8); S. Rozenberg (4); S. Genevay (9);
Section Rachis de la Societe Francaise de Rhumatologie; (1) Division of General Medical Rehabilitation, Geneva University Hospitals, Switzerland; (2) Division of Rheumatology, CHU Henri-Mondor Creteil, Paris, France; (3) Division of Clinical Epidemiology, Geneva University Hospitals, Switzerland; (4) Division of Rheumatology, CHU de la Pitie-Salpetriere, Paris, France; (5) Unité du Dos, CHU Dinant Godinne UcL Namur, Dinant, Belgique; (6) Department of Physical Medicine and Rehabilitation, Liege University Hospital Center, Belgium; (7) Clinique de Medecine Physique et Readaptation, CHU Brugmann, Bruxelles, Belgique; (8) Spine Centre, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland; (9) Division of Rheumatology, Geneva University Hospitals, Switzerland.

INTRODUCTION: The Core Outcome Measure Index (COMI) is a multidimensional questionnaire that investigates five dimensions in low back pain (LBP) patients, but does not address the psychological dimension. As the biopsychosocial perspective is recognized as important to capture the entire clinical picture of these patients, this multicenter prospective cohort study was designed to investigate the psychometric properties of a modified version of the COMI (COMIAD) which included 2 additional items, exploring anxiety and depression, respectively. METHODS: 168 subacute or chronic LBP patients recruited in spine clinics completed a set of questionnaires before and after treatment (follow-up at 4 to 6 months). Construct validity was explored by comparing each item of the COMIAD to validated full-length questionnaires. The psychometric properties of the COMI and COMIAD were then compared.

RESULTS: The two new items showed, good internal consistency, high correlations with the corresponding full-length questionnaires, no floor or ceiling effect and good reproducibility (test-retest agreement kappa 0.68 for anxiety, 0.62 for depression). The addition of the 2 items did not alter internal validity (Cronbach’s alpha=0.88 and 0.87, respectively). The minimal detectable change, the Minimal Clinically Important Improvement and the Patient Acceptable Symptom State were only minimally affected by the changes.

DISCUSSION: The questions exploring anxiety and depression have good intrinsic psychometric capacities and did not significantly modify the psychometrics of the original COMI questionnaire. The COMIAD, offers the possibility to include the psychological dimension in the multidimensional evaluation without significantly affecting questionnaire length.

SP53
DOES LOW BACK PAIN IN PATIENTS WITH EARLY-STAGE SPONDYLOLYSIS HAVE SPECIFIC CHARACTERISTICS? SECOND REPORT
Shiro Sugiura1,2 Satoru Nishikawa1, Takeshi Toyooka1, Tetsuo Shiga1, Kazumi Otsuki1, Kazuhsa Kitou1, Yuka Takata1, Tohru Ishizaki1, Yasutaka Omori1, Akito Takata1, Ayako Kote1, Takane Suzuki2, Chisato Morii2 Akihiro ogawa3, Yasuchika Aoki4;
1Nishikawa Orthopaedic Clinic 2Department of Bioenvironmental Medi-cine, Graduate School of Medicine, Chiba University 3Department of rehabilitation, Toho university sakura medical center 4Department of Orthopaedic Surgery, Eastern Chiba Medical Center

INTRODUCTION: We previously reported that finger tip-sized pain and unilateral low back pain (LBP) may be specific characteristics of early-stage spondylysis (ESS). This is the second report on the efficacy of
physical signs to assess ESS, focusing on qualities, extent and location of LBP. In this study, we investigated larger numbers of adolescent patients with LBP and used logistic regression analyses.

METHODS: Patients (n=104, less than 18 yrs-old) with acute LBP (less than 1 month) were included. All patients were evaluated by plain radiography and MRI; patients who showed obvious pathological findings other than ESS (e.g., disc herniation, infection, etc.) were excluded. All patients were evaluated by the following examinations: hyperextension and hyperflexion tests (pain provocation tests in standing position), pain quality (sharp/dull), pain extent (finger tip-sized area/palm-sized area) and pain location (unilateral/center). To evaluate the usefulness of the tests, clinical characteristics between ESS and non-specific LBP (NS-LBP) groups were compared.

RESULTS: Of 104 patients, 58 had ESS (ESS group: mean age: 14.5 yrs-old; 44 male/14 females) and 46 had no pathological findings that explained the LBP origin (NS-LBP group: mean age: 14.5 yrs-old; 27 males/19 females). Chi-square test showed that pain quality (sharp), pain extent (finger tip-sized) and pain location (unilateral) were significantly associated with ESS. Among these physical signs, a regression analysis revealed that unilateral LBP was most associated with ESS (p value less than 0.05; OR=9.15).

DISCUSSION: Our study revealed that the hyperextension test, generally recognized to be a useful test for ESS, was not significantly associated with ESS. Our results indicate that sharp, finger tip-sized pain and unilateral LBP may be specific characteristics of ESS. Besides, among these physical signs, a regression analysis revealed that unilateral low back pain location is the most characteristic of ESS.

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SP54
THE IMPACT OF A PRECISE MECHANICAL DIAGNOSIS FOR LBP: A COST COMPARISON WITH STANDARD COMMUNITY CARE
Donelson, Ronald G. 1; Spratt, Kevin F. 2; Gray, Richard 3; Miller, Mark 3;
1. Self-Care First, Hanover, NH USA 2. Geisel School of Medicine at Dartmouth, Dept. of Orthopaedics, Lebanon, NH, USA 3. Integrated Mechanical Care, Talla-hassee, FL, USA

INTRODUCTION: The cost of treating low back pain (LBP) continues to increase with little evidence of improved outcomes. The lack of reliable and validated diagnoses resulting in a wide range of ineffective treatments is at the heart of this problem. But there is considerable reliability and validity evidence indicating that a mechanical diagnosis revealing a directional preference identifies treatments that improve clinical outcomes. No study has looked at the cost impact of this intervention. Research question: does determining a baseline mechanical diagnosis linked to specific care reduce a large employer’s costs of treating LBP disorders compared with usual community care?

METHODS: Employees with a diagnosis from a comprehensive list of lumbar diagnostic codes, excluding only fractures, dislocations, and infections, elected either community care (CC) or care in company clinics with mechanical care (MC). CC treatment was reimbursed using standard fee-for-service and MC care using a negotiated case-rate. All claims one year after intake were compared between groups with claims-based co-morbidity data and patient demographics used for risk-adjustment.

RESULTS: 456 subjects had MC compared with 11,471 with CC care. In general, demographics and co-morbidities were similar across the two groups. The table below summarizes provider differences in
direct costs for inpatient charges across years, all differences significant at p<.0001.

**DISCUSSION:** The substantially lower per patient per month adjusted savings for MC care reflected lower use of MRI, injections, and surgeries resulting in fewer treatments and quicker return to work, all predicated by a precise mechanical diagnosis leading to specific treatments. These real-life cost-savings data for this cohort speak to the economic value (quality/cost) of basing treatment on individual’s mechanical characteristics rather than treating non-specific symptom(s) with one-size-fits-all treatments. Treatments that reduce the need for further care have great value.

**INTRODUCTION:** This study evaluated a protamine based polyelectrolyte complex (PEC) developed to utilize heparin in enhancing the biological activity of low-dose recombinant human bone morphogenetic protein -2 (rhBMP-2) in spinal fusion.

**METHODS:** A polyelectrolyte shell was deposited on the surface of alginate microbead templates using the polycation (protamine)/polyanion (heparin) layer-by-layer polyelectrolyte self-assembly protocol. rhBMP-2 was loaded onto the outermost layer via heparin affinity binding. Loading and release of rhBMP-2 were evaluated in vitro. The Bone inductive ability of 20-fold reduction of rhBMP-2 with the different carrier vehicle was evaluated using a posterolateral spinal fusion model in rats. All rats underwent surgeries with implantation of mPCL-TCP scaffolds, incorporating four different hybrid constructs (n=5), namely (Group 1) 500 ng rhBMP-2 delivered by Protamine PEC microbeads; (Group 2) 500 ng rhBMP-2 delivered by PLL PEC microbeads; (Group 3) absorbable collagen sponge with 500 ng rhBMP-2; and (Group 4) no rhBMP-2 group as negative control.

**RESULTS:** In vitro uptake and release analysis, protamine based PEC showed higher uptake and significantly enhanced control release when compared to PLL based PEC (p<0.05). In vivo implantation with protamine-based and PLL-based PEC showed better fusion performances when compared with absorbable collagen sponge delivered same dose of rhBMP-2, and negative control group through manual palpation, µCT, and histological analyses. The quantitative parameters of trabecular bone microarchitecture including BV/TV, Tb.Th, BS/TV, and Tb.N, showed the highest values in groups 1 and 2, with
majority parameters reached statistically significant as compared with Groups 3 and 4 (Figure 1).

**DISCUSSION:** Solid posterolateral spinal fusion was achieved with 20-fold reduction of rhBMP-2 when delivered using protamine based PEC carrier in the rat posterolateral spinal fusion model.

**METHODS:** A total of 100 patients with coxalgia (24 men, 76 women; average age, 60.0 years; range, 16-88 years) were included. We retrospectively evaluated clinical and X-ray findings of hip joints and total spinal alignment as follows: 1) range of motion (ROM) score and pain score from the Japanese Orthopaedic Association (JOA) hip score; 2) leg length discrepancy; 3) stage of osteoarthritis (OA) of the hip; 4) spinal coronal balance (C7-central sacral vertical line (CSVL)); and 5) spinal sagittal balance (sagittal vertical axis (SVA), pelvic tilt (PT), and pelvic incidence (PI))

**RESULTS:** There was a significant positive correlation between C7-CSVL and leg length discrepancy (r=0.35). Further, there was a significant positive correlation between SVA and the stage of hip OA (r=0.46). There also was a significant negative correlation between SVA and ROM score of the hip (r=−0.36).

**DISCUSSION:** In the current study, increasing leg length discrepancy tended to influence spinal coronal malalignment. In addition, progressive OA and decreased ROM of the hip tended to influence spinal sagittal malalignment. When evaluating spinal alignment, attention should be paid to the OA stage and ROM of the hip joint.

**SP56**
**HIP-SPINE SYNDROME: CROSS-SECTIONAL STUDY OF SPINAL ALIGNMENT IN PATIENTS WITH COXALGIA**

Miyagi M, Fukushima K, Inoue G, Nakazawa T, Imura T, Saito W, Takahira N, Takaso M; Department of Orthopedic Surgery, Kitasato University, School of Medicine

**INTRODUCTION:** Patients presenting with hip diseases sometimes have coexisting spine diseases, known as the “hip-spine syndrome”. The relationship between hip diseases and lumbar spine diseases has been the focus of many studies; however, there are few reports that have evaluated total spinal alignment in patients with coxalgia. In this study, we evaluated the relationship between hip joints and spinal alignment in patients with coxalgia.

**SP57**
**THE CLINICAL COURSE OF PAIN AND FUNCTION IN OLDER ADULTS WITH A NEW PRIMARY CARE VISIT FOR BACK PAIN**

Sean D. Rundell, DPT, PhD,1,2 Karen J. Sherman, PhD, MPH,3,4 Patrick J. Heagerty, PhD,5 Charles N. Mock, MD, PhD, MPH,4,6 Jeffrey G. Jarvik, MD, MPH, 2,7;
1)Department of Rehabilitation Medicine, University of Washington, Seattle, WA 2)Comparative Effectiveness, Cost, and Outcomes Research Center, University of Washington, Seattle, WA 3)Group Health Research Institute, Seattle, WA 4) Department of Epidemiology, University of Washington, Seattle, WA 5)Department of Biostatistics, University of Washington, Seattle, WA
INTRODUCTION: Little research has investigated the long-term prognosis of back pain in older adults. We report the clinical course of older adults presenting to a new primary visit for back pain by describing pain intensity, disability, pain interference, and resolution of back pain over 12 months.

METHODS: We conducted a prospective, inception cohort study. Participants were adults ≥65 years from primary care settings of three integrated healthcare systems in the United States. They were a part of the Back pain Outcomes using Longitudinal Data (BOLD) registry. We included 5211 (99.5%) of the 5,239 BOLD participants who had reached their 12 month follow-up date. Baseline measurements included: demographics, the EQ-5D, duration of back pain, expectation for recovery, depression, and anxiety. Patient reported outcomes, including back related disability (Roland Morris Disability Questionnaire), numerical rating scale of pain, pain interference, and resolution of back pain were collected at baseline, 3, 6 and 12 months.

RESULTS: Most improvement occurred within the first 3 months. The number and proportion with a 30% improvement in back pain increased from 1,950 (42.3%) at 3 months to 1,994 (44.8%) by 12 months. We found 1,331 (28.8%) and 1,576 (35.4%) had a 30% improvement in disability at 3 and 12 months, respectively. Only 23.0% reported their back pain had resolved at 12 months. Improvements in disability and interference with activity over 12 months differed by age, back pain duration, depression symptoms, anxiety symptom, and expectation for recovery.

DISCUSSION: Among older adults in primary care practice settings presenting with a new visit for back pain, the majority have persistent symptoms, disability and interference over 12 months of follow-up. Future research is needed to identify risk factors for persistent symptoms and effective interventions.

SP58
IS THE PRE-OPERATIVE MRI APPEARANCE OF LUMBAR MULTIFIDUS PROGNOSTIC FOR OUTCOMES OF LUMBAR DECOMPRESSION?
M Zotti, Ww Yoon, T Clifton(*), M Piche, F Vilas-Boas, B Freeman;
Spinal Injuries Unit, Royal Adelaide Hospital, South Australia, Australia

INTRODUCTION: There has been increasing interest in study of the appearance of paraspinal muscles on magnetic resonance imaging and correlation to spinal outcomes. Our purpose was to assess whether the preoperative MRI appearance of multifidus was predictive of outcomes for lumbar spinal stenosis surgery. It was hypothesised that patients with fatty atrophy on MRI would have significantly poorer clinical outcomes than those with-out.

METHODS: A review of patients who had undergone lumbar spinal stenosis surgery in the previous 2 years was undertaken. ODI and COMI outcome scores were calculated pre and post operatively. Elliptical cross sectional area mapping of multifidus, and the Kader et al. (2000) classification on MRI was undertaken. Also measured were the posterior adipose tissue layer, L5 vertebral body, areas of critical stenosis and psoas muscle calibre.

RESULTS: 66 patients (41 female, 25 male) met the inclusion criteria and underwent analysis. The proportions of the cohort who improved more than 40% in their COMI and ODI when comparing the cohorts of patients with CSA < 8.5cm2
compared to ≥8.5cm² were significantly different (47% v 79% [p=0.02] and 32% v 68% [p=0.006]). For patients with a Kader grade of 0-2 and CSA ≥8.5cm² there was significantly more percentage improvement with ODI/COMI [means 84, 75] compared to Kader 2-3 and CSA <8.5cm² [means 28,23] (p=0.05).

**DISCUSSION:** The appearance of lumbar multifidus on preoperative MRI is predictive for outcomes of lumbar spinal stenosis surgery with better results at a minimum of 1 year in patients with less fatty degenerative changes and higher cross sectional area. This has implications for use in the perioperative setting and further research on the value of preoperative imaging for other spinal surgery is indicated.

**SP59**

**EFFICACY OF INTRADISCAL INJECTION OF ANTIVASCULAR ENDOTHELIAL GROWTH FACTOR (PEGAPUTANIB) FOR THE TREATMENT OF DISCOGENIC LOW BACK PAIN**

Jun Sato(1), Sumihisa Orita(1), Kazuyo Yamauchi(1), Go Kubota(1), Kazuhide Inage(1), Takeshi Sainoh(1), Kazuki Fujimoto(1), Yasuhiro Shiga(1), Koki Abe(1), Hiroto Kanamoto(1), Masayuki Miyagi(2), Kazuhiro Takehashi(1), Seiji Ohtori(1);

(1) Dept. of Orthopaedic Surgery, Graduate School of Medicine, Chiba University (2) Department of Orthopaedic Surgery, Kitasato University, Japan

**INTRODUCTION:** Inflammatory cytokines and nerve ingrowth have attracted attention as therapeutic targets for discogenic low back pain. Anti-tumor necrosis factor-α (TNFα) and interleukin-6 (IL-6) inhibitors are reportedly effective for low back pain in the short-term, but their long-term usefulness is not known. Vascular endothelial growth factor (VEGF) increases levels of inflammatory cytokines and causes nerve ingrowth. Several authors have reported an increase of VEGF in painful discs in animals and humans. Here, we prospectively investigated the efficacy of a VEGF inhibitor for discogenic low back pain.

**METHODS:** We examined 20 patients with chronic discogenic low back pain. Pain was diagnosed based on persistence after >3 months of conservative treatment, Pfirrmann grade ≥3 for one level intervertebral disc degeneration on MRI, and pain provocation after discography. A solution of anti-VEGF 165 aptamer pegaptanib sodium (0.3 mg) and 0.5% bupivacaine (2 mL) was administered into discs under fluoroscopy (treatment group, n = 10). A control group (n = 10) received a single administration of 0.5% bupivacaine (2 mL). Low back pain was evaluated using a visual analog scale before; 1 day, and 1, 2, 3, 4, and 6 weeks after administration. Serum cytokine levels (VEGF, IL-6, TNF-α) as markers of pain were determined before and 2 weeks after administration.

**RESULTS:** Low back pain in the treatment group was significantly reduced for 4 weeks compared with pretreatment (p<0.05). Low back pain at 3 and 4 weeks after administration was significantly decreased in the treatment group compared with the control group (p<0.05). Significant serum cytokine level changes were noted after administration in both groups. No harmful side effects were seen in either group.

**DISCUSSION:** Anti-VEGF therapy is more effective for treatment of discogenic low back pain for up to one month after treatment compared with bupivacaine alone.
SP60
A SHORT-TERM RANDOMIZED TRIAL OF LIMAPROST ALFADEX AND CELECOXIB IN PATIENTS WITH LUMBAR SPINAL STENOSIS
Naotaka Mamizuka1, Koichi Hashimoto2, Takeo Mammoto1, Atsushi Hirano1, Masataka Sakane2, Hiroshi Nakajima3, Hiasnori Kameda4, Yoshio Nakata2, Keiko Fujie2, Masaki Tatsumura1, Naoyuki Ochiai5, Masashi Yamazaki2;
1Department of Orthopaedic Surgery, University of Tsukuba, Mito Clinical Education and Training Center, Mito Kyodo General Hospital, 2Faculty of Medicine, University of Tsukuba, 3Komatsu Orthopaedic Surgery Hospital, 4Department of Orthopaedic Surgery, Namegata General Hospital, 5Department of Orthopaedic Surgery, Kikkoman General Hospital

PURPOSE: Limaprost alfadex (Limaprost), a prostaglandin E1 analog, has vasodilatory properties and increases blood flow of the nerve root. However, it has not been clarified whether limaprost affects pain sensation associated with radiculopathy due to lumbar spinal stenosis (LSS). The aim of this study was to compare the efficacy of oral Limaprost (Limaprost) with nonsteroidal anti-inflammatory drugs (Celecoxib) for LSS.

METHODS: In a single-blind, open-label, active-controlled, randomized, parallel-group comparison, multicenter trial by the central registration system with the data center, we randomly assigned 134 patients who had lumbar central spinal stenosis based on a self-reported diagnostic support tool. The study was approved by the institutional review board at each site and was overseen by an independent data and safety monitoring board. Limaprost, or Cerecoxib were administered orally for 8 weeks. The primary outcomes were the score on the Japanese version of Zurich Claudication Questionnaire (total score of ZCQ (tZCQ), in which scores were modified as range from 0 to 100). The secondary outcomes were the subscales of symptom severity (ssZCQ) and of physical function (pfZCQ). ZCQ. As a method of analysis, we used ITT analysis, FAS analysis and PPS analysis. For this research project, was carried out a clinical trial registration in UMIN-CTR.

RESULTS: At 8 weeks, tZCQ, ssZCQ and pfZCQ were significantly improve in each group. We observed no significant difference between Limaprost and Celecoxib in all scales by ITT analysis, FAS analysis and PPS analysis, respectively.

DISCUSSION: This study shows Limaprost and Celecoxib offered short-term benefit for LSS and the difference between groups were not observed.
INTRODUCTION: A newly proposed pedicle screw placement technique utilizes a new start point and insertion angle, which takes advantage of the cortical bone structures in the posterior vertebra and pedicle. Although this new system has been used in single level spinal fusion in the treatment of some conditions, it is not clear whether it could be applied to long segment fusion, especially with significant instability. The purpose of this research was to compare the initial fixation quality of the new construct and standard pedicle screw construct in stabilizing a three level lumbar spinal segment with low grade spondylolisthesis.

METHODS: Eight fresh frozen lumbar spines (T12-S1) were obtained. Low-grade spondylolisthesis was simulated at the level of L1-4 by removing the facet joints and longitudinal ligaments. Each specimen was instrumented with the standard and cortical trajectory pedicle screw systems. A non-destructive flexibility test was performed to compare the intact, unstable, and fused spines. Range of motion at each level was compared between the constructs during flexion, extension, lateral bending, and axial rotations. The global and inter-level vertebral motions were captured with reflective markers and infrared cameras.

RESULTS: The low-grade spondylolisthesis model significantly increased the ROM in all planes of motion (P<0.05). Both fixation techniques provided significant reduction in the ROM (P<0.05). There were no significant difference in ROM between the pedicle screw fixation and cortical fixation in of the planes (P>0.05).

DISCUSSION: The new cortical fixation system has clinical advantages such as smaller incision, decreased blood loss, etc. Cortical trajectory screw fixation provided stabilization to multilevel lumbar segment with low grade spondylolisthesis compared to the standard trajectory pedicle screw construct. However, the long-term performance of the new fixation system has to be investigated in the future studies.
METHODS: Radiographs for 161 asymptomatic volunteers (mean age 42.2 years, range 18-82) were used. Each lumbar level was assessed for degeneration and 653 non-degenerated levels were found. Segmental TPDR was calculated as the ratio of translation to rotation based on measurements obtained using validated software.

RESULTS: MANOVA analysis indicated that intervertebral level (P<0.0001), and age (P<0.01) were associated with TPDR variation, whereas gender (P=0.87) and global (L1-S1) rotation (P=0.14) were not. Further analysis found that only at L1-2 was age significant, and R2 was only 0.04 so pooling data for all ages, both genders, and levels of global motion were deemed appropriate. Table I provides the TPDR values at each level. Based on the 95% confidence intervals for this data, the upper bound for normal TPDR is approximately 0.8 at L1-2 to L4-5 and 0.5 at L5-S1.

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean TPDR</th>
<th>StdDev TPDR</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1-L2</td>
<td>131</td>
<td>0.51</td>
<td>0.13</td>
<td>0.76</td>
</tr>
<tr>
<td>L2-L3</td>
<td>135</td>
<td>0.56</td>
<td>0.11</td>
<td>0.78</td>
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<tr>
<td>L3-L4</td>
<td>139</td>
<td>0.60</td>
<td>0.11</td>
<td>0.81</td>
</tr>
<tr>
<td>L4-L5</td>
<td>143</td>
<td>0.53</td>
<td>0.14</td>
<td>0.81</td>
</tr>
<tr>
<td>L5-S1</td>
<td>104</td>
<td>0.18</td>
<td>0.15</td>
<td>0.47</td>
</tr>
</tbody>
</table>

DISCUSSION: Based on routine flexion/extension radiographs, quantifiable values were identified to define lumbar segmental instability. These can be used to calculate a Z-score (TPDR for a patient minus mean normal population derived in this study divided by the standard deviation) to provide an easily interpreted stability index to better appreciate the instability magnitude (e.g. 2 SD above normal vs. 5 SD above normal). Intervertebral rotation and translation were strongly associated with global rotation (L1-S1), TPDR was not, suggesting TPDR has the advantage of being less dependent on patient effort, which is may be important in clinical back pain populations.

GP3
INTERVERTEBRAL IMPLANT DESIGN CAN INFLUENCE VISCOELASTIC RESPONSE OF UNDERLYING BONE UNDER DYNAMIC LOADING
Antonio Valdevit(1), Rebecca Chung(1), Marina Dawoud(1), Peter F. Ullrich, Jr.(2), Michelle B. Gallagher(2), Jennifer M. Schneider(2);
(1)Stevens Institute of Technology, Hoboken, NJ, (2)Titan Spine, LLC, Mequon, WI

INTRODUCTION: Viscoelastic materials can be characterized by magnitude of the complex modulus and Phase Lag (δ). Intervertebral cage designs engaging the stronger vertebral periphery with increased endplate contact would display favor-able stiffness and Phase Lag under cyclic loading.

METHODS: A threaded titanium cage, an oval shaped open titanium cage and a PEEK cage were examined. Using porcine vertebral bodies, 600 cycles of loading from -50N to -350N was applied at 1Hz. Stiffness from loading and unloading portions of each cycle were computed, averaged across 6 samples of each design and initialized to zero. Complex Stiffness was computed and subjected to non-linear regression resulting in a rate of change per cycle (K value) and the Plateau (asymptotic limit). Parameters were compared using a 1 way ANOVA with a Tukey post-hoc test for design differences (α < 0.05).

RESULTS AND DISCUSSION: Complex Stiffness (Figure 1A) displayed significant differences in initial magnitude (Yo) and rate change (K value) for all implants (P< 0.001). For Phase Lag, (δ ) (Figure 1B), dual exponential fits were preferred, leading to K Fast and K Slow values. For K Fast, both Titanium implants were statistically greater than PEEK implants (P< 0.003). For K Slow, all implants were different from each other
(P< 0.001). Complex Stiffness allows investigation of viscoelastic effects of the implant on underlying bone. While this concept stems from material modulus, the extension may be applied to structural stiffness. The Complex Stiffness indicated open Titanium implants displayed reduced K values for magnitude. For Phase Lag (δ), the K slow component of the open Titanium implant was statistically reduced compared to other implants, indicating a slower more gradual change in stiffening and altered viscoelastic changes in underlying bone. Clinically, reduced viscoelastic effects lead to reduced stiffening long term and may improve healing rates due to improved fluid flow within the site.

GP4
A BIOMECHANICAL COMPARISON OF PEDICLE SCREWS PLACED BY CORTICAL BONE TRAJECTORY (CBT) AND CONVENTIONAL METHOD-A CADAVERIC AND FINITE ELEMENT STUDY
Ken Ninomiya1, Tateru Shiraishi1, Ryoma Aoyama1, Satoshi Nori1, Ukei1 Anazawa1, Hiraku Hotta1, Seiji Ueda2;
1. Tokyo Dental College Ichikawa General Hospital, Orthopedics Surgery 2. Saiseikai Yokohama City Nanbu Hospital, Orthopedics Surgery

INTRODUCTION: Cortical bone trajectory (CBT) was a trajectory of pedicle screw followed by an engaging maximally cortical bone on pedicle. The aim of this study was to make and to validate the finite element model (FEM) and to identify anchorage performance of CBT using FEA.

METHODS: For FEA, L5 vertebra was built by using MECHANICAL FINDER software (RCCM). CAD data of pedicle screw was obtained from OSTEOGRIP screw (Medtronic). Trabecular bone was simulated using 2-mm tetrahedral elements and the outer surface of the cortical shell was modeled using 2-mm triangular-plates. An axial loading at 1nm/300times was applied on screw and the site of fracture was investigated. For cadaveric pullout study, screws were placed on five L5 vertebrae as described in the ASTM-F543 and the site of fracture was investigated. To study screw strength using FEA, 38 patients (average 68 year-old, male 26 and female 12) were involved. An axial loading was applied on screw and pullout force was defined as being when at least one element was fractured according to a report of Imai. Bone density was calculated and was correlated with pullout strength using Pearson’s correlation coefficient. Statistical analysis was performed using Fisher exact test and p< 0.05 was considered as statistically significant.

RESULTS: Fracture of vertebrae occurred on pars interarticularis by cadaveric study and FEM. The average pullout force (N) of screws placed by CBT and conventional PLIF were 78.3±31.3 and 40.9±24.7 respectively (p<0.01). The average bone density (mg/cm3) was 296±62.6. There were linear correlations between the pullout force of CBT and conventional PLIF and bone density (CBT: r=0.65, p<0.01: conventional r=0.47, p<0.01).

DISCUSSION: This study suggests that the FEA model is validated by cadaveric study and CBT is stronger against pullout force than conventional trajectory. There is a
significant relationship between bone density and screw pullout force.

GP5
EFFECT OF LOAD HISTORY ON OVINE INTERVERTEBRAL DISC BIOMECHANICS
Addison S. Goodley (1) Meghna Ramaswamy (1) Adam H. Hsieh (1, 2);
(1) Fischell Department of Bioengineering, University of Maryland, College Park, USA (2) Department of Orthopaedics, University of Maryland, Baltimore, USA

INTRODUCTION: Mechanical loading alters IVD biomechanical properties by modifying fluid distribution, hydrostatic pressure and tissue response. This study examines the effect that high (0.75MPa) and low (0.05MPa) applied recovery loading has on ovine IVD mechanics and post-load recovery.

METHODS: Lumbar motion segments (n=18) were harvested, surrounding tissues removed, and frozen until testing. Specimens were thawed overnight and subjected to either healthy or adverse recovery loading between multiple short-term, high-load exertion challenges. Prior to testing, motion segments from the healthy (0.05MPa axial compression, 7 transient 2MPa challenge loads every 900s) and adverse (0.75MPa axial compression, similar transient loading) groups underwent cyclic compression to resolve post-mortem super-hydration effects. Nucleus pulposus (NP) pressure, disc height and radial bulge were measured. Measurements were further interpreted using viscoelastic and NP shear models.

RESULTS: Differences in NP pressure generation from initial (Ch1) to final challenge (Ch7) were significant (p<0.05) between adverse (reduced 0.311±0.196 MPa from Ch1 to Ch7) and healthy groups (within 0.092±0.082MPa of Ch1). Adverse groups exhibited -0.502±0.118 strain during Ch7 and -0.197±0.080 strain at the end of the test. The healthy group averaged -0.308±0.029 strain (p<0.05) for the same Ch7 load, and exhibited 0.077±0.030 strain during final recovery (p<0.05). In adverse loading, disc bulge was 0.44±0.04mm while healthy discs bulged only 0.06±0.12mm (p<0.05). Models suggest reduced endplate permeability and potentially damaging shear stresses in the adverse loading group.

DISCUSSION: High IVD loading during recovery phases inhibited NP pressure generation during challenge loads and reduced disc height. Meanwhile, low loading maintained consistent pressure generation and enabled disc height recovery between challenge loads. This study demonstrates limited fluid recovery in highly loaded IVD.

GP6
THE EFFECTS OF UNIAXIAL STRAIN ON NOTOCHORD CELLS AND HUMAN CHORDOMA CELL LINES
Carlos Luna 1, Elizabeth Shagnea 1, Lauren Resutek 1, Adam H. Hsieh 1, 2;
1 Fischell Department of Bioengineering, University of Maryland, College Park, USA. 2 Department of Orthopaedics, University of Maryland, Baltimore, USA.

INTRODUCTION: Notochord cells (NC) are present in all vertebrate as part of the notochord, the main axial support that leads to the formation of the spine. In humans, NCs participate in axial develop-
ment, then reside in the nucleus pulposus (NP) and disappear by adulthood. Their disappearance is often related to intervertebral disc degeneration. During development and in the NP, NCs are subjected to mechanical stress, yet little is known about their response to strain. In this work, we investigated the response of NC to in vitro strain by measuring cell behavior, morphology and phenotype.

METHODS: We developed a polydimethylsiloxane (PDMS) chamber suitable for in vitro cell-culture and compliant to unidirectional strain. Notochord cells were isolated from NP tissue from the caudal discs of Sprague-Dawley Rat tails. Human chordoma cells (HC), thought to originate in the notochord (UCH-1, UCH-2 and MUG-Chor1) were obtained from the Chordoma Foundation and were used to evaluate their potential as a cell line to study notochord cell phenotype.

RESULTS: Initial experiments showed that NC and HC morphology is affected by 10% strain. HC cells retained notochord-like characteristics when their morphology was circular, compared to an elongated shape. Their notochord-like phenotype was over expressed when they reached confluency, compared to single cells, demonstrating that HC can be used to analyze notochord behavior but only under certain conditions. Lastly, we analyzed the effects of strain in the intracellular vacuoles of NC and chordoma cells by measuring the loss of fluorescence intensity as a function of time.

DISCUSSION: This study examined the effects of uniaxial tensile strain on NCs and HC cells. We studied the potential of HC cell lines for the study of notochord-like behavior. This study furthers our knowledge of notochord behavior and mechanical loading, which is relevant for the study of intervertebral discs and vertebrae development.

GP7
DIFFERENTIATION OF HUMAN INDUCED PLURIPOTENT STEM CELLS INTO NEURAL CREST STEM CELLS IN VITRO
Abe Rei, Orita Sumihisa, Suzuki Miyako, Inage Kazuhide, Kubota Go, Saino Takeshi, Sato Jun, Fujimoto Kazuki, Takahashi Kazuhisa, Kuniyoshi Kazuki, Ohtori Seiji;
Department of Orthopaedic Surgery, Chiba University, Chiba, JAPAN

INTRODUCTION: Peripheral nerve damage due to trauma, etc. leave severe sequelae such as paralysis and sensory analgesia-blunted in time but has been shown to effect the neural stem cell transplantation and Schwann cell transplantation for the nerves have been damaged by previous studies. Supply of cells in a simple and stable way towards the cell transplantation is required. It is therefore an object of the present study, induced pluripotent stem cells (iPS cells; induced pluripotent stem cell); is to induce differentiation (NCSC; neural crest stem cell) nerve from without using a feeder cell crest stem cells.

MATERIAL AND METHODS: The human iPS cells underwent monolayer culture using ips maintenance medium on plastic dishes were coated Matrigel. After that, it was differentiated in about 7 to 10 in were cultured in Neural crest differentiation medium containing a GSK3 inhibitor and SB431542 NCSC. A marker of NCSC as indicators of differentiation p75, Hnk1, for a marker of hiPS Sox2 was immunocytochemical staining (n = 2).

RESULTS: A stem cell marker in iPS sox2 is positive (positive rate > 99%), whereas the p75 is a nervous system markers negative (positive rate 0%), Sox2 is negative in NCSC, p75 is positive (positive rate 65 ± 9%) I showed. Therefore, the iPS were differentiated into NCSC was suggested.

DISCUSSION: We have succeeded to be differentiated from the iPS cells into NCSC by a simple method without using a feeder cell transplantation of iPS-derived NCSC
effect to peripheral nerve injury treatment is expected.

**GP8**

**BIOMECHANICAL EFFECT OF NUMBER AND SPACING OF SACROILIAC JOINT STABILIZATION IMPLANTS: A FINITE ELEMENT ANALYSIS**

Derek P. Lindsey, M.S.*, Ali Kiapour, Ph.D. #, Scott A. Yerby, Ph.D. *, Vijay Goel, Ph.D. #; * - SI-BONE, Inc., San Jose, CA; # - E-CORE, Toledo, OH

**INTRODUCTION:** Sacroiliac (SI) joint fusion using minimally invasive placement of implants is an option to relieve pain resulting from SI joint disorders. Variations in sacral morphology (i.e. normal vs dysmorphic) may require alterations in placement of fixation hardware to prevent patient injury. These variations may restrict the placement (e.g. number, spacing) of hardware for SI joint fusion, which in turn may limit the stability of the treated SI joint. This finite element study therefore investigated the effect of number of implants and their spacing on the stability of the treated SI joint.

**METHODS:** An experimentally validated lumbo-pelvic finite element model was used to calculate SI joint range of motion (ROM) before and after treatment. Loading in flexion, extension, lateral bending (LB), and axial rotation (AR), was simulated with a 400N compression follower-load plus a 10N·m moment. The sacral cancellous bone was assigned heterogeneous material properties. Treatment consisted of lateral placement of either 2 or 3 implants (iFuse Implant®; SI-BONE) using a posterior technique; implants were placed superior, lateral (middle), and/or inferior to the S1 foramen. The reduction in motion was compared with the intact condition and between the treated models.

**RESULTS:** The placement of 3 implants reduced the SI joint range of motion by 66% (flexion), 60% (extension), 32% (LB) and 63% (AR). Placement of 2 implants reduced the range of motion by an average of 58% (flexion), 50% (extension), 25% (LB) and 56% (AR). Models without a superior, middle, or inferior implant reduced the stability by an average of 29%, 6%, and 19%, respectively, compared with the 3 implant model.

**DISCUSSION:** Implant number and spacing altered the treated SI joint ROM. This study demonstrates that 3 implants had the greatest stability. In the models with 2 implants, the model with a superior and an inferior implant (i.e. largest spacing) provided the most stabilization.

![Graph](image)

**GP9**

**INTERSPINOUS PROCESS IMPLANT APERIUS PERCLID CAUSES WEAR OF THE SPINOUS PROCESSES. AN EXPERIMENTAL BIO-MECHANICAL STUDY**

Jonas Hvannberg MD, Christian Hagelberg MD, Lars Ekström BS, Klas Halldin MD, PhD, Helena Brisy MD, PhD and Adad Baranto MD, PhD;
Department of Orthopaedics, Institute of Clinical Sciences at Sahlgrenska Academy University of Gothenburg and Sahlgrenska University Hospital, Gothenburg, Sweden.

**INTRODUCTION:** There are few biomechanical studies on interspinous process implants (IPD) but none investigating the amount of wear on spinous processes. Therefore the objective of the present
study was to investigate the effect of repetitive loading of the interspinous implant Aperius PerLiD on the spinous processes in a biomechanical porcine model.

**METHODS:** Four lumbar spines from 6 months old porcine were divided into seven segments, which received interspinous implants. The segments were exposed to 20,000 cyclical loads where after the wear of the segments was registered. The wear of the spinous processes was measured in mm on following CT-scans.

**RESULTS:** The mean maximal deformation of porcine specimens was 1.79 mm (median 1.9, SD 0.25) where the largest deformation occurred in the first quarter of the loading (<5000 cycles). The mean and the median depth of the wear of the porcine spinous process on CT examinations was 9.6 and 10.1 mm (1.8 SD, Range 8.2-12.1) respectively. The mean length of the wear was 36.1 mm (Range 29-40) and the mean and median area of the wear of the spinous processes was 353.6 mm² and 384 mm² respectively (101.9 SD, Range 200.1-413.4 mm). The limitations are that the loading time is short with few cycles and that 3-dimensional analyses of the spinous process wear could not be made due to the nature of the CT-scans.

**DISCUSSION:** The IPD Aperius caused significant wear of the spinous processes after cyclically loading. How these findings influence the short and long term result of this implant remains to be investigated in further biomechanical and clinical studies. For future development of this type of devices, a proper selection of materials and design is essential to minimize wear effects on the spinous processes and thereby increase the possibilities for the devices to function as suggested.

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**GP10**

**THE EFFECT OF STANDING VS. VARIANTS OF THE SEATED POSITION ON LUMBAR INTERSEGMENTAL ANGULATION AND SPACING: A RADIOGRAPHIC STUDY OF 20 ASYMPTOMATIC SUBJECTS**

Todd F. Alamin, MD Vijay Agarwal, MD Albi Quelli, MD Neil Shah, MD; 
Stanford University School of Medicine

**INTRODUCTION:** Pain while sitting is the primary complaint of many patients with lumbar spinal ailments, including those with “discogenic” low back pain and lumbar disc herniations. It is clinically evident that certain sitting positions are worse than others with regards to their propensity to cause significant pain in these patients, but there has been little basic research on the different mechanical stresses that different sitting positions place on the spine. We undertook this study to examine the intersegmental effect of different sitting positions on the lumbar spines of 20 healthy male volunteers, and to compare it to baseline data obtained in the standing position.

**METHODS:** Twenty healthy male volunteer subjects were recruited. Lateral lumbar spine radiographs were obtained in the standing position, and in three distinct sitting positions. Anterior and posterior disc height, disc space angulation, L1-S1 angulation and interspinous distance were measured. Average disc height was calculated as the arithmetic average of the anterior and posterior disc heights.

**RESULTS:** The L1-S1 lordotic angle in the standing position (48.8±14.7 degrees) was found to be statistically significantly greater than that measured in any of the sitting positions: the kneeling chair (34.0±17.7 degrees), hard back chair (28.6±14.3 degrees), and the stool (16.6±15.6 degrees). Total average disc height (arithmetic sum of average disc heights L2-S1) in the lumbar spine varied
with position: standing (48.9mm +/-10.1) > kneeling chair (46.9mm +/-10.3) > hard back chair (46.4mm +/-9.5) > stool (44.7mm +/-9.2). Average posterior disc height, for the hard back chair (8.2±2.4mm) and the stool (8.4±2.2mm) was greater than in the standing position(7.5±1.8mm).

**DISCUSSION:** A better understanding of seating positions added to by this report may lead to both a better understanding of the reasons for the common complaint of pain with sitting as well as improvements in chair design for such patients.

**GP11**

**ANALYSIS OF THE PSOAS MAJOR MUSCLE ACTIVITY USING FINE-WIRE ELECTROMYOGRAPHY DURING FULL SQUAT EXERCISE**

Naoto Matsunaga(1), Koji Kaneoka(1), Yu Okubo(2), Kiyotaka Hasebe(1), Atsushi Imai(1), Paul Hodges(3);
(1) Faculty of Sport Sciences, Waseda University, Saitama, Japan (2) Faculty of Health and Medical Care, Saitama Medical University, Saitama, Japan (3) University of Queensland, Australia

**INTRODUCTION:** Squat is a representative exercise to strengthen lower extremity muscle with repeated hip flexion and extension movement. Psoas major (PM) is prime mover for hip flexion, but activity of the PM during squat is not clear. Therefore, the purpose of this study was to compare the PM activity during full squat exercise between the phases.

**METHODS:** Seven healthy men were participated in this study. The activities of 7 muscle types were measured, including the rectus abdominis, external oblique, internal oblique, erector spinae (ES), rectus femoris (RF), gluteus maximus (GM), and PM. For the PM, we used intramuscular fine-wire electrodes to detect the electromyographic (EMG) signals. The other muscles were measured by using surface electrodes. The subjects performed full squat exercises. To analyze EMG data, we divided squat exercise into following 8 phases: upright, early descent, intermediate descent, late descent, bottom position, early ascent, intermediate ascent and late ascent phase. The EMG amplitudes for each phase were calculated and compared using a 1-way analysis of variance (ANOVA).

**RESULTS:** Figure showed that the activity of the PM during full squat exercises. There were significant differences for the PM, RF, ES and GM between phases. The activity level of the PM is greater during late decent and bottom position phases than the other phases.

![Figure](image)

**DISCUSSION:** The activity of PM increased in late descent and bottom position phase. It was reported that the PM activity level is high during hip flexion exercise at deep hip flexion position (Andersson E et al. 1995). These results suggested that the PM may...
work at deep hip flexion position to control center of gravity and lumbar lordosis. In conclusion, deep squat produced high activation in the PM.

**GP12**

INVESTIGATING THE ASSOCIATION BETWEEN NATURALLY DEVELOPING SPINAL DISORDERS AND MUSCLE FATTY DEGENERATION IN A CANINE MODEL

Stephen H. M. Brown, Alexandra B. Harriss, Assaf Lerer, Thomas G. Koch, Thomas Gibson, Stephanie G. Nykamp; University of Guelph

**INTRODUCTION:** Muscle fatty infiltration has often been identified in human patients suffering from chronic back pain. Dogs of certain breeds are susceptible to developing chronic degenerative spinal disorders and thus provide a naturally developing animal model that can be used to draw links to the human condition. The goal of this study was to quantify, via MRI, the magnitude of fatty infiltration in spine muscles of chondrodystrophic (CD) and non-chondrodystrophic (NCD) dogs suffering from both intervertebral disc herniation (IVDH) and non-disc related spinal disorders, and relate this to IVD degeneration (IVDD).

**METHODS:** MRIs from 180 dogs were separated into four groups: 1) CD with IVDH; 2) CD with non-IVDH spinal pathology; 3) NCD with IVDH; 4) NCD with non-IVDH spinal pathology. At intervertebral levels T12-T13 to L6-L7, IVDD was subjectively graded and muscle-fat indices (MFIndex) were quantified for multifidus, erector spinae and psoas muscles.

**RESULTS:** IVDD grade was higher (p < 0.001) for CD compared to NCD dogs, and for dogs with IVDH compared to dogs with non-IVDH pathology. MFIndices of multifidus and psoas were higher (p < 0.01), indicating greater fatty infiltration, for NCD compared to CD dogs, and for dogs with non-IVDH pathology compared to dogs with IVDH. Erector spinae demonstrated higher (p < 0.001) MFIndices compared to multifidus and psoas; however, this level of fatty infiltration was not dependent upon breed or pathology.

**DISCUSSION:** Dogs with higher IVDD grades had less fatty infiltration within their multifidus and psoas muscles compared to those with lower IVDD grades. This finding was consistent across both CD and NCD breeds as well as across dogs with IVDH and non-IVDH spinal pathology. Thus, the presence or severity of IVDD is not uniquely related to muscle fatty infiltration in these muscles, but rather the presence, or possibly severity or chronicity, of general spine pathology is likely a better predictor of fatty infiltration.

**GP13**

ARE KINEMATIC MEASURES OF MOTION OF THE LOWER LUMBAR SPINE RELATED TO PFIRRMANN GRADE?

Muturi G. Muriuki #, Robert M. Havey #, Leonard I. Voronov #, Gerard Carandang #, Laurie Lomasney $, Avinash G. Patwardhan #,$; #. Edward Hines Jr VA Hospital, Hines, IL. $ Department of Orthopaedic Surgery and Rehabilitation, Loyola University Chicago, Maywood, IL

**INTRODUCTION:** Pfirrmann Grade is used to assess intervertebral disk degeneration based on the appearance of the intervertebral space on T2-weighted MR images. There is little data on the correlation between Pfirrmann grade and biomechanical assessment of motion in the lower lumbar spine.

**METHODS:** The intervertebral disks of 54 intact lumbar cadaveric spines (Age 19–73 yrs; 34 M, 20 F) were graded using the central T2-weighted MRI sagittal slice with maximum vertebral body volume. Specimens were tested in flexion-extension with and without 400N follower preload (flexion
and extension limits of 8Nm & 6Nm). Vertebral motion and applied moment data were used to calculate L4–L5 & L5–S1 segmental range of motion (ROM); high flexibility zone (HFZ) & low flexibility zone (LFZ) angular stiffness; and HFZ size in flexion and extension. Flexion and extension were defined based on the specimen’s posture at the start of the experiments. Three groups based on Pfirrmann grade classification were used in data analysis (Group I: grade 1 & 2; Group II: grade 3; Group III: grade 4 & 5). Effects were assessed using repeated measures ANOVA. RESULTS: The effect of Group membership on HFZ stiffness, flexion ROM and HFZ size was interactive with preload (p<0.046). Flexion HFZ stiffness increased 22%, 47% and 129% for Group I, II and III (Figure). Under preload, Group III HFZ stiffness was larger than Groups I and II combined (p<0.05). Group I and II flexion HFZ stiffness were not statistically different (p=0.9). Without preload there were no significant differences between Groups I, II and III (p>0.2).

DISCUSSION: Pfirrmann grade and compressive preload had an effect on quality & quantity of motion. This data adds to the few biomechanical studies evaluating correlations of Pfirrmann grade and biomechanics.

GP14
OSTEOPOROTIC PAIN CAN BE ACTIVATED VIA BARORECEPTOR TRPV4 IN OVARIECTOMIZED RATS
Sumihisa Orita, Go Kubota, Kazuhide Inage, Takeshi Sainoh, Jun Sato, Kazuki Fujimoto, Yasuhiro Shiga, Hirotu Kanamoto, Kazuyo Yamauchi, Kazuhiro Takahashi, Seiji Ohtori; Department of Orthopaedic Surgery, Graduate school of Medicine, Chiba University, Japan

INTRODUCTION: Osteoporotic state itself can generate pain, called osteoporotic pain. One mechanism for this pain includes increased expression of calcitonin gene-related peptide (CGRP; an inflammatory pain-related biomarker) in the dorsal root ganglia (DRG) innervating osteoporotic vertebrae in ovariectomized (OVX) rats, inducing susceptibility to pain. One study revealed involvement of neuropathic pain using a mechanically compressed coccygeal vertebrae model in OVX rats to evaluate the effect of longitudinal gravity, which contains a factor of mechanical injury induced by the compression stress itself. Transient receptor vanilloid 4 (TRPV4) is known to be a baroreceptor, which responds to compression pressure. In the present study, we aimed to evaluate the effect of mechanical stress on osteoporotic vertebrae by investigating TRPV4 involvement in OVX rats with no mechanical loading.

METHODS: The expression of CGRP-immunoreactive (-ir) and TRPV4-ir nerve fibers in DRG innervating L3 vertebrae of Sprague Dawley rats labeled with a neurotracer (Fluorogold: FG) were statistically examined using immunofluorescence techniques. Double-stained FG-positive DRG neurons with CGRP-ir and TRPV4-ir fibers were evaluated in control, sham, and ovariectomized (OVX) rats (n = 7, each group). P<0.05 was considered statistically significant. RESULTS: FG-positive DRG neurons were observed among the three groups, mainly
in L1-3 DRG, with no significance group differences. There were significantly more CGRP- and TRPV4-stained FG-positive DRG neurons in the OVX group than the other groups (P<0.05).

**DISCUSSION:** Sensory innervation of osteoporotic rat vertebrae showed increased expression of CGRP and TRPV4 in DRG neurons innervating the osteoporotic vertebrae, which suggests the possible involvement of increased stress on osteoporotic vertebrae. These findings demonstrate that the osteoporotic state itself can generate pain under conditions susceptible to compression stress loading.

**GP15**

**ADJACENT SEGMENT PATHOLOGY AFTER THORACOLUMBAR FUSION IN THORACOLUMBAR FRACTURES ; RISK FACTOR ANALYSIS ON DEMOGRAPHICS, RADIOLOGICAL FACTORS, AND SPINOPELVIC PARAMETERS**

Chang-Hoon Jeon, Nam-Su Chung, Han-Dong Lee, Ji-Sang Youn;
Department of Orthopaedic Surgery, Ajou University School of Medicine, Suwon, Republic of Korea

**INTRODUCTION:** Although numerous studies have reported the adjacent segment pathology (ASP) after lumbar fusion, little attention has been paid to the ASP after thoracolumbar fusion. The purpose of this study was to investigate risk factors for the occurrence of ASP after thoracolumbar fusion in thoracolumbar fractures.

**METHODS:** We retrospectively reviewed a cohort of 44 patients with thoracolumbar (T10-L2) fracture treated with posterior fusion using pedicle screw instrumentation that had taken MRI at the time of index treatment and at least 2-year follow-up. The radiological ASPs including disc degeneration, disc herniation, spinal stenosis and spondylolisthesis were evaluated. Demographic factors including age, sex, body mass index, and injury level, as well as radiological factors including fracture kyphosis and spinopelvic parameters were investigated to determine the relevant factors.

**RESULTS:** The mean age was 38.7±13.1 years and the number of male patients was 24 (54.5%). The most frequently injured level was T12 (15 cases) followed by, L1 (13), L2 (9), T10 (6), and T11 (1). The mean instrumentation level was 3.5 ± 0.9. ASPs were occurred as 6 of adjacent disc degeneration, 4 of adjacent disc herniation and 5 of spinal stenosis. Age among the demographic factors was the only relevant factor for the occurrence of ASP (P = 0.02). There was no significant difference in sex (P = 0.342), body mass index (P = 0.515), injury level (P = 0.728), kyphotic angle (P = 0.495), pelvic incidence (P = 0.338), sacral slope (P = 0.391), pelvic tilt (P = 0.652), lumbar lordosis (P = 0.107), thoracic kyphosis (P = 0.704), C7 plumb line (P = 0.524) regarding the occurrence of ASP.

**DISCUSSION:** The occurrences of ASPs after thoracolumbar fusion were not affected by fracture kyphosis and spinopelvic parameters. Age was associated with the occurrence of ASP, which may imply that ASP after thoracolumbar fusion result from natural degeneration.

**GP16**

**RELIABILITY OF DISC SIGNAL, AREA AND HEIGHT MEASUREMENTS USING SEMI-AUTOMATED LUMBAR DISC SEGMENTATION ON T2-WEIGHTED MR IMAGES**

Vahid Abdollah MSc 1 Eric C Parent PT PhD 2
Michele Crites Battéi PT PhD 3;
1 PhD Student, Department of Physical Therapy, Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, AB, CA 2
Associate Professor, Department of Physical Therapy, Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, AB, CA 3
Professor & Canada Research Chair in Common Spinal Disorders, Department of Physical Therapy, Faculty of Rehabilitation Medicine,
INTRODUCTION: Disc degeneration (DD) affects disc biochemistry and morphology. Use of semi-automated segmentation to efficiently measure related disc parameters on T2-weighted MR images could aid the study of DD. This study aimed to determine the reliability of disc signal, area and height measurements using such an approach.

METHODS: L4-5 and L5-S1 discs were measured on 44 mid-sagittal images obtained with a 3T MRI scanner in subjects with back pain (43±13yrs). One rater analyzed images twice and another once, while blinded to prior measurements. Users drew two lines tangential to the endplates above and below the disc. Signal variations in the neighboring structures were used to automatically segment each disc into 4 ROIs: whole disc, nucleus, anterior and posterior annulus. For each ROI, mean signal intensity (SI) and area were calculated. Several measurements of disc height were also calculated, including disc area/width, using 60, 80 or 100% of the total disc width, Hurxthal’s, Dabbs’ and Miyakoshi’s methods.

RESULTS: Intra-rater intra-class correlation coefficients (ICC(3,1)) ranged from 0.93-1.00 for SI and area for the whole disc and nucleus; 0.84-0.99 for area-based disc height methods, and was lower for other height methods (0.76-0.96) or for annulus ROIs (0.50-0.76) (Table 1). Inter-rater reliability coefficients (ICC(2,1)) were 0.92-1.0 for the SI and area for the whole disc and nucleus; 0.99 for area-based height methods and; lower, for other height methods (0.84-0.98) and for annulus ROIs (0.33 to 0.58).

DISCUSSION: Using semi-automated segmentation, excellent reliability was found for all parameters in the nucleus and whole disc and for area-based disc heights using less than 100% width. Semi-automated segmentation holds promise for increasing the efficiency, precision and reliability of such disc degeneration assessments.

| GP17 | BIOMECHANICAL ANALYSIS OF A SLIDING PEDICLE SCREW SYSTEM FOR EARLY-ONSET SCOLIOSIS |

Zhihua Ouyang1,2, Rob Tisherman1, Wenjun Wang2, Gwendolyn Sowa1, Kevin Bell1, James D. Kang1;

[1] Ferguson Laboratory for Ortho-pedic and Spine Research, University of Pitts-burgh, Pitts-burgh, PA, 15213, USA [2] Department of spinal surgery, the 1st affiliated hospital of University of South China, Hengyang, 421001, China.

INTRODUCTION: Most current non-fusion surgeries for patients with early-onset scoliosis (EOS) need repeated lengthening surgeries as patients grow. A sliding pedicle screw system (SPSS) was developed to treat spinal deformities without any repeated operative lengthening and has been evaluated in a porcine model and used clinically showing favorable results. However, there are concerns about the stability and the fusion efficacy of the SPSS. Therefore, this study analyzed the stability of SPSS versus conventional instrumentation.
METHODS: Fresh-frozen skeletally mature thoracic sheep specimens (n=3) (T4-L1) were tested under three different conditions: Intact, SPSS(three pairs of conventional fusion screws in the middle segment(T8-T10) and four pairs (T5/6 and T12/13) of sliding screw in the top and bottom for continuous vertical growth) and Fixed(all screws are conventional screws for rigid fusion). The distal-most segments were instrumented with clinical pedicle screws for fixation and manipulation with a six-axis test robot. The specimen was loaded to a pure moment target of 2.5Nm for Flexion/Extension (FE), Left/Right Lateral Bending (LB), and Left/Right Axial Rotation (AR) using a previously developed hybrid control algorithm1 and range of motion (ROM) was recorded.

RESULTS: The mean ranges of motion for the intact spinal specimen were 59.3, 120.7, and 109.0 degrees for FE, LB, and AR respectively. SPSS significantly decreased ROM for FE, LB, and AR by 71.5%, 71.4%, and 64.3% respectively (p<0.001) (Figure 1), and there was no significant difference between the SPSS and the Fixed groups.

DISCUSSION: These preliminary results showed that the SPSS provides mechanical stability similar to conventional instrumentation and so it seems promising for the treatment of EOS patients. Further investigation is needed to confirm our preliminary findings and verify its ability to maintain continuous growth in EOS patients. 1. Bell KM, J. Biomech 2013.
RESULTS: There were 15 levels with a definite fluid sign, 12 with a possible fluid sign, and 35 with no fluid sign. The mean QSI was significantly greater ($p < 0.05$, ANOVA) at levels with a definite fluid sign versus levels without (see figure).

DISCUSSION: There was a statistically significant relationship between radiographically assessed QSI and MRI facet fluid sign. The fluid sign is considered one of the best available indicators of at least one type of instability. Using the fluid sign as the standard, these data help to validate QSI as a quantifiable radiographic metric for instability.

GP19

A 3D NON-INVASIVE MRI-BASED DISC STRAIN TEMPLATE AND INTERNAL VALIDATION OF A FINITE ELEMENT MODEL

Brent L. Showalter (1), John F. DeLucca (2), Daniel H. Cortes (2), Jeffrey T. Duda (1), Jonathon H. Yoder (1), Nathan T. Jacobs (1), Alexander C. Wright (1), James C. Gee (1), Edward J. Vresilovic (3), and Dawn M. Elliott (2);

(1) University of Pennsylvania, (2) University of Delaware, (3) Pennsylvania State University

INTRODUCTION: We recently non-invasively measured internal 3D strains in human intervertebral discs undergoing axial compression. While providing unprecedented insight into disc internal strain, wide variability in strain fields (Fig. 1 Disc 1-4) hindered general analysis. The objective of this study was to generate a 3D average of disc strain, known as a strain template. A secondary objective was to use the template to internally validate strains predicted by a finite element model, an advance not previously achieved in disc modeling.

METHODS: The 3D strain of four human L4-L5 grade 3 discs undergoing 13% axial compression were used to create the template. First, using an optimization algorithm in ANTs, images of the uncompressed discs were used to create an average disc shape, or disc anatomical template. Next, the individual strain tensors were transformed to the template space. The four transformed subject strain tensors were averaged to create a disc strain template.

RESULTS: The disc anatomical template maintained the shape of an intervertebral disc. The first strain invariant, a measure of volume change, demonstrated that the template reduced subject variability while preserving general trends (Figure 1). Axial strain in the disc varied from -17.5 to 2.5%. Radial and Circumferential strains ranged from -3.5 to 8.7% and 0 to 5.9%, respectively. Circumferential, radial, and axial strain components were highest in the posterior and posterolateral regions of the disc. Template strain results were within 1-3% strain of the finite element predictions.

DISCUSSION: The strain template enabled general analysis by suppressing individual variations while highlighting population...
trends. The template permits non-invasive strain measurements in damage-prone regions of the disc, such as the posterolateral region, that previous methods have not captured. In addition, the measured strain was used to internally validate a finite element model for the first time.

**GP20**

DOES THE APPLICATION SITE OF SPINAL MANIPULATION THERAPY ALTER SPINAL TISSUE LOADING?

Martha Funabashi (1), Greg Kawchuk (1), Francois Nougarou (2), Martin Descarreaux (2), Narashima Prasad (1);

(1) University of Alberta, Edmonton, AB, Canada (2) University of Quebec at Trois-Rivieres, Trois-Rivieres, QC, Canada

**INTRODUCTION:** Prior investigations have demonstrated that forces created by spinal manipulative therapy (SMT) are not distributed equally between spinal tissues. As a result, this study was designed to determine if changing the site of SMT application alters loads experienced by spinal tissues.

**METHODS:** In 13 porcine cadavers, a servo-controlled linear actuator provided a standardized postero-anterior 300N SMT to 6 different cutaneous locations on the left side of the lumbar spine: L2/L3 and L3/L4 facet joints (FJ), L3 and L4 transverse processes (TVP), and the space between the FJs and TVPs (BTW). During SMT application, vertebral kinematics were tracked optically using indwelling bone pins. Each motion segment was then removed and mounted in a parallel robot equipped with a 6-axis load cell. The movements of each SMT application at each site were replayed by the robot with the intact specimen and then following serial removal of spinal ligaments, FJs and IVD. Peak loads induced by SMT were recorded and specific axes were analysed using a linear mixed model analysis. This study was approved by the Animal Care and Use Committee of the University of Alberta.

**RESULTS:** The statistical analysis demonstrated a significant difference in relative peak loads as a function of application site (p<0.05). Specifically for forces, the IVD was more sensitive than other spinal tissues when SMT was applied at different sites. Relative peak loads were significantly different when SMT was applied at L4 than at L3 or BTW. Application of SMT at different sites generated significant changes in applied moments in all spinal tissues (p<0.05).

**DISCUSSION:** The results of this work supports the conclusion that vertebral kinematics arising from SMT are influenced by the application site of SMT. This work suggests that specific spinal tissues can be targeted, or avoided, by precise placement of SMT application.

**GP21**

ROLE OF MUSCLE DAMAGE ON LOADING AT THE LEVEL ADJACENT TO A LUMBAR SPINE FUSION – A BIOMECHANICAL ANALYSIS

Masoud Malakoutian 1, John Street 2, Hans-Joachim Wilke 3, Ian Stavness 4, Marcel Dvorak 2, Sidney Fels 5, Thomas Oxland 1,2;

1 Department of Mechanical Engineering, University of British Columbia, Vancouver BC, Canada. 2 Department of Orthopaedics, University of British Columbia, Vancouver BC, Canada. 3 Institute of Orthopaedic Research and Biomechanics, Center of Musculoskeletal Research, University of Ulm, Ulm, Germany. 4 Department of Computer Science, University of Saskatchewan, Saskatoon SK, Canada. 5 Department of Electrical and Computer Engineering, University of British Columbia, Vancouver BC, Canada.

**INTRODUCTION:** Adjacent segment changes to a spinal fusion have been studied using in vitro techniques, but these produce obvious results. Therefore, alternative approaches are needed that
better represent the complexity of the lumbar spine, particularly in situations where the paraspinal muscles are dysfunctional. Musculoskeletal models of the lumbar spine hold promise in this regard, but have not been used to address the effect of muscle damage on adjacent segment loading. The objective of this study was to investigate the effect of muscle damage on post-operative spinal loading at the adjacent levels to a spinal fusion during upright postures by using a recently developed musculoskeletal model of the lumbar spine. METHODS: A musculoskeletal model of the spine was created in ArtiSynth, a biomechanical modelling software toolkit. The model included the entire spine, with the lumbar vertebrae being mobile, and 210 muscle fascicles. The loading at the L1-L2 and L5-S1 were estimated before and after simulated paraspinal muscle damage along the lumbar spine, both with a spinal fusion at L2-L5 and with no spinal fusion (Figure 1).

RESULTS: The axial compressive forces at the adjacent levels increased after simulated muscle damage, with the largest changes being at the rostral level (78% increase in presence of spinal fusion; 73% increase without spinal fusion) compared to the caudal level (41% in presence of fusion and 32% without fusion). Shear forces increased in a similar manner at both the rostral and caudal levels.

DISCUSSION: A musculoskeletal model of the lumbar spine predicted increased compressive forces after muscle damage at the adjacent levels to a spinal fusion. The largest increases were at the rostral adjacent segment compared to the caudal level, and the changes occurred with or without a spinal fusion. This suggests that the paraspinal muscles of the lumbar spine play an important role in the etiology of adjacent segment changes beside a spinal fusion.

GP22
THE ASSOCIATION BETWEEN WHOLE BODY VIBRATION AND SPINE DEGENERATION ON IMAGING – A SYSTEMATIC REVIEW
Luciana Gazzi Macedo Michele C. Battié Tapio Videman;
Common Spinal Disorders Research Group, Faculty of Rehabilitation Medicine, University of Alberta, Canada.

INTRODUCTION: The relationship between whole body vibration (WBV) and spine degeneration has been a topic of study for decades, and related beliefs form the basis of occupational health policies, despite uncertainties regarding supporting evidence. Thus, the objective of this study was to conduct a systematic review of the association of WBV and spine degeneration observed on imaging.

METHODS: Cross-sectional, case-control and cohort studies evaluating occupational loading as the exposure and spine degeneration on imaging as the outcome were systematically reviewed. We followed the Cochrane guidelines using GRADE to summarize the evidence.

RESULTS: The review included 12 original studies; 6 of driving, 1 specifically of tractor drivers, 1 of police officers and machine operators, 1 of train conductors and 3 of flight pilots. Data of only 2 studies evaluating driving and disc degeneration were pooled (n=434) for L2-S1 spine levels. The results demonstrated that drivers had lower disc signal intensity at L3/ only
(pooled OR=0.57; 95%CI 0.35 to 0.93) when compared to non-drivers. All of the other 10 studies did not find significant associations between WBV and lumbar spine degeneration. Given the methodological quality of the studies in the review, and the inconsistency of associations across spinal levels when present, moderate quality evidence suggests that WBV is not associated with greater spine degenerative changes.

**DISCUSSION:** The findings of this review suggest that WBV does not influence spine degeneration. Although the only pooled analysis in this review suggested that WBV was associated with disc degeneration at one spinal level, only 2 studies were included and the pooled OR was small and of questionable clinical significance. More importantly, the results of the other 10 studies support the conclusion that WBV does not have a significant or consistent effect on degeneration, and the occasional positive finding had high likelihood of being a chance finding.

**GP23**

**THE ASSOCIATION BETWEEN OCCUPATIONAL LOADING AND SPINE DEGENERATION ON IMAGING – A SYSTEMATIC REVIEW**

Luciana Gazzi Macedo Michele C. Battié Tapio Videman;
Common Spinal Disorders Research Group, Faculty of Rehabilitation Medicine, University of Alberta, Canada.

**INTRODUCTION:** Heavy occupational physical loading has long been suspected of increasing spine degeneration. However, inconsistencies between studies have led to uncertainty about the relationship. Thus, we conducted a systematic review of the association of occupational loading and spine degeneration observed on imaging.

**METHODS:** Cross-sectional, case-control and cohort studies evaluating occupational loading as the exposure and spine degeneration on imaging as the outcome were systematically reviewed. We followed the Cochrane guidelines, using GRADE to summarize the evidence.

**RESULTS:** The review included 18 original studies and 1 follow-up study. Five of the 7 studies evaluating professional athletes demonstrated that higher levels of physical activity were related to higher levels of spine imaging findings, although often inconsistently related to specific degenerative findings and spinal levels. Of the 13 studies evaluating other occupations, 8 evaluated specific job requirements and 5 compared different types of occupations; in total, 10 supported the effects of loading on some aspect of degeneration. Given the methodological quality of the studies included in the review and the heterogeneity of exposures and outcomes, there is low grade evidence for athletes and moderate grade evidence for other occupations suggesting higher levels of exposure are associated with modestly greater spinal degeneration, although the results were inconsistent.

**DISCUSSION:** Although findings of the association between occupational loading and disc degeneration are largely conflicting, it does seem that activities involving axial rotation have an effect on the spines of athletes over time, but this needs further evaluation. The results also suggest that certain occupations and associated physical loading are associated with greater spine degeneration, although the differences in loading conditions and outcomes between studies make it is difficult to draw specific conclusions.
GP24
SLANTED CENTER CRACKS IN SIMULATED ANNULUS FIBROSUS PRODUCE GREATER STRESS CONCENTRATIONS THAN EDGE CRACKS
John M. Peloquin¹ and Dawn M. Elliott²;
¹University of Pennsylvania, Philadelphia, PA. ²University of Delaware, Newark, DE.

INTRODUCTION: Cracks in the annulus fibrosus form as a part of intervertebral disc degeneration. Cracks are important because they have the potential to alter disc mechanics, facilitate herniation, and agitate nerves in the outer annulus. However, study of crack propagation has been hampered by an inability to reproduce it in ex vivo tissue testing. Prior attempts used uniaxial tension, so we hypothesized that applying biaxial tension or varying the crack angle relative to the collagen fibers may increase the chance of crack propagation. This hypothesis was tested using finite element analysis (FEA).

METHODS: Three loading cases were examined: center crack biaxial (CCB), center crack uniaxial (CCU), and single-edge notch (SENT). Additionally, the angle of the crack (relative to the fibers) was adjusted in 15° increments from 0° to 90°. The applied stretch was 14%, representing in situ loading. The stretch was either parallel to the fibers (CCU and SENT) or equibiaxial (CCB). Greater fiber stress at the crack tip was considered to represent greater risk of crack propagation.

RESULTS AND DISCUSSION: The center-cracked specimens exhibited great sensitivity to fiber angle, with slanted cracks producing much greater crack tip stresses than the standard orientation perpendicular to the fibers (Figure 1a). By comparison, the SENT case exhibited a much smaller increase in stress with slanting of the crack. Slanted cracks rotate and remain sharp in the CCB and CCU cases, but blunt in the SENT case, reducing the stress (Figure 1b). Crack propagation tests using center-cracked specimens with slanted cracks are therefore recommended. By creating a local stress concentration, cracks have the potential to cause overstraining of the annulus fibrosus at otherwise safe organ-scale loads. The combination of numerical tools with experimental crack propagation data is necessary to evaluate these risks for clinically-representative cracks.

GP25
EFFECT OF AXIAL COMPRESSION ON INTERVERTEBRAL DISC TORSIONAL MECHANICS
Semih E. Bezi and Grace D. O’Connell;
Department of Mechanical Engineering, University of California, Berkeley

INTRODUCTION: The primary function of the intervertebral disc is to absorb and transfer large complex loads placed on the spine, including combinations of compression, tension, bending, and torsion. Collagen fibers in the annulus fibrosus are oriented at ±30° to the horizontal plane, suggesting an important role in load distribution during torsional loading. However, there is little data on the torsional mechanical function of the healthy, injured or degenerated disc. The objective of this study was to evaluate the
effect of axial compressive preload on torsional mechanics of healthy discs.

**METHODS:** Motion segments were prepared from bovine caudal spine sections. Axial compression (20 – 750N) was applied, followed by 20 cycles of torsion (±50, 0.5Hz). Torque-rotation data from the final cycle was analyzed. A Pearson’s correlation was performed to determine the effect of axial compression prestress on torsional mechanics.

**RESULTS:** The torque-rotation response was slightly nonlinear (Fig. 1A). There was a strong linear correlation between torsional stiffness, shear modulus, and energy loss per volume with respect to axial compressive load (Fig. 1B-D). Within the physiological range of axial compressive preload (1.0MPa), there was up to a 5-fold increase in torsional mechanical properties.

**DISCUSSION:** Evaluating the combined effect of axial compression with torsion is important for understanding common disc injuries, such as herniations and annular tears. The findings reported here demonstrate a strong correlation between physiological levels of axial compressive prestress and torsional mechanical function of the disc. Future work will evaluate the effect of axial compression prestress on healthy and degenerated human discs. In conclusion, this preliminary data with healthy bovine discs provides a baseline understanding of disc function under axial rotation with applied axial compression, which will be useful for validating finite element models of the disc joint.

**GP26**

**GREATER LUMBAR LORDOSIS IN WOMEN: POSTURAL AND MORPHOLOGICAL SEX-DIFFERENCES OF THE LUMBOSACRAL SPINE**


**INTRODUCTION:** Women have been proposed to have greater lumbar lordosis (LL) than men to aid in bearing a pregnancy load, but support for this theory is equivocal. Some studies report sex-differences while others do not. Quantifying whether or not a relationship between sex and LL exists is a critical step in understanding postural mechanics, advancing patient-oriented treatment, and optimizing surgical correction of postural deficits. We hypothesize 1) that women have greater LL than men, 2) that sex-differences in LL are accentuated when standing, and 3) that sacral orientation in relation to LL also exhibit sex-differences. This study is the first to quantify sex-differences in the in vivo lumbar spine and pelvis in a controlled population.

**METHODS:** We measured sagittal lumbosacral morphology on 200 (retrospective) radiographs (taken in standing or supine posture) from women and men. Measurements included: lumbar angle (L1 to S1 cranial endplates), lumbar vertebral body and disc wedging angles, sacral slope (which is dependent on posture) and pelvic
incidence (which is not dependent on posture).

RESULTS: Lumbar angle, representative of lordotic curvature, was 7.3° greater in women than men when standing. No significant sex-differences in lumbar angle exist when supine. This difference in standing lumbar angle is supported by greater lordotic wedging of the lumbar vertebrae (L1-L5) in women. Sacral slope was greater in women than men when standing, but no significant sex-differences in pelvic incidence were found. This implies that sex-differences in sacral orientation are dependent on posture.

CONCLUSIONS: We found that women have greater LL than men when standing. Sex-differences in the lumbar spine appear to be supported by postural differences in sacralorientation and morphological differences in the vertebral body wedging. Sex-differences in the lumbar spine should be considered when surgical adjustments of LL are made to correct sagittal balance.

GP27

CHANGES IN THE HUMAN LUMBAR SPINE AFTER LONG DURATION SPACEFLIGHT: AN MRI STUDY

Stephanie L Miller (1), Jeannie F Bailey (1,2), Dezba G Coughlin (1), Alan R Hargens (3), Jeffrey C Lotz (1);

(1) Department of Orthopaedic Surgery, University of California San Francisco; (2) Anthropology and Orthopaedics and Sports Medicine, University of Washington Seattle; (3) Department of Orthopaedic Surgery, University of California San Diego

INTRODUCTION: Spaceflight results in moderate to severe lumbar pain, and astronauts experience a 4.3-fold increase in herniation risk upon return to earth. However, it is unclear what precise role long-term spinal unloading plays in the etiology of disc herniation. We hypothesize that spine unloading during spaceflight causes fluid shifts in lumbar discs that lead to degeneration during spaceflight and elevated injury risk upon re-exposure to gravity.

METHODS: 3T MRI scans of three astronaut lumbar spines were obtained before, immediately after, and 30 days after 6-month ISS missions. Lumbar lordosis (L1-S1 cranial endplates), disc wedging angle, average disc height, and disc water content (T2-weighted intensity) were measured at each time point and used to quantify disc morphology and health.

RESULTS: Lumbar lordosis decreased by 12% (p = 0.042) following spaceflight, but each disc did not respond equally. The pre-flight T2 value was a major predictor of disc swelling during microgravity (r = 0.59, p < 0.001; Figure 1). Each disc wedging angle change correlated with its water content change (r = 0.31, p = 0.030). While average disc height did not change (98% of pre-flight height), posterior disc height increased significantly (111% of pre-flight height, p = 0.016).

DISCUSSION: Our results indicate that the extent by which microgravity affects spinal discs is dependent on pre-flight disc quality. Loss of lumbar lordosis likely leads to reduced range of motion in flexion, which may, in turn, lead to increased herniation risk during active flexion under
gravity loading. Understanding how long-duration microgravity adversely affects the spine may help clarify injury risk factors under normal terrestrial conditions.

![Figure 1: Pre-flight water content is a predictor of the extent of disc swelling during spaceflight.](image)

**GP28**

THE EFFECT OF STANDING AND DIFFERENT SITTING POSITIONS ON LUMBAR LORDOSIS: RADIOGRAPHIC STUDY OF 30 HEALTHY VOLUNTEERS

Park Si Young Seung Woo Suh Jae Young Hong; Department of Orthopaedic Surgery Korea University College of Medicine

**INTRODUCTION:** Sitting on a chair is one of the most common positions for humans. Sitting may contribute to flattening of the lumbar curve and an increase in intra-discal pressure. Prolonged sitting is generally accepted as an important risk factor for LBP and it is frequently suggested that a lordotic posture should be maintained in the lumbar spine when sitting. The purpose of this study was to find the ideal sitting position by measuring the changes in lumbar lordosis and pelvic parameters in various sitting positions.

**METHODS:** Thirty healthy volunteers were enrolled in the study. Lateral lumbosacral radiographs were taken in standing and five sitting positions on a chair. Radiographic measurement of lumbar lordosis, segmental angle, and pelvic parameters was performed in each position. Statistical analysis was performed to identify a correlation between changes in the lumbar lordosis and pelvic parameters in each positions.

**RESULTS:** Lumbar lordosis in standing was 48.5° ± 8.7. Sitting significantly decreased lumbar lordosis and segmental angle when compared with standing (p<0.05). The lower lumbar segmental angles (L4-L5 and L5-S1) significantly decreased in all sitting positions (p<0.05), but the decrease was relatively less on the chair with lumbar support and in the 90°-angled chair. The sacral slope decreased and the pelvic tilt increased with decreasing lumbar lordosis in the sitting positions.

**CONCLUSION/DISCUSSION:** Sitting causes a reduction in lumbar lordosis and sacral slope when compared with standing. Theses can cause a spino-pelvic imbalance and may result in chronic LBP. Our study showed that sitting on a chair with back support induced minimal changes to lumbar lordosis. It would be a much more ideal position to sit on a chair with back support than sitting on other types of chairs.

**GP29**

LOW BACK PAIN: A BIOMECHANICAL RATIONALE BASED ON "PATTERNS" OF DISC DEGENERATION

Gregory A. Von Forell, PhD (1); Trevor K. Stephens (1); Dino Samartzis, DSc (2); Anton E. Bowden, PhD (1);

(1) Dept of Mechanical Engineering, Brigham Young University, Provo, UT, USA (2) Dept of Orthopaedics and Traumatology, University of Hong Kong, Pokfulam, Hong Kong, SAR, China

**INTRODUCTION:** Due to the complex etiology of low back pain, it is often difficult to identify the specific factors that contribute to the symptoms of a particular patient. Disc degeneration is associated with the development of low back pain, but its presence is not always synonymous with symptoms. However, studies have suggested that “patterns” of disc degeneration may provide insight into such
pain generation rather than the overall presence of degenerative changes. Specifically, individuals with contiguous multi-level disc degeneration have been shown to exhibit higher presence and severity of low back pain as compared to patients with skipped-level disc degeneration (i.e., healthy discs located in between degenerated discs). The objective of the present work was to determine how patterns of multi-level disc degeneration influence the biomechanical behavior of the lumbar spine.

METHODS: Biomechanical differences between clinically reported patterns of degeneration were analyzed using nonlinear finite element models of the lumbar spine. Thirteen separate patterns were simulated under normal physiological loading conditions in each of the primary modes of spinal motion.

RESULTS: The results showed that stresses and forces of the surrounding ligaments, facets, and pedicles at certain vertebral levels of the spine were generally lower in than skipped-level disc degeneration cases than in the contiguous multi-level disc degenerations cases even when the skipped-level contained more degenerated discs.

DISCUSSION: To our knowledge, this is the first study to illustrate the biomechanics of specific patterns of disc degeneration of the lumbar spine. Utilizing a multi-level disc degeneration model, our study provides insights as to why various patterns of disc degeneration throughout the lumbar spine may affect motion, as well as deformation of soft tissue structures that may have bearing in the clinical pathway of pain generation.

GP30
ANALYSIS OF PSOAS MAJOR ACTIVITY USING FINE-WIRE ELECTROMYOGRAPHY DURING SIT-UP EXERCISES
Hasebe Kiyotaka1,2, Kaneoka Koji1, Okubo Yu3, Matsunaga Naoto1, Toyone Tomoaki4, Paul Hodges5;
(1)Faculty of Sports Science, Waseda University, Saitama, Japan (2)Department of Rehabilitation, Teikyo University Mizonokuchi Hospital, Kanagawa, Japan (3)Faculty of Health and Medical Care, Saitama Medical University, Saitama, Japan (4)Department of Orthopedic Surgery, Teikyo University Mizonokuchi Hospital, Kanagawa, Japan (5) School of Health and Rehabilitation Sciences, University of Queensland, Queens-land, Australia

INTRODUCTION: Sit-up exercises commonly used to strengthen the abdominal muscles. Bent-knee sit-ups are recommended to increase psoas major (PM) activity; however, the PM activity pattern during sit-up exercise is not clear. Therefore, the purpose of this study was to clarify PM activity using fine-wire electrodes during sit-up exercise.

METHODS: Nine healthy men participated in the study. Electromyographic (EMG) signals were measured during the following 4 types of sit-up exercises; sit-up with knee straight and non-fixed feet, sit-up with knee bent and non-fixed feet, sit-up with knee straight and fixed feet, sit-up with knee bent and fixed feet. Fine-wire electrodes were inserted in the right PM, and surface electrodes were attached to the right rectus abdominis, external oblique, internal oblique, and rectus femoris (RF). Each sit-up was divided into 3
phases (early flexion, intermediate flexion, and late flexion) according to the head position. The EMG amplitudes (% of maximum voluntary contraction [%MVC]) for each phase and muscle onset relative to the onset of head movement (0 s) were determined, and evaluated using two-way analysis of variance (p<.05).

RESULTS: The PM activity was significantly greater during intermediate flexion (24.5±5.2 %MVC), and late flexion (24.0±4.6 %MVC) than during early flexion. The RF activity was significantly greater during sit-ups with fixed feet than during sit-ups with non-fixed feet. The onset of PM and RF activities was significantly later than that of the abdominal muscles. Additionally, the onset of PM activity during sit-ups with feet fixed was earlier than that during sit-ups with non-fixed feet.

DISCUSSION: PM activity was significantly greater during intermediate flexion, and late flexion than during early flexion. Juker et al. reported that PM activity was high in the hip deep flexion position. The present study results suggest high activation of the PM during sit-up exercises in the hip flexion position.

INTRODUCTION: Successful fusion of spinal segments requires sufficient stability, which may be challenging for minimal invasive surgical techniques. The new BoneWelding® technology allows the connection of the facet joints by inserting a polymeric implant into a prepared cavity inside a facet joint. By melting the implant’s surface (Turris® Facet Fuser, SpineWelding AG) in situ with an ultrasound tool, the polymer flows into the trabecular structure of the facets. The polymer immediately hardens and “fuses” the facets. The goal of this study was to investigate in vitro and with finite element calculations the primary stability of this immediate “fusion” and to compare it to the gold standard technique with an internal fixator.

METHODS: For the in vitro study, 6 human lumbar segments (3 x L2-3 and 3 x L4-5) with an average age of 70 years were used. The segments were first tested in the following order: intact, with an anterior lumbar cage system (SynCage-LR) stand alone, and stabilized with an additional internal fixator (CD HORIZON® LEGACY™ 5.5 by Medtronic). Then, the fixator was removed and the facets “fused” bilaterally with the new technique (see figure). Pure unconstrained moments (7.5 Nm) in all three anatomical motion-planes were successively applied for each segment condition. The same situations were modelled using a validated, non-linear, three-dimensional FE-model of a human lumbar spinal segment L4-L5 and then compared to the equivalent in vitro tests.

RESULTS: In vitro both the internal fixator and the facet fuser reduced the range of motion (RoM) similarly by nearly 80% in flexion, extension, and in lateral bending; and in axial rotation by 40%. The FE-results indicated that the Turris® Facet Fuser causes a reduction of the RoM by 90% in all directions.

GP31
FACET FUSION WITH THE NEW BONE-WELDING TECHNOLOGY PROVIDES IMMEDIATELY ADEQUATE STABILITY TO AN INTERNAL FIXATOR. IN VITRO AND FINITE ELEMENT STUDIES.
Hans-Joachim Wilke [1], Stefan Midderhoff [1], Benedikt Schlager [1], Patrick Weresch [1], Mario Lehmann [2], Stephanie Göbel [2], Andrea Mueller [2], Ulrich Berlemann [3], Joerg Mayer [2];
DISCUSSION: The Turris® Facet Fusers in combination with a lumbar cage system seem to provide adequate stability compared to the gold standard with an internal fixator with a minimal invasive approach.

GP32
ANALYSIS OF PSOAS MAJOR ACTIVITY DURING ACTIVE STRAIGHT LEG RAISE BY USING FINE-WIRE ELECTROMYOGRAPHY
Yu Okubo(1), Koji Kaneoka(2), Kiyotaka Hasebe(2), Naoto Matsunaga(2), Atsushi Imai(2), Paul Hodges(3);
(1) Faculty of Health and Medical Care, Saitama Medical University, Saitama, Japan (2) Faculty of Sport Sciences, Waseda University, Saitama, Japan (3) The University of Queensland, Australia

INTRODUCTION: Active straight leg raise (ASLR) is commonly used for exercising the hip flexors such as the psoas major (PM) and rectus femoris (RF). However, few studies have reported on the nature of PM activity during ASLR. This study aimed to clarify the activity pattern of the PM during ASLR by using fine-wire electromyography.

METHODS: Nine healthy men participated in this study. Electromyographic (EMG) and motion analysis data were obtained synchronously during ASLR to the maximum flexion angle. Fine-wire electrodes were inserted into the right PM under ultrasound guidance while surface electrodes were attached to the right rectus abdominis, external oblique (EO), internal oblique (IO), and RF. The ASLR was divided into 3 phases (early flexion, intermediate flexion, and late flexion) by using the hip flexion angle. For each muscle, EMG amplitudes (%MVC) in each phase were calculated and evaluated by using the 2-way analysis of variance. Moreover, the timing of muscle onset relative to the onset of hip flexion movement (0 s) were determined and compared for each muscle.

RESULTS: The PM activity gradually increased during the late flexion phase and was significantly greater during both the intermediate (18.1±9.3 %MVC) and late flexion phases (33.0±19.6 %MVC). The timing of the onset of the PM and RF relative to the onset of hip flexion movement were -33±245 ms and -3±119 ms, respectively. This was earlier than that of the EO (267±360 ms) and IO (248±255 ms).

DISCUSSION: Yoshio et al. reported that the PM works physically as an effective hip flexor over the 45° hip flexion angle. Therefore, this study indicates that PM activity is high during the deep flexion position at the hip joint in ASLR. In terms of muscle activity onset, the results show that activity onset of the lower extremity muscles is earlier than that of the abdominal muscles ipsilateral to the elevated leg. The onset of activity in the contralateral muscles should be examined in future studies.

GP33
POROSITY AND THICKNESS OF THE VERTEBRAL ENDPLATE DEPEND ON LOCAL MECHANICAL LOADING
Uraj Zehra MD, Kate Robson-Brown PhD*, Michael A. Adams PhD, Patricia Dolan PhD;
Centre for Comparative and Clinical Anatomy, University of Bristol, Bristol, U.K.
*School of Archaeology and Anthropology, University of Bristol, Bristol, U.K.

INTRODUCTION: Endplate porosity is important for disc metabolite transport, and yet recent research shows that porosity increases with age and disc degeneration. We hypothesise that endplate porosity is largely determined by
mechanical loading from adjacent intervertebral discs, and that disc degeneration depends more on intradiscal stresses than endplate porosity.

**METHODS:** 40 motion segments (T8-9 to L4-5) were dissected from 23 cadavers aged 48-98 yrs. Each was subjected to 1 kN compression, while intradiscal stresses were measured by pulling a pressure transducer along the disc’s mid-sagittal diameter. “Stress profiles” revealed the average pressure in the nucleus, and the maximum stress in the anterior and posterior annulus. Discs, with 5 mm of vertebral body on either side, were then scanned using micro-CT (resolution 35µm) to calculate thickness and porosity in the mid-sagittal region of all 80 endplates. Average values for the anterior, central and posterior regions of each endplate were obtained. Disc degeneration was assessed macroscopically on a scale 0-48.

**RESULTS:** Endplate porosity was inversely related to its thickness, being greatest in the thin central region opposite the nucleus, and least near the periphery (Fig. 1). Superior endplates (relative to the disc) were 14% thicker (P<0.001) and 4% less porous (P=0.008) than inferior. In each of the three endplate regions (anterior, central and posterior), porosity was inversely related to mechanical loading (pressure or maximum stress) in the adjacent disc region (P<0.01 in all cases). Disc degeneration score increased with increasing porosity (R2=0.20, P<0.01) but was most highly correlated with reduced nucleus pressure (R2=0.46, P<0.001) and reduced maximum stress in the anterior annulus (R2=0.31, P<0.001).

**DISCUSSION:** Mechanical loading is a major determinant of endplate thickness and porosity. Disc degeneration is more closely related to reduced disc stresses than to endplate thickness or porosity.

**GP34**

**A METHOD TO DETERMINE THE PELVIC TILT BASED ON ANTEROPOSTERIOR RADIOGRAPHS**

Masatsugu Tsukamoto, Tadatugu Morimoto, Tomohito Yoshihara, Masaru Kitajima, Mitoki Sonohota, Masaaki Mawatari; Department of Orthopedic Surgery, Faculty of Medicine, Saga University, Saga, Japan

**INTRODUCTION:** The pelvic tilt (PT) is an established measure of the position which has been tied to sagittal plane spinal deformities. However, the femoral heads are often poorly visualized on sagittal films. Blondel and Schwab et al. reported the sacro-femoral-pubic angle (SFP angle) as a coronal parameter which can reliably estimate the PT (Blondel Method). Kitajima et al. and Doiguchi et al. also reported simple method to determine the pelvic inclination angle (PIA) based on coronal films (Kitajima Method and Doiguchi Method). The aim of this study was to compare these methods for estimating the PT using films of adults.

**METHODS:** This was a retrospective review of 172 adult patients (36 males and 136 females, mean age of 65 years old) who had undergone hip surgery at our institution. Lateral and anteroposterior (AP) whole spine radiographs were prospectively taken of all patients before surgery. The parameters that were measured were the PT on lateral radiographs and the PIA on AP radiographs. The correlations of the PT and PIA were analyzed using Pearson’s correlation coefficients. An approximate expression to
approximate the PT from the PIA was formed by using the correlations of the PT and PIA (PT by the Blondel Method (B-PT) = 75-SFP angle, by the Kitajima Method (K-PT) = 35-0.7×PIA, by the Doiguchi Method (D-PT) = 0.6×PIA+2). The error of the PT and other parameters (B-PT, K-PT and D-PT) was calculated.

RESULTS: The PT was significantly correlated with the B-PT, K-PT and D-PT (r=0.65, 0.68, 0.73, respectively. p < 0.01 for all comparisons). The error of the PT and B-PT, K-PT and D-PT was 2.3±8.2, -1.2±6.8, -0.9±6.3 degrees, respectively. The error of the PT and B-PT differed significantly from that in the other two groups.

DISCUSSION: When lateral radiographs do not permit the assessment of pelvic parameters, the SFP angle and PIA can serve as valuable alternatives for the evaluation of the PT by using the approximate expression determined in this study.

METHODS: LBP subjects and asymptomatic controls attended 3 sessions over 7 days. On sessions 1 and 2, LBP subjects received SMT (+LBP/+SMT, n = 32) while asymptomatic controls did not (-LBP/-SMT, n = 57). In these sessions, spinal stiffness and multifidus thickness ratios were recorded before and after SMT and on day 7. Apparent diffusion coefficients (ADC) from lumbar discs were measured from +LBP/+SMT subjects before and after SMT on session 1 and from LBP controls who did not receive SMT (+LBP/-SMT, n = 16). +LBP/+SMT subjects were dichotomized as responders/non-responders based on self-reported disability on day 7. Groups were compared by ANCOVAs.

RESULTS: After the first SMT application, SMT-responders displayed significant decreases in spinal stiffness and increases in multifidus thickness ratio sustained over 7 days (p < 0.05); these findings were absent in other groups. Likewise, only SMT-responders displayed significant post-SMT improvement in ADC (p < 0.05).

DISCUSSION: The SMT-responders showed coherent changes between self-reported and objective measures of spinal function. This coherence was absent in asymptomatic or untreated controls. These data imply that SMT impacts biomechanical variables within SMT-responders that are not present in all LBP patients. This work lays a foundation to investigate the heterogeneous nature of LBP, mechanisms underlying distinct therapeutic response and the biomechanical/imaging features defining responders at baseline.

GP35

DO LOW BACK PAIN PARTICIPANTS RECEIVING SPINAL MANIPULATIVE THERAPY DIFFER BIOMECHANICALLY FROM UNTREATED OR ASYMPTOMATIC CONTROLS?
Arnold Wong, Sukhvinder Dhillon, Eric Parent, Narasimha Prasad, Greg Kawchuk; University of Alberta

INTRODUCTION: Some, but not all low back pain (LBP) patients report improved function after spinal manipulative therapy (SMT). Separate studies have shown these subjects display immediate physical changes following SMT compared to non-responders. Currently, the importance of these findings remains uncertain given methodological differences between studies including a lack of controls. This study examined if LBP subjects receiving SMT differed biomechanically from asymptomatic/untreated controls.

GP36

BIOMECHANICAL MECHANISM OF THE FORMATION OF THE INTRAVERTBRAL CLEFTS IN OSTEOPOROTIC VERTEBRAL COMPRESSION FRATURES: A CADAVER STUDY
Chongyan Wang, Fengdong Zhao, Junhui Liu, Shengyun Li, Mevlan Mamut;
INTRODUCTION: Although the ischemic necrosis has been proposed as one cause of the intravertebral clefts (IVC) in osteoporotic vertebral compression fracture (OVCF), the pathomechanism of it remains poorly understood. Biomechanical factor might play an important role in the formation of the IVC, however, to date, there is no related research focusing on it.

METHODS: Ten senile spinal segments T12-L2 confirmed by DEXA were obtained at autopsy from subjects aged around 65 years old and underwent X-ray and CT scans. They were subjected to axial compression firstly to initiate compressive fracture of the L1 vertebral body, during which failure loads, strain information were collected and further X-ray and CT scan were performed to confirm the fracture of L1 vertebral body. Afterward, flexion cyclic loading was performed using a Bionix Test Machine (MTS) with 1500 cycles (5 Hz, 100–600 N). The formation of IVC was confirmed by CT scans, and microfractures in the vertebral body were evaluated by micro CT.

RESULTS: Compared with the initial vertebrae, there existed obvious IVCs in the L1 vertebral body of all the specimens after cyclic loading, and all the IVCs were connected with the basivertebral foramen. The vertebral body height was significantly reduced after flexion cyclic loading, which was in accordance with the loss of basivertebral foramen height. MicroCT revealed that the trabecular bone volume fraction in the basivertebral foramen area is significantly lower than others.

CONCLUSION: The cyclic loading on the OVCF body can exactly induced the formation of the IVC, thus, the biomechanical reason can be inferred from the current test. The severity and clinical relevance of the injuries sustained by the specimens tested in flexion cyclic loading also suggest that fracture initiates in the basivertebral foramen area.

GP37

EFFECT OF BIOACTIVE PEDICLE SCREWS PRODUCED BY CHEMICAL AND HEAT TREATMENTS ON BIOCOMPATIBILITY AND BONE-BONDING ABILITY: SHORT- AND MIDDLE-TERM RESULTS

Koji Akeda1, Tomiharu Matsushita2, Seiji Yamaguchi2, Tadashi Kokubo2, Koichiro Murata1, Norihiko Takegami1, Junichi Yamada1, Akihiko Matsumine1, Atsumasa Uchida1, Akihiro Sudo1;
1. Department of Orthopaedic Surgery, Mie University Graduate School of Medicine. 2. Department of Biomedical Science, College of Life and Health Science, Chubu University

INTRODUCTION: The use of a pedicle screw (PS) system has become increasingly common in spinal surgery; however, significant clinical problems, including the loosening and back-out of PSs, exist. Micromovements between the screw surface and bone tissue can induce activation of osteoclasts, osteolysis and formation of fibrous tissue. Titanium (Ti)-6Al-4V alloy, widely used in spinal instrumentation with a PS system, does not form a chemical bond with bone. We have previously reported that bioactive PSs prepared by chemical and heat treatments form a layer of hydroxyapatite (HA) on the surface of screws in vitro. The purpose of this study was to determine the short and middle term results of bioactive PSs on bone-bonding ability in vivo.

METHODS: PSs (diameter: 2.5 mm; length: 14 mm) were prepared from Ti-6V-4Al alloy
and bio-activated by NaOH-CaCl2-heat-water treatments. Animal study: six 11-month-old female beagle dogs were used; bioactive and control (without bioactivation) PSs were placed from L1 to L6. One and three months after surgery, lumbar spines were removed, followed by biomechanical (torsional screw extraction and pull-out strength) and histological analyses.

**RESULTS:** The mean extraction torque was 1.2 times higher for bioactive PSs compared to controls at one month after surgery, and 1.4 time higher at three months (p<0.05). Histologically, bone tissue was closely attached to the surface of both control and bioactive PSs at one month. However, the ratio of contact area between bone tissue and screw surface was 1.5 times higher in bioactive PSs compared to controls at three months.

**DISCUSSION:** Bioactive PSs prepared by chemical and heat treatments form a layer of HA on the surface of screws in vitro and increase biocompatibility and bonding ability with bone in vivo at one and three months after PS insertion. Further long-term studies are needed to determine the effectiveness of bioactive PSs.

**GP38**

**THE EFFECT FOR THE NEUROPATHIC PAIN OF SEROTONIN NORADRENALINE REUPTAKE INHIBITORS (SNRIS) BY NUCLEUS PULPOSUS APPLIED ON THE NERVE ROOT IN RATS**

Junichi Handa, MD, Miho Sekiguchi, MD, PhD, and Shin-ichi Konno, MD, PhD;
Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine, Fukushima, Japan

**INTRODUCTION:** Some antidepressants are used for treating neuropathic pain. Several studies investigated the effect of serotonin noradrenaline reuptake inhibitors (SNRI) for neuropathic pain, and those that did were interested in diabetic neuropathy, as opposed to other causes of neuropathic pain such as radiculopathy from disc herniation. The aim of this study was to investigate the effect of SNRI on pain-related behavior in a rat model of neuropathic pain.

**METHOD:** A total of 267 rats were divided into two surgical groups: nucleus pulposus (NP) application group (NP group) and the sham-operated group (sham group). NP group was then divided into three subgroups: NP + S (saline), NP + DL (low-dose duloxetine), and NP + DH (high-dose duloxetine). Behavior tests were carried out on days 0, 2, 7, 14, 21, and 28. Immunohistochemical examinations were performed on post-operative days 7, 21, and 28. Tumor necrosis factor alpha (TNF), nerve growth factor (NGF), brain-derived neurotrophic factor (BDNF), glial fibrillary acidic protein (GFAP), and ionized calcium-binding adapter molecule 1 (Iba1) antibodies were used. Immunoblotting examinations for TNF, NGF, and BDNF were performed on post-operative days 14, 21, and 28.

**RESULTS:** The NP + DH and NP +DL subgroups had improved pain threshold 21 days after surgery, whereas the NP + S subgroup did not (p<0.05). The NP + DH subgroup observed a low TNF expression level in the DRG 28 days after surgery (p<0.05). In the NP + S sub-group, the expression of Iba1 in microglia was observed in the spinal cord (SC). In the NP + DH and NP + DL subgroups, the expression changes of NGF were significantly lower (p<0.05), and BDNF tended to be low compared to the NP + S rats 21 days after surgery.

**DISCUSSION:** Duloxetine improved pain-related behavior using a rat model for neuropathic pain. SNRIs may prove efficacious for the treatment of clinical neuropathic pain.
GP39

LUMBAR SEGMENTAL INSTABILITY IS NOT NECESSARILY RELATED TO DISC DEGENERATION ALONE
Kazuhiro Hasegawa, Ko Kitahara, Haruka Shimoda, Keiji Ishii, Masatoshi Ono, Takao Hamma; Niigata Spine Surgery Center, Niigata, Japan

INTRODUCTION: Disc degeneration is generally considered a main cause of low back pain in conjunction with segmental instability (inst). The biomechanical evidence is, however, sparse. The purpose of this study is to clarify a relationship between disc degeneration and inst using an original intraoperative measurement system (IOM).

METHODS: 109 discs with symptomatic degenerative disc diseases (mean age 66.3y, 27y~84y, M/F=56/53) and 8 asymptomatic discs with Pfirrmann classification (P-class) 1 or 2 (mean age 42.8y, 27y~69y, M/F=5/3) were enrolled. IOM is the first clinically available system which performs a cyclic flexion-extension displacement of the segment and can determine neutral zone (NZ, [mm/N]). Inst was defined as a segment with NZ>2mm (JBJS2011), and 109 patients were divided into two groups, inst+ and inst-. SF-36 physical function (SF-36) and VAS of low back pain (VAS) were compared between the two groups. For all the 117 discs, relationships between NZ and the segmental range of motion (ROM)/disc height (DH) were analyzed. NZ was also compared among P-class, Modic type, and axial CT findings (facet type and facet opening) using one-way ANOVA.

RESULTS: SF-36 in inst- was significantly higher than that in inst+ (p<0.05), while VAS in inst- was lower than that in inst+ (p<0.05). There was no significant relationship between NZ and ROM or DH. There was neither significant difference in NZ among P-class and Modic type. On the other hand, regarding facet type, NZ in wrapped type was significantly lower than the other types (p<0.05), and the segment with facet opening had a tendency of higher NZ than that without facet opening (p=0.058).

DISCUSSION: The present study showed that the grade of disc degeneration did not correspond to inst represented by NZ, suggesting that lumbar segmental instability is not necessarily related to disc degeneration alone but to multifactors including facet joint pathology.

GP40

THE INFLUENCE OF FACET JOINT ORIENTATION AND FACET TROPISM ON THE STRESS AT THE ADJACENT SEGMENT AFTER LUMBAR FUSION SURGERY: A BIO-MECHANICAL ANALYSIS
JH Park, MD, Ho-Joong Kim, MDa, Kyung-Tak Kang, MSb, Ju-Hyun Son, MSb, Choon-Ki Lee, MDC, Bong-Soon Chang, MDC, Jin S. Yeom, MDa;
Hallym University Kang-dong Sacred Heart Hospital, Seoul, Korea, Spine Center and Department of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Bundang Hospital, 166 Gumiro, Bundang-gu, Sungnam, , Republic of Korea bDepartment of Mechanical Engineering, Yonsei University, 134 Shinchon-dong, Seodaemun-gu, Seoul, Republic of Korea cDepartment of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Hospital, 101 Dae-hangno, Jongno-gu, Seoul, 1, Republic of Korea
INTRODUCTION: Facet joint orientation and facet tropism influence the biomechanics of the corresponding segment. Therefore, the sagittal orientation or tropism of the facet joint adjacent to the fusion segment seems a potential risk factor for ASD. However, there have been no biomechanical studies regarding this issue. Therefore, the purpose of this study was to investigate the association between adjacent facet orientation and facet tropism and stress in adjacent disc/facet joints using finite element analysis.

METHODS: Four intact (F50-, F55-, F60, and FT-intact) and matched L3-L4 fusion (F50, F55-, F60, and FT-fusion) models with different facet joint orientation (50°, 55°, 60° relative to the coronal plane, and facet tropism, respectively) at both L2–L3 facet joints were simulated. F55 intact model was validated in the previous study. In each model, intradiscal pressures and facet contact force at the L2–L3 segment were investigated under pure moments and anterior shear force.

RESULTS: Compared to the matched-intact model, the F60-fusion model yielded the highest and largest percentage increase of intradiscal pressure at the L2-3 segment under flexion, torsion moment, and anterior shear force among the F50-, F55-, and F60-fusion models (Figure). F60-fusion model also demonstrated the largest facet contact force under torsion moment among the F50-, F55-, and F60-fusion models. In all conditions tested, the FT- fusion model demonstrated the highest intradiscal pressure and facet contact force of all the models (Figure).

DISCUSSION: Facet joint orientation and tropism at the adjacent segment influences the overstress of the adjacent segment, especially under the clinical circumstance of increased anterior shear force.

GP41
SHIFT OF THE PEDICLE SCREW IN THE VERTEBRA ACCOMPANIED WITH CHANGE IN THE DISC ANGLE FOLLOWING INSTRUMENTED FACET FUSION FOR DEGENERATIVE LUMBAR SPONDYLOLISTHESIS
Tomohiro Miyashita 1) Hiromi Ataka 2) Kei Kato 1) Takaaki Tanno 2); 1) Spine Center, Matsudo City Hospital 2) Spine Center, Matsudo Orthopaedic Hospital

INTRODUCTION: Based on a long-term follow-up study of facet fusion (FF) for degenerative lumbar spondylolisthesis (DLS), we reported that FF is a minimally invasive and suitable method for DLS. However, the disc angle at the fused level, which became lordotic immediately after surgery owing to the prone operative position, decreased gradually within 6 months to almost the same as that in the preoperative neutral position. We assessed the shift of the pedicle screws (PS) in the vertebra to identify the mechanism of the change in the disc angle.

METHODS: Twenty-nine patients who underwent FF for single-level DLS and CT immediately after surgery and 6 months later were retrospectively reviewed. From these, 9 patients, in whom the disc angle had decreased by more than 4° after surgery to the same as that in the preoperative neutral position, were selected to capture the shift of the PS. The patients in whom CT showed PS loosening and/or pseudoarthrosis were excluded. We reconstructed a CT plane, which was vertical to the cranial endplate of the vertebra in which the PS was inserted and passed through a cannula of percutaneous PS. We
measured the angle between the cranial endplate and the cannula on the plane.

RESULTS: Of 18 PSs, the angle of only 2 changed by more than 2° in the upper vertebra of the fused level. The tip of the shifting PS moved cranially. However, in the lower vertebra, the angle of 11 out of 18 PSs changed by 2-6°, and the tip of all these PSs shifted caudally.

DISCUSSION: The change in the disc angle after FF is thought to be caused by the PS shifting in the vertebra without loosening and by remodeling of the bone around it according to the biomechanical load. In other words, the PS itself is limited in its ability to maintain a lordotic disc angle, and even with the insertion of a cage, lumbar alignment would return to the preoperative neutral position owing to sinking of the cage. We conclude that in situ fusion is a rational approach for DLS.

GP42

SACROILIAC JOINT IMPLANT PLACEMENT AND ORIENTATION AFFECT INITIAL JOINT STABILITY: AN IN VITRO BIOMECHANICAL STUDY

Hector Soriano-Baron, MD †, Derek P. Lindsey, MS *, Nestor Rodriguez-Martinez, MD †, Phillip Reyes, BSE †, Anna Newcomb, MS †, Scott A. Yerby, PhD *, Neil Crawford, PhD †;
† - Barrow Neurological Institute, Phoenix, AZ, * - SI-BONE, Inc., San Jose, CA

INTRODUCTION: Minimally invasive fusion is one treatment for patients suffering from pain resulting from sacroiliac (SI) joint disorders. Pelvic trauma fixation studies showed that both placement and orientation of hardware within the sacrum affect fixation strength. This study investigated the biomechanical effects of two implant placement techniques for SI joint fusion.

METHODS: Seven cadaveric specimens (L4-pelvis) were tested using pure moment loading of 7.5N.m. Flexion-extension, lateral bending, and axial rotation SI joint ranges of motion (ROM) were measured using an optoelectronic system for three conditions: intact, cut pubic symphysis, and treated. After intact testing, the pubic symphysis was cut to allow independent motion of the SI joints. Three implants (iFuse Implant System®; SI-BONE) were laterally placed using the posterior or trans-articular techniques (Figure 1). The posterior technique placed the implants parallel and ventral to the posterior wall of the sacral body; inline on the inlet view, and parallel on the outlet view. The trans-articular technique positioned the middle implant such that it crossed the hyaline cartilage. The reductions in SI motion (%) were compared to 0 using a one-sample t-test. Paired t-tests were used to compare the techniques. P-values <.05 were considered significant.

RESULTS: Posterior placement significantly reduced mean ROM in flexion-extension (27%), lateral bending (28%), and axial rotation (32%). Trans-articular placement significantly reduced the mean ROM in flexion-extension (41%), lateral bending (36%), and axial rotation (36%). No differences were detected between the posterior and trans-articular techniques.

DISCUSSION: Posterior and trans-articular placement of SI joint fusion implants significantly reduced the flexion-extension, lateral bending, and axial rotation ROMs. Within the safe zones of the sacrum, a surgeon has flexibility regarding the placement of implants for minimally invasive SI joint fusion.

GP43

SACROILIAC JOINT FUSION MINIMALLY AFFECTS LUMBAR SEGMENT MOTION: A FINITE ELEMENT ANALYSIS

Derek P. Lindsey, M.S. *, Ali Klapour, Ph.D. †, Scott A. Yerby, Ph.D. *, Vijay Goel, Ph.D. †; * - SI-BONE, Inc., San Jose, CA; † - E-CORE, Toledo, OH
INTRODUCTION: The pain generators for low back pain include the lumbar spine, hips, and sacroiliac (SI) joints. One treatment is arthrodesis to stiffen the motion segment to relieve the pain. Rigid lumbar fixation has been shown to increase biomechanical stresses at the adjacent levels. The use of rigid fixation for SI joint fusion may alter the biomechanical stresses of the adjacent lumbar segments, although the magnitude and potential consequences are currently unknown. This finite element study investigated the impact of SI joint fusion on both the SI joint and the adjacent lumbar segment ranges of motion (ROM).

METHODS: An experimentally validated model (L1-pelvis) was used to investigate the effects of SI joint fusion. Loading of the intact condition was simulated using a 400N follower load with 10N-m moment. Flexion-extension, lateral bending, and axial rotation ROMs were calculated for the SI joint and each lumbar motion segment. Three SI joint implants (iFuse Implant®; SI-BONE) were placed in the model; the bone/implant interface was modeled to simulate a press fit interface. The treated ROMs were calculated with a 400N follower load and equivalent intact model rotation (hybrid protocol). The changes from intact to treated condition were compared with previous lumbar arthrodesis studies.

RESULTS: Placement of the fusion devices reduced the SI joint ROM in flexion-extension (54%), lateral bending (25%), and axial rotation (50%). The ROM at the adjacent level (L5-S1) increased in flexion-extension (3%), lateral bending (1%), and axial rotation (4%).

DISCUSSION: Fusion reduced the SI joint ROM in flexion-extension, lateral bending, and axial rotation, consistent with a previous cadaveric experiment. Adjacent segment ROMs were minimally increased when compared with lumbar fusion studies that report adjacent segment increases of 20-136%. Minimal increase in ROM of the adjacent lumbar levels suggest that SI joint fusion will not be deleterious to those levels.

GP44
A GAIT ANALYSIS IN PATIENTS WITH ADULT SPINAL DEFORMITY USING A TREADMILL
Keiji Ishii, Kazuhiro Hasegawa, Haruka Shimoda, Masatoshi Ono, Takao Honma; Niigata Spine Surgery Center

INTRODUCTION: A treatment plan for adult spinal deformity (ASD) is based on X-ray evaluation. The static evaluation, however, seems not enough for the purpose and a dynamic evaluation is necessary. The purpose of this study is to analyze gait of ASD cases and compare a relation between static alignments and dynamic parameters.

METHODS: Seventeen cases with ASD (male4, female13, 50-85 year-old) (Group A) were prospectively investigated and compared with five healthy cases (Group N). Their overground and treadmill gait was analyzed and compared using video camera and software. Sagittal spinopelvic alignments (Thoracic Kyphosis, Lumbar Lordosis, Sacral Slope, Pelvic Tilt, Pelvic
Incidence, T1-SPI and SVA), gait parameters (walking velocity, stride length, cadence and double supporting period) and alignments during gait (C7-SPI, hip flexion angle and knee flexion angle) were measured. C7-SPI was defined as the angle between the vertical plumb line and the line drawn from C7 to greater trochanter.

RESULTS: In both groups, walking velocity and stride length of treadmill gait were lower than those of over ground gait with a predominant difference in Group A. C7-SPI did not necessary correspond to radiographic indicators of anterior trunk inclination. There was no regular pattern in hip or knee angle in Group A. Eleven of Group A were unable to contact by heel at the time of initial contact in treadmill walking.

DISCUSSIONS: ASD cases appear to adjust their alignment by regulating posture in gait and the pattern as well as compensating by pelvis and lower limb, suggesting that conventional X-ray evaluation alone is not enough for evaluating spinal balance.

METHODS: We evaluated 12 patients with L4 spondylolisthesis (average age 57.2 years) who underwent stand-alone anterior interbody fusion (fusion group). MRI was performed 10 years after surgery. Patients with low back pain and without lumbar spinal stenosis were used as age matched controls. Cross-sectional area (CSA) of the dural sac (DS) and LF from L1-2 to L5-S1 calculated by PACS were evaluated and compared.

RESULTS: Spinal fusion with correction loss (average, 4.75 mm anterior slip) was achieved in all patients 10 years after surgery. Average CSAs of the DS and LF from L1-2 to L5-S1 were not significantly different between control and fusion groups (DS, control: 172 mm2, fusion: 150 mm2, LF, control: 95 mm2, fusion: 78 mm2) (P > 0.05). Average CSA of the LF was not significantly different at each level from L1-2 to L5-S1 in the control group (P > 0.05). However, average CSA of the LF in L4-5 fusion level (30 mm2) was significantly less compared with levels L1-2 to L3-4 and L5-S1 in the fusion group (P < 0.05). Although patients had 4.75 mm anterior slip, average CSA of the DS in the L4-5 fusion level in fusion group was not significantly different from other levels in either group (P > 0.05).

DISCUSSION: The LF is considered thickened by age and instability. In the current study, stability induced a reversible change of the LF and sustained remodeling of the spinal canal. This finding may explain the pain relief found after indirect decompression fusion with correction loss.

INTRODUCTION: One reason for compression of the spinal nerve in patients with lumbar degenerative spondylolisthesis is the thickness and flexure of the ligamentum flavum (LF). Anterior fusion without direct posterior decompression, so called “indirect decompression” is considered to restore disc height and stretch the flexure of LF, and as a result, the spinal canal diameter increases. The aim of this study was to determine if there is a change in LF thickness after anterior fusion.

DISCUSSION: The LF is considered thickened by age and instability. In the current study, stability induced a reversible change of the LF and sustained remodeling of the spinal canal. This finding may explain the pain relief found after indirect decompression fusion with correction loss.

GP45

REVERSIBLE CHANGE OF LUMBAR LIGAMENTUM FLAVUM
Department of Orthopaedic Surgery, Graduate School of Medicine, Chiba University, Japan

GP46

IS WORSENING OF BACK PAIN AT FLEXION A SYMPTOM OF DISCOGENIC LOW BACK PAIN?
INTRODUCTION: Many textbooks report that worsening of back pain at flexion on physical examination is a symptom of discogenic low back pain (DLBP). However, the validity of this symptom is unclear if patients are limited to true DLBP. We aimed to evaluate the validity of worsening of back pain at flexion as a symptom of DLBP in selected patients.

METHODS: A total of 127 patients with LBP alone and no accompanying radicular pain were investigated. Patients had only one or two levels of disc degeneration on MRI. When pain was provoked during discography, we performed anterior interbody fusion surgery for patients in whom conservative therapy was not effective (87 patients, average age 42.1 years). VAS and a questionnaire regarding symptoms including worsening of pain at standing, sitting, flexion, and extension were conducted before surgery. We followed up 77 patients (average follow-up, 8.5 years). Selected DLBP was diagnosed when patients experienced more than 70% pain relief (VAS) after surgery; we retrospectively evaluated symptoms before surgery in these patients.

RESULTS: Average VAS score and RDQ were significantly improved after surgery (P < 0.05). Sixty-three patients (82%) showed pain relief after surgery (>=70% pain relief), but 14 patients (18%) did not (< 70% pain relief). Thus, we defined the 63 patients as selected DLBP patients. Back pain was present at all times in 90% of patients, worsening of back pain at standing in 30%, at sitting in 70%, at flexion in 65%, and at extension in 35% of patients.

DISCUSSION: If DLBP is diagnosed strictly based on MRI, discography results, and surgical results, 65% of patients showed worsening of back pain at flexion. However, 35% of patients showed worsening of back pain at extension. We recommend taking this symptom into consideration at physical examination of patients with DLBP.

GP47
’SURPRISE’ LOADING IN FLEXION INCREASES THE RISK OF DISC HERNIATION DUE TO ANNULUS-ENDPLATE JUNCTION failure: A MECHANICAL AND MICRO-STRUCTURAL INVESTIGATION
Kelly R. Wade, Peter A. Robertson, Ashvin Thambyah, Neil D. Broom; Experimental Tissue Mechanics Laboratory, Department of Chemical and Materials Engineering, University of Auckland, New Zealand. Department of Orthopaedic Surgery, Auckland City Hospital, New Zealand.

INTRODUCTION: Clinical evidence indicates the involvement of the endplate in herniation. It is known that both an elevated rate of compression and a flexed posture are necessary to cause disc failure either within the mid-span of the annulus or at the annular-endplate interface. However, the question of what effect sudden or surprise loading might have on the mode of failure is, as yet, unanswered. Therefore, the objective of this study was to provide a microstructural analysis of the mechanisms of annular wall failure in healthy discs subjected to flexion and a rate of compression comparable to the maximum rate at which the muscles of the spinal column can generate a force.

METHODS: 24 healthy mature ovine lumbar motion segments were compressed to failure in high physiological flexion (10 degrees). This occurred over approximately 5mm of crosshead displacement in 0.75s which resulted in a displacement rate of 400mm/min (defined as a surprise rate) and was intended to simulate the maximum rate at which the muscles of the spinal column can generate a force. The damaged discs were then analysed microstructurally.
RESULTS: 58% of discs suffered annular-endplate junction rupture, 25% suffered mid-span annular rupture, and the balance of 17% endplate fracture. Micro-structural analysis indicated that annular rupture initiated at the endplate apical ridge in the mid-to-outer region of the annulus in both annular-endplate and mid-span annulus rupture.

CONCLUSION: Motion segments subjected to a surprise loading rate are likely to fail via some form of annular rupture. Failure under such sudden loading occurs mostly via rupture of the annular-endplate junction and is thought to arise from a rate-induced mechano-structural imbalance between the annulus and endplate.

GP48
DEVELOPING METHODS OF IN VIVO MRI MEASUREMENT OF SPINAL CORD DISPLACEMENT IN THE THORACOLUMBAR REGION OF ASYMPTOMATIC SUBJECTS WITH UNILATERAL AND BILATERAL STRAIGHT LEG RAISE TESTS
Rade M.1,2, Shacklock M.3, Könönen M.4 Vanninen R.4, Marttila J.4, Kankaanpää M.5, Airaksinen O.1;
1. Kuopio University Hospital, Department of Physical and Rehabilitation Medicine, Kuopio, Finland 2. Prim. Dr. Martin Horvat Orthopaedic and Rehabilitation Hospital, Rovinj, Croatia. 3. Neurodynamic Solutions, Adelaide, Australia 4. Kuopio University Hospital, Department of Radiology, Kuopio, Finland. 5. Tampere University Hospital, Department of Physical and Rehabilitation Medicine, Tampere, Finland.

INTRODUCTION: Conus medullaris displacement with unilateral and bilateral Straight Leg Raise test (SLR) has previously been presented and the “principle of linear dependence” linking magnitude of conus medullaris displacement to displacement of L5 and S1 nerve roots and number of nerve roots involved into the movement has been proposed. However, in those studies, due to the device architecture, only 50° of hip flexion could be achieved. In this controlled radiologic study we aimed to verify i) whether conus medullaris displacement varies with greater range of hip flexion ii) if the acquired data support the “principle of linear dependence”, iii) present methodological advances relevant to this line of research.

METHODS: Ten asymptomatic volunteers were scanned with a 1.5T magnetic resonance (MR) scanner using a device that permits greater ranges of SLR and different scanning sequences for planning (T2 weighted turbo spin echo sequence) and for measurement purposes (T2 weighted spc 3D-sequence). The 3D scanning sequence allowed for ad-hoc reconstruction of 1mm thick axial, coronal and sagittal slices.

RESULTS: Pearson’s correlations were higher than 0.99 for both intra- and inter-observer reliability and the observed power was 1 for each tested maneuver. The conus displaced caudally in the spinal canal by 3.54±0.87 mm (µ±SD) with unilateral (p ≤0.001) and 7.42±2.09 mm with bilateral SLR (p ≤0.001).

DISCUSSION: Conus displacement increased with hip flexion angle, while maintaining the relationship between magnitude of conus displacement and number of nerve roots involved into the movement, supporting the “principle of linear dependence” presented earlier. Moreover, the use of T2 weighted spc 3D-sequence allowed for better identification of conus medullaris which reflected in higher values of intra and inter observer reliability testing with relevant increase in the clinical feasibility of the proposed methods.

GP49
DO THE SPINOPELVIC PARAMETERS AFFECT THE ADJACENT SEGMENT PATHOLOGY AFTER LUMBAR FUSION?
Chang-Hoon Jeon, Nam-Su Chung, Han-Dong Lee, Ji-Sang Youn;
INTRODUCTION: The sagittal orientation of spine and the spinopelvic parameters are closely associated each other and recognized to be an important biomechanical factor in the pathogenesis of spinal degeneration. Many studies found significant correlations between spinopelvic malalignment and lumbar degenerative disorders. The aim of this study was to investigate that the adjacent segment pathology (ASP) is associated with spinopelvic parameters.

METHODS: Seventy-five patients who had undergone spinal fusion (ALIF 38, PLF 37) for lumbar degenerative diseases and had taken MRI at the time of index treatment and at least 5-year follow-up were included. The control cohort involved 66 patients with non-fusion (decompression 28, conservative treatment 38). ASP was evaluated using preoperative and follow-up MRI. Spinopelvic parameters and sagittal balance were measured using lateral radiographs of the whole spine in standing position. The association of ASP and spinopelvic parameters was analyzed.

RESULTS: The mean age was 51.9 ±14.6 years and the number of male patients was 31 (41.3%). The mean MRI follow-up duration was 90.5 ± 29.1 months (range, 60~164 months). The occurrence of ASP was 24% in the fusion group and 19% in the non-fusion group (P = 0.692). There was no significant difference in pelvic incidence (P = 0.619), sacral slope (P = 0.560), pelvic tilt (P = 0.521), lumbar lordosis (P = 0.597), thoracic kyphosis (P = 0.453), and C7 plumb line (P = 0.521) regarding the occurrence of ASP in the fusion group. There was also no significant difference in all spinopelvic parameters regarding the occurrence of ASP in the non-fusion group.

DISCUSSION: While many studies found significant correlations between spino-pelvic parameters and lumbar degenerative disorders, there was no correlation between ASP and pelvic parameters in lumbar fusion for degenerative disc diseases.

GP50
ANNULUS FIBROSUS TENSILE PROPERTIES: BIOMECHANICAL CONSEQUENCES DUE TO AGE AND THE IMPLICATIONS FOR INJURY
Diane E. Gregory, Danielle M. Stewart, Lauren A. Monaco;
Wilfrid Laurier University Waterloo, Ontario, Canada

INTRODUCTION: Changes in cell type, cell viability, hydration, nuclear pressure, annulus fibrosus (AF) layer buckling, disc bulging and AF stress concentrations have all been shown to occur in the aging intervertebral disc (IVD). The aim of this study was to compare the IVD water content and the tensile properties of single lamellae of young (<12 months) and adult (2-7 years) ovine IVDs.

METHODS: One lumbar IVD was excised from each of eight adult and five young ovine spines. From each IVD, a maximum of four single AF lamellae were harvested (two anterior; two posterior). Tissues were mounted in a tensile testing apparatus (Biotester 5000; Cellscale, Waterloo, ON, Canada) such that the intralamellar matrix was isolated. Following a 10mN preconditioning period, tissues were pulled until failure at a rate of 2 %/sec. An additional lumbar IVD from excised from each of five young and five adult ovine spines and was incubated at 65°C for 24 hrs. Water content was determined by comparing the IVD wet weight to the IVD dry weight following incubation. The effect of age (young versus adult) was statistically examined for each tensile property and IVD hydration.

RESULTS: No differences in either toe-region (p=0.13) or failure strain (p=0.41)
were observed between the two age groups. However, young samples reached higher stress values at the end of the toe-region (p=0.002) and higher stress values at failure (p=0.001) when compared to the adult samples. Young samples were also stiffer compared to the adult samples (p=0.007). No difference in water content was observed between the young and adult IVDs (p=0.56).

**DISCUSSION:** This study was the first to show that the intralamellar matrix of single AF lamellae is weaker and more compliant in an adult ovine group compared to a young group. These changes do not appear to be a result of differences in IVD hydration but more likely due to the other remarkable age-related changes that occur that ultimately weaken the IVD as a whole.

**GP51**

**REGULATION OF THE MAPK/ERK SIGNALING PATHWAYS OF THE OXYGEN CONDITION IN THE INTERVERTEBRAL DISC CELL**

Young-Mi Kang 1, 2, Ji-Hye Kim 2, Jae-Ho Yang2, Sun-Young Kim2, Kyung-Soo Suk2, Hak-Sun Kim2, Hwan-Mo Lee 2, Seong-Hwan Moon 1, 2, *;

1BK21 Medical science Graduated School, College of Medicine, Yonsei University, Seoul, Korea 2Department of Orthopaedic Surgery, College of Medicine, Yonsei University, Seoul, Korea

**INTRODUCTION:** The nucleus pulposus, core part of intervertebral disc (IVD) is an avascular and hypoxic tissue in which IVD metabolism maintains. GLUT-1 expression is also stimulated in a variety of cells under hypoxic condition, a response that is mediated by the transcription factor HIF-1α. Among various phenotypes, type II collagen and glucose transporter-1(GLUT-1) proved to be phenotypical signature of nucleus pulposus. Simulated conditions with various lower oxygen concentrations might reveal valuable information regarding IVD matrix metabolism. Therefore, the objective of this study is to evaluate behavior of IVD cells such as matrix gene expressions under various hypoxic conditions.

**MATERIALS AND METHODS:** Human disc tissues were collected during surgery from patients (age range 45-59 years) with degenerative lumbar conditions and cultured. The IVD cells were seeded at a cell density of 70 cells cm-1 for protein and RNA isolation in hypoxia condition (1% O2; 6% O2; deferoxamine 1mM; deferoxamine 10mM; deferoxamine 100mM with 5% CO2, 37 ºC) and normoxic condition (21% O2, 5% CO2, 37 ºC). phospho-MEK1/2, phospho-ERK1/2, phospho-P90RSK, and phospho-c-Raf expression were confirmed by western blot.

**RESULTS AND DISCUSSION:** The protein expressions of phospho-ERK1/2, phospho-MEK1/2, and phosphor-c-Raf increased in 6 percent oxygen, 1mM, and 10mM deferoxamine concentration as comparing with normoxic condition. However, there is no significant difference in the protein expression of phosphor-P90RSK among groups. Hypoxic condition in the IVD cells stimulated ERK/MAPK signaling pathways. Our data demonstrated that hypoxic condition regulates metabolism in the IVD cells. Hence hypoxic condition renders phenotypical maturation in IVD cells, which provided important mechanism for disc tissue engineering in hypoxia. Also, this study suggests that the oxygen concentration can be important for the IVD cell metabolism although further work is required to confirm this observation.

**GP52**

**CO-LOCALIZATION OF NUCLEUS PULPOSUS CELLS AND BONE MARROW CELLS TRIGGERS AN INNATE IMMUNE RESPONSE IN VITRO**

Lu B, Dudli S, Lotz JC;

Department of Orthopaedic Surgery
University of California San Francisco
INTRODUCTION: Autoimmune response to nucleus pulposus cells (NPCs) may enhance pathologic conditions in intervertebral disc degeneration, disc herniation and vertebral bone marrow lesions. However, there is still uncertainty how the immune response is triggered and which cell types are involved.

METHODS: NPCs were extracted from adult rat tails. Mononuclear cells (MNCs) were isolated from rat femoral and tibial bone marrow. Autologous NPCs and MNCs were co-cultured or cultured alone. Gene expression of IL1A, IL2, IL4, IL6, IL10, IL12A, IL17a, CFS2, MMP-13, and TNFA were quantified. Pooled RNA from the NPC and MNC single culture served as control. Flow cytometric analysis of intracellular TNF-a, the protein product of TNFA, was performed to identify the cell type expressing TNF-a.

RESULTS: Compared to control, co-cultured NPCs and MNCs (ratio=1:2) expressed more than 50-fold IL1A (Figure 1A), 2-fold TNFA (Figure 1B), and 7-fold IL10. There was no change in the expression of IL6, IL12A, CFS2 and MMP13, while IL2, IL4, and IL17a were not expressed at all. Intra-cellular TNF staining revealed that both NPCs (Figure 1C) and MNCs (Figure 1D) have increased TNF-a expression in co-culture.

DISCUSSION: Lack of IL2, IL4, and IL17A gene expression indicates that lymphocytes were not activated in co-culture. Rather, up-regulation of IL1A, TNFA, and IL10 suggests activated macrophages, either via the classical (IL1A, TNFA) or alternative pathway (IL10). Therefore, our data indicate that co-localization of NPC with MNC can trigger an innate immune response. Further, intracellular cytokine staining for TNF-a reveals both NPC and MNC are a TNF-a source. These data indicate that vertebral endplate damage and NPC and MNC comingling may initiate bone marrow lesions.

GPS3
ELEVATED GLYCOHEMOGLOBIN HBA1C IS ASSOCIATED WITH REDUCED SPINAL MOBILITY INDEPENDENT OF BMI
A. Real, S. Illien-Jünger, S.A. Qureshi, A.C. Hecht, J.C. Iatridis;
Leni & Peter W. May Department of Orthopaedics, Icahn School of Medicine at Mount Sinai, New York, NY

INTRODUCTION: While it has been shown that intervertebral disc degeneration (IVDD) is associated with obesity, a potential relationship between diet, diabetes, and spine mobility in adults has not been thoroughly examined. The aim of this study was to investigate the independent effects of glycohemoglobin (HbA1c) levels on spine mobility of adults in the context of a nation-wide nutrition and physical examination survey.

METHODS: Multivariate regression analysis was performed on 2009-2010 National Health and Nutrition Examination Survey data with Stata version 13.1 software. The study population included 4,275 individuals of diverse ethnic backgrounds aged 20-69 years. Dependent variables included metrics of cervical, thoracic, and lumbar spine mobility: occiput-to-wall distance, chest expansion, and modified Schöber test measurements. Covariates included race,
gender, and smoking as binary variables, as well as age, BMI, family income ratio to poverty, and HbA1c as continuous variables. Regression was performed with the jackknife regression command, and significance was determined by p below .05. The absence of multicollinearity was confirmed by examining the variance inflation factors of the estimates (VIF below 4).

**RESULTS:** HbA1c significantly contributed to reduced spinal mobility in both cervical (occiput-to-wall) and thoracic (chest expansion) spine with coefficients of 0.11±0.04 (cm/%HbA1c) and -0.10±0.03 (cm/%HbA1c) respectively. When restricted to the diabetic cohort alone (HbA1c ≥ 6.5%, n = 358) HbA1c also significantly contributed to reduced lumbar (Schöber) spinal mobility with a coefficient of -0.12±0.04 (cm/%HbA1c).

**DISCUSSION:** Our findings show a significant and independent association of HbA1c with reduced spinal mobility in a database collected and maintained by the Center for Disease Control. This epidemiological observation corroborates laboratory data linking hyperglycemia to IVD tissue changes and may eventually inform new IVDD treatment strategies.

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**GP54**

**IN VIVO ANNUlar REPAIR USING HIGH-DENSITY COLLAGEN GEL SEeded WITH FIBROCHOndRocytes**

Yu Moriguchi MD PhD, Brandon Borde BS, Peter Grunert MD, Thamina Khair BA, Katherine Hudson BS, Lawrence Bonassar PhD, Roger Hartl MD;

Weill Cornell Medical College Department of Neurological Surgery, Cornell University Department of Biomedical Engineering

**INTRODUCTION:** Discectomy of herniated intervertebral discs (IVDs) successfully alleviates associated neurological symptoms but fails to repair the underlying degenerative disc process. Persistent annular defect post discectomy is associated with an increased risk of reherniation, progressive IVD degeneration, and chronic low back pain. Recently, we demonstrated the ability of riboflavin cross-linked high density collagen gels (HDC) to facilitate annular repair in vivo (1). In this study, AF fibrochondrocytes were seeded in the HDC gel to enhance the reparative process at the site of the annular defect.

**METHODS:** 20 athymic rats, punctured with an 18-gauge needle in the tail disc, were divided into three groups: 1) untreated (n=4); 2) injected with crosslinked HDC (n=8); 3) injected with fibrochondrocyte-laden crosslinked HDC (n=8). Sheep AF fibrochondrocytes labeled with Dil at a concentration of 106 cells/ml were mixed with HDC gels prior to injection. MR imaging and histological sections were performed.

**RESULTS:** Compared to the puncture, untreated group, at 1 week, both HDC gel groups showed significantly higher retention of NP size and hydration, while only the cell-laden group better maintained NP retention up to 5 weeks based on repeated measure ANOVA. The untreated discs showed substantial NP herniation by 2 weeks and NP absence with signs of
degeneration by 5 weeks (Fig 1a, b). Implanted fibrochondrocytes were detected by Dil in the process of reorganization of the gels (Fig 1c). Histological assessments indicate that while gels influence the sealing of the defect, the addition of cells accelerates the reparative process at the site of the annular defect as early as 2 weeks (Fig 1d).

**DISCUSSION:** In vivo studies on the cell-based annular repair are few in number. Our preliminary findings suggest that fibrochondrocytes can potentially improve HDC gel-based annular repair. Long term study with sufficient sample size are necessary to confirm these results.

**GP55**

**RAPAMYCIN, BUT NOT OTHER MTOR MODULATORS, IS PROTECTIVE AGAINST INTERVERTEBRAL DISC CELLULAR APOTOPSIS, SENESCENCE, AND EXTRACELLULAR MATRIX DEGRADATION**

Takashi Yurube (1,2), Thomas P. Lozito (1), Robert A. Hartman (3), Pedro H. I. Pohl (1), Zhang Zhongying (1,2), Kotaro Nishida (2), Masahiro Kurosaka (2), Nam V. Vo (1), Gwendolyn A. Sowa (1,3), James D. Kang (1);

(1) Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, PA (2) Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, Kobe, Japan (3) Department of Physical Medicine & Rehabilitation, University of Pittsburgh, Pittsburgh, PA

**INTRODUCTION:** The mammalian target of rapamycin (mTOR) is a serine/threonine kinase that plays a key role in cell growth and homeostasis. mTOR complex 1 (mTORC1) is regulated by Akt. Akt is a prosurvival mediator regulated by mTOR complex 2 (mTORC2). Roles of mTOR signaling in disc cells and matrix remain unclear. Our objective was to elucidate effects of mTOR inhibition and to provide insight into potential therapeutic targets in this pathway.

**METHODS:** Rabbit annulus fibrosus cells were cultured with 10 ng/ml interleukin (IL)-1α with a mTORC1 inhibitor rapamycin (Rap), Rap&an Akt inhibitor MK-2206 (MK), or a dual mTORC1 and mTORC2 inhibitor PP242 (PP). 1) To clarify drug toxicity, cell viability was measured. 2) To assess autophagy, autophagic flux and mTOR signaling were monitored by Western blotting. 3) To analyze cell fate, apoptosis and senescence were evaluated. 4) To examine matrix metabolism, catabolic and anti-catabolic molecule expression and aggrecan degradation were investigated.

**RESULTS:** 1) Based on optimal cell viability, 100 nM Rap, 5 nM MK, and 100 nM PP were selected for the remainder of experiments. 2) Rap increased an autophagy marker, LC3-II, and decreased a negatively correlated marker, p62/SQSTM1. Rap&MK and PP markedly increased LC3-II and decreased p62/SQSTM1. In mTOR pathway, while Rap decreased mTOR and its effector, p70/S6K, but increased Akt phosphorylation, Rap&MK and PP decreased all these
phosphorylation. 3) Rap reduced but Rap&MK and PP elevated IL-1α-induced apoptotic cleaved PARP and senescent p16/INK4A. 4) Rap increased TIMP-1 and decreased IL-1α-activated MMP-3, MMP-13, and MMP-cleaved aggrecan fragments. Rap&MK and PP further elevated IL-1α-induced changes.

**DISCUSSION:** Rap is protective but Rap&MK and PP are harmful to the disc. Complete mTOR inhibition may lead to homeostatic failure. Beneficial effects of mTORC1 inhibition depend on activation of Akt rather than of autophagy. Only Rap is a promising drug to treat disc disease.

**GP56**

**MICROSTRUCTURED COCULTURE CONSTRUCTS ENHANCE IVD TISSUE ENGINEERING IN DEGENERATIVE ENVIRONMENTS**

*Ann Ouyang, Alec Cerchiari, Xinyan Tang, Zev J. Gartner, Tamara Alliston, Jeffrey C. Lotz; University of California, San Francisco*

**INTRODUCTION:** Tissue engineering is a promising treatment to restore degenerated IVD matrix. Coculture of mesenchymal stem cells (MSCs) and nucleus pulposus cells (NPCs) enhances chondrogenic activity, especially when cells are in a pellet configuration. Because large pellets are difficult to implant surgically, we fabricated injectable cocultured micropellets, which mimic the structure of large pellets, maintain chondrogenic gene expression, and reduce inflammatory responses in degenerative media conditions.

**METHODS:** MSCs and NPCs (50:50 ratio) were seeded in 100-μm agarose wells (50:50 ratio). The cells condensed into micropellets after 12 hours. Four experimental groups were created: micropellets; MSCs; NPCs; and individual mixed MSCs and NPCs. The groups were cultured in MSC growth media or inflammatory-hypoxic media (10 ng/ml of IL-1?, 10 ng/ml of TNF–?, 2% O2) for 21 days. mRNA expression of chondrogenic (Agg and Col2a1) and catabolic (MMP13) genes was assessed by qPCR (normalized to GAPDH). To visualize pellet structure, cells were labeled with Dil and DiO membrane dyes.

**RESULTS:** In growth media, coculture groups showed higher Agg and Col2a1 gene expression levels than MSCs, but lower levels than NPCs (Panel A, *p<0.05, ANOVA). In inflammatory conditions, NPCs had a significant increase in MMP-13 expression, while micropellets showed a significant decrease, and MSCs and individual mixed cells had no significant change (Panel B, *p<0.05, multiple t-tests). Additionally, we observed that micropellets self-organized into structures with MSC cores (red) surrounded by NPCs (green) (Panel C).

**DISCUSSION:** Cocultured micropellets were more synthetic relative to MSCs, more resistant to inflammation relative to NPCs and individual mixed cells, and able to self-assemble into a bilaminar structure. The
fabricated micropellets combine the benefits of pellet culture with the convenience of injectability to improve IVD regeneration.

**GP57**

**ADVANCED GLYCATION ENDPRODUCTS (AGES) INDUCE HYPERTROPHIC AND OSTEOGENIC DIFFERENTIATION IN NUCLEUS PULPOSUS (NP) CELLS**

S. Illien-Jünger, A. Real, O.M. Torre, W. Kindschuh, S. Qureshi, A.C. Hecht, J.C. Iatridis; Leni & Peter W. May Department of Orthopaedics, Icahn School of Medicine at Mount Sinai, New York, NY

**INTRODUCTION:** Intervertebral disc (IVD) degeneration (IDD) is a major cause of back pain and there is evidence that IDD correlates with AGE accumulation. We recently showed that AGE accumulation is associated with ectopic calcification and hypertrophy in mice. The aim of this study is to investigate effects of AGES on NP cell calcification and osteogenic differentiation and to assess if AGES are associated with ectopic calcification in degenerated human IVDs.

**METHODS:** Bovine NP cells were cultured in hypoxia and stimulated with AGE-BSA media in low glucose DMEM. For controls, AGE-BSA was substituted with BSA. After a 4-day culture, calcification (von Kossa), hypertrophy (collagen 10; COL10) and osteogenic differentiation (osteopontin; OPN) was determined by histology, immunocytochemistry and Western blot. Percent positive cells were quantified using CellProfiler (www.cellprofiler.org). Human IVDs from autopsy were stained for methylglyoxal-H1 (MG-H1), receptor of AGE (RAGE), OPN and COL10; p<0.05 was considered significant.

**RESULTS:** AGE exposure led to increased ectopic calcification (Fig. 1A) and elevated COL10 and OPN expression (Fig.1B; COL10: p=0.003; OPN: p=0.012). Analyses of human IVDs revealed that areas of ectopic calcification were often located close to fissures and were associated with AGE accumulation (Fig. 1C). Co-expression of MG-H1 and RAGE was observed within hypertrophic chondrocyte-like cells that were organized in clusters surrounded by granulated tissue. This pattern was also observed for OPN and COL10 positive cells (Fig.1C).

**DISCUSSION:** Here we identified a relationship between AGE accumulation and NP calcification suggesting that AGES can induce NP differentiation into hypertrophic chondrocytes and osteoblasts in vitro. Moreover, AGE accumulation correlated with osteogenic differentiation in human IVDs from autopsy, suggested that targeting AGES may be a potential strategy for biological treatment of IDD. Funded by NIH/NIAMS R01 AR05739

![Figure 1: A: AGEs induce hypertrophy and calcification. B: AGE-induced ectopic calcification in NP cells as shown by accumulation of extracellular calcification (von Kossa). Black arrowheads indicate calcification. C: Effect of AGES on NP cells following 4-day culture. Representative images of top: OPN and bottom: COL10 immunocytochemistry. A: Human IVD from autopsy stained for AGE and COL10 (Scale bar: 100 μm). B: Human IVD from autopsy stained for AGE and COL10 (Scale bar: 100 μm). C: Human IVD from autopsy stained for AGE and COL10 (Scale bar: 100 μm). D: Human IVD from autopsy stained for AGE and COL10 (Scale bar: 100 μm).]

**GP58**

**THE RELATIONSHIP BETWEEN THE ANTERIOR LONGITUDINAL LIGAMENT AND INTERVERTEBRAL DISC DEGENERATION IN THE LUMBAR SPINE**


[1] Anthropology and Orthopaedics & Sports Medicine, University of Washington, Seattle,
INTRODUCTION: The anterior longitudinal ligament (ALL) spans the anterior boarder of the vertebral column in a continuous fashion, and shares a source of innervation with the anterior annulus fibrosus (AAF). While much is known about histo-pathological patterns of disc degeneration, little is known about potentially coincident ALL changes. Using 3T MRI performed on fresh cadaveric lumbar spines, we assessed ALL thickness in relation to disc degeneration. Then, using histology, we assessed how ALL tissue degeneration compared to that of the adjacent AAF. Furthermore, to investigate if the ALL is a potential source of pain, we quantified ALL innervation.

METHODS: From six cadaveric lumbar spines (T11-S1), we collected MRI images (in situ) and mid-sagittal histology of 35 motion segments. On T2-weighted MRI images, we measured ALL thickness and disc degeneration via Pfirrmann grade. On histological sections, we measured tissue disorganization of both the ALL and AAF and innervation (PGP 9.5 immunohistochemistry) of the ALL.

RESULTS: Within individual spines, average lumbar disc degeneration positively correlated with average thickness of the ALL (r=0.69). Yet, within individual motion segments, ALL thickness was not related to adjacent disc degeneration. However, we observed a positive association between ALL disorganization and AAF disorganization (p=0.01), as well as, between ALL disorganization and ALL innervation (p=0.03).

CONCLUSIONS: Histologically, we observed that the ALL degenerates in proportion to the adjacent AAF, and may be a source of pain with degeneration. Using MRI, we found that the average ALL thickness across all levels increases with disc degeneration, but surprisingly this relation-ship between thickness and disc health was not apparent at individual motion segments. This may be because the ALL is continuous along the spinal column, and consequently integrates effects of degeneration at multiple levels.

GP59
DEVELOPMENT OF A NOVEL INDUCIBLE SYSTEM TO REGULATE EXPRESSION OF THE THERAPEUTIC TRANSGENE TIMP1, CONFIRMED BY BOTH TRANSFECTION AND INFECTION.
Zhihua Ouyang1,3, Yingchao Han1, Adam Richardson1, Qing Dong1, Maximiliane Hall-baum1, Wan H. 1, Ying Tang2, Bing Wang2, Nam Vo1, Gwendolyn Sowa1, +James D. Kang1;
1Ferguson Laboratory for Orthopedic and Spine Research, University of Pittsburgh, Pittsburgh, PA, 15213, USA 2Molecule Therapy Laboratory, Department of Orthopedic Surgery, University of Pittsburgh, Pittsburgh, PA, 15219, USA, 3Department of spinal surgery, the 1st affiliated hospital of University of South China, Hengyang, 421001, China.

INTRODUCTION: Excessive mechanical and inflammatory stress upregulates matrix metalloproteinase (MMP) activity and breaks down of extracellular matrix, which can lead to intervertebral disc degen-
eration (IDD). Gene therapy using Tissue Inhibitor of Metalloproteinase -1 (hTIMP1) has shown efficacy in treating IDD. We developed a new recombinant adenovirus-associated viral (rAAV) vector, rAAV-NFkB-hTIMP1 which is designed to produce the therapeutic gene product TIMP1 only when the cells experience stress.

**METHODS:** Cultured Rabbit annulus fibrosis (rAF) cells were divided into six groups; Control (cell only); rAAV-CMV-hTIMP1 (cells transfected with plasmid DNA or infected with virus) and rAAV-NFkB-hTIMP1 (cells transfected with plasmid DNA or infected with virus) treated with and without IL-1b. The NF-kB activation after IL-1b stimulation was verified by NF-kB nuclear translocation. Protein and mRNA expression of hTIMP1 was determined by ELISA and RT-PCR, respectively.

**RESULTS:** Over 80% of transfected cells exhibited NF-kB activation after IL-1b stimulation as determined by NFkB nuclear translocation. RT-PCR analysis demonstrated the level of hTIMP1 transcription in cells transfected with rAAV-NFkB-hTIMP1 increased 20 fold in the IL-1b stimulated condition compared to nonstimulated control. ELISA assay also showed 5 fold greater hTIMP1 protein concentration in culture media of cells transfected with rAAV-NFkB-hTIMP1 and treated with IL-1b. As expected, group rAAV-CMV-hTIMP1 produced high levels of hTIMP1 protein with or without IL-1b stimulation. (Figure 1). Our preliminary infection experiment demonstrated similar trends as transfection.

**DISCUSSION:** These results demonstrate the novelty of this enhanced safety strategy in which the NF-kB element containing promoter ensures that the transgene hTIMP1 is expressed highly only under conditions of inflammatory stress typically found in injured and degenerating discs to block MMP-mediated matrix proteolytic destruction.

**GP60**

**CULTURE OF NUCLEUS PULPOSUS PROGENITOR CELLS IN HYPEROSMOSIS**

Samantha CW Chan1,2, Daisuke Sakai3,4 and Benjamin Gantenbein1,4;

1 Institute for Surgical Technology and Biomechanics, University of Bern, CH 2
2 Bioactive materials, EMPA, Swiss Federal Laboratories for Materials Science and Technology, St Gallen, Switzerland 3 Department of Orthopedic Surgery, Tokai University School of Medicine, Isehara, Kanagawa, Japan 4 AOspine Research Network, Dübendorf, Switzerland

**INTRODUCTION:** The high glycosaminoglycans side-chains of the aggrecan in the intervertebral disc (IVD) raise the osmolarity of the nucleus pulposus, therefore, nucleus pulposus cells (NPC) are under hyperosmotic condition inside the disc. Recent studies raised contradictory results in the NPC responses to isosmotic and hyperosmotic culture conditions, while one proposed hyperosmotic culture condition could preserve the matrix production activity of NPC, but another study suggested that a hyperosmotic condition reduced NPC viability and matrix production. This study aims to monitor cell growth and changes of the NPC phenotype in isosmotic and hyperosmotic culture condition by monitoring some of their important NPC surface antigens by flow cytometry.

**METHODS:** Human NPC cells were expanded in monolayer culture to passage 1 and then seeded at 10,000 cells in each well of
the 6-well plate in duplicates and cultured in alpha-MEM containing 10% FCS either in isosmotic medium (300 Osm/L), or in hyperosmotic medium (400 Osm/L) adjusted with 1% 5 M NaCl and 0.4 M KCl. Cells were trypsinized after 7 days culture and stained with three NPC surface markers (GD2, Tie2, CD24) for flow cytometry characterization. Cumulative population doubling and changes of NPC cell surface antigens were monitored at day 0, 7, 14, 21 and 28.

**RESULTS:** Cumulative population doubling time indicated that NP cell growth was inhibited in hyperosmotic condition over the 28-day culture, which was 50% lower in hyperosmotic condition than isosmotic condition (Figure 1). Our data indicated that the hyperosmotic culture medium could inhibit the growth of NPC both in monolayer culture. It is postulated that the hyperosmotic condition in the NP plays a role in maintaining the quiescent state of the NP cells and maintenance of their phenotype.

**DISCUSSION:** Our data indicated that the hyperosmotic culture medium could inhibit the growth of NPC both in monolayer and 3D alginate beads culture.

**Figure 1.** NPC cumulative population doubling in isosmotic or hyperosmotic medium in monolayer (left) and 3D alginate beads (right). Cell growth was statistical significantly higher in isosmotic then hyperosmotic media starting from day 14, 21 and 28. (N=6) Cells cultured in alginate were recovered after 28 days culture. * indicate statistical significantly difference between isosmotic and hyperosmotic condition: * p<0.05, ** <0.001, *** <0.0001, **** p<0.00001.

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**GP61**

**NEUROPEPTIDE Y PROTEIN EXPRESSION IN THE ANNULUS FIBROSUS IN RESPONSE TO CHEMICAL AND MECHANICAL STRESS**

Adam Olsen, Joao Paulo Coelho, Nam Vo, James Kang, Gwendolyn Sowa;

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**University of Pittsburgh Medical Center, Departments of Orthopaedic Surgery and Physical Medicine & Rehabilitation**

**INTRODUCTION:** Previous studies from our laboratory have explored the responses of rabbit annulus fibrosus fibrochondrocytes to mechanical and inflammatory stress. While chemical stress reliably induced a catabolic response, mechanical stress produced differential responses with moderate strain imparting protection and high strain producing cellular responses detrimental to extracellular matrix homeostasis. In this study, we sought to explore the presence and concentration of neuropeptide Y, a molecule with reported gene expression but unknown function in the annulus fibrosus, in the conditioned media of cells exposed to mechanical and inflammatory stress.

**METHODS:** Fibrochondrocytes from the annulus fibrosus of 6-8 month old female rabbits were harvested immediately following sacrifice. For cells exposed to chemical stimuli, 1ng/ml rhIL-1α was added to media prior to incubation or simultaneously with tensile strain. For groups exposed to tensile strain, plates were loaded into the Flexcell system and exposed to strain at 3%, 6%, and 18% for 24h. NPY was detected in the conditioned media via ELISA and NPY/total protein concentrations were calculated.

**RESULTS:** Exposure to IL alone did not significantly affect NPY concentration with a trend of 21% increase from controls. Exposure to tensile strain did significantly affect NPY, with decreases at low (3%) strain (38% decrease vs. control) and increases at high (18%) strain (64% increase vs. control). In the 18% strain group, the addition of IL-1 resulted in a 163% increase in NPY concentration over control.

**DISCUSSION:** This study is the first to demonstrate that the NPY protein is expressed by annulus fibrosus cells, and
also suggests that NPY is involved in the cellular response to detrimental levels of mechanical and inflammatory stress. While IL-1 alone did not affect NPY concentration, detrimental strain resulted in elevated NPY, a result that was more pronounced with addition of IL-1.

**GP62**

**CAN DIRECT NON-VIRAL GENE THERAPY BE APPLIED TO WHOLE INTERVERTEBRAL DISCS?**

Rahel D May1, Daniela A Frauchiger1, Amiq Gazdhar2, Thomas Geiser2, Lorin M Benneker3 & Benjamin Gantenbein1;

1 Tissue and Organ Mechano Biology, Institute for Surgical Technology and Biomechanics, University of Bern, Bern, Switzerland 2 Department of Pulmonary Medicine, University Hospital, Bern, Switzerland 3 Department of Orthopaedic Surgery, Inselspital, University of Bern, Bern, Switzerland

**BACKGROUND:** Focusing on non-viral gene therapies and their possible translation into the clinics, we investigated if GDF6 can induce regeneration of degraded NP. We hypothesized that IVD transfected with plasmid over-expressing GDF6 also up-regulates other NP- and chondrogenic cell markers and enhances ECM deposition.

**METHODS:** Bovine IVD cells were isolated by pronase/collagenase II overnight digestion. After monolayer expansion up to passage 3, cells were transfected with the plasmid pGDF6 (RG211366, Origene) or with GFP control using the Neon® transfection system (Invitrogen), both equipped with a Cytomegalovirus (CMV) promoter to induce transient over-expression. To test a non-viral gene therapy applied directly to 3D whole organ culture, bovine IVDs were harvested from fresh tails obtained from the abattoir within 5h post-mortem. Discs were then pre-incubated for 24 h in high glucose Dulbecco’s Modified Eagle Medium and 5% fetal calf serum. Each disc was transfected by injection of 5 µg of plasmid GDF6 into the center by 25G needle and using Hamilton syringe. Electroporation was performed using 2-needle array electrode or tweezer trodes (Fig. 1); 8 pulses at 200mv/cm with an interval of 10ms were applied using ECM830 Square Wave Electroporation System (Harvard Apparatus). After transfection discs were cultured for 72 h to allow expression of GFP or GDF6. Discs were then fixed, cryosectioned and analysed by immuno-fluorescence.

**RESULTS:** Best results for transfection of bovine NP and AF cells in monolayer were obtained using 1400V, 20 ms and 2 pulses with a ~25% efficiency using 0.15 M cells and 3 µg DNA. Organ IVD culture transfection revealed GFP positive staining in the centre of the disc using 2-array needles. Results from tweezer trodes did not show any GFP positive cells.

**DISCUSSION:** We identified novel parameters to successfully transfect primary bovine IVD cells. For transfection of whole IVDs electroporation parameters need to be further optimized.

**GP63**

**THE RELATIONSHIP BETWEEN LUMBAR DISC HERNIATION AND ANAEROBIC BACTERIAL INFECTION OF INTERVERTEBRAL DISCS**

Urushibara Makoto, Aihara Takato, Hatakeyama Kenji; Dept. of Orthopedic Surgery. Funabashi Orthopedic Hospital, Funabashi-city, Japan

**INTRODUCTION:** Several studies have shown that anaerobic bacteria, predominantly Propionibacterium acnes, may be responsible for low-grade infection of the intervertebral discs of patients with lumbar disc herniation (LDH). Recent studies also suggest an association between anaerobic bacterial infection and Modic changes in the vertebrae. The purpose of this study
was to investigate the presence of bacteria in the intervertebral disc material obtained during surgery for LDH.

**METHODS:** This case series included immunocompetent patients with radiculopathy who were positive for LDH on magnetic resonance imaging (MRI). All patients had undergone primary surgery at a single level after failure of conservative treatment. Exclusion criteria were history of acute systemic infection, diabetes mellitus, systemic steroid use, chemotherapy, and other conditions involving compromised immunity. Excised disc materials were incubated under standard aerobic and anaerobic conditions for 7 days at 35°C. Stringent antiseptic sterile protocols were followed to minimize the risk of contamination of wound culture. Furthermore, we determined the presence of Modic changes in the vertebrae on MRI and investigated the association between Modic changes and anaerobic bacteria.

**RESULTS:** Thirty patients were included in this study. There were 21 males and 9 females, with a mean age of 47 years. MRI showed Modic changes in 9 of the 30 patients (type 2 in 8 patients, type 3 in 1 patient, and type 1 in 0 patients). None of these samples yielded growth of anaerobic or aerobic bacteria. No association was observed between Modic changes (types 2 and 3) and anaerobic bacteria.

**DISCUSSION:** Our results showed no evidence of bacteria in the disc material obtained during surgery for LDH. No patient had type 1 Modic changes; therefore, we need to examine additional studies regarding Modic change type 1 to assess the relationship between Modic changes and anaerobic bacteria.

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**GP64**

**BRACHYURY IS AN ESSENTIAL TRANSCRIPTION FACTOR FOR MAINTAINING HOMEOSTASIS IN NOTOCHORDAL CELLS**

Nobuyuki Fujita1, Ryuichi Watanabe1, Satoshi Suzuki1, Takeshi Fujii1, Tomohiro Hikata1, Kota Watanabe2, Ken Ishii1, Takeshi Miyamoto1, Yoshiaki Toyama1, Morio Matsumoto1; 1 Department of Orthopedic Surgery, Keio University School of Medicine, Tokyo, Japan, 2 Department of Advanced Therapy for Spine and Spinal Cord Disorders, Keio University, Tokyo, Japan

**INTRODUCTION:** Brachyury is required for the differentiation of the axial midline mesoderm into the notochord. Moreover, brachyury is known to be a specific marker of the notochord, notochord-derived tumors, and NP. Nonetheless, the function of brachyury in notochordal cells is not yet fully understood. The main objective of this study was to clarify the role of brachyury for homeostasis maintenance in notochordal cells.

**METHODS:** We used U-CH1-N cells, which are a chordoma cell line with characteristics similar to those of notochordal NP cells. To determine the function of brachyury, a lentiviral knockdown of its gene was established in U-CH1-N cells. All measurements were made in triplicate. Data are presented as mean ± standard deviation (SD). Differences between the groups were analyzed by the Student t test (*p < 0.05).

**RESULTS:** The brachyury-knockdown cells became spindle shaped (Fig 1A). The MTT assay revealed profoundly decreased viability of brachyury-knockdown cells (Fig 1B). Down-regulation of brachyury strongly inhibited the protein expression of PCNA (Fig 1C), indicating that brachyury regulated cell proliferation in notochordal cells. Real-time RT-PCR showed that the mRNA expression of type II collagen and aggrecan, but not type I collagen, was significantly decreased by brachyury silencing. To gain further insight into the
molecular mechanisms via which brachyury affects the expression of chondrogenic ECM, we quantified the mRNA expression of the Sox trio in brachyury-knockdown U-CH1-N cells. Real-time RT-PCR shows the expression of Sox5 and Sox6, but not Sox9, was significantly decreased by brachyury silencing. Moreover, we found that the mRNA expression of the other notochordal cell markers such as CD24 and CTGF was significantly suppressed in the brachyury-knockdown U-CH1-N cells. CONCLUSION: Brachyury controls homeostasis of notochordal cells by regulating proliferation potency and synthesis of cartilage matrix.

GP65
RELATIONSHIP LOW BACK PAIN AND LUMBAR DISC DEGENERATION ON MRI: A CROSS SECTIONAL STUDY USING YOUNG NURSING STUDENTS
Kenji Kobayashi, Yoshiharu Kawaguchi, Hiroto Makino, Shoji Seki, Taketoshi Yasuda, Tomoatsu Kimura;
Department of Orthopedic Surgery, Toyama University

INTRODUCTION: The relationships between low back pain (LBP) and lumbar disc degeneration have been examined in many studies, however, the conclusions are still controversial. This study aimed to investigate lumbar disc degeneration on magnetic resonance imaging (MRI), and whether these changes associate with LBP using young nursing students in their 20’s.

METHODS: We examined 352 nursing students in our university (12 males and 340 females, mean age was 20.5 years). All students took MRI of lumbar spine. We could obtain the information about LBP by questionnaire from 171 subjects. Four observers in our team evaluated MRI images. The grade of disc degeneration were determined by Schneiderman’s four grade classification and a total score (DDD score) which is the summation of score of each lumbar levels. We evaluated association between LBP and total DDD score, and Schneiderman’s score at each lumbar level.

RESULTS: The lower lumbar discs tended to be more severe degenerated: in 352 MRI images, Schneiderman’s grade ≥ 2 at each levels are 17%at L1/2, 16% at L2/3, 13% at L3/4, 21% at L4/5 and 33% at L5/S1. From 171 questionnaire, total DDD score was not associated with LBP (p=0.35, odds ratio=1.36), but only Schneiderman’s grade of L4/5 disc was associated with LBP (p=0.002, odds ratio=3.09)

DISCUSSION: This study revealed LBP was associated with Schneiderman’s grade of L4/5 disc, but not total DDD score. Thus, lower lumbar disc degeneration might be closely related to LBP in young subjects.

GP66
INHIBITORY EFFECT OF VITAMIN E ON NO PRODUCTION IN NUCLEUS PULPOUS-DERIVED INFLAMMATORY REACTION
Kimihioko Makiyama, Kazuo Nakanishi, Toru Hasegawa;
Department of Orthopedic Surgery Kawasaki Medical School

INTRODUCTION: It has been reported that vitamin E, which has received attention as a potent antioxidant, has an anti-inflam-
matory effect in addition to its direct antioxidant effect. It modulates the levels of superoxide, prostaglandin E2, and cytokines, thereby inhibiting nitric oxide (NO) production at inflammatory sites. We have hypothesized that vitamin E is effective in preventing the development of neuropathic pain through its ability to inhibit NO production at sites of lumbar disc herniation (LDH) induced inflammation. The purpose of this study was to examine the inhibition of NO production via the addition of vitamin E to a nucleus pulposus-macrophage coculture model.

METHODS: Ninety-seven 12week old male Sprague Dawley rats were used in the study. Rat nucleus pulposus-inflammatory macrophage coculture with and without the addition of vitamin E were set up, and NO levels in the coculture medium at 2 hours and at 1 week of incubation were assessed.

RESULTS: In both groups, the NO level in the co-culture medium was significantly higher at 1 week of incubation than that at 2 hours of incubation. Additionally, the NO level in coculture medium was significantly lower in the vitamin E added coculture group than in the non-vitamin E added coculture group. These findings indicate that the elevation of NO, a mediator of inflammation, occurred in the rat nucleus pulposus inflammatory macrophage cultures, and this elevation was inhibited in the vitamin E added coculture.

DISCUSSION: Previous reports suggest that chemical factors, such as NO and inflammatory cytokines, are involved in the mechanism of neuropathic pain in LDH. Additionally, NO has been reported to be an important cause of neuropathic pain in LDH. The results revealed that vitamin E is capable of inhibiting NO production, a cause of neuropathic pain in LDH, through its anti-inflammatory effect, and may serve as a new therapeutic strategy.

GP67
PGE2 NEGATIVELY REGULATES MMP-1 EXPRESSION BY INDUCING DUSP-1 IN HUMAN INTERVERTEBRAL DISC CELLS
Makiko Yorifuji, Yasunobu Sawaji, Hidekazu Suzuki, Kenji Endo, Hitetoshi Tanaka, Taiichi Kosaka and Kengo Yamamoto;
Department of Orthopedic Surgery, Tokyo Medical University

INTRODUCTION: Degeneration of the intervertebral disc (IVD) preceding peripheral nerve innervation is considered as one of the pathogeneses of developing discogenic pain. Because the extracellular matrix in the nucleus pulposus and anulus fibrosus mainly consists of types II and I collagen, respectively, the collagenase MMP-1 plays a key role in IVD degeneration. We previously reported that IL-1 induction of MMP-1 was augmented by a selective COX-2 inhibitor but inhibited by adding PGE2 exogenously in isolated human IVD cells, and suggested that PGE2 has a negative feedback role in MMP-1 regulation. Here, we investigated a mechanism in which PGE2 suppresses MMP-1 expression by focusing on the MAP kinase pathway and the phosphatase of MAP kinases; dual-specificity phosphatase (DUSP)-1.

METHODS: Isolated human IVD cells were stimulated with IL-1 in the presence or absence of PGE2 or MAP kinase inhibitors (SB203850 for p38, U0126 for ERK, and SP600125 for JNK). MMP-1 expression was measured by real-time PCR and Western blotting. MAP kinase phosphorylation was detected by Western blotting. DUSP-1 expression and its production were analyzed by real-time PCR and Western blotting, respectively.

RESULTS: PGE2 suppressed the IL-1 induction of MMP-1 at the mRNA and protein levels. IL-1 activated the MAP kinases. PGE2 strongly induced DUSP-1 and suppressed all three MAP kinases. The IL-1
induction of MMP-1 expression was suppressed by the inhibitor of p38 but not by that of JNK and ERK.

**DISCUSSION:** The suppressive mechanism of MMP-1 by PGE2 was investigated. PGE2 strongly induced DUSP-1, which in turn dephosphorylated p38, JNK, and ERK. Among all three MAP kinases, p38 appears to be the signal that induces NGF expression. Our data suggest that PGE2 has a novel biological action that suppresses MAP kinases by inducing DUSP-1, and the inhibition of the p38 signal would be a therapeutic target that may prevent disc degeneration following peripheral nerve innervation.

**GP68**

**PGE2 NEGATIVELY REGULATES NGF EXPRESSION BY INDUCING DUSP-1 IN HUMAN INTERVERTEBRAL DISC CELLS**

Yasunobu Sawaj, Hidekazu Suzuki, Kenji Endo, Hidetoshi Tanaka, Taiichi Kosaka and Kengo Yamamoto;

Department of Orthopedic Surgery, Tokyo Medical University

**INTRODUCTION:** Innervation of peripheral nociceptive nerve fibers into a degenerated intervertebral disc (IVD) is associated with nerve growth factor (NGF) expression and is considered as one of the pathogeneses of developing discogenic pain. We previously reported that IL-1 induction of NGF was augmented by a selective COX-2 inhibitor but inhibited by adding PGE2 exogenously in isolated human IVD cells, and suggested that PGE2 has a negative feedback role in NGF regulation (Alimasi et al. Spine 2013). Here, we investigated a mechanism in which PGE2 suppresses NGF expression by focusing on the MAP kinase pathway and the phosphatase of MAP kinases; dual-specificity phosphatase (DUSP)-1.

**METHODS:** Isolated human IVD cells were stimulated with IL-1 in the presence or absence of PGE2 or MAP kinases inhibitors (SB203850 for p38, U0126 for ERK, and SP600125 for JNK). NGF expression was measured by real-time PCR and ELISA. MAP kinase phosphorylation was detected by Western blotting using phospho-specific antibodies. DUSP-1 expression and its production were analyzed by real-time PCR and Western blotting, respectively.

**RESULTS:** PGE2 suppressed the IL-1 induction of NGF at both the mRNA and protein levels. IL-1 activated the MAP kinases p38, JNK, and ERK. PGE2 strongly induced DUSP-1 and suppressed all three MAP kinases. IL-1 induction of NGF expression was suppressed by the inhibitor of JNK but not by that of p38 and ERK.

**DISCUSSION:** The suppressive mechanism of NGF by PGE2 was investigated. PGE2 strongly induced DUSP-1, which in turn dephosphorylated p38, JNK, and ERK. Among all three MAP kinases, JNK appears to be the signal that induces NGF expression. Our data suggest that PGE2 has a novel biological action that suppresses MAP kinases by inducing DUSP-1, and the inhibition of the JNK signal would be a therapeutic target that may relieve NGF-related discogenic pain.

**GP69**

**STEROTACTICALLY-DELIVERED, FLUOROSCOPICALLY GUIDED NEEDLE PUNCTURE INJURY INDUCED DEGENERATION OF THE RAT TAIL DISC: CELLULAR AND MOLECULAR PHENOTYPING TELLS THE "TAIL"

Mattia A1, Karim MZ1, Kim S1, Wang X1, Singh J2, Zhou S3, Erwin WM1, 4, 5;

1 Genetics and Development, Toronto Western Research Institute 2 Canadian Memorial Chiropractic College 3 University of Toronto 4 Divisions of Neurological and Orthopaedic Surgery, University of Toronto 5 Research, Canadian Memorial Chiropractic College

**INTRODUCTION:** We have previously reported NCCM can suppress inflammatory
and death ligand-induced apoptosis in bovine, murine and human NP cells. Here we detail for the first time, the development of a novel fluoroscopically-guided, stereotactically delivered needle puncture-induced model of disc degeneration and characterization of important cellular signaling and phenotypic responses to injury.  

**METHODS:** 12-week old female Wistar rats were anaesthetized (isofluorane) and secured to a mounting board with tape within the field of a stereotactic device. A specially designed 35 degree, 26-gauge needle was attached to a Hamilton syringe and using fluoroscopic control the disc was completely penetrated from dorsal to ventral for each of 4 contiguous discs in the rat tail beginning at Caudal 2-6. We injured 4 discs/animal in 27 animals. The disc was penetrated to emerge through the opposite annulus, allowed to rest for one minute and then retracted back within the nucleus pulposus for another minute and then slowly retracted. We injected Mobicox subQ for analgesia post procedure. We then marked the skin overlying the injected discs with a permanent marker and removed the animals to a warmed cage for recovery. We sacrificed the 3 rats per time point at day 0, 72 hours and then each week for up to 10 weeks and harvested the injured discs at each time point for total protein and immunohistochemical analysis.  

**RESULTS:** All stem and notochordal cell markers (Oct 4, nanog, brachyury and galectin 3) were undetectable by 10 weeks and the active form of IL-1B and Cox2 as well as MMP-3 and -13 plus the disappearance of TIMP-1 occurred abruptly at 10 weeks. Sox9 increased its expression beginning at 3 weeks and collagen 1 and 2 increased expression acutely and continued.  

**CONCLUSIONS:** This novel method of IVD NP injury completely alters the IVD NP from a notochordal-rich to a fibrocartilagenous phenotype and can be used to evaluate biologic therapies for degenerative disc disease.

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**GP70**

**NOTOCHORDAL CELL-SECRETED FACTORS RESCUE HUMAN NUCLEUS PULPOSUS CELLS FROM APOPTOSIS AND EXTRACELLULAR MATRIX DEGRADATION: IMPLICATIONS FOR A NOVEL MINIMALLY INVASIVE THERAPY FOR THE DEGENERATIVE DISC**

Mehrkens KA1, Matta A2, Karim MZ2, Kim S2, Wang X2, Erwin WM2,3,4;  
1 Orthopaedic and Spine Surgery, University of Basel, Switzerland 2 Genetics and Development, Toronto Western Research Institute 3 Divisions of Neurological and Orthopaedic Surgery 4 Research, Canadian Memorial Chiropractic College

**INTRODUCTION:** Here we have investigated the effects of nonchondrodystrophic (NCD) canine intervertebral disc (IVD)-derived notochordal cell conditioned medium (NCCM) and chondrodystrophic (CD) canine IVD-derived conditioned medium (CDCM) upon human nucleus pulposus (NP) cells under pro-death and degeneration conditions.  

**METHODS:** We developed NCCM and CDCM from hypoxic culture of freshly isolated NPs from NCD and CD canines respectively, and cultured human NP cells (obtained at spinal surgery). The cells were cultured with ADMEM/F-12 (control
media), NCCM, or CDCM under hypoxic conditions (3.5% O2) and treated with IL-1α+FasL or Etoposide (all supplemented with 2% fetal bovine serum). We determined the levels of activated caspase-8, caspase-9, and caspase-3/7 activity in all donors as well as changes in extracellular matrix and apoptosis-related genes of donors in which NCCM suppressed activated caspase 3/7 activity as compared to those that did not. We evaluated the expression of a panel of cytokines on responders vs non-responders and probed for the expression of anti-apoptotic proteins as well as the integrity of the mitochondrial membrane (JC-1 dye and flow cytometry) (Fig 1).

RESULTS: NCCM inhibits apoptosis in a caspase-dependent fashion and by upregulation of of an apoptotic inhibitor ‘XIAP’ and the pro-survival factor ‘Rab25’. NCCM also upregulates a number of important extracellular matrix molecules and down regulates a number of matrix metalloproteinases. NCCM-responder cells express low levels of IL-6 and -8 but non-responders express elevated levels of these cytokines. NCCM maintains mitochondrial membrane integrity that is otherwise lost in the presence of etoposide.

CONCLUSIONS: NCCM protects mitochondrial membrane integrity in NP cells, suppresses apoptosis of human NP cells via activation of xIAP Rb25 and inhibits ECM degradation. Active components within NCCM could be harnessed in a novel minimally invasive treatment for degenerative disc disease.

GP71

COMPARISON OF AN ANTI-INFLAMMATORY DRUG DELIVERY SYSTEM VERSUS MSC THERAPY TO CONTROL INFLAMMATION IN A PRO-INFLAMMATORY INTERVERTEBRAL DISC ORGAN CULTURE SYSTEM

Graciosa Q. Teixeira1-3, Catarina L. Pereira2,3, Jürgen Mollenhauer4, Hans-Joachim Wilke1, Anita Ignatius1, Mário A. Barbosa2,3, Raquel Gonçalves2*, Cornelia Neidlinger-Wilke1*;

1Institute of Orthopaedic Research and Biomechanics, Center for Musculoskeletal Research, University of Ulm, Germany, 2Institute of Biomedical Engineering (INEB), Universidade do Porto, Portugal, 3Instituto de Ciências Biomédicas Abel Salazar (ICBAS), Universidade do Porto, Portugal, 4NMI Natural and Medical Sciences Institute at the University of Tübingen, Reutlingen, Germany (*, equal contribution)

INTRODUCTION: The pro-inflammatory microenvironment in degenerated intervertebral discs is a challenge for biological regenerative treatments. We have established a pro-inflammatory disc organ culture model in which we compared two different therapeutic approaches with regard to their anti-inflammatory effect: (a) a biomaterial-based strategy using Chitosan/Poly-(γ-glutamic acid) nanoparticles with Diclofenac (DF-NPs) or (b) a cell therapy approach using MSCs in Albumin/Hyaluronan hydrogel (Alb).

METHODS: Bovine caudal disc cultures (4-10/condition) were needle-punctured and stimulated with IL-1β (10 or 100ng/mL) 3h after the stimulus, discs were treated with (a) DF-NPs or (b) human MSCs for 48h. Untreated discs were used as controls. Gene expression of pro-inflammatory factors (TNF-α, IL-6, IL-8), matrix metalloproteinases (MMP1, 3), and ECM proteins (Coll II, Agg) was analyzed by RT-PCR.
Prostaglandin E2 (PGE2) was quantified in medium supernatants by ELISA. Cell viability was analyzed by LIVE/DEAD assay and metabolic profile was traced by Glucose/Lactic acid monitoring. Kruskal-Wallis or Mann-Whitney test (p<0.05) was used for statistical analysis.

**RESULTS:** Df-NPs injection induced statistically significant down-regulation of IL-6 and MMP1, and up-regulation of Coll II and Agg when compared to IL-1β stimulated groups, as well as decrease in PGE2 (Fig.1). Preliminary results of MSC treated groups showed slight down-regulation of IL-6 and -8 expression compared to IL-1β stimulus alone. PGE2 results revealed variability between MSCs donors. In all test conditions, cells remained viable and showed similar metabolism.

**DISCUSSION:** DF-NPs were able to significantly reduce the pro-inflammatory response induced by IL-1β treatment. Current long-term experiments will show if increase of Coll II and Agg can be confirmed by immunohistochemistry. MSCs short-term treatment showed high donor variability and has to be critically evaluated with regard to controlling inflammation.

**GP72**

**ASSOCIATION BETWEEN RANK/RANKL SIGNALING AND PROINFLAMMATORY CYTOKINES IN RAT INTERVERTEBRAL DISC CELLS**

Norihiko Takegami, Koji Akeda, Koichiro Murata, Junichi Yamada, Akihiro Sudo;

**Department of Orthopaedic Surgery, Mie University Graduate School of Medicine, Mie, Japan**

**INTRODUCTION:** The receptor activator of NF-κB ligand (RANKL), a member of the TNF superfamily, functions by promoting osteoclast differentiation. RANK/RANKL signaling stimulates the expression of proinflammatory cytokines through NF-κB pathways. We have previously reported expression of the RANK/RANKL/OPG (osteoprotegerin) system (RRO system) in human and rat intervertebral discs (IVDs). The purpose of this study was (1) to examine the effect of a proinflammatory cytokine on the expression of the RRO system, and (2) to evaluate the effect of RANKL on the expression of a proinflammatory cytokine with/without IL-1β stimulation in the rat IVD.

**METHODS:** 12-week-old male SD-rats were used. Annulus fibrosus (AF) and nucleus pulposus (NP) cells isolated from dissected thoracolumbar discs were monolayer-cultured. (1) The AF and NP cells were cultured with or without recombinant human IL-1β (rhIL-1β) in DMEM/F12 containing 0.3% FBS for 24 hours. The mRNA expression of RRO was examined using real-time PCR. (2) Rat disc cells were cultured with or without recombinant human RANKL in the presence or absence of rhIL-1β in DMEM/F12 containing 0.3% FBS for 24 hours. The mRNA expression level of IL-1β was examined using real-time PCR.

**RESULTS:** (1) mRNA expression levels of RANKL by AF and NP cells and RANK by NP cells were significantly up-regulated by stimulation with IL-1β in a dose-dependent manner (P<0.01). (2) Treatment with RANKL did not induce a significant effect on the mRNA expression of IL-1β. However, the mRNA expression of IL-1β was significantly up-regulated by stimulation of RANKL with IL-1β (P<0.01).
DISCUSSION: The results of this study showed that mRNA expressions of RANK/RANKL were regulated by the stimulation of IL-1β. The expression of IL-1β was significantly enhanced by stimulation with RANKL in the presence of IL-1β stimulation. The RANK/RANKL/OPG system may play a role in the process of disc degeneration mediated by proinflammatory cytokines.

GP73
OSTEOGENIC DIFFERENTIATION OF HUMAN INTERVERTEBRAL DISC CELLS: THE FIRST STEP TOWARDS BIOLOGICAL FUSION?
Sarah Turner(1,2), Birendra Balain(1), Matthew Ockendon(1), Shashank Chitgopkar(1) and Sally Roberts(1,2);
(1) Spinal Studies, Robert Jones and Agnes Hunt Orthopaedic Hospital NHS Foundation Trust, Shropshire, UK. (2) ISTM, Keele University, Staffordshire, UK.

INTRODUCTION: Spinal fusion is used to treat back pain associated with degeneration of the intervertebral disc, but the surgery involved is invasive and expensive. There is much research into cell therapy for regenerating degenerate discs, but little on developing a cellular technique for fusing discs between vertebrae. This study aimed to determine the ‘best’ method for driving disc cells towards an osteogenic phenotype which could lead to a less invasive spinal fusion.

METHODS: Nucleus pulposus (NP) cells were isolated from surgical samples of discs and grown in monolayer or 3D explant culture (controlled for swelling). They were treated with factors to induce osteogenic differentiation, for up to 28 days, including vitamin D3, parathyroid hormone or BMPs 2, 7 and 2/7 heterodimer, as well as ‘osteogenic’ medium containing dexamethasone, L-ascorbic acid-2-phosphate and β-glycerophosphate. Human bone marrow derived mesenchymal stem cells (MSCs) were used as positive controls. Successful differentiation was determined by alkaline phosphatase activity, or, for 3D cultures, cryosections stained with haematoxylin and eosin (H and E), von Kossa or Alizarin red to assess mineralization or osteogenesis.

RESULTS: In monolayer, human NP cells were capable of osteogenic differentiation, but not quite to the extent seen by human MSCs. The greatest increase in alkaline phosphatase was seen with the osteogenic media, with the other factors assessed showing less osteogenic differentiation of the NP cells. In 3D explant culture, mineralisation and osteogenesis was seen in the tissue cultured in standard osteogenic media.

DISCUSSION: The results of this study indicate that the cells of human degenerate intervertebral discs are capable of osteogenic differentiation. Currently the most successful method of achieving this, both in monolayer and in tissue explant culture, is via the application of standard osteogenic differentiation media.

GP74
REACTIVE OXYGEN SPECIES ARE THERAPEUTIC TARGETS FOR INTERVERTEBRAL DISC DEGENERATION
1Satoshi Suzuki, 1Nobuyuki Fujita, 2Naobumi Hosogane, 1Ken Ishii, 1Ryuchi Watanabe, 1Tomohiro Hickata, 3Keiyo Takubo, 4Kota Watanabe, 1Keisuke Horiuchi, 1Yoshiaki Toyama, 1 Takeshi Miyamoto, 1 Morio Matsumoto;
1 Department of Orthopedic Surgery, Keio University, Shinjuku, Tokyo, Japan 2 Department of Orthopedic Surgery, National Defense Medical College, Tokorozawa, Saitama, Japan 3 Department of Cell Differentiation, The Sakaguchi Laboratory of Developmental Biology, School of Medicine, Keio University, Shinjuku, Tokyo, Japan 4 Department of Advanced Therapy for Spine and Spinal Cord Disorders, Keio University

INTRODUCTION: Intervertebral disc degeneration (IVDD) is a major cause of many
degenerative spinal conditions, but the interaction between IVDD and oxidative stress induced by Reactive oxygen species (ROS) is not yet well understood. The objective of this study was to clarify the molecular mechanisms of oxidative stress in annulus fibrosus (AF) cells and to determine whether ROS represent a therapeutic target for IVDD.

METHODS: We used rodent puncture model for IVDD. Antibody to nitrotyrosine (an oxidative stress marker) was used for puncture model and human IVD samples. Rat AF cells were isolated and we treated with H2O2, buthionine sulfoximine (BSO), TNF-α with or without N-acetyl cysteine (NAC) and MAPK inhibitors for 24 h. We measured the relative mRNA expression of TNF-α, MMP-3, COX-2 and aggrecan. Western blotting were performed for detecting intracellular signaling, and flow cytometry for intracellular ROS. To access the effect of anti-oxidant treatment, we administered NAC orally to puncture model rats daily.

RESULTS: We found increased numbers of nitrotyrosine-positive cells in the AF of this model and human degenerative disc. mRNA expression of TNF-α, MMP-3 and COX-2 was significantly induced by treatment with both H2O2 and BSO, whereas aggrecan was reduced in a dose-dependent manner. Western blot analysis showed that MAPKs were maximally phosphorylated 10 min after treatment with H2O2, and treatment with MAPK inhibitors showed a significant suppression in mRNA expression of COX-2. ROS levels were increased in AF cells after treatment with TNF-α, and we found that NAC abolished the induction of TNF-α MMP-3 and COX-2 mRNA expression and the reduction in aggrecan expression in both ROS and TNF-α treated AF cells. Finally, real-time RT-PCR revealed that NAC treatment significantly reduced the mRNA expression of TNF-α and induced that of aggrecan in the AF tissues of this model.

CONCLUSION: NAC can be a therapeutic option for intervertebral disc degeneration.

GP75

COMPARISON OF MODIC CHANGES IN THE LUMBAR AND CERVICAL SPINE, IN 3167 PATIENTS WITH AND WITHOUT SPINAL PAIN

Li Shengyun, Zhao FengDong;
Department of Orthopedics, Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University

BACKGROUND: There are few comparisons of Modic changes (MCs) in the lumbar and cervical spine. Purpose: Compare the prevalence of MCs in the lumbar and cervical spine, and determine how MC prevalence depends on spinal pain, age, disc degeneration, spinal level, and the presence or absence of kyphosis.

STUDY DESIGN: Retrospective clinical survey.

MATERIALS AND METHODS: Magnetic resonance images (MRIs) were compared from five patient groups: 1. 1223 patients with low-back pain/radiculopathy only; 2. 1023 patients with neck pain/radiculopathy only; 3. 497 patients with concurrent low-back and neck symptoms; 4. 304 asymptomatic subjects with lumbar MRIs; and 5. 120 asymptomatic subjects with cervical MRIs.

RESULTS: The prevalence of MCs was higher in those with spinal pain than in those without, both in the lumbar spine...
(21.0% vs 10.5%) and cervical spine (8.8% vs 3.3%). Type II MCs were most common and Type III were least common in all groups. The prevalence of lumbar MCs in people with back pain was little affected by the presence of concurrent neck pain, and the same was true for the prevalence of cervical MCs in people with neck pain with or without concurrent back pain. When symptomatic patients were reclassified into two groups (back pain, neck pain), the prevalence of lumbar MCs in people with back pain was greater than that of cervical MCs in people with neck pain. The prevalence of lumbar and cervical MCs increased with age, disc degeneration, (descending) spinal level, and increased kyphosis.

CONCLUSIONS: There is a significantly higher prevalence of MCs in patients with back and neck pain. The reported association with increased kyphosis (flat back) is novel.

GP76
BMPs ENHANCE IN VITRO TISSUE REGENERATION BY HUMAN DEGENERATED NUCLEUS PULPOSUS CELLS
A. Krouwels (1), J.D. Iljas (1), A.H. Kragten (1), S.G.M. Plomp (1), W.J.A. Dhert (1,2), F.C. Oner (1), L.B. Creemers (1);
1 Department of Orthopedics, University Medical Center Utrecht, Utrecht, The Netherlands 2 Department of Equine Sciences, Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands

INTRODUCTION: Bone morphogenetic proteins (BMPs) are known to enhance tissue production by various cell types. In bone regeneration, heterodimeric forms of BMPs were shown to be more effective than homodimers. In this study we investigate which BMP is most suitable for regeneration by human degenerated nucleus pulposus cells, and whether also for these cells heterodimers are more effective than homodimers.

METHODS: Nucleus pulposus (NP) cells from 4 human Thompson grade III donors were cultured for 28 days on collagen II coated filters. Several rhBMPs (BMP2, BMP4, BMP6, BMP7, combinations of BMP2+6, BMP2+7, BMP4+7 and heterodimers BMP2/6H, BMP2/7H and BMP4/7H) were added to the culture. TGF-β2 was included as a positive control. Matrix production as reflected by the amount of glycosaminoglycans (GAGs) was measured with a dimethylmethylene blue assay on papain digests and conditioned medium. DNA content was measured with a Picogreen assay. Statistical analyses included multivariate ANOVA and post-hoc Tukey (* p<0.001, + p ≤0.005, # p≤0.01, ^ p<0.025, $ p<0.05).

RESULTS: Cells cultured with BMP4+7 and BMP4/7H produced the highest amounts GAG/DNA (Figure 1A). The highest total GAG production was observed for BMP4, BMP4+7 and BMP2/7H (Figure 1B). The heterodimer BMP2/7 produced significantly more total GAG than the homodimers combined and BMP2 alone, but was not different from BMP7 alone. No such differences were observed for the BMP2/6H or BMP4/7H. Incorporation of the formed GAGs is most efficient for cells cultured with BMP4/7H, which was significantly higher than cells cultured with, BMP2, BMP7, BMP2+6, BMP2+7 and TGF-β2.

DISCUSSION: BMP4 seems to be the most potent factor for improving matrix production by NP cells in vitro. The
The role of Caveolin-1 in intervertebral disc degeneration and regeneration

Frances C. Bach(1), Lucy Verdonschot(1), Anita Krouwels(2), Alberto Miranda Bedate(1), Laura B. Creemers(2), Björn P. Meiij(1), Keita Ito(2,3), Marianna A. Tryfonidou(1);

(1) Department of Clinical Sciences of Companion Animals, Faculty of Veterinary Medicine, Utrecht University, the Netherlands
(2) Department of Orthopaedics, University Medical Center Utrecht, the Netherlands
(3) Orthopaedic Biomechanics, Department of Biomedical Engineering, Eindhoven University of Technology, the Netherlands

INTRODUCTION: Like humans, dogs suffer from spontaneous intervertebral disc (IVD) degeneration with similar macroscopic, histopathological, and biochemical characteristics. Early canine IVD degeneration is characterized by replacement of notochordal cells (NC) by nucleus pulposus cells (NPC). Microarray analysis has shown that caveolin-1 expression was correlated with IVD degeneration. The aim of this study was to determine the role of caveolin-1 in IVD degeneration/regeneration.

METHODS: Caveolin-1 protein expression and apoptosis levels (TUNEL assay) were determined in IVDs of wild type (WT) and caveolin-1 knockout (KO) mice, and canine IVDs of different degeneration grades. NPC from canine and human early degenerated IVDs were cultured for 28 days in aggregates and treated with chondrogenic medium (incl. TGFα1) alone or in combination with caveolin-1 scaffolding domain (CSD) peptide. DNA, glycosaminoglycan (GAG) content and gene expression profiles were determined.

RESULTS: The NP of WT mice was rich in viable NC, whereas the NP of caveolin-1 KO mice contained significantly less cells with higher apoptotic activity. In canine IVDs, caveolin-1 expression decreased during early degeneration and thereafter increased in later stages of degeneration, together with significantly increased apoptotic activity. CSD did not exert regenerative effects on human or canine NPC in culture.

DISCUSSION: Caveolin-1 plays a crucial role in preservation of NC, underscored by the NP phenotype of caveolin-1 KO mice. Although caveolin-1 expression may be related with cell senescence in canine IVD
degeneration, we cannot exclude that it may still be a useful disease modifying agent since it is known to influence degeneration related signaling pathways. CSD did not exert regenerative effects on NPC, but since caveolin-1 has anti-inflammatory properties, it may exert beneficial effects under inflammatory conditions. This work was supported by an AOSpine Research Network grant (SRN2011_11)

GP78
THE SPECIES-SPECIFIC REGENERATIVE EFFECT OF NOTOCHORDAL CELL-CONDITIONED MEDIUM ON DEGENERATED HUMAN NUCLEUS PULPOSUS CELLS
Frances C. Bach(1), Stefan A.H. de Vries(2), Anita Krouwels(3), Alberto Miranda Bedate(1), Laura B. Creemers(3), Björn P. Meij(1), Keita Ito(2,3), Marianna A. Tryfonidou(1);
(1) Department of Clinical Sciences of Companion Animals, Faculty of Veterinary Medicine, Utrecht University, the Netherlands, (2) Orthopaedic Biomechanics, Department of Biomedical Engineering, Eindhoven University of Technology, the Netherlands, (3) Department of Orthopaedics, University Medical Center Utrecht, the Netherlands

INTRODUCTION: During intervertebral disc (IVD) degeneration, notochordal cells (NCs) are replaced by nucleus pulposus cells (NPCs). NCs secrete factors with considerable regenerative potential, making them an interesting focus for regenerative strategies. The aim of this study was to delineate whether secreted factors from NC-rich NP tissue of different species have a differential regenerative effect on degenerated human NPCs.

METHODS: Histology, DNA and GAG content per mg wet tissue weight of healthy human, porcine, and canine NC-rich NP tissues were compared. NP tissue of each species was cultured for 4 days and NC-conditioned medium (NCCM) was collected. Human NPC micro-aggregates from mildly degenerated IVDs were cultured for 28 days in human, canine, or porcine NCCM. Glycosaminoglycan (GAG) content (corrected for DNA) was determined, and Safranin O/Fast Green staining and gene expression profiling was performed.

RESULTS: Canine and porcine NPs contained more NCs than human NPs and canine NPs had significantly more DNA and GAG per mg tissue weight than human or porcine NPs. NCCM from all tested species significantly increased the DNA content and extracellular matrix production (GAG content) compared with untreated NPCs. Porcine and canine NCCM were significantly more potent than human NCCM in inducing matrix production, but not as potent as TGF-α1.
DISCUSSION: Secreted factors from healthy human, canine, and porcine NC-rich NP tissue have a regenerative effect on mildly degenerated human NPCs, indicating a cross-species effect. Human NCCM was less potent than canine and porcine NCCM generated under identical conditions. The species-specific NP properties appear to influence the regenerative capacity of NCCM on NPCs. This work was supported by an AOSpine Research Network grant (SRN2011_11).

GP79

IS PREGNANCY RELATED TO DISC DEGENERATION AND LOW BACK PAIN?? -A PROSPECTIVE COHORT STUDY-
Hiroto Makino, Yoshiharu Kawaguchi, Shoji Seki, Taketoshi Yasuda, Kayo Suzuki, Tomoatsu Kimura; Department of Orthopaedic Surgery, Faculty of Medicine, University of Toyama

INTRODUCTION: Low back pain (LBP) is a major problem in modern society. Lumbar disc diseases (LDDs) are the main cause of LBP. We showed the natural course of lumbar disc degeneration in young students last year. LBP is a serious problem in the perinatal period. In this study, we examined whether pregnancy is associated with disc degeneration.

METHODS: We examined 83 nursing students who entered our university from 1996 to 2003. During their time as a student, we performed the first MRI. The second MRI was performed after graduation when they were working as a nurse. Pregnancy history, during the period between the first and second MRI, was collected via questionnaire. We used Schneiderman’s classification for evaluating disc degeneration on MRI and defined the disc degeneration disease score, or DDD score, as the summation of the degeneration grade at each disc level. Based on the questionnaire data, we divided subjects into two groups: pregnancy (Group P) and no pregnancy (non-P). We evaluated the change in DDD score for each group. Also, we investigated the prevalence of LBP during pregnancy using a questionnaire.

RESULTS: Of 83 nursing students, 45 replied to the questionnaire: 14 had a pregnancy history (Group P), 31 did not (Group non-P). The DDD score was increased from 5.5 to 6.4 in Group P and from 5.8 to 6.6 in Group non-P. There was no significant difference between the two groups in DDD progression (p= 0.34). The level showing worsened Schneiderman’s grade was generally lower (L4-S, L5-S1) disc. Although 9 of 14 pregnant women (64.3%) indicated that LBP appeared or became worse during pregnancy, there was no significant association between the progression of disc degeneration and LBP (p= 0.2).

DISCUSSION: There was no significant association between lumbar disc degeneration and pregnancy; although most pregnant women complain of LBP, there was no significant association between the progression of disc degeneration and LBP.

GP80

THREE-DIMENSIONAL MICRO-COMPUTED TOMOGRAPHY ANALYSIS OF THE INTERVERTEBRAL DISC AFTER LUMBAR FACETECTOMY IN THE RAT
1Fukui D., 2Murata K., 2Shoju S., 2Chang K., 2Yamada K., 2Sato R., 3Naiki M., 4Inoue N., 2Masuda K., 1Kawakami M.;
1Spine Care Center, Wakayama Medical University Kihoku Hospital, Wakayama, Japan 2Department of Orthopaedic Surgery, School of Medicine, University of California, San Diego, CA 3Institute of Bio-Active Science, Nippon Zoki Pharmaceutical Co, Hyogo, Japan 4Department of Orthopedic Surgery, Rush University Medical Center, Chicago, IL

INTRODUCTION: Lumbar facetectomy has been reported to cause hypermobility at
the operated level in a rat model. However, morphological changes of the motion segment associated with facetectomy have not been well studied. The purpose of this study was to evaluate structural changes of the lumbar spine after facetectomy in the rat utilizing three-dimensional (3D) µCT analysis and histology.

**METHODS:** Thirty male SD rats were divided into three groups. In the Sham group (n=13), only exposure of bilateral facet joints at the L4-5 level was performed. In the experimental group (Exp group; n=13), complete resection of bilateral L4-5 facet joints was achieved. Naïve non-operated rats (n=4) were used as controls. At 7 weeks postoperatively, when gait abnormality was seen in the Exp group, all animals were euthanized. The 3D disc height distribution and the 3D mean disc height at the lumbar levels were computed utilizing 3D µCT analyses. Histological changes were scored as reported by Chujo, et al.

**RESULTS:** On µCT images, irregularity of the endplates at the L4-5 segment was observed in the Exp group, but not in the Sham group. Kyphotic changes and increased disc height (p<0.001), with an increased histological score, were seen at the L4-5 level in the Exp group. Disc height at adjacent segments in the Exp group was lower than that in the Sham group (p<0.05). Histological scores were also higher in the Exp group.

**DISCUSSION:** Degenerative changes were observed at the facetectomy level; these may correspond to the previously reported hypermobility after facetectomy. Interestingly, disc height increased at facetectomy levels; the paradoxical increase in disc height with other degenerative changes may have been caused by resection of the multifidus muscle associated with facetectomy, as manifested by kyphotic changes at the operated level. This animal model may be useful to create mechanically-induced disc degeneration without direct tissue damage to the disc.

**GP81**

**CHEMOKINE RECEPTOR ANTAGONISTS CAN INHIBIT MACROPHAGE MIGRATION INDUCED BY ANNULUS FIBROUS AND NUCLEUS PULPOSUS CELLS**

Peng Shi, DDS, PhD 1; Ana V. Chee, PhD 1; David K. Liu, MS 1; Ding Chen, MD 2; Zemin Li, MD 3; Chundo Oh, PhD4; Di Chen, MD, PhD 4; Gunnar B. J. Andersson, MD, PhD 1; Howard S. An, MD 1;

1. Department of Orthopedic Surgery, Rush University Medical Center, Chicago, IL, USA; 2. Department of Ortho-pedics, Xiangya Hospital of Central South University, Hunan, P.R. China; 3. Department of Spine Surgery, First Affiliated Hospital of Sun Yat-Sen, Guangzhou, P.R. China; 4. Department of Biochemistry, Rush University Medical Center, Chicago, IL, USA.

**INTRODUCTION:** Higher levels of inflammatory cytokines and macrophage markers have been detected in the intervertebral discs of patients with disc degenerative disease and discogenic pain. These findings suggest that macrophage recruitment into the disc plays a role in inflammation and back pain. The aims of these studies are to determine 1) changes in chemokine expression in annulus fibrosus (AF) and nucleus pulposus (NP) cells after treatment with interleukin (IL)-1; 2) the correlation of chemokine expression with macrophage recruitment into the disc; and 3) if chemokine receptor antagonists can block macrophage migration.

**METHODS:** NP and AF monolayer cells (isolated from 6 donors) were treated with IL-1 for 24 hours. Protein levels of chemokines were determined using a Luminex multiplex assay. Chemotaxis of human monocytic cells (THP-1) was assayed using 3 µm Transwell inserts and conditioned media of NP and AF cells. Inhibition of macrophage migration was determined
using antagonists of chemokine (C-C motif) receptor-1 (CCR1) and CCR2 (Chemo-Centric).

**RESULTS:** Compared to the untreated controls, IL-1 treated NP and AF cells produced higher amounts of chemokines: chemokine (C-C motif) ligand (CCL)2 (178- and 193-fold), CCL3 (from undetectable to 831 and 447 pg/mL) and CCL5 (126- and 165-fold), respectively. Conditioned media from IL-1 treated cells were able to induce a 6-fold higher migration rate of THP-1 cells than the controls. Macrophage migration was inhibited by 60% in presence of CCR1 antagonist and 94% in the presence CCR2 antagonist.

**DISCUSSION:** These studies show that NP and AF cells express chemokines that attract macrophages into the disc. Migration of monocytes can be induced by the chemokines released from NP and AF cells treated with IL-1 which can be blocked by either CCR1 or CCR2 antagonists. These results suggest that antagonists against CCR1 and CCR2 may be used as potential therapeutic agents to inhibit macrophage migration into the disc.

**GP82**

**REVASCULARIZATION OF LUMBAR INTERVERTEBRAL DISC ALLOGRAFT AFTER TRANSPLANTATION**

Yong-Can Huang1, Jun Xiao2, William W. Lu1, Victor Y.L. Leung1, Keith D.K. Luk1;
1Department of Orthopaedics and Traumatology, The University of Hong Kong, Pokfulam, Hong Kong SAR, China; 2Department of Joint Surgery, Nanfang Hospital, Southern Medical University, Guangzhou, China

**INTRODUCTION:** The normal intervertebral disc is avascular and completely fed by the surrounding vasculature. During transplantation, the nutrient pathway of disc allograft was suspended completely, which probably led to loss of nutrient supply and therefore allograft degeneration. Revascularization of disc allograft is the pre-requisite for nutrient reestablishment. Nevertheless, little is known as to whether the host vasculature could reach and nourish a disc allograft. Therefore, the aim of this study was to focus on the revascularization of the disc allograft after transplantation in a goat model, which in turn enabled the understanding of how the nutrient pathway was re-established.

**METHODS:** Twenty male goats were used in this study, with 5 goats as disc allograft donors and the remaining 15 goats as allograft recipients. Disc allograft transplantation without internal fixation was performed at L4/L5. Five goats were sacrificed at 1.5, 6 and 12m postoperatively respectively. The transplanted segments were harvested, fixed, sagittally cut and decalcified for H&E staining to observe the blood vessel formation at the endplate area, anterior outer annulus area, posterior outer annulus area, inner annulus area, and nucleus area. The blood vessel density and the vessel area were then measured.

**RESULTS:** Blood vessels were first found in the marrow space of the bony endplate and the outer annulus at 1.5 month postoperatively. Then, they were able to penetrate to reach the cartilaginous endplate and the inner annulus after 6 months. Interestingly, the endplate area possessed the most abundant blood vessels, with the highest level of vessel density and area at the final follow-up. None of these newly formed vessels invaded the nucleus area during the observation period.

**DISCUSSION:** Revascularization of the postoperative disc allograft was determined. But revascularization is not equivalent to the reestablishment of nutrient diffusion in the disc allograft, which needs further investigation.
GP83
MITOCHONDRIAL MEMBRANE POTENTIAL, NUCLEAR SIZE AND GENE EXPRESSION CHANGES DURING HUMAN DISC CELL APOPTOSIS: IN VITRO AND IN VIVO ANNULUS FINDINGS
Helen E. Gruber, Ph.D., Gretchen L. Hoelscher, M.S., Synthia Bethea, B.S., and Edward N. Hanley, Jr., M.D.; Department of Orthopaedic Surgery, Carolinas Medical Center, Charlotte, N.C. U.S.A.

INTRODUCTION: Mitochondrial-dependent intrinsic signaling pathways are well-recognized components of apoptosis (programmed cell death). Disc cell apoptosis is important because it leads to decreased cell numbers. Our objective was to further explore and define mitochondrial mechanisms related disc cell apoptosis in the human annulus.

METHODS: IRB-approved research first used high content screening to study nuclear morphology/mitochondrial membrane potentials in cultured annulus cells; these findings led us to then evaluate disc tissue gene expression related to loss of mitochondrial membrane integrity, decreased mitochondrial membrane potentials, and links to proinflammatory cytokines.

RESULTS: Cultured cells showed significantly increased nuclear size (an indicator of apoptosis) with increasing Thompson grade (p=0.00001). A significant negative correlation for mitochondrial potential (resulting from the difference in the electrical potential generated by the electrochemical gradient across the inner mitochondrial membrane) vs. Thompson grade was identified in cultured human annulus cells in control conditions (r²=0.356, p=0.0001; Figure 1). Cells exposed to the K+ ionophore valinomycin (at sub-lethal levels to induce apoptosis) showed significant reduction in mitochondrial potential vs. control cells. More degenerated Thompson grade IV/V discs vs. healthier grade I-III discs showed significant upregulation of genes with recognized apoptosis roles in mitochondrial potential decline (p53, ITM2B, beta macroglobulin and cathepsin B) and TNF-α associations (cathepsin B, RAC1 and PPT1).

DISCUSSION: Studies confirmed in vivo expression of apoptosis-related genes associated with loss of mitochondrial membrane integrity and decreased mitochondrial membrane potential with increasing Thompson scores. These data, consistent with our novel in vitro findings, stress the importance mitochondrial changes related to apoptosis and TNF-α during disc degeneration.

GP84
BLOCKING THE FUNCTION OF INFLAMMATORY CYTOKINES AND MEDIATORS BY USING IL-10 AND TGF-BETA: A POTENTIAL BIOLOGICAL IMMUNOTHERAPY FOR INTERVERTEBRAL DISC DEGENERATION
Wei Li; Chun Chen; Zhiwei Jia; Xuedong Bai; DiKe Ruan; Department of Orthopedics, Navy General Hospital, Beijing 100048, China

INTRODUCTION: The debilitating effects of lower back pain are a major health issue worldwide. A variety of factors contribute to this, and oftentimes intervertebral disc degeneration (IDD) is an underlying cause
of this disorder. Inflammation contributes to IDD, and inflammatory cytokines play key roles in the pathology of IDD. This study characterized the potential to suppress inflammatory cytokine production in degenerative intervertebral disc (NP) cells by treatment with IL-10 and TGF-beta in a canine model of IDD.

**METHODS:** IDD was induced surgically in six male beagles, and degenerative NP cells were isolated and cultured for in vitro studies on cytokine production. Cultured degenerative NP cells were divided into four experimental treatment groups: untreated control, IL-10-treated, TGF-beta-treated, and IL-10- plus TGF-beta-treated cells. Cultured normal NP cells served as a control group. TNF-alpha expression was evaluated by FACS analysis and ELISA; moreover, ELISA and real-time PCR were also performed to evaluate the effect of IL-10 and TGF-beta on NP cell cytokine expression in vitro.

**RESULTS:** The major findings of these analysis are that after treatment with IL-10 and TGF-beta, the expression of extracellular and intracellular TNF-alpha and IL-1beta was suppressed, while the expression of inflammatory cytokines in untreated normal NP cells was significantly lower than that in untreated degenerative NP cells. Our results demonstrated that IL-10 and TGF-beta treatment suppressed the expression of TNF-alpha and IL-1beta and inhibited the development of inflammatory responses.

Furthermore, their combined use produced a higher level of inhibition of TNF-alpha and IL-1beta than either TGF-beta or IL-10 alone. IL-10 and TGF-beta should be evaluated as therapeutic approaches for the treatment of lower back pain mediated by IDD.

**GP85**

**MEASURES OF PARTICIPATION IN LOW BACK PAIN: A REVIEW**

McKillop, A.B., Battié, M.C.; Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, AB, Canada

**INTRODUCTION:** Outcome measures in LBP research generally can be divided into three broad domains according to the International Classification of Functioning, Disability and Health (ICF) framework of the WHO, which include body structures/functions (e.g. Pain VAS), activities (e.g. Oswestry Disability Index), and participation. While some argue that participation (e.g. engaging in valued social roles) is the most important outcome domain to individuals, particularly with chronic health problems, it is seldom measured in LBP, with the exception of work status. There appears to be little awareness of appropriate outcome measures of participation. The aim of this review was to identify measures of participation appropriate for use in individuals with LBP.

**METHODS:** A thorough search for reviews of participation measures used for any medical condition was conducted. Guided by the ICF, each measure identified was screened to determine if it fell within a predefined conceptualization of participation. Measures were not included if they were not easily accessible, deemed to have high participant burden or included items specific to conditions other than back pain.

**RESULTS:** Of the 127 measures identified, 9 were deemed relevant for individuals with
LBP, including Nottingham Health Profile (Part 2), Participation Objective Participation Subjective instrument (Participation Objective portion), PAR-PRO, Late-Life Function and Disability Instrument (disability component), Work and Social Adjustment Scale, Participation Assessment with Recombined Tools-Objective, Utrecht Scale for Evaluation of Rehabilitation-Participation (Frequency and Restrictions subscales), Community Integration Questionnaire, and Adelaide Activities Profile. Each has strengths and limitations to consider. DISCUSSION: This review identified 9 measures of the important outcome domain of participation deemed appropriate for individuals with LBP, which could enhance outcome measurement in patients with LBP.

GP86
THE RELATION OF SOCIAL SUPPORT AND DEPRESSION IN PATIENTS WITH CHRONIC LOW BACK PAIN
McKillop A.B, Carroll L.J, Jones C.A., Battié M.C.; Faculty of Rehabilitation Medicine and School of Public Health, University of Alberta, Edmonton, AB, Canada

INTRODUCTION: Depression is a common condition in those with low back pain, and is associated with poorer patient outcomes, such as greater disability, increased pain levels and chronicity. Social support is a modifiable factor that may influence depressive symptoms in people with low back pain and, if so, could be a consideration in low back pain management when depression is an issue. The aim of the present study was to examine social support as a prognostic factor for depressive symptoms and recovery from depression in patients with low back pain problems.

METHODS: Patients with chronic low back pain (n=508), recruited from four imaging centres in Alberta, Canada, completed an initial survey following imaging, with follow-up survey approximately one year later. Social support was measured by the Medical Outcomes Study Social Support Survey and depressive symptoms were measured by the Centre for Epidemiologic Studies Depression Scale. Other demographic and health data were also collected and possible confounding factors were considered. Multivariable linear and logistic regression analyses were used to examine the relationship between social support and depression. RESULTS: More social support (overall functional social support) at baseline was associated with less depressive symptoms (?=1.68 95% CI 0.36, 3.00) and recovery from depression (OR=0.25 95% CI 0.11, 0.59) at one-year follow-up. In addition, associations were found between specific aspects (subscales) of social support - emotional/informational support and tangible support - and these two depression outcomes.

DISCUSSION: This study provides evidence that greater social support is associated with less depression one year later. Since social support is potentially modifiable, more research is needed to better understand this relationship as it relates to chronic low back pain management.

GP87
AN EPIDEMIOLOGIC STUDY FOR PARA-SPINAL MUSCLE ATROPHY OF THE LUMBAR SPINE IN THE COMMUNITY
Otani K, Kikuchi S, Yabuki S, Nikaido T, Watanabe K, Kato K, Shida T, Konno S; Dept. of Orthopaedic Surgery, Fukushima Medical University School of Medicine, Fukushima City, Japan

INTRODUCTION: It is considered that paraspinal muscle atrophy should affect spinal malalignment. However, there is still unknown the detail of paraspinal muscle atrophy etiology. The purpose of this study was to clarify the epidemiology for
paraspinal muscle atrophy of the lumbar spine in the community.

**METHOD:** 207 people in community individuals agreed to participate in this study. They were received conventional MR imaging of lumbar spine (T1 sagittal, T2 sagittal and axial). Fatty degeneration of paraspinal muscle was evaluated by three grades (none, slight, severe) (Kim 2013). Paraspinal muscle atrophy was evaluated by T-back value (Takayama 2012). And other anatomical factors such as vertebral fracture (Genant 1993), endplate change (Viedeman 1995) and DDD score (Kawaguchi 1999, Cheung 2006) were also assessed.

**RESULT:** 1) Fatty degeneration of paraspinal muscle stared in 50 years. Around 50% of 70 years was evaluated as severe. 2) Paraspinal muscle atrophy suddenly increased in 70 years. Around one fourth was evaluated as presence of atrophy. 3) Fatty degeneration and atrophy of paraspinal muscle were severer in female. 4) Number of vertebral fracture, endplate change and DDD score did not have any influence on fatty degeneration and atrophy of paraspinal muscle.

**DISCUSSION AND CONCLUSION:** In order to keep spinal alignment through prevention of paraspinal muscle atrophy, intervention might be needed in 50 years or before. Further study is needed such as how to prevent paraspinal muscle atrophy.

**GP88**

**EVALUATION OF AN AUTOMATED COMPUTER-BASED MEASUREMENT OF PFIRRMANN GRADE IN INTERVERTEBRAL DISCS FROM SPINAL MRI**

Meelis Lootus, Timor Kadir, Andrew Zisserman, Iain McCall, Jill Urban, Jeremy Fairbank; Oxford University, Oxford University, Oxford University, Keele University, Oxford University, Oxford University

**INTRODUCTION:** The Pfirrmann classification is an established technique to grade intervertebral disc degeneration, however inter- and intra-observer variability of the grading is a challenge. We propose a fully automated, computer-based system for Pfirrmann grading on clinical MRI offering a quantified second opinion to clinicians, and spine researchers.

**METHODS:** The computer program automatically finds all the vertebrae and discs, then assigns a grade based on the disc intensity histogram, and the disc height. The program was evaluated using discs from MRIs of 114 symptomatic back pain spines from the European Genodisc cohort giving a total of 684 discs. The scans originate from patients from multiple hospital sites, using a wide range of scanners and protocols. Pfirrmann grades (1-5) were marked by an expert radiologist.

**RESULTS:** Example results are seen in Fig. 1. The program produces grades that are within one grade of the radiologist’s grading in 85.8% of all discs. The program runs on a regular laptop and provides the results in under 1 sec.

**DISCUSSION:** The results indicate that the computer program can produce gradings close to those of the expert radiologist in most cases. One limitation of our study is that expert grading was performed by one radiologist. We could improve this by using more experts and obtaining a consensus. Another limitation is that the grades were only evaluated to within ±1 Pfirrmann grade, in effect reducing the 5 grades to 3. This was done to limit the effect of variability in the radiological mark-up. Nevertheless, the system could still output the full range of Pfirrmann grade, and in addition, provide a continuous score from 1-5, which could be clinically useful in addition to the quantized score. Our results indicate that an automated computer-based method might be able to provide quantitative disc grades to assist a
radiologist with image assessment. This would be useful to reduce intra- and inter-radiologist variability.

**GP89**

ATHLETICS AND LOW BACK PAIN: RESULTS OF A CROSS-SECTIONAL STUDY

Fabio Zaina (1), Sabrina Donzelli(1), Sara Scirè (2), Monia Lusini (1), Salvatore Minnella (1), Stefano Negrini (3)/(4);

(1) ISICO (Italian Scientific Spine Institute), Milan, Italy (2) Università Cattolica del Sacro Cuore, Milan, Italy (3) University of Brescia, Italy (4) IRCCS Don Gnocchi, Milan, Italy

**INTRODUCTION:** Low back pain (LBP) is frequent in professional and competitive sport with prevalence relying also on the kind of sport, while recreational activity can be protective from pain. The aim of the present study is to compare the prevalence of LBP in competitive athletes with respect to recreational athletes.

**METHODS:** We designed a cross-sectional study. A convenience sample of 240 subjects was selected: 160 competitive Athletics athletes (AA Group; 80 women) were compared to 80 recreational athletes (RA group; 40 women) of the same age (25y). We proposed a questionnaire to collect data on LBP. AA was divided in 4 subgroups for a further explorative analysis each made of 20 males and 20 females: throwing Group (TG), Jumping (JG), Endurance Running (EG) and Fast Running (FG). Odds ratios (OR) and 95% Confidence Interval (95CI) have been calculated, logistic regression was performed.

**RESULTS:** Competitive athletes have not a higher likelihood of developing LBP with to recreational athletes. In the AA group LBP was more likely to arise in males (OR 1.98, CI95% 1.14-3.46). Subgroup analysis: jumpers, speed runners and throwers are more likely to experience LBP during athletic preparation periods (OR respectively resulted 4.82, 3.2, 2.6; CI95% respectively 2.1-11.3; 1.4-7.6 and 1.1-6.2). Jumpers and throwers are more prone to avoid training due to LBP (OR 2.94 and 2.40 CI95%1.3-6.5 and1.1-5.3 respectively)

**DISCUSSION:** Competitive and recreational athletics athletes show similar risks of LBP. Nevertheless, the subgroup analysis suggests each activity to have a different impact on pain. The training phase seems also relevant in predicting LBP, probably due to the higher level of work typical of such training phases. In the light of the present findings the need for larger studies rises, aiming to deepen these issues with a more detailed subgroup analysis.

**GP90**

AUTOMATED COMPUTER-BASED RANKING OF HERNIATED/BULGED DISCS IN SPINAL MR IMAGES

Meelis Lootus, Timor Kadir, Andrew Zisserman, Jill Urban, Jeremy Fairbank, Iain McCall; Oxford University, Oxford University, Oxford University, Keele University, Oxford University, Oxford University

**INTRODUCTION:** We measure severity of herniation/bulge using a fully automatic computer based program ranking the cases purely by their morphological severity.

**METHOD:** We evaluate the accuracy of the automated computer assistance system using clinical sagittal MRI scans. We performed experiments on intervertebral discs in spinal MR images from 129 symptomatic back pain spines from in the
European Genodisc cohort. 774 lumbar discs were marked by an expert radiologist with labels for bulge and herniation. The patients originate from multiple sites, and exhibit a number of radiological findings. The computer system operates completely automatically by locating the vertebrae and discs and then producing a score of bulge/herniation for later ranking or categorization into either bulged/herniated, or normal. The experiments were performed on discs from T12/L1 to L4/L5 levels.

RESULTS: The system categorized correctly 80.4% of the discs on bulge/herniation vs. normal categorization. Figure shows discs ranked from least severe to most severe.

DISCUSSION: The proposed system runs on a regular laptop and provides the result within a fraction of a second. It has the potential to be used within back pain research as a tool to facilitate imaging phenotype assessment. The system works across different patient ages, and images from different hospital sites and scanners. One limitation of the current work is that herniation and bulge are considered as one category despite the limited clinical utility of bulges. This is because we base the analysis only on the sagittal slices. In future, we can incorporate axial slices into the program to potentially distinguish herniations from bulges. Another limitation is that the assessments of only one expert radiologist were used as ground-truth in both the development and testing of the system. Our results indicate that a computer based system might be utilized automatically to assess spinal MR images as an aid for radiology reporting.

GP91
A FRAMEWORK FOR THE AUTOMATED RADIOLOGICAL MEASUREMENT OF SPINES FROM MRIS
Meelis Lootus, Timor Kadir, Andrew Zisserman, Iain McCall, Jill Urban, Jeremy Fairbank; Oxford University, Oxford University, Oxford University, University of Keele, Oxford University, Oxford University

INTRODUCTION: We propose a framework for the automated extraction of a number of radiological measurements from lumbar MRIs. The framework aims to provide objective, automated quantification of a range of structures of interest. Analogous frameworks exist in other fields, for instance in brain analysis. As an illustration of the capabilities of the framework, we present results automatically measuring narrowing, Pfirrmann grade, and herniation/bulge. Such measurements can, for example, facilitate the development of objective and consistent imaging phenotypes within the context of large research studies but ultimately lead to clinical application.

METHODS: The framework takes as input a clinical spine MRI, and gives a number of outputs, see Fig. 1: boxes around vertebrae, delineations of vertebrae, discs, and dural sac; and various radiological measurements of the discs. The framework was used to automatically analyse the spinal MRIs from 129 symptomatic back pain spines from the European Genodisc cohort and detect the presence of disc narrowing, herniation/bulges and assess Pfirrmann grade. An expert radiologist manually assessed each of 1800 discs and this was used as the ground-truth. As an example, the Pfirrmann grade was
assessed to within +/- 1 grade of the radiological assessment.

RESULTS: We present details of Pfirrmann and herniation/bulging in separate abstracts. The framework achieves accuracies of 83.7% for narrowing detection, 87.4% for Pfirrmann grade and 80.3% for bulge/herniation detection. The system ope-rate in less than a second on a standard laptop.

DISCUSSION: The proposed framework has the potential to provide researchers with an efficient and objective tool for the analysis of large cohorts of MR images. Applications might include the development and assessment of imaging biomarkers in back pain research, but ultimately with sufficient development, validation and trial the framework could be used to develop clinical decision support tools.

GP92
CAN POSTURAL CUING SELECTIVELY INCREASE LOCAL EXTENSOR ACTIVATION DURING LUMBAR REHABILITATION EXERCISES IN PERSONS WITH CHRONIC OR RECURRENT LOW BACK PAIN? AN EMG ASSESSMENT USING FINE WIRE ELECTRODES
George Beneck, Paul Keri, David Weberg;
Department of Physical Therapy, California State University Long Beach, Long Beach, CA

INTRODUCTION: Localized impairment of lumbar multifidus (LM) size and activation is common among persons with low back pain (LBP). However, rehabilitation exercises generally activate across lumbar extensors. Selective activation of lower LM was recently shown using a short lordosis posture. The purpose of this experiment was to determine if postural cuing using a short lordosis during lumbar rehabilitation exercises will increase lower LM activation without concurrently increasing global extensor activation in persons with chronic or recurrent LBP.

METHODS: Nine persons with chronic or recurrent LBP were trained in 10 lumbar rehabilitation exercises with and without short lordosis (SL) over four sessions. Following training, bilateral intramuscular recordings of the L5 deep multifidus (DM) and the T12 longissimus thoracic (LT) were performed during randomly ordered rehabilitation exercises with and without SL. EMG signals were sampled at 2000 Hz and high pass filtered at 10 Hz. The root-mean-square of the EMG signal was normalized to the root-mean-square of the highest one second of a maximum voluntary isometric contraction (MVIC). A 3-way repeated measures ANOVA (muscle x posture x exercise) was performed.

RESULTS: A main effect for posture (P<0.002) indicated that using a SL increased activation across muscles. A muscle x posture interaction (p=0.016) indicated
that subjects selectively increase DM activation using a SL. When averaged across the ten exercises, using a SL resulted in higher DM activity in contrast to performing the exercises in the standard manner (40.6±16.6% vs 47.0±17.3% MVIC). Activation of LT only increased from 35.4±13.9 to 37.0±15.9% MVIC with SL.

**DISCUSSION:** This analysis indicates that using a SL during lumbar rehabilitation exercises may better promote recovery of normal multifidus function in persons with LBP than traditional rehabilitation exercises alone. This more targeted intervention has the potential to improve clinical outcomes.

**GP93**

**COULD DURAL SAC CROSS-SECTIONAL AREA (DCSA) ON MRI PREDICT LSS SYMPTOM FOR SIX-YEAR FOLLOW-UP?**

*Otani K, Kikuchi S, Yabuki S, Nikaido T, Watanabe K, Kato K, Shida T, Konno S; Dept. of Orthopaedic Surgery, Fukushima Medical University School of Medicine, Fukushima City, Japan*

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

**METHOD:** Initially, 459 people in community individuals agreed to participate in this study. They were interviewed and received conventional MR imaging of lumbar spine. The presence of LSS was assessed by a specially designed questionnaire (Konno S, BMC Musculoskellet Disord. 2007). The dural sac cross-sectional area (DCSA) of L1/2 - L5/S1 on T2 weighted image was measured by using conventional method (Hamanishi C, JSD 1994). Leg symptom intensity was evaluated as leg pain or numbness by a 10-point numerical rating scale (NRS). The Roland-Morris Disability Questionnaire (RDQ) was used to measure disease-specific disability. After six years, 232 people (male:73, female:159) (follow-up rate 50.5%) could be assessed for LSS using the same questionnaire. 8 people received operation caused by LSS. These participants were included in LSS positive at six-year follow-up.

**RESULTS:** At six years follow-up, 57 participants were judged as LSS positive. 12 of 52 participants (23.1%) were judged as LSS positive at the initial analysis and 45 of 180 participants (25%) were newly appeared for LSS positive for six years. By a multiple logistic regression analysis, only NRS of leg symptom at the first year statistically influenced on the presence of LSS positive at six-year follow-up (Odds ratio 4.925). Magnitude of dural tube compression was not detected as a predictive factor for the presence of LSS.

**DISCUSSION AND CONCLUSION:** At least for six-year follow-up, magnitude of dural sac cross-sectional area did not predict the presence of LSS directly. There is still unclear influence of anatomical dural tube compression on the presence of LSS symptom.

**GP94**

**DOES PHYSICAL THERAPY AFFECT THE PHYSICAL FUNCTION AND RADIOGRAPHIC PARAMETERS IN PATIENT WITH SAGITTAL IMBALANCE?**

*Atsunori Yuasa, PT; Masahiro Kanayama, MD; Tomoyuki Hashimoto, MD; Fumihiro Oha, MD; Akira Iwata, MD; Shingo Onda, MD; Kaoru Tashiro, MD; Spine Center, Hakodate Central General Hospital, Hakodate, Japan*

**INTRODUCTION:** Surgical intervention such as spinal osteotomy is emphasized in the treatment of sagittal imbalance. However, it remains unclear whether or not physical
therapy could be a treatment option for sagittal imbalance. The objective of this study is to evaluate the efficacy of physical therapy on the physical function and radiographic parameters in patients with sagittal imbalance.

METHODS: Eleven patients who underwent physical therapy for sagittal imbalance were reviewed. They were 2 males and 11 females with a mean age of 76 years old. Physical therapy program included (1) range of motion (ROM) exercise for knee and hip joints, (2) muscle strength training for lower extremities, (3) postural control exercise and (4) locomotion training. Clinical and radiographic evaluations were performed before treatment and after 3-week program. Clinical outcome measures were hip and knee ROMs, maximum walking speed for 10-m distance, 6-minute walking distance, and visual analog scale of back pain. Radiographic parameters included anterior deviation of C7 plumb line (C7PL) and pelvic tilt (PT).

RESULTS: Hip and knee extension ROMs were improved from -6.4+/−8.1 to +7.7+/−5.6 degrees (p<0.001) and -11.3+/−7.1 to -5.5+/−4.7 degrees (p<0.001), respectively. VAS of back pain was 61+/−21 before treatment and 46+/−28 after the program. Maximum walking speed and 6-minute walking distance were also improved from 13.5+/−5.8 to 10.3+/−2.5 seconds (p=0.023), and 189+/−141 to 250+/−136m (p=0.014), respectively. Radiographic parameters did not significantly change after the program: 14.6+/−4.4 to 12.1+/−6.4 cm in C7PL, and 38.4+/−11.9 to 37.1+/−11.3 degrees in PT.

DISCUSSION: The current physical therapy program improved hip and knee ROMs and walking capacity in patients with sagittal imbalance. However, back pain relief was limited. As well, physical therapy provided no effect on the radiographic parameters regarding sagittal imbalance and pelvis retroversion.

GP95
MRI FEATURES OF DISC DEGENERATION AND VERTEBRAL FRACTURE IN PATIENTS WITH DEGENERATIVE LUMBAR PARASPINAL MUSCLES

Kazushi Takayama, Teruo Kita, Akito Yabu, Kazuya Nishino, Hideki Sakanaka, Yoshihi Yamano, Hiroaki Nakamura;
Dept. of Orthopaedic Surgery, Seikeikai Hospital, Osaka, Japan; Dept. of Orthopaedic Surgery, Osaka City University Graduate School of Medicine, Osaka, Japan

INTRODUCTION: From our previous MRI study, we reported that age-related decrease of the cross-sectional area of the lumbar paraspinal muscles could be easily assessed using visualization of the groove between the paraspinal muscles as an indicator, and that the lumbar lordosis was significantly decreased in patients in whom the groove could not be visualized. In this study, we compared the severity of disc degeneration and frequency of existing vertebral fracture which could have an influence on the age-related lumbar spinal degeneration and the spinal alignment, between patients with and without paraspinal muscle atrophy.

MATERIALS AND METHODS: The paraspinal groove was absent in 141 of 704 patients who underwent MRI of the lumbar spine during the 1-year study period. Of the 141 patients in whom the paraspinal groove could not be visualized, the 120 patients who were aged 60 years or over (40males, 80females; mean age, 73years) were included in this study, together with 120 patients matched for age and sex, in whom the paraspinal groove could be visualized. The body mass index (BMI) and lumbar lordosis (L1 to S1) on T2-weighted sagittal MR images were measured. The severity of the disc degeneration at L1/2 to L5/S was semiquantitatively evaluated using the Pfirrmann grading scale (Grade I to V scored from 1 to 5; a higher score indicates more severe degeneration). Old
vertebral fracture, nonunion, or vertebral collapse at Th11 to L5 was considered as existing vertebral fracture.

**RESULTS:** Patients with paraspinal atrophy had a significantly lower BMI and a significantly decreased lumbar lordosis. Furthermore, disc degeneration was significantly more severe (mean score, 4.0 vs. 3.5; p < 0.01) and existing vertebral fracture was more frequent (27.5% vs. 8.3%) in this group of patients.

**CONCLUSION:** These results suggest that paraspinal muscle atrophy may be associated with advanced disc degeneration and decreased lumbar lordosis due to existing vertebral fracture.

**INTRODUCTION:** The painDETECT questionnaire (PDQ) is one of the screening tools for neuropathic pain (NeP). However, the evaluation of NeP due to lumbosacral spine disease (NeP-LD) is considered to be difficult using any screening tools. The purpose of this study was to develop a screening tool of “Spine PainDETECT” distinguishing NeP-LD efficiently.

**METHODS:** A total of 85 patients diagnosed with lumbosacral spine disease, who have NeP with mild to severe pain intensity for more than three months participated. As a control group, 45 patients with joint disease categorized as having nociceptive pain were enrolled. It enforced the Japanese version of PDQ in all participants and conducted following analysis. First, we calculated respective weight coefficients of the 9 PDQ-items by the discriminant analysis to discriminate NeP-LD from nociceptive pain efficiently. Secondly we performed the discriminant analysis using the stepwise method to set simpler weight coefficients of the PDQ items.

**RESULTS AND DISCUSSION:** 1. The weight coefficients of the respective PDQ items for screening of NeP-LD and the constant term were calculated (table 1). By applying the resultant discriminant function, we could classify the participants’ pain complaint as NeP-LD, if the numerical value of the discriminant function was >1, or nociceptive pain if it was <1. The area under the ROC curve was 0.79 for decision cut-off point. This cut-off point showed 84.4% sensitivity and 70.6% specificity for diagnosis of NeP-LD. The sensitivity was good as a screening tool. 2. We further calculated much simpler weight coefficients of the PDQ only for “electric shock-like pain” and “numbness” items and the constant term to screen NeP-LD (table 1). The area under the ROC curve was 0.79 for decision cut-off point. This cut-off point showed 82.3% sensitivity and 66.7% specificity for diagnosis of NeP-LD.
CONCLUSION: We successfully developed the efficient screening tool Spine Pain-DETECT for NeP-LD.

GP97
HOW TO DIFFERENTIATE RADICULOPATHY FROM MONONUEROPATHY MULTIPLEX: CHURG-STRAUSS SYNDROME INITIALLY DIAGNOSED AS LUMBAR DISC HERNIA OR LUMBAR SPINAL CANAL STENOSIS
Kosei Nagata, M.D.;
Department of Orthopaedic Surgery, Yokohama Rosai Hospital

BACKGROUND: Churg- Strauss syndrome (CSS) is a rare systemic vasculitis and difficult to diagnose because small size clinics have limits on image studies or blood tests. CSS contains a lot of symptoms including peripheral dysesthesia caused by mononeuropathy multiplex which are similar to radiculopathy of lumbar disc hernia(LDH) or lumbar spinal canal stenosis(LSCS). Therefore, CSS patients with mononeuropathy multiplex often visit to orthopaedic clinics. However, orthopaedic doctors or spine neurosurgeons have little knowledge to make a diagnosis of CCS. The purpose of this report is finding out cost-effective making a diagnosis of CSS with neuropathy.

METHOD: Our study is retrospective review of a consecutive series of patients who introduced to our department by other clinics from March 2006 to April 2013, fulfilling the American College of Rheumatology diagnosis criteria for CSS. Five patients were matched this criteria and they were initially diagnosed as LDH or LSCS by at least two medical institutions. The following period was from one to seven years.

RESULT: We shortened the duration of diagnosis from 49 days to one day. All patients had past histories of asthma or eosinophilic pneumonia. Laboratory data showed abnormally increased eosinophil counts. Nerve conduction study of all patients revealed axonal damage patterns. All patients’ paralysis recovered to the useful level after high dose steroid treatment.

DISCUSSION: White blood cell count is useful as a screening test of CSS, not antineutrophilic cytoplasmic antibody. The combination of image studies and nerve conduction study is an important diagnostic method of CSS. Orthopaedic doctors should not hesitate to check laboratory data in front of patients with paralysis of lower extremities and past history of treatment-resistant asthma.

GP98
OPTIMAL CONDITION OF HEPARIN-CONJUGATED FIBRIN WITH BONE MORPHOGENETIC PROTEIN-2 FOR SPINAL FUSION IN A RABBIT MODEL
Jae-Young Hong1 MD PhD; Sun-Woong Kang2 PhD; Jung-Wook Kim1 MD; Seung-Woo Suh3 MD PhD; You-Jin Ko1 MS; Jung-Ho Park1 MD PhD.;
1Department of Orthopedics, Korea University Ansan Hospital, Ansan, South Korea; 2Next-generation Pharmaceutical Research Center, Korea Institute of Toxicology, Daejeon, Republic of Korea; 3Scoliosis Research Institute, Department of Orthopedics, Korea University Guro Hospital, Seoul, South Korea.
INTRODUCTION: Heparin-conjugated fibrin (HCF) is a carrier for long-term release of bone morphogenetic protein-2 (BMP-2) and has been shown to promote bone formation in animal models. We performed an experimental study to find the optimal dose of BMP-2 with an HCF carrier that promotes bone formation comparable to that of autograft while minimizing complications in spinal fusion.

METHODS: Twenty-four rabbits underwent posterolateral fusion of the L5-6 spinal segments. Different concentrations of HCF BMP-2 (1/10, 1/20, 1/30 or 1/40) were implanted in the spines of experimental rabbits, and autograft or INFUSE was implanted in the spines of controls. Eight weeks after treatment, spinal fusion efficacy was evaluated by plain radiography, micro-computed tomography (micro-CT), mechanical testing, and histomorphometry.

RESULTS: Similar to autograft, the 1/40 HCF BMP-2 showed significant bone formation in micro-CT and histomorphometry with mechanical stability. However, the other HCF BMP-2 concentrations did not show significant bone formation when compared to autograft. Although conventional BMP-2 (INFUSE) led to higher bone formation and stability, it also led to excessive ectopic bone and fibrous tissue formation.

DISCUSSION: This study suggests the optimal concentration of BMP-2 using HCF for spinal fusion, which may decrease the complications of high-dose conventional BMP-2.

GP99
UNILATERAL LUMBAR SPONDYLOLYSIS MOST LIKELY PROCEED TO BILATERAL SPONDYLOLYSIS
Hatakeyama Kenji, Aihara Takato, Urushibara Makoto; Funabashi Orthopedic Hospital

INTRODUCTION: Although adolescent patients with lumbar spondylolysis often complain of unilateral low back pain, the painful side is sometimes contralateral side of pars defect. It may mean that this is the time when unilateral spondylolysis proceed to bilateral spondylolysis. However, there are few reports about this. The purpose of this study was to investigate whether unilateral spondylolysis proceed to bilateral spondylolysis or not.

METHODS: From 2012.4 to 2014.7, 102 adolescent patients (85 men and 17 women, mean age; 14.9 years, range 10 to 18) who came to our hospital and was diagnosed lumbar spondylolysis with both CT and MRI, were included. We retrospectively reviewed both CT and MRI in order to determin their spondylolysis stages: 1) very-early, 2) early, 3) progressive and 4) terminal stage. And we classified the lamina of spondylolysis into three groups; unilateral spondylolysis gorup (U-group), bilateral spondylolysis but different stages at left and right side (BU-group) and bilateral spondylolysis with same stage (B-group). We compared these three groups about the stages of spondylolysis.

RESULTS: The number of lamina with spondylolysis was 111, because 9 patients had spondylolysis at two levels. U-group consisted of 42 lamina, BU-group 43 and B-group 26. The number of lamina at three groups devided by stages was: U-group; 1) n=12, 2) n=26, 3) n=3, 4)n=1, BU-group; n=0, 4, 16, 23, B-group; n=2, 3, 5,16, respectively. There was significant difference between three groups about stages when asessed with multiple comparision
procedure (Steel-Dwass method). Namely, U-group was at less progressive stage than BU-group and B-group (p<0.01), and BU-group less than U-group (p<0.05).

CONCLUSION: In this study, bilateral lumbar spondylolysis were at more progressive stages than unilateral lumbar spondylolysis. This suggests that non-union or non-treatment of unilateral lumbar spondylolysis most likely proceed to bilateral lumbar spondylolysis.

GP100
DETECTION OF STRESS AT THE SACRUM USING BONE SINGLE-PHOTON EMISSION COMPUTED TOMOGRAPHY/ COMPUTED TOMOGRAPHY AFTER INSTRUMENTED LUMBAR FUSION
Young-Hoon Kim, MD, Kee-Yong Ha, MD; Department of Orthopaedic Surgery, Seoul St. Mary’s Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea

INTRODUCTION: The clinical role of bone single-photon emission computed tomography/computed tomography (SPECT/CT) for evaluating strain to the sacrum including sacroiliac joint (SIJ) arthritis and sacrum insufficiency fracture (SIF) after instrumented lumbar or lumbosacral fusion with features of clinical adjacent segment pathology (CASP) has not been established. Objective: To determine the clinical role of bone SPECT/CT to detect stress at the sacrum in patients with CASP after instrumented lumbar/lumbosacral fusion.

METHODS: Sixty-six patients, who were diagnosed with CASP after satisfactory lumbar or lumbosacral fusion from February 2012 to August 2013, were examined by bone SPECT/CT. SIJ arthritis and SIF were defined as anatomic abnormalities along with increased activity lesions. Clinical and functional outcomes were evaluated using the visual analogue scale, the Oswestry Disability Index, and SPECT/CT.

RESULTS: Mean patient age was 67.4 years, and the symptom-free period was 7.6 years after surgery. Mean bone mineral density (BMD) was -3.1. Sixteen of the 66 (24.2%) patients showed hot uptake in the sacrum; 11 had SIJ arthritis (16.7%) and five had SIF (7.5%). Patients showing increased activity in the sacrum (n = 16) tended to be older than those in the normal activity group (n = 50) (p = 0.117). No difference was observed between the two groups regarding fused levels (2.2 vs. 2.3, p = 0.458), BMD (−3.2 vs. −3.2, p = 0.563) or symptom-free period (7.6 years vs. 6.8 years, p = 0.880).

DISCUSSION AND CONCLUSIONS: Symptoms in patients with CASP may be related to SIJ arthritis or SIF. The spine surgeon should evaluate SIJ arthritis or SIF for CASP, and bone SPECT/CT could be a useful screening method to rule out SIJ arthritis or SIF after instrumented lumbar or lumbosacral fusion.

GP101
LOW BACK PAIN IN JUVENILE BASKETBALL PLAYER
Kazuyuki Watanabe, Kenichi Otoshi, Miho Sekiguchi, Kiyomi Tsuda, Shin-ichi Kikuchi, Shin-ichi Konno; 1)Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine 2)Treasure Ring?Basketball Clinic

INTRODUCTION: Low back pain (LBP) is a significant problem not only in the adults, but also in elementary and middle school pupil. Competitive sports activities including basketball are reported to be one of the risk factor of LBP. The purpose of this study was to evaluate the state of LBP and related factors in juvenile basketball players.

METHODS: Three hundred eighty-four basketball players (165 boys, 219 girls, average age: 10.8 years) were included in this study. Current LBP, history of LBP, severity of LBP, and other pain such as
knee pain and ankle pain were examined by self-completed questionnaire. The number of practice days and total time of practice for a week were examined. In physical examination, heel-buttock distance (HBD) and sit-and-reach flexibility were examined for evaluation of flexibility of lower extremity. Statistical analysis was performed by chi-square test, Wilcoxon test, logistic regression analysis. A p-value less than 0.05 was considered significant.

RESULTS: Fifteen players (3.9%) had LBP at examination. The players with current LBP showed higher age, more practice days, more knee pain and ankle pain compared with the players without LBP (p<0.05). Seventy-one players (18.5%) reported history of LBP. They showed higher age, more practice days, more knee pain and ankle pain compared with the players without history of LBP (p<0.05). Ten players had to stop to play basketball due to LBP. They showed decrease of flexibility of anterior thigh compared with the players who could play basketball despite of their LBP (p<0.05).

DISCUSSION: The results of this study showed that juvenile basketball players with LBP were older, had more practice days for a week, and complicated lower extremity pain compared with the players without LBP. These findings indicated that LBP was one of the sign of overuse similar to knee pain and ankle pain. The decrease of flexibility of anterior thigh was considered to relate worsening of LBP.

GP102
SPINO-PELVIC ALIGNMENT IN PATIENTS WITH COMPLETELY DISLOCATED HIPS
Yoshihara T, Morimoto T, Tsukamoto M, Sonohata M, Mawatari M;
Department of Orthopedic Surgery, Faculty of Medicine, Saga University

INTRODUCTION: There are many papers concerning the spino-pelvic sagittal alignment of normal volunteers and patients with certain spinal disorders, osteoarthritis of the hip and the aged spine. However, there have been few reports on the influence of completely a dislocated hip on the sagittal alignment of the spine. The purpose of this study was to compare the spino-pelvic alignment between unilateral and bilateral cases of completely dislocated hips.

METHODS: The subjects included two male and 27 female patients with an average age of 63 years (range, 35 to 80 years) treated by total hip arthroplasty for a completely dislocated hip (Crowe IV). The subjects were divided into a unilateral group (n=13) and bilateral group (n=16). Lateral whole spine radiographs were prospectively taken of all patients before surgery. The parameters of the sagittal spino-pelvic alignment examined were the lumbar lordosis (LL: L1-S1), sacral slope (SS), pelvic lordosis (PR-S1) and the offset between the center of the femoral heads and the sacrum (SFD). If the pelvic radius line was posterior to the vertical line through the hip axis, the angle between the two lines was a negative number; if it was anterior, it was a positive number. The significance of differences among the two groups was evaluated by Student’s t-test. A value of P<0.05 was considered to be significant.

RESULTS: The mean LL, SS, PR-S1 and SFD in the unilateral and bilateral groups were 53.3° and 67.2°, 41.4° and 49.3°, -36.1° and -54.7° and 11.8 mm and 29.3 mm, respectively. There were significant differences between the two groups for the LL and PR-S1 (P<0.05) and for SFD (P<0.01). However, there was no significant difference in the SS between the groups (P=0.210).

DISCUSSION: In the present study, the spino-pelvic parameters in the bilateral group were significantly more severe than those in the unilateral group. This was
because the hip center had markedly shifted in a posterior direction in patients with bilateral completely dislocated hips. The spino-pelvic alignment in patients with completely dislocated hips was compensated for by anterior angulation of the pelvis and by the lumbar hyperlordosis in the standing position.

**GP103**

**THE EFFECTS OF EXTENSION EXERCISE ON DISC MORPHOLOGICAL AND SIGNAL CHARACTERISTICS**

*Vahid Abdollah Msc 1 Eric C Parent PT PhD 2 Michele Crites Battillé PT PhD 3;*

1 PhD Student, Department of Physical Therapy, Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, AB, CA 2 Associate Professor, Department of Physical Therapy, Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, AB, CA 3 Professor & Canada Research Chair in Common Spinal Disorders, Department of Physical Therapy, Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, AB, CA

**INTRODUCTION:** Lumbar extension has been shown to increase disc height and reduce disc bulging, and is hypothesized by McKenzie exercise therapists to assist with recentering nucleus material. The aim of this study was to determine the immediate effect of extension exercises on morphological and signal characteristics of the disc using precise, quantitative MRI measures in patients with low back pain.

**METHODS:** Mid-sagittal T2-weighted MR images of 22 subjects with low back pain (43±13yrs) and an Oswestry disability score of over 25% were analyzed. The levels analyzed exhibited substantial degeneration in the majority of subjects. Images were obtained in supine using a 3T MRI scanner before and after 3 sets of 10 repetitions of prone extension exercises, followed by 10 minutes in supine extension. Image analysis was conducted offline using custom MATLAB image analysis software. Two lines tangential to the endplates were drawn above and below the disc, and signal intensity variations across the neighbouring structures were used to semi-automatically segment each disc into 2 ROIs at L4-5 and L5-S1: whole disc, and nucleus. Images were measured twice. Mean intensity and area of the whole disc and nucleus, disc height at 80% of the disc width and motion segment angle were measured. Paired-t-tests were used to test for post-exercise differences.

**RESULTS:** There were no significant post-exercise differences in disc height, disc angle, signal intensity and area of the entire disc or nucleus at either level (Table 1). The intra-rater reliability of the measured parameters was good, ranging from \(\text{ICC}(3,1)\) 0.85 to 0.99 (Table 1).

**DISCUSSION:** The lack of significant post-exercise differences suggests that the effects of extension on the disc documented by others are transient and not sustained immediately after adopting the supine position.

| Table 1: Results of the paired-samples t-tests comparing quantitative MRI measures of the whole disc and nucleus from before to after extension exercises. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | ICC(3,1)        |                | ICC(3,1)        |                |
| Disc Height     | 0.91            | 0.81            | 0.84            | 0.81            |
| Disc Area       | 0.91            | 0.81            | 0.84            | 0.81            |
| Motion Segment Angle | 0.91 | 0.81 | 0.84 | 0.81 |
| Nucleus Height  | 0.91            | 0.81            | 0.84            | 0.81            |
| Nucleus Area    | 0.91            | 0.81            | 0.84            | 0.81            |

**GP104**

**DO THE HEIGHT AND THE SEX AFFECT THE LOCATION OF CONUS MEDULLARIS? 455 MRI ANALYSIS OF ASIAN YOUNG ADULT POPULATION**

*Chang-Hoon Jeon, Nam-Su Chung, Han-Dong Lee, Ji-Sang Youn Chang-Hoon Jeon, Nam-Su Chung, Han-Dong Lee, Ji-Sang Youn;*

Department of Orthopaedic Surgery, Ajou University School of Medicine, Suwon, Republic of Korea

**INTRODUCTION:** The position of conus medullaris has been described in various studies with cadavers and in vivo using MRI. Most studies demonstrated that the
conus medullaris is located at around L1-2 level with wide variations. The aim of this study was to investigate the location of conus medullaris in Asian young adult population and to determine the relevant factors including height and sex.

**METHODS:** This study consisted of 455 Asian young adult patients who had taken lumbar MRI and were excluded for deformity, congenital anomaly, or fracture. The tip of the conus was accepted as the most caudal point of the cord that could be visualized on the sagittal sequence. A perpendicular line to the long axis of spinal cord was used to locate the conus level and define the relation with the adjacent vertebrae. The vertebral body was divided into three parts (upper, middle, and lower one-thirds) and the intervertebral disc was considered as a separate region.

**RESULTS:** The mean age was 20.8 ±2.5 years and the number of male patients was 261 (43.3%). The most frequently distributed level was the L1-2 disc (22.7%) followed by lower part of L1 (21.7%), middle part of L1 (17.4%), upper part of L2 (13.0%), upper part of L1 (10.1%), lower part of T12 (7.2%), middle part of L2 (4.3%), lower part of T12 (2.9%), and middle part of T12 (1.4%). The distribution of conus medullaris in male was located higher than that of female groups (P = 0.04). There was no statistical difference regarding the height of the patients (P = 0.54).

**DISCUSSION:** This study demonstrated that the location of conus medullaris of Asian young adult population is not different from western population. Height was not a determinant factor for the location of conus medullaris. The distribution of conus medullaris was located higher in male than in female.

**GP105**

**NEUROPATHIC PAIN COMPONENTS IN PATIENTS WITH LUMBAR SPINAL STENOSIS**

Si Young Park*, Howard S An**, Seong Hwan Moon#, Hwan Mo Lee#, Seung Woo Suh*, Jae Young Hong* and Myo Jong Kim*;
Department of Orthopedic Surgery Korea University, College of Medicine, Seoul, Korea*
Rush University Medical Center, Chicago, USA** Yonsei University, College of Medicine, Seoul, Korea#

**INTRODUCTION:** Chronic pain disorders, including nociceptive pain, neuropathic pain (NP) and mixed pain have heterogeneous etiologies. Pain related to lumbar spinal stenosis (LSS) follows a similar pattern with a mixed pathophysiology resulting in a variability of symptoms. The aim of our study was to determine the prevalence and characteristics of neuropathic pain in patients with lumbar spinal stenosis (LSS) using subgroup analysis based on symptoms.

**METHODS:** We prospectively enrolled with LSS (n=86) who were scheduled to undergo spinal surgery. The patients were divided into two groups according to their chief complaint of radiculopathy or neurogenic claudication. Back and leg pain was measured by a visual analogue scale (VAS), and the Leads Assessment of Neuropathic Symptoms and Signs (LANSS) was used to assess sensory dysfunction. Health-related quality of life was measured with the Korean version of the Oswestry Disability Index (ODI). Statistical analysis was performed to find the relationship between LANSS scores and the other scores.

**RESULTS:** From our sample of 86 patients, 31 (36.0%) had a neuropathic pain component with 24 (63.4%) in the radiculopathy group having neuropathic pain. However, only seven patients (15.6%) in the neurogenic claudication group had neuropathic pain. The LANSS pain score
was not significantly correlated with the VAS score for back pain, but did correlate with the VAS score for leg pain (R=0.73, p<0.001) and ODI back pain score (R=0.54, p<0.01).

CONCLUSION/DISCUSSION: One third of patients with LSS had a neuropathic pain component. The presence of radiculopathy correlated strongly with neurogenic claudication. The severity of leg pain and ODI scores were also closely related to having a neuropathic pain component. This data will be useful in understanding the pain characteristics of LSS and in better designing clinical trials for neuropathic pain treatment in patients with LSS.

GP106
ANTI-NGF THERAPY FOR PAIN ORIGINATING FROM MUSCLE INJURY IN RATS
Masahiro Suzuki(1), Seiji Ohtori(1), Yoshihiro Sakuma(2), Sumihisa Orita(1), Kazuyo Yamashita(1), Go Kubota(1), Yasuhiro Oikawa(3), Kazuhide Image(1), Takeshi Sainoh(1), Jun Sato(1), Kazuki Fujimoto(1), Yasuhiro Shiga(1), Koki Abe(1), Hiroto Kanamoto(1), Kazuhiisa Takahashi;

(1) Dept. of Orthopaedic Surgery, Graduate School of Medicine, Chiba University (2) Department of Orthopaedic Surgery, National Hospital Organization, Chiba Medical Center (3) Department of Orthopaedic Surgery, Teikyo University Chiba Medical Center, Chiba, Japan

INTRODUCTION: Muscle-derived pain is a possible source of novel pain pathogenesis, although the mechanism for such pain remains unclear. We have reported NGF (nerve growth factor) as a proinflammatory mediator involved in acute pain, and clinical trials have shown the effectiveness of NGF antibody for lower back pain suggesting its use in pain management. Here, we aimed to examine the effects of anti-NGF antibody on sensory innervation in muscle-derived pain using a muscle injury model.

METHODS: Nervous system tracer Fluoro-Gold (FG) was applied to both gastrocnemius muscles of 24 male Sprague-Dawley rats prior to injury to stain sensory innervation. The drop-mass method was used to damage the right gastrocnemius muscle of the posterior limb (injury side), and the left side remained intact. 50 μl anti-NFG was injected into the injured gastrocnemius muscle of 12 rats. Tissues were evaluated 3, 7 and 14 days post-injury by hematoxylin and eosin (HE) staining. The percentage of cells immuno-labeled with calcitonin gene-related peptide (CGRP; a pain-related neuropeptide) of the total number of FG-positive cells was determined in bilateral L1 to L6 dorsal root ganglia (DRG) 7 days post-injury.

RESULTS: HE staining showed active inflammation such as increased basophil and eosinophil accumulation at the injury site 3 days post-injury, and scar tissue formation 2 weeks post-injury. Injection of anti-NFG reduced muscle necrosis 3 days post-injury, and resulted in replacement of granulation tissue and muscle fiber regeneration 1 week post-injury. Anti-NFG also significantly inhibited (38.2%) the increase in CGRP labeling among FG-positive cells on the ipsilateral side (49.6%; P < 0.05).

DISCUSSION: This study showed active inflammation induced by NGF, which may contribute to pain after muscle injury. Anti-NFG antibody successfully inhibited inflammation and the pain-related mediator NGF. This mechanism of myogenic pain suggests targeting local NGF control in pain management.
GP107
CAN FITNESS AND MOVEMENT QUALITY PREDICT BACK INJURY IN ELITE TASK FORCE POLICE OFFICERS? A 5-YEAR LONGITUDINAL STUDY
Stuart McGill+, David Frost+, Thomas Lam#, Tim Finlay*, Kevin Darby*, Jordan Cannon+;
+ Spine Biomechanics Laboratories, University of Waterloo, # FITS,Toronto, *Toronto Police Services, Canada

INTRODUCTION: Elite police work has bursts of intense physically demanding work requiring high work capacity, and movement competency which are assumed to increase one’s injury resilience. The purpose of this study was to follow members of an elite police force (N=53) to test whether back injuries (N=14) could be predicted from measures of fitness and movement quality.

METHODS: In this prospective cohort study, subjects were measured at baseline on a variety of fitness variables, (measures of torso endurance, relative and absolute strength, hip ROM, and movement quality using the Functional Movement Screen (FMS) and other dynamic movement tests to measure movement competency). Back injury was monitored over a five-year follow up period.

RESULTS: When each single variable was considered, having more abdominal endurance was the most highly associated with injury (T-test p=0.078), and a poor movement competency score with Sahrmann’s pelvic rock test being the second most linked to back injury ((p=0.083). Regression analysis on grouped variables showed back injury was best predicted with seven variables (Torso Endurance: Static sit-up posture, Biering-Sorensen static extension, The ratio of these two, Side plank, Hip Mobility: Hip extension with knee flexed, Hip extension with knee extended, Movement quality: Pelvis rock movement) (p<0.001, 2=26.561, R2=0.581, 64% sensitivity and 95% specificity for an overall concordance of 87%).

DISCUSSION: Overall, the ability to predict back injury was not high, suggesting that there is more complexity in the interactions between exposure, movement competency, training, fitness and injury that may occlude the true relationship between these variables. Our observations over the past 5 years with this group of police officers, is that the “fitter” officers may be aggravating injury in the weight room during strength and conditioning sessions, obscuring the link between fitness and movement competency, and injury rates.

GP108
EFFICACY OF CAUDAL EPIDURAL BLOCK FOR POSTOPERATIVE SPINAL EPIDURAL HEMATOMA AFTER SURGERY OF LUMBAR CANAL STENOSIS
Nobuyuki Fujita1, Tomohiro Hikata1, Akio Iwanami1, Kota Watanabe2, Ken Ishii1, Yoshiaki Toyama1, Masaya Nakamura1, and Morio Matsumoto1;
1 Department of Ortho-paedic Surgery, Keio University School of Medicine, Japan 2 Department of Advanced Therapy for Spine and Spinal Cord Disorders, Keio University, Japan

INTRODUCTION: We conducted a retrospective study on efficacy of caudal epidural block (EDB) for postoperative spinal epidural hematoma without neurologic deficit after surgery of lumbar canal stenosis

METHODS: Of 28 patients who were diagnosed as postoperative spinal epidural hematoma after surgery of lumbar canal stenosis between September 2008 and August 2014, 23 patients were treated conservatively without surgical removal of hematoma. These cases were divided into the E group, treated with EDB after diagnosis of hematoma and the N group, without EDB. In these 2 groups, we
assessed ages at surgery, sex, Body Mass Index (BMI), operative time, estimated blood loss, Numerical Rating Scale (NRS) before and 1 day after EDB, days of hospital stay, JOA scores at the time of admission and discharge. Statistical analysis was performed using the Student t test and p<0.05 was considered as statistically significant.

RESULTS: The number of subjects in Groups E and N were 5 and 18, with a mean age of 67.8 and 71.5, respectively. No significant difference was observed in sex (E: Male 2/Female 3, N: Male 12/Female 6), BMI (E:27.7, N:26.0), operative time (min) (E:70, N:95.6), estimated blood loss (ml) (E:57.5, N:71.3), JOA scores on admission (E:14.5, N:14.1). While there was no significant difference in NRS before EDB (E:6.8, N:4.9), the amount of NRS change 1 day after the block in group E (2.8) was significantly higher than group N (1.1). No significant difference was observed in days of hospital stay (E: 15.3, N: 16.6), JOA scores (E:19.3, N:20.3) and NRS (E:2.5, N:1.9) at the time of discharge.

DISCUSSION: The patients with postoperative spinal epidural hematoma accompanied by no neurologic deficit had pain relief gradually even without EDB. Our results showed that EDB had no effect on clinical outcome and days of hospital stay. However, EDB is effective treatment for early pain control of patients with postoperative spinal epidural hematoma.

GP109
ROLE OF BFGF RELEASED FROM MICROGLIA ON NEUROPATHIC PAIN
Hisako Fujimaki, Gen Inoue, Kentaro Uchida, Masayuki Miyagi, Hiroyuki Sekiguchi, Jun Aikawa, Wataru Saito, Masashi Takaso;
Department of Orthopedic Surgery, Kitasato University School of Medicine

INTRODUCTION: Neuropathic pain is a serious clinical problem, although the underlying etiology is not fully understood. Recent evidence indicates that certain growth factors released from activated microglia play an important role in neuropathic pain. Basic fibroblast growth factor (bFGF) is one such growth factor that we reported to be related to spinal astrocyte and microglia activation in chronic neuropathic pain. In this study, we evaluated the role of bFGF in spinal microglia in the development and maintenance of neuropathic pain in the rat spinal nerve ligation (SNL) model.

METHODS: 6-week-old Sprague-Dawley rats in which the L5 spinal nerve was ligated were used to model neuropathic pain. To evaluate the contribution of bFGF in neuropathic pain, we injected neutralizing antibodies to bFGF (50µg /40ul) intrathecally twice a week. To assess the progression of neuropathic pain, behavioral tests were conducted with von Frey filaments. To analyze glial cell activation or inflammatory markers induced in the spinal cord, we measured the genetic expression of specific cell markers via RT-PCR and immunohistochemistry.

RESULTS: After SNL, spinal bFGF mRNA increased within 6 hours. Double immunohistochemistry indicated a co-localization of bFGF with activated microglia, but not with activated astrocytes 1 day after SNL. Neutralizing antibodies to bFGF reduced mechanical allodynia development and mRNA levels of myeloperoxidase (MPO), which were co-localized with activated microglia.

DISCUSSION: In this study, bFGF immediately increased in spinal microglia during allodynia development after SNL. Neutralization of bFGF attenuated allodynia, potentially via suppression of MPO in spinal microglia. Elucidation of the dynamics of microglial activation and bFGF in the initial stages after peripheral nerve injury might be used to treat the development and progression of allodynia.
and bFGF may represent a viable therapeutic target for neuropathic pain.

**GP110**

**IMPACT OF CROSS-LEGGED SITTING (ANKLE ON KNEE) POSTURE ON TRUNK MUSCLE ACTIVITIES: AS COMPARED WITH CHAIR SITTING POSTURE**

Tomofumi Ezure and Takato Aihara; Funabashi Orthopedic Hospital, Funabashi-city, Japan

**INTRODUCTION:** We often feel low back pain when we sit with our leg crossed, however, there have been few reports concerning the trunk muscle activities at cross-legged sitting posture (CLS). The purpose of this study was to compare the trunk muscle activities at CLS with those at chair sitting posture (CS).

**METHODS:** Approval of this hospital’s ethics committee and informed consent to inclusion in the study from 10 healthy men, who did not have any previous back and lumbar disorders, were obtained. The surface electromyogram Myosystem 1400 was used for the measurement of the muscle activities. The activities of lumbar multifidus muscle (MF), lumbar part of the iliocostalis lumborum muscle (IL), rectus muscle of abdomen (RA), and external oblique muscle (EO) were evaluated. The measurement postures were CLS (right ankle on left knee) and CS (Fig.). Average amplitudes were normalized to the amplitude in maximal voluntary contraction (MVC) with their CLS and CS for 20 seconds, and %MVC values were calculated. All %MVC values were statistically compared between at CLS and at CS by Mann-Whitney U test. A P value < 0.05 was considered statistically significant.

**RESULTS:** The %MVC of MF at CLS (mean, 5.6) was significantly lower than that at CS (mean, 11.5). The %MVC of IL at CLS (mean, 15.1) was significantly larger than that at CS (mean, 3.8). The %MVC of EO at CLS (mean, 3.8) was significantly lower than that at CS (mean, 7.6). The mean %MVC of RA at CLS was 3.6 and that at CS was 4.8, and these were not significantly different between at CLS and at CS.

**DISCUSSION:** From the results of this study, the activity of MF was significantly lower at CLS than at CS. Wong et al. reported that MF played a crucial role in maintaining segmental lumbar stability and preventing recurrence of low back pain (2013, JOSPT). Therefore, cross-legged sitting (ankle on knee) posture could lead to low back pain because of the low activity of lumbar multifidus muscles.

![Fig. The measurement postures were CLS (right ankle on left knee) with their spine at neutral position and with their left hip and knee joints at 90 degrees flexion (left), and CS with their spine at neutral position and with their bilateral hip and knee joints at 90 degrees flexion (right).](image)

**GP111**

**EFFICACY OF ANTI-NAV1.7 ANTIBODY ON THE SENSORY NERVOUS SYSTEM IN A RAT MODEL OF LUMBAR INTERVERTEBRAL DISC INJURY**

Daisuke Nojima(1), Seiji Ohtori(1), Yoshihiro Sakuma(2), Sumihisa Orita(1), Kazuyo Yamashita(1), Go Kubota(1), Yasuhiro Oikawa(3), Takeshi Sainoh(1), Kazuhide Inagai(1), Jun Sato(1), Kazuki Fujimoto(1), Yasuhiro Shiga(1), Koki Abe(1), Hiroto Kanamoto(1), Kazuhisa Takahashi(1);
(1) Dept. of Orthopaedic Surgery, Graduate School of Medicine, Chiba University (2) Department of Orthopaedic Surgery, National Hospital Organization, Chiba Medical Center (3) Department of Orthopaedic Surgery, Teikyo University Chiba Medical Center, Chiba, Japan

**INTRODUCTION:** Discogenic low back pain pathophysiology is not fully understood.
Prostaglandins and cytokines produced by degenerated discs cause pain. Tetrodotoxin-sensitive voltage-gated sodium (NaV) channels are associated with primary sensory nerve transmission, and the NaV1.7 channel has emerged as an analgesic target. We found that disc injury increases NaV1.7 expression in DRG neurons innervating injured discs. This study aimed to examine the effect of blocking NaV1.7 on sensory nerves after disc injury.

**METHOD:** Using a rat model, we labeled DRG neurons innervating L5/6 discs with FluoroGold (FG) neurotracer. Twelve rats underwent intervertebral disc puncture (puncture group), 6 rats underwent sham surgery (non-puncture group). The injury group was divided into a 10 μl saline infuion group (puncture + saline group) and a NaV1.7 inhibition group, injected with 10 μl of anti-NaV1.7 antibody (puncture + anti-NaV1.7 group); n = 6 per group. Seven days post-surgery, L1 to L6 DRGs were harvested, sectioned, and immunostained for CGRP (inflammatory pain marker), and the proportion of CGRP-immunoreactive (ir) DRG neurons of all FG-positive neurons was evaluated.

**RESULTS:** The ratio of CGRP-ir DRG neurons to total FG-labeled neurons in intervertebral discs from L1 to L6 in the puncture + saline group significantly increased (58.5%) compared with the non-puncture group (31.9%; p<0.05). However, application of NaV1.7 antibody into the disc significantly decreased the ratio of CGRP-ir DRG neurons to total FG-labeled neurons after disc puncture (puncture + saline: 58.5%, puncture + NaV1.7: 42.9%; P <0.05).

**DISCUSSION:** CGRP expression in disc-innervating DRG neurons increased after disc puncture. However, NaV1.7 antibody suppressed CGRP expression in disc DRG neurons. Anti-NaV1.7 antibody can be a therapeutic target for pain control in patients with lumbar disc degeneration.

**GP112**
**CORRELATION BETWEEN BLOOD PRESSURE AND BLOOD LOSS DURING LUMBAR SPINAL FUSION SURGERY**

Jun Sato(1), Sumihisa Orita(1), Masayuki Miyagi(2), Kazuyo Yamauchi(1), Go Kubota(1), Kazuhide Inage(1), Takeshi Sainoh(1), Kazuki Fujimoto(1), Yasuhiro Shiga(1), Koki Abe(1), Hiroto Kanamoto(1), Kazuhisa Takahashi(1), Hisanori Yogo(1), Seiji Ohtori(1);
(1) Dept. of Orthopaedic Surgery, Graduate School of Medicine, Chiba University (2) Department of Orthopaedic Surgery, Kitasato University, Japan

**INTRODUCTION:** Hypotensive anesthesia is sometimes used to minimize intraoperative blood loss during spinal surgeries. Intraoperative blood pressure can affect intraoperative blood loss even when hypotensive anesthesia is not used. However, no study has examined the relationship between such blood pressure and blood loss in patients receiving standard blood pressure control. Herein, we retrospectively examined the relationship between blood pressure and blood loss during posterolateral fusion (PLF) surgeries.

**METHODS:** This study examined 20 PLF cases with single level decompression performed in the past 3 years and whose anesthesia risk was a physical status of ≤2. Blood pressure measurements were extracted from anesthetic records at 5-minute intervals from the beginning to end of surgery. Patients were excluded if mean blood pressure was less than 70 mm Hg, the upper limit of hypotensive anesthesia. The Pearson product-moment correlation coefficient was used to examine the relationship between circulatory parameters such as intraoperative blood pressure and intraoperative blood loss.
RESULTS: Thirteen patients satisfied the criteria. Mean operative time was 197±40 min and mean blood loss was 304±162 ml. The patients had significantly greater intraoperative blood loss per body weight and per operative time when they had higher mean intraoperative blood pressure (R=0.58, P=0.038) or a larger difference between the mean preoperative blood pressure at rest and the mean intraoperative blood pressure (R=0.69, P=0.009).

DISCUSSION: This study clearly showed a relationship between intraoperative blood loss and intraoperative blood pressure even when blood pressure was maintained within normal range. Thus, lowering intraoperative blood pressure was thought useful in controlling intraoperative blood loss. However, it is more effective to use the mean blood pressure at rest as the target blood pressure, and it is dangerous to lower intraoperative blood pressure unnecessarily.

GP113
LACK OF PROGNOSTIC MODEL VALIDATION IN LOW BACK PAIN PREDICTION STUDIES
Greg McIntosh MSc, Ivan Steenstra PhD, Hamilton Hall MD, Tom Carter BSc PT;
CBI Health Group Research Department; Institute for Work & Health, Toronto, Canada

INTRODUCTION: Prospective validation is an essential component of a properly conducted clinical prediction paper. The minimum standard should be statistical validation of the predictor variables in patients in whom the model was developed. Without validation, so-called prediction models are only described traits or characteristics of the sample studied. These studies have limited generalizability (external validity). The purpose of this review was to examine the frequency with which LBP prediction studies utilize either statistical or prospective methods of prognostic model validation.

METHODS: A literature search was conducted of all articles published in either Spine or the Spine Journal between January 2013 and January 2014. An initial screen of prognosis or prediction papers identified 56 potential studies (Spine =44, Spine Journal=12); 32 were excluded (21-not prediction studies, 11-review articles). Based on the standards set by Wasson and Laupacis et al., full texts of the remaining 24 articles were further scrutinized for prediction study quality.

RESULTS: Of the 24 included papers, 16 were surgical studies. None of the studies employed any methods of statistical validation (reproducibility of predictor variables, or of the final model). Based on the study designs and lack of statistical validation, only 2 studies used the correct terminology for describing associations/relationships between independent and dependent variables; the other studies provided no validation for the predictors that they documented.

DISCUSSION: Surgeons and researchers must consider sophisticated and rigorous methods of statistical/external validity for prediction/prognostic findings; otherwise, incorrect assumptions and conclusions may be made about some patients in your clinical practice. Without any validation methods, studies that claim to have developed prediction models actually only describe traits or characteristics of the studied sample.

GP114
SEVERE LOW BACK PAIN IN PATIENTS WITH RHEUMATOID ARTHRITIS IS ASSOCIATED WITH DISEASE ACTIVITY SCORE BUT NOT WITH RADIOLOGICAL FINDINGS
Kentaro Yamada 1), Akinobu Suzuki 1), Shinji Takahashi 1), Hiroyuki Yasuda 1), Tatsuya Koike 2), Hiroaki Nakamura 1);
INTRODUCTION: Several reports demonstrated that low back pain (LBP) in patients with rheumatoid arthritis (RA) was more common than in those without RA. Radiologic examination of patients with RA often reveals lumbar lesions induced by RA, including lumbar scoliosis, spondylolisthesis, or vertebral fracture. However, no report has discussed the risk factors for LBP in patients with RA including radiographic findings and other characteristics. The purpose of this study was to investigate the prevalence and associated factors of severe LBP among patients with RA.

METHODS: This cross-sectional study included 201 patients with RA without prior spinal surgery. Severe LBP was defined as that with a visual analog scale (VAS) score of ≥50 mm within the previous 4 weeks. Lumbar lesions, sagittal alignment, and disc degeneration were evaluated by plain standing X-rays and magnetic resonance imaging. Associated factors of severe LBP were investigated with patient characteristics including severity of RA and radiological findings, using multiple logistic regression analysis to obtain adjusted odds ratio (aOR) and 95% confidence intervals (CI).

RESULTS: Forty-eight patients (23.8%) had LBP with a VAS score of ≥50 mm. Multivariate analysis indicated that the associated factors for severe LBP were female (aOR 4.0, CI 1.0-14.9), smoking (aOR 3.0, CI 1.1-8.8), and moderate (aOR 3.2, CI 1.0-9.8) and high (aOR 7.0, CI 1.5-33.5) disease activity on the Disease Activity Score in 28 joints–erythrocyte sedimentation rate (DAS28-ESR). There was no relationship between severe LBP and any radiological findings.

DISCUSSION: The prevalence of severe LBP was relatively high in patients with RA. This study indicated the factor most closely associated with severe LBP was disease activity score, but not radiological findings. Appropriate control of RA might be important in terms of control of LBP.

GP115
ETHNIC VARIATION IN CORRELATION BETWEEN SAGITTAL PARAMETERS AND HRQOL (COMPARISON BETWEEN JAPANESE AND NORTH AMERICAN POPULATION)
Naobumi Hosogane1, Christopher Ames2, Virginie Lafage3, Yukihiro Matsuyama4, Hiroshi Taneichi5, Yu Yamato4, Daisaku Takeuchi5, Kota Watanabe6, Yoshiaki Toyama7, Morio Matsumoto7;
1 National Defense Medical College, Orthopedic Surgery 2 University of California, San Francisco, Neurosurgery 3 New York University Hospital for Joint Disease, Spine Division 4 Hamamatsu University School of Medicine, Orthopedic Surgery 5 Dokkyo Medical University, Orthopedic Surgery 6 Keio University, Advanced Therapy for Spine and Spinal Cord Disorder 7 Keio University, Orthopedic Surgery

INTRODUCTION: Sagittal alignments including pelvic parameters have drawn attention in the evaluation of HRQOL in adult spinal deformity (ASD) patients. Radiographic thresholds of disability for sagittal vertical axis (SVA), pelvic tilt (PT) and mismatch between pelvic incidence (PI) and lumbar lordosis (LL) have been reported and used as goals of correction surgery. These are based on North American (USA) databases, it is unclear these thresholds vary among different ethnicities. The purpose of this study was to compare the radiographic disability thresholds between USA and Japanese (JP) ASD patients.

METHODS: Retrospective, multicenter study of 595 ASD patients with baseline radiographs and Oswestry Disability Index (ODI) from USA (11 sites, 402 patients) and JP (3 sites, 193 patients). ASD patient (>18
years old) with at least one of followings were included, Cobb>20°, SVA>5cm, PT 25°, thoracic kyphosis>60°. Sagittal parameters and disability thresholds defined with linear regression analysis using ODI were compared between two cohorts.

**RESULTS:** Mean age (USA 52.5 ± 22.5 vs. JP 53.4 ± 22.4 years old) and gender (USA 85% females, JP 86% females) were similar, however USA had more revisions (USA 48% vs. JP 2%). In sagittal plane, PI was significantly smaller in JP (USA 55.4 ± 12.8° vs. JP 50.6 ± 12.1°), whereas PT and PI-LL were similar. Mean ODI at baseline was significantly lower in JP (36.2%) compared to USA (43.7%). Linear regression analysis revealed higher PI-LL threshold in JP (USA 14.3° vs. JP 25.4°) corresponding to ODI=40% (severe disability). Thresholds of PT (USA 22.9° vs. JP 21.1°) and SVA (USA 58.7 mm vs. JP 49.68 mm) were similar between two ethnics.

**DISCUSSION:** JP showed higher PI-LL threshold corresponds to ODI=40%, indicating JP ASD patients may experience less disability than USA to the mismatch of PI and LL. Further studies are necessary to evaluate the differences in normative values of ODI, pelvic morphology or life styles between the ethnics.

**GP116**

**INTERVERTEBRAL DISC AND CARTILAGE ENDPLATE INJURY PATTERNS OF OSTEOPOROTIC VERTEBRAL FRACTURES**

Tatsuhiko Fujiwara1, Koji Akeda2, Norihiko Takegami2, Junichi Yamada2, Tetsushi Kondo1, Akihiro Sudo2;

1. Department of Orthopaedic Surgery, Murase Hospital 2. Department of Orthopaedic Surgery, Mie University Graduate School of Medicine

**INTRODUCTION:** The basic unit of the spinal column, the intervertebral disc (IVD)-cartilage endplate (CEP) complex interposed between vertebral bodies (VBs), plays an important role in biomechanical and biological properties of the spine. Signal alterations within VBs have been the focus of the magnetic resonance imaging (MRI) diagnosis of osteoporotic vertebral fractures (OVFs), however less attention has been paid to those of the IVD-CEP complex. The purpose of this study was to evaluate the incidence and occurrence pattern of IVD-CEP complex injuries in acute or sub-acute OVF s evaluated by MRI.

**MATERIALS AND METHODS:** A total of 86 acute or sub-acute OVF patients (25 men, 61 women, mean age: 80.3 years), determined by MRI, were subjects of this study. CEP injuries, determined by the presence of cortical discontinuity in T1-images, were divided into 3 groups based on the location of injury (anterior, middle and posterior). IVD injuries, evaluated by changes of signal intensity within a disc compared with normal adjacent levels in T2 STIR images, were divided into two types (diffuse or focal pattern). The association between the incidence of CEP and IVD injuries was statistically analyzed.

**RESULTS:** CEP injury was observed in 58 of the 87 levels studied (67%) (superior only: 50%; inferior only: 7%; both endplates: 43%). CEP injury was the most common in the middle third of the vertebral column (81%). IVD injury was observed in 56 of the 87 levels (64%) studied. The diffuse pattern within discs was more common (78%) than the focal pattern (22%). The incidence of IVD injuries was significantly associated with CEP injuries (p<0.05).

**DISCUSSION:** CEP injury (67%) and IVD injury (64%) were commonly seen in acute or sub-acute OVF; the incidences of these injuries were significantly associated. Future prospective studies are needed to investigate whether CEP and/or IVD injuries are implicated in the natural course or treatment outcome of OVF s.
GP117
DEVELOPMENT OF DIAGNOSTIC CRITERIA FOR OSTEOPOROTIC THORACOLUMBAR VERTEBRAL FRACTURE
Masahiro Suzuki, Tetsuhiro Ishikawa, Masaaki Aramomi;
Sanmu Medical Center, Chiba, Japan

INTRODUCTION: An estimated 700,000 osteoporotic vertebral compression fractures occur in the United States each year. The definitive method to determine the presence of a fresh fracture is magnetic resonance imaging (MRI), but access to MR scanning is limited and expensive. Although some investigations have reported that the closed-fist percussion test is useful to diagnose fresh fractures, it is negative in many patients. The purpose of this study is to evaluate some clinical signs that may help to diagnose fresh vertebral fractures.

METHODS: Twenty-four consecutive patients with acute thoracolumbar vertebral fractures were diagnosed using MRI. Fractures caused by high-energy trauma, cases with burst fractures, and patients with severe dementia were excluded. We assessed changes in vertebral wedging using supine and standing lateral radiographs, and evaluated back pain by percussion of the spine, its intensity using the Visual Analog Scale (VAS), and the patients’ most painful motion by questionnaire: i.e. “rolling over in bed”, “sitting up from supine position”, or “standing and walking”. Diagnosis of a fresh fracture on MRI and vertebral instability on lateral radiographs were assessed by two spine surgeons.

RESULTS: Twenty-eight vertebrae were assessed in 2 males and 22 females with a mean age of 79.0 years (range, 63-91 years). L1 was the most common level affected (12 cases), with two at T10, four at T11, five at T12, two at L2, six at L3, one at L4, and three at L5. The median VAS for back pain was 7.7 (range, 4-10). Ten patients (42%) were positive for the percussion test. The most painful motion was “rolling over in bed” (12%), “sitting up from supine position” (79%), and “standing and walking” (8%). Vertebral body instability was observed in 19 cases (79%).

DISCUSSION: To diagnose fresh fractures, the examiner should focus on patients’ pain when sitting up from supine position and vertebral instability evaluated from supine and standing lateral radiographs.

GP118
THE TREATMENT OF NOCTURNAL LEG CRAMPS BY MEDIAL BRANCH BLOCKADE OF THE DEEP PERONEAL NERVE FOLLOWING LUMBAR SURGERY
Takayuki Imura, Gen Inoue, Toshiyuki Nakazawa, Wataru Saito, Masayuki Miyagi, Kentaro Uchida, Takanori Namba, Masashi Takaso;
Department of Orthopaedic Surgery, Kitasato University, School of Medicine

INTRODUCTION: Patients with lumbar disease sometime complain of leg cramps, defined as acute and involuntary painful contractions of the muscles in the lower extremities. In this prospective comparative cohort study, we investigated the effectiveness of the block of the medial branch of the deep peroneal nerve as a treatment for leg cramps in patients with lumbar disease after lumbar spinal surgery.

METHODS: Sixty-six postoperative patients after lumbar spinal surgery were divided into block group (n=41) and control group (n=25). Patients in block group underwent the block of the medial branch of the deep peroneal nerve at the distal two-thirds of the interspace between the first and second metatarsals, using 5.0 ml of 1.0% lidocaine. The frequency and severity were evaluated and compared between two groups.

RESULTS: Frequency of nocturnal leg cramps was reduced to less than quarter in 61.0% (n=25) and less than half in 80.5%
(n=33) of the patients at 2 weeks after the block. In control group, leg cramps reduced in approximately one-third of patients (32.0%), unchanged in 60.0%. The percentage of the patients that cramps reduced less than quarter or less than half was significantly larger in block group (p<0.05 and p<0.01, respectively). Severity of each cramp improved in approximately two-third (63.4%; n=26) and unchanged in one-third (31.7%; n=13) of patients in block group.

**DISCUSSION:** Our results could not demonstrate clearly the blockade affected hyperexcitability of peripheral motor axon or central site as spinal cord. Although, based on the results, blocking the transmission of the nerve impulses and stopping the positive feedback loop between peripheral afferents and alpha motor neurons, produces very effective and long lasting action to reduce both the severity and frequency of leg cramps. The block of the medial nerve branch of the peroneal nerve could be an effective treatment for nocturnal cramps, which is easy to perform with low risk, and long lasting.

**GP119**

**PREOPERATIVE ZINC DEFICIENCY IS A RISK FACTOR FOR SURGICAL-SITE INFECTION IN LUMBAR DECOMPRESSION SURGERY: A PROSPECTIVE COHORT STUDY**

Kinshi Kato; Shoji Yabuki; Koji Otani; Takuya Nikaido; Kazuyuki Watanabe; Shin-ichi Kikuchi; Shin-ichi Konno;
Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine

**INTRODUCTION:** Zinc deficiency represents a potential risk factor for surgical-site infection (SSI), by delaying wound healing. However, whether zinc deficiency represents a risk factor for SSI has not been confirmed. The purpose of this study was to investigate the association between zinc deficiency and SSI in lumbar decompression surgery.

**METHODS:** Participants comprised 158 consecutive patients scheduled to undergo lumbar decompression surgeries in our hospital. Patients were divided into two groups on the basis of preoperative serum zinc levels: a zinc-deficient group (Group Z, Zn <80 mg/dL; n=71); and a non-zinc deficient group (Group N, Zn ≥80 mg/dL; n=87). Patients were followed prospectively for 3 months after surgery. SSI was diagnosed according to Centers for Disease Control and Prevention criteria. Logistic regression analysis was used to adjust for confounding factors (age, sex, body mass index, smoking status, usage of steroids, liver or renal dysfunction, diabetes mellitus, serum albumin level, operation duration, and amount of bleeding). Values of P < 0.05 were considered statistically significant.

**RESULTS:** The follow-up rate was 100%. SSI was confirmed in 9 of the 158 patients (5.7%). Three patients with deep SSI were detected, comprising 2 patients in Group Z and 1 patient in Group N. Superficial SSI was detected in 5 patients in Group Z, and 1 patient in Group N. For patients undergoing lumbar spinal surgery, logistic regression with propensity score adjustment for confounding factors identified preoperative serum zinc level as a significant predictor of postoperative SSI (odds ratio [OR], 4.48; 95% confidence interval [CI], 1.03-30.87; P=0.04).

**DISCUSSION:** Incidence of deep and superficial SSI was higher in patients with zinc deficiency than in those with no zinc deficiency. Serum zinc levels should be assessed as a potential risk factor for SSI prior to lumbar decompression surgery.
GP120
LUMBAR SPINE FACET JOINT OSTEOARTHRITIS IN PROFESSIONAL BASEBALL PLAYERS: COMPARISON WITH AGE- AND SEX-MATCHED CONTROLS
Kinshi Kato; Shoji Yabuki; Koji Otani; Takuya Nikaido; Ken-ichi Otoshi; Kazuyuki Watanabe; Shin-ichi Kikuchi; and Shin-ichi Konno;
Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine, Fukushima, Japan

INTRODUCTION: Lumbar spine facet joint osteoarthritis (OA) is a pathologic condition suggested as a source of low back pain (LBP). Due to repeated, localized mechanical stress at the facet joints, facet joint OA is reportedly frequent in high-level baseball players. However, the association between LBP and radiographically observed facet joint OA remains unclear. The purpose of this study was to assess the prevalence, distribution, morphology and symptoms of lumbar spine facet joint OA in professional baseball players compared with age- and sex-matched controls.

METHODS: Group B comprised 21 professional baseball players (11 pitchers, 10 fielders; mean age, 25.8 years). Group C comprised 95 age- and sex-matched controls (95 males; mean age, 24.0 years) who had undergone whole-spine computed tomography for examination of high-energy multiple injuries in the emergency department of our institute between April 2010 and July 2014. Subjects with a history of previous lumbar spine surgery were excluded. The prevalence, distribution, and morphology of both the left and right side of lumbar spine facet OA were reviewed. Wilcoxon and chi-square tests were used for statistical analyses.

RESULTS: Facet OA of lumbar spine was significantly more common in Group B (63.2%) than in Group C (5.9%; p<0.0001). The distribution of lumbar spine facet OA peaked at L4-L5 in both groups. Asymmetrical facet OA of the lumbar spine was also significantly more frequent in Group B (57.9%) than in Group C (2.0%; p<0.0001). However, only one pitcher with asymmetrical facet OA had symptomatic OA as evaluated by intra-articular diagnostic injections.

DISCUSSION: The frequency of lumbar spine facet OA was dramatically increased among professional baseball players compared with age- and sex-matched controls. Dynamic mechanical stress may thus influence the development of lumbar spine facet joint OA in young baseball players. However, few cases of symptomatic facet OA were encountered in our study.

GP121
IMPACT OF SPINAL DEFORMITY DUE TO OSTEOPOROTIC VERTEBRAL FRACTURE ON SAGITTAL ALIGNMENT OF THE WHOLE SPINE
Terumasa Ikeda Hiroshi Miyamoto Kazuki Hashimoto Masao Akagi;
Department of Orthopaedics Surgery Kindai University Faculty of Medicine

INTRODUCTION: Sagittal imbalance of the spine disturbs the activity of daily life of the patients because they hardly stand up and walk. Kyphosis due to osteoporotic vertebral fracture (OVF) can be a cause, thus we evaluated the impact of spinal deformity due to OVF on sagittal alignment of the whole spine and clinical outcome.

METHODS: Forty-three patients who suffered OVF without neurogenic symptoms were enrolled (7 males, 36 females, and mean age of 76 years old). Spinopelvic lateral radiographs in standing position were taken. Lumbar lordosis(LL), thoracic kyphosis(TK), sacral slope(SS), pelvic tilt(PT), pelvic incidence(PI), and sagittal vertical axis(SVA) were measured. SQ grading was used for evaluating the severity of the fracture. Clinical outcome were assessed using JOABPEQ. The patients were classified into three groups
(A: SVA < 40mm, B:40 < SVA< 95mm, C: SVA> 95mm). The radiographic parameters, numbers of fractures, SQ grade, and JOABPEQ were compared among the groups.

RESULTS: A mean SVA (mm) were A:17.4, B:60.5, C:129 respectively. A mean numbers of fractures were A:1.9, B:2.4, C:4.8. Numbers of Grade 3 in SQ grade were A:6, B:17, C:39. LL in group C was significantly smaller (28°) compared to those in group B(47°) and C(45.3°) although no significant difference was found regarding TK, SS, PT, and PI among the groups. In any items except pain of JOABPEQ, group C obtained the worst points, especially lumbar spine function (A:75, B:46.8, C:36).

DISCUSSION: The present study has demonstrated that sagittal imbalance due to OVF was greatly influenced by the numbers and the severity of vertebral fractures. It was demonstrated that SVA was more correlated with LL compared to TK. JOABPEQ also showed dysfunction of lumbar spine in group C. Therefore, compensatory function of lumbar spine is the most important factor for maintaining sagittal alignment in osteoporotic patients, and correction surgery of lumbar spine can be a key strategy for treating such patients.

GP122
IMPLEMENTATION OF A CONSERVATIVE CARE REGISTRY FOR PATIENTS SEEKING OUTPATIENT REHABILITATION
Lis, Angela, PhD,* Weiser, Sherri, PhD,* DeCastro, Carlo, MS,* Campello, Marco, PhD.*
*Occupational and Industrial Orthopaedic Center (OIOC), Hospital for Joint Diseases, Program of Ergonomics and Biomechanics, New York University Langone Medical Center, New York, NY.

INTRODUCTION: A registry for patients with spine pain and other musculoskeletal (MSK) disorders was implemented in an interdisciplinary outpatient rehabilitation facility for clinical and research purposes.

METHODS: Predictor and outcome variables were selected from the MMICS recommendations; a systematic literature review and interests of the development group. An expert review of the test battery took place to minimize patient burden, and assure face and content validity. The registry was revised twice. The current database includes clinical, psychosocial and demographic variables (Figure 1). Staff was trained in questionnaire administration, data collection, data entry into a HIPPA secure server, data interpretation and utilization. Staff practiced these protocols to proficiency. The database is organized by episodes of care defined as any set of contiguous visits that are separated by no more than 90 days. Data collection points are baseline (evaluation), during treatment (6th visit) and discharge. Data collection began in 2009 and is ongoing.

RESULTS: A total of 3512 episodes were registered from June 2009 to July 2014. Spine pain represented 70% of the cases. Of those registered, 1990 (57%) had only baseline data, 1133 (32%) had one additional data collection point (during treatment or discharge), and 389 (11%) had two additional data collection points (during treatment and discharge).

DISCUSSION: A registry for conservative care in patients with spine pain and other MSK disorders has been successfully implemented. It provides quality assurance data and information about treatment
outcomes. To assure high quality data, staff training, content modification and implementation monitoring must be ongoing and requires a dedicated staff member. For research purposes, missing data may introduce systematic bias. Possible reasons for missing data may be problems with sustainability, data collection and entry or patient adherence. This issue was explored in another study.

**GP123**

**INTRODUCING ACCEPTANCE AND COMMITMENT THERAPY TO A PHYSIOTHERAPY LEAD PAIN REHABILITATION PROGRAMME: AN ACTION RESEARCH STUDY**

Karen Barker K.(1,2), Leila Heelas L (1), Fran Toye F.(1);  
(1)Oxford University Hospitals NHS Trust, Nuffield Orthopaedic Centre, Oxford, United Kingdom, (2) University of Oxford, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, Oxford, United Kingdom

**INTRODUCTION:** Recent developments in pain rehabilitation emphasise the importance of promoting psychological flexibility. Acceptance and Commitment Therapy (ACT) is one approach that has been shown to be effective. However, no previous research concerning the experience of physiotherapists implementing ACT has been published. The aim of this study was to explore the experiences of clinicians learning and applying this approach.  

**METHODS:** Using Action Research a planned introduction of ACT was studied. The team undertook training, planned the introduction of ACT to the clinical programmes and completed reflective diaries and recorded discussions at team meetings. A researcher collected interview data which was analysed using Interpretative Phenomenological Analysis.  

**RESULTS:** The findings describe potential barriers and facilitators to an ACT philosophy within a physiotherapy led pain management service: (1) the need to understand pain as an embodied experience; recognised that using an embodied therapeutic model could profoundly threaten a person's sense of legitimacy. (2) the need to reconstruct the meaning of 'Acceptance' and the challenge of utilising the word 'acceptance' which could have connotations of passivity. (3) the benefits of utilising value-based goals within ACT, but also the challenges for both patients and physiotherapists. (4) Integral to a therapeutic definition of acceptance was the professional challenge of moving away from diagnosis and 'fixing' towards 'sitting with' patients. Participants described this as uncomfortable because it did not fit their biomedical training.  

**DISCUSSION:** ACT has successfully been adopted into a physiotherapy pain programme; the understanding of the uncertainties and threat to existing practices and views of professionalism was helpful in developing a training needs analysis for the team.

**GP124**

**EVALUATION OF THE LEVELS OF CURVE, ENDPLATE AND FACET JOINT EROSION IN DEGENERATIVE LUMBAR SCOLIOSIS PATIENTS WITH RHEUMATOID ARTHRITIS - MATCHED COHORT STUDY**

Hiroyuki Yasuda1), Akinobu Suzuki2), Kentaro Yamada2), Shinji Takahashi2), Hidetomi Teraiz2), Masatoshi Hoshina2), Hiromitsu Toyoada2), Sho Dohzono2), Kohji Tama2), Hiroaki Nakamura2);  
1)Department of Orthopedic Surgery, Osaka General Hospital of Japan Railway Company  
2)Department of Orthopedic Surgery, Osaka City University Graduate School of Medicine

**INTRODUCTION:** The lumbar lesion in rheumatoid arthritis (RA) has been paid less attention, but some previous studies demonstrated the high prevalence of degenerative lumbar scoliosis (DLS). The lumbar lesion accompanied with RA is
often difficult to treat, and it is important to know the characteristics of lumbar lesion in RA patients. In this study, we focused on the levels of curve and the degree of endplate and facet joint, and evaluated these parameters in DLS patients with RA and without RA using plain X-ray and MRI.

METHODS: A total of 54 patients with scoliosis who fulfilled the revised criteria of the American Rheumatism Association were included in this study. As control, age, sex, and Cobb angle matched 54 patients without RA were selected and also included. We evaluated the levels of curve, superior/inferior end vertebra, apical vertebra and on plain X-rays and the degree of erosion in endplate and facet joint on MRI from L1/2 to L5/S using Yamada’s classification (Yamada et al. J Spinal Disord Tech 2014;27:E128-8211;E135). These parameters were compared between RA group and non-RA group.

RESULTS: The levels of curve were more in RA group (RA group: 5.0 ± 1.3 levels, non RA group: 3.6 ± 0.6 levels). The level of apical vertebra located significantly higher in RA than non-RA group. The level of superior end vertebra located also significantly higher in RA group, but there was no difference in the level of inferior end vertebra between two groups. The degree of erosion in endplate and facet joint at L1/2 were significantly severer in RA group.

DISCUSSION: The present results showed the levels of curve were more, the level of superior end vertebra and apical vertebra located upper level, and the degree of endplate and facet joint erosion were severe in RA patients. These results indicated that RA might injure endplate and facet joint not only in lower level but also in upper level and affect the more levels of curve in RA patients.
VF had been present in all 4 (100%, p = 0.01) and in 7 of 8 patients (88%, p = 0.002), respectively, in the Ris group and in 6 of 7 (86%, p = 0.02) and in 4 of 7 (57%, NS) patients, respectively in the Ris+K2 group. The serum NTX level in participants with pretreatment VFs was significantly higher than that in those who did not already have VFs in both the Ris (p = 0.01) and Ris+K2 (p = 0.03) groups.

**DISCUSSION:** VF incidences were significantly high in participants with pretreatment VFs independent of the type of treatment for osteoporosis. Incidence of LBP was significantly high only in participants who had pretreatment VFs and who were treated with Ris monotherapy.

**GP126**

**RISK FACTORS FOR MIDDLE COLUMN INJURY FOLLOWING OSTEOPOROTIC VERTEBRAL FRACTURES**

Hoshino M.1, Tsuji T.2, Terai H.1, Namikawa T.3, Kato M.3, Matsumura A.3, Suzuki A.1, Toyoda H.1, Takayama K.1, Takaoka K.2, Nakamura H.1;

1 Dept. of Orthopedic Surgery, Osaka City University Graduate School of Medicine, Osaka, Japan. 2 Spine Center, Shiraniwa Hospital, Nara, Japan. 3 Dept. of Orthopedic Surgery, Osaka City General Hospital, Osaka, Japan.

**INTRODUCTION:** We have previously reported that middle column injury following osteoporotic vertebral fracture (OVF) is a significant risk factor for poor clinical and radiological outcomes in patients. This study aimed to determine the factors affecting middle column injury.

**METHODS:** A total of 435 OVF patients (80 men and 355 women; mean age, 76.4 years) from 25 institutes were enrolled in this clinical study. Middle column injury was diagnosed by MRI at the time of injury. Sex, age, bone mineral density, body mass index, cause of injury (falls, heavy-duty lifting, and unknown), level of fracture, previous vertebral fracture, regular exercise before fracture, comorbidities (stroke, Parkinson’s disease, cardiovascular disease, kidney disease, liver disease, respiratory disease, and diabetes), and smoking history were explanatory variables. We performed multivariate logistic regression analysis and obtained odds ratios (ORs).

**RESULTS:** Middle column injury was found in 133 (31%) patients. In multivariate analysis, thoracolumbar fracture (T11-L2) was significantly associated with middle column injury (OR 2.76, P = 0.0006). In comorbidities, Parkinson’s disease and diabetes were marginally associated with middle column injury (OR 4.83, P = 0.069; OR 1.69, P = 0.085, respectively). None of the other examined variables were significant risk factors for middle column injury.

**DISCUSSION:** This study shows that thoracolumbar fracture, Parkinson’s disease, and diabetes are risk factors for middle column injury following OVF. The cause of injury does not affect middle column injury. Our results suggest that middle column injury easily occurs in fragility fractures, regardless of energy resulting from trauma. In cases of thoracolumbar fractures, sufficient attention should be paid to treatment because of the high risk of middle column injury.

**GP127**

**EFFECT OF SPINOPELVIC ALIGNMENT ON THE UNION OF THORACOLUMBAR OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURE**

Akira Iwata, MD1; Masahiro Kanayama, MD1; Fumihiro Oha, MD1; Shingo Onda, MD1, Kaoru Tashiro, MD1, Tomoyuki Hashimoto, MD1; Norimasa Iwasaki, MD2;

1 Spine Center, Hakodate Central General Hospital, Hakodate, Japan 2 Department of Orthopaedic Surgery, Hokkaido University, Sapporo, Japan

**INTRODUCTION:** Global spinal malalignment might increase the load sharing at the fracture site, resulting in deterioration
of fracture healing. This study aimed to evaluate the effect of spinopelvic alignment on the union status of thoracolumbar osteoporotic vertebral compression fracture (OVCF).

METHODS: Thirty-eight patients who were treated non-operatively for a single-level thoracolumbar fresh OVCF were enrolled. They were treated with soft lumbosacral orthosis and underwent osteoporosis treatment using 20ug of daily teriparatide (TPD) (n=18) or 35mg of weekly alendronate (BP) (n=20). Radiographic parameters included pelvic incidence (PI), pelvic tilt (PT), lumbar lordosis (LL), thoracic kyphosis (TK), sagittal vertical axis (SVA), and distance between SVA and the center of fractured vertebra (DSVA). Measurements were performed using an upright whole-spine radiograph before treatment. Union was diagnosed as the presence of trabecular continuity using CT at 6 months after injury.

RESULTS: Twenty-three patients achieved a radiographic union at 6 months after injury. Spinopelvic parameters in the union group (n=23, TPD: BP = 11:12) versus non-union group (n=15, TPD: BP = 7:8) were shown as follows: 55.6+/-2.6 vs. 57.5+/-3.2 degrees in PI (P=0.658); 22.0+/-2.0 vs. 27.5+/-2.5 degrees in PT (P=0.096); 37.9+/-3.3 vs. 29.8+/-4.1 degrees in LL (P=0.131); 36.4+/-2.8 vs. 40.0+/-0.4 degrees in TK (P=0.476); 4.5+/-0.9 vs. 6.8+/-1.1 cm in SVA (P=0.128); 4.1+/-0.8 vs. 7.4+/-1.0 cm in DSVA (P=0.016). Differences were not statistically significant in PI, PT, LL, TK and SVA. Adjusted by pharmaceutical agents, DSVA was significantly larger in the non-union group than the union group (P=0.014).

DISCUSSION: The current study demonstrated that larger DSVA is a significant risk factor for non-union in thoracolumbar OVCF. Larger DSVA will lead to increase the bending moment at the fractured vertebra, which might deteriorate the fracture healing in thoracolumbar OVCF.

GP128

EXPRESSION OF GLIAL CELL LINE-DERIVED NEUROTROPHIC FACTOR IN THE HUMAN INTERVERTEBRAL DISC

Junichi Yamada1, Koji Akeda1, Koichi Masuda2, Keianne Yamada2, Kevin Cheng2, Norihiko Takegami1, Akihiro Sudo1;

1Department of Orthopaedic Surgery, Mie University Graduate School of Medicine
2Department of Orthopaedic Surgery, University of California, San Diego.

INTRODUCTION: Intervertebral disc (IVD) degeneration is one of the important factors responsible for low back pain. A family of neurotrophins, including NGF, BDNF and NT-3, has been shown to be present in the IVD and is considered to play a role in inflammatory responses and pain transmission. The glial cell line-derived neurotrophic factor (GDNF) family, belonging to the TGF-α superfamily, is crucial for the development of the nervous system and pain transmission; however, the expression of GDNF in IVD tissues remains unknown. The purpose of this study was to (1) examine the expression of GDNF, and (2) evaluate the effect of a proinflammatory cytokine on GDNF expression by human IVD cells.

METHODS: Human nucleus pulposus (NP) and annulus fibrosus (AF) cells, separately isolated from IVD tissues (Pfirrmann’s classification grades 2-3) obtained from spine surgery, were cultured in monolayer. Immunohistochemical analysis and western blotting were performed to examine the protein level of GDNF. To examine the effect of proinflammatory cytokines on the expression of GDNF, AF and NP cells were cultured in the presence of interleukin-1β (IL-1β; 0.1-10 ng/ml). mRNA expression of GDNF was quantified by real-time PCR.
RESULTS: Confocal microscopy analysis showed that immunoreactivity against anti-GDNF antibody was clearly identified within the cytoplasm of human AF and NP cells. Western blotting analysis confirmed the presence of GDNF protein in both AF and NP cells. GDNF mRNA was expressed by human AF and NP cells; those expressions were significantly upregulated by IL-1β (10 ng/ml) treatment (AF: 222-fold, NP: 37-fold, P<0.01, respectively).

DISCUSSION: Our results demonstrate, for the first time, that human NP and AF cells constitutively express GDNF at both mRNA and protein levels. The results of this study suggest the possibility that the enhanced expression of GDNF within degenerated discs may be associated with the generation of discogenic pain.

GP129
LUMBAR SPINAL STENOSIS AFFECTS HEALTH-RELATED QOL AND WORK CONTINUATION
Shoji Yabuki, Miho Sekiguchi, Koji Otani, Shin-ichi Kikuchi, Shin-ichi Konno;
Department of Orthopaedic Surgery,
Fukushima Medical University School of Medicine

INTRODUCTION: The purpose of the current study was to clarify the relationship between lumbar spinal stenosis (LSS) and health-related QOL, and the frequency of treatment for LSS and absence from work due to LSS in Japanese general population.

METHODS: The study population consisted of all residents aged 40 to 79 years old in Japan who were able to respond to a questionnaire. Sampling was performed by stratified two-stage random sampling. Of the 4,400 subjects, questionnaires were obtained from 2,666 (response rate: 60.6%). The mean age (standard deviation) of the respondents was 60.0 (10.9) years. The proportion of males was 47.4%. Of the respondents, 153 were regarded as having LSS according to the LSS-diagnostic support tool (LSS group). The others (2,513) were classified into non-LSS group. Health-related QOL was evaluated using SF-36. All 8 domains and component summary scores were compared between two groups. The frequency of treatment for LSS and absence from work due to LSS symptoms were also analyzed in LSS group.

RESULTS: LSS group showed statistically significant lower scores on all 8 physical and mental domains and the physical and mental component summary scores compared with non-LSS group. The frequency of treatment for LSS was 75%. 18 persons were treated as in-patients. Mean hospitalization was 46.2 days. The frequency of absence from work due to LSS symptom was 9.8%.

DISCUSSION: LSS had a strong negative effect on not only physical but also mental QOL compared with non-LSS group. Also, LSS requires considerable financial resources for treatment. This study has several limitations. First, image examinations were not performed for objective diagnosis. Second, this study was a cross-sectional study. Thus, causal relationship between LSS and lower QOL could not be determined. In conclusion, LSS had a strong negative effect on not only physical but also mental QOL in the Japanese general population.

GP130
DETERMINANTS OF OUTCOMES IN A DOSE-RESPONSE TRIAL OF SPINAL MANIPULATION FOR THE CARE OF CHRONIC LOW BACK PAIN
Mitchell Haas, DC, MA 1 Darcy Vavrek, ND, MS 1 Moni Blazej Neradilek, MS 2 Nayak Polissar, PhD 2; 1 University of Western States 2 The Mountain-Whisper-Light Statistics

INTRODUCTION: We identified determinants of future chronic low back pain (cLBP) outcomes from a randomized trial of
spinal manipulation at two clinically relevant time points: beginning and end of care.

**METHODS:** Participants, 400 with cLBP, were randomized to receive 18 sessions of treatment over 6 weeks. Spinal manipulation was performed by a chiropractor at 0, 6, 12, or 18 visits (dose), with light-massage control at remaining visits. Pain was evaluated for 52 weeks (0 – 100 scale). 75% of cases were used to develop predictive models with stepwise regression across all time points using generalized estimating equations. Dose, pain and disability, demographics, general health status, psychosocial, and objective exam findings were investigated as predictors. Confirmatory models used the remaining 25% of cases. One analysis used baseline variables; another used variables collected at the end of care (6 weeks).

**RESULTS:** For the baseline predictor model, higher dose of care and better general health were significant determinants of lesser follow-up pain, whereas greater baseline pain was a significant predictor of greater pain. The determinants explained R-squared=26.8% of the variance in pain outcomes. The prediction error, standard error of the estimate (SEoE), was 17.4. Confirmatory analysis did not demonstrate good generalizability of the model with R-squared=6.6%. However, the prediction error was similar (SEoE=19.4). For the end-of-care predictor model, 6-week pain scores and pain with right lateral bending was significantly associated with greater future pain. The model explained 36.6% of the variance in future pain and SEoE=16.3. Confirmatory analysis demonstrated adequate generalizability with R-squared=26.1% and a similar prediction error (SEoE=17.5).

**DISCUSSION:** Current pain, general health, pain with movement, and dose of care are predictive of population trends in future cLBP intensity. Prediction of future pain for individuals remains allusive.

**GP131**

**SURGICAL RISK ASSESSMENT OF THE VASCULAR INJURY ON BI- OR TRI-CORTICAL PENETRATING WITH S1 PEDICLE SCREW**

Fumitake Tezuka, Toshinori Sakai, Yoichiro Takata, Kosaku Higashino, Koichi Sairyo;
Department of Orthopedic Surgery, Tokushima University

**INTRODUCTION:** To achieve a stronger fixation of S1 pedicle screw (S1 PS), bi or tricortical screw fixation is advantageous in lumbosacral multi-level interbody fixation. However, there is a risk of vascular injury of the front of sacrum by screw insertion. In this study, we assessed the vascular structure ventral aspect of the sacrum in the situation of S1 pedicle screwing toward the promontory.

**METHODS:** We evaluated 40 adult abdominal contrast-enhanced multidetector 3D-CT scans (28 men and 12 women). The mean age was 65.0 years old (range 46 - 83). On the axial plane of the CT scan parallel to S1 endplate, we checked the location (zone 1, 2, 3, and 4) and distance from the sacrum, of the vascular structures; external iliac artery / vein (EIA / EIV), internal iliac artery / vein (IIA / IIV), common iliac artery (CIA / CIV) / vein, inferior mesenteric artery (IMA), and median sacral artery (MSA).

**RESULTS AND DISCUSSION:** Vascular structures anterior to the sacrum was located on; R EIA: zone 1 (11 cases), zone 2 (29), L EIA: zone 3 (28), zone 4 (12), R IIA: zone 1 (2), zone 2 (38), L IIA: zone 3 (30), zone 4 (10), MSA: zone 2 (14), zone 3 (25), and IMA: zone 2 (3), zone 3 (36). Average distance from the sacrum were; R EIA: 23.9 mm, L EIA: 24.1 mm, R IIA: 6.0 mm, L IIA: 12.9 mm, MSA: 0.8 mm, and IMA: 6.7 mm. Veins: less than about 7 mm. From the
results of this study, vasculature structures were concentrated in zone 2 or 3, and particularly right IIA and MSA, IMA were located within 10 mm distance from the anterior surface of sacrum. Bilateral CIV/IIV were located within 3 mm. When we insert S1 PS, we should pay attention to their vascular structure.

GP132
DOES THE MORPHOLOGY OF THE FACET JOINT AFFECT UNILATERAL AND BILATERAL SPONDYLOLYSIS?
Hayato Ishitani, Naoki Ishigaki, Tomofumi Ezure, and Takato Aihara;
Funabashi Orthopedic Hospital, Funabashi-city, Japan

INTRODUCTION: This study was undertaken to determine whether the morphology of the facet joint contributes to unilateral and bilateral spondylysis.

METHODS: Sixty-eight junior athletes (JA) with low back pain were reviewed. They were classified into three groups according to CT and MRI: B group (22 JA with L5 bilateral spondylolysis), U group (27 JA with L5 unilateral spondylolysis), and C group (19 JA without spondylolysis). The ages of the B, U, and C groups showed no significant differences among them. Using multislice CT, the same observer measured the sagittal orientation of the L4/5 and L5/S1 facet joint angles from the axial sections. In the B and C groups, there were no significant differences between the left and right measurements, therefore, all of the measurements were given as the mean of them. Facet joint angles were statistically compared using Tukey’s test for differences among B group, the spondylolysis side in the U group (UL), the normal side in the U group (UN), and C group.

RESULTS: The L4/5 facet joint angles were significantly more coronally orientated in B and UL groups than in C group. There were no significant differences among the four groups concerning the L5/S1 facet joint angles (Fig.).

DISCUSSION: We think that a more coronal orientation of the L4/5 facet joint is likely to increase the point loading through the L5 pars interarticularis in extension and rotation. Although the L4/5 facet joint angles were not significantly different between UN and C groups by Tukey’s test, they were significantly more coronally orientated in UN group than in C group by
unpaired t-test (P=0.039). Therefore, if a subject has coronally orientated L4/5 facet joint, unilateral spondylolysis at L5 may be occurred on the more coronally orientated side, and the other coronally orientated side may be the risk of spondylolysis. We think that the early diagnosis and the preventative treatments are important for unilateral spondylolysis.

GP133
COURSE OF ACTIVE SPONDYLOLYSIS WITH OR WITHOUT CONSERVATIVE TREATMENT
Atsushi Fujiwara, Taro Kuramochi*, Hitoshi Akutsu*, Sho Fujiiwara and Yu Fujiwara;
Fujiwara Orthopedic Clinic, Tochigi, Japan
Kuramochi Hospital*, Tochigi, Japan

INTRODUCTION: Spondylolysis has been reported to be detectable on MRI even in the occult phase on plain radiography. The conservative treatment consists of wearing a brace and/or cession of sports activities for several months, then the compliance to the treatment was not so good. The purpose of this study was to re-examine the course of pain and activity level in treated and untreated patients with active spondylolysis diagnosed on MRI.

METHODS: This study consisted of 31 consecutive patients with symptomatic active spondylolysis on MRI. There were 28 boys and 3 girls with a mean age of 14. On MR images, the progress status of pars interarticularis was graded with the system proposed by Hollenberg et al. Twenty-one patients agreed with the conservative treatment, another 10 patients did not agree with it. All the patients were re-examined for the survey of pain and sports activity level at least 6 months later.

RESULTS: Re-examination was done on average of 23 months later. In the treatment group, 20 of 21 (95%) patients had no pain, and 21 patients (100%) were free of any sports activities. Although treated, one patient with back pain at the survey originally had bilateral grade 2 L4 spondylolysis. In the untreated group, on the other hand, 6 of 10 patients (60%) were free of pain, but all 10 patients had same sports activity level before. The 6 patients with no pain had no L4 vertebral involvement, and 5 of 6 patients showed grade 1 spondylolysis. Four patients with back pain at the survey, on the other hand, originally had more than grade 2 spondylolysis (2 patients at bilateral L4, and 2 at L5).

DISCUSSION: The conservative treatment seemed to be effective in terms of but back pain not sports activity later. The vertebral level involved and the stage of spondylolysis could affect the course of active spondylolysis. These results should be considered in selection of a candidate for and modification of conservative treatment for active spondylolysis on MRI.

GP134
INTERVERTEBRAL DISC VACUUM PHENOMENON IS ASSOCIATED WITH MODIC CHANGES IN THE ADJACENT ENDPLATE: IMPLICATIONS FOR DISCOGENIC BACK PAIN.
Junhui Liu, Fengdong Zhao;
Department of Orthopaedics, Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University, Hangzhou, China

BACKGROUND: Back pain often arises from degenerative changes in lumbar intervertebral discs and their adjacent endplates. A painful endplate is not easy to identify in patients, but could possibly be revealed by inflammatory-like ‘Modic’ changes (which are visible on magnetic resonance imaging (MRI) scans) and by a ‘vacuum phenomenon’ (VP) within the disc (which can be visualized by plain radiographs and computed tomography (CT)). We hypothesize that Modic changes and a VP often co-exist in those lumbar levels
most closely associated with back pain (L4-5 and L5-S1).

**OBJECTIVE:** To investigate the association of lumbar vacuum disc with back pain and Modic changes of lumbar spinal endplate

**METHODS:** We scanned 682 consecutive inpatients (293 women and 389 men; mean age, 60.2 years; age range, 37–87 years) of the Department of Orthopaedics from 2011 August to 2014 August. All patients suffered from lumbar degenerative diseases. Patients were excluded if they had an acute vertebral fracture, known or suspected spondylo-discitis, recent spinal surgery (< 4 months), or a history of malignant tumors. Whether the patients had back pain or not were evaluated, and the DR, CT and MRI images of these patients were reviewed, so that the prevalence and location of VPs and Modic changes could be compared at each spinal level.

**RESULTS:** 4310 discs were studied from 862 patients. The number of discs shown to have a VP was 287 (8.4%) using CT, 107 (3.1%) using radiographs, and 178 (5.2%) using MRI. Of the 287 discs with a CT-diagnosed VP, 77 (11.3%) were L4-5, and 117 (17.2%) were L5-S1. 350 of the 4310 discs (10.3%) exhibited Modic changes, with prevalence of type I, type II and type III Modic changes being 1.6%, 8.2% and 0.4% respectively. Modic changes usually occurred adjacent to L4-5 discs (116/682, 17.0%) or L5-S1 discs (150/682, 22.0%). The prevalence of back pain was higher in the VP group than no-VP group, VPs were significantly associated with Modic changes Type II at L4/5 (p<0.05) and at L5/S1 (p<0.05). CONCLUSION: VPs are closely associated with back pain and Modic changes in the lower lumbar spine. Further investigations may be warranted when radiographs or CT identify a VP in a lumbar disc.

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**GP135**

**CHARACTERISTICS OF LUMBAR VERTEBRAL DEFORMITY IN A POPULATION-BASED COHORT STUDY OF VERTEBRAL FRACTURE**

1Koji Aki, Toshihiro Kato, Norihiro Takegami, Junichi Yamada, Ko Kato, Akihiro Sudo;

1. Department of Orthopaedic Surgery, Mie University Graduate School of Medicine. 2. Department of Orthopedic Surgery, Suzuka Kaisei Hospital

**INTRODUCTION:** Vertebral fractures (VFs) in the lumbar region are relatively rare. However, vertebral deformity in the lumbar region has a great impact on sagittal spinal alignment; therefore appropriate treatment of lumbar VFs is of great importance. The purpose of this study was to examine the characteristics of lumbar vertebral deformity in a population-based prospective cohort.

**METHODS:** The subjects of this study were 227 inhabitants (69 men, 158 women: mean age: 70.1 years) of a typical mountain village who underwent medical examinations from 1997 to 2009 and were followed for 4 years. Lateral thoracic and lumbar spine radiographs of each subject were taken; the extent (G1: mild, G2: moderate, G3: severe) and type (wedge, biconcave, crush) of the prevalent fractures at baseline and new (subsequent) fractures during the 4 year follow-up periods were evaluated using a semi-quantitative technique. The spinal level of VF was divided into 3 groups: thoracic (T: T1-T9), thoracolumbar (TL: T10-L2) and lumbar (L: L3-L4).

**RESULTS:** Prevalent VFs were identified in 52% (119) of subjects. Among these, 23% (27) subjects had VFs in the L level (T: 37%, TL: 70%). In all spinal levels, a significantly higher percentage of G1 deformity was identified (T: 81%, TL: 83%, L: 86%). The percentage of wedge deformity was significantly higher in T and TL levels, however,
that of crush deformity (43%) was significantly higher in the L level. New VFs were found in 28% (63) of subjects during 4 years, including new lumbar VFs in 15% (10). The percentage of crush deformity (40%) was significantly higher, and that of wedge deformity (20%) lower, in the L level compared to those of the T and TL levels (P<0.01).

**DISCUSSION:** This study showed that lumbar VFs occurred in approximately 20% of all VF-positive subjects. The occurrence rate of crush deformity was significantly higher in the lumbar spine.

**GP136**

**COMPARISON OF THE EFFECTIVENESS OF LOXOPROFEN SODIUM AND CELECOXIB FOR POSTOPERATIVE PAIN IN PATIENTS AFTER THE SPINAL SURGERY: RANDOMIZED CONTROLLED STUDY.**

Hiroyuki Sekiguchi1, Gen Inoue1, Toshiyuki Nakazawa1, Takayuki Imura1, Wataru Saito1, Kentaro Uchida1, Masayuki Miyagi1, Naonobu Takahira1, Masashi Takaso1;

1 Department of Orthopaedic Surgery, Kitasato University School of Medicine 2 Department of Rehabilitation, Kitasato University School of Allied Health Sciences.

**INTRODUCTION:** Nonsteroidal anti-inflammatory drugs (NSAIDs) are often used to treat inflammation, pain, and fever associated with various diseases, but no gold standard exists for the management of postoperative pain following spinal surgery. In this study, we compared the analgesic efficacy of loxoprofen sodium (loxoprofen) and celecoxib for postoperative pain management following spinal surgery.

**PATIENTS AND METHODS:** One-hundred thirty-nine patients (mean age: 62.2 years old) were randomly assigned to 2 groups before surgery: loxoprofen group (n=73, 180 mg/day) and celecoxib group (n=66, 200 mg/day), and administered each of them from 1 day until 7 days after the surgery. Numeric rating scale (NRS) was evaluated periodically at 9 predefined time points every day and compared between 2 groups. Laboratory data and the adverse events were also recorded.

**RESULTS AND DISCUSSION:** There was no significant difference between loxoprofen and celecoxib in maximum and mean NRS on each day, suggesting the comparable analgesic effect of these two kinds of NSAIDs. Evaluating the single administration, more improvement in NRS between pre-administration (baseline) and 30 minutes or 2 hours after administration was obtained in loxoprofen group. This tendency was also shown in both slight pain (NRS<5 at baseline) and severe pain (NRS<5 at baseline) One patient in loxoprofen group was prohibited to continue administration on day 4 because of clinical renal dysfunction. One patient in celecoxib group quitted the administration on day 2 because of patient’s offer.

**CONCLUSIONS:** Both loxoprofen sodium and celecoxib were well tolerated to relief acute postoperative pain after the spinal surgery. A single administration of loxoprofen showed superior and rapid effectiveness compared with celecoxib, even in both slight and severe postoperative pain.

**GP137**

**PATHOLOGICAL MECHANISMS OF LUMBAR SPINAL STENOSIS USING PAINDETECT**

Takahashi N1,3; Shirado O2; Kobayashi K1,3; Mashiko R1,3; Konno S3;

1 Department of Orthopaedic Surgery, Minami Aizu General Hospital, Minami Aizu Town, Japan, 2 Department of Orthopaedic and Spinal Surgery, Aizu Medical Center Fukushima Medical University, Aizuwakamatsu City, Japan, 3 Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine, Fukushima City, Japan
INTRODUCTION: The pathological mechanisms of lumbar spinal stenosis are unclear, and few studies have used the painDETECT questionnaire to quantify the pathological mechanisms of lumbar spinal stenosis. The purpose of this study was to quantify the pathological mechanisms of low back pain and/or leg pain caused by lumbar spinal stenosis using the painDETECT questionnaire.

METHODS: A total of 102 patients (37 males, 65 females) at two facilities were newly diagnosed with lumbar spinal stenosis by medical history, physical findings, a clinical diagnostic support tool for lumbar spinal stenosis, and the findings of magnetic resonance imaging. Patient condition was evaluated at the first medical examination using the painDETECT questionnaire, the numerical rating scale, the Roland-Morris Disability Questionnaire, the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire, and the 36-Item Short-Form Health Survey. The pathological mechanism of low back pain and/or leg pain caused by lumbar spinal stenosis was classified as one of the following three possibilities based on the results of the painDETECT questionnaire: 1) nociceptive pain; 2) neuropathic pain; or 3) unclear. Statistical analyses were performed using the Kruskal-Wallis test. Values of $p < 0.05$ were considered to indicate statistical significance.

RESULTS: Fifty-nine subjects (57.9%) were classified as nociceptive pain, 18 (17.6%) as neuropathic pain, and 25 (24.5%) as unclear. The neuropathic pain group had significantly lower quality of life associated with low back pain, bodily pain, lumbar function, social life function, physical function, and mental health ($p < 0.05$) than both other groups.

CONCLUSIONS: Patients with neuropathic back and/or leg pain caused by lumbar spinal stenosis may have lower physical and/or psychological quality of life than patients with pain caused by other mechanisms.

GP138
THE RADIOGRAPHIC EVALUATION OF LUMBAR INSTABILITY FOR DEGENERATIVE SPONDYLOLISTHESIS CASE - DIFFERENCES BETWEEN GRAVITY LOADING AND NON-LOADING POSITION

Hideki Shigematsu1), Tokuji Kashiro2), Eiichirou Iwata1), Akinori Okuda1), Yasuhiro Morimoto1), Yasuhiro Tanaka1);
1) Nara Medical University, Department of orthopaedic surgery 2) Takai Hospital, Department of orthopaedic surgery

INTRODUCTION: To date, we routinely examine the segmental instability for lumbar spondylolisthesis before surgery. Generally most of spine surgeon evaluated the patients with dynamic X-ray. However there is no well-defined method for evaluation of segmental instability and there is no consensus which is best to take dynamic X-ray under gravity loading or under unloading.

PURPOSE: The purpose of this study is to compare three evaluations for segmental instability, especially 1) sagittal translation, 2) sagittal translation and 3) vertical movement.

MATERIAL AND METHODS: We recruited the patients who had L4 spondylolisthesis and came to our outpatient department. We evaluated 17 patients. We took dynamic X-rays under gravity loading (erect) and un-loading (recumbent) on each patient. We compared dynamic X-rays between two positions. We measured 1) intervertebral kyphotic angle (IKA), 2) %slip, 3) the area of disc space (Figure). The statistical difference was determined by paired t-test. Difference with $p<0.05$ was considered significant.

RESULTS: 1) IKA Flexion: 2.9±6.5 degrees on erect. 1.1±4.8 degrees on recumbent (p=0.03). Extension: 7.6±5.0 degrees on
erect. 7.5±5.7 degree on recumbent (p=0.85) 2) %Slip Flexion: 18.0±9.1 % on erect. 18.6±7.6 % on recumbent (p=0.67). Extension: 14.7±7.7 % on erect. 13.8±8.1 % on recumbent (p=0.50) 3) The area of disc space Flexion: 26.9±7.0 % on erect. 28.7±7.9 % on recumbent (p=0.10). Extension: 30.2±7.3 % on erect. 31.0±8.0 % on recumbent (p=0.41)

**DISCUSSION:** Normally we use maximum kyphosis of disc angle and maximum %Slip as instability indexes. Our results only showed that it was statistically significant decrease lordosis angle in flexion of recumbent position. There were no statistical significant differences between erect and recumbent position regarding extension X-rays. Although the previous reports recommended taking standing or sitting dynamic X-rays for evaluation, we could not find great advantages under loading X-rays.

![Figure: How to measure](image)

**GP139**

**VALIDATION OF ANTHROPOMETRIC TOOLS FOR SCREENING OF UNDIAGNOSED VERTEBRAL FRACTURES IN ELDERLY FEMALES**

Tadatsugu Morimoto, Masatsugu Tsukamoto, Tomohito Yoshihara, Motoki Sonohata, Masaaki Mawatari;
Department of Orthopedic Surgery, Faculty of Medicine, Saga University

**INTRODUCTION:** Vertebral fractures (VFs) are common but often asymptomatic. In addition, each vertebral fracture subsequently increases the risk of additional fractures. Therefore, in order to prevent further fractures, the use of a screening tool is necessary to detect existing asymptomatic VFs.

**METHODS:** The subjects included 234 female patients (average age: 65 years range 33 to 90 years) treated with THA due to osteoarthritis of the hip. Patients with a discrepancy in leg length above 2cm and a previous history of hip or spine surgery were excluded from the study. We investigated the arm-height distance (AHD), historical height loss (HHL: the change form the patient’s tallest recalled height), rib-pelvis distance (RPD: the distance between the 11th rib and iliac crest) and female osteoporosis self-assessment tools score (FOSTA: (body weight-age) x0.2). Positive findings were defined as ≥4cm for AHD and HHL, as ≤ two fingerbreadths for RPD, and ≤4 for FOSTA. The sensitivity, specificity and positive likelihood ratio (LR) of these tools for detecting VFs were determined.

**RESULTS:** Of the study subjects, 9%(22 patients) had vertebral fractures. The mean AHD, HHL and FOSTA scores in the patients with and without VFs were 3.4 cm and1.9 cm (P<0.001), 5.3 cm and 2.3cm(P<0.001) and -5.4 and 2.0(P<0.001), respectively. The sensitivity, specificity and LR for AHD, HHL, RPD and FOSTA in predicting VFs were 0.48, 0.74 and 1.85 (95%CI: 1.08-2.77) 0.73, 0.79 and 3.44 (95%CI: 2.3-4.39) 0.77, 0.60 and 1.91(95%CI: 1.36-2.30) and 0.77, 0.78 and 3.50 (95%CI: 2.41-4.31), respectively.

**DISCUSSION:** An HHL of ≥4cm and FOSTA scores of ≥4 effectively predict VFs. Since the HHL and FOSTA values have advantages in terms of reasonable validity, simplicity and low cost, these screening tools may be used to prevent additional VFs when X-rays are not available.
GP140
PROGNOSTIC FACTORS ASSOCIATED WITH THE INDICATION FOR SURGICAL MANAGEMENT OF LUMBAR SPINAL STENOSIS
Masayoshi Fukushima,1) Ko Matsudaira,2) Hiroyuki Oka,2) Nobuhiro Haraguchi,3) Junichi Ohya,1) Yasushi Oshima,1) Hirotaka Chikuda,1);
1) Department of Orthopedic Surgery and Spinal Surgery in the University of Tokyo Hospital. 2) Medical research and Management for Musculoskeletal pain in 22nd Century Medical and research Center at the University of Tokyo Hospital. 3) Department of Orthopedic Surgery in Japanese Red Cross Musashino Hospital.

INTRODUCTION: There are still insufficient data on the management of lumbar spinal stenosis (LSS) due to lack of the prognostic factors associated with the need for surgery.

METHODS: Patients with LSS were enrolled from the University of Tokyo and related facilities. Eligibility criteria were as follows: age 50-85 years and conditions that met the LSS definition: presence of neurogenic intermittent claudication caused by numbness and/or pain in the lower limbs; and magnetic resonance imaging-confirmed symptomatic LSS. Exclusion criteria were as follows: suspected lumbar disk herniation; peripheral arterial disease, history of spinal surgery, myelopathy, or peripheral neuropathy; disorders potentially hindering gait besides LSS. We followed up 274 patients (151 men; mean age, 71 ± 7.4 years) for 3 years to identify prognostic factors. We used a multivariate logistic regression model to investigate the association between the indication for surgical treatment (within 3 years) and age, sex, complications, depression, illness duration, presence of cauda equina symptoms and the presence of degenerative spondylolisthesis/scoliosis.

RESULTS: In the survey conducted 3 years after treatment, 185 patients responded, (follow-up rate 67.5%). In 82 patients, surgery was performed during the follow-up period. The multivariate logistic regression model revealed that the presence of cauda equina symptoms (odds ratio [OR] = 3.31; 95% confidence interval [CI], 1.50-7.31) and the presence of degenerative spondylolisthesis/scoliosis (OR=2.53; 95% CI, 1.13-5.65) were significantly associated with the indication for surgical treatment within 3 years.

DISCUSSION: This study showed that the presence of cauda equina symptoms or degenerative spondylolisthesis/scoliosis is a prognostic factor associated with the indication for surgery for patients with LSS. These results suggest that these factors should be considered when deciding on surgical treatment.

GP141
EFFECT OF SYSTEMIC ADMINISTRATION OF THE ANTI-INTERLEUKIN-6 RECEPTOR ANTIBODY TOCILIZUMAB IN PATIENTS WITH REFRACTORY LOW BACK AND LEG PAIN
Department of Orthopaedic Surgery, Graduate School of Medicine, Chiba University

INTRODUCTION: Increased levels of interleukin-6 (IL-6) in the degenerate intervertebral disc/zygapophyseal joint are associated with chronic pain, and IL-6 and spinal cord glial cells with the pathogenesis of neuropathic pain. We reported that intradiscal injection of the IL-6 inhibitor tocilizumab controlled discogenic low back pain for approximately 4 weeks but did not show a long-term effect. The objective of the current study is to examine the effect of systemic tocilizumab in the treatment of refractory low back and leg pain.

METHODS: Twelve patients with refractory low back and leg pain (6 men, 6 women; mean age, 63.9 years; no pain relief after ≥3 months conservative treatment) due to
lumbar spinal stenosis, degenerative spondylolisthesis, or lumbar disc herniation were included. Those with serious comorbidities were excluded. Tocilizumab 162 mg subcutaneous injection was administered twice at 2-week intervals. Serum IL-6, TNF?, and VEGF levels were checked at baseline and 1 month after treatment. Main outcomes were (1) patient-reported numeric rating scale (NRS) for low back and leg pain and numbness at baseline and post-dose day 1 and weeks 1, 2, 4, 8, 12, and 16; (2) Oswestry disability index (ODI) at baseline and post-dose weeks 4, 8, 12, and 16; (3) serum cytokine levels at baseline and 1 month post-dose; and (4) adverse events.

RESULTS: NRS and ODI improved significantly after treatment (p<0.05), with notable improvement in numbness by week 16. Serum VEGF levels decreased, with significant pre- vs. post-treatment changes (p<0.05).

DISCUSSION: Systemic tocilizumab provided effective symptom relief without obvious adverse events. VEGF levels were correlated with symptom improvement; VEGF may be a potential biomarker for pain. The current results suggest that IL-6 is involved not only locally, at the site of pain origination, but also centrally, in the process of pain transmission. Thus, systemic IL-6 inhibition may provide long-term pain relief.

GP142
THE RELATIONSHIP BETWEEN PREVIOUS HISTORY OF LOW BACK PAIN AND THE FINDINGS ON MAGNETIC RESONANCE IMAGING

Juichi Tonosu1), Hiroyuki Oka2), Ko Matsudaira2), Akira Higashikawa1);
1) Department of Orthopaedic Surgery, Kanto Rosai Hospital 2)Department of Medical Research and Management for Musculoskeletal Pain, 22nd Century Medical & Research Center, Faculty of Medicine, University of Tokyo

INTRODUCTION: Magnetic resonance imaging (MRI) can identify underlying pathologies of low back pain (LBP). However, the importance of the findings on MRI is unclear because of the limited number and quality of studies. Thus, we evaluated the association between MRI findings and previous LBP symptoms in participants without current LBP.

METHODS: Current LBP was defined as pain localized between the costal margin and the inferior gluteal folds during the past month. Ninety-two participants without current LBP were included in this study. Sagittal T2-weighted MRI was used to assess the intervertebral space from T12/L1 to L5/S1. These images were classified into 5 grades based on the Pfirrmann grading system (grades ≥3 indicated disc degeneration). Furthermore, we evaluated the presence of disc bulging, high intensity zone (HIZ), and spondylolisthesis at each level. To determine the reliability of the radiologic interpretations, intraobserver and interobserver kappa values of each MRI finding were evaluated. Using chi square and Fisher’s exact test, we compared the MRI findings between groups with (27 participants) and without (65 participants) previous LBP without current LBP. Previous LBP defined as being involved with the history of medical consultation. P<0.05 was considered significant.

RESULTS: The intraobserver and interobserver variabilities for each MRI finding, evaluated using kappa analysis, were 0.60–0.85 and 0.64–0.93, respectively. Participants had an average age of 34.9 years. There were no significant differences in age between groups. The group of participants with previous LBP presented a significantly higher incidence of disc degeneration at T12/L1, L3/4, L4/5, and L5/S1 and of disc bulging at L4/5 and L5/S1. There were no significant differences in HIZ and spondylolisthesis between groups.
DISCUSSION: MRI findings consistent with Pfirrmann grade ≥3 and disc bulging, especially at the lower lumbar disc level, were associated previous LBP.

GP143
INTERVERTEBRAL BRIDGING OSSIFICATIONS INCREASE THE RISK OF INTRAVERTEREBRAL CLEFT FORMATION FOLLOWING A VERTEBRAL COMPRESSION FRACUTRE
Atsushi Kimura, M.D., Teruaki Endo, M.D., Hirokazu Inoue, M.D., Katsushi Takeshita, M.D.; Department of Orthopaedics, Jichi Medical University, Tochigi, Japan

INTRODUCTION: The thoracolumbar junction is a site of predilection for intervertebral cleft (IVC) formation following VCF because it represents a biomechanical transition zone between the rigid thoracic spine and its more flexible lumbar counterpart. We hypothesized that intervertebral bridging ossifications, which occur most commonly at the lower thoracic spine, would increase the risk of IVC formation by increasing the biomechanical stress to the fracture site. The purpose of this study was to determine whether the presence of intervertebral bridging ossifications is associated with IVC formation following a vertebral compression fracture (VCF).

METHODS: Patients with VCF who received conservative treatment for a minimum of 3 months were recruited over a 3-year period. Baseline radiographs obtained within a month of onset were compared between 50 patients who developed IVC at 3-month follow-up (IVC group) and age-matched 100 patients without IVC (control group). Intervertebral bridging ossification was defined as complete bridging of the intervertebral space by ossification. The presence of bridging ossification was assessed at each intervertebral level from T9/10 to L5/S. In addition to the absolute levels of bridging ossifications, the level relative to a fresh VCF was recorded (Figure 1).

RESULT AND DISCUSSION: The most common level for VCF was L1 in both groups. The incidence of bridging ossification at levels T9/10 and T10/11 was significantly higher in the IVC group than in the control group (P = 0.010 and 0.047, respectively; Fisher’s exact test). Patients IVC group showed a significantly higher incidence of bridging ossification at the second proximal intervertebral segment than those in the control group (P = 0.003). These results suggest that a fresh VCF with bridging ossification at the second proximal intervertebral level is associated with increased risk of IVC formation. Strict conservative treatment is recommended in such cases.

GP144
RELATIONSHIP BETWEEN AGE-RELATED CHANGES IN THE PARAVERTEBRAL AND PSOAS MUSCLES OF THE LUMBAR SPINE AND LOW BACK PAIN: THE WAKAYAMA SPINE STUDY
Hiroshi Hashizume1, Noriko Yoshimura2, Hiroshi Yamada1, Hirooyuki Oka2, Hiroki Iwahashi1, Takahide Sasaki1, Yuyu Ishimoto1, Keiji Nagata1, Masatoshi Teraguchi1, Ryoei Kagotani1, Shigeyuki Muraki2, Akihito Minamida1, Yukihiro Nakagawa1, Munehito Yoshida1;
INTRODUCTION: A definite algorithm for imaging muscles around the lumbar spine is yet to be established, although magnetic resonance imaging (MRI) is widely used worldwide. We elucidated age- and sex-related degenerative changes in parametrical (PVM) and psoas muscles (PM) of the lumbar spine, and the relationship of these changes to low back pain (LBP) in a general population.

METHODS: This cross-sectional, population-based cohort in Japan included 952 subjects who had participated in the second survey of the Wakayama Spine Study; of these, 794 (male, 239; female, 555; mean ± SD age, 63.6 ± 13.1 years) underwent MRI. The cross-sectional area (cm²) and percentage of fatty degeneration in the PVM at the L1 upper end-plate level, and PM and PVM at the L5 upper end-plate level were measured using the Digital Imaging and Communications in Medicine software. Information on the presence of LBP and visual analog scale (VAS) score for LBP were obtained via interviews. The relationship between muscular changes and LBP was determined using a multiple logistic regression analysis, after adjusting for age, body mass index, and sex. P-values less than 0.05 were considered as statistically significant.

RESULTS: The mean cross-sectional areas of PVM and PM around the lumbar spine reduced significantly with age in both sexes (Table). Men had higher decreased ratios than women. Fatty degeneration was significantly predominant in PVMs in both sexes. Multiple logistic regression analysis revealed a significant relationship between fatty degeneration of the PVM at the L1 level and LBP and high VAS scores for LBP.

DISCUSSION: This novel study determined the significant relationship between PVM degeneration and LBP in a general population. Follow-up of this cohort will elucidate risk factors of PVM degeneration and cutoff parameters associated with LBP.

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GP145

THE EFFECT OF SERM (SELECTIVE ESTROGEN RECEPTOR MODULATOR) ON OSTEOPOROTIC SPINAL ARTHRODESIS USING RAT MODEL

1Song Bae Park, M.D., 2Chun Kee Chung, M.D., PhD, 2Chi Heon Kim, M.D., PhD;

1Department of Neurosurgery, Seoul National University Boramae Medical Center, Seoul, Korea 2Department of Neurosurgery, Seoul National University College of Medicine, Clinical Research Institute, Seoul National University Hospital, Seoul, Korea

INTRODUCTION: Selective estrogen receptor modulator (SERM) prohletes osteoblasts, improves bone mechanical strength and increases bone mineral density. The raloxifene as a SERM may be superior in new bone formation and bone healing to BPs. Until now, there was no study about effect of raloxifene on bone formation except fracture healing and improvement of implant fixation to bone. we evaluated the effect of raloxifene on bone formation using osteoprotic rat spine fusion.

METHODS: Female Sprague Dawley rats (n=80) were ovariectomized or sham-operated, and randomized into three groups: Sham (sham-operated + fusion), OVX (OVX + fusion) and SERM (OVX + fusion + SERM). Six weeks after ovar-
ectomy, unilateral lumbar spine fusion was performed using autologous iliac bone. Animals were sacrificed 4 and 8 weeks after arthrodesis, and bone formation was assessed by measuring bone mineral density and mRNA expression, manual palpation, and radiological evaluation.

**RESULTS:** The SERM group showed more compacted bone between transverse process at 8 weeks after fusion surgery than those of OVX and Sham groups. The fusion rate of Sham, OVX, and SERM group at 8 weeks after fusion surgery was 33.3%, 11.1%, and 44.4% respectively. The bone formation rate in SERM group was significantly superior to that in OVX group (p= 0.050). In SERM group, bone turnover markers increased than that in the OVX group.

**CONCLUSION:** The bone remodeling in grafted area of SERM group was superior of that of OVX group. The administration of SERM could improve the outcome of spinal fusion in the osteoporotic patient.

**GP146**

**THE TIME-DEPENDENT EFFECT OF IBANDRONATE ON BONE GRAFT REMODELING IN AN OVARIECTOMIZED RAT SPINAL ARTHRODESIS MODEL**

1Sung Bae Park, M.D., 2Chun Kee Chung, M.D., PhD, 2Chi Heon Kim, M.D., PhD;
1Department of Neurosurgery, Seoul National University Boramae Medical Center, Seoul, Korea. 2Department of Neurosurgery, Seoul National University College of Medicine, Clinical Research Institute, Seoul National University Hospital, Seoul, Korea

**INTRODUCTION:** In osteoporotic patients undergoing spinal arthrodesis, the use of BPs remains controversial with regard to bone fusion. There is no consensus about the appropriate time to give BPs to patients with osteoporosis undergoing spinal arthrodesis. We aimed to study the effect of bisphosphonates (BPs), given at different times, on the bone response to osteoporotic spinal arthrodesis.

**METHODS:** Female Sprague Dawley rats (n=100) were ovariectomized (OVX, n=80) or non-OVX operated (n=20) and randomized into five groups: non-OVX group, osteoporosis group, osteoporosis with early BP group, osteoporosis with simultaneous BP group, and osteoporosis with late BP group. Eight weeks after ovariectomy, lumbar spinal arthrodesis was performed using autologous tailbones. Animals were sacrificed 4 and 8 weeks after arthrodesis, and bone formation was assessed by measuring bone mineral density and mRNA expression, manual palpation, radiological evaluation, and histomorphometry.

**RESULTS:** Compared with late administration, early administration of ibandronate increased femur bone mineral density in OVX rats and did not hinder bone fusion. Radiological analysis showed that groups given early ibandronate had increased bone volume in the grafted site 8 weeks after surgery. Histomorphometric analysis showed that ibandronate positively affected endochondral and intramembranous ossification. In the OVX groups, ibandronate increased bone turnover to a level similar to that in the non-OVX group. These findings suggested that early administration of ibandronate did not inhibit osteogenesis, including endochondral and intramembranous ossification and fusion rate.

**CONCLUSION:** Our results suggest that the early administration of BPs may not hinder the bone fusion of osteoporotic patients undergoing spinal arthrodesis.

**GP147**

**A PREDICTIVE MODEL FOR SPONDYLOLISTHESIS PROGRESSION BASED ON RADIOGRAPHIC PARAMETERS**

William Slikker III, MD; Alejandro A. Espinoza Ortias, PhD; Joe Y.B. Lee, MD; Louis Fogg, PhD;
INTRODUCTION: Dynamic instability and preserved intervertebral disc height (DH) are associated with future slip progression in degenerative spondylolisthesis (DS), whereas spondylotic changes and disc degeneration may represent mechanisms for re-stabilization. The objective of this study was to develop a model to predict dynamic instability and the progression of degenerative spondylolisthesis using said radiographic parameters.

METHODS: Preoperative radiographs of the lumbar spine from 125 patients with known diagnosis of L4-L5 DS who underwent decompression and fusion were obtained in this IRB-approved retrospective study. Neutral, flexion, and extension views were used to determine degree of slip, DH, translational motion, angular motion, spondylotic changes, and lumbar lordosis. These parameters were used in a stepwise logistic regression analysis to determine the optimal combination of disc characteristics for predicting DS, which was further validated by a Receiver-Operator Curve.

RESULTS: Preserved DH was significantly associated with dynamic instability in patients with DH; whereas disc degeneration and spondylotic changes were inversely related to dynamic instability. Six radiographic parameters (Anterior/Posterior-DH and slip for both flexion/extension views) had significant Wald statistics in the predictive model which found a cutoff score of 0.9 to classify instability in subjects (score>0.9 was deemed unstable). The ROC curve shows excellent specificity-sensitivity features (Fig.1).

DISCUSSION: The resulting predictive model based on radiographic parameters was able to detect instability in DS patients. The association between DH and instability may represent a greater potential for slip progression over time in these patients. In contrast, disc degeneration on MRI, and spondylotic changes were inversely related to dynamic instability and may represent re-stabilization mechanisms that decrease the chance of future slip progression in DS.

GP148

EPIDEMIOLOGICAL STUDY OF LUMBAR SPINAL STENOSIS: 10-YEAR COMMUNITY FOLLOW-UP
Takahiro Igari, Koji Otani, Miho Sekiguchi, Naoyuki Oi, Shin-ichi Kikuchi, Shin-ichi Konno;
Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine, Fukushima, Japan

INTRODUCTION: Lumbar spinal stenosis (LSS) is a common disease in the elderly and has a negative impact on quality of life (QOL). However, little has been reported on the long-term natural history of LSS in the community. The aim of this study was to clarify the natural history of LSS in community-dwelling people.

METHODS: A total of 1149 people (395 males, 754 females; age range 30-89 years) agreed to participate in this study, and all of them were interviewed in 2004. The presence of LSS was diagnosed by a specially designed questionnaire. Ten-year follow-up was performed in 2014 by mail questionnaire. The presence of LSS
(diagnostic support tool), low back pain-related QOL (RDQ) and health-related QOL (SF-36) were evaluated in 2014.

**RESULTS:** A total of 190 (16.5%) of 1149 people were diagnosed with LSS in 2014. Meanwhile, subjects with LSS in 2004 included 189 people (16.4%), and 71 of 189 subjects (37.6%) were LSS-positive in both 2004 and 2014, while 118 of 189 subjects (62.4%) switched from LSS-positive in 2004 to LSS-negative in 2014. There were 960 LSS-negative subjects in 2004, and 119 of 960 subjects (12.4%) switched from LSS-negative in 2004 to LSS-positive in 2014, while 841 of 960 subjects (87.6%) were LSS-negative in both 2004 and 2014. LBP-related QOL changed with LSS symptoms (improved or worsened).

**CONCLUSIONS:** The prevalence of LSS increased with age. The rate of LSS-negative that switched to LSS-positive increased with age, except in the 60s. Meanwhile, the rate of LSS-positive that switched to LSS-negative decreased with age. Over 10 years, the LBP-related QOL score and LSS symptoms were correlated.

**GP149**

**DO SPONDYLOLYSIS AND ISTMIC SPONDYLOLISTHESIS CAUSE LOW BACK PAIN IN ADULTS? SYSTEMATIC REVIEW OF OBSERVATIONAL STUDIES**

Viktor Bartanusz, Carol M. Ashton, Nelda P. Wray, Nicholas S. Andrade;
Department of Neurosurgery, University of Texas Health Science Center at San Antonio, San Antonio, Texas, USA Center of Outcomes Research, Houston Methodist Research Institute, Houston, Texas, USA

**INTRODUCTION:** The hypothesis that spondyloysis (SL) and/or isthmic spondylolisthesis (IS) cause low back pain (LBP) in the general adult population is widely accepted, however it should be rigorously examined, especially before recommending surgical intervention. In particular, if SL/IS cause LBP, individuals with these conditions should be more prone to LBP than those without SL/IS. The goal of the study was to assess whether the published primary data demonstrate an association between SL/IS and LBP in the general adult population.

**METHODS:** We searched PubMed in August 2013 to identify epidemiological studies that provided sufficient data for calculating the association between SL/IS and LBP in adults. Studies were classified as to design and other attributes, and the methodological quality of the cohort and case-control studies was evaluated using the Newcastle-Ottawa scale.

**RESULTS:** Of the 15 studies that met inclusion criteria, one was a cohort study, 7 were case-control studies, and 7 were cross-sectional surveys (Figure 1). Quantitative synthesis across studies was not performed because of wide variations in study years and countries, type of study samples, ascertainment methods of risk factor and outcome, and methodological quality. Neither the cohort study nor the two highest-quality case control studies detected an association between SL/IS and LBP; the same is true for most of the other 15 studies.
DISCUSSION: There is no strong or consistent association between SL/IS and LBP in epidemiological studies of the general adult population that would support a hypothesis of causation. It is possible that SL/IS coexist with LBP, and observed effects of surgery and other treatment modalities are primarily due to benign natural history and nonspecific treatment effects, which are known to be particularly strong for surgical interventions directed at subjective outcomes.

GP150
CHARACTERISTICS OF LUMBAR SPONDYLOLYSIS IN ELEMENTARY SCHOOL AGE CHILDREN
*Department of Orthopedic Surgery, Tokushima University, Tokushima, Japan,
**Hachioji Sports Clinic, Tokyo, Japan

INTRODUCTION: Lumbar spondylolysis, a stress fracture of the pars interarticularis in the lumbar spine, is often precipitated by trauma, but there may be a congenital predisposition. There have been few studies on spondylolysis in young children, a group suited to studies on the influence of congenital defects. The purpose of this study was to identify the clinical features of lumbar spondylolysis in elementary school age children to provide clues to its pathogenesis.

METHODS: Thirty lumbar spondylolysis patients (23 boys, 7 girls, including a pair of twins; mean age, 9.5 years; age range, 5-12 years), were studied. Patient data were collected on history of athletic activity, symptoms at first consultation, and radiological findings such as spinal level, stage of the stress fracture, and skeletal age.

RESULTS AND DISCUSSION: Among the 30 patients, 27 (21 boys, 6 girls) had L5 spondylolysis (90.0%). Only 2 patients had no history of athletic activity before first consultation. All except 2 patients complained of low back pain. In those 2 patients was diagnosis of L5 spondylolysis incidental. In the 27 patients with L5 spondylolysis, 17 (63.0%) had terminal-stage fracture and 25 (92.6%) had spina bifida occulta (SBO) of the S1 lamina. Sixteen of the 27 (59.3%) had SBO of the affected lamina (L5) and S1 lamina. In contrast, the 3 patients with L3 or L4 spondylolysis presented no evidence of SBO. Skeletal age in 23 of the 27 L5 spondylolysis patients (85.2%) was in the cartilaginous stage and in the remaining 4 patients was in the apophyseal stage. Lumbar spondylolysis in elementary school age children was commonly a terminal-stage bone defect at L5, which was not necessarily related to history of athletic activity, and it was sometimes asymptomatic. It was also often associated with SBO, indicating a possible genetic predisposition. These findings may help guide future elucidation of disease pathogenesis.

GP151
DIFFUSION TENSOR IMAGING PARAMETERS OF RADICULOPATHY IN PATIENTS WITH LUMBAR DISC HERNIATION
Yawara Eguchi1, Yasuhiro Oikawa3 Munetaka Suzuki1, Kazuhisa Takahashi2, Seiji Ohtori2;
1 Department of Orthopaedic Surgery, Shimoshizu National Hospital, 934-5, Shikawatashi, Yotsukaido, Chiba, Japan 2Department of Orthopaedic Surgery, Graduate School of Medicine, Chiba University, 1-8-1 Inohana, Chuo-ku, Chiba, Japan 3Department of Orthopaedic Surgery, Teikyo University Chiba Medical Center, 3426-3, Anegasaki, Ichihara, Chiba, Japan

INTRODUCTION: The purpose of this study was to evaluate the time course of changes in Diffusion tensor imaging (DTI) parameters such as fractional anisotropy (FA)
values and apparent diffusion coefficient (ADC) values and to investigate the correlation between neurological severity and DTI parameters in patients with radiculopathy caused by lumbar disc herniation.

**METHODS:** Eleven patients who had unilateral radiculopathy with lumbar disc herniation and received microendoscopic discectomy underwent DTI on a 1.5T MR scanner. The time course of changes in DTI parameters: mean FA and ADC values, and the correlation between DTI parameters and neurological severity were investigated before and at 6 months after surgical treatment.

**RESULTS AND DISCUSSION:** Mean FA values were significantly lower and mean ADC values were significantly higher in compressed nerves than in intact nerves. Although FA values were increased significantly at 6 months after surgical treatment, ADC values decreased but this difference was not significant. There were strong correlations between DTI parameters such as FA value and indications of neurological severity including the Japanese Orthopedic Association (JOA) score and the Roland-Morris Disability Questionnaire (RDQ). DTI parameters of the lumbar nerve can be used as diagnosis, quantitative evaluation, and follow-up of lumbar nerve entrapment.

**GP152**

**USEFUL INDEX OF LABORATORY ANALYSIS FOR EARLY SURGICAL SITE INFECTION FOLLOWING POSTERIOR INSTRUMENTED LUMBAR FUSION FOR DEGENERATIVE SPINE DISEASE**

Eiichiro Iwata1), Hideki Shigematsu1), Akinori Okuda1), Yasuhiro Morimoto1), Keisuke Masuda1), Munehisa Koizumi2), Hiroshi Nakajima3), Yasuhiro Tanaka1);

1) Department of Orthopedic Surgery, Nara Medical University 2) Department of Orthopedic Surgery, Nara Prefecture General Medical Center 3) Department of Orthopedic Surgery, Otemae Hospital

**INTRODUCTION:** Surgical site infection (SSI) is serious complication of spinal instrumentation surgery. Early diagnosis and treatment are very important. We calculated sensitivity and specificity of some indexes of laboratory analysis for a detection of early SSI. The aim of the present study is to clarify the characteristics of each index.

**MATERIALS AND METHODS:** We retrospectively reviewed laboratory analysis of posterior instrumented lumbar fusion for degenerative spine disease cases between 2003 and 2013. We defined six indexes of early SSI in the present study as previously reported. Each index is shown in Table. We calculated the sensitivity and specificity of each index. Statistical analysis was performed with fisher's exact test and a p value of less than 0.05 was considered significant.

**RESULTS:** A total of 85 patients data were enrolled in the present study. Of these, five patients developed early SSI. Sensitivity and specificity of each index were shown in Table. There was significant statistical difference in index[c] and [f].

### Sensitivity and specificity of each index of early SSI

<table>
<thead>
<tr>
<th>Index</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[a]</td>
<td>20.0%</td>
<td>77.5%</td>
<td>0.690</td>
</tr>
<tr>
<td>[b]</td>
<td>20.0%</td>
<td>85.0%</td>
<td>0.680</td>
</tr>
<tr>
<td>[c]</td>
<td>40.0%</td>
<td>97.5%</td>
<td>0.016*</td>
</tr>
<tr>
<td>[d]</td>
<td>40.0%</td>
<td>86.5%</td>
<td>0.166</td>
</tr>
<tr>
<td>[e]</td>
<td>9%</td>
<td>96.3%</td>
<td>0.832</td>
</tr>
<tr>
<td>[f]</td>
<td>80.0%</td>
<td>80.0%</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

(Statistics: Fisher’s exact probability test)

**DISCUSSION AND CONCLUSION:** In the present study, index[c] would be a useful for definitive diagnosis, based on its high specificity. Besides, index[f] would be a useful for screening test, based on its high
sensitivity. Although many authors reported the index of laboratory analysis for detection of SSI, we think that it is important to understand the characteristics of each index.

GP153
ELEVATED LEVELS OF PHOSPHORYLATED NEUROFILAMENT HEAVY SUBUNIT IN THE CEREBROSPINAL FLUID OF PATIENTS WITH LUMBAR SPINAL STENOSIS
Junichi Ohya, Hirotaka Chikuda, Toru Ogata, Kentaro Hayakawa, Yasushi Oshima, Yuki Taniguchi, Yoshitaka Matsubayashi, Yoh Kumano, Masayoshi Fukushima, Takeshi Ouchi, Sakae Tanaka;
Department of Orthopaedic Surgery, Faculty of Medicine, The University of Tokyo

INTRODUCTION: The phosphorylated neurofilament heavy subunit (pNfH) is an axon fiber structural protein released into the cerebrospinal fluid (CSF) after nerve damage. Although previous studies have reported elevated CSF levels of pNfH in various neurological diseases, the levels have not been examined in patients with spinal stenosis. The purpose of this study was to investigate the CSF levels of pNfH in patients with lumbar spinal stenosis (LSS), and to examine the relationship between these levels and the severity of LSS.

METHODS: We included consecutive patients with LSS who underwent myelography for preoperative evaluation. CSF samples from patients with idiopathic scoliosis served as controls. The CSF levels of pNfH were measured using an enzyme-linked immunosorbent assay. Patients were grouped into tertiles according to their symptom severity and pain grading using the Zurich Claudication Questionnaire (ZCQ) and the numerical rating scale (NRS) for sciatic pain. The patients were classified into three groups based on their morphological grading (using the CSF/rootlet ratio) of LSS by axial magnetic resonance imaging. The relationship between the CSF pNfH levels and the severity of LSS was assessed by an analysis of variance.

RESULTS: Thirty-three patients with LSS were included (13 males and 20 females; mean age, 73.2 years; range, 58–88 years). Most patients (n = 32) were positive for pNfH in their CSF (mean, 1,344 pg/mL; range, 149–9,250 pg/mL), while all control subjects were negative. The patients in the third tertiles of the ZCQ and NRS tended to have higher levels of pNfH compared to the other groups. There was no association between the CSF level of pNfH and the morphological severity of LSS.

DISCUSSION: Patients with LSS had elevated pNfH levels in their CSF. Patients with severe clinical symptoms were more likely to exhibit high levels of pNfH. Our results indicate that pNfH may be a useful biomarker for compressive spinal disorders.

GP154
COMPARISON OF SPINOPELVIC ALIGNMENT IN THE TREATMENT OF DEGENERATIVE SAGITTAL IMBALANCE OF THE LUMBAR SPINE
Dong-Gune Chang, MD, * Kee-Yong Ha, MD,† Young-Hoon Kim, MD,† Jang-Woon Kim, MS, Jin-Hyok Kim;
* Seoul Spine Institute, Sanggye Paik Hospital, College of Medicine, The Inje University, Seoul, Korea † Department of Orthopaedic Surgery, Seoul St. Mary’s Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea

INTRODUCTION: Many papers have reported the surgical results after PSO and ILF for patients with fixed adult deformities. However, little is known about the difference between PSO and ILF corrections of spinopelvic alignment in adults with DSI. Therefore, we compare pedicle subtraction osteotomy (PSO) and iliac fixation (ILF) without osteotomy as methods of correcting lumbar spine
deformities due to degenerative sagittal imbalance (DSI) through the evaluation of the changes in spinopelvic alignment.

**METHODS:** DSI patients who had undergone PSO or ILF with a minimum of 2-year follow-up (FU) were retrospectively studied in PSO (n=30) or ILF (n=25) groups. Lumbar lordosis (LL), thoracic kyphosis (TK), and sagittal vertical axis (SVA) were measured as spinal parameters and pelvic incidence (PI), sacral slope (SS), and pelvic tilt (PT) were used as measurements of pelvic parameters. Clinical outcomes were evaluated using a visual analogue scale (VAS) and Oswestry Disability Index (ODI) scores.

**RESULTS:** There were no statistically significant differences between the PSO and ILF groups with regards to age and fused segments, but there were significant differences in operative time and estimated blood loss. Concerning spinal parameters, there were significant increases of LL and TK in PSO group immediate postoperatively (LL: P = 0.014, TK: P = 0.017) and at the 2-year FU (LL: P = 0.021, TK: P = 0.022), but no significant difference in SVA was evident between the two groups. Within the pelvic parameters, there was a significant increase of SS and decrease of PT in the ILF group immediate postoperatively (SS: P = 0.013, PT: P = 0.009) and at the 2-year FU (SS: P = 0.024, PT: P = 0.027), but the PI in both groups was not changed after surgery and there was no significant difference between two groups. VAS and ODI were significantly improved after surgery in both groups.

**DISCUSSION:** The PSO group was better than the ILF group in the correction of the LL and TK, but not with regards to the pelvic parameters. The ILF group was superior in the correction of the pelvic orientation as compared to the PSO group when the PI was constant after surgery. Ultimately, ILF effectively achieves better correction of the pelvic parameters (SS and PT).

**GP155**

**SURGICAL OUTCOMES FOLLOWING POSTERIOR HEMIVERTEBRA RESECTION AND SHORT SEGMENT FUSION WITH PEDICLE SCREW FIXATION FOR CONGENITAL SCOLIOSIS IN CHILDREN UNDER AGE 10 YEARS**

Dong-Gune Chang, MD,* Jin-Hyok Kim, MD,* Dong-Ju Lim,* MD, Ji-Seok Jang, MD,* Kee-Yong Ha, MD,† Se-Il Suk, MD*;

* Seoul Spine Institute, Sanggye Paik Hospital, College of Medicine, The Inje University, Seoul, Korea † Department of Orthopaedic Surgery, Seoul St. Mary’s Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea

**INTRODUCTION:** This is the first long term follow-up on surgical outcomes of posterior hemivertebra resection and short segment fusion using segmental pedicle screw fixation in children under age 10 years with congenital scoliosis.

**METHODS:** Congenital scoliosis patients (n=18) under age 10 years at the time of the surgery were treated by posterior hemivertebra resection and bilateral pedicle screw fixation. The mean age at the time of surgery was 6.6 years (range, 2.6-9.8). They were retrospectively studied with a mean follow-up of 11.4 years (range, 7.1-17.3)

**RESULTS:** The mean Cobb angle of the main curve was 34.4° before surgery, 8.6° after surgery, and 12.9° at last follow-up. In the compensatory cranial curve, the preoperative Cobb angle of 14.5° was corrected to 5.9° postoperatively and was 8.4° at last follow-up. In the compensatory caudal curve, the preoperative Cobb angle of 17.4° improved to 4° postoperatively and 6.6° at last follow-up. There were no crankshaft phenomena and no clinical and radiographic features suggestive of spinal stenosis during follow-up. There were no
major vascular or neurological complications related to the pedicle screws.

**DISCUSSION:** Posterior hemivertebra resection following pedicle screw fixation in congenital scoliosis is a safe and effective procedure that can achieve rigid fixation, deformity correction and restore spinal balance. This study showed that early posterior hemivertebra resection of congenital scoliosis before structural changes occur above or below can reduce fusion length, prevent curve progression and effectively achieve a more satisfactory correction without hazardous iatrogenic spinal stenosis, crankshaft phenomena or neurologic complications.

**GP156**

**RESULTS OF A COMPLEX CASE PEER REVIEW PROGRAM IN A PRIVATE PRACTICE SPINE SPECIALTY CLINIC**

Richard D. Guyer, MD, Jennifer Shivers, PA, Donna D. Ohnmeiss, DrMed, Jack E. Zigler, MD, Scott L. Blumenthal, MD;

Texas Back Institute and the Texas Back Institute Research Foundation; Plano, Texas

**INTRODUCTION:** Determining operative intervention in complex spine cases is very challenging. Collaboration may facilitate decision making. The purpose of this study was to describe a practice-based peer-review program in a private practice and analyze its impact on surgeries performed.

**METHODS:** Pre-operative case review was initiated in 2009 for proposed complex surgeries (excluding acute trauma, deformity, and tumor): fusion of 3 or more levels, significant anesthesia or vascular risk factors, body mass index greater than 40, multiple prior surgeries at the same level, and advanced age. Indications /rationale for surgical plans were discussed and the committee agreed with the plan or suggested changes. Surgery logs were reviewed to monitor compliance with submitting cases to review and to compare the proposed vs. actual surgery performed.

**RESULTS:** The committee reviewed 275 proposed surgeries. An overview of the outcomes is shown in the figure. In 45.1% of cases, the committee agreed with proposed surgery. Among cases where the committee disagreed with proposed surgery, the surgery was changed to the committee recommended procedure in 22.5%; in 13.9% the proposed surgical plan was modified but not to the extent recommended by the committee, and in 15.9% the proposed surgery was performed, although the committee disagreed. In 34.4% of cases where the committee disagreed with proposed surgery, no surgery was undertaken. Of note, in all cases where the committee recommended less surgery (such as fewer levels, or not a 360 fusion) than proposed and this was done, there have been no reoperations to expand to the proposed surgery.

**DISCUSSION:** The peer-review program impacted many reviewed cases. By using well-defined criteria, cases can be identified to review with the goal of increased safety and quality by taking advantage of multiple surgeons’ experience to derive a treatment plan after non-operative care fails. This program can serve as a model for other clinics.

![Diagram of surgery outcomes]
GP157
COMPARISON OF TLIF (TRANSFORAMIAL LUMBAR INTERBODY FUSION) VERSUS LLIF (LATERAL INTERBODY FUSION) IN THE ABILITY TO RESTORE FORAMINAL HEIGHT
Mr Ravikiran Shenoy Mr Robert Lee Mr Radu Popa Mr Lester Wilson;
Royal National Orthopaedic Hospital, Stanmore, London

INTRODUCTION: Lumbar interbody fusion aims to achieve stability, pain relief and indirect foraminal decompression. This study aimed to analyse CT scans in patients who have had transforaminal lumbar interbody fusion (TLIF) or lateral lumbar interbody fusion (LLIF) comparing pre and post operative foraminal height and investigate if one of these methods is more effective in increasing foraminal height.

METHODS: A retrospective study including non random-ised patients who underwent a TLIF or LLIF procedure and who had adequate pre and post-operative CT scans for comparison. Indications for surgery, level of surgery and demographic details of patients were collected. Foraminal height on the right and left side was measured on CT scans in each patient at the operated level.

RESULTS: Twenty two patients who had TLIF (n=11) or LLIF (n=11) were included in the study. Indications for surgery in those who had a TLIF procedure were back pain (n= 8), spondylolisthesis (n=2) and degenerative spinal disease (n= 1). TLIF was performed at L4/5 space in 6 patients, L5/S1 in 4 patients and L3/4 in 1 patient. Increase in foraminal height was achieved following surgery; (mean +/- SEM) 1.78 +/- 0.85mm on the operated side and 0.59+/- 0.44 on the contra lateral side. Indications for surgery in those who had a LLIF procedure were back pain (n= 6), degenerative spinal disease (n=4) and spondylolisthesis (n=1). LLIF was performed at L3/4 space in 6 patients, L2/3 in 2 patients, L4/5 in 2 patients and T12/L1 in 1 patient. Increase in foraminal height was achieved following surgery; (mean +/- SEM) 1.33 +/- 0.53 on the operated side and 2.44 +/- 0.83 on the contra lateral side. These changes were significant only with LLIF both on the operated side (p= 0.03 ) and the contra lateral side (p= 0.02).

DISCUSSION: LLIF is more effective in achieving indirect foraminal decompression by increasing foraminal height compared to TLIF. Further randomised studies are recommended to confirm this.

GP158
COMPARING OUTCOMES OF VARIOUS SURGICAL MANAGEMENT OPTIONS FOR LUMBAR DEGENERATIVE SPONDYLOLISTHESIS
Burleson JR, Wagner PJ, Connolly PJ, DiPaola CP, Stauff MP;
UMass Memorial Medical Center, University of Massachusetts Medical School, Worcester MA

INTRODUCTION: There are multiple options for surgical treatment in patients with lumbar degenerative spondylolisthesis. The options include: decompression, decompression with a non-instrumented fusion, and decompression with an instrumented fusion. Often surgeons also perform interbody fusions from various approaches, including: anterior, anterolateral, lateral, transforaminal, and posterior. The decision regarding the optimal surgical treatment is based on multiple variables, but differs between surgeons. The purpose of this study is to compare the outcomes of patients with lumbar degenerative spondylolisthesis who are treated with different surgical techniques.

METHODS: We performed an ambispective review of the UMass Spine Center registry for patients with degenerative spondylolisthesis who were treated surgically at our institution from 2006-2013. The patients
were stratified based on procedure. We compared the cohorts using the following variables: demographics, rate of re-operation, levels of fusion, and pre/post operative SF-36 score.

**RESULTS:** Our review captured 154 patients (74% female). The average age for all patients was 61 years old. The surgical procedures were performed by five fellowship trained orthopaedic spine surgeons. Follow-up ranged from 1-6 years with an average of 2.4 years. Patients in every group saw an improvement in their SF-36 scores at the latest follow up.

**DISCUSSION:** Our results demonstrate that all patients had significant improvement from pre-operatively to 1 year post-operatively except for the cohort that had an ALIF with posterior instrumented fusion. The re-operation rate was higher with increasingly complex surgical procedures. Further prospective research is needed in order to determine the optimal surgical treatment for each patient with lumbar degenerative spondylolisthesis who fails non-operative treatment.

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**GP159**

**SUCCESSFUL POSTERIOR INTERTRANSVERSE ARTHRODESIS IN A RABBIT MODEL USING A NOVEL COMPOSITE TISSUE ENGINEERING SCAFFOLD AND AUTOLOGOUS BIOLOGIC FACTORS**

Jeffrey Van Eps, MD, Joseph Fernandez-Moure, MD, MS, Fernando Cabrera, MD, Silvia Minardi, MS, Ennio Tasciotti, PhD, Bradley Weiner, MD; 1. Department of Surgery & Department of Orthopedics and Sports Medicine, Houston Methodist Hospital, Houston, TX, 77030 2. Surgical Advanced Technologies Lab, Center for Regenerative Medicine, Houston Methodist Research Institute, Houston, TX, 77030

**INTRODUCTION:** With the increased implementation of spinal instrumentation and fusion, a demand for biologic alternatives to morbid autografting or prosthetic implants has emerged. Additionally, platforms utilizing bone morphogenic proteins (BMPs) are limited by their potential side effects. We hypothesized that successful posterior lumbar arthrodesis could be accomplished in rabbits, using only autologous platelet-rich plasma (PRP) and a novel mineralized, composite scaffold.

**METHODS:** A proprietary magnesium-hydroxyapatite/collagen 70/30 wt% biohybrid scaffold was implanted in sixteen New Zealand White rabbits randomly assigned to two experimental groups undergoing L5-L6 posterior intertransverse arthrodesis – scaffold alone (S1) or scaffold + PRP (S2). Autologous PRP was isolated from whole blood preoperatively for S2 rabbits and activated with CaCl and thrombin. The left anatomic side of each animal received decortication alone, serving as an internal control (IC). DynaCT imaging was performed at 2, 4, and 6 weeks postoperatively, and differences in experimental side/IC bone volume were quantified on a Siemens Inveon system using thresholds of 200 Hounsfield units (HU) and 500 HU respectively.

**RESULTS:** Both groups displayed significantly more osteogenesis on the experimental side versus IC (p less than 0.05), confirming scaffold osteoinductivity. More robust osteogenesis and successful fusion was only seen in S2 rabbits, confirmed histologically. Compared to S1, PRP-treated rabbits displayed significantly higher mean total bone (trabecular + cortical, 200 HU) at 4 and 6 weeks, and mature cortical bone (500 HU) production at 6 weeks (p less than 0.05, Figure 1).

**DISCUSSION:** This work confirms the osteoinductive nature of our novel scaffold and the potential for successful spinal fusion without synthetic or prosthetic agents. The enhanced tissue effects affor-
GP160
PREDICTORS OF RESIDUAL LOW BACK PAIN AFTER MICROENDOSCOPIC LAMINOTOMY ON LUMBAR CANAL STENOSIS
Toyoda H, Dohzono S, Matsumoto T, Terai H, Suzuki S, Hayashi K, Tamai K, Nakamura H; Dept. Orthopaedic Surgery, Osaka City University Graduate School of Medicine, Osaka, Japan

INTRODUCTION: It was still unclear that lumbar spinal stenosis (LSS) may result in low back pain (LBP) as well as pain in the legs. Decompressive surgery for LSS is the most frequently performed spine operation, but there have been few studies about the effectiveness in relieving LBP. In the present study, we analyzed the predictors of residual LBP after minimally invasive decompression surgery.

METHODS: We retrospectively reviewed 93 consecutive patients with LSS who underwent MEL. We excluded patients with other conditions that could affect functional status and finally 88 patients (aged 68.5 ± 10.2 years) were analyzed. Mean follow up period was 18.8 ± 8.8 months. Patients'clinical data and radiographic parameters were analyzed using binary logistic regression analysis to detect factors significantly related with the occurrence of residual LBP.

RESULTS: The mean JOA score was 14.0±4.2 points preoperatively and improved to 25.2±3.5 points at the latest follow up. The mean VAS for low back pain was 45.4±30.9 preoperatively and improved to 15.1±20.6 at the latest follow up. In univariate analysis, mean symptom duration before surgery, VAS for LBP before surgery and sagittal vertical axis were significant associated with residual LBP. In multivariate analysis, symptom duration before surgery (26M≤) (OR: 6.8) and sagittal vertical axis (50mm≤) (OR: 6.6) were significantly associated with residual low back pain.

DISCUSSION: We speculated that neural compression is the main cause of the low back pain of the patients with LSS and preoperative sagittal radiographic parameters also have strong effect on the residual LBP after operation.

GP161
PROSPECTIVE CLINICAL AND RADIOLOGICAL INVESTIGATION OF FUSION AT THE LUMBOSACRAL JUNCTION WITH AN ANTERIOR STAND-ALONE DEVICE
Christoph J. Siepe (1), Katrin Stosch-Wiechert (1), Franziska Heider (1), Phat Amnajtrakul (2), Alexander Krenauer (1), Ulrike Szeimies (3), Axel Stäbler (3), Christoph Mehren (1), Andreas Korge (1), H. Michael Mayer (1);
(1) Schön Clinic Munich Harlaching, Spine Center; Munich, Germany (2) King Bhumibol Adulyadej Hospital, Orthopedic Department; Bangkok, Thailand (3) Radiological Institute Munich Harlaching; Munich, Germany

INTRODUCTION: Fusion of lumbar motion segments has been shown to be effective for the treatment of low back pain (LBP) from degenerative disc disease (DDD). However, previous fusion techniques performed via posterior approaches have been associated with a variety of negative side effects. The goal of this investigation was to assess the clinical and radiological results in a cohort of patients treated with
an anterior stand alone fusion (ASAF) device (Synfix LR, DePuy Synthes).

**METHODS:** Clinical outcome scores VAS, ODI and satisfaction rates were acquired prospectively. Evaluation of radiological data included the pre- and postoperative segmental and global lumbar lordosis, neuroforaminal height and width. Interbody fusion was assessed from postoperative CT scans (n=37). The minimum FU was 12 months.

**RESULTS:** 71/77 patients were available for final FU, resembling a 92.2% FU rate after a mean FU of 35.1 months (12.0–85.5 months). The overall results revealed a highly significant improvement from baseline VAS and ODI levels (p<0.0001). 77.5% (n=55/71) of all patients reported a ‘highly satisfactory’ or a ‘satisfactory’ outcome, 22.5% of patients were not satisfied. The overall complication rate was 12.7% (n=9/71). Radiographic analysis demonstrated a significant increase of segmental lordosis from 16.1° - 26.7° (p<0.0001). A high rate of solid 1st - 2nd degree interbody fusion was confirmed in 97.3% of all cases.

**CONCLUSION:** The current data demonstrate satisfactory clinical results following anterior stand alone fusion (ASAF). Patient safety was proven with acceptable complication and reoperation rates. Radiological data demonstrated a significant reconstruction of lordosis, was accompanied by solid interbody fusion in 97.3% of all cases. ASAF is a viable treatment alternative which may serve to avoid fusion related negative side affects, which have previously been linked to a variety of posterior instrumented fusion techniques.

**GP162**

**INCIDENCE OF COMPLICATIONS AND ADVERSE EVENTS AFTER VIDEO ASSISTED THORACIC SURGERIES (VATS) AT THE SPINAL COLUMN: RESULTS OF A SYSTEMATIC RETROSPECTIVE ANALYSIS OF 282 CASES**

Schoen Kliniken München Harlaching, Wirbelsäulenzentrum, München Germany

**INTRODUCTION:** In the 1990’s, the popularity of minimally invasive procedures such as the video assisted thoracic surgery (VATS) has increased immensely. VATS is a procedure with minimal tissue trauma and a broad spectrum of indications. The use of a validated classification system of complications has not been published for VATS. The study aim is the retrospective analysis of the incidence and degree of perioperative complications after VATS based on the Dindo (I) and Rampersaud Severity of Adverse Events (II) score systems and the utilization of this data in further clinical studies.

**METHODS:** 282 cases (average age 62 (15-86) years, n=170 female, n=112 male) with thorascoscopic procedures from 2008 – 2013 were included. The analysis of perioperative (30d) complications were based on the classification score I and II. The present data were correlated with the kind, scope and degree of intervention and the patients’ demographic.

**RESULTS:** The overall complication rate of anterior procedures utilizing both scoring systems was 71% (201/282). The complication rates of Grade I-II anterior procedures were 78% and 85%, respectively by scoring I and II. Evaluation of anterior procedures for Grade III-V, requiring surgical intervention, shows a complication rate of 15.9% using I scoring and 15.2% using II scoring. In 6 % of the cases (n=18) a Re-Operation took place in the first 5 years.
postoperative. The mortality rate was 0.7% (n=2/282).

**DISCUSSION:** The data of this study represents an analysis of complications after VATS. Using this scoring system, 78% of complications that occurred could be treated without surgical interventions. The described rate of Grade III-V complications and postoperative Re-Operations compared to open procedures shows that the VATS is a safe and valuable operative technique. The study data shows that the surgical complications should be collected prospectively with validated scores for all complex spine surgeries.

**RESULTS:** Co-morbidities were hypertension in 65%, diabetes in 31%, ischemic heart disease in 38%, cerebral infarction in 13%, and history of malignant tumor in 17%. In Group A, 61 patients were classified as ASA 2, and 14 as ASA 3. There were 17 patients in ASA 2 and one in ASA 3 in Group B. Overall surgical site complication rate was 13%: 8% in group A (SSI in 5, implant failure in 1) vs. 28% in group B (SSI in 3, implant failure in 1). Group B had significantly higher rate of surgical site complications than Group A. Perioperative systemic complications were one GI tract bleeding in Group A, and one cerebral infarction in Group B, which were not fatal. Both groups showed significant improvement in JOA score (11.4 to 17.9 in Group A, and 8.9 to 15.3 in Group B).

**GP163**

**RISK AND BENEFIT OF SPINAL INSTRUMENTATION IN SUPER ELDERLY PATIENTS**

1 Shingo Onda, Masahiro Kanayama, Tomoyuki Hashimoto, Fumihiro Oha, Akira Iwata, Kahoru Tasiro, Takamasa Watabanbe 2 Kazuo Kaneko; 1 Spine Center, Hakodate Central General Hospital 2 Department of Orthopedics Surgery, Juntendo Medical University

**INTRODUCTION:** We investigated risk and benefit of spinal instrumentation in patients who were 80 years or older.

**METHODS:** 93 consecutive patients who underwent thoracolumbar or lumbar instrumentation surgery for degenerative disorders at the age of 80 years or older. They were divided into Group A (80-84 years, n=75) and Group B (85-94 years, n=18). Spondylolisthesis, spinal and/or foraminal stenosis with instability, and multiply operated back were treated by PLF or PLIF/TLIF. Thoracolumbar vertebral collapse was treated by anterior fusion (AF). Group A included 62 patients with PLIF/TLIF, 8 with PLF, and 5 with AF. There were 10 patients with PLIF/TLIF and 8 with PLF in Group B. Co-morbidities, ASA classification, perioperative complications and JOA score were examined.

**RESULTS:** Co-morbidities were hypertension in 65%, diabetes in 31%, ischemic heart disease in 38%, cerebral infarction in 13%, and history of malignant tumor in 17%. In Group A, 61 patients were classified as ASA 2, and 14 as ASA 3. There were 17 patients in ASA 2 and one in ASA 3 in Group B. Overall surgical site complication rate was 13%: 8% in group A (SSI in 5, implant failure in 1) vs. 28% in group B (SSI in 3, implant failure in 1). Group B had significantly higher rate of surgical site complications than Group A. Perioperative systemic complications were one GI tract bleeding in Group A, and one cerebral infarction in Group B, which were not fatal. Both groups showed significant improvement in JOA score (11.4 to 17.9 in Group A, and 8.9 to 15.3 in Group B).

**DISCUSSION:** Thoracolumbar and lumbar instrumentation surgeries provided successful outcomes even in super elderly patients. Although no fatal systemic complications occurred, surgical site complications arose more frequently in those over 85 years. When a spinal instrumentation is attempted in super elderly patients, caution should be more focused on the risk of surgical site complications rather than perioperative systemic complications.
GP164
RADIOGRAPHIC RISK FACTORS FOR POOR SURGICAL OUTCOMES IN THE PATIENTS WITH LUMBOSACRAL FORAMINAL STENOSIS WHO UNDERWENT DECOMPRESSION
Shinozaki Y1)3), Ishii K2)3), Kojima K1)3), Mima Y1)3), Nishida M1)3), Takahashi Y1)3), Kobayashi Y1)3), Toyama Y2)3), Matsumoto M2)3), Ogawa J1)3);
1) Spine Center, Shizuoka Red Cross Hospital, Shizuoka, Japan 2) Dept. of Orthopaedic Surgery, Keio University, School of Medicine, Tokyo, Japan 3) Keio Spine Research Group (KSRG)

INTRODUCTION: We evaluated the radiographic and clinical outcomes in the patients with lumbosacral (L5/S1) foraminal stenosis (LSFS) who underwent decompression.

METHODS: The subjects consisted of 48 patients (30 men, 18 women; mean age of 67.0 years) who underwent extra-foraminal decompression for LSFS and were followed for a minimum of 2 years. The patients were divided into 2 groups according to JOA recovery rate (RR): favorable outcome (F) group and poor outcome (P) group (RR?20%). Foramen was divided into 3 zones (Z): Z1 (medial), Z1/2 (transition between medial and lateral) and Z2 (lateral foramen). We evaluated preoperative X-ray findings, foraminal width (FW) and foraminal height (FH) at different zones using reconstructed multidetector-row computed tomography to identify the risk factors for poor surgical outcomes.

RESULTS: Twenty nine patients were classified as F group (mean RR of 86.0%) and 19 as P group (mean RR of 12.0%). Of all patients, minimum FW and/or FH were less than 6mm. There was no significant difference in lumbar scoliosis, L5 posterior listhesis, L5/S1 intervertebral angle and the number of patients with minimum FW or FH less than 6mm between 2 groups. In patients with FW less than 6mm, the average FW in P group was significantly less than that in F group at Z1 (4.2mm, 5.4mm: p?0.05), but no at Z1/2 (5.4mm, 5.6mm: N.S.) and Z2 (13.1mm, 13.2mm: N.S.). In patients with FH less than 6mm, the average FH in P group was significantly less than that in F group at Z1 (5.9mm, 7.1mm: p?0.01) and Z1/2 (4.8mm, 5.6mm: p?0.05), but no at Z2 (3.5mm, 3.7mm: N.S.).

DISCUSSION: FW or FH less than 6mm might be a diagnostic factor for LSFS. Transverse stenosis at Z1 and vertical stenosis at Z1 or Z1/2 were preoperative radiographic risk factors for poor outcomes following decompression. It was suggested extra-foraminal decompression results in an inadequate decompression in medial foramen. In such patients, we recommend TLIF to achieve fully decompress Z1.

GP165
THE PREDICTIVE FACTORS FOR EARLY DIAGNOSIS OF PULMONARY EMBOLISM AFTER LUMBAR SPINE SURGERY
Hirokazu Inoue, Hideaki Watanabe, Yasuyuki Shiraishi, Atsushi Kimura, Teruaki Endo, Katsushi Takeshita;
Department of orthopaedic surgery, Jichi medical university

INTRODUCTION: Pulmonary embolism (PE) is a risk of mortality following lumbar spine surgery. The purpose of this study was to evaluate whether asymptomatic PE can be predicted by blood coagulation markers preoperatively or soon after spine surgery.

METHODS: Sixty patients (25 female, 35 male) with a mean age of 69 years (range: 43 to 88) underwent lumbar spine surgery at one institution. The patients with any history of cerebral vascular accident or arterial thrombotic episode were excluded. Sixteen-row multidetector computed tomo-graphy was performed before surgery and 3 days after surgery for dia-
gnosis of asymptomatic PE. Blood samples were taken to measure the plasma levels of soluble fibrin monomer complex, D-dimer, total plasminogen activator inhibitor type-1, white blood cell count, and platelet count preoperatively, at day 1, day 4, and day 7.

RESULTS: No patient had symptomatic PE before or after lumbar spine surgery. The incidences of asymptomatic PE before and after surgery were no (0%) and six (10%) patients, respectively. D-dimer at day 3 after surgery in the post-op PE group (median: 4.3 μg/ml; interquartile range: 3.3 to 8.3) was significantly higher than the post-op no-PE group (median: 2.0 μg/ml; interquartile range: 1.4 to 2.9) (p<0.05). There was no significant difference in other parameters between the 2 groups.

DISCUSSION: In this study, we identified the incidences of asymptomatic PE before and after spine surgery and found that elevated D-dimer at day 3 after surgery was associated with asymptomatic PE. Elevated D-dimer at 3 days postoperatively is a predictive factor for early diagnosis of PE after lumbar spine surgery.

GP166
CLINICAL FEATURES OF SYMPTOMATIC EPIDURAL HEMATOMA IN POSTOPERATIVE SPINAL PATIENTS
Masato Anno, Takashi Yamazaki, Nobuhiro Hara, Keiji Hayakawa;
Department of Orthopaedic Surgery, Musashino Red Cross Hospital

INTRODUCTION: Neurologic deterioration due to postoperative spinal epidural hematoma (PSEH) is a rare but devastating complication that often requires surgical intervention. Clinical features in patients with PSEH have not been clearly identified.

OBJECTIVES: In order to characterize the clinical features and incidence of PSEH which required surgical evacuation.

METHODS: Patients who underwent spinal surgery at a single institution between 1999 and 2013 were retrospectively reviewed. During this period, 3371 spinal surgeries were performed and 15 patients developed new onset neurological deterioration due to PSEH which required surgical evacuation. The factors studied were the incidence of PSEH, the interval from the initial surgery to the onset of neurological deterioration, symptoms and neurological outcome.

RESULTS: The incidence of PSEH which required surgical evacuation was 0.44% (15 of 3371) in total, 0.58% (5 of 856) in cervical spine, 0.60% (2 of 332) in thoracic spine, 0.37% (8 of 2183) in lumbar spine. No case developed symptomatic PSEH in patients with anterior surgery (0 of 176). Neurological deteriorations were seen between 0 and 7 days (average, 2.57 days) after the initial surgery. Paralysis was observed in 8 patients, severe pain in 5 patients, bladder dysfunction in 1 patient, fever and consistent pain in 1 patient. Most patients who underwent cervical or thoracic spinal surgery developed paralysis (80% (4 of 5) in cervical spine, 100% (2 of 2) in thoracic spine). In patients with lumbar spinal surgery, severe leg pain was the predominant initial symptom (62.5% (5 of 8)). Neurological recovery was good in 10 cases, partial in 3 cases and poor in 2 cases.

CONCLUSIONS: In most cases, diagnosis of PSEH was easy and done through a simple physical examination. However, spine surgeons should be aware that some other subtle symptoms such as slight pain or unnoticeable bladder dysfunction could be an initial and only symptom due to PSEH.
GP167
A RANDOMIZED STUDY OF EPIDURAL CATHETER VS. IV PCA FOR POSTOPERATIVE PAIN CONTROL AFTER ONE- AND TWO-LEVEL LUMBAR FUSIONS
Todd Alamini, MD Agnes Ith, BS Ivan Cheng, MD Serena Hu, MD; Stanford University School of Medicine

INTRODUCTION: Pain control for patients in hospital after lumbar fusion can be difficult; the optimal approach to postop pain control has not yet been determined.

METHODS: 50 patients undergoing one or two level lumbar fusion were studied prospectively and randomized to postoperative pain control with an IV PCA or with an epidural catheter placed 2-4 levels above the proximal fusion level. Pain levels, postoperative narcotic use as well as hospital stay, the incidence of nausea, vomiting, itching, hypotension, and mobilization data was recorded and compared from group to group. Epidurals were maintained for 2-3 postoperative days.

RESULTS: Data was available at the time of abstract submission for 37 randomized patients; the rest will be added at the time of the presentation. 17 patients were randomized to the PCA group, and 20 to the epidural group. One patient who was randomized to the epidural group had the epidural aborted after technical difficulties with its placement. Hospital stay was 4.4d in the PCA group, and 4.3d in the epidural group. The incidence of nausea/vomiting were 82% and 60% and itching were 17% and 25% in the PCA vs epidural groups (statistically similar). Postop pain scores were significantly lower in the PCA vs. Epidural groups (p=.035): 4.8/5.1/4.8/4.8 vs. 2.6/2.5/2.9/2.6 on postop day 0,1,2,3. Postoperative symptomatic hypotension was seen in 3/17 PCA patients and 2/20 Epidural patients

DISCUSSION: Both groups did well after surgery, with an average length of stay that was similar. The epidural group had less overall pain in the first three days after surgery. The likelihood of postoperative nausea and vomiting, itching, and hypotension were similar in the two groups. The epidural catheter seems to be a good method of achieving better postoperative pain control than the traditional IV PCA.

GP168
A CLINICAL STUDY ON PRESERVING SPINOUS PROCESS AT DECOMPRESSION SURGERY FOR LUMBAR SPINAL STENOSIS ~FOLLOW-UP STUDY~
Hatakeyama Kenji, Aihara Takato, Urushibara Makoto; Funabashi Orthopedic Hospital

INTRODUCTION: There was little advantage in preserving spinous processes in one year follow-up for bilateral decompression via unilateral approach (BDU) when comparing to laminotomy with cutting the basal part of those (ML). The purpose of this study was to evaluate the role of spinal processes by analyzing clinical results of BDU at two-year follow-up after surgery.

METHODS: From 2010 to 2012, 50 consecutive patients with lumbar spinal stenosis, who underwent decompression surgery, were included. These surgeries were performed by one surgeon (H.K) and ML was done mainly in former period, on the contrary, BDU in later period. The number of patients was 26 in ML and 24 in BDU. We compared the clinical outcome of these two groups. As clinical index, we used Japanese Orthopaedic Association Back Pain Questionnaire (JOABPEQ) score and VAS score of low back pain (LBP), leg pain and leg numbness. We evaluated them at before-surgery, 1, 3, 6, 12 and 24 months after surgery.

RESULTS: There was no difference between two groups about age, the number of levels decompressed, all five factors of JOABPEQ score and VAS scores before
surgery (p≤0.2). Improvement rate of JOABPEQ score of BDU group was not significantly different. Regarding VAS scores of low back pain, BDU seemed to have advantage to ML at all times to two years, but not significant. In both groups, JOABPEQ scores were better at 3 or 6 months after surgery.

DISCUSSION: We make an effort to preserve spinous processes, because we believe those are important for spinal stability and those has a function of posterior loading. However, within two-year follow up, no statistical superiority was seen on this study for preserving spinous process. We think further follow up and more cases are needed to prove the advantages of this surgery.

GP169

CLINICAL OUTCOME OF MICROENDOSCOPIC LAMINOTOMY FOR DEGENERATIVE LUMBAR SPONDYLOLISTHESIS – IN COMPARISON WITH THE CASES WITHOUT SPONDYLOLISTHESIS

Akinobu Suzuki, Hiromitsu Toyoda, Hidetomi Terai, Masatoshi Hoshino, Kazunori Hayashi, Koji Tamai, Hiroaki Nakamura;
Department of Orthopaedic Surgery, Osaka City University Graduate School of Medicine

INTRODUCTION: It is still controversial in the choice of surgical methods for spinal stenosis with degenerative spondylolisthesis (DS). In recent years, many minimum invasive decompression techniques have been developed, and those techniques also have potential to minimize the risk of progression of instability following surgery. The purpose of this study was to investigate the clinical outcome of microendoscopic laminotomy (MEL) for DS, and to compare with that for spinal stenosis without DS.

METHODS: Thirty-six patients with DS and 44 patients without DS who underwent MEL for spinal stenosis were included in this study. Spondylolisthesis was defined as more than 3mm slip to adjacent vertebrae. Operation time, intraoperative blood loss and intra- or peri-operative complications were recorded for each case. In terms of clinical outcome, Japanese orthopaedic association score for low back pain (JOA score) and visual analogue scale (VAS) for low back pain, leg pain and numbness were evaluated preoperative, and at scheduled time after operation.

RESULTS AND DISCUSSION: The average age at surgery was significantly higher in DS group. There was not significant difference in pre-operative JOA score and each VAS score between two groups. Operative time and intraoperative blood loss per level were similar between the groups. Intraoperative complication including dural tear, nerve root injury, and wrong level surgery were occurred in 5 patients of DS group and 2 patients of non-DS group, but there was no significant difference. In both groups, JOA score and each VAS score significantly improved at 3months after surgery, and those improvements were maintained during follow-up period. Clinical outcome of MEL for spinal stenosis with DS is comparable with that for spinal stenosis without DS. MEL is effective and less invasive method, and it can be one of the treatment choice for spinal stenosis with DS.

GP170

CLOSURE OF THE INTERVERTEBRAL DISC ANNULUS FIBROSUS USING A NOVEL SUTURE APPLICATION DEVICE – IN VIVO PORCINE AND EX-VIVO BIOMECHANICAL EVALUATION

*Department of Surgery, University of Toronto ±Department of Kinesiology, University of Waterloo
**INTRODUCTION:** Defects in the annulus fibrosus (AF) remain a challenge in the surgical treatment of lumbar disc herniations with persistent defects allowing potential re-herniation of nucleus pulposus (NP) tissue. We performed an ex vivo evaluation and in vivo feasibility study of a kerrison-shaped suture device designed to achieve closure of AF defects. A cervical porcine model was chosen to simulate human lumbar discs.

**METHODS:** Ex vivo: 20 porcine spinal units were explanted and subject to mock discectomy. The annular defect was closed using a 2-0 non-absorbable (UHMWPE) suture and Dines knot. The knot was backed up with 2, 3 or 4 throws. The spinal unit was subject to 4000 cycles of flexion/extension with 1500N of axial load, and assessed for knot slippage. In vivo: 3 pigs (53-57 kg) were anaesthetised and underwent a ventral surgical approach to the cervical spine. The AF of two discs was incised with a scalpel in a vertical fashion and simulated partial NP discectomy performed. The defect was closed at one level using the AnchorKnot™ device to apply the non-absorbable suture with a Dines knot and 4 throws. The pigs were observed for 4 weeks before euthanasia. The excised cervical spine underwent 7T MRI followed by histological H+E evaluation.

**RESULTS:** A Dines knot with 4 throws experienced no slippage after 4000 cycles. This configuration was tested in vivo. Clinically, the neurological examination in treated pigs was normal following surgery. Histological and MRI assessment confirmed sustained defect closure at four weeks. There was no significant reaction to the suture material and no nucleus pulposus extrusion at any of the sutured levels.

**DISCUSSION:** This study demonstrates that it is technically feasible to perform AF defect closure in a porcine model. This novel device achieved AF defect closure that was maintained through four weeks in vivo. Further study is required to assess whether this technique may reduce the incidence of early disc re-herniation.

**GP171**

**PERCUTANEOUS VERSUS MINI-OPEN PEDICLE SCREW INSERTION: COMPARISON OF SURGICAL OUTCOMES**

Orthopedic department of Shiraniwa Hospital, Orthopedic department of Osaka-City University Hospital

**INTRODUCTION:** The percutaneous pedicle screw (PPS) technique and the pedicle screw (PS) insertion method using the Wiltse approach (mini-open method) are typical procedures in minimally invasive spine stabilization surgery, and are reported to have many benefits including reductions in infection rates, paraspinal muscle damage, and residual low back pain. However, there are few reports comparing the outcome of these two procedures. This study compares the PPS and mini-open techniques, and their respective outcomes.

**METHODS:** We retrospectively studied 55 consecutive patients who underwent posterior lumbar interbody fusion in our hospital, 24 of whom underwent the PPS technique and 31 the mini-open procedure. Operation time, blood loss per fused interbody, blood test data (creatine kinase, C-reactive protein, white and red blood cell counts, and hemoglobin, preoperatively and on postoperative days 1, 4, and 7), postoperative use of analgesics (diclofenac, pentazocine), pedicle penetration rate of PS, and rate of union at 1 year after surgery were compared between the two groups. Student’s t-test and the chi-squared test were used for statistical comparisons.
RESULTS: Operative time in the PPS group was significantly shorter (170 min vs 197 min for the mini-open group; p<0.05). Blood loss tended to be smaller in the PPS group, but not significantly so (447.7 ml vs 545.1 ml; p=0.09). Pedicle penetration rate was significantly lower in the PPS group (9.1% vs 18.5%; p<0.05). There were no significant differences in blood test data, amount of analgesics, and rates of union.

DISCUSSION: There was no difference in the extent of invasiveness and rates of union between the PPS and mini-open procedures. However, the PPS technique required less operative time and pedicle penetration in comparison with the mini-open procedure. PPS fixation is therefore an easier and safer procedure.

GP172
FAVORABLE INDIRECT DECOMPRESSION IN LUMBAR SPINAL STENOSIS PATIENTS BY OBLIQUE LATERAL INTERBODY FUSION
Sumihisa Orita, Jun Sato, Go Kubota, Kazuhide Inage, Takeshi Sainoh, Kazuki Fujimoto, Yasuhiro Shiga, Hiroto Kanamoto, Kazuyo Yamauchi, Kazuhisa Takahashi, Seiji Ohtori; Department of Orthopaedic Surgery, Graduate school of Medicine, Chiba University, Japan

INTRODUCTION: Oblique lateral interbody fusion (OLIF) is one of less invasive LIF procedures with mini-open approach to access the anterolateral portion of the intervertebral disc. LIF enables indirect decompression (ID) of the spinal canal through restoration of the disc height and obtaining a sufficient foramen, while the efficacy and actual status of ID is unclear. The present study aimed to assess these features in comparison with direct decompression (DD).

METHODS: In total, 17 patients who underwent OLIF surgery were enrolled. Most patients showed subtotal/total block on myelography. Eight patients underwent DD who were the initial series of cases immediately after the introduction of the procedure or severe stenosis patients who required physical decompression for conditions such as foraminal intervertebral herniation with motor deficits, whereas the others ID. We evaluated the visual analog scale (VAS) score for lower back pain (LBP), radicular pain in the lower extremity (RP), and numbness in the lower extremity (Num) at baseline and 3 days, 7 days, 1 month, 3 months, and 6 months after surgery. The postoperative day on which patients could successfully walk 100 m was assessed as the indication of activity recovery. Significance was set at P < 0.05.

RESULTS: The LBP, RP, and Num did not significantly differ between the DD and ID groups at baseline. With regard to LBP and RP, the ID group exhibited a more significant improvement at 3 days after surgery. Numb showed a significant improvement at 7 days after surgery, which remained significant over the following 6 months. The ID patients could walk ≥100 m at an earlier date compared to DD patients.

DISCUSSION: Among patients who underwent OLIF, ID patients showed significant improvements in LBP, RP, and especially Num, as well as significant functional recovery. This may be associated with the protective effect afforded by ID, without the need for any direct invasive procedure involving the spinal nerve.

GP173
REVISION AND RE-REVISION SURGERY FOR CLINICAL ADJACENT SEGMENT PATHOLOGY AFTER INSTRUMENTED LUMBAR FUSION
Young-Hoon Kim, MD, Kee-Yong Ha, MD; Department of Orthopaedic Surgery, Seoul St. Mary’s Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea

INTRODUCTION: Although clinical adjacent segment pathology (CASP) requiring revision surgery after instrumented spinal
fusion is common, revision surgery is known to be riskier long-term wise compared to primary surgery. Studies determining the causes and causative factors for re-revision surgery, however, are insufficient.

**OBJECTIVE:** To determine the incidence and risk factors of revision and re-revision for CASP and to investigate which radiological findings were commonly seen in CASP patients after instrumented lumbar fusion for degenerative lumbar disorders.

**METHODS:** Patients who underwent revision surgery for CASP were enrolled. Radiological and clinical outcomes were performed prospectively. The number of radiological findings for ASP was determined on the basis of a 7-point scale that gave 1 point for each radiological finding. All patients were divided into 2 groups in respect to fusion procedure. Group I included patients undergoing floating fusion. Group II included patients undergoing non-floating fusion. Both groups were compared via point differential of radiological findings.

**RESULTS:** 61 patients underwent revision surgery for CASP. Average age was 67.6 ± 4.5 years. The time period from initial operation to revision surgery was 91.0 ± 9.4 months. RASP score was on average 3.4 ± 0.4 in Group I and 4.2 ± 0.3 in Group II. 7 (11.5%) patients underwent re-revision surgery. The time period between revision and re-revision surgery was 56.3 months. The cause of re-revision surgery was related to loss of lumbar lordosis after revision surgery.

**DISCUSSION:** The cumulative RASP score closely correlated with CASP. The most common finding of RASP was collapse of intervertebral disc space with sclerosis. The spinopelvic malalignment with loss of lumbar lordosis should be corrected to avoid re-revision surgery. We recommended that spine surgeons pay close attention to proximal segments when planning re-revision surgery after revision surgery for CASP.

**GP174**

**BONE CHANGES FOLLOWING EXPERIMENTAL PAEDIATRIC SPINAL CORD INJURY IN A RAT MODEL**

M. R. Zarrinkalam (1), B. J. C. Freeman (1, 2, 3), A. Mulaibrahimovic (1), A. Nguyen (1), I. J. Llewellyn-Smith (4) and J. M. Clark (5);


**INTRODUCTION:** Patients with Spinal Cord Injury (SCI) display significant bone loss mainly confined to the lower extremities and pelvis. There is consensus that mechanical unloading is the primary cause of this bone loss. SCI has detrimental effects on skeletal health. The impact of SCI on bone growth and skeletal development has not been definitively established. The aim of this study was to investigate the effects of SCI on bone growth and the skeletal development in juvenile / adolescent rats.

**METHODS:** Juvenile male rats (8 weeks) were subjected to T4-5 laminectomy alone (Con, n=4) or followed by durotomy and T4 level sharp surgical spinal cord transection (SCI, n=7). All animals were killed at post-surgical week 12 (adolescent) with the femur and humerus collected for analysis. Physical properties were measured using scalimetry. Trabecular bone morphology was assessed with micro computed tomography (microCT). Specimens were then decalcified and processed for haematoxylin and eosin differential staining for the evaluation of endochondral bone and growth plate histology.
RESULTS: At week 12, both femoral length and humeral length were decreased in the SCI-rats compared to controls. Mid-femoral shaft outer diameter and cortical thickness were also reduced in the SCI-rats. MicroCT analysis of the distal femur confirmed defects in trabecular micro-architecture, specifically trebecular number and separation. In contrast, humeral shaft diameter and trabecular bone parameters were indistinguishable between the groups. Histologically, a woven bone appearance, under-mineralised bone lesions, and physeal dysplasia were observed in the distal femoral metaphysis of the experimental group.

DISCUSSION: We report growth retardation, physeal changes and histological abnormalities consistent with impaired mineralization in young, rapidly growing SCI-ed paraplegic animals. Bone growth defects in the forelimbs may indicate a more widespread impact of SCI on the skeletal system.

GP175
CLINICAL OUTCOMES OF SPINAL FRACTURES IN PATIENTS WITH ANKYLOSING SPINAL DISORDERS
Tanaka Masaru, Itoi Akira, Mogami Atsuhiko, Takeda Jun, Obayahi Osamu;
Department of Orthopaedic Surgery, Juntendo Shizuoka Hospital

INTRODUCTION: Spinal fractures in the ankylosed spine are often unstable due to the ossification of supportive and elastic soft tissues and may cause neurological deficit as a result of displacement. The aim of this study is to investigate clinical outcomes after spinal fractures in patients with ankylosing spinal disorders (ASD): ankylosing spondylitis (AS) and diffuse idiopathic skeletal hyperostosis (DISH).

METHODS: Between the years 2007 and 2014, a total of 10 thoracic or lumbar spinal fractures affecting 9 consecutive patients (6 males, 3 females, mean age of 83.3 years) with ASD were retrospectively reviewed. We evaluated fracture type, fracture level, neurologic status, treatment modality, union of the fracture and ADL.

RESULTS: Extension type fractures occurred in 9 of 10 fractures (90%). Thoracolumbar spine was involved in 7 of 10 fractures (70%). All patients demonstrated ADL deterioration due to severe back pain and/or neurological deficit. 3 of 9 patients (33.3%) demonstrated neurological deficit, and 2 of 3 patients showed delayed paralysis. Surgery was performed on 5 patients. The most common surgical treatment was multilevel posterior fusion. All patients received surgery improved ADL early after surgery and the union of the fracture was achieved in 3 patients with a minimum 6-month follow-up. However one patient died caused by complications after surgery. Bracing was used as the definitive treatment in 4 patients and for palliative reasons in 3 of 4 patients deemed too medically unstable for surgery. 2 of 4 patients received conservative treatment developed ADL deterioration due to disuse and 3 of 4 fractures developed nonunion.

DISCUSSION: The current study showed multilevel posterior fusion allows effective fracture healing and conservative treatment is more likely to develop nonunion and ADL deterioration in spite of non-neurological deficit. To improve ADL early, we advocate surgery in the treatment of spinal fractures in the ankylosed spine.

GP176
MICROSURGICAL LUMBAR LAMINOPLASTY WITH IN SITU FUSION FOR DEGENERATIVE SPONDYLOLISTHESIS
Janina Kueper; Joseph T. Nguyen, M.S.; Russel C. Huang, M.D.; Hospital for Special Surgery, 535 East 70th Street, New York City, NY 10021, USA
INTRODUCTION: Microsurgical Lumbar Laminoplasty (MLL) is a less disruptive technique for decompression than the more traditional Laminectomy. Patients with Spondylolisthesis may profit from its preservation of stabilizing structures of the spine, allowing for the avoidance of instrumented fusion in some cases. This is the largest series evaluating the outcomes following MLL with in situ fusion.

METHODS: All patients who underwent MLL with in situ fusion by a single fellowship trained spinal surgeon were reviewed retrospectively. Multivariable logistic regression models were developed to evaluate potential risk factors for adverse postoperative outcomes.

RESULTS: 88 patients in total received a MLL with in situ fusion from 3/5/2010 to 3/20/2014. Patients were operated on 1.6 ± 0.7 levels. The EBL was 96.9 ± 79.3 ml whilst the operative time was 113.3 ± 37.5 minutes. 3.3 % required an immediate revision surgery for two persistent CSF leaks and a seroma. At the first postoperative follow up after 6.1 ± 0.8 weeks, the VAS was improved by a mean 4.1 points, the ODI by 16.8 points, the PCS by 6 and the MCS by 4.4 points. 2.2 % required revision surgery, consisting of an additional lumbar decompression and one lumbar fusion. At the final follow up after 16.4 ± 26 weeks, 30.7 % of patients experienced residual symptoms, the most common of which were lower back pain (13.4 %) and lower extremity pain (12.4 %). No factors were found to be predictive of residual symptoms at the primary or final postoperative follow up or of postoperative complications. No factors were found to be predictive of revision surgery, although the existence of a cyst (p=0.059) or prior spinal surgery (p=0.055) were loosely correlated with this postoperative outcome.

DISCUSSION: The preservation of bony-, muscular- and ligamentous structures removed during the more traditional laminectomy for decompression allow for the safe and effective in situ fusion of the lumbar spine with low revision rates.

GP177

DESIGN OF THE DOMINO TRIAL: A RANDOMISED CONTROLLED TRIAL ON THE COST-EFFECTIVENESS OF MINIMALLY INVASIVE SPINAL FUSION COMPARED TO OPEN SPINAL FUSION FOR PATIENTS WITH NEUROGENIC CLAUDICATION OR RADICULAR LEG PAIN DUE TO SPINAL STENOSIS

Jeroen G.J. Huybregts1, Carmen L.A. Vleggeert-Lankamp1,2, Pieter J. Schutte1,3, Carel H. Diekerhof4, Leti van Bodegom-Vos1, Theo Stijnen1, M. Elske van den Akker-van Marle1, Marc L.J.F. Schröder5, Ronald H.M.A. Bartels6, Christiaan M. Haitink7, George Homminga8, Adam Swets9, Wilco C. Peul1, Wilco C.H. Jacobs1;

1 Leiden University Medical Centre, Leiden, The Netherlands 2 Spaarned Hospital, Hoofddorp, The Netherlands 3 Rijnland Hospital, Leiderdorp, The Netherlands 4 St. Elisabeth Hospital, Tilburg, The Netherlands 5 Bergman Clinics, Naarden, The Netherlands 6 Radboud University Medical Centre, Nijmegen, The Netherlands 7 Medical Centre Alkmaar, Alkmaar, The Netherlands 8 NedSpine, Ede, The Netherlands 9 Gelderse Vallei, Ede, The Netherlands Correspondence: j.g.j.huybregts @lumc.nl, Department of Neurosurgery, Leiden University Medical Centre, Albinusdreef 2, PO Box 9600, 2300 RC Leiden, The Netherlands

INTRODUCTION: Minimally invasive surgery is expected to increase the speed of recovery after lumbar spine spondylo- desis and thereby to lower the costs from societal perspective (faster return to work, less medical consumption, shorter hospital stay, fewer infections). Evidence to support claims of cost reduction is lacking. The objective of this trial is to evaluate the cost-effectiveness of minimally invasive posterior lumbar fusion in spinal stenosis patients, compared to traditional open fusion.
METHODS/RESULTS: The study is a multi-centre, randomised controlled trial. Patients with one- or two-level lumbar spinal stenosis with neurogenic claudication or radicular leg pain, unresponsive to conservative treatment, where the spine is likely to destabilise with decompression only, will be included. In the intervention group, one- or two-level minimally invasive surgery for decompression and (interbody) fusion will be carried out. The control intervention is traditional, open decompression and (interbody) fusion with midline incision and muscle detachment to over the facet joints. The appropriate sample size is 340 patients (170 patients per group), based on a recovery time difference of one month. The primary outcome parameter is the time spent in recovered state during the first year, based on the Oswestry Disability Index. Secondary outcome parameters are Quality of Life (EuroQoL, transformed QoL VAS, SF36), costs, VAS leg and back pain, Zurich Claudication Questionnaire, Likert perceived recovery, complications, perioperative morbidity and fusion.

DISCUSSION: Evidence for the cost-effectiveness of minimally invasive posterior lumbar fusion compared to open fusion is lacking. The results of this study can shed a light on the clinical effectiveness of the minimally invasive technique, as on its cost-effectiveness. The results may convince health insurance companies to cover the higher costs of the minimal invasive technique and to attribute to value based medicine.

GP178
COMPARING THE USE OF SHARED DECISION MAKING AND DECISION QUALITY AMONG PATIENTS REFERRED FOR ELECTIVE SPINE SURGERY OR JOINT ARTHROPLASTY
Karen Sepucha, PhD; Thomas D. Cha, MD, MBA; Leigh Simmons, MD; Mahima Mangla; Sandra Feibelmann, MPH; Janet M. Dorrwachter, NP; Steven J. Atlas, MD, MPH; Massachusetts General Hospital, Boston, MA, USA

INTRODUCTION: Shared decision making (SDM) seeks to improve decision quality by ensuring patients make informed decisions reflecting their goals and preferences. Patient decision aids (PtDA) can support SDM and improve decision quality. We compared SDM and decision quality for elective spine and joint replacement surgery within one academic orthopedic department.

METHODS: Patients referred to either a spine or hip/knee arthroplasty specialist were recruited and within a week of an initial visit were mailed a survey including questions about knowledge (total score 0-100), overall treatment preference, and decision making process (total score 0-100). Decision quality was examined for patients who did and did not receive a PtDA (educational booklet and DVD).

RESULTS: We received 101/151 (66.9%) spine and 223/307 (72.6%) hip/knee surveys. A minority of patients reported receiving a PtDA (20% for spine and 32% for hip/knee), but those who did reported reviewing at least some of the PtDA (89% of spine and 85% of hip/knee). Mean total knowledge scores were lower for spine than hip/knee patients (29.6% vs. 56.4%). More spine patients were extremely concerned about having surgery (25.7% vs. 19.9%) and less likely to prefer surgery compared to hip/knee patients (39% vs. 65%). Compared to non-PtDA patients, PtDA patients had higher knowledge scores (mean difference 17.2% for spine p=0.002 and 3.9% for knee/hip p=0.3), and higher decision process scores (mean difference 9.6% for spine p=0.24 and 10.1% for hip/knee p=0.01). A clear treatment preference was similar among spine (74% PtDA vs. 77% no PtDA p=0.78) but higher
for knee/hip patients (92% PtDA vs. 79.7% no PtDA \( p=0.06 \)).

**DISCUSSION:** Even when available, PtDAs were not commonly used to support SDM. However, spine patients who received PtDAs had better knowledge and decision quality scores. Integrating PtDAs into routine practice may improve patient’s decision making regarding elective orthopedic procedures.

**GP179**

**VERSATILITY OF POSTERIOR PERCU- TANEOUS SPINAL FIXATION IN META- STATIC SPINE TUMOUR SURGERY: A PROSPECTIVE ANALYSIS**

Naresh Kumar, Aye Sandar Zaw, Pang Hung Wu, Rishi Malhotra, Milindu Makandura, Gabriel Liu, Joseph Thambiah, Hee-Kit Wong; National University Health System

**INTRODUCTION:** Posterior percutaneous spinal fixation (PPSF) is one of the main modalities of minimally invasive surgery. There have been a number of studies which evaluated the outcomes PPSF but none of them assessed in detail regarding the versatility of PPSF in metastatic spinal disease (MSD). This study was designed to evaluate feasibility and spectrum of application of PPSF in management of MSD, highlighting its clinical advantages.

**METHODS:** Twenty-seven consecutive patients with MSD treated with PPSF in our institution from January 2011 to June 2014 were studied. All patients, after a multidisciplinary assessment, were considered for surgical intervention due to clinical presentation of either neural deficit, skeletal instability, or both. Some of these patients belonged to poor prognostic category based on survival prognostic scoring systems. The patients were categorized into seven groups depending on the modality of PPSF used. Demographic data, operative details, and clinical outcomes were investigated for each category and compared pre and postoperatively.

**RESULTS:** The median age was 60 years (range: 49-78yrs). Generally, all patients either maintained or improved their neurological status and achieved pain alleviation. Ambulatory status and ECOG scores were also improved using any modality of PPSF. Pure stabilization group had the lowest amount of mean blood loss (92 ml), shortest operative time (180 minutes), ICU (1 day) and hospital stays (10 days) while long construct group was observed to have greatest amount of blood loss (355 ml), longest operative time (305 minutes) and ICU stay (2.5 days).

**DISCUSSION:** For patients with MSD, even with predicted poor prognosis on survival prognostic scoring systems, it is possible to improve functional outcomes and quality of life with PPSF keeping surgical morbidity to a minimum. PPSF allows addressing patients with pure spinal instability successfully with least morbidity.

**GP180**

**INTRAOPERATIVE ANTERIOR CAGE MIGRA- TIONS IN POSTERIOR LUMBAR INTER- BODY FUSION: A REPORT OF TEN PATIENTS**

Murase S*, Takeshita Y*, Kunogi J†, Sano S‡, Yamazaki T§, Inanami H, Miyoshi K*;* 
*Department of Spine and Orthopaedic Surgery, Yokohama Rosai Hospital, Yokohama, Japan. †Department of Spine and Orthopedics Surgery/Spine Center, Japanese Red Cross Medical Center, Tokyo, Japan. ‡Orthopedic Department, Sanraku Hospital, Tokyo, Japan. §Department of Orthopedics, Musashino Red Cross Hospital, Tokyo, Japan. Department of Orthopaedic Surgery, Iwai Orthopaedic Medical Hospital, Tokyo, Japan.

**INTRODUCTION:** Posterior lumbar interbody fusion (PLIF) has become popular with spine surgeons, but some technique-related complications exist. Intraoperative anterior cage migration is a rare com-
plication associated with major vascular injury and few cases have so far been reported.

**METHODS:** We describe 10 cases of anterior cage migration after PLIF from five institutions and elucidate the causes, treatment, and complications.

**RESULTS:** In two patients when a second cage was inserted it ejected the opposite side’s cage. In eight patients the technique to achieve an optimum cage position caused dislodgement. Two cage migration cases were conservatively observed and cages were immediately removed in four cases and later removed in four cases. A posterior approach was used in three cases and an anterior approach in five cases. Vena cava injuries occurred in two cases. One occurred during insertion and resulted in torrential venous bleeding from the disc space. The cage was directly removed with an introducer and bleeding was controlled by packing with gelfoam and surgicel. Thereafter, deep vein thrombosis occurred and an inferior vena cava filter was inserted. The other case occurred during cage removal by the retoroperitoneal approach seven days after the first surgery. The cage migrated into the inferior vena cava and a 2 cm tear occurred during cage removal. A vascular surgeon unsuccessfully attempted a surgical repair of vena cava injury. To control bleeding and avoid mortality, both the inferior vena cava and common iliac veins were clamped. After surgery the patient suffered from severe leg swelling, but conservatively improved.

**DISCUSSION:** In all 10 cases, the cage migrations were caused by technical errors. This method requires precise preoperative evaluation and cautious surgical techniques. Two of our cases suffered vena cava injuries. If cage migration occurs, then cage removal should be carefully planned with a vascular surgeon.

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**GP181**

**NECESSITY OF DISCECTOMY FOR DECOMPRESSION IN LUMBAR CANAL STENOSIS**

1 Hiroshi Nakamura 2 Takashi Yamazaki 3 Sei Terayama,

1 Mishuku Hospital 2 Japanese Red Cross Musashino Hospital 3 Sangubashi Spine Surgery Hospital

**INTRODUCTION:** The necessity for discectomy when magnetic resonance images (MRI) show a bulging disk before decompression surgery for lumbar canal stenosis is unclear. This study aims to determine criteria for a discectomy. Our criteria for a discectomy were the appearance of a bulging disc in MRI accompanied by spontaneous leg pain or a positive Straight Leg Raising (SLR) test.

**METHODS:** Lumbar decompression was conducted in 89 consecutive patients with canal stenosis. We retrospectively evaluated the postoperative results (Japanese Orthopaedic Association score (JOAS), complications, recurrence, and satisfaction).

**RESULTS:** A one year follow up was made of 79 patients (59 men and 20 women). The mean age of these patients was 70.7 years (range 46-87 years). Our criteria were met in 12 patients and they underwent a discectomy (group A). Our criteria were met 7 patients, of which we did not discover any disk herniation at surgery (group B). A bulging disk was shown in 26 patients on MRI, but without clinical criteria (group C). No tension sign or spontaneous leg pain was found in 34 patients without disk bulging (group D). The average preoperative JOAS was 11.3, 12.7, 14.2, and 13.3 for each group respectively and significantly improved to 23.6, 22.7, 21.8 and, 21.3 respectively after surgery. Postoperative JOAS was not significantly different between groups. Satisfaction scores were 100% for groups...
A and B, 92.3% for group C, and 91.2% for group D. Incidental dural tearing occurred in a patient from group A. In group C, 2 patients had recurrence, but it was caused by disease in adjacent segments.

**DISCUSSION:** Unnecessary disectomy should be avoided because it can result in a damaged nerve root or incidental dural tearing from nerve root traction. A bulging disk on MRI with spontaneous leg pain or positive SLR test are useful criteria for determining the necessity of disectomy.

**GP182**

**EFFICACY OF TERIPARATIDE VERSUS BISPHOSPHONATE OSTEOPOROSIS TREATMENT IN ANTERIOR SPINAL RECONSTRUCTION FOR OSTEOPOROTIC VERTEBRAL COLLAPSE**

Masahiro Kanayama, MD; Kiyoshi Kaneda, MD; Tomoyuki Hashimoto, MD; Fumihiro Oha, MD; Akira Iwata, MD; Shingo Onda, MD; Kaoru Tashiro, MD; Takamasa Watanabe MD; Spine Center, Hakodate Central General Hospital, Hakodate, Japan

**INTRODUCTION:** Recent advances in osteoporosis treatment might reduce the risk of instrumentation failure and subsequent fracture in spinal reconstruction. The object is to investigate the effect of teriparatide (TPD) versus bisphosphonate (BP) on the radiographic outcomes of anterior spinal reconstruction for osteoporotic vertebral collapse.

**METHODS:** We retrospectively reviewed 31 consecutive patients who underwent anterior spinal reconstruction for thoracolumbar vertebral collapse and osteoporosis treatment using TPD or BP throughout the postoperative period. Patients in BP group received 35mg of alendronate (n=18) or 17.5mg of risedronate (n=4). All in TPD group (n=9) were treated by daily 20-ug TPD. Mean follow-up period was 28 months. Radiographic assessment included kyphosis at the operative levels and loss of correction. The rates of posterior reinforcement and adjacent vertebral fracture were also reported.

**RESULTS:** Preoperative kyphosis at the operative levels was 31.3 degrees in BP group versus 36.8 in TPD group, which improved to 16.6 versus 17.9 degrees postoperatively and 24.1 versus 28.6 degrees at the final follow-up. Loss of correction was not statistically different between the groups. Posterior reinforcement was required in 13.6% in BP group and 11.1% in TPD group. Prevalence of adjacent vertebral fracture was 13.6% in BP group and 0% in TPD group.

**DISCUSSION:** Before BP and TPD became available for osteoporosis treatment, posterior reinforcement was required in 19.3%; adjacent vertebral fractures occurred in 22.6% in our published data (JSST 2010). The current study demonstrated that BP and TPD reduced the rate of posterior reinforcement by half; adjacent vertebral fractures were decreased to one-half by BP, and could be prevented by TPD. Although anterior spinal reconstruction had a limitation regarding kyphosis correction, it could successfully treat 90% of osteoporotic vertebral collapse under the current osteoporosis treatment.

**GP183**

**A CASE-CONTROLLED STUDY EVALUATING THE EFFECT OF CONE BEAM CT (O-ARM®) IMAGING AND NAVIGATION ON PEDICLE SCREW PLACEMENT IN ELECTIVE, PRIMARY, NON-DEFORMITY ADULT SPINAL SURGERY**

Juliet Blatke, Jason Strelzow, Danny Mendelsohn, Nicolas Dea, Charles Fisher, Marcel Dvorak, John Street.; Department of Orthopaedics, University of British Columbia, Vancouver, Canada Division of Neurosurgery, Department of Surgery, University of British Columbia, Vancouver, Canada Combined NeuroSurgical and Orthopaedic Spine Program, Vancouver General Hospital
INTRODUCTION: Intra-operative CT and navigation systems (NAV) may provide an opportunity to improve precision and accuracy of spinal instrumentation, and in so doing, improve patient outcomes. Our study aimed to examine the efficacy and safety of NAV for pedicle screw placement in elective, primary, non-deformity adult spinal surgery cases.

METHODS: All patients who underwent pedicle screw fixation with O-arm® imaging and StealthStation® navigation between January 2008 and December 2012 were analyzed. Patients were matched with historic case controls (NonNAV). Diagnosis, number of pedicle screws, timing and degree of malposition were recorded. Screws with pedicle breach greater than 0mm were recorded as misplaced. All patients had a minimum 1 year follow-up. Quantitative statistical analysis compared screw placement between NAV and NonNAV cases.

RESULTS: 89 patients met inclusion criteria by primary diagnosis in the NAV group. Demographic and diagnostic data were not significantly different between groups [p=0.269]. All categories of primary diagnosis demonstrated reduction (p=0.05) in the rate of screw malposition with navigation. Pedicle screw malposition was significantly more common for spondylolisthesis (p<0.005) and inflammatory arthropathy cases (p=0.028). The number of screws revised during the same admission was significantly different (0 in the NAV group vs. 3, p <0.005). Late post-operative surgical revision occurred in 7 patients in the Non-NAV group requiring readmission within one year compared to zero in the NAV cohort (p <0.008). Rates of adverse events were not significantly different between groups.

DISCUSSION: Intraoperative 3D imaging with navigation provides an equally safe, and more accurate and precise tool for pedicle screw placement than traditional techniques in adult spine surgery. Our data demonstrated a difference in the need for revision screw placement. This technology reduces screw revision rates and surgical revision rate.

GP184
MEDICAL RISK FACTORS FOR OPIOID-RELATED ADVERSE EVENTS AFTER LUMBAR LAMINECTOMY AND FUSION
1Mark Kurd, M.D.; 2Kevin Ong, Ph.D.; 3Scott Lovald, Ph.D.; 3Edmund Lau, M.S.; 4David Polly Jr, M.D.; 5Kris Radcliff, M.D.;
1Rothman Institute, Bryn Mawr, PA; 2Exponent, Philadelphia, PA; 3Exponent, Menlo Park, CA; 4University of Minnesota, Minneapolis, MN; 5Rothman Institute, Egg Harbor Township, NJ

INTRODUCTION: Patients often experience acute postoperative pain following spine surgery, with as many as 22.4% of unplanned readmissions within 30 days related to pain (Pugely 2014). IV narcotics are commonly used to manage pain, but may be associated with opioid-related adverse events (ORAE) and patient risk factors are not well established. We evaluated the relative risk for ORAE following lumbar laminectomy (LL) and posterior lumbar fusion (LF) in the Medicare population.

METHODS: Patients were identified from the 2010-2012 5% Medicare data. The patient risk factors for newly diagnosed ORAEs at 90-days post-surgery were evaluated using multivariate Cox regression.

RESULTS: Respiratory complications, urinary retention, post-operative nausea and vomiting (PONV), acute delirium, and paralytic ileus were the most commonly diagnosed ORAE from 16,765 LF and 24,514 LL patients. Older patients (adjusted hazard ratio (AHR): 1.37 (LL) and 1.51 (LF) for 80-84 vs. 65-69 y.o.), those with more comorbidities (AHR: 2.49 (LL) and
2.15 (LF) for 5+ vs. 0 Charlson score), history of COPD/emphysema (AHR: 1.37 (LL) and 1.28 (LF)), and of lower socioeconomic status (AHR: 1.29 (LL)) had higher risks of respiratory complications. Older, obese (LL only), and sicker patients had higher risk of acute delirium. Risk factors for urinary retention were older age (AHR: 2.38 (LL) and 2.16 (LF) for 85+ vs. 65-69 y.o.), more comorbidities (1.59 (LF) for Charlson score of 5+ vs. 0), and men (AHR: 2.13 (LL), 2.27 (LF)), while older patients (AHR: 1.43 (LF) for 75-79 vs. 65-69 y.o.), patients with more comorbidities (AHR: 2.41 (LL) and 2.31 (LF) for Charlson score of 5+ vs. 0), and women (AHR: 1.86 (LL), 1.64 (LF)) had elevated risk for PONV. Men had 61% (LL) and 45% (LF) higher risks of paralytic ileus.

**DISCUSSION:** Our study quantified the elevated ORAE risk in certain patient groups, particular older patients and those with more comorbidities. Closer attention to these patients may help minimize

**GP185**

**OPIOID-RELATED ADVERSE EVENTS WITH LUMBAR SPINE SURGERY: IS THE RISK REAL?**

1Mark Kurd, M.D.; 2Kevin Ong, Ph.D.; 3Scott Lovald, Ph.D.; 3Edmund Lau, M.S.; 4David Polly Jr, M.D.; 5Kris Radcliff, M.D.; 1Rothman Institute, Bryn Mawr, PA; 2Exponent, Philadelphia, PA; 3Exponent, Menlo Park, CA; 4University of Minnesota, Minneapolis, MN; 5Rothman Institute, Egg Harbor Township, NJ

**INTRODUCTION:** Although lumbar spine surgery has positive outcomes, as many as 22.4% of unplanned readmissions within 30 days post-surgery are related to pain (Pugely 2014). The most common pain management protocol is intravenous narcotics, but this may be associated with opioid-related adverse events (ORAE), such as respiratory complications and post-operative nausea and vomiting (PONV) (Kessler 2013). This study evaluated ORAE risk using a nationally representative sample of elderly lumbar spine surgery patients.

**METHODS:** Using the 5% Medicare physician/ carrier claims data (2010-2012), lumbar laminectomy (LL) and posterior lumbar fusion (LF) patients were identified. The 90-day postoperative risk of newly-diagnosed ORAEs was assessed, using ICD-9 diagnosis codes for respiratory complications, paralytic ileus, PONV, acute delirium, urinary retention, etc.

**RESULTS:** A total of 16,765 LF and 24,514 LL Medicare patients were identified. Respiratory complications (bradypnea, pulmonary insufficiency, asphyxia, and hypoxemia) were the most commonly diagnosed ORAE (LF: 9.0% and LL: 6.3%). Urinary retention rates of 5.8% were diagnosed for both LF and LL patients. The rate of PONV was 3.8% and 2.8% following LF and LL, respectively, while the corresponding rates of acute delirium were 3.2% and 2.1%, respectively. Paralytic ileus occurred in 2.2% and 1.3% of LF and LL patients, respectively.

**DISCUSSION:** Although opioids are effective and are the most common treatment protocol for acute postoperative pain after lumbar spine surgery, the reliance on opioid analgesics exposes patients to ORAEs. These complications not only adversely affect the patient but also increase healthcare costs. Future research should explore the risk benefit ratio of alternative non-opioid pain strategies.

**GP186**

**NATIONAL TRENDS IN THE SURGICAL MANAGEMENT OF LUMBAR ISTHMIC SPONDYLOLISTHESIS: 1998 TO 2011**

Rebekah Belayneh, Brandon Raudenbush DO

Caroline P. Thirukumar, MBBS, MHA Yue Li

PhD Addisu Mesfin MD

University of Rochester Strong Memorial Hospital
INTRODUCTION: Isthmic Spondylolisthesis (ISY) is present in up to 6% of the North American population and is rarely symptomatic. When conservative treatment fails, surgery is an option. National trends in the surgical management of ISY are not known. Our study attempts to identify national trends in operative care of adult isthmic spondylolisthesis in the United States.

METHODS: We used the Healthcare Cost and Utilization Project’s (HCUP) Nationwide Inpatient Sample (NIS) databases (1998-2011), ICD-9-CM diagnosis and codes, and Diagnosis Related Groups to retrospectively identify adult ISY cases that were treated surgically using either anterior or posterior or combined fusion approaches.

RESULTS: Between 1998 and 2011: surgical treatment rates increased 3.9 times. The proportion of anterior approach declined from 83% to 50% of all ISY surgeries, whereas posterior approach increased significantly from 16% to 40%. For anterior surgeries, mean hospitalization charges increased from $35,555 to $100,110 (p<0.01); mean length of stay decreased from 4.6 to 3.3 days (p<0.01); and, complication rate decreased from 11% to 2% (p<0.01). For posterior surgeries, mean hospitalization charges increased from $33,207 to $102,575 (p<0.01); mean length of stay decreased from 4.8 to 3.6 days (p<0.01); and, complication rate decreased from 11% to 3% (p<0.01).

DISCUSSION: Our results indicate a dramatic decrease in anterior-based surgery, a greater utilization of posterior-based surgery, and higher complication rates with combined procedures. Hospital costs and length of stay are increased with combined procedures. Comorbidities and patient age were higher in the posterior group. Complications were lowest in the posterior group but trended lower in all groups. Our study is clinically relevant as it demonstrates the national trend and increase in posterior surgery for the treatment of adult isthmic spondylolisthesis.

GP187

PRE-SURGICAL IMAGING, TESTING AND INJECTION UTILIZATION IN ELECTIVE THORACOLUMBAR SPINE SURGERY CANDIDATES

Edward Abraham, Alana Green, Greg McIntosh, Neil Manson, Hamilton Hall;
Canada East Spine Centre, Horizon Health Network, Saint John, NB, Canada; Dalhousie University of Medicine, Saint John, NB, Canada; Canadian Spine Outcomes and Research Network (CSORN), Toronto, Canada.

INTRODUCTION: The objective was to assess the utilization of imaging, tests and injections in spine surgery candidates in the six months prior to surgical booking.

METHODS: We conducted a retrospective analysis of prospectively collected data from the Canadian Spine Outcomes and Research Network (CSORN). Twelve spine surgery sites across Canada contributed patient data for possible spine surgery cases between October 2008 and September 2014. Patients (n=527) had degenerative spinal pathology or deformity of the thoracolumbar region.

RESULTS: Patients reported 836 counts of one use, 274 counts of 2 uses, 126 of 3 and 236 counts of +3 uses. This equals a conservative estimate (if +3=4) of 1471 imaging, tests and/or injections. EMG/nerve conduction tests and bone scans were utilized the least. MRI had the highest prevalence of use, followed by x-rays.
There was no statistically significant difference in the frequency of x-ray utilization in those with deformity, fracture or spondylolisthesis compared to those with infection, tumour, disc herniation, degenerative disc disease or stenosis. There was a significant difference in pain ratings by imaging frequency: those with no x-ray had significantly higher leg pain ratings than those with +3 x-rays (p<0.05) - patients with no CT imaging had the highest leg pain ratings; patients with +3 CT scans had the lowest leg pain ratings (p<0.05) - those with one MRI had significantly higher leg pain ratings than those with +3 x-rays (p<0.05).

**RESULTS:** Patients reported 1-2 physician visits 572 times, 3-10 visits 366 times, 10+ visits 81 times. This equals at least 2561 visits, and a conservative maximum (if >10=11) of 5695 visits. Not surprisingly, family doctors accounted for the most visits and naturopaths the fewest. Consultations with another spine surgeon represented the second highest utilization; this ‘doctor shopping’ was most prevalent in Ontario (p<0.05). For patient-reported disability (ODI), patients who never saw an emergency physician reported significantly less disability than those who saw an emergency physician (p<0.05). There were no differences in baseline ODI for other spine surgeon, rheumatologist, family doctor, naturopath or “other”. Patients who never saw a pain management specialist reported significantly less disability than those who saw one >10times (p<0.05). There were no differences in baseline pain ratings or health score for those who went to another physician, with the exception of family doctors; those with >10 visits had higher baseline leg pain and lower health scores (p<0.05).

**DISCUSSION:** Given the similarities in baseline characteristics pertaining to pain, disability and health state in this study, spine patient utilization of physician resources is high and variable. A focused strategy to provide appropriate, targeted triage and care to spine patients is needed across Canada.

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**GP188**

**PRE-SURGICAL PHYSICIAN UTILIZATION IN ELECTIVE THORACOLUMBAR SPINE SURGERY CANDIDATES**

Edward Abraham, Alana Green, Greg McIntosh, Neil Manson, Hamilton Hall;
Canada East Spine Centre, Horizon Health Network, Saint John, NB, Canada; Dalhousie University of Medicine, Saint John, NB, Canada; Canadian Spine Outcomes and Research Network (CSORN), Toronto, Canada.

**INTRODUCTION:** Our objective was to assess the frequency of physician utilization in spine surgery candidates in the six months prior to surgical booking, and present the differences across Canada.

**METHODS:** We conducted a retrospective analysis of prospectively collected data from the Canadian Spine Outcomes and Research Network (CSORN). Twelve spine surgery sites across Canada contributed data for spine surgery candidates from 2008-2014. Patients (n=537) had degenerative spinal pathology or deformity of the thoracolumbar region.

**RESULTS:** Patients reported 1-2 physician visits 572 times, 3-10 visits 366 times, 10+ visits 81 times. This equals at least 2561 visits, and a conservative maximum (if >10=11) of 5695 visits. Not surprisingly, family doctors accounted for the most visits and naturopaths the fewest. Consultations with another spine surgeon represented the second highest utilization; this ‘doctor shopping’ was most prevalent in Ontario (p<0.05). For patient-reported disability (ODI), patients who never saw an emergency physician reported significantly less disability than those who saw an emergency physician (p<0.05). There were no differences in baseline ODI for other spine surgeon, rheumatologist, family doctor, naturopath or “other”. Patients who never saw a pain management specialist reported significantly less disability than those who saw one >10times (p<0.05). There were no differences in baseline pain ratings or health score for those who went to another physician, with the exception of family doctors; those with >10 visits had higher baseline leg pain and lower health scores (p<0.05).

**DISCUSSION:** Given the similarities in baseline characteristics pertaining to pain, disability and health state in this study, spine patient utilization of physician resources is high and variable. A focused strategy to provide appropriate, targeted triage and care to spine patients is needed across Canada.
**GP189**

**COCCYDYNIA AND SACRAL SIZE: A NEW RADIOLOGICAL PREDICTIVE FACTOR**

*J Richards (1), W Leigh (2), R Fraser (3);*  
(1) Royal Adelaide Hospital, Adelaide, Australia  
(2) Millennium Institute of Sports, Auckland, New Zealand  
(3) St Andrews Hospital, Adelaide, Australia

**INTRODUCTION:** Coccydynia is a painful condition that is exacerbated by sitting. Recent CT (1) and MRI (2) studies of both asymptomatic and symptomatic coccygeal morphologies have demonstrated that females have a shorter, straighter more retroverted coccyx, a higher rate of sacrococcygeal and intercoccygeal fusion and a higher incidence of a bony spicule. Morphological studies have not commented on any relationship between coccydynia and sacral length or number of segments. We postulate patients with prominence of the sacro-coccygeal joint due to bony anomalies such as extra sacral segments and transitional vertebrae are predisposed to coccydynia.

**METHODS:** A retrospective review of notes and radiological comments from a single surgeon series of 39 operatively managed cases from 1991 – 2014. All patients complained of prolonged disabling pain in the region of the coccyx with localized tenderness that limited sitting other than when seated on a toilet seat or cut-out cushion.

**RESULTS:** Of the 39 cases comments regarding morphology were available for 35. 26 were noted to have more than the standard 5 sacral segments, 5 had transitional vertebrae and 4 had associated coccygeal anomalies. All underwent surgical resection of the coccyx and trimming of the distal end of the sacrum. Two small wound break downs occurred as did one superficial infection and one case of hypergranulation. The outcome was considered satisfactory in all but 7 patients.

**DISCUSSION:** The high incidence of additional sacral segments in this series of coccydynia provides an explanation as to why some individuals are predisposed as well as a rationale for surgical excision of the coccyx and trimming of the distal sacrum. 1) Woon JT, Perumal et al. CT Morphology and morphometry of the normal adult coccyx. European Spine Journal 2013 22: 863-870 2) Woon JT, Maigne JY et al. Magnetic resonance imaging morphology and morphometry of the coccyx in coccydynia. Spine 2013 38/23 E1437 – E1445

**GP190**

**PRE-OPERATIVE “AMBER FLAG” PSYCHOLOGICAL MEASURE SCORES AND PATIENT EXPECTATIONS**

*Neil Manson, Alana Green, Greg McIntosh, Edward Abraham, Hamilton Hall;*  
Canada East Spine Centre, Horizon Health Network, Saint John, NB, Canada Dalhousie University of Medicine, Saint John, NB, Canada Canadian Spine Outcomes and Research Network (CSORN), Toronto, Canada

**OBJECTIVES:** A primary objective of elective thoracolumbar surgery is to correct radicular symptoms – a reduction in back pain is desired but supplementary. Nonetheless, many patients still perceive back pain to be the primary indication for surgery. Patient expectations have been shown to have a strong impact on recovery. The purpose of this study was to determine whether there is a correlation between “amber flag” scores on pre-operative psychological measures and patient expectations.

**METHODS:** This was a retrospective analysis of prospectively collected Canadian Spine Outcomes and Research Network (CSORN) data (n=568). Twelve spine surgery sites across Canada contributed data from possible spine surgery cases between October 2008 and September 2014. Two patient types were...
investigated: those without amber flags (SF12-MCS=42 and PHQ9<15 and EQ5D-AD=none or moderate, n=424) and those with amber flags (SF12-MCS=42+ or PHQ9=15+ or EQ5D-AD=extreme, n=144). Prior to surgery, patients were asked to choose the single most important change that they expect will occur as a result of their operation.

RESULTS: A Spearman’s Rho analysis showed a weak correlation between patient expectations and psychological amber flags. Those without amber flags listed a reduction in leg pain as their number one reason significantly most often (37.3%) and those with amber flags listed a reduction in back pain significantly most often (41.7%) (rs[568] = .13, p < .013); however, the effect size was very small. Pain was significantly more important than function to both groups (p<0.05).

DISCUSSION: Clinicians need to address patient expectations with patients who demonstrate psychosocial symptoms on pre-operative questionnaires. Those with amber flags had particularly discordant expectations from their operating surgeon.

GP191
THE IMPACT OF THE CAGE HEIGHT, DIAMETER AND POSITIONING ON CLINICAL AND RADIOGRAPHIC OUTCOME OF THE EXTREME LATERAL INTER-BODY FUSION
Yu Moriguchi, Christoph P. Hofstetter, M.D., PH.D. 1, Marjan Alimi. M.D 1, Apostolos J. Tsiouris M.D. 2, Eric Elowitz M.D. 1, Roger Härtl, M.D.1;
1 Brain and Spine Center, Department of Neurological Surgery and 2 Department of Neuro-radiology Weill Cornell Medical College, New York-Presbyterian Hospital, New York, New York

INTRODUCTION: Extreme lateral interbody fusion (ELIF) is a novel technique for anterior spinal fixation and indirect decompression of neural elements. The aim of the current study was to determine certain parameters of the interbody cage that would result in better radiographic and clinical outcome.

METHODS: We performed a retrospective analysis of 145 ELIFs in 90 patients. Intervertebral disc height, foraminal height, cage position and lumbar lordosis were determined on pre-operative, post-operative, and the latest follow-up studies. Clinical outcomes were evaluated by Oswestry Disability Index and Visual Analogue Scale.

RESULTS: At the time of last follow-up (17.7 ± 1.1 months), two factors determined restoration of foraminal height: the amount of increase in the disc height (implant height - preoperative disc height) and the footprint of the intervertebral spacer. Cages that had increased the disc height by 6 - 9 mm yielded in significantly greater restoration of foraminal height compared to the grafts that had increased the disc height by 0 - 3 mm (P les than 0.01) or 3 - 6 mm (P less than 0.05). In addition, 22 mm spacers allowed for a significantly higher increase in the foraminal height compared to 18 mm spacers (P less than 0.001). Interestingly, neither cage position nor posterior instrumentation had statistically significant influence on restoration of foraminal height. Both, lordotic and non-lordotic cages allowed for increased lumbar lordosis on post-operative imaging. Clinical evaluation revealed a mean ODI, VAS back, buttock and leg pain improvements of 21.1 %, 3.7, 3.6 and 3.7 points, respectively.

DISCUSSION: In ELIF, cage width and height but not cage position, determine restoration of foraminal height. The optimum cage width was found to be 22 mm and the optimal amount of increase in disc height was 6 to 9 mm.
MINIMALLY INVASIVE INSTRUMENTED FACET FUSION FOR ELDERLY PATIENTS OVER 75 YEARS OLD WITH DEGENERATIVE LUMBAR SPONDYLOLISTHESIS: SIMILAR CLINICAL OUTCOMES TO YOUNGER PATIENTS

Kei Kato 1), Hiromi Ataka 2), Tomohiro Miyashita 1), Takaaki Tanno 2);
1) Spine center, Matsudo city hospital 2) Spine center, Matsudo orthopaedic hospital

INTRODUCTION: We have reported good clinical results for minimally invasive instrumented facet fusion (FF) for degenerative lumbar spondylolisthesis (DLS). In this study, we assessed patient-based functional outcomes of FF in patients more than 75 years old.

METHODS: Twenty-seven patients more than 75 years old who underwent FF for single level DLS were reviewed after a minimum 1-year follow-up (elderly group). A control group included 33 patients less than 65 years old who underwent the same surgery. Comorbidities, perioperative adverse events, patient-based functional outcomes using the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ) and Roland–Morris Disability Questionnaire (RDQ) were compared between the two groups. The fusion rates assessed using CT were also compared.

RESULTS: The prevalence of comorbidities was 96% in patients from the elderly group, and was significantly higher than the 69% in patients from the control group (p = 0.02). No perioperative adverse events were observed in either group. Therapeutic effectiveness rate for 4 domains of the JOABPEQ (low back pain, lumbar function, walking ability, and mental health) showed no significant differences between the two groups. Social life function was an exception. Patients in both groups demonstrated significant improvements in RDQ values after surgery. The fusion rate was 85% in the elderly group and 94% in the control group and was not significantly different (p = 0.49).

DISCUSSION: Minimally invasive instrumented FF appears to be a safe and justifiable treatment for DLS even in patients older than 75 years with comorbidities, providing improvements in functional disabilities comparable to those in younger patients.

COMPUTER ASSISTED SURGERY IS AN EFFECTIVE EDUCATIONAL TOOL FOR THE TRAINING OF ORTHOPAEDIC SURGERY RESIDENTS IN PEDICLE SCREW PLACEMENT

Ahmed Aoude, MD, M.Eng; Hamzah Alhamzah, MD; Maryse Fortin PhD, CAT(C); Peter Jarzem, MD, FRCS; Jean Ouellet, MD, FRCS; Michael H. Weber, MD, PhD, FRCS;
McGill University Health Centre, Division of Orthopaedics Surgery, Montreal, Canada

INTRODUCTION: The accurate placement of pedicle screws in vertebral pedicles is very complex and pedicle screw malposition can have significant complications. The training of orthopedic residents in adequate pedicle screw placement is therefore very important. The purpose of this study was to investigate the effectiveness of computer assisted surgery (CAS) as a tool for the training of orthopedic residents in pedicle screw placement.

METHODS: A total of 24 orthopedic residents participated in this study. Each resident was randomly assigned to place a screw using the free hand technique (FH) and CAS technique on one of three cadavers (Cobb angles 5º, 15º and 67º), at randomly selected thoracolumbar vertebral levels. All residents were blinded to their colleagues’ pedicle screw placements and were asked to fill a short questionnaire at the end of the session to evaluate their
experience. Computed tomography images were obtained for each cadaver to assess pedicle screw placement accuracy and classified as follows: A) screw completely in pedicle, B) screw outside of pedicle < 2mm, C) screw outside of pedicle 2-4mm, D) screw outside pedicle > 4mm.

RESULTS: Five screws were classified as grade A or B (safe zone) and 19 as grade C or D (unsafe zone) using FH in comparison to 15 and 9 using CAS, respectively (p = 0.008). Severe spine deformity (Cobb angle > 67°) was associated with lower accuracy using FH (p=0.03). A greater number of screws were placed in the unsafe zone while using FH in the lumbar spine (p=0.004). The self-reported survey showed that 65% of the residents still preferred using FH.

DISCUSSION: CAS improved screw placement accuracy and can be successfully used as an educational training tool for orthopedic surgery residents. However, CAS may need to be more user friendly in order to improve resident’s self-perception of its use.

GP194

UNILATERAL TUBULAR APPROACH FOR BILATERAL LAMINECTOMY: EFFECT ON IPSILATERAL AND CONTRALATERAL BUTTOCK AND LEG PAIN

Yu Moriguchi, Marjan Alimi, MD 1; Christoph P. Hofstetter, MD, PHD 1; Jose M. Torres-Campa 1; Guang-Ting Cong, BS 2; Rodrigo Navarro-Ramirez 1; Roger Hartl, MD 1;
1 Weill Cornell Brain and Spine Center, Department of Neurological Surgery, Weill Cornell Medical College, New York-Presbyterian Hospital, New York, NY

INTRODUCTION: Tubular laminectomy is an effective procedure for treatment of concomitant lumbar spinal stenosis (LSS) and lateral recesses stenosis. Most surgeons familiar with the procedure agree that the tubular approach appears to afford a more complete decompression of the contralateral thecal sac and nerve root, as compared to the ipsilateral side. With this study we sought to answer the question whether this is reflected in clinically significant differences between the ipsilateral and contralateral side pain improvements.

METHODS: Patients with LSS and concomitant lateral recesses stenosis, who had similar bilateral VAS scores, and underwent a tubular (MIS) laminectomy, were included. At the last follow-up, the extent of VAS score improvement on the approach side was compared to that of the contralateral side. We tested the hypothesis that the pain relief would be similar on both sides, regardless of the side of approach.

RESULTS: Thirty-three patients were included in our retrospective study. At the latest follow up of 25.8±3.4 months, there were statistically significant improvements in ODI and back VAS scores (p=0.002 and p<0.0001, respectively). In addition, buttock VAS scores were significantly improved both on the ipsilateral and the contralateral side (p=0.001, and p=0.001, respectively). Similarly, leg VAS scores were improved significantly on both sides (p=0.001, and p=0.001, respectively). There were no statistically significant differences between the extent of pain improvement on the ipsilateral and the contralateral side.

DISCUSSION: The unilateral approach for bilateral decompression is an effective procedure that results in similar improve-
ment of the ipsilateral and the contralateral pain in patients with central canal stenosis and lateral recesses stenosis, with relatively symmetric symptoms on both sides. The approach side makes no difference in the extent of improvement of the ipsilateral and the contralateral side pain scores.

**GP195**

**EXTREME LATERAL INTERBODY FUSION FOR UNILATERAL SYMPTOMATIC VERTICAL FORAMINAL STENOSIS**

Yu Moriguchi, Christoph P. Hofstetter, M.D., Ph.D. 1, Marjan Alimi, M.D 1, Apostolos J. Tsiouris M.D. 2, Eric Elowitz M.D. 1, Roger Härtl, M.D.1;

1 Weill Cornell Brain and Spine Center, Department of Neurological Surgery and 2 Department of Neuro-radiology Weill Cornell Medical College, New York-Presbyterian Hospital, New York, New York

**INTRODUCTION:** Spinal deformity of the adult lumbar spine may occur de novo due to degenerative disease or following decompressive surgery. Asymmetric loss of disc height may lead to unilateral vertical foraminal stenosis and radiculo-pathy. The current study aimed to investigate whether restoration of foraminal height at the symptomatic level using single-level extreme lateral interbody fusion (ELIF) may alleviate unilateral radi-cular pain.

**METHODS:** In a retrospective cohort study, patients with single level unilateral vertical foraminal stenosis (foraminal height < 15 mm) and corresponding unilateral radicular pain who underwent ELIF were included. Demographic and peri-operative data were collected. Functional data (Visual Analogue Scale (VAS) for buttock, leg and back, as well as Oswestry Disability Index (ODI)) and radiographic measurements (bilateral foraminal height, disc height, segmental coronal Cobb angle and regional lumbar lordosis) were collected pre-operatively, postoperatively and at the last follow-up.

**RESULTS:** A total of 23 patients with a mean age of 66 years were included. The foraminal height of stenotic side was significantly increased by ELIF from the pre-operative value of 11.0 mm to 18.1 mm post-operatively (p less than 0.001). The increase was durable at last follow-up of 11 ± 3.7 (SE) months (17.1 mm; p less than 0.001). Preoperative VAS buttock and leg on the stenotic side, VAS back, and the ODI were significantly improved postoperatively and at the last follow-up. The postoperative FH on the stenotic side showed correlation with the VAS buttock and VAS leg on the stenotic side. Also at the last follow-up, FH on the stenotic side showed correlation with VAS leg on the stenotic side.

**DISCUSSION:** Single-level ELIF is an effective procedure for treatment of symptomatic unilateral vertical foraminal stenosis. The foraminal height increase correlates with pain improvement on the symptomatic side.

**GP196**

**LONG TERM SURVIVAL ANALYSIS OF A FIXED INTERSPINOUS SPACER: MAINTENANCE OF EFFECTIVENESS?**

Jamie A Nicholson, Andrew D Duckworth, Chloe EH Scott, John G Burke† and JN Alastair Gibson; The Royal Infirmary and University of Edinburgh, Edinburgh, Scotland †The Galway Clinic, Doughiska, Ireland
INTRODUCTION: Although conceived as an alternative to fusion for patients with chronic low back pain and instability, fixed interspinous spacers are now more frequently inserted to maintain foraminal height following decompression. There is limited data on the long term outcome of spacers used for this purpose.

METHODS: All patients who underwent single or multi-level decompression with a fixed interspinous spacer over an eight year period were retrospectively reviewed to determine the indications for surgery, complications, further interventions and mode of device failure.

RESULTS: During the study period 248 Wallis type ligaments were placed in 213 patients of mean age 57yrs (range 21-87) presenting with spinal stenosis 76%, disc prolapse 21%, black disc disease 3% and spondylolisthesis 0.5%. Median follow-up was 4.5 yrs (range 1-7.7) which included 9 deaths and an additional 20 patients lost to follow-up. Early complications were found in 15 patients, 7 presenting with a wound infection, 5 a seroma and 3 a dural tear. In the follow-up period repeat MR imaging was undertaken in 93 (44%) due to ongoing or new symptoms with a recurrent stenosis evident in 41 (19%) (same level 21 patients, adjacent 15, same plus adjacent 5) at a mean of 31 months (SD 18.0). Isolated central stenosis was found in 13 (10 at same level) and combined foraminal and central stenosis in 28 (18 at same level). Revision decompression was undertaken in 19 (9%) of the patients (spacer retained in 4 and removed in 15), four of which underwent fusion. Five others underwent a nerve root injection. Two year implant survival rate was 98.8% (95%CI: 95.6-100), and five year 92.1% (95%CI: 88.6-99.5; Figure 1 Kaplan-Meier Survivorship).

DISCUSSION: Our series revealed an acceptable survivorship with a low rate of repeat decompression and fusion. The Wallis ligament appears to be a useful adjunct to decompression but whether foraminal re-stenosis is prevented in the long term remains uncertain.

GP197
STENOTIC RATIO IS THE MOST USEFUL PARAMETER TO IDENTIFY PATIENTS WITH LUMBAR FORAMINAL STENOSIS NEEDING SURGERY OR NOT -MRI STUDY USING 3D T1 SPACE SEQUENCE
Kentaro Yamada, Yuichiro Abe, Yasushi Yanagibashi, Takahiko Hyakumachi, Shigenobu Satoh; Department of Orthopaedic surgery, Wajokai Eniwa Hospital

INTRODUCTION: Several imaging techniques have been proposed to diagnose Lumbar foraminal stenosis (LFS), but most of them focused on the most stenotic area or transversed nerve root in the neural foramen. Moreover, the differences between patients needing surgery and those with successful conservative treatment have not been discussed. We focused on stenotic length in the neural foramen. The purpose of this study was to compare among patients needing surgery, those with successful conservative treatment, and asymptomatic patients for LFS at L5-S using 3D MRI.

METHODS: MRI images were obtained by 3D T1 SPACE sequence with a 3.0-T scanner. The oblique images were reconstructed along L5-S foramen (Fig A). LFS was defined a slice of perineural fat obliteration.
at the vertical plane to the oblique images. Stenotic ratio (SR) was calculated by a ratio of stenotic length to the length of each foramen (Fig B). The minimum diameter of the nerve root (d) and the maximum transverse angle of nerve root (α) were also investigated. A total of 31 patients without evidence of lumbar canal stenosis at L4-S were included in this study. Each foramen at L5-S was divided into 3 groups: LFS needing surgery (Group 1) 10 foramina, LFS with successful conservative treatment (Group 2) 5 foramina, and asymptomatic foramen (Group 3) 47 foramina. The SR, d and α were compared among the three groups.

RESULTS: Significant difference between Group 1 and 3 was found in all parameters: SR, d, and α. However, significant difference between Group 1 and 2, or 2 and 3 was only found in SR. SR showed a stepwise increase from Group 3 to Group 1 (Group 1: 50.3±22.4%, Group 2: 17.6±4.9%, Group 3: 6.5 ±10.0%).

DISCUSSION: This study indicated that the ratio of stenotic length to the foraminal length was a more useful parameter to identify patients with LFS needing surgery or not, than the past reported parameters. The oblique imaging by 3D T1 SPACE was suitable to evaluate LFS including far-lateral stenosis.

GP198
SURGICAL OUTCOMES OF VERTEBROPLASTY WITH POSTERIOR INSTRUMENTED FUSION SURGERY FOR OSTEOPOROTIC VERTEBRAL COLLAPSE
Kazuya Kishima, Keishi Maruo, Tokuhide Moriyama, Toshiya Tachibana, Shinichi Inoue, Humihiro Arizumi, Shinichi Yoshiya; Department of Orthopaedic Surgery, Takarazuka city hospital Department of Orthopaedic Surgery, Hyogo College of Medicine

INTRODUCTION: Vertebroplasty (VP) with posterior spinal fusion (PSF) surgery often require for severe osteoporotic vertebral collapse (OVC) with neurological deficit. We performed VP with PSF (2 above, 2 below) using hydroxyapatite (HA) block since 2009. Then we changed bone material to calcium phosphate cement (CPC) and shorter fusion area (2 above, 1 below) since 2011. The purpose of this study was to compare the clinical outcomes between HA group and CPC group for OVC patients.

METHODS: A total of 36 patients (HA group 20, CPC group 16) who underwent VP with PSF for OVC between 2009 and 2013 were included in this study. The mean age at surgery was 75 years (range: 58-88) with 15 males. The mean follow-up period was 22months (range: 12-59). Teriparatide was used in 19 patients. Radiographic assessment including loss of correction, screw loosening and subsequent vertebral fracture were compared among two groups. Clinical outcome was assessed using VAS score, ADL, and complications between two groups.

RESULTS: There was no significant difference in age (HA group 76 years, CPC group 75 years) and gender (HA gropes female 65%, CPC group female 50%). Longer fusion was performed in HA group (HA group 5.5 vertebrae, CPC group 4.8 vertebrae). Operation time was significantly longer in HA group (259 minutes) than CPC group.
(192 minutes). There were no significant difference in estimated blood loss (EBL), loss of correction, screw loosening, and subsequent vertebral fracture. SSI was found in 4 cases (HA group 1, CPC group 3). New-onset vertebral fracture observed trend toward increasing in HA group (45% vs 25%). Revision surgery was performed in 2 cases of CPC group (cement leak 1, implant failure 1). Level of ADL was increased more than 1 rank after surgery in all cases.

**DISCUSSION:** The clinical outcomes of VP with PSF for OVC with neurological deficit were mostly favorable. In addition, shorter fusion surgery may prevent new fracture after instrumented fusion surgery for osteoporotic patients.

**GP199**

THE IMPACT OF TYPE OF LUMBAR FUSION SURGERY ON POSTOPERATIVE RTW STATUS IN A WORKERS’ COMPENSATION SETTING

Joshua T. Anderson, BS Ryan J. Duff, BA, Uri M. Ahn, MD Nicholas U. Ahn, MD; University Hospitals Case Medical Center 
Department of Orthopaedic Surgery

**INTRODUCTION:** U.S. workers’ compensation (WC) subjects tend to have worse clinical outcomes following lumbar fusion than the general population. However, relatively few studies evaluate outcomes within this clinically distinct population. We evaluated a cohort of WC subjects who underwent fusion for degenerative disc disease (DDD) to determine the impact type of fusion has on postoperative return to work (RTW) status.

**METHODS:** We included 1407 subjects from the Ohio Bureau of Workers’ Compensation (BWC) that underwent discogenic fusion between 1993-2010. Included subjects underwent ALIF, PLF, PLIF, PLF with PLIF, or 360 degree fusion. Subjects were considered returned to work if they made a stable return within 2 years of fusion and maintained this for more than 6 months of the following year. We utilized a multivariate logistic regression analysis, while correcting for a number of relevant covariates, to determine how type of fusion affects RTW status.

**RESULTS:** Overall, only 369 (26.2%) of all subjects met our RTW criteria after fusion. RTW rates by fusion type were as follows: ALIF 21.7% (23/106), PLF 26.1% (75/287), PLIF 36.0% (68/189), PLF with PLIF 23.8% (159/668), and 360 degree 28.0% (44/157). In the regression model, type of fusion was an independent predictor of RTW status (p=0.041). ALIF (OR 0.43) and PLF with PLIF (OR 0.59) were both negatively associated with RTW status compared to PLIF. Additional preoperative predictors of RTW status included: psychotherapy utilization (p=0.001; OR 0.35), spondylosis (p=0.026; OR 0.60), working within same week as fusion (p=0.001; OR 2.19), age greater than 50 (p=0.004; OR 0.63), and chronic opioid analgesia (p=0.001; OR 0.55). Legal representation was nearing significance (p=0.067; OR 0.75).

**DISCUSSION:** The type of fusion WC subjects with DDD underwent was found to be an independent predictor of postoperative RTW status. ALIF and PLF with PLIF subjects returned to work at the lowest rates and PLIF subjects at the highest.

**GP200**

EFFECT OF RH BMP-2 ON LUNG CANCER SPINE METASTASIS IN RODENTS

Marco Mendoza, Kevin A. M. Sonn, Sharath S. Bellary, Chawon Yun, Sohaib Z. Hashmi, Abhishek S. Kannan, John T. Nelson, Amruta Ashtekar, Anjan Ghosh, Nicholas Shawen, Michael S. Nickoli, Jason H. Ghodasra, Michael Okoli, Stuart Stock, Erin L. Hsu, Wellington K. Hsu; Department of Orthopaedic Surgery, Northwestern Feinberg School of Medicine
INTRODUCTION: Lung cancer is the second most prevalent cancer, and spinal metastases are found in 30-90% of patients with death attributed to cancer. Due to bony destruction caused by metastases, surgery is often required to restore spinal alignment and stability. Use of rhBMP-2 in patients with a history of cancer is contraindicated due to the controversial question of tumor propagation. Current literature provides no consensus on the effects of BMP on metastasis. Direct intraosseous injection of cancer cells into the vertebral body affords the opportunity to quantify the effects of rhBMP-2 on spinal metastasis.

METHODS: Luciferase-labeled A549 lung adenocarcinoma cells were pre-treated with saline (Group A) or with 100ng/ml rhBMP-2 (Group B), followed by implantation into the L5 vertebral bodies (VB) of 42 athymic rats (5x104 cells/rat). After 4 weeks, in vivo bioluminescent imaging (BLI) was performed, and average signal radiance was quantitated. Radiography and microCT were used to visualize and quantitate osteolysis, followed by histological analysis.

RESULTS: At 4 weeks post-implantation, BLI showed focal signals in the L5 VB of 13/14 animals from Group A (n=14) and 16/18 from Group B (n=18). Average tumor burden was 7.43x103 p/s/cm2/sr (Group A) and 1.11x104 p/s/cm2/sr (Group B; Fig 1a). X-ray and microCT demonstrated osteolysis in 100% of animals with focal signal on BLI. MicroCT quantification demonstrated significant bone loss in both groups compared to age-matched controls but no difference between the study groups (Fig 1b). Histological analysis demonstrated L5 tumor invasion.

DISCUSSION: These findings provide a reliable in vivo model to study isolated spinal metastases. The data support the notion that in vitro exposure to rhBMP-2 does not promote growth and development of lung cancer spine lesions. Subsequent evaluation of rhBMP-2 use in a fusion setting after the establishment of the cancer lesion will provide further clinical relevance.

GP201
RADIOLOGICAL RISK FACTORS FOR INSTRUMENTATION FAILURES AFTER MINIMALLY INVASIVE TRANSFORAMINAL LUMBAR INTERBODY FUSION
Moon-Chan Kim, Hung-Tae Chung, Woo Chul Kim, Hong Suk Lee, Dong Wook Jung;
Department of Orthopaedic surgery Busan Bumin Hospital, South Korea

INTRODUCTION: Minimally invasive transforaminal lumbar interbody fusion has become an increasingly popular method. The aim of this study was to determine radiological risk factors for instrumentation failures after minimally invasive transforaminal lumbar interbody fusion (MITLIF).

METHODS: From November 2008 to April 2012, 127 (52 men and 75 women with mean age 53.4[34-79] years) consecutive patients who had received one or two level minimally invasive transforaminal lumbar interbody fusion(MITLIF) for degenerative lumbar disease and who were followed up for more than 2 years were analyzed. Instrumentation failures were defined when a implant migration and breakage were observed. Statistical analyses with multifactorial logistic regression models were used to identify radiological risk factors of instrumentation failures associated with minimally invasive transforaminal lumbar interbody fusion(MITLIF).

RESULTS: Of 127 patients( one level: 102 patients, two level: 25 patients), 7 patients
had instrumentation failure and the failure rate was 5.5% (cage migration: 4 patients, screw migration: 2 patients, screw breakage: 1 patient) and instrumentation failures occurred within 2.4±5.6(1-8) months of surgery. Statistical analysis with logistic regression model revealed that preoperative disc height (Odds ratio: 3.142, 95% Confidence interval 1.101-3.814) and Slip angle (Odds ratio: 2.712, 95% Confidence interval 1.001-1.634).

DISCUSSION: The following radiological parameters were risk factors for instrumentation failures with minimally invasive transforaminal interbody fusion (MITLIF): increased preoperative disc height, increased angulation of the disc. The risk factors must be identified to prevent instrumentation failure.

GP202

PEDICLE SCREW MALPOSITION INRevision Spinal Surgery: Efficacy of Intra-Operative CT Based Navigation
Harvey Wu, Andrew Pennington, Juliet Batke, Kaiyun Yang, Charles G. Fisher, Marcel F.S. Dvorak, John Street;
University of British Columbia, Department of Orthopaedics, Division of Spine

INTRODUCTION: Revision surgery poses unique technical challenges for pedicle screw instrumentation. Use of intra-operative 3D imaging with navigation has been underreported in spine revision surgery. The aim of this study was to examine pedicle screw malposition rates and patient outcomes in revision surgeries comparing O-arm® and StealthStation® navigated cases to traditional freehand techniques.

METHODS: This ambispective study compared 2 matched cohorts of patients undergoing revision thoracolumbar surgery. Study group comprised 56 consecutive patients who underwent O-arm® and StealthStation® navigated pedicle screw instrumentation (NAV) between 1 January 2008 and 31 December 2012. Control group comprised 34 historical matched cases with surgery between 1 January 2006 and 31 December 2008, using traditional non-navigated (freehand or fluoroscopic) techniques (nonNAV). Cases were matched on age, gender, surgical location, number of surgical levels and primary diagnosis.

RESULTS: A significant difference existed in the number of misplaced screws between NAV and nonNAV (31 vs. 54, p<0.001). Mean number of misplaced screws per case was 0.57 (SD=0.92) NAV and 1.86 (SD=2.49) nonNAV (p=0.01). Number of screws revised intra-operatively was not significant (10 vs. 7, p=0.54). One NAV and two nonNAV patients required early postoperative screw revision during the same admission (p=0.33). No difference was seen in grade of screw malposition (p=0.11), anatomical location (p=0.26), duration of surgery (p=0.11), incidental dural tear (p=1.00), wound infection (p=1.00), or length of stay (p=0.78). A significant difference in intra-operative massive blood loss existed; 3.3% of NAV cases compared to 7.8% of nonNAV.

DISCUSSION: This early analysis of revision surgery demonstrates an increased accuracy of pedicle screw placement utilizing O-arm® and StealthStation® without an increase in OR time. Clinical outcomes between NAV and nonNAV cases were similar.

GP203

ACCELEROMETER- DERIVED PHYSICAL ACTIVITY AND LOWER EXTREMIT Y FUNCTIONAL CHANGES FOLLOWING LUMBAR SPINAL STENOSIS DECOMPRESSION
Matthew Smuck, MD*, Matthew P. Buman, PhD*, Ma Agnes Martinez Ith*, Christy Tomkins-Lane, PhD*
* Department of Orthopaedic Surgery, PM&R Section, Stanford University ^ School of Nutrition and Health Promotion, Arizona State University
**INTRODUCTION**: Objective methods are needed to better quantify functional outcomes following spine surgery. To date accelerometers have not been widely used to evaluate surgical outcomes despite their promise to detect small but meaningful changes in physical activity. Maintained lower extremity function in late life is known to reduce morbidity and mortality. The purpose of this study is to assess changes in physical activity and lower extremity function in patients with lumbar spinal stenosis undergoing spinal decompression surgery.

**METHODS**: Patients (N=14) wore an accelerometer for 7 consecutive days (Actigraph GT3x+), completed a validated self-report physical activity questionnaire (CHAMPS questionnaire) and a short battery of lower extremity physical performance tests (Short Physical Performance Battery [SPPB]: gait, leg strength, and standing balance) at baseline (T0), 1-mo post-operation (T1), and 3-mo post-operation (T2). Moderate-vigorous physical activity (MVPA) was defined using published thresholds (>1952cts/min) for accelerometer data, and using standard metabolic equivalents (>3.0 METS) for self-reported activities. Mixed-effects models were fitted to examine within-group changes in these variables.

**RESULTS**: Patients were 57% female, 43% Caucasian, overweight (27.6±5.1kg/m2), and of older age (73.4±8.1 years). Improvements in accelerometer and self-reported MVPA were not significant (p>0.05); however, effect sizes were moderate to large for accelerometer-derived MVPA at T1 (diff=9.6mins, d=0.98) and T2 (diff =8.0mins, d=0.4), and small for self-reported PA at T1 (diff=5.3mins, d=.01) and T2 (diff=9.2mins, d=0.3). Improvements in SPPB scores were significant (F[2,19.1], p=.01), with large effects sizes at T1 (diff=1.9, d=1.6) and T2 (diff=1.5, d=0.8).

Sub-analyses revealed SPPB total score changes were due to gait and leg strength, but not standing balance.

**DISCUSSION**: Lower limb functional improvements are observed following spinal stenosis decompression. Changes in MVPA are detectable but non-significant. Alternate techniques are necessary to optimize evaluation of accelerometer-derived measures of community physical performance following spinal stenosis decompression.

**GP204**

**INTRA-OPERATIVE CONE BEAM CT (O-ARM®) AND STEREOTACTIC NAVIGATION (STEALTHSTATION®) SYSTEM IN COMPLEX ADULT SPINE SURGERY – EARLY EXPERIENCE AND LEARNING CURVE**

Ana Contreras, Juliet Batke, Nicolas Dea, Marcel F. S. Dvorak, Charles G. Fisher, John Street;

University of British Columbia, Department of Orthopaedics, Division of Spine Surgery

**OBJECTIVES**: There is limited data evaluating the clinical learning curve for surgeons and its relationship to patient outcomes when using intra-operative navigation and imaging systems. We examined the clinical learning curve and patient outcomes of using O-Arm® and StealthStation® for 6 fellowship trained Spine Surgeons at our institution, a single quaternary referral center, from 2009-2013.

**METHOD**: This ambispective study examined 231 surgical cases where O-arm® and StealthStation® were used to facilitate pedicle instrumentation. The learning curve was determined by examining total operative time and blood loss, operative time and blood loss per surgical level, and the incidence of surgery related adverse events (AEs) by year. AEs were prospectively collected using the Spine adverse events severity system (SAVES).
RESULTS: At our institution, all spine surgeons were using O-arm® and StealthStation® by the beginning of 2009. 231 patients had screws placed using the O-arm® and StealthStation® between 1 January 2009 and 31 December 2012. There were 19 screws placed per year, with 131 cases in 2009 to 758 screws in 75 cases in 2012, p<0.05. The average estimated blood loss (EBL) decreased from 1229 mLs in 2009 to 907 mLs in 2012, p<0.05. The EBL per case per number of levels instrumented decreased from 5.72 mLs in 2008 to 2.39 mLs in 2012, p<0.05. Mean operating time decreased from 407 to 378 mins from 2009 to 2012, p<0.05. The number of misplaced screws per case decreased from 0.78 to 0.54 from 2009 to 2012, p<0.05. There were no significant differences in incidences of dural tear, surgical site infection or other surgical AEs over the study period.

CONCLUSIONS: Our results demonstrate that there is a learning curve to the use of intra-operative CT based navigation, as measured by OR time, intra-operative blood loss and screw malposition. There were no significant differences in surgical AEs during this learning period.

GP205
INTERVERTEBRAL GRAFT BONE UNION DOSE NOT AFFECT THE SHORT-TERM OUTCOME OF TRANSFORAMINAL INTER-BODY FUSION
Masumi Iwabuchi, Osamu Shirado, Hiroko Taguchi, Hironari Toshiki; Department of Orthopaedic and Spinal Surgery, Aizu Medical Center at Fukushima Medical University, Aizu-Wakamatsu City, Fukushima, Japan

INTRODUCTION: The association between intervertebral graft bone union and the short-term outcome in patients after transfomaminal interbody fusion (TLIF) was investigated by a cohort study. METHODS: Forty-three patients (male: 19, female: 24, age: 38-88, most age group: 70s) who received single level TLIF for lumbar degenerative disorders and passed more than 1 year (mean period: 18 months) were examined. Contents of the patients were as follows: degenerative spondylolisthesis; 25, spondyloytic spondylolisthesis; 5, foraminal stenosis; 12, facet cyst; 1. X-ray CT was used for the evaluation of intervertebral graft bone union. Multiple linear regression analysis was performed to determine the association between intervertebral graft bone union and the outcomes that contained VAS (low back pain, lower limb pain, lower limb numbness), RDQ, JOABPEQ and SF-36. Age, gender, intervertebral level, smoking, loosening of instruments, reduction of adjacent intervertebral disc height and slipping of adjacent vertebral body were applied as confounding factors. Body mass index and the preoperative value of the each outcome were applied as prognostic factors.

RESULTS: 1) Union rate of intervertebral graft bone: 72.1% (31/43 cases). 2) VAS: No association was detected between the bone union and every VAS. 3) RDQ: No association was detected between the bone union and RDQ. Intervertebral level and preoperative score of RDQ were associated with RDQ. 4) JOABPEQ: No association was detected between the bone union and every functional score of JOABPEQ. Intervertebral level and adjacent vertebra body slipping were associated with the score of low back pain. 5) SF-36: No association was detected between the bone union and every subscale of SF-36.

DISCUSSION: The study shows that intervertebral graft bone union in TLIF dose not affect the short-term outcomes that contain VAS and QOL. Long-term follow-up and investigation will be needed in order to acquire more authentic results.
GP206
RISK FACTORS FOR THE OCCURRENCE OF LUMBAR FORAMINAL STENOSIS AFTER MICROSURGICAL DECOMPRESSION FOR CENTRAL SPINAL CANAL STENOSIS
Kono Hiroshi, Matsuda Hideki, Cho Hisanori, Takahashi Yoshifumi;
Department of Orthopaedic surgery, Ishikire-seiki Hospital 18-28 Yayoi-cho Higashiosaka, Osaka, Japan

INTRODUCTION: Radicular pain due to lumbar foraminal stenosis sometimes occurs after decompression for central spinal canal stenosis. We studied risk factors for the occurrence of this condition during the postsurgical follow-up period.

METHODS: We reviewed data on 136 consecutive patients (66 men and 70 women, mean age 68.7) who underwent microsurgical decompression of the central spinal canal at L4–L5 level. Six (4.4%) underwent decompression of 8 foramina at L5–S1 level to treat recurrent radicular pain at 7-88 months (mean = 26) after the initial surgery. The effects of various parameters on the occurrence of L5–S foraminal stenosis were assessed by logistic regression. In addition, T1-weighted sagittal magnetic resonance imaging (MRI) of the L5–S foramina had been used to detect foraminal stenosis before the original operation.

RESULTS: Three of 66 men and 3 of 70 women underwent foraminal decompression. Among patients with narrowing of the L5–S disk space, the proportion was 4/61. By level of spinal canal decompression, proportions were as follows: L4–5, 3/96; L3–5, 1/26; L4–5, 2/12; L2–5, 0/1; L3–5, 0/1. The proportion was 3/34 among those with degenerative lumbar scoliosis (DLS) >10° and 2/56 among those with L4 degenerative spondylosis; it was 5/124 among those who underwent bilateral decompression using a unilateral approach and 1/12 among those who underwent medial fenestration. None of these variables showed a statistically significant effect. None of the 198 patients with no foraminal stenosis on preoperative MRI underwent foraminal decompression; 5 of 64 with mild stenosis and 1 of 10 with moderate to severe stenosis did.

DISCUSSION: Special care should be taken in patients undergoing decompression at L4–5 and those with DLS, even if only mild foraminal stenosis is found on MRI. Lumbar central spinal canal decompression may exacerbate foraminal stenosis even if performed using a minimally invasive technique.

GP207
INTERVERTEBRAL CAGE POSITION DETERMINES MONO-SEGMENTAL LORDOSIS IN LUMBAR SPINE RECONSTRUCTION WITH PLIF
Peter A Robertson Priyan R Landham Angus S Don;
The Orthopaedic Clinic Mercy Specialist Centre 100 Mountain Road, Epsom Auckland, New Zealand 1023

INTRODUCTION: Optimum sagittal balance in lumbar fusion surgery may improve outcomes and reduce adjacent segment degeneration. Posterior Lumbar Interbody Fusion (PLIF) surgery aims to optimise disc height, achieve interbody fusion and optimise lordosis. When paired interbody cages are inserted it is unclear how implant factors and surgical technique affects the result. This study aims to clarify the relationship between cage parameters and cage positioning (reflecting surgical technique) in terms of lordosis optimisation.

METHOD: 83 patients underwent single level PLIF between L3 and S1. Surgery was performed using paired ‘insert and rotate’ lordotic spacers, bone graft and posterior pedicle screw stabilisation. Pre and postoperative segmental lordosis along
with cage position were measured on standing x-rays. Cage position was determined with a ‘centre point ratio’ where the length of the inferior endplate of the disc is divided by the distance between the centre of the two cages and the posterior margin of the disc. This created a ratio where values >0.5 indicated anterior position of the spacers within the disc.

RESULTS: The segmental lordosis at the fused level was increased in 83% of patients by a mean of 5.73°(SD 7.21°). Anterior cage position (as signified by an increasing paired cage centre-point ratio) was significantly correlated with an increase in mono-segmental lordosis (P<0.01). In terms of cage size, increasing anterior cage height had a significant negative correlation with lordosis gain (P<0.01). Asymmetrical cage placement with increasing total cage length showed a non-linear negative trend with lordosis gain. There were no significant correlations between other cage shape parameters (including manufacturer’s lordosis) and final lumbar lordosis.

Conclusions: Anterior symmetrical cage placement is a key technical factor when trying to improve lumbar lordosis during PLIF surgery. In addition the cage should be of moderate height and length.

GP208

PLATELET-RICH PLASMA COMBINED WITH HYDROXYAPATITE/COLLAGEN FOR POSTEROLATERAL LUMBAR FUSION PROMOTED BONE FORMATION IN RATS

Shintaro Rakuman1, Go Kubota2, Kazuyo Yamauchi 2, Sumihisa Orita 2, Kazuhide Inage2, Sainoh Takeshi2, Jun Sato2, Kazuki Fujimoto2, Yasuhiro Shiga2, Kazuhsa Takahashi, Seiji Ohtori2;

1 School of Medicine, Chiba University 2 Dept. of Orthopaedic Surgery, Graduate School of Medicine, Chiba University

INTRODUCTION: Platelet-rich plasma (PRP) is an autologous blood product with a large number of platelets in a small volume of plasma. PRP has been reported to have a positive effect on bone formation because it contains several kinds of growth factors. Further, we have previously found that PRP appears to promote bone formation in posterolateral lumbar fusion (PLF) in rats. Recently, hydroxyapatite/collagen (HA/Col) has also been shown to have a positive effect on bone formation. However, the effects of the combination of PRP and HA/Col on PLF have not been reported. The purpose of this study was to examine the effect of HA/Col with PRP on bone formation in PLF in a rat model.

METHODS: A total of 30 rats were used: 10 underwent PLF with only HA/Col (HA/Col group), 10 underwent PLF with HA/Col and PRP (PRP group), and 10 underwent only decortication of transverse processes (control group). 10 rats were used as blood donors. Five and 10 weeks after surgery, Xp examinations were performed to evaluate bone formation, and 10 weeks after surgery, spinal fusion was evaluated on the basis of manipulation and histological analysis.

RESULTS: The control group showed no evidence of spinal fusion postsurgery. The bone volumes observed in the PRP group were significantly greater than those observed in the HA/Col group at five and 10 weeks (p < 0.05). Manipulation and histological analysis revealed that spinal fusion in the PRP group was significantly greater than that in the HA/Col group at 10 weeks (p < 0.05).

DISCUSSION: PRP with HA/Col was applied to PLF to examine its ability to induce bone formation and bone union in a rat model. The results suggest that a combination of PRP and HA/Col could be useful in PLF.
GP209
INFLUENCE OF PARASPINAL MUSCLE DEGENERATION ON CLINICAL OUTCOMES AND GLOBAL SAGITTAL ALIGNMENT IN PATIENTS WITH LUMBAR SPINAL STENOSIS. FOCUSING ON GENDER DIFFERENCE
Sho Dozhono, M.D., Ph.D., Masatoshi Hoshino, M.D., Ph.D., Akinobu Suzuki, M.D., Ph.D., Hiromitsu Toyoda, M.D., Ph.D., Hitetomi Terai, M.D., Ph.D., Hiroaki Nakamura, M.D., Ph.D.;
Department of orthopedic surgery, Yodogawa Christian Hospital, Osaka, Japan, 533-0024 1-7-50 Kunijima Higasiyodogawa-ku, Osaka, Japan

INTRODUCTION: There is little knowledge about the correlations between morphological changes to paravertebral muscle (PVM) and clinical outcomes in patients with LSS. On the other hand, there are several reports about the difference of PVM degeneration between genders. The purpose of this study was to identify the relationships between PVM degeneration and postoperative radiological findings or clinical data in LSS patients according to gender difference.

METHODS: The records of 60 patients (30 male and 30 female) who underwent microendoscopic laminotomy (MEL) for LSS were retrospectively reviewed. The minimum duration of clinical and radiologic follow-up was one year. On axial T2-weighted MRI, the cross sectional area (CSA) and the percentage of fat infiltration (%FI) of multifidus and erector muscle at L2-3, L3-4, and L4-5 level were calculated using Image J. Correlation was calculated between %FI of PVM and the following variables: age, BMI, JOA scores, VAS (LBP, leg pain and leg numbness), sagittal vertical axis (SVA), and L1S1 angle at latest follow-up.

RESULTS: The male LSS patients exhibited a larger PVM and lower %FI of PVM than the female patients. %FI of PVM at L4-5 level was significantly higher than L2-3 and L3-4 level in both men and women. In the male patients, %FI of PVM at L4/5 level showed a correlation with age, JOA scores and SVA at final follow-up (r = 0.535 / -0.464 / 0.543, respectively; p<0.01). Stepwise multiple regression analysis showed that age and SVA at final follow-up were independently associated with %FI of PVM at L4/5 level. In the female patients, %FI of PVM at L4/5 level tend to correlated with BMI (r = 0.351; p = 0.053).

DISCUSSION: Clinical and radiological parameters associated with PVM degeneration were different according to gender. In the male, FI of PVM was more prominent in older LSS patients, and those can be used as an associated factor of postoperative SVA. However, in the female, only BMI was associated with PVM degeneration.

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<thead>
<tr>
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<th>Male</th>
<th>Female</th>
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GP210
PREOPERATIVE PREDICTORS FOR GOOD POSTOPERATIVE SATISFACTION AND FUNCTIONAL OUTCOME IN LUMBAR SPINAL STENOSIS SURGERY WITH A FIVE AND TEN YEAR FOLLOW-UP
Tuomainen I1, Aalto T1, Vanhanen S1, Leinonen V2, Herno A1, Kröger H3, Airaksinen O1;
1Department of Physical and Rehabilitation Medicine, Kuopio University Hospital, P.O.Box 1777, FIN-70211 Kuopio, Finland 2Department of Neurosurgery, Kuopio University Hospital, Kuopio, Finland 3Department of Orthopaedics and Traumatology, Kuopio University Hospital, Kuopio, Finland
INTRODUCTION: In this study our aim was to evaluate the preoperative predictors in lumbar spinal stenosis (LSS) for a good postoperative outcome (satisfaction with surgery and functional improvement) with a five and ten year follow-up.

METHODS: At baseline total of 102 LSS patients were operated (mean age 62 years, 59 women and 43 men). In the five year follow-up study there were 74 LSS patients (mean age 67 years, 48 women and 26 men) and in the 10 year follow-up study there were 72 LSS patients (mean age 69 years, 45 women and 27 men). In this prospective clinical study patients completed a questionnaire before surgery and 2, 5 and 10 years after the surgery. Preoperative patient-related predictors, self-rated health, comorbidities, use of analgesic and previous lumbar operation were assessed. A good functional outcome was determined as more than 30% relative improvement compared to score before the surgery in the Oswestry Disability Index (ODI). Satisfaction with the surgical outcome was determined to be good if the patient response was either “totally cured” or “condition has considerably improved”. Satisfaction was evaluate with a seven-category scale and the other five responses (“condition has slightly improved” or worse) were determined as a worse outcome.

RESULTS: The predictor for the good improvement in the ODI was regular preoperative analgesic use 12 months or less (OR 3,372; 95% CI 1,081-10,521; p=0,036) at the five year follow-up. At the ten year follow-up the predictors for the good improvement in the ODI were regular preoperative analgesic use 12 months or less (OR 4,428; 95% CI 1,313-14,934; p=0,016) and non-smoking (OR 5,830; 95% CI 1,422-23,894; p=0,014). There were not statistically significant predictors for the postoperative satisfaction at the five and ten year follow-up.

CONCLUSION: In summary, regular analgesic treatment preoperatively for 12 months or less predicted a good postoperative functional improvement in LSS.

GP211
ANALYSIS OF RISK FACTORS OF PYOGENIC DISCITIS FOLLOWING DECOMPRESSION SURGERY FOR LUMBAR CANAL STENOSIS
Ken Ninomiya 1,8, Nobuyuki Fujita 2,8, Ken Ishii 2,8, Naobumi Hosogane 3,8, Tomohiro Hikata 2,8, Kota Watanabe 4,8, Shinjiro Kaneko 5,8, Yasuyuki Fukui 6,8, Takahiro Koyanagi 7,8, Tateru Shiraishi 1,8, Yoshiaki Toyama 2,8, Morio Matsumoto 2,8;

INTRODUCTION: There have been few reports of pyogenic discitis following lumbar decompression surgery. The purpose of this study was to identify risk factors of discitis after lumbar laminectomy.

METHODS: Data were examined from patients undergoing lumbar laminectomy without discectomy in 5 hospitals from April, 2007 to March, 2012. Postoperative discitits were defined as 1) clinical symptoms such as fever, 2) increase of WBC count and CRP, 3) disc destruction on MRI. A 4:1 matched cohort (control group) was created based on age, sex and level of decompression. Types of pathogens causing discitis were investigated. To identify the risk factor, body mass index, number of decompressed laminae, surgery time, intraoperative blood loss, past medical history, degeneration of endplate (Modic
DISCUSSION: Our data suggest that Modic type 1 and diabetes are risk factors of pyogenic discitis after lumbar laminectomy. There have been some reports that pyogenic spondylitis may manifest as Modic type 1. However, there was no significant difference of preoperative BT and hematologic findings between two groups. We hypothesize that destruction of endplate in Modic type 1 provides a suitable environment inside disc for bacteria to survive and proliferate.

GP212
REVERSIBILITY OF NERVE ROOT SEDIMENTATION SIGN IN LUMBAR SPINAL STENOSIS PATIENTS AFTER DECOMPRESSION SURGERY
   1. Department of Orthopaedic Surgery, Medical Faculty, University of Greifswald, Germany 2. Centre for Health Sciences Zurich University of Applied Sciences Winterthur, Switzerland and Centre for Medical Research University of Western Australia Perth, Australia 3. Institute for Evaluative Research in Medicine University of Bern Switzerland 4. The Screening and Test Evaluation Program, University of Sydney, Sydney, Australia 5. Department of Orthopaedic Surgery, Medical Faculty, University of Greifswald, Germany 6. Department of Orthopaedic Surgery, Asklepios Klinikum Uckermark, Schwedt, Germany

INTRODUCTION: The Nerve Root Sedimentation Sign (Sign) is a new radiological sign in the diagnosis of lumbar spinal stenosis (LSS). As patients with a positive Sign may benefit from surgical decompression the Sign might help spine surgeons make treatment decisions. This study investigated if in patients with LSS a positive Sign will turn negative after lumbar decompression and to describe its possible association with clinical outcomes.

METHODS: Prospective cohort of 30 consecutive LSS patients undergoing spine surgery comparing ODI, VAS, walking distance on the treadmill and MRI of the lumbar spine pre-op with 3-month follow-up (FU) data in regard to the presence of nerve root sedimentation (negative Sign). The short FU was chosen to exclude adjacent segment disease and influence of surgical technique on clinical outcomes in long-term FUs.

RESULTS: All patients (16 male, median age 73 yrs [range 44-86] had a positive pre-op Sign with a median preop ODI of 66 [20-
GP213
THE SURGICAL TREATMENT OF PYOGENIC SPONDYLITIS USING POSTERIOR INSTRUMENTATION WITHOUT ANTERIOR DEBRIDEMENT AS A PRIMARY SURGERY
Tetsuhiro Ishikawa, Masaaki Aramomi; Sanmu Medical Center, Chiba, Japan

INTRODUCTION: Pyogenic spondylitis is often difficult to treat conservatively. Single- or two-stage anterior debridement and bone grafting and combined anterior and posterior surgery are effective, but controversy exists with regard to which surgery must be chosen and when. Furthermore, older patients are sometimes unsuitable for anterior surgery because of their general condition or medical comorbidities. The purpose of this study was to evaluate the outcomes of posterior instrumentation surgery without anterior debridement as a primary surgery for pyogenic spondylitis in our facility.

METHODS: We reviewed 12 patients (6 males and 6 females) with pyogenic spondylitis who received posterior instrumentation between 2004 and 2014. Their mean age was 72.1 years (range, 60-85), and the average length of follow-up was 11 months. Five had a thoracic lesion, and 7 had a lumbar lesion. Five to 9 levels were included in the fixation (mean, 6.3 levels). Percutaneous screw systems were used in 3 cases. Screws were not placed in infected vertebrae to prevent the spread of infection. The causative bacteria were identified in only one patient (MSSA). Four patients had a history of diabetes, one had a history of pharyngeal cancer and one had a history of liver cancer.

RESULTS: The mean operating time was 273 minutes, and the mean intra-operative blood loss was 353 ml. The infection resolved in all cases, and C-reactive protein levels normalized at a mean of 49 days post-operatively. Secondary anterior debridement and bone grafting were performed in 3 cases because of major vertebral body collapse, and 2 cases showed screw loosening that required additional posterior instrumentation surgery.

DISCUSSION: Posterior stabilization provides early post-operative mobilization. In this series, single-stage posterior fusion was as effective as primary surgery for pyogenic spondylitis. However, anterior surgery with structural anterior support is essential if a large anterior bony defect is present.
**INTRODUCTION:** We have developed a minimally invasive laminotomy using endoscope to lumbar spinal disorders since 1998. The novel microendoscopic laminotomy (MEL) technique helps to preserve the facet joints, posterior ligament complex and soft tissues as much as possible. The purpose of this study was to investigate the clinical outcomes of MEL for degenerative lumbar spondylolisthesis, and to clarify which factors influenced the poor clinical outcomes.

**METHODS:** From 2008 to 2012, all patients, who developed a surgical treatment for LSS including DS on L3/4 or L4/5 single level, underwent MEL surgery at authors' institute. A total of 196 patients (87 males, 109 females; age: 69.8 years) were reviewed prospectively. The Japanese Orthopaedic Association scoring system (JOA score) was evaluated preoperatively and more than 2-years postoperatively. A poor improvement was defined as less than 50% recovery rate. Multivariate logistic regression analysis was accomplished for the preoperative factor which influenced poor improvement. The factors were selected as follows: age, sex, JOA, slippage, spinal instability, disc height, osteoarthritis of facet joint, endplate signal change, disc degeneration and sagittal alignment. All parameter were analyzed statistically (p<0.05).

**RESULTS:** Finally, 153 patients were reviewed. The final followed period was 30.5 months. The JOA recovery rate was 64.8±24.7%. The overall result was the defined poor improvement in 30.7% of patients. As the results of multivariate logistic regression analysis, the factor related to the poor improvement was endplate changes, and the odds ratio was 2.6. The endplate changes were also significantly related to slippage.

**CONCLUSION:** This observation suggests that the long-term results after MEL were well. The endplate signal changes were associated with postoperative clinical outcomes and slippage.

**GP215**

**TRANSFORAMINAL ENDOSCOPIC FOR A-MINOTOMY FOR ACUTE NEURALGIA**

J.N.Alastair Gibson, Menno Iprebungr*

*The Royal Infirmary and University of Edinburgh, Edinburgh, Scotland; *Iprenburg Herniaklinie, 9341 AH Veenhuizen, Drenthe, Netherlands

**INTRODUCTION:** Improvements in HD camera technology, purpose designed reamers and endoscopic powered diamond cutting drills now potentially allow adequate foraminotomy through a transforaminal endoscopic approach. We aimed to determine the safety and effectiveness of transfuraminal endoscopic foraminotomy (TEF) as an alternative to open decompression by laminotomy.

**METHODS:** 34 patients (mean age 56 ±12 yrs, 22m, 12f) with MR proven foraminal neural compression were admitted for TEF. All patients were treated under analgesia in a lateral position with bi-planar imaging. Cannulated or olive-tipped reamers were used for access and a diamond burr for marginal resection of the facets. Outcome scores were collected preoperatively at 3 months and 2 years. A historical group of 25 patients treated with open laminotomy (age 57±13, 11m 13f) was used for comparison of in-patient stay and rate of revision surgery within 2 years.

**RESULTS:** 36 foramina were widened by TEF (5 L3/4, 17 L4/5, 14 L5/S1) with trimming of the disc margin performed in
26. Median surgical time was 60min (range 33-140) and radiation time 43±16s (mean±SD). Pain in the most affected leg decreased from 6.6±2.1 pre-operatively to 2.4±2.4 at 6 weeks and 1.6±2.2 at 2 years. Back pain decreased from 5.7±2.7 to 2.4±2.4 and 1.1±2.2 with ODI falling from 40±17 to 19±13 and 9±13 (all p<0.001). No operative complications occurred; 4 required repeat surgery (2 repeat TEF and 2 Axialif fusion). Only 6 patients required overnight admission. All 23 working pre-surgery returned to work at a median time of 28 days. These figures compared to a 12% revision and a mean in-patient stay of 2.3±1.2 nights after open laminotomy.

**DISCUSSION:** Our results suggest that transfacial endoscopic foraminotomy is a safe and cost-effective alternative to open laminotomy and foraminotomy with a low rate of early revision surgery. Rapid recovery and an early return to work are expected.

**GP216**

**MMP-12 EXPRESSION UNDER NEUROPATHIC PAIN: A RODENT L5 SPINAL NERVE LIGATION MODEL**

1Wing Moon Raymond Lam PhD, 1Tao Hu PhD, 2Nurul Dinah Bte Kadir Bsc, 2Roger Chun Man Ho MBBS, MRCPsych, FRCP, 3Sanjay Khanna PhD, 4Kishore Bhakoo PhD, 5Yulin Lam PhD, 1Hee-Kit Wong MBBS, MMed, FRCS, MChOrth, FAMS;

1Department of Orthopaedic Surgery, Yong Loo Lin School of Medicine, National University of Singapore, Singapore 2Department of Psychological Medicine, Yong Loo Lin School of Medicine, National University of Singapore, Singapore 3Department of Physio-logy, Yong Loo Lin School of Medicine, National University of Singapore, Singapore 4Director, Translational Imaging Industrial Laboratory, Singapore Bioimaging Consortium, A*STAR 5Department of Chemistry, Faculty of Science, National University of Singapore, Singapore

**INTRODUCTION:** Matrix metalloproteinases degrade extracellular matrix to facilitate immune cell infiltration. It plays an important role in neuropathic pain development and maintenance. Recent research evidences showed high MMP-12 expression in neuroinflammation condition. Hence, we hypothesised that MMP-12 is up-regulated in neuropathic pain patients. This study aims to verify and localise MMP-12 up-regulation in the dorsal root ganglion (DRG) of spinal nerve ligation (SNL) model.

**METHODS:** Twelve male adult Sprague Dawley rats were divided into 2 groups: 1) Sham-operated (n=6); 2) SNL (n=6). On day 1, the left lumbar 5 (L5) nerve root was ligated in SNL but it was only exposed in Sham-operated by removing the transverse process. Von Frey tactile stimulation and thermal sensory tests were conducted on Day 0, 5, 7 and 13. On Day 14, rats were sacrificed and DRG of L5 were harvested for immunohistochemical staining (IHC) (anti-CD 68, anti-GFAP, and anti-MMP-12). MMP-12, GFAP and CD-68 labelled cells were then localized and quantitatively measured. **RESULTS:** SNL rats showed a significant lower mechanical threshold and thermal withdrawal latency of paw ipsilateral to ligated L5 in SNL than Sham-operated on Day 5, 7 and 13. Marker labelled/tissue area of ligated DRG (MMP-12: 0.895 ± 0.156%, p=0.01; CD-68: 3.023 ± 1.598%, p=0.04) is significantly higher than non-ligated DRG (MMP-12: 0.157 ± 0.045%; CD-68: 0.049 ± 0.001%) and Sham-operated (MMP-12: 0.351 ± 0.159%; CD-68: 0.007 ± 0.008%). GFAP encircled neuron in ligated DRG (83.83 ± 18.16%, p=0.02) is significantly higher than non-ligated L5 DRG (20.53 ± 9.02%) and Sham-operated (30.41 ± 15.32%).

**DISCUSSION:** This study demonstrates that MMP-12 is up-regulated in SNL model. MMP-12 degrades the matrix to promote infiltration of macrophages and cause indirect activation of satellite cells, indicat-
ing its possible role in neuropathic pain initiation and maintenance.

GP217
PATIENT-BASED SURGICAL OUTCOMES OF POSTERIOR LUMBAR INTERBODY FUSION: PATIENT SATISFACTION ANALYSIS
Shinya Okuda, MD, PhD,1 Takahito Fujimori, MD, PhD,2 Takenori Oda, MD, PhD,2 Ryoji Yamasaki, MD,1 Takafumi Maeno, MD,1 Tomoya Yamashita, MD,1 Tomya Matsumoto, MD, PhD,1 and Motoki Iwasaki, MD, PhD1;
1. Department of Orthopaedic Surgery, Osaka Rosai Hospital 2. Department of Orthopaedic Surgery, Sumitomo Hospital

INTRODUCTION: There have been no reports of patient-based surgical outcomes of posterior lumbar interbody fusion (PLIF) for lumbar spondylolisthesis. Therefore, the purpose of this retrospective study was to investigate: 1) patient-based surgical outcomes of PLIF; 2) correlations between patient-based surgical outcomes and surgeon-based surgical outcomes; and 3) factors associated with patient satisfaction.

METHODS: Patients who underwent PLIF for lumbar spondylolisthesis between 1996 and 2008 and were followed for at least 2 years were reviewed (n=273). The average follow-up period was 8 years. Surgical outcomes were assessed using an original questionnaire, the numerical rating scale (NRS), the 36-Item Short Form Health Survey (SF-36), the Japanese Orthopedic Association score (JOA score), and the recovery rate. The original questionnaire consisted of 5 categories, with scoring out of 100 points for surgery, satisfaction, improvement, recommendation to others, and willingness to undergo repeat surgery on a 5-point scale. Patient-based outcomes were divided into 3 groups according to the questionnaire responses as Positive (very satisfied or satisfied), Intermediate (neither satisfied nor dissatisfied), and Negative (dissatisfied or very dissatisfied) and were compared with the JOA scores.

RESULTS: The average patient-evaluated score for surgery was 82 points. The positive response rate in each category was 82% for satisfaction, 87% for improvement, 66% for recommendation to others, and 72% for willingness to undergo repeat surgery. The average pre- and postoperative JOA scores were 12 and 24, respectively. The average recovery rate was 70%. There were significant correlations between all sections of questionnaire and the JOA score, NRS, and physical component scores of the SF-36. Postoperative permanent motor loss was major factor related to a negative response.
GP218
COMPARISON OF CLINICAL OUTCOMES FOR ANTERIOR VS. 360 FUSION AT THE FUSION LEVEL OF LUMBAR HYBRID (TOTAL DISC REPLACEMENT / FUSION) SURGERY
Ernesto Otero-Lopez, MD, Scott L. Blumenthal, MD, Richard D. Guyer, MD, Jack E. Zigler, MD, Donna D. Ohnmeiss, DrMed;
Texas Back Institute and Texas Back Institute Research Foundation; Plano, Texas

INTRODUCTION: Surgical options for 2-level symptomatic disc degeneration generally include fusion, total disc replacement (TDR), or a hybrid with fusion at one level and TDR at the other. Hybrids often involve an instrumented 360 fusion. Using a stand-alone anterior interbody fusion (ALIF) in a hybrid has rarely been addressed. The purpose of this study was to compare outcomes of hybrid surgery using ALIF vs. 360 at the fusion level.

METHODS: Hybrid surgery was performed in 135 patients with TDR at one level and ALIF (n= 83) or instrumented 360 fusion (n=52) at the other. Mean follow-up was 24 months. Outcome measures included Oswestry Disability Index (ODI), visual analog scales (VAS) assessing back and leg pain, and reoperations.

RESULTS: Mean blood loss was significantly less with hybrid/ALIF than hybrid/360 (71.7 vs. 142.1 ml; p<0.01). Mean preoperative ODI scores were approximately 46 in both groups and improved significantly in both groups to approximately 30 (p<0.01) with no significant difference between groups (p>0.40). VAS back and leg pain scores also improved significantly in both groups with no significant differences between them (Figure 1). The reoperation rate was significantly greater with hybrid/360 than hybrid/ALIF (23.1% vs. 3.6%; p<0.01). Reoperations after hybrid/360 included 6 cases for removal of painful posterior instrumentation, one to treat a wound infection, one decompression of the fused level, 3 for symptomatic adjacent segments, and 2 due to TDR malpositioning or displacement. Hybrid/ALIF reoperations included 2 for decompression of stenosis and one underwent fusion 2 levels above the index level.

DISCUSSION: Outcomes were similar in hybrids performed with ALIF vs. 360 adjacent to the TDR level with the exceptions of significantly greater blood loss and reoperation rate with hybrid/360. These results support that unless there is a clear indication for posterior surgery, stand-alone ALIF is a viable option for lumbar hybrid surgery.

GP219
INCIDENCE AND EFFECT OF DURAL TEARS ON SURGICAL OUTCOMES AFTER LUMBAR SPINAL MICROENDOSCOPIC SURGERY: A PROPENSITY-MATCHED ANALYSIS
Kazuhito Soma *1 Yasushi Oshima *1 Hirohiko Inanami *2;
*1 Department of Orthopaedic Surgery, Faculty of Medicine, The University of Tokyo *2 Iwai Orthopaedic Medical Hospital

INTRODUCTION: Because microendoscopic lumbar spine surgery has recently been applied to more complicated cases, the number of surgery-related complications could be higher. The purpose of this study is to examine the incidence and management of dural tears and to investigate their
influence on patient-reported outcomes using a propensity-matched analysis.

**METHODS:** A total of 922 patients underwent microendoscopic surgery of the lumbar spine between February and December 2012. The incidence and management of dural tears were investigated. Of these, the effect of dural tears on surgical outcomes was investigated in patients who responded to the questionnaire both preoperatively and 3–12 months postoperatively using a propensity-matched analysis. Outcome measures including the Numeric Rating Scale for back and leg pain, Oswestry Disability Index, JOA score, and Short Form-36 were used.

**RESULTS:** Microendoscopic discectomy for lumbar disc hernia was performed on 474 patients, whereas microendoscopic laminectomy and posterior lumbar interbody fusion for lumbar canal stenosis were performed on 271 and 177 patients, respectively. Dural tears occurred in 49 patients; of these, 23 patients (2.5%) required suture repair of the dura mater under a total microendoscopic procedure. Of the 600 patients who responded to the questionnaire both pre- and postoperatively, 38 patients with dural tears were compared with the matched 38 patients without dural tears. The operation time was significantly longer in patients with dural tears; however, there were no significant differences in each outcome between the two groups.

**DISCUSSION:** Repairing the dural sac under the total microendoscopic procedure, which requires a longer operation time, is technically demanding. In particular, it is quite difficult to repair it on the contralateral side of the surgical approach. When dural tears are properly repaired, surgical outcomes are not influenced.

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**GP220**

**ANATOMICAL ANALYSIS FOR PREVENTION OF VESSEL INJURIES ON TRANSFORAMINAL APPROACH OF PERCUTANEOUS ENDOSCOPIC LUMBAR DISCECTOMY**

Fumitake Tezuka, Toshinori Sakai, Yuichiro Goda, Yoichiro Takata, Kosaku Higashino, Koichi Sairyo; Department of Orthopedic Surgery, Tokushima University

**INTRODUCTION:** Percutaneous endoscopic lumbar discectomy (PELD) is a minimally invasive procedure for the surgical treatment of lumbar disc herniation (LDH). However, when we perform PELD with transforaminal (TF-PELD) approach for lower lumbar spine, there are some problems such as interference with iliac crest and vascular injury. The purpose of this study is to examine (1) the operability of TF-PELD for lower lumbar spine, and (2) the vascular structure to avoid critical complications.

**METHODS:** We evaluated 100 adult abdominal contrast-enhanced multidetector 3D-CT scans (60 men and 40 women). The mean age was 64.9 years old (range 36 - 89). At the L4-5 and L5-S disc level, we evaluated two values (α degree, D mm) influenced on the trajectory of the TF approach. The α degree was measured as a maximum inclination angle of the trajectory. The D mm was a distance on the middle line between the posterior edge of disc and the trajectory. In addition, we examined morphological variations on iliac crest and vessel variations on the lumbo-sacral area.

**RESULTS AND DISCUSSION:** (1) Operability of TF-PELD: Trajectory of the TF-PELD interfered with iliac crest at L4-5 in 45.5% subjects, at L5-S in 95.5% subjects. Mean α degree was 84.5° at L4-5 and 56.0° at L5-S. Mean D mm was 2.2 mm at L4-5 and 15.0 mm at L5-S. (2) The vascular structure and TF-PELD: Dorsal branches of the lumbar or
iliolumbar artery were detected on the trajectory in 86.5% patients at L4-5 disc level, and 57% at L5-S disc level. From the results of this study, trajectory of TF-PELD may be limited by its surrounding anatomical structures. Two values ($\alpha^\circ$, $D$ mm) indicated that treatment for the central type of LDH at L5-S disc level was considered more difficult than at L4-5 due to iliac crest. To avoid vascular injuries, we must pay attentions to the branches of the lumbar and iliolumbar arteries on the trajectory line.

**INTRODUCTION:** Previous studies have discussed the selection of the lower instrumented vertebra (LIV) to best preserve motion segments and obtain coronal balance. However, reports evaluating the selection of the upper instrumented vertebra (UIV) when treating Lenke type 5C curves are not available. To assess whether a short fusion strategy is applicable when treating adolescent idiopathic scoliosis (AIS) with Lenke type 5C curve by posterior correction and fusion surgery using pedicle-screw constructs.

**METHODS:** We evaluated 29 patients who were treated surgically for AIS with Lenke type 5C curve (mean age 16.8±4.7 years; range 10–29 years). The mean follow-up period was 28.0±6.3 months (24–48 months). We compared radiographic parameters and clinical outcomes between patients with an upper instrumented vertebra (UIV) at the end vertebra (EV) (n=10) and those treated by short fusion (S), with a UIV one level caudal to the EV (n=19 patients).

**RESULTS:** In the EV group, a preoperative mean Cobb angle of 50±15° was corrected to 8±7°, which was maintained at the final follow-up (7±1°). In the S group, a mean preoperative Cobb angle of 47±4° was corrected to 8±5°, but this increased significantly to 12±7° at final follow-up (p=0.033). The mean correction rate at final follow-up was significantly lower in the S group (72%) than in the EV group (86%) (p=0.027). Coronal and sagittal balance, thoracic kyphosis, lumbar lordosis, L4 tilt, and clinical outcomes evaluated by SRS-22 were equivalent between the two groups.

**DISCUSSION:** SRS-22 scores and radiographic parameters other than the correction rate were equivalent between the two groups. A short fusion strategy, in which the UIV is one level caudal to the upper end vertebra, is applicable to posterior correction and fusion surgery.
with pedicle-screw constructs for Lenke type 5C curves.

**GP222**

**FREQUENCY OF FIRST AND SECOND REVISION SURGERY BECAUSE OF ADJACENT OR REMOTE SEGMENTAL DISEASE AFTER POSTERIOR LUMBAR INTERBODY FUSION**

Fujimoto K1, Yamagata M2, Ikeda Y2, Nakajima F2, Hashimoto M2, Yamauchi K1, Orita S1, Kubota G1, Inage K1, Saino T1, Sato J1, Shiga Y1, Abe K1, Kanamoto H1, Takahashi K1, Ohtori S1;

1Department Orthopedic Surgery, Graduate School of Medicine, Chiba University
2Department Orthopedic Surgery, Chiba Rosai Hospital

**INTRODUCTION:** While posterior or transforaminal lumbar interbody fusion (PLIF or TLIF) is a common treatment for lumbar spinal diseases, various complications such as adjacent or remote segmental disease have been reported. We investigated the timing and indications for first and second revision surgery after initial PLIF or TLIF.

**METHODS:** We investigated 559 patients who had lumbar spondylolisthesis or lumbar spondylolytic spondylolisthesis and underwent PLIF or TLIF at our hospital. The average follow-up period was 6 ± 2 years.

**RESULTS:** Twenty-eight of 559 patients (5.0%) underwent revision surgery. Nine patients underwent their revision surgery because of problems with nonunion at the level of fusion. The most common indication for revision surgery was adjacent or remote segmental disease (19 cases: 3.4%). The level of interbody fusion, sex, age, and extent of osteoporosis did not affect the frequency of revision surgery because of adjacent or remote segmental disease (P > 0.05). For patients who underwent revision surgery because of adjacent or remote segmental disease, the average time between the initial and revision surgery was 42.2 (1–104) months; 13 of the patients underwent the revision surgery more than 3 years after their initial surgery, and the other 6 underwent revision surgery within 2 years. Of these 19 patients, 5 needed further revision surgery. These patients had undergone more extensive fixation in the first revision.

**DISCUSSION:** The current study found that patients with adjacent or remote segmental disease (19 cases: 3.4%) needed revision surgery at different times during more than 5 years-follow-up from their initial surgery. The level of interbody fusion, sex, age, and extent of osteoporosis did not affect the frequency of revision surgery. However, more extensive interbody fusion at the revision significantly increased the frequency of further revision surgery because of adjacent or remote segmental disease.

**GP223**

**MONITORING THE QUALITY OF ROBOT-ASSISTED PEDICLE SCREW FIXATION IN THE LUMBAR SPINE BY USING A CUMULATIVE SUMMATION TEST (CUSUM)**

Ho-Joong Kim, MDa, Seung Hoo Lee, MDa, Bong-Soon Chang, MDb, Choon-Ki Lee, MDb, Teck Onn Lim, MDC, Ling Ping Hoo, PhDa, Je-Min Yi, MDe, Jin S. Yeom, Mda;

a) Spine Center and Department of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Bundang Hospital, 166 Gumiro, Bundang-gu, Sungnam, Republic of Korea
b) Department of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Hospital, 101 Daehangno, Jongno-gu, Seoul, Republic of Korea
c) ClinResearch Sdn Bhd, D7-3-1, Block D7, Pusat Perdagangan Dana 1,Jalan PJU 1A/46, PJU 1A,47301 Petaling Jaya, Selangor, Malaysia.
d) Stats Consulting Sdn Bhd, D7-3-1, Block D7, Pusat Perdagangan Dana 1,Jalan PJU 1A/46, PJU 1A,47301 Petaling Jaya, Selangor, Malaysia.
e) Department of Ortho-paedic Surgery, Kangwon National University Hospital,
INTRODUCTION: Although robot-assisted pedicle screw fixation reduces screw misplacement rates and provides critical support for minimally invasive surgical (MIS) procedures, there have been no reports relating to the monitoring of quality control of the accuracy of this robot-assisted pedicle screw fixation procedure. The aim of this study was to monitor the quality control of robot-assisted pedicle screw fixation accuracy by using a cumulative summation test (CUSUM) at the initial stage of its application.

METHODS: Patients with lumbar spinal stenosis scheduled to undergo surgery were randomly and equally assigned through 1:1 allocation to a robot-assisted minimally invasive posterior lumbar interbody fusion (Rom-PLIF) group or a conventional open posterior PLIF using free hand technique (Cop-PLIF) group. The accuracy of pedicle screw placement was evaluated using postoperative computed tomography. The primary outcome was the CUSUM analysis for monitoring the quality control of the accuracy of pedicle screw insertion between the Rom-PLIF and Cop-PLIF groups.

RESULTS: Of the 80 pedicle screws inserted in each group, four screws in the Rom-PLIF group, and seven in the Cop-PLIF group, breached the pedicle. Of these 11 offending screws, four cases were categorized as grade B in the Rom-PLIF group, while six were grade B and one case was grade C in the Cop-PLIF group, using the Gertzbein and Robbins’s classification. Throughout the monitoring period, there was no CUSUM test-derived indication that the quality of performance of the pedicle screw fixation procedure was inadequate in either group.

DISCUSSION: Firstly, this study demonstrates the adequacy of quality control of robot-assisted pedicle screw fixation even early in the application period based on the CUSUM analysis. Secondly, the CUSUM test can be a useful tool for monitoring the quality of procedures related with spine surgery.

GP224
CAN DYNAMIC RADIOGRAPHY AND CT DETERMINE THE FLEXIBILITY OF THE LUMBAR SPINE IN ELDERLY PATIENTS WITH KYPHOSCOLIOSIS?

Department of Orthopaedic Surgery, Graduate School of Medicine, Chiba University, Chiba, Japan.

INTRODUCTION: Presurgical flexibility is considered important to determine the type of corrective surgery for degenerative lumbar kyphoscoliosis. We sought to determine the reliability of dynamic radiography and CT for estimating the flexibility of lumbar segments in elderly patients with kyphoscoliosis before oblique lateral interbody fusion (OLIF).

METHODS: We evaluated 60 intervertebral discs in 42 patients with kyphoscoliosis (22 women) with a mean age of 63.1 years
who underwent mini-open anterior retroperitoneal lumbar interbody fusion using an anterior approach. We examined indicators of preoperative rigidity by radiography and 3-dimensional CT. We divided patients into 2 groups, a hard group (existing continuity of osteophytes in facet joints on CT without instability) and a nonhard group. We defined instability as >10° change in intervertebral disc angle and more than 3 mm slipping at flexion and extension. Final measurements were evaluated 6 months after surgery. We compared the extent of correction by OLIF surgery between the 2 groups.

RESULTS: The hard group consisted of 21 intervertebral discs and the nonhard group of 39. After surgery the mean intervertebral height increased from 5.7 mm to 11.2 mm, the intervertebral angle in frontal radiographs decreased 3.1° to 1.5°, and slipping on lateral radiographs was from 2.5 mm to 0.8 mm for 60 discs (P < 0.05). However, there was no significant difference in final correction of these parameters between the 2 groups. For the 60 discs, local lordosis improved from 3.0° to 7.1° after surgery (P < 0.05), and correction of the lordosis in the nonhard group was significantly better than in the hard group.

DISCUSSION: Presurgical dynamic radiography and CT did not predict the final OLIF correction of intervertebral angle, height, or slipping. Only presurgical rigidity influenced postsurgical improvement of segmental lordosis, and these RESULTS indicate the necessity for posterior osteotomy in patients with simple kyphosis.

GP225

INFLUENCE OF CATASTROPHIZING ON TREATMENT OUTCOMES AFTER LUMBAR SPINE SURGERY IN PATIENTS WITH LUMBAR SPINAL STENOSIS

Ho-Joong Kim, MD1, Jong Woong Park, MD1, Kyoung-Tak Kang, MS2, Bong-Soon Chang, MD3, Choon-Ki Lee, MD3, Jin S. Yeom, MD1; 1Spine Center and Department of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Bundang Hospital, 166 Gumiro, Bundang-gu, Sungnam, 463-707, Republic of Korea 2Department of Mechanical Engineering, Yonsei University, 134 Shinchon-dong, Seodaemun-gu, Seoul, Republic of Korea 3Department of Orthopaedic Surgery, Seoul National University College of Medicine and Seoul National University Hospital, 101 Daehangno, Jongno-gu, Seoul, 110-744, Republic of Korea

INTRODUCTION: Among psychological variables, pain catastrophizing is known as a key variable contributed to pain experience. However, there is little evidence concerning the effect of preoperative catastrophizing on surgical outcomes. We aimed to investigate the influence of pain catastrophizing—measured using the pain catastrophizing scale (PCS)—on treatment outcomes after lumbar spine surgery in patients with lumbar spinal stenosis (LSS).

METHODS: We enrolled 138 patients who were scheduled to undergo spine surgery for LSS. Based on their PCS scores, patients were assigned to low (PCS score < 25, n = 68) and high PCS groups (PCS score ≥ 25, n = 70). The primary outcome was the Oswestry Disability Index (ODI) at 12 months after surgery. For 12 months after surgery, the changes in the ODI and visual analog scale (VAS) for back and leg pain were compared between the groups.

RESULTS: The ODI and VAS for back and leg pain at 12 months after surgery did not significantly differ between the low and high PCS groups. Twelve months after surgery, the mean ODI (95% confidence interval [CI]) in the low and high PCS groups were 26.4 (21.0–31.8) and 25.5 (20.7–30.4), respectively. The mean difference (95% CI) of ODI between the low and high PCS groups was 3.6 (-6.3 to 8.1; P = 0.806). However, the ODI and VAS for back and leg pain significantly decreased over
time after surgery in both groups (P < 0.001 for three variables). The effect of the interaction between the PCS group and follow-up time on the ODI and VAS for back pain was significant (P = 0.016 and 0.030, respectively) (Figure).

**DISCUSSION:** Preoperative catastrophizing did not always result in poor outcomes at 12 months after surgery. The 1-year RESULTS of spine surgery for LSS indicated that catastrophizing could moderate the efficacy of surgical treatment of LSS.

**INTRODUCTION:** Minimally invasive posterior lumbar interbody fusion (MI-PLIF) is reportedly less invasive to the back muscle and delivers similar clinical outcomes in the short term compared to conventional PLIF. Since there is little data on its long-term outcomes, specifically the incidence of adjacent segment pathology (ASP) in MI-PLIF, we examined the average 7.1-year surgical outcomes of MI-PLIF in spondylolisthesis patients.

**METHODS:** In 2004–2009, 52 consecutive patients with spondylolisthesis underwent single-level MI-PLIF. Of those cases, 38 (mean age, 59.2 years) who were followed up for a minimum of 5 years were retrospectively reviewed (mean follow-up period, 7.1 years). Decompression, slip reduction, and lumbar interbody fusion with cages and pedicle screws were performed via expandable tubular retractors placed in the gap between the multifidus and the longissimus muscles on both sides. Patients were followed up every 6 months after surgery. Surgical outcomes were evaluated using the Japanese Orthopedic Association (JOA) score and Oswestry Disability Index (ODI). The development of the radiographical and clinical ASP (RASP and CASP) was also examined. **RESULTS:** Fusion was achieved in 37 of 38 cases. The mean percentage slip decreased from 16.5% to 6.0% (P<0.01) and the mean segmental lordotic angle at the fusion level increased from 11.9 to 15.1 (P<0.01) after surgery. The mean JOA score before surgery and at the final follow-up were 15.6 and 25.7 (P<0.01), respectively (mean recovery rate, 76.0%). The mean ODI before surgery and at final follow-up were 40.8% and 15.6%, respectively (P<0.01). RASP developed in 10 cases, of which three were symptomatic.

**DISCUSSION:** In this follow-up study, the incidence of CASP was 7.9%. In other cases, surgical outcomes were good irrespective of the existence of RASP. The long-term

**GP226**

**SINGLE-LEVEL MINIMALLY INVASIVE POSTERIOR LUMBAR INTERBODY FUSION IN PATIENTS WITH SPONDYLOLISTHESIS: MINIMUM 5-YEAR FOLLOW-UP WITH CLINICAL AND RADIOLOGICAL OUTCOMES**

Takahiro Tsutsumimoto, Mutsuki Yui, Hiroki Ohba, Takayuki, Kamanaka, Hiromichi Misawa; Spine Center, Yodakubo Hospital
INTRODUCTION: A psychological distress, such as anxiety and depression, is known to affect clinical outcomes in surgically treated patients with lumbar spinal stenosis (LSS). However, associations between various types of preoperative psychological assessments and surgical outcomes of LSS have not been established. The purpose of this study was to examine if preoperative psychological conditions affected surgical outcomes in LSS patients.

METHODS: A retrospective cohort study was conducted to analyze 86 patients with LSS undergoing surgery between 10/2010 and 12/2012 (58% male; mean age 64 years). As preoperative psychological assessments, the Pain Catastrophizing Scale (PCS), Pain Anxiety Symptom Scale (PASS-20), Self-Rating Questionnaire for Depression (SRQ-D), Hospital Anxiety and Depression Scale (HADS), Brief Scale for Psychiatric Problems in Orthopaedic Patients (BS-POP) and scores of the psychological disorder calculated with the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ) were used. The visual analog scale (VAS) for patient’s satisfaction and low back pain 6 months after surgery was measured. Relationships between VASs and preoperative psychological assessment scores were statistically analyzed.

RESULTS: VAS of low back pain at follow-up was significant correlated with preoperative JOABPEQ, PCS, PASS-20 and SRQ-D scores (P<0.05), but not HADS and BS-POP. There were no significant relationships between these psychological assessments and patients’ satisfaction for surgery.

DISCUSSION: We found that some of preoperative psychological conditions related to severity of postoperative low back pain in LSS patients, but not others. All preoperative psychological measures didn’t resulted in an impact on patient’s satisfaction. This might suggest that low back pain is quite different from surgical satisfaction. Various preoperative psychological assessments may be useful in predicting postoperative low back pain of LSS patients before.
bilateral laminar fenestration, and FF with autologous bone harvested from the spinous process. PPS were then inserted through the fascia. We evaluated the FF rate using computed tomography (CT), the range of motion (ROM) at the fused level on a flexion-extension lateral X-ray, preoperatively and at the final follow-up, and the therapeutic effectiveness of FF using the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ).

**RESULTS:** The FF rate was 86.5%. At the final follow-up, all patients with adequate FF on CT had no recognized motion at the fused level. In 11 patients with inadequate FF, the average ROM significantly decreased from preoperative 14.2 degrees to postoperative 4.4 degrees. Therapeutic effectiveness on the JOABPEQ was demonstrated in the Walking ability score by 92.0% of the patients and in the Low back pain score by 73.1%.

**DISCUSSION:** Park et al reported that FF alone is an effective surgical option for DLS. However, in their method, a bone graft was harvested from the iliac crest and a conventional pedicle screw system was used. We devised a less invasive FF using a local bone graft and a PPS system. The clinical outcomes and the fusion rate of FF with the PPS system were comparable to those with conventional PLF. Thus, FF with a PPS system is a useful technique for the management of DLS.

**GP229**

**INFLUENCE OF PELVIC INCIDENCE-LUMBAR LORDOSIS MISMATCH ON SURGICAL OUTCOMES OF SHORT-SEGMENT LUMBAR INTERVERTEBRAL FUSION**

Yasuchika Aoki MD1, Arata Nakajima MD2, Hiroshi Takahashi MD2, Atsuya Watanabe MD1, Takayuki Nakajima MD1, Makoto Takazawa MD1, Kazuhisa Takahashi MD3, Seiji Ohtori MD3, Koichi Nakagawa MD2;
1Department of Orthopaedic Surgery, Eastern Chiba Medical Center 2Department of Orthopaedic Surgery, Toho University

**Medical Center 3Department of Orthopaedic Surgery, Graduate School of Medicine, Chiba University**

**INTRODUCTION:** Recently, it has been reported that pelvic incidence-lumbar lordosis (PI-LL) mismatch is related to low back pain (LBP), disability, and postoperative complication. Importance of PI-LL mismatch is being emphasized particularly in long-segment fusion for adult spinal deformity, however, there are few studies describing influence of PI-LL on surgical outcomes after short-segment fusion. In this study, we have examined whether PI-LL mismatch affects surgical outcomes of short-segment lumbar intervertebral fusion for lumbar degenerative diseases.

**METHODS:** Patients with lumbar degenerative disease treated by short-segment (1 or 2 levels) lumbar interbody fusion were divided into group A (PI-LL≥11°; n=30) and group B (PI-LL<10°:n=22) by postoperative evaluation. Surgical outcomes were evaluated by Nakai score (Excellent: 3~Poor: 0), visual analog scale (VAS; 0-100mm; for LBP, lower-extremity pain, and numbness) and Oswestry disability index (ODI). In addition, detailed VAS for LBP in motion, standing, and sitting was used. Post-operative data was acquired at least one year following surgery.

**RESULTS:** Surgical outcome (Nakai score) of group A was significantly worse than group B (2.07 vs 2.59, p=0.008). No significant difference in ODI and VASs for lower-extremity pain and numbness was found between the two groups, however, group A showed worse VAS for LBP, pre- and postoperatively (63.2, 23.8) than group B (48.9, 14.1). Detailed VAS evaluation revealed that only postoperative LBP in standing was worse in group A (25.8) than group B (11.9, p=0.039).

**DISCUSSION:** This study first reports that PI-LL influences postoperative residual LBP, but lower extremity symptoms after short-
segment fusion. Among three types of LBP, LBP in standing is most strongly related to PI-LL mismatch. From these observations, surgeons should pay attention to sagittal alignment, and avoid postoperative PI-LL mismatch, even when treating patients with short-segment fusion.

**GP230**

**RELATIONSHIPS BETWEEN POSTERIOR LIGAMENTOUS COMPLEX INJURY AND RADIOGRAPHIC PARAMETERS IN PATIENTS WITH THORACOLUMBAR BURST FRACTURES**

Akihiko Hiyama, Masahiko Watanabe, Hiroyuki Katoh, Masato Sato, Daisuke Sakai, Toshihiro Nagai, Joji Mochida; Department of Orthopaedic Surgery, Tokai University School of Medicine

**INTRODUCTION:** The purpose of this study was to determine whether radiographic findings associated with thoracolumbar burst fractures could also indicate the presence of posterior ligamentous complex (PLC) injuries, which were identified through short-tau inversion-recovery (STIR)-weighted MRI.

**METHODS:** Sixty-four patients were surgically treated for thoracolumbar burst fractures between April 2007 and February 2014 at our institution. Twenty-four patients were excluded from this study because of the lack of STIR-weighted MRIs, and therefore 40 patients were included in this study. The patients were divided into two groups based upon the integrity of the PLC, which was evaluated using STIR-weighted MRI: a P group with a PLC injury and a C group without such injury. The following radiographic parameters were evaluated: loss of vertebral body height (LOVBH), local kyphosis (LK), vertebral body translation, canal compromise (sagittal transverse ratio, STR), interlaminar distance (ISD), supraspinous distance (SSD) and interspinous distance (ISD). Frankel scale score and total severity score (load sharing and thoracolumbar injury classification systems, respectively) were also evaluated.

**RESULTS AND DISCUSSION:** Preoperative STIR-weighted MRI showed that 25 patients had a PLC injury (P group: 15 men and 10 women), and 15 patients did not have a PLC injury (C group: 8 men and 7 women). More patients in the P group had an LK<20°: 14 patients in the P group and 1 patient in the C group (p<0.01). The % SSD differed between the P and C groups (118.8% ± 53.4% and 88.0% ± 24.3%, respectively; p<0.05). Multivariate logistic analysis showed that an LK <20° was a risk factor for PLC injury in patients with thoracolumbar burst fractures (odds ratio, 55.5 [95% confidence interval, 1.30–2360.1]; p<0.05). These results demonstrate that while LOVBH, vertebral body translation, and canal compromise do not correlate significantly with the presence of a PLC injury in patients with thoracolumbar fractures, an LK <20° and increased % SSD are associated with a PLC injury.

**GP231**

**MULTI-LEVEL LUMBAR FUSION FOR DEGENERATIVE DISC DISEASE IS A RISK FACTOR FOR HIGHER RATES OF POSTOPERATIVE FAILED BACK SYNDROME IN A WORKERS’ COMPENSATION SETTING**

Anderson JT, Duff RJ, Ahn UM, Ahn NU; University Hospitals Case Medical Center Department of Orthopaedics, Case Western Reserve University School of Medicine, University of Minnesota - Twin Cities, New Hampshire NeuroSpine Institute, University Hospitals Case Medical Center Department of Orthopaedics

**INTRODUCTION:** Lumbar fusion surgery performed for degenerative disc disease (DDD) and discogenic low back pain (LBP) is associated with variable clinical outcomes. Studies have shown that U.S. workers’ compensation (WC) subjects tend to have
worse clinical outcomes following fusion than the general population. We evaluated a large cohort of WC subjects who underwent fusion for DDD and discogenic LBP to determine how levels fused impacted rates of postoperative failed back surgery syndrome (FBSS).

**METHODS:** We identified 933 subjects from the Ohio Bureau of Workers’ Compensation (BWC) that underwent posterolateral lumbar fusion (PLF) with or without interbody fusion (PLIF) for DDD and discogenic LBP between 1993-2010. We utilized a multivariate logistic regression analysis, while correcting for a number of relevant covariates, to identify independent predictors of postoperative FBSS within 3 years after fusion.

**RESULTS:** Multi-level fusion was a significant positive predictor of postoperative FBSS (p=0.035, OR 1.57). 14.4% (57/397) of multi-level fusion subjects developed FBSS within 3 years after fusion, compared to only 10.8% (58/536) single level fusion subjects. Additional predictors of FBSS included: undergoing PLF with PLIF (p=0.001, OR 3.28) and male gender (p=0.038, OR 1.63). 15.5% of subjects who underwent PLF with PLIF developed FBSS, compared to only 5.0% of subjects who underwent standalone PLF. 13.5% of males developed FBSS, compared to only 9.9% of females. Predictors nearing statistical significance included: preoperative radiculopathy (p=0.06, OR 1.61), age greater than 50 at fusion (p=0.062, OR 0.60), and chronic opioid analgesia before fusion (p=0.072, OR 1.52).

**DISCUSSION:** Multi-level fusion was a significant predictor of postoperative FBSS. The WC population is clinically-distinct from the general population. It appears that better means of evaluating the appropriateness of multi-level fusions within this population may require further investigation.

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**GP232**

**VALIDATION OF THE JAPANESE ORTHOPEDIC ASSOCIATION SCORING SYSTEM BASED ON PATIENT-REPORTED IMPROVEMENT AFTER POSTERIOR LUMBAR INTERBODY FUSION**

Takahito Fujimori, MD1, Shinya Okuda, MD2, Ryoji Yamasaki, MD2, Takafumi Maeno, MD2, Tomoya Yamashita2, Tonomi Matsumoto2, Motoki Iwasaki, MD2, Eiji Wada, and MD3, Takenori Oda, MD1;

1Department of Orthopedic Surgery, Sumitomo Hospital, Osaka, Japan 2Department of Orthopedic Surgery, Osaka Rosai Hospital 3 Department of Orthopedic Surgery, Ehime Prefectural Central Hospital

**INTRODUCTION:** Few studies have examined the relationship between the JOA scoring system and patient-reported improvement.

**METHODS:** Between 1996 and 2008, 273 patients who underwent posterior lumbar interbody fusion for spondylolisthesis were analyzed. Patients were divided into five anchoring groups based on self-reported improvement from “Very improved” to “Much worse”. Outcomes (i.e., recovery rate (%), amount of change from preoperative condition, and postoperative score) based on the JOA scoring system were compared among groups. Using the patient-reported improvement scale as an anchor, the predictive value of each outcome was examined. The cut-off point and the area under the curve (AUC) that differentiated “Improved” from “Neither improved nor worse” was calculated using a receiver-operating characteristic (ROC) curve analysis.

**RESULTS:** Recovery rate and postoperative score were significantly different in 9 of 10 pairs of anchoring groups. The amount of change was significantly different in six pairs. Spearman’s correlation coefficient for the 5 scale-anchors of patient’s reported improvement was 0.20 (P = 0.001) for the baseline score, 0.31 (P <
0.001) for the amount of change, 0.55 (P < 0.001) for the recovery rate, and 0.55 (P < 0.001) for the postoperative score. According to ROC analysis, the best cut-off points and AUCs were 13 points and 0.69, respectively, for the amount of change, 67% and 0.73, respectively, for recovery rate, and 23 points and 0.72, respectively, for postoperative score. CONCLUSIONS: The JOA scoring system was a valid method for assessment of patient-reported improvement. Patient-reported improvement was more likely to be associated with the final condition, such as postoperative score or recovery rate, rather than the change from the from the preoperative condition.

GP233
ESTABLISHING THE INJURY SEVERITY OF THORACOLUMBAR TRAUMA: CONFIRMATION OF THE HIERARCHICAL STRUCTURE OF THE AOSPINE THORACOLUMBAR SPINE INJURY CLASSIFICATION SYSTEM
Gregory D Schroeder MD1*, Alexander R Vaccaro, MD, PhD1 Christopher K. Kepler MD, MBA1, John D. Koerner MD1, Alan Hilibrand MD1 Cumhur Oner MD, PhD2, Marcel Dvorak MD3, Luiz Vialle4 MD, PhD, Bizhan Aarabi5 MD, Carlo Bellarba6 MD, Michael G Fehlings7 MD, PhD, Klaus J. Schnake8 MD, Max Reinhold10 MD, Jens Chapman11MD, S. Rajasekaran12 MD, Frank Kandziora8 MD, PhD; 1. The Rothman Institute at Thomas Jefferson University 2. University Medical Center, Utrecht, the Netherlands 3. Vancouver General Hospital, Vancouver, British Columbia, Canada 4. Catholic University, Curitiba, Brazil 5. University of Maryland School of Medicine, Baltimore, Maryland 6. University of Washington, Seattle, WA 7. University of Toronto, Ontario, Canada 8. Berufsgenossenschaftliche Unfallklinik Frankfurt, Center for Spinal Surgery and Neurotraumatology, Frankfurt/Main, Germany 10. Medical University Innsbruck, Department of Orthopaedic Surgery, Anichstrasse 35, 6020 Innsbruck, Austria 11. Orthopaedic Surgeon, Seattle, Washington 12. Ganga Hospital, Coimbatore, Tamil Nadu India

INTRODUCTION: The AOSpine Thoracolumbar Spine Injury Classification System was recently published and combines elements of both the Magerl system and the Thoracolumbar Injury Classification System (TLICS); however the injury severity of each fracture has yet to be established. The objective of this study is to develop a validated regional and global injury severity scoring system for thoracolumbar trauma.

Material and METHODS: A survey was sent to 100 AOSpine members from all six AO regions of the world (North America, South America, Europe, Africa, Asia and the Middle East). Each respondent was asked to numerically grade the severity of each variable of the AOSpine Thoracolumbar Spine Injury Classification System including the morphology, neurologic grade and patient specific modifiers. A grade of zero was considered to be not severe at all, and a grade of 100 was the most severe injury possible.

RESULTS: Seventy-four AOSpine surgeons from all six AO regions of the world numerically graded the severity of each variable of the AOSpine Thoracolumbar Spine Injury Classification System to establish the injury severity score. The reported fracture severity increased significantly (p < 0.0001) as the subtypes of fracture Type A and Type B increased, and a significant difference (p < 0.0001) in severity was established for burst fractures with involvement of two versus one endplates. Lastly, no regional or experiential difference in severity or classification was identified.

DISCUSSION: Development of a globally applicable injury severity scoring system for thoracolumbar trauma is possible. This study demonstrates no regional or experiential difference in perceived severity or thoracolumbar spine trauma. The
AOSpine Thoracolumbar Spine Injury Classification System provides a logical approach to assessing these injuries and enables rational strategies for treatment.

**GP234**

**IS PUBLICLY AVAILABLE INTERNET INFORMATION ON RHBM-2 AND THE INFUSE RELIABLE?**

Duff RJ, Anderson JT, Ahn UM, Ahn NU;
University Hospitals Case Medical Center Department of Orthopaedics, Case Western Reserve University School of Medicine, University of Minnesota - Twin Cities, New Hampshire NeuroSpine Institute, University Hospitals Case Medical Center Department of Orthopaedics

**INTRODUCTION:** Patients increasingly use publicly accessible internet information to aid in medical decision making. Unfortunately, studies have shown that medical internet information on orthopedic devices is often incomplete and potentially misleading. Physicians should be aware of the controversy surrounding these devices. To date, no such study has been performed on bone morphogenetic proteins (BMP) or INFUSE, a relatively controversial fusion device.

**METHODS:** We used the search engines Google, Yahoo!, and Bing with the search terms BMP, rhBMP-2, and INFUSE to identify 105 sites providing information on BMP. Sites were then analyzed by their content, discussion: of BMP treatment, and literature references.

**RESULTS:** Private medical group websites represented 12.4% of the total, academic medical group sites 3.8%, insurance company sites 5.7%, industry sites 11.4%, news sites 28.6%, and other sites 38.1%. At least one appropriate indication was listed in only 29.5% of websites. At least one appropriate contraindication was listed in only 15% of all sites. Contraindication reporting rates were highest among insurance groups (0-66.7%). The most commonly reported benefit was having no donor site pain due to lack of bone harvest (29.5% among all sites). Complication rate reporting was lowest among industry and private medical websites (16.7% and 30.6% respectively). Increased cancer risk was not reported in industry groups but was reported in rates greater than 20% in all other categories of websites. Overall discussion of conservative treatments was markedly low among all websites (5.7%).

**DISCUSSION:** Our study shows the inadequacy of medical information regarding INFUSE online. This lack of quality internet information poses a potential problem given the potential influence the internet has on patient decision making. Therefore, it should be a top priority for physicians utilizing BMP to share with their patients the full benefits, risks, and alternatives to its use.

**GP235**

**PREOPERATIVE LUMBAR DISCOGRAPHY IS ASSOCIATED WITH HIGHER RATES OF FAILED BACK SYNDROME FOLLOWING LUMBAR FUSION IN A WORKERS’ COMPENSATION SETTING**

Anderson JT, Duff RJ, Ahn UM, Ahn NU; USA; University Hospitals Case Medical Center Department of Orthopaedics, Case Western Reserve University School of Medicine, University of Minnesota - Twin Cities, New Hampshire NeuroSpine Institute, University Hospitals Case Medical Center Department of Orthopaedics

**INTRODUCTION:** The safety and efficacy of lumbar discography (LD) is currently under contention. The clinically distinct workers’ compensation (WC) population tends to have worse clinical outcomes following lumbar fusion than in the general population. This study directly evaluates the impact of preoperative LD on rates of failed back surgery syndrome (FBSS) after lumbar fusion.
METHODS: We identified 1591 subjects from the Ohio Bureau of Workers’ Compensation that underwent lumbar fusion for degenerative disc disease (DDD) and discogenic low back pain (LBP) between 1993-2010, of which 682 also underwent LD before fusion. We utilized a multivariate logistic regression analysis. We corrected for a number of relevant covariates to determine the impact that discography and other independent variables had on postoperative rates of FBSS. RESULTS: LD was associated with significantly higher rates of FBSS within 3 years after fusion (p=0.047, OR 1.41). 13.9% (95/682) of LD subjects, compared to 8.8% (80/909) of controls developed FBSS. Subjects in the LD group were supplied with prescription opioid analgesics for an average of 129.7 additional days after fusion. Other preoperative risk factors included: ability to remain at work within same week as index fusion (p=0.018), male gender (p=0.034, OR 1.50), number of days prescribed with opioids (p=0.016), and fusion technique (p=0.003). Subjects who underwent standalone posterolateral lumbar fusion or 360 degree fusion developed FBSS at lower rates (5.4% and 7.1%, respectively) than subjects that underwent PLF with posterior lumbar interbody fusion or standalone anterior lumbar interbody fusion (ALIF) (15.7% and 10.2%, respectively). DISCUSSION: Our study shows an association between preoperative LD and the development of failed back syndrome after fusion surgery as well as considerably more opioid analgesic use. The outcomes of this study should raise concerns regarding the current role of discography in the WC population.

GP236
THE LATERAL INTERBODY DISABILITY INDEX: A NOVEL APPROACH TO ASSESS TRANSIENT THIGH PAIN POST LATERAL LUMBAR INTERBODY FUSION
Dr. Joseph R. O’Brien, MD, MPH-1 Colin M. Haines, MD-1 Bradley Fox-1 Esther Moberg, MPH-2 Gita Joshua-2;
1-The George Washington University Department of Orthopedic Surgery, Washington, DC 2-Globalus Medical, Audubon, PA

INTRODUCTION: Transient ipsilateral thigh pain after a lateral transpoas approach is reported. There is an absence of uniform methodology to quantify this pain. This study looks to fill this void by utilizing a novel postoperative outcome measure called the Lateral Interbody Disability (LID) Index. METHODS: A one year retrospective review of 14 patients who underwent lateral lumbar interbody fusion (LLIF) to treat degenerative disc disease. Visual Analog Scale (VAS) scores were collected preoperatively and 52 weeks postoperatively. The LID Index was collected 2, 6, 12, 24, and 52 weeks postoperatively. The LID Index consists of three multiple choice questions, a numeric pain scale, and a diagram of the human body. The LID Index has a maximum score of 20 and a minimum score of 0. Severe leg pain is defined as >7 on the pain scale. RESULTS: LID Index scores at 2, 6, 12, 24, and 52 weeks were: 8.1 ± 4.7 (n=14), 4.9 ± 5.7 (n=9), 6.7 ± 3.8 (n=6), 3.4 ± 2.9 (n = 5), and 5.83 ± 6.32 (n=12) respectively. Postoperative severe leg pain was noted in two patients at 2 weeks (n= 14), one patient at 6 weeks (n= 9), one patient at 12 weeks (n=6), and three patients at 52 weeks (n=12). Preoperative VAS arm/leg pain and neck/back pain of 67.9 ± 31.4 and 74.3 ± 35.7 (n=14) respectively were noted. Postoperative 52 week VAS arm/leg pain
and neck/back pain were 6.7 ± 16.3 and 15.0 ± 28.1 (n=6) respectively.

**DISCUSSION:** The percent of patients who experience transient thigh pain post-LLIF varies; it was found that the LID Index is an effective tool for evaluating this pain. The LID Index combines the strengths of the VAS, Brief Pain Inventory, and patient self-report questionnaire techniques into one easy to use index. This study utilizing the LID Index is the first of its kind. Currently, the LID Index is being implemented in prospective LLIF studies to continue to evaluate its validity.

**GP237**

**RELIABILITY ANALYSIS OF THE AOSPINE THORACOLUMBAR SPINE INJURY CLASSIFICATION SYSTEM BY A WORLDWIDE GROUP OF NAÏVE SPINAL SURGEONS**

Christopher K. Kepler, MD MBA1, Alexander R. Vaccaro, MD PhD1, John Koerner, MD1, Alan Hillbrand MD1, Marcel Dvorak, MD3, Frank Kandziora, MD PhD10, Shanmuganathan Rajasekaran, MD5, Bizhan Aarabi, MD6, Luiz Vialle, MD PhD7, Michael G. Fehlings, MD PhD2, G;

1 Thomas Jefferson University & Rothman Institute, Philadelphia, PA 2 University of Toronto Spine Program and Toronto Western Hospital, Toronto, Ontario, Canada 3 University of British Columbia, Vancouver, British Columbia, Canada 5 Ganga Hospital, Coimbatore, Tamil Nadu India 6 University of Maryland Medical Center, College Park, Maryland 7 Catholic University of Parana, Curitiba, Brazil 8 Medical University Innsbruck, Department of Orthopaedic Surgery, Anichstrasse 35, 6020 Innsbruck, Austria 9 AO Clinical Investigation and Documentation, Stettbachstrasse 6, 8600 Duebendorf, Switzerland 10 Berufsgenossenschaftliche Unfallklinik Frankfurt, Center for Spinal Surgery and Neurotraumatology, Friedberger Landstrasse 430, 60389 Frankfurt/Main, Germany 11 University of Washington School of Medicine, Harborview Medical Center, 325 9th Avenue, Box 359798, Seattle, WA 98104, United States 12 University of Utrecht, School of Medicine, Heidelberglaan 100, 3584 CX Utrecht, Netherlands

**INTRODUCTION:** The AOSpine Thoracolumbar Spine Injury Classification System was recently published and combines elements of both the Magerl system and the Thoracolumbar Injury Classification System (TLICS); however the worldwide applicability has yet to be established.

**MATERIAL AND METHODS:** A previously described classification system of thoracolumbar injuries which consists of a morphologic classification of the fracture, a grading system for the neurologic status and relevant patient-specific modifiers was applied to 25 cases by 100 spinal surgeons from across the world twice independently, in grading sessions 1 month apart. The results were analyzed for classification reliability using the Kappa coefficient.

**RESULTS:** The overall Kappa coefficient for all cases was 0.56 which represents moderate reliability. Kappa values describing interobserver agreement were 0.80 for type A injuries, 0.68 for type B injuries and 0.72 for type C injuries, all representing substantial reliability. The lowest level of agreement for specific subtypes was for fracture subtype A4 (Kappa=0.19). Intraobserver analysis demonstrated overall average Kappa statistic for subtype grading of 0.68 also representing substantial reproducibility.

**DISCUSSION:** In a worldwide sample of spinal surgeons without previous exposure to the recently described AOSpine Thoracolumbar Spine Injury Classification System, we demonstrated moderate interobserver and substantial intraobserver reliability. These results suggest that most spine surgeons can reliably apply this system to spine trauma patients as or more reliably than previously described systems.
**GP238**

**COMPARISON OF DEGENERATIVE CHANGES AMONG TWO DIFFERENT PARASPINOUS UNILATERAL APPROACHES FOR LUMBAR DECOMPRESSION**

Masahiro Morita, Hiroaki Nakamura;
Izumi municipal hospital, Osaka city university graduate school of medicine

**INTRODUCTION:** The purpose of this study is to investigate the degenerative changes of two different paraspinous unilateral approaches for lumbar decompression.

**METHODS:** Each consecutive 30 patients underwent decompression surgery with and without cutting of the spinous process were chosen as Group-1 and -2. We investigated the degenerative changes in radiological and MRI findings of the patients. There were no statistical differences among two groups in relation to the number of levels decompressed, postoperative period of radiological and MRI findings used for evaluation, and recovery rate of Japanese Orthopaedic Association (JOA) score.

**RESULTS:** There were no statistical differences between Group-1 and -2 in relation to the parameters of preoperative radiological and MRI findings used for evaluation. The average period between pre- and postoperative radiological finding was 47.8±6.5 months in Group A and 48.0±7.7 in Group B, and that of MRI finding was 38.7±7.6 in Group A and 42.4±9.3 in Group B. There were no statistical differences between Group-1 and -2 in relation to comparison of radiological findings. On the other hand, there were statistical differences between Group-1 and -2 in comparisons of MRI findings. The ratio of cross sectional area of multifidus was calculated at every disc level decompressed, which was defined as the postoperative cross sectional area divided by the preoperative one. The ratio of cross sectional area was smaller in Group A on both of ipsilateral or contralateral side of unilateral approach.

**DISCUSSION:** This study revealed that paraspinous unilateral approach with spinous process preservation is less-invasive for multifidus compared to that with cutting of the spinous process. However, this fact did not induce the differences among Group-1 and -2 within a follow-up period of this study in relation to the degenerative changes of radiological findings and recovery rate of JOA score.

**GP239**

**ANALYSIS OF INTERNET INFORMATION ON A CONTROVERSIAL PROCEDURE: KYPHOPLASTY**

Anderson JT, Duff RJ, Sullivan TB, Ahn UM, Ahn NU;
University Hospitals Case Medical Center Department of Orthopaedics, Case Western Reserve University School of Medicine, University of Minnesota - Twin Cities, University Hospitals Case Medical Center Department of Orthopaedic, Case Western Reserve University School of Medicine, New Hampshire Neurospine Institute, University Hospitals Case Medical Center Department of Orthopaedics

**INTRODUCTION:** Patients frequently turn to the internet for self-education before making medical decisions. It has been shown that internet information influences patient decision making. Prior studies on internet information on orthopaedic devices and procedures reveal an inadequacy in quality, non-biased information. No such study has been performed on kyphoplasty, a controversial treatment option for osteoporotic compression fractures.

**METHODS:** Search engines Google, Yahoo!, and Bing with the search term kyphoplasty were used to identify 105 websites offering information on kyphoplasty. Sites were then evaluated for authorship, content, and references cited.
RESULTS: Of 105 sites evaluated, 21% were sponsored by an academic institution, 61% by a private group, 5% by industry firms, and 13% by other organizations. At least one appropriate indication for kyphoplasty was provided in 63% of sites, and 39% of sites discussed at least one contraindication. No sponsorship subset had more than 50% of sites reporting a contraindication. All sites evaluated offered at least one benefit to treatment with kyphoplasty at a mean of 3.7 benefits discussed per site. In contrast, only 55% of sites discussed at least one complication of treatment with kyphoplasty at a mean of 2.9 complications described per site, and 51% of sites mentioned an alternative method of treatment. Peer reviewed literature was referenced by 23% of sites. Descriptions of techniques used in kyphoplasty were included in 93% of sites, and 50% of sites supported descriptions with illustrations or videos.

DISCUSSION: Our study revealed a striking inadequacy of quality internet information regarding kyphoplasty. Information presented was both incomplete and potentially misleading. Physicians should address the deficiencies of internet information on kyphoplasty with patients considering the procedure.

GP240
CAN INTERNET INFORMATION ON VERTEBROPLOSTY BE A RELIABLE MEANS OF PATIENT SELF-EDUCATION?
Joshua T. Anderson, BS Ryan J. Duff, BA T. Barrett Sullivan, MD Uri M. Ahn, MD Nicholas U. Ahn, MD;
University Hospitals Case Medical Center Department of Orthopaedic Surgery

INTRODUCTION: The internet has become an increasingly common tool utilized by patients to help with medical decision-making. Studies have demonstrated the lack of quality medical information online and how this information does indeed affect patient choices. No such study has been performed on vertebroplasty, a controversial minimally invasive cement augmentation procedure used to treat osteoporotic vertebral compression fractures.

METHODS: Search engines Google, Yahoo!, and Bing with the search term vertebroplasty were used to identify 105 websites offering information on vertebroplasty. Sites were then evaluated for authorship, content, and references cited.

RESULTS: Sixteen percent of sites were sponsored by an academic institution, 62% by a private group, 8% by biomedical device companies, and 14% were otherwise sponsored. Appropriate indications were referenced in 74% of sites while only 45% discussed a contraindication to the procedure. Benefits were expressed by 100% of sites, but risks were only outlined in only 53%. Alternative treatments were mentioned by 51% of sites. 27% of sites referenced peer reviewed literature, 41% offered experiential or non-cited data based on American populations, and 7% offered analogous data from international populations. 99% of sites provided step-by-step descriptions of the procedure while 44% of sites also included images.

DISCUSSION: Our analysis reveals a striking insufficiency of high quality, publically accessible internet information necessary for proper patient education on vertebroplasty. Internet information on vertebroplasty is potentially misleading and raises the concern that information made available to the public lends itself more toward patient recruitment than to education. Patients should be counseled regarding the limitations of information present on the internet.
GP241
PREVALENCE AND MECHANISMS OF ADJACENT SEGMENT DISEASE FOLLOWING LUMBAR SPINE FUSION FOR DIALYSIS-ASSOCIATED SPONDYLOSIS IN LONG-TERM HEMODIALYSIS PATIENTS
Keishi Maruo, Toshiya Tachibana, Shinichi Inoue, Fumihiro Arizumi, Shinichi Yoshiya; Department of Orthopaedic Surgery, Hyogo College of Medicine

INTRODUCTION: Dialysis-associated spondylosis (DAS) in the lumbar spine is a serious complication which includes destructive kyphosis, vertebral slippage, and extradural amyloid deposit in long-term hemodialysis patients. Fusion surgery may accelerate adjacent segment disease (ASD) especially in the case of adjacent amyloidosis. However, the adjacent segment pathology for DAS is currently unclear. The objective of this study was to assess the prevalence and mechanisms of adjacent segment disease following lumbar instrumented fusion surgery for DAS.

METHODS: A consecutive series of 36 long-term hemodialysis patients who underwent lumbar instrumented fusion surgery for DAS between 1999 and 2013 were included in this study. The mean age at surgery was 64.5 years (range 49-79) with 21 males. The mean follow-up period was 2 years. The average length of hemodialysis was 22.5 years. Of these cases, 14 were single-level, 22 were multilevel fusion. ASD was defined as adjacent disc collapse and adjacent segment stenosis. The Japanese Orthopedic Association score (JOA score), recovery rate, and reoperation were reviewed.

RESULTS: The mean JOA score significantly increased from 13.5 before surgery to 21.3 at the final follow-up. The mean recovery rate was 51.4%. Six of the 36 patients died within 1 year after index surgery. More than 1 year of follow-up after surgery was available for 30 patients. Symptomatic ASD occurred in 43% (13/30) of the cases. Of the 13 cases, 5 had adjacent segment disc collapse and 8 had adjacent segment stenosis. Three cases (10%) required reoperation due to proximal adjacent segment stenosis. Multilevel fusion surgery increased the risk of ASD compared with single-level fusion surgery (61% vs. 38%). The recovery rate was significantly lower in the ASD group than the non-ASD group (61% vs. 38%).

DISCUSSION: Symptomatic ASD occurred in 43% of the cases. Three cases required revision surgery. Multilevel fusion surgery increased the risk of ASD in DAS.

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GP242
PERCENTAGE OF TUMOR OCCUPATION IN THE SPINAL CANAL AND CLINICAL SYMPTOMS OF SCHWANNOMA IN THE CAUDAL EQUINA: ANALYSIS OF 22 CASES
Kengo Fuji, MD; Masataka Sakane, MD, PhD; Tetsuya Abe, MD, PhD; Toshinori Tsukanishi, MD; Hiroshi Noguchi, MD; Keita Nakayama, MD; Masashi Yamazaki, MD, PhD; Dept. of Orthopaedic Surgery, Tsukuba University

INTRODUCTION: The incidence of occult tumors of the cauda equina is believed to be increasing, according to the widespread use of magnetic resonance imaging (MRI). However, little is known about the relationship between the size of the tumor and clinical symptoms. We analyzed the relationship between the percentage of tumor occupation (PTO) in the spinal canal and clinical symptoms.

METHODS: We retrospectively analyzed 22 patients (9 males and 13 females, mean age 55.3 years) diagnosed between April 2004 and July 2014. Patients were radiologically diagnosed with Schwannoma in the caudal equina. Axial and sagittal MRI slices (T2WI) in which the sectional area of the tumor was greatest were analyzed; the PTO in each slice was calculated using Image J software (NIH, USA). Clinical
symptoms and the results of physical exams were retrospectively collected from medical records. Symptoms associated with the tumor included lower back pain, muscle weakness or sensory disturbance in lower extremity, bowel or bladder disturbance, night pain, Dejerine phenomenon, straight leg raise test (SLRT), femoral nerve stretching test, and Kemp test. PTO between the symptom positive and negative groups for each parameter were analyzed by Mann-Whitney-U test; a p value less than 0.05 was considered statistically significant.

RESULTS: PTO was 5-10% (mean 9%) in axial slices and 23-31% (mean 30%) in sagittal slices in 4 cases in which the tumor were not related to clinical symptoms. In the 18 cases in which symptoms were associated with the tumor, PTO were 11-86% (mean 50%) in axial slices and 43-88% (mean 71%) in sagittal slices. PTO in axial slices were significantly higher when Dejerine symptoms were positive and in the presence of muscle weakness, SLRT, and Kemp sign.

DISCUSSION: A PTO less than 20% in axial slices or less than 40% in sagittal slices can be an index of asymptomatic tumors. Our results showed that PTO calculated by MRI may predict the development of symptoms.

GP243
SURGICAL RESULTS FOR 2-LEVEL POSTERIOR LUMBAR INTERBODY FUSION (PLIF) - CT EVALUATION OF THE FUSION-
Hiroyuki Aono MD, PhD 1 Hidekazu Tobimatsu MD 1 Yukitaka Nagamoto MD, PhD 1 Motoki Iwasaki MD, PhD 2;
1:Osaka National Hospital 2:Osaka Rosai Hospital

INTRODUCTION: Posterior lumbar interbody fusion (PLIF) is general surgical procedure for degenerative lumbar diseases and fusion rate of single PLIF is reported 90-98.8%. However, there are few reports concerning 2-level PLIF and no report has focused on fusion rate of 2-level PLIF. The purpose of this study was to evaluate clinical and radiological outcomes of 2-level PLIF for degenerative lumbar diseases including CT evaluation of fusion.

METHODS: This retrospective study included 31 patients who underwent 2-level PLIF for degenerative lumbar diseases between 2006 and 2013. There were 7 men and 24 women with mean age of 73 years. Preoperative diagnosis were 2-level degenerative spondylolisthesis in 27 patients and others in 4. Interbody fusion was performed by placing two cages with a minimum of two autologous bone blocks and chips from local excised bone. The fusion area was L2/3/4 in 2 patients, L3/4/5 in 22 and L4/5/5 in 7. Operation time and blood loss were recorded. Clinical status was evaluated by the Japanese Orthopedic Association (JOA) score and sagittal alignment of the lumbar spine was assessed by comparing serial plain radiographs. Fusion status was assessed by CT scan at one year after surgery. We diagnosed non-union when clear zone around cages or blocks is apparent.
RESULTS: Mean operation time was 226 minutes and mean blood loss was 558ml. The mean JOA score improved from 12.1 points before surgery to 23.8 at final follow up. Sagittal alignment angle (T12/S1) was improved from 34.2° before surgery to 39.5° at final follow up. Solid fusion was achieved in 27 patients (87%). All patients with L2/3/4 PLIF obtained fusion and 20 patients out of 22 with L3/4/5 PLIF had fusion. However, only 1 patient out of 7 with L4/5/S PLIF had obtained fusion. Non-union was observed caudal segment in all patients and one patient was symptomatic.

DISCUSSION: To the best of our knowledge, there are only 2 reports concerning 2-level PLIF and in their reports, fusion rate was 95% and 100% in radiographic evaluation. In this study, improvement in JOA score and lumbar lordosis was not different in previous reports. However, fusion rate was lower by CT evaluation and non-union was concentrated in L5/S segment with L4/5/S PLIF.

GP244
LOW BACK PAIN FOLLOWING MICROENDOSCOPIC DECOMPRESSION FOR DEGENERATIVE LUMBAR SPONDYLOLISTHESIS

Takato Aihara, Kenji Hatakeyama, Makoto Urushibara, and Juntaro Ouchi; Dept. of Orthopedic Surgery, Funabashi Orthopedic Hospital, Funabashi-city, Chiba, Japan

INTRODUCTION: The purpose of the present prospective study was to assess the efficacy of microendoscopic decompression (MED) in the treatment of low back pain (LBP) associated with degenerative lumbar spondylolisthesis (DS).

METHODS: Between 2006 and 2011, 52 consecutive patients with DS were treated surgically. All patients underwent MED. The MED procedure was intended to perform sufficient decompression while preserving the posterior structures of the spine. Fusion was not performed. All 52 patients were prospectively followed, and clinical outcomes were evaluated by using a visual analogue scale (VAS) to assess pain and numbness and the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ). Lateral radiographs in flexion, extension, and the neutral position were obtained before and after MED to measure the intervertebral angles and percentages of slipping. The mean duration of follow-up was 28.1 months.

RESULTS: LBP according to the VAS scores and LBP assessed by the JOABPEQ had significantly improved after MED (P value less than 0.0001). Spondylolisthesis and instability before and after MED had no influence on the improvement in LBP and on LBP after MED. However, the improvement in LBP was significantly correlated with the improvement in the other four functional scores assessed on the JOABPEQ and with the improvement in leg pain and numbness assessed on the VAS (Fig.).
**DISCUSSION:** We reported that MED was a useful, minimally invasive surgery that could lead to a better clinical outcome (including LBP) than decompression with fusion for DS (2012, JMR and 2013, ISSLS). From the results of these and the present studies, decompression of the nerve roots and cauda equina for relief of sciatica and/or cauda equina symptoms provided relief of sciatica and/or cauda equina symptoms, and LBP. The findings of the present small study suggest that radicular and/or cauda equina compression might be a possible cause of LBP.

**GP245**

**OSTEOPOROTIC SPINAL FRACTURES WITH NEUROLOGICAL COMPROMISES**

Kee-Yong Ha, Young-Hoon Kim, Sang-Hyun Cheon;

Department of Orthopedic Surgery, Seoul St. Mary’s Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea.

**INTRODUCTION:** Osteoporotic spinal fractures (OSFs) with neurological compromises have been increasingly reported. The purpose of this study is to investigate the clinical and radiological characteristics of these complicated OSFs.

**METHODS:** From 2008 to 2012, consecutive surgical cases for OSFs with neurologic complications that have at least 2 years follow-up (mean 30 ± 8.9 months) were analyzed. Thirty-one cases (M: F= 14:17) with mean age of 73 ± 8.3 years were included. Patients with infections, malignancies and fractures secondary to major trauma were excluded. Visual analogue scale (VAS), Oswestry disability index (ODI) and Frankel grade was used for clinical assessment. Clinical manifestations and radiological findings, including those of local kyphosis and dislodgement of implant, were assessed.

**RESULTS:** The causative findings of neurologic compromises were divided into two types. Type I was characterized by the presence of intravertebral cleft and fracture instability at the affected vertebra. Type II was characterized by no evidence of non-union in the affected vertebra but the progressive kyphosis and aggravation of pre-existing stenotic conditions. Myelopathy developed in 21 patients and radiculopathy was noted in 10 patients. The thoracolumbar junction (n=19) was the main level involved. Mean time interval from injury and surgery was 2.8 months (range, 1-8). Preoperative pain (VAS: 7.1±2.1) and disability (ODI: 68 ± 17.7) were improved at the last follow-up (VAS: 4.5±2.5, ODI: 44.2±13.9). Improvement of neurologic impairments more than one Frankel grade was observed in 13 patients (43%). Anterior corpectomy and reconstruction was done for 18 patients, and posterior reconstruction was done for 13 patients. There were no significant differences in perioperative complications or clinical results along the type of surgical reconstruction or causes of neurologic compromises. However, metallic dislodgement is frequently found in the posterior reconstruction group.

**CONCLUSIONS:** Although most OSFs can be successfully treated with conservative treatment, late neurologic compromises could be developed by the aggravation of stenotic condition or nonunion of the involved vertebrae. Therefore we should be aware of late neurologic compromises following OSFs. Moreover, further studies are needed to address the issue of appropriate treatment for these patients.

**KEY WORDS:** Osteoporotic fractures, Compression fractures, Neurologic manifestations
GP246
POLYEOLECTROLYTE COMPLEX CARRIER ENHANCES THERAPEUTIC EFFICIENCY AND SAFETY PROFILE OF BMP-2 IN PORCINE LUMBAR INTERBODY FUSION MODEL
Ming Wang, MD1; Sunny Akogwu Abbah, MD,PhD1; Tao Hu, MD1; Raymond Wing Moon Lam, PhD1; Soo Yein Toh, Bsc1; Tong Liu, PhD2; Simon Cool, PhD1,3; Kishore Bhakoo, PhD 4; Jun Li, PhD 5,6; James Cho Hong Goh, PhD 1,6; Hee-Kit Wong, FRCS1;

INTRODUCTION: Supraphysiological doses of BMP-2 are administered to achieve consistent spinal fusion which has led to complications. Heparin modified polyelectrolyte complex (PEC) carrying reduced BMP-2 doses of 0.5 μg was demonstrated to achieve consistent spinal fusion with reduction of complications in rodent model. This study evaluates the effect of polyelectrolyte complex carrier in enhancing the therapeutic efficiency and safety profile of BMP-2 in a large animal model.

METHODS: Three segment (L3-L6) anterior lumbar interbody fusions (ALIF) with instrumentation were performed on 6 pigs using three different doses of BMP-2 viz: 1) 50µg, 2) 150 µg, and 3) 300 µg. The BMP-2 was delivered using heparin modified alginate microbeads loaded into biodegradable cage. Fusion performance was evaluated after 3 months.

RESULTS: Manual palpation and micro computed tomography showed consistent fusion in all experimental group. Heterotopic bone formation beyond the cage implant area was more evident in Group 2 and Group 3 compared to Group 1. Similarly, superior bone micro-structure was observed in the new bone with the lowered BMP-2 dose. Biomechanical evaluation revealed enhanced stiffness of the operated segments compared to non-operated segments (p<0.05). Mechanical stability was maintained despite dose reduction of BMP-2. Although the mineral apposition rate was higher in Group 3, unsatisfactory bony micro-structure with decreased trabecular number were observed in Group 3 compared to Group 1.

CONCLUSIONS: PEC carrying low doses of BMP-2 achieved consistent interbody fusion. We observed dose related reduction in heterotopic ossification without compromising the stability of the fused segments. PEC carrier reduces the efficacious doses of BMP-2. This could enhance the safety profile of BMP-2 and reduce dose related complications.

GP247
EVALUATION OF CLINICAL RELEVANCE TO SRS-SCHWAB CLASSIFICATION AND CORRELATION BETWEEN CLINICAL INDEX AND RADIOLOGICAL INDEX FOR DEGENERATIVE LUMBAR SCOLIOSIS
Young-Hoon Kim, MD, Won-Hee Jang, M.D., Kee-Yong Ha, M.D;
Department of Orthopaedic Surgery, Seoul St. Mary’s Hospital, College of Medicine, The Catholic University of Korea

INTRODUCTION: Objective. To evaluate the clinical relevance to SRS-Schwab classification and analyze the correlation between radiological index and clinical
index for degenerative lumbar scoliosis (DLS).

**METHODS:** In this retrospective cohort study, 216 DLS patients were divided into 2 groups: a non-operative group (146 patients) and operative group (70 patients). For radiological assessment, coronal Cobb’s angle, coronal imbalance (CI), lumbar lordosis (LL), pelvic incidence (PI), sagittal vertical axis (SVA) and pelvic tilt (PT) were measured. For clinical assessment, the Oswestry Disability Index (ODI), the Visual Analog Scale (VAS), and SRS-23 were used.

**RESULTS:** In non-operative group, ODI, back VAS, leg VAS and SRS each averaged 26.3±18.2, 4.0±2.8, 3.3±2.8 and 73.7±10.3, respectively. In operative group, ODI, back VAS, leg VAS and SRS was 49±18.6, 7.1±2.7, 7.7±2.8, and 71.2±14.0, respectively. In operative group, clinical outcomes showed higher scores with statistical significance (p=0.000) except SRS (p=0.303). CI was 12.4±13.6 mm in non-operative group and 15.1±14.3 mm in operative group, but showed no statistical significance (p=0.187). Coronal Cobb’s angle was 21.5±9.7° in non-operative group, and 20.2±6.6° in operative group, but showed no statistical significance (p=0.285). For PI and LL, the average significantly decreased in operative group (p=0.016, 0.007, respectively), but PT average increased in non-operative group. PI-LL and SVA did not show statistical significance between 2 groups (p=0.149, 0.313, respectively).

**DISCUSSION AND CONCLUSIONS:** Although DLS is an adult spinal deformity, SRS-Schwab classification for DLS has limitations of clinical relevance in the context of treatment option. Performing surgical treatment for DLS is correlated with clinical outcomes, but not correlated with grade of the radiological parameters by Schwab-SRS classification.

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**GP248**

**PREOPERATIVE MR IMAGING IN PATIENTS WITH INTERMITTENT NEUROGENIC CLAUDICATION: RELEVANCE FOR DIAGNOSIS AND PROGNOSIS**

Moojen WA, Schenck CD, Lycklama a Nijeholt GJ, Jacobs WCH, Van der Kallen BF, Arts MP, Peul WC, Vleggeert-Lankamp CLAM; Netherlands

**INTRODUCTION:** Magnetic resonance imaging (MRI) is an important tool to confirm the diagnosis of lumbar spinal stenosis (LSS) as a cause for intermittent neurogenic claudication. It is believed that the narrowness of the lumbar spinal canal correlates to the severity of complaints, and that it may be a good predictor of clinical outcome if treated. However, this hypothesis has never been (prospectively) tested.

**METHODS:** We studied baseline MRIs of 155 patients with intermittent neurogenic claudication and lumbar spinal stenosis. MRI and patient data were gathered from participants of a randomized trial. Three raters were asked to evaluate the MRIs (Schizas scale). Symptom severity at baseline and at one-year follow-up were quantified. The radiological scores were correlated with clinical baseline and outcome scores to assess diagnostic and prognostic value of MRI findings at baseline.

**RESULTS:** There was good agreement on the clinically relevant level of lumbar spinal stenosis (kappa range 0.57 to 0.64). MRI assessment of grading of compression (kappa of agreement ranges 0.33-0.46) did not correlate with baseline MRDQ, nor with outcome based on postoperative change in MRDQ (p-value 0.61). However, both absence of epidural fat and presence of tortuous caudal nerves on MR images (kappa of agreement ranges 0.53-0.72 and 0.67-0.70 respectively) in patients with LSS
were relatively good predictors for satisfactory recovery after surgery (p-values 0.03 and 0.01).

**CONCLUSION:** The grading of compression on the preoperative MRI is neither ambiguous nor correlation to severity of clinical condition. It does furthermore not have the ability to predict the outcome after one year if surgically treated.