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## Oral Platform Abstracts

### OUTCOMES COMMITTEE AWARD

#### 100. Determining the Quality and Effectiveness of Spine Surgery: Patient Satisfaction is Not a Valid Proxy

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**Introduction:** Patients' satisfaction with care has emerged as a proxy for quality due to its feasibility of collection. We set out to determine whether patient satisfaction is a valid measure of quality and effectiveness of care in a prospective longitudinal spine registry.

**Methods:** All patients undergoing spine surgery over 6-month period were enrolled into a prospective registry and followed for 3 months. Patient reported outcomes, patient satisfaction with outcome and with provider care, and 90-day morbidity were recorded. ROC curve analysis was used to determine if improvement in quality of life (QOL, SF-12 PCS) and disability (ODI/NDI) accurately predicted patient satisfaction [Area under the curve (AUC): <0.7: poor, 0.7-0.8: fair, >0.8: good accuracy]. Multivariate logistic regression was performed to determine if surgical morbidity (quality) or improvement in disability and QOL (effectiveness of care) were independently associated with patient satisfaction.

**Results:** 422 (84%) patients completed all questionnaires. Satisfaction with provider care: In ROC analyses, extent of improvement in QOL and disability predicted satisfaction with very poor accuracy, Figure 1 & 2. In regression analysis, 3-month morbidity, re-admission, improvement in QOL, or improvement in general health (HTI) were not associated with satisfaction with care, Table 1. Satisfaction with outcome: In ROC analyses, improvement in QOL and disability predicted satisfaction with fair accuracy, Figure 1 & 2. In regression analysis, improvement in QOL, disability, and general health were independently associated with satisfaction with outcome, Table 2. Neither 90-day morbidity nor re-admission were associated with satisfaction with outcome.

**Conclusion:** Patient satisfaction with provider care is not a valid measure of quality or effectiveness of surgical spine care. Patient satisfaction with outcome may be used as a fair proxy for effectiveness but is not a valid measure of quality. Patient satisfaction metrics represent patient's subjective contentment with healthcare experience and should not be used as a measure of quality or effectiveness.

#### 101. The National Neurosurgery Quality and Outcomes Database (N2QOD) Pilot: Patient-centered Measurement of Quality and Effectiveness of Care

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Ford Health System), Timothy C. Ryken MD MS FACS (Iowa Brain & Spine Institute), Gregory W. Balturshot BS, MD (Central Ohio Neurological Surgeons, Inc.), Daniel Robert Fassett MD (Illinois Neurological Institute), Ralph Reeder, Clinton F. Miller MD (Coastal New Hampshire Neurosurgeons), Thomas B. Briggs MD (Springfield Neurological Institute, LLC), Thomas W. Graham MD, Barton L. Guthrie MD (University of Alabama, Birmingham), J. Frederick Harrington MD (University of New Mexico Health Center), Christopher I. Shaffrey MD FACS (University of Virginia), Eric H. Elowitz MD (Weill Cornell Medical College/Department of Neurological Surgery), Kevin T. Foley MD FACS (Semmes-Murphey Neurologic & Spine Institute), Frank Harrell, Robert Dittus

**Introduction:** The Institute of Medicine (IOM) and the American Recovery and Reinvestment Act of 2009 have called for the establishment of prospective registries to capture patient-centered data from real-world practice to guide evidence-based reform. As a result, the AANS launched the National Neurosurgery Quality and Outcomes Database (N2QOD) March, 2012 as a twenty-five center pilot project: a web-based, prospective, longitudinal one-year outcomes registry (the lumbar spine module).

**Methods:** Using a centrally coordinated (Vanderbilt Institute of Public Health) and standardized process of representative sampling, six patients per week per site undergoing surgery for one of five diagnoses (Table 1) were prospectively entered into the REDCap™ web-based portal. Site-specific and risk-adjusted national norms are reported back to sites, Figure 1. Pilot year goals are to 1) generate an accurate quality measurement and reporting infrastructure for neurosurgeons, and 2) accurately define risk-adjusted national benchmarks of outcome using manual data entry, validated outcomes instruments, and high degree of quality control from which to subsequently validate automated data entry tools.

**Results:** Within five months, 1481 patients were enrolled, representing 140 surgeons, 32 hospital systems, 22 U.S. states. Cumulative missing registry data was 1.8%. Three-month follow up was 87.3%. 90-day re-admission and re-operation was 8% and 3%, respectively, and varied as a function of lumbar diagnosis, Table 2. Significant improvements in pain, disability, QALY and return to work were reported by patients with all five diagnoses, Figure 2. Utilization of arthrodesis (Figure 3) and extent of surgical effectiveness varied across centers, Figure 4. Significant variation in the risk-profile and disease-severity of patients was observed across sites, highlighting the need for robust risk adjustment, Figure 5.

**Conclusion:** Initial results suggest that a prospective, nation-wide, outcomes-based registry will be feasible. N2QOD aims to provide practice-specific evidence that empower subscribing sites to demonstrate the quality, effectiveness, and value of their care specific for their unique patient population in an emerging culture of public profiling and value-based purchasing.

#### 102. Spine Surgery Referrals Redirected through a Multidisciplinary Care Pathway: Appropriateness of Non-surgeon Triage and Effects on Imaging Utilization

Daryl R. Fourney MD FACS FRCS(C) (Royal University Hospital), Danica Kindrachuk

**Introduction:** In attempt to address rising costs and clinical variability including the rate of imaging utilization and surgical referral, multidisciplinary care pathways for back pain have been implemented around the world, each with unique approaches to classification, triage, and provision of care. No comparative studies have been

performed to determine efficacy. The Saskatchewan Spine Pathway (SSP) includes triage clinics staffed by specialized physiotherapists. During the early implementation of the SSP, these clinics screened a backlog of elective spine surgery referrals. There is very limited data regarding the efficacy of non-surgeon triage of lumbar spine referrals.

**Methods:** A retrospective analysis of 87 patients with lower back and leg pain initially referred to a spine surgeon but triaged by the SSP clinic between May 1-November 30, 2011. Diagnosis was by the classification of Hall et al. Pain and disability were scored by visual analog pain scale (VAS), modified Oswestry Disability Index (ODI) and EuroQol EQ5D.

**Results:** 62 (71.26%) patients (Group A) were discharged after patient education, self-care advice and/or referral for additional mechanical therapies. 25 (28.74%) patients (Group B) were referred for surgical assessment. The surgical yield in Group B was 44%, compared to 15% for all new spine referrals prior to implementation of the SSP: an almost three-fold increase. For the combined cohorts, we estimate that the triage clinic prevented 50/87 (57.5%) MRI studies. Non-surgeon triage captured all red flags detected by the surgeon. Patients in Group B were much more likely to have a leg-dominant pain pattern ( $p = 0.0088$ ) and had significantly greater ODI ( $p = 0.0121$ ) and EQ5D Mobility ( $p = 0.0484$ ) scores.

**Conclusion:** The SSP is an effective clinical spine pathway for reducing unnecessary imaging and surgical referrals.

### 103. Comparative Effectiveness, Cost Utility and Cost Benefit Analysis of Intra-Operative Neuromonitoring in Cervical Spine Surgery: Where is the Value?

Scott L. Zuckerman MD BS (Vanderbilt University School of Medicine), Saniya S. Godil MD (Vanderbilt University), Scott L. Parker MD, Joseph S. Cheng MD MS (Vanderbilt University Medical Center), Clinton J. Devin MD, Matthew McGirt MD (Vanderbilt University Medical Center)

**Introduction:** The use of Intra-operative neuromonitoring (IOM) modalities has not been clearly demonstrated to influence patient outcomes favorably compared to the added cost it incurs. We set out to assess the value of IOM in patients undergoing cervical surgery in a prospective cohort study.

**Methods:** All patients undergoing elective cervical spine surgery for degenerative spondylosis over a 1-yr period at a single institution were enrolled into a prospective registry. Data collected included demographics, treatment variables, IOM parameters, and 90-day surgical morbidity. Patient reported outcomes (PRO), return to work and medical resource utilization were prospectively recorded at baseline and 3-months. CPT codes 95920[baseline electrophysiologic testing (charged per hour)], 95295 and 95926[SSEP monitoring], 95928 and 95929[MEP monitoring], and 95937[neuromuscular junction testing] were used to calculate the direct cost of using IOM for cervical surgery (Payer perspective). The cost of IOM per reduction in surgical morbidity (Cost-benefit analysis), and the difference in mean total cost per QALY-gained with IOM via incremental cost-effectiveness ratio [ICER] (Cost-utility analysis), was assessed.

**Results:** A total of 180 patients underwent cervical spine procedures (102 IOM and 78 non-IOM). Baseline characteristics were similar between the two groups ( $p > 0.05$ ), Table 1. IOM changes were noted in only 4(4.0%) patients undergoing IOM and surgical strategy was modified in only 1(1.0%). There was no significant difference in 90-day morbidity and improvement in PROs at 3-months ( $p > 0.05$ ) between the two groups, Table 1. The average added cost of IOM per patient was \$1,208 (Medicare) and \$2,054 (private payer) with no associated reduction in surgical morbidity. The ICER for IOM versus not was \$358,205/QALY.

**Conclusion:** In a real comparative effectiveness study of patients undergoing elective cervical spine surgery, IOM was associated with significant added cost without a corresponding benefit in safety or patient outcomes. This resulted in a non-cost effective ICER score.

IOM appears to be an area where cost can be saved without sacrificing surgical quality or patient safety.

### 104. Incidence and Clinical Outcomes of Patients Requiring Repeat ACDF Surgery Due to Adjacent Level Disease

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**Introduction:** To study the long-term effects of repeat ACDF surgery approached anteriorly versus posteriorly for adjacent segment disease (ASD) in the cervical spine.

**Methods:** 888 patients received ACDFs for symptomatic degenerative disease of the cervical spine over the past 22 years at our institution. Of these, 108 patients received repeat ACDF surgeries due to symptomatic ASD. 77 received revision surgeries anteriorly, and 31 received posterior surgeries. Pre, intra, peri, and post-operative data were collected via clinical notes and patient interviews. Patients were followed up for an average of  $111.8 \pm 76.5$  months after the first ACDF.

**Results:** In general, patients who were operated on posteriorly were older ( $53.2 \pm 12.6$  vs  $47.7 \pm 9.3$ ,  $p < 0.01$ ), and were more likely to be female (67.7% vs. 36.4%,  $p < 0.01$ ). There were no statistical differences between the two cohorts in terms of comorbidities such as diabetes, COPD, CAD, osteoporosis, obesity, smoking history, hypertension, and depression. Patients operated on posteriorly were more likely to have myelopathy (41.9% vs. 15.6%,  $p = 0.03$ ) and scored worse on the Nurick and ASIA scales ( $p < 0.01$ ). Patients approached posteriorly had  $2.0 \pm 1.3$  spinal levels fused, compared with  $1.3 \pm 0.6$  ( $p < 0.01$ ) in the anterior cohort, and experienced more blood loss ( $p < 0.01$ ). Peri-operatively, patients receiving revision surgeries posteriorly had significantly longer lengths of stay ( $5.7 \pm 4.1$  vs.  $2.7 \pm 3.26$ ,  $p < 0.01$ ), higher rates of wound infection (22.6% vs. 0.0%,  $p < 0.01$ ), lower rates of dysphagia (6.45% vs 10.4%,  $p < 0.01$ ), higher rates of rehabilitation (22.6% vs. 0.0%,  $p < 0.01$ ), but no differences in rates of DVT, PE, pneumonia, hematoma, wound dehiscence, C5 nerve root palsy, or death. Post-operatively, patients in both cohorts experienced a significant self-reported improvement in symptoms (43.8% vs. 44.4% in the anterior vs. posterior cohort, respectively), but patients approached posteriorly had a statistically significantly higher risk of recurrent radiculopathy ( $p = 0.04$ ).

**Conclusion:** The pathophysiology behind adjacent segment disease after ACDF has yet to be unambiguously established. Here, we present one of the largest Western cohorts of patients undergoing repeat ACDF due to adjacent segment disease. This study provides one of the longest and most comprehensive follow-ups of this challenging patient population.

### 105. Lateral Mass Screw Fixation in the Cervical Spine: A Systematic Review

Jeffrey D Coe MD (Silicon Valley Spine Institute), Alexander R. Vaccaro MD, Andrew T. Dailey MD (University of Utah Hospital), Richard L. Skolasky MD, Rick Sasso MD, Steven C Ludwig MD (University of Maryland Department of Orthopaedics), Erika Brodt, Joseph Dettori

**Introduction:** The purpose of this study is to describe the safety profile and effectiveness of lateral mass screw fixation (LMSF) when used for stabilization and fusion of the posterior cervical spine.

**Methods:** A systematic search was conducted in MEDLINE and the Cochrane Collaboration Library for articles published between January 1, 1980 and December 31, 2011. We included all articles

evaluating safety and/or clinical outcomes in adult patients undergoing posterior cervical subaxial fusion using lateral mass instrumentation with plates or rods for degenerative disease (spondylosis), trauma, deformity, inflammatory disease, and revision surgery which met our a priori inclusion/exclusion criteria.

**Results:** We included 20 articles (2 retrospective comparative cohort studies and 18 case-series) that met our inclusion/exclusion criteria. Both cohort studies compared lateral mass screw fixation (LMSF) with wiring and found that the risk of complications was comparable between treatments (range, 0% 7.1% vs. 0% 6.3%, respectively). Fusion was similar in both groups as reported by one study (100% vs. 97%, respectively). Complication risks were low following lateral mass screw fixation across 18 case-series. Nerve root injury attributed to screw placement occurred in 1.0% of patients (95% CI; 0.3%, 1.6%). There were no cases of vertebral artery injury reported. Hardware complications such as screw/rod pullout, screw/plate breakage and screw loosening occurred in less than 1% of the screws inserted. Fusion was achieved in 97.0% of patients across nine case-series.

**Conclusion:** The risks of complications are low and fusion is high when lateral mass screw fixation is used in patients undergoing posterior cervical subaxial fusion. Nerve root injury attributed to screw placement occurred in only 1% of 1041 patients. There were no cases of vertebral artery injury identified in 758 patients. Screw/rod pullout, screw/plate breakage and screw loosening occurred in less than 1% of the screws inserted.

#### MAYFIELD CLINICAL SCIENCE AWARD

##### **106. Comprehensive Medical Management of Lumbar Disc Herniation, Stenosis and Spondylolisthesis is Not Effective in Real-world Care: A Value Analysis of Cost, Pain, Disability, and Quality of Life**

*Scott L. Parker MD, Saniya S. Godil MD (Vanderbilt University), Scott L. Zuckerman MD BS (Vanderbilt University School of Medicine), David Chau BS, Stephen Mendenhall BS, Joseph S. Cheng MD MS (Vanderbilt University Medical Center), Matthew McGirt MD (Vanderbilt University Medical Center)*

**Introduction:** Current healthcare reform calls for reduction of procedures/treatments that are less effective, more costly, and of little "value". We assessed the two-year cost and effectiveness of comprehensive medical management for lumbar spondylolisthesis, stenosis and herniation utilizing a prospective single-center multidisciplinary spine center registry in a real-world practice setting.

**Methods:** Patients with lumbar spondylolisthesis (n=50), stenosis (n=50) and disc herniation (n=50) non-operatively managed were entered into a prospective registry. Comprehensive medical management included spinal steroid injections, physical therapy, bracing, and various narcotic and non-narcotic oral agents. Baseline and two-year patient-reported outcomes were assessed. Back-related medical resource utilization and work-day losses were prospectively collected and used to calculate Medicare fee-based direct and indirect costs. Costs were assessed from the payer and societal perspectives.

**Results:** Baseline characteristics are presented in Table 1. Two year back pain, leg pain, disability, quality of life, depression, and general health state were not significantly improved with medical management, Figure 1 & Table 2. Eighteen (36%) patients with spondylolisthesis, 11(22%) with stenosis, and 17(34%) with disc herniation eventually required surgical management due to lack of improvement, Table 3 & Figure 2. Mean two-year cost of medical management was \$6,606 for spondylolisthesis, \$7,747 for stenosis, and \$7,097 for herniation. Cost-components are specified in, Table 4. Overall, medical management was associated with a mean two-year cost \$7,150 without a significant gain in QALYs (Value = \$102,143/QALY gained).

**Conclusion:** In this prospective registry, comprehensive medical

management was shown to provide no durable improvement for patients with degenerative lumbar spondylolisthesis, stenosis or disc herniation. From both the societal and payer perspective, medical management of lumbar stenosis, spondylolisthesis and disc herniation is of minimal value given its lack of utility despite its cost. The findings from this real-world practice setting may more accurately reflect the true value and effectiveness of non-operative care in this patient population.

##### **107. Comparative Effectiveness, Cost Utility and Cost Benefit Analysis of Intra-Operative Neuromonitoring in Lumbar Spine Surgery: Where is the Value?**

*Saniya S. Godil MD (Vanderbilt University), Scott L. Zuckerman MD BS (Vanderbilt University School of Medicine), Scott L. Parker MD, Oran Aaronson MD (Vanderbilt University Medical Center), Clinton J. Devin MD, Matthew McGirt MD (Vanderbilt University Medical Center)*

**Introduction:** The use of intra-operative neuromonitoring (IOM) modalities has not been clearly demonstrated to influence patient outcomes favorably compared to the added cost it incurs. We set out to assess the value of IOM in patients undergoing lumbar fusion surgery in a prospective cohort study.

**Methods:** All patients undergoing elective lumbar fusion surgery (1-3 levels) for degenerative spondylosis over a 1-yr period at a single institution were enrolled into a prospective registry. Data collected included demographics, treatment variables, IOM parameters, and 90-day surgical morbidity. Patient reported outcomes(PRO), return to work and medical resource utilization were prospectively recorded at baseline and 3-months. CPT codes 95920[baseline electrophysiologic testing (charged per hour)], 95861[EMG monitoring], 95295 and 95937[neuromuscular junction testing] were used to calculate the cost of using IOM(Payer perspective). The cost of IOM per reduction in surgical morbidity (Cost-benefit analysis), and the difference in mean total cost per QALY-gained with IOM via incremental cost-effectiveness ratio(ICER)(Cost-utility analysis), was assessed.

**Results:** A total of 246 patients underwent lumbar fusion surgery (54 IOM and 192 non-IOM). The two groups were similar at baseline, Table 1. IOM changes were noted in only 2(3.7%) patients undergoing IOM and surgical strategy was modified. There was no significant difference in 90-day morbidity and improvement in PROs at 3-months (p>0.05) between the two groups, Table 1. The average added cost of IOM per patient was \$902(Medicare) and \$1,533(private payer) with no associated reduction in surgical morbidity. The ICER for IOM versus not demonstrated non-IOM use as dominant, Figure 1.

**Conclusion:** In a real world comparative effectiveness study of patients undergoing elective lumbar fusion surgery, IOM was associated with significant added cost without a corresponding benefit in safety or patient outcomes. This resulted in an ICER score suggesting that non-IOM is dominant. IOM appears to be an area where cost can be saved without sacrificing surgical quality or patient safety.

##### **108. Single Institution Clinical Outcomes Indicating Patients with Posterior Lumbar Fusion with an Interbody Device have Better Outcomes than Without an Interbody Device.**

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**Introduction:** Despite numerous efforts, the optimal posterior lumbar fixation technique has yet to be established. It is well accepted that the addition of an interbody device provides favorable anatomical, biomechanical, physiological, and fusion outcomes at the affected spinal location; however, the superiority in clinical outcomes has yet



to be recognized. The goal of this study is to evaluate the clinical advantages of posterior lumbar interbody fusion (PLIF) compared to the common posterolateral fusion (PLF) with pedicle screw instrumentation.

**Methods:** 800 consecutive patients who underwent lumbar fusion using either PLF (N= 300) or PLIF (N=500) were reviewed. Patient surgical outcomes were evaluated based on complications, symptomatic improvement, hospitalized days, re-operation incidence, and Prolo/ Oswestry disability index (ODI) outcome scores.

**Results:** The average length of follow-up was 12 months for PLIF patients and 33 months for PLF patients. The preoperative diagnosis was similar in both cases with degenerative disk disease and spondylolisthesis as the main pathologies. PLF patients had a 8% rate of cumulative complications. Mean hospital stay was 7 days with a re-operation rate of 28%. The average economical, functional and total Prolo scores for this group were 3.7, 3.8, and 7.5, respectively. Mean postoperative ODI was 20%, and 91% of patients showed symptomatic improvement at 3 months follow-up. PLIF patients had a 5% rate of cumulative complications. Mean hospital stay was 5.1 days with a re-operation rate of 14 %. The average economical, functional and total Prolo scores for PLIF were 4.0, 4.0, and 8.11, respectively. The mean postoperative ODI was 18.9%, and 84% of patients showed symptomatic improvement at 3 months follow-up. PLIF cases showed better clinical outcomes according to Prolo scores (P= <0.01). In addition, PLF cases showed a significant increase in the incidence of re-operation (P= 0.02) and length of hospital stay (P= 0.001) when compared to PLIF.

**Conclusion:** PLF and PLIF have shown to be safe treatment procedures with low complications rates. Overall outcomes were better with PLIF procedures, in addition to lesser rates of reoperation and hospital stay compared to the PLF technique.

#### **109. Does Recombinant Human Bone Morphogenetic Protein-2 (BMP) Use in Adult Spinal Deformity (ASD) Increase Complications and Are Complications Dose Related? A Prospective, Multicenter Study of 257 Consecutive Patients**

*Shay Bess MD (Rocky Mountain Hospital for Children), Breton G. Line BSME (Rocky Mountain Scoliosis & Spine), Oheneba Boachie-Adjei MD, Robert Hart MD (Ohsu Spine Center), Virginie Lafage PhD, Frank Schwab MD, PhD, Behrooz A. Akbarnia MD, Christopher P. Ames MD (University of California San Francisco Neuro Surgery), Douglas C. Burton MD, Richard A. Hostin MD, Eric Klineberg MD (University of California-Davis), Gregory Mundis MD (San Diego Center for Spinal Disorders), Christopher I. Shaffrey MD FACS (University of Virginia), Justin S. Smith MD PhD (University of Virginia Health System), International Spine Study Group*

**Introduction:** As off-label BMP use in ASD surgery has increased, BMP associated complications and under-reporting of acute complications have come under scrutiny. Purpose: evaluate BMP associated complication rates following ASD surgery.

**Methods:** Multicenter, prospective analysis of complication rates following ASD surgery for consecutive ASD patients receiving BMP (BMP) or no BMP (NOBMP). Inclusion criteria: age ≥18 years, ASD surgery 100 kyphosis (TK) > 60 degrees, complete demographic, radiographic, and operative data, and minimum 8 weeks follow up. Rates of major, minor, and complications requiring surgery evaluated. Correlations between total BMP dose, BMP dose/level and complications evaluated. Multivariate analysis performed.

**Results:** 257 of 316 patients, mean follow up 20.3 months (range 2.2-38), met inclusion criteria. BMP (n=155; average PSF dose 2.4mg/level; range 0-12 mg/level; average interbody dose 2 mg/level; range 0-18 mg) and NO BMP (n= 102) had similar age, BMI, smoking history, prior spine surgery, maximal scoliosis, SVA, levels fused, and estimated blood loss (p>0.05). BMP had greater Charlson comorbidity index, operative time, osteotomies/patient, and anteroposterior surgery (p<0.05). Total complications per patient were greater for

BMP vs. NOBMP (1.0 vs.0.5; p<0.05), however major complications, neurological and wound complications, superficial and deep infections, and complications requiring surgery were similar for BMP vs. NOBMP (p>0.05). Total posterior (PSF) BMP dose statistically correlated with total, major and neurological complications (p<0.05), however r values indicated small correlations (0.32, 0.14 and 0.14, respectively). PSF BMP dose per level did not correlate with major, wound or neurological complications, deep infections or return to OR (p<0.05).

**Conclusion:** BMP use in ASD, at BMP dose/level reported, is not associated with wound, superficial or deep infections or return to OR. Further research is needed to evaluate long term complications and complications associated with higher dosing.

#### **110. Results of the AANS membership survey on adult spinal deformity knowledge base: impact of training, practice experience and assessment of potential areas for improved education**

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**Introduction:** Adult spinal deformity(ASD) surgery is increasing in the spinal neurosurgeon's practice. A survey of neurosurgeon AANS membership assessed general deformity knowledge base and impact of current training, education and practice experience to identify areas of opportunity for improved education.

**Methods:** 11 questions developed and agreed upon by experienced spinal deformity surgeons tested ASD knowledge and were sub-grouped into five categories; (1)radiology/spinal pelvic alignment, (2)health related quality of life(HRQOL), (3)surgical indications, (4)operative technique, and (5)clinical evaluation. Chi-square test compared differences based on participant demographics. Three participant demographic questions were included(years of practice, spinal surgery fellowship training, percentage of practice comprised by spinal surgery).

**Results:** 1456 neurosurgeons responded. 43% had practiced >10 years. 20% completed a spine fellowship. 32% devoted >75% of their practice to spine. Overall correct answer percentage was 42%. Radiology/spinal pelvic alignment questions had overall lowest percentage correct(39%) while clinical evaluation questions had the highest(46%). HRQOL and surgical indications both had 44% correct and operative technique was lower(40%). >10 years in practice, spine fellowship, and >75% spine practice were significantly associated with overall percentage correct(p=0.004,<0.001,<0.001, respectively). >10 years in practice was significantly associated with increased percent correct answers to surgical indications and clinical evaluation questions(p=0.04,<0.001, respectively). Spine fellowship was highly significantly associated with percent correct in all categories(p<0.001,0.001,<0.001,<0.001,0.02,<0.001). >75% spine practice was highly significantly associated with percent correct(p<0.001 for all five categories). Interestingly, the highest error rate was seen in risk for postoperative coronal imbalance with a very low percent correct response(23%). The percent correct was no better in the fellowship group(26%).

**Conclusion:** Our data suggest that current ASD knowledge could be improved in neurosurgery. Knowledge may be augmented with increased neurosurgical experience, additional spinal surgery training, and dedicated spine practices. Neurosurgical education should particularly focus on radiology/spinal pelvic alignment especially pelvic obliquity and coronal imbalance and operative techniques for ASD.

**111. The Schwab-SRS Adult Spinal Deformity Classification: Assessment and Clinical Correlations Based On A Prospective Operative and Non-Operative Cohort**

Virginie Lafage PhD, Frank Schwab MD, PhD, Christopher I. Shaffrey MD FACS (University of Virginia), Justin S. Smith MD PhD (University of Virginia Health System), Bertrand Moal MS, Christopher P. Ames MD (University of California San Francisco Neuro Surgery), Kai-Ming G. Fu MD PhD (Weill Cornell Medical College), Praveen V. Mummaneni MD (University of California San Francisco Spine Center), Douglas C. Burton MD, Munish Gupta MD (University of California - Davis; Ortho Surgery), Vedat Deviren MD (University of California San Francisco), Gregory Mundis MD (San Diego Center for Spinal Disorders), Robert Hart MD (Ohsu Spine Center), Shay Bess MD (Rocky Mountain Hospital for Children), International Spine Study Group

**Introduction:** The Schwab-SRS Classification of Adult Spinal Deformity (ASD) is a validated system that provides a common language for the complex pathology of ASD. Classification reliability has been reported; however, correlation with treatment has not been assessed. Purpose: assess association between disability, classification type/modifier and ASD treatment.

**Methods:** Prospective analysis of consecutive ASD patients from a multi-center spinal deformity study group. Inclusion criteria: age =18 yrs and scoliosis =20°, sagittal vertical axis (SVA) =5cm, pelvic tilt (PT) =25° or thoracic kyphosis (TK)> 60°. All patients had 36" standing x-rays. Differences in demographics, health related quality of life (HRQOL; ODI, SRS, SF36), and classification curve type/modifier distribution between operative (OP) and nonoperative (NONOP) treatment were evaluated.

**Results:** 757 patients (mean age 53 yrs, range 18-85) met inclusion criteria. OP (n=311) were older (mean age 56 vs 51 yrs), had greater BMI (27.7 vs 25.7), more previous surgery (45% vs 19%), and greater Charlson comorbidity index (1.1 vs 0.85) than NONOP (n=446), respectively (p<0.05). OP had worse HRQOL scores on all surveys than NONOP (p<0.05). OP and NONOP had similar coronal alignment (p<0.05). OP had worse sagittal spinopelvic alignment for all measures than NONOP except cervical lordosis, TK and pelvic incidence (PI). OP had greater percentage of pure sagittal classification (type S; OP=23%, NON=14%; p<0.05). OP had worse grades for all modifier categories: PT (26% vs 16%), PI-lumbar lordosis mismatch (37% vs 21%) and global sagittal alignment (29% vs 9%), OP vs NONOP, respectively (p<0.05).

**Conclusion:** Prospective analysis of OP vs NONOP treated ASD patients demonstrated OP patients were older, had more co-morbidities, greater disability and worse sagittal spinopelvic alignment as defined by the Schwab-SRS Classification subtype and sagittal modifiers. This classification is descriptive, correlates with HRQOL scores, and corresponds to treatment preference for ASD.

**112. Diffusion Tensor Imaging Detects Morphological Changes in the Spinal Cord after Stem Cell Transplantation**

Shekar N. Kurpad MD PhD (Medical College of Wisconsin), Michael Jirjis BS, Brian Schmit PhD

**Introduction:** Our goal was to determine whether morphological and functional changes induced by stem cell implants can be detected using magnetic resonance diffusion tensor imaging (DTI).

**Methods:** One week after inducing a moderate spinal cord injury at the T8 level in a group of Sprague Dawley rats, rodent derived C17.2 neural stem cells were transplanted into the site of injury and compared against groups that received sham injection or immunosuppression only. In vivo DTI was performed 2, 5, and 10 weeks post injury on a 9.4 T Bruker using a spin-echo imaging sequence with 12 directions and a b = 500 s/mm<sup>2</sup>. DTI analysis was performed in the cervical segments of the spinal cord. Mean Diffusivity (MD) was calculated in region of

interest (ROI) selections for each axial slice. Since this particular stem cell line is known to produce allodynia of the forelimbs and changes to the astrocyte structure in the cervical spinal cord, average MD in the cervical segments, for each of the in vivo scan time points were compared against data from forelimb hot plate tests.

**Results:** As shown in our previous studies, heat tolerance in the forelimbs C17.2 recipients was found to be significantly decreased compared to the sham group (Tukey test; P < 0.01). Correspondingly, At 5 weeks after injury, MD of the stem cell line increased to an average of 1.44x10<sup>-3</sup> s/mm<sup>2</sup> in the cervical segments while comparison groups averaged 0.98x10<sup>-3</sup> s/mm<sup>2</sup>. Post-hoc Tukey's HSD tests showed that the stem cell group had significantly higher MD than the other groups (p<0.05). This statistical difference between the stem cell line and the other groups was maintained for the 10 week post injury in vivo scans.

**Conclusion:** These results indicate that mean diffusivity measures can be used to assess interventions that produce changes in the spinal cord structure and function.

**113. Improved Correlation of Motor or Sensory Deficits with Diffusion Tensor Imaging Study of the Spinal Cord in Patients with Unilateral Deficits**

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**Introduction:** To improve the clinical correlation of magnetic resonance imaging with patient motor or sensory status, we assessed the feasibility of spinal diffusion tensor imaging (DTI) in patients with spinal cord pathology and unilateral deficits.

**Methods:** Hospital ethics board approval was obtained. DTI was performed in the spinal cord of 21 subjects (13 patients and 8 controls). DTI was done in the cervical region for all the controls and in the pathological region of the spinal cord for patients. Fractional anisotropy (FA) and mean diffusivity (MD) were calculated by marking region of interests separately on the left and on the right in the spinal cord axial sections for patients and controls and the values were compared.

**Results:** DTI was able to be successfully performed in both the healthy controls and patients. In controls, there was no difference in the mean FA values between the right and left side (right = 0.592 ± 0.088, left = 0.570 ± 0.085; t-test, p=0.579). The MD values also did not differ between the right and left side (right = 1.149 ± 0.148, left = 1.173 ± 0.143; t-test, p=0.707). In patients, there was a significant difference in the mean FA values on the normal side (0.413 ± 0.110) compared to the affected side (0.261 ± 0.091); t-test, p=0.0028. There was also a difference in the MD values on the normal side (0.881 ± 0.139 x 10<sup>-3</sup> mm<sup>2</sup>/s), compared to the affected side (1.996 ± 0.153 x 10<sup>-3</sup> mm<sup>2</sup>/s, t-test, p=0.0001).

**Conclusion:** Spinal tractography is a feasible technique to assess spinal cord pathology and correlates with patients with unilateral neurological deficits. In the future, this technique may become a useful tool for assessing the spinal cord to identify unilateral lesioned tracts that correlate with functional deficits.

**114. Responsiveness and Sensitivity of a Clinical Impairment Measure Specific for Traumatic Tetraplegia: An International Multi-Centre Assessment of the GRASSP Version 1.0**

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**Introduction:** GRASSP was developed to capture subtle changes in neurological impairment of the upper extremity after cervical spinal

cord injury (SCI) during the acute, sub-acute, and chronic phases. Psychometric properties of reliability and validity are well established. Responsiveness testing is required to understand application of the GRASSP in clinical trials and interventional studies. Scientific Aims: 1) To develop responsiveness, and establish the sensitivity of GRASSP 2) To establish how the measure can be applied in clinical trials and interventional studies.

**Methods:** A prospective longitudinal study including individuals with acute tetraplegia is currently being conducted as a multi-centre/multi-national study. Serial testing consists of GRASSP, International Standards for Neurological Classification for Spinal Cord Injury (ISNCSCI), Spinal Cord Independence Measure (SCIM), Capabilities of Upper Extremity Questionnaire (CUE), Questionnaires and Life Satisfaction Survey (LISAT-11) administered 0 to 10 days, 1, 3, 6, and 12 months post injury. Analysis: A comparison of the standardized changes from baseline to each time point for GRASSP and ISNCSCI using the Freidman and Wilcoxin signed rank test will be conducted to determine amount of change captured by all measures.

**Results:** Sample: To date 122 patients have been enrolled (45-Can, 77-Eur), 80 (20-Can, 60-Eur) with 6 month follow up and 55 with (Can-10, Eur-48) with 12 month follow up. Enrollment in Europe is closed and in Canada will close in December 2012.. Results: Sub-analysis of small datasets show increased sensitivity of GRASSP in measuring the upper limb when compared to ISNCSCI across the recovery of one year.

**Conclusion:** GRASSP Version 1.0 is a sensitive upper limb impairment measure which will be useful in clinical and research settings to assess the sensory, motor and functional changes occurring after injury. The subtleties that the measure characterizes are valuable in elucidating the underlying approaches to improve concomitant hand function and define efficacy of new interventions.

### 115. Adult Intramedullary Spinal Cord Tumors: A 12-year Institutional Experience

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**Introduction:** Adult intramedullary spinal cord tumors (IMST) are an uncommon, but important entity. There have been few long-term studies that characterize progression-free survival of patients undergoing attempted resection. We present one of the largest series to date of adult patients undergoing IMST resection with long-term follow-up.

**Methods:** Seventy-nine consecutive adult IMST were analyzed retrospectively over a span of 12 years (1998-2010) at Cleveland Clinic. Patients were excluded on the basis of age <18 years, previous resections, metastatic disease, von Hippel-Lindau, and patients undergoing biopsy alone (resection must have been attempted for inclusion). The Modified McCormick Scale was applied to all patients both preoperatively and at last available follow-up.

**Results:** Of 79 patients, mean age was 44.2 years, with mean follow-up 51 months. Ependymomas comprised 48% of cases, astrocytomas 15%, and angiomas 15%. Gross total resection (GTR) was achieved in 66%; 71% of these cases had a visible plane of dissection (POD). There was a significant relationship ( $p < 0.001$ ) between POD and GTR. Postoperative neurological decline was present in 16%, but overall neurological improvement at last follow-up was 76%. Progression-free survival of ependymomas was 95.8 months and 62 months for low grade astrocytoma. Motor evoked potentials (MEPs) dropped below 50% during 20% of cases, which was not related to other outcomes. There was no relationship between ability to achieve GTR and progression free survival or overall outcome.

**Conclusion:** In our 12-year institutional experience of IMST resection, intraoperative POD was significantly related to ability

to achieve GTR. Achieving GTR was not significantly related to progression free survival or neurological outcome, which a finding worthy of further investigation. While this may represent one of the largest and best characterized series to-date, continued follow-up and observation will be essential to better characterize these patients.

### 116. Adverse Events in Emergent Oncologic Spine Surgery: A Prospective Analysis

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**Introduction:** Reporting on the morbidity and mortality of spine surgery in the literature has been primarily retrospective. Emerging prospective analyses of adverse events (AE) demonstrate significantly higher rates, suggesting under reporting in retrospective and prospective studies without AE as a targeted outcome. Emergency oncologic spine surgeries are generally palliative, to improve pain, neurology and health related quality of life. With limited life expectancy, adverse events can have catastrophic implications; therefore an accurate AE incidence must be considered in the surgical decision-making.

**Methods:** Prospective cohort study in a quaternary care referral center of consecutive patients between January 1, 2009 and December 31, 2010. Inclusion criteria were all patients undergoing emergency surgery for metastatic spine disease. AE data was reported and collected on standardized AE forms (SAVES) at weekly-dedicated M&M rounds attended by surgeons, house staff and nursing. After discharge AE were captured at 6 and 12 week follow-up.

**Results:** 42 patients met inclusion criteria, 22 males and 20 females. Data is complete in 100% (42 patients). Thirty-four patients (80.9%) had at least one adverse event. Four patients (9.5%) died during their admission. Intra operative surgical adverse events were observed in 42.9% of patients (9.5% incidental durotomy, 26.1% major blood loss above 2 liters). Transient neurologic deterioration occurred in 4 patients (9.5%). Infectious complications in this patient population were significant (surgical site: 7.2%; other: 54.8%). Delirium complicated the postoperative period in 23.8% of cases.

**Conclusion:** When evaluated in a rigorous prospective manner, metastatic spine surgery is associated with a higher morbidity than previously reported. This AE incidence must be considered by the patient, oncologist and surgeon in determining appropriate management and preventative strategies to reduce AE in this fragile patient population.

### 117. Predictors of Survival Following Surgical Management of Breast Cancer Metastatic to the Spine

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**Introduction:** The incidence of breast cancer causing metastatic epidural spinal cord compression (MESCC) is increasing, emphasizing the need to determine which patients are the best for aggressive surgical resection. We detail previously unreported features predictive of outcomes following spinal surgery for breast metastases.

**Methods:** A retrospective review was performed of all patients treated from June 2002 to August 2011 for surgical management of MESCC. Forty-three patients met the selection criteria for surgery. Survival curves were compared using the log-rank test. Correlation between variables was assessed using Pearson product-moment cor-



relation coefficients. Analyses were performed using STATA 12.0.

**Results:** Median survival for all patients was 29.3 months. Patients who underwent breast surgery for local control of cancer had a significantly higher median survival following spine surgery for MESCC (33.5 months) than patients who had no breast surgery (13.5 months,  $P = 0.0414$ ). A shorter time period between diagnosis of primary cancer and spine surgery was significantly associated with worse prognosis. Patients who required metastatic spine surgery within 2 years of primary breast cancer diagnosis had a lower median survival (13.5 months vs. 40.9 months,  $P = 0.0097$ ), and consisted primarily of patients who did not receive primary breast surgery (67%). Following the trend, patients who required spine surgery within 6 years of primary cancer diagnosis also had a lower median survival (23.1 months vs. 42.4 months,  $P = 0.0433$ ). The majority of these patients (70%) had undergone breast cancer surgery and experienced a swifter progression towards MESCC requiring surgery. Premenopausal status ( $P = 0.003$ ) and younger age (mean 46.4,  $P = 0.0001$ ) were associated with a quicker disease progression following breast surgery.

**Conclusion:** Breast cancer surgery and the time from primary cancer diagnosis to MESCC surgery were predictive of outcomes following spinal surgery. Age and menopausal status were associated with the rate of pathologic spinal metastases development following breast cancer surgery.

## Top Breakout Sessions Oral Platform Papers

### 118. Clinical Outcomes and Cost Utility of Adult Spinal Deformity Surgery in Real-World Care

*Matthew McGirt MD (Vanderbilt University Medical Center), Saniya S. Godil MD (Vanderbilt University), Scott L. Zuckerman MD BS (Vanderbilt University School of Medicine), Scott L. Parker MD, David Shau B.S., Stephen Mendenhall B.S., Joseph S. Cheng MD MS (Vanderbilt University Medical Center), Clinton J. Devin MD*

**Introduction:** In the era of healthcare reform, costs are not sustainable. Spinal deformity surgeries are expensive, incurring exorbitant costs to the hospital and patient, reaching as high as \$60,754 per surgery. Through the use of a prospective registry, we sought to determine the effectiveness and value (cost-utility) of adult spinal deformity surgery in real world care.

**Methods:** All patients undergoing elective spine surgery for thoraco-lumbar spinal deformity ( $\geq 5$  levels) at a single institution were enrolled into a prospective registry. Patient demographics, treatment variables, and 90-day surgical morbidity were assessed. Baseline and one-year patient reported outcomes (PROs) were prospectively assessed. DRG and CPT based Medicare fees and resource utilization were used to estimate overall direct healthcare costs. Patient and caregiver work-day losses were used to calculate indirect costs. The value of adult spinal deformity surgery was calculated as cost per QALY gained (Cost-utility analysis).

**Results:** A total of 37 patients were included in the study. Baseline characteristics, treatment variables and 90-day morbidity are described in Table 1. All PROs showed significant improvement at 1-yr ( $p < 0.05$ ), Figure 1. Seventy eight percent of the patients returned to work post-operatively and 67.7% of the patients came off narcotics postoperatively, Figure 2&3. Twenty-six (70.3%) patients reported an improvement in general health and 31 (83.8%) patients were satisfied with their outcome. The total mean cost (direct + indirect cost) was \$44,126 $\pm$ 10,654. The estimated QALY gain over 5-years was 0.90 QALYs, Figure 4. The cost utility (value) of adult deformity surgery was \$51,610/QALY gained.

**Conclusion:** Surgical management adult spinal deformity leads

to significant improvement in pain, disability, and quality of life. Although spinal deformity surgery incurs exorbitant costs to the hospital and patient, the estimated cost per QALY gained value over five years suggests that it is a cost effective option in long term compared to non-operative management which does not lead to any improvement in quality of life.

### 119. Comparative Effectiveness and Cost-Benefit Analysis of Topical Vancomycin Powder in Posterior Spinal Fusion for Spine Trauma and Degenerative Spine Disease

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**Introduction:** Surgical site infection (SSI) is a morbid complication with high cost in management of surgical spine patients. In this era of healthcare reforms, adjuvant therapies that not only improve quality, but also decrease cost, are considered of highest value. We introduced local vancomycin powder into our practice of posterior spinal fusion for spine trauma and degenerative spine disease and set out to determine the value and cost benefit of using vancomycin powder in surgical sites to prevent postoperative infections.

**Methods:** A retrospective review of patients undergoing posterior spinal fusion for trauma or degenerative disease over a 2-year period at a single institution was performed. One group (control group) received standard systemic prophylaxis only, whereas another (treatment group) received 1g of local vancomycin powder spread over the surgical wound in addition to systemic prophylaxis. Incidence of infection was the primary outcome evaluated and billing records were reviewed to determine total infection-related medical cost (cost of re-operation/wound debridement, medications, diagnostic tests). The payers cost was estimated to be 70% of the total billing cost.

**Results:** A total of 110 patients (Control=54, treatment=56) with spine trauma and 455 patients (Control=318, treatment=137) with degenerative disease were included. Control and treatment groups were similar at baseline. Use of vancomycin powder led to significant reduction in infection rate [Spine trauma: 13% vs. 0% ( $p = 0.02$ ); Degenerative spine disease: 5.3% vs. 0% ( $p = 0.005$ )]. No adverse effects of vancomycin use occurred. Mean cost of post-operative surgical site infection was \$33,705, Table 1. Use of vancomycin powder led to cost savings of \$438,165 per 100 posterior spinal fusions performed for traumatic injuries and \$178,637 per 100 posterior spinal fusions performed for elective degenerative pathology.

**Conclusion:** The use of topical vancomycin powder was associated with a significant reduction in incidence of postoperative infection, as well as infection-related cost. Use of adjuvant vancomycin powder is an effective and cost-saving option for preventing postoperative infections in posterior spinal fusion.

### 120. The Effect of Surgery on Health Related Quality of Life and Functional Outcome in Patients with Metastatic Epidural Spinal Cord Compression—the AOSpine North America Prospective Multicenter Study

*Michael G. Fehlings MD PhD FRCSC FACS (Toronto Western Hospital), Branko Kopjar MD, Charles Fisher MD, Alexander R. Vaccaro MD, Paul M. Arnold MD (Department of Neurosurgery), Laurence D. Rhines MD (University of Texas-MD Anderson Cancer Center), James M. Schuster MD (University of Pennsylvania), Joel Finkelstein MD (Sunnybrook Health Sciences Center), Mark B. Dekutoski MD (The Mayo Clinic), Ziya L. Gokaslan MD (Johns Hopkins University), John France MD*

**Introduction:** Studies suggested that combined surgery and radiotherapy provides optimal neurological recovery in patients with epi-

dural spinal cord compression (MESCC). The impact of surgery on functional and quality of life outcomes is less clear.

**Methods:** To date, 163 patients with solitary symptomatic MESCC were enrolled in a prospective multi-center, ongoing cohort study. Patients were followed for 12 months.

**Results:** The average age was 59 years (SD 12, range 29-85) with 57% males. Common primary sites were lung (23%), breast (15%), prostate (13%), kidney (13%), other genitourinary (4%) and, unknown (16%). Baseline Visual Analog Pain (VAS) level was 7.1 (SD 2.4); the ODI was 43.3 (SD 24.3); the SF36v2 Physical Component Score (PCS) was 32.3 (SD 7.7) and, the EQ-5D was 0.39 (SD 0.26). 43% of the subjects had normal ASIA motor impairment grade "E"; 38% had grade "D"; 15% "C", 1% "B" and, 2% "A". Median survival was 234 days (95% CI 151-304 days). 33% survived 12 months or more. Survival was strongly associated with the site of the primary neoplastic disease ( $P < .05$ ). About 64% of patients with breast cancer and only 14% of patients with lung cancer survived 12 months. Median survivals were 569 and 105 days in the breast and lung cancer groups, respectively. Patients who survived 3 months experienced significant improvement in pain, function and health utility. At 3 months, Pain VAS improved for 1.8 (SD 2.9) ( $P < .01$ ) and, ODI for 11.6 (SD 32.0) ( $P < .01$ ) and EQ5D .15 (SD .31) ( $P < .01$ ). The improvement in SF36v2 PCS and MCS were not statistically significant. The gains in EQ5D, ODI and VAS Pain were maintained in patients who survived 6 months.

**Conclusion:** Surgically treated patients with MESCC are a diverse group of patients with different prognoses. Survival prognosis is associated with type of primary cancer with lung cancer being associated with the poorest prognosis and breast cancer with the best. The surviving patients experience clinically relevant symptoms improvement and gains in function and utility. Our analysis supports use of surgery in patients with survival expectancy of 3 months or more.

### 121. Analysis of Lumbar Plexopathies and Nerve Injury after Lateral Retroperitoneal Transposas Approach: Diagnostic Standardization and Review

Amir Ahmadian MD (University of South Florida), Armen R. Deukmedjian MD (University of South Florida), Naomi Abel, Elias Dakwar MD, Juan S. Uribe MD (University of South Florida - Division of Neurosurgery)

**Introduction:** The minimally invasive lateral retroperitoneal transposas approach has become an increasingly popular means of fusion. The most frequent complication is related to lumbar plexus nerve injuries. Diagnosis can be made based on distribution of neurological deficit following the motor/sensory nerve injury. However, the literature has failed to provide a clinically relevant description of these complications. With accurate clinical diagnosis spine practitioners can provide more precise prognostic and management recommendations to include observation, nerve blocks, neurodestructive procedures, medications, or surgical repair strategies.

**Methods:** A thorough literature search of the MEDLINE database up to June 2012 was performed to identify studies that reported lumbar plexus and nerve injuries after the minimally invasive lateral retroperitoneal transposas approach. Included studies were assessed for described neurological deficits post-operatively. A clinically relevant assessment of lumbar plexus nerve injury was derived to standardize early diagnosis and outline prognostic implications.

**Results:** 74 citations screened, 57 articles were assessed and 18 studies selected with a total 2,310 subjects. 304 patients were reported to have possible plexus related complications. Incidence of documented nerve/root injury and abdominal paresis ranges from zero to 3.4% and 4.2% respectively. Motor weakness ranged from 0.7% to 33.6%. Sensory complications ranged from 0% to 75%. A lack of consistency in the descriptions of the lumbar plexopathies/nerve injury as well as lack of diagnostic paradigms was noted across studies reviewed.

**Conclusion:** There is underreporting of postoperative lumbar

plexus nerve injury and a lack of standardization of clinical findings of neural complications related to the minimally invasive lateral retroperitoneal transposas approach. The provided diagnostic paradigm allows for an efficient and accurate classification of postoperative lumbar plexopathies and nerve injury.

## Oral Poster Abstracts

### 200. Motor Axon Misdirection and Behavioral Deficit in Rat Sciatic Neuroma in Continuity Injuries

Jacob D. Alant MBChB MMed FRCSC, Ferry Senjaya, Aleksandra Ivanovic, Joanne Forden, Antos Shakhbazau, Rajiv Midha MD (University of Calgary)

**Introduction:** Management of traumatic neuroma-in-continuity (NIC) injuries poses ongoing challenges for peripheral nerve surgeons. Axonal misdirection with non-specific reinnervation, frustrated regeneration and axonal attrition are believed to be among the anatomical substrates that underlie the poor functional recovery associated with these devastating injuries. Functional deficits associated with axonal misdirection in experimental non-transection injuries have not been studied. We hypothesized that experimental NIC injuries would result in motor axon misdirection and persistent deficits.

**Methods:** 42 rats were randomized into 7 groups for sciatic nerve surgeries (Fig.1). NIC injuries were simulated by a modified malleus nipper (MN). Serial skilled locomotion analysis was performed up to 12 weeks. Retrograde labeling of motoneurons was performed by Fast Blue and Di-I application to the medial gastrocnemius (MG) and sural nerves respectively and tibialis anterior muscles were weighed.

**Results:** Muscle weights of NIC groups were similar to crush injuries (Fig.2). Ladder rung slip ratios show statistically significant differences at weeks 6 and 12 (Fig.3) and the NIC injury groups included injuries ranging functionally from axotomy to neurotmesis. The motoneuron pool sampling technique used was successful to reveal the same trend of axonal misdirection into MG and sural nerves (Fig.4). The highest relative misdirection was observed in the MN+50g and TRANSECTION groups (Fig.5). Statistically significant attrition of motor axons to the major motor (MG) nerve was also demonstrated (Fig.6). Good positive and negative correlations were observed respectively between average misdirection, motoneuron count and final functional deficits (fig.7).

**Conclusion:** Our novel injury model prominently demonstrates motor axon misdirection and attrition in NIC injuries of mixed motor nerves that correlate well with long-term functional deficits, despite successful muscle reinnervation. Although the theory is widely accepted, to our knowledge, this is the first experimental evidence to demonstrate the important detrimental role of misguided axonal regeneration in NIC injuries.

### 201. Dual Regeneration of Muscle and Nerve by Intravenous Administration of Human Amniotic Fluid derived Mesenchymal Stem Cells Regulated by Stromal Cell derived Factor-1 $\alpha$ in a Sciatic Nerve Injury Model

Dar-Yu David Yang MD PhD (ChangBing ShowChwan Memorial Hospital), Hung-Chuan Pan MD PhD (Department of Neurosurgery, Taichung Veterans General Hospital), Fu-Chou Cheng PhD (Taichung Veteran General Hospital)

**Introduction:** Human amniotic fluid derived mesenchymal stem cells (AFMSCs) have been shown to promote peripheral nerve regeneration. The expression of stromal cell derived factor-1 $\alpha$  (SDF-1 $\alpha$ ) in



the injured nerve exerts a trophic effect by recruiting progenitor cells that promote nerve regeneration. In this study, the authors investigated the feasibility of intravenous administration of AFMSCs according to SDF-1a expression time profiles to facilitate neural regeneration in a sciatic nerve crush injury model.

**Methods:** Peripheral nerve injury was induced in 63 Sprague-Dawley rats by crushing the left sciatic nerve using a vessel clamp. The animals were randomized into 1 of 3 groups: Group I, crush injury as the control; Group II, crush injury and intravenous administration of AFMSCs ( $5 \times 10^6$  cells for 3 days) immediately after injury (early administration); and Group III, crush injury and intravenous administration of AFMSCs ( $5 \times 10^6$  cells for 3 days) 7 days after injury (late administration). Evaluation of neurobehavior, electrophysiological study, and assessment of regeneration markers were conducted every week after injury. The expression of SDF-1a and neurotrophic factors and the distribution of AFMSCs in various time profiles were also assessed.

**Results:** Stromal cell derived factor-1a increased the migration and wound healing of AFMSCs in vitro, and the migration ability was dose dependent. Crush injury induced the expression of SDF-1a at a peak of 10-14 days either in nerve or muscle, and this increased expression paralleled the expression of its receptor, chemokine receptor type-4 (CXCR-4). Most AFMSCs were distributed to the lung during early or late administration. Significant deposition of AFMSCs in nerve and muscle only occurred in the late administration group. Significantly enhanced neurobehavior, electrophysiological function, nerve myelination, and expression of neurotrophic factors and acetylcholine receptor were demonstrated in the late administration group.

**Conclusion:** Amniotic fluid derived mesenchymal stem cells can be recruited by expression of SDF-1a in muscle and nerve after nerve crush injury. The increased deposition of AFMSCs paralleled the expression profiles of SDF-1a and its receptor CXCR-4 in either muscle or nerve. Administration of AFMSCs led to improvements in neurobehavior and expression of regeneration markers. Intravenous administration of AFMSCs may be a promising alternative treatment strategy in peripheral nerve disorder.

## 202. Intercostal to Long thoracic Nerve Transfer for the Treatment of Winged Scapula a Cadaveric Feasibility Study

Robert G. Louis MD, Theofanis F Kollias BS (St George's University School of Medicine), R. Shane Tubbs PhD, PA-C, Marios Loukas MD PhD, W. Jeffrey Elias MD (University of Virginia Health Systems)

**Introduction:** Winging of the scapula occurs from a variety of injuries to the long thoracic nerve. Despite its relatively common occurrence, very few surgical procedures are attempted to reinnervate the muscle and restore shoulder function. We investigated the technical feasibility of harvesting intercostal nerves (IN) for nerve transfer to the long thoracic nerve (LTN) for the treatment of winged scapula.

**Methods:** Ten formalin fixed adult human cadavers (20 sides) were examined. The LTN was identified along the lateral border of serratus anterior (SA) and IN were identified along the inferior surface of each rib at the mid-axillary line. At the level of the mid-clavicular line, each IN was sectioned and mobilized. Measurements were made of the length and diameter of each IN available for mobilization from both the anterior axillary and mid-clavicular lines to the LTN. All measurements were made with calipers.

**Results:** Within each specimen, the length of each 3rd, 4th, 5th and 6th IN was sufficient to bridge the distance between the second and sixth intercostal spaces along the mid axillary line. Mobilizing of the IN from midaxillary to mid-clavicular lines was sufficient in each specimen to achieve tensionless anastomoses to the LTN at the second intercostal space.

**Conclusion:** Nerve transfer of multiple IN to the LTN is possible and may provide surgeons the ability to restore shoulder function for scapular winging. In cases of total brachial plexus injury, where musculocutaneous restoration is a priority, the 5th and 6th IN can still be used for anastomosis to LTN.

## 203. The Diagnostic Assessment of Hand Elevation Test in Carpal Tunnel Syndrome

Insoo Kim MD PhD (Keimyung University Dongsan Medical Center)

**Introduction:** The aim of this study is to establish the value of hand elevation test as a reproducible provocative test for the diagnosis of carpal tunnel syndrome (CTS).

**Methods:** We had a prospective study of 45 hands of 38 patients diagnosed with carpal tunnel syndrome between April 2003 and August 2005. The diagnosis of carpal tunnel syndrome was based on the American Academy of Neurology clinical diagnostic criteria. Experimental and control group patients underwent Tinel's test, Phalen's test, carpal compression test and hand elevation test as provocative tests for carpal tunnel syndrome.

**Results:** We used chi-square analysis to compare with Tinel's test, Phalen's test, carpal compression test and hand elevation test. The sensitivity and specificity of the hand elevation test is 86.7 % and 88.9 % each. Tinel's test had 82.2 % sensitivity and 88.9 % specificity. Phalen's test had 84.4 % sensitivity and 86.7 % specificity. Carpal compression test had 84.4 % sensitivity 82.2 % sensitivity. Comparisons of sensitivity and specificity between hand elevation test and Tinel's test, Phalen's test, and carpal compression test had no statistically significant differences. To compare the diagnostic accuracies of four tests, the area under the non-parametric receiver operating character (ROC) curve was applied.

**Conclusion:** The hand elevation test has higher sensitivity and specificity than Tinel's test, Phalen's test, and carpal compression test. Chi-square statistical analysis confirms the hand elevation test is not ineffective compared with Tinel's test, Phalen's test, and carpal compression test.

## 204. Nerve Isografts in Inbred Lewis Rats Have Minimal Rejection and Support Axonal Regeneration

Amgad S. Hanna MD FAANS (University of Wisconsin School of Medicine), Katie Kaeppler, Colton Thompson, Joanna Zurko, Euhua Hwang, Mark Ehlers, Daniel Hellenbrand

**Introduction:** In the past few decades, there has been extensive interest and use of peripheral nerve grafts (PNG) in research. Pre-degenerated PNGs have been shown to be effective in facilitating axonal growth in the injured spinal cord. Previous studies have used allografts in combination with an immunosuppressant, such as cyclosporine A (CSA) or more recently FK506, to prevent graft rejection. CSA has been shown to be involved in nephrotoxicity, hepatotoxicity, and cardiotoxicity, as well as increased susceptibility to infection. One way to overcome the drawbacks of the use of allografts is to use isografts from an inbred rat line, the Lewis rats. We posit that the use of inbred Lewis rats would eliminate the need for an immunosuppressant, such as CSA, in peripheral nerve transplant studies. Eliminating the need for immunosuppression would more closely mimic PNG use in humans and would reduce harmful side effects associated with graft rejection and immunosuppression regimens.

**Methods:** This study included four groups of rats: Lewis rats with an isograft (Lewis ISO), Lewis rats with an autograft (Lewis Auto), SD rats with an allograft (SD no CSA), and SD rats with an allograft that were immunosuppressed with CSA (SD + CSA). To detect activated cytotoxic T-cells, slides were stained using anti-CD8-a; to detect ED1+ macrophages, slides were stained with anti-CD68 antibody; to detect regenerated axons, slides were stained with anti-neurofilament antibody.

**Results:** At 28 days, SD rat allografts with no CSA had significantly more cytotoxic T-cells than other groups. The Lewis autografts and Lewis isografts had significantly more axons crossing the centerline of the image versus the SD rat allografts with no CSA.

**Conclusion:** The results from this study demonstrate that isografts

in Lewis rats are histocompatible and support axonal regeneration. Therefore, Lewis rat peripheral nerve isografts could be used as a research model to better mimic clinical autografts.

### 206. Accurately Measuring Outcomes after Surgery for Adult Chiari I Malformation: Determining the most Valid and Responsive Instruments

Saniya S. Godil MD (Vanderbilt University), Scott L. Parker MD, Scott L. Zuckerman MD BS (Vanderbilt University School of Medicine), Stephen Mendenhall B.S., Matthew McGirt MD (Vanderbilt University Medical Center)

**Introduction:** There has been a transition to utilizing patient reported outcome instruments (PROi) to assess surgical effectiveness. However, none of these instruments have been validated for outcomes of adult Chiari I Malformation. We set out to determine the relative validity and responsiveness of common PROi in accurately measuring outcomes for adult Chiari I Malformation.

**Methods:** Fifty patients undergoing suboccipital craniotomy for adult Chiari I Malformation were entered into an prospective registry and followed for one year. Baseline and 1-year PRO [VAS-Head, VAS-Neck, NDI, Headache Disability Index (HDI), SF-12, Zung Depression and EQ-5D] were assessed. A level of improvement in general health after surgery was defined as meaningful effectiveness. In order to assess the validity of PROi to discriminate between meaningful improvement versus not, receiver operating characteristic (ROC) curves were generated for each outcomes instrument. The difference between standardized response means (SRM) in patients reporting meaningful improvement versus not was calculated to determine the relative responsiveness of each outcomes instrument.

**Results:** For pain and disability, NDI was the most accurate discriminator of meaningful effectiveness (AUC: 0.90) and also most responsive to post-operative improvement (SRM difference: 1.87), Table 1 and Figure 1. For general health and quality of life, SF-12 PCS, EQ-5D and Zung were all accurate discriminators of meaningful effectiveness, however, SF-12 PCS and EQ-5D were most accurate. SF-12 PCS was also most responsive, Table 1 and Figure 1.

**Conclusion:** For pain and disability, NDI is the most valid and responsive measure of effectiveness after surgery for Chiari I Malformation. For health-related quality of life, SF-12 PCS and EQ-5D are the most valid and responsive measures of effectiveness after surgery for Chiari I Malformation. NDI with SF-12 or EQ-5D is the most valid measure of pain and disability, and quality of life in patients with Chiari I Malformation and should be considered in cost-effectiveness studies.

### 207. The Biomechanics of a Unilateral Approach to Minimally Invasive Lumbar Decompression—A Cadaver Study

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**Introduction:** Minimally invasive lumbar decompression, using tubular retractors and a unilateral approach for bilateral decompression, has become a common modern approach for lumbar stenosis. In addition to known advantages of this technique with peri-operative outcomes, this approach may potentially mitigate post-operative increases in segmental motion.

**Methods:** Six human complete lumbar cadaveric specimens were used. With the use of a 400 N follower-load, each specimen was tested in the following conditions: flexion, extension, left and right axial rotation, and left and right lateral bending. Each testing condition was evaluated following three separate interventions at a single-level (L4/

L5): 1) Minimally invasive decompression (MI-D), 2) Facet-sparing, bilateral decompression, and 3) Bilateral decompression with a wide medial facet removal. Range of motion following each testing condition was compared to intact specimens.

**Results:** Both a minimally invasive and traditional decompression create significant increases in ROM in all conditions. With flexion-extension testing, ROM at the operative level (L4/L5), increased with each intervention. With flexion-extension testing, ROM at L4/L5 for intact, MI-D, traditional decompression, and wide-decompression was 9.2, 9.6, 10.7, and 12.3 degrees, respectively. Similar serial increases in segmental motion were found with other testing conditions. When compared to the MI approach, traditional decompression produces a significantly greater increase in ROM in flexion-extension ( $p < 0.005$ ) and axial rotation ( $p < 0.05$ ). When compared to the intact spine, the MI-D approach may cause increased ROM with lateral bending on the approach side ( $p < 0.05$ ). Lateral bending on the non-approach side is not significantly changed when compared to intact specimens. Lastly, wide bilateral medial facet removal (40-50%) causes a statistically significant increase in segmental motion. This increase in motion is especially notable with axial rotation.

**Conclusion:** While both minimally invasive and traditional lumbar decompressions may increase post-operative ROM in all conditions, a minimally invasive approach causes significantly less segmental mobility. With an MI approach, increased movement with lateral bending is only toward the approach side. Further, non-facet sparing decompression is further destabilizing in all conditions, especially axial rotation.

### 208. The Impact of Obesity on Patient-reported Outcome Measures after Degenerative Cervical Spine Disease Surgery

Brenda Machado Auffinger MD (University of Chicago Medical Center), Sandi Lam MD (University of Chicago Medical Center), Jennifer Kraninger, Jingjing Shen MD, Ben Z. Roitberg MD (University Of Chicago)

**Introduction:** Obesity is a growing public health problem. A considerable number of patients undergoing cervical spine surgery are obese, but the correlation between obesity and surgical outcome is still unclear.

**Methods:** We analyzed a prospectively-collected spine surgery registry with patient-reported outcome (PRO) measures. Visual Analog Scale (VAS), Neck Disability Index (NDI), Short Form-36 (SF-36) and patient rating scores were collected preoperatively, 3 and 6 months post-surgery. Mixed-effects linear models and linear regression models were applied to investigate the relationship between different World Health Organization obesity classifications and surgical outcome.

**Results:** 88 patients had surgery for degenerative cervical spine disease with 97.72% follow-up at 3 months and 94.31% at 6 months postoperatively. Mean age was 56.57 years, 51.59% were female, and 21.27% were smokers. Mean body index mass (BMI) was 27.92 kg/m<sup>2</sup>±7.9; 28.57% were overweight (BMI 25-29.9), 31.57% were obese (Class I obesity, BMI 30-34.9). Overall complication incidence was 3.4%. BMI categories did not correlate with surgical complication (R<sup>2</sup>: 0.06) or age (R<sup>2</sup>: -0.07). Surgical complications correlated with smoking (R<sup>2</sup>: 0.356,  $p < 0.001$ ). Through linear regression analysis, we found a positive correlation between BMI and VAS at 6 months (R<sup>2</sup>: 0.298,  $p < 0.05$ ) and between BMI and change in NDI (between baseline-6 months) (R<sup>2</sup>: 0.385,  $p < 0.01$ ) suggesting that obese patients had less improvement and more pain 6 months postoperatively than non-obese patients. Overweight patients had worse MCS values (R<sup>2</sup>: -0.275,  $p < 0.05$ ), obese patients had worse patient ratings (R<sup>2</sup>: 0.333,  $p < 0.05$ ). Severely obese (Class II obesity, BMI 35-39.9) patients displayed worse General Health (GH) scores in the SF-36 at 6 months (R<sup>2</sup>: -0.297,  $p < 0.05$ ).

**Conclusion:** Obesity is a prevalent condition in degenerative cervical spine surgery patients. Obesity was not correlated with increased incidence of surgical complications. Obese patients had worse postoperative PRO scores and less overall patient-rated improvement when compared to non-obese patients.

### 209. Extent of Pre-operative Depression is Associated with Return to Work after Lumbar Fusion for Spondylolisthesis

Stephen Mendenhall B.S., Scott L. Parker MD, David Shau B.S., Saniya S. Godil MD (Vanderbilt University), Matthew McGirt MD (Vanderbilt University Medical Center)

**Introduction:** Low back pain is the most expensive cause of work-related disability in the U.S., with indirect costs secondary to missed work contributing a significant portion of overall cost. Identifying factors associated with an increased duration of missed work post-operatively could be used to more effectively select patients with the greatest opportunity for a successful outcome, and reduce the associated indirect costs of spine surgery. We set out to determine the effect of pre-operative depression on post-operative return to work in patients undergoing TLIF for degenerative spondylolisthesis.

**Methods:** Fifty-eight patients undergoing TLIF for grade I degenerative lumbar spondylolisthesis were included. Patient demographics, clinical presentation, radiological studies, and operative variables were assessed. Patient-assessed outcome (PRO) measures (VAS, ODI, EQ-5D) were prospectively obtained via phone interview at baseline and two-years post-operatively. To understand the factors associated with prolonged return to work (RTW), univariate linear regression analysis and stepwise multivariate Cox proportional hazards model was used.

**Results:** All PROs significantly improved two years after TLIF ( $p < 0.001$ ). Of the 32 patients working prior to surgery, 26 (81%) returned to work post-operatively, Figure 1. Independent of patient age; pre-operative pain, disability, and quality of life; and extent of post-operative improvement, increased pre-operative Zung depression score remained significantly associated with a prolonged return to work ( $p = 0.02$ ), Figure 2 and Table 1. There was a step-wise increase in return to work for patients with higher pre-operative Zung depression score, Figure 3.

**Conclusion:** Independent of post-operative improvement in pain, disability, and quality of life, the extent of pre-operative depression was an independent predictor of time to return to work in patients undergoing TLIF, suggesting that regardless of how successful TLIF surgery may be, greater depression will delay or prohibit ability to return to work post-operatively. Pre-operative Zung scores may help to identify and stratify patients least likely to return to work post-operatively.

### 210. Laminoplasty vs Laminectomy and Fusion to Treat Cervical Spondylotic Myelopathy: Outcomes of the Prospective Multicenter AOSpine International CSM Study

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**Introduction:** The optimal posterior surgical approach to treat cervical spondylotic myelopathy (CSM) remains debated with varying opinions favoring laminectomy and fusion vs. laminoplasty. To address this controversy, we present an analysis of a prospective observational multicenter study examining outcomes of surgical treatment for CSM.

**Methods:** Subjects included were a part of a larger ongoing prospective observational study that has enrolled 492 subjects with CSM involving 16 clinical sites in Europe, Asia, North and South America.

Of those, 108 received laminectomy and fusion; 66 received laminoplasty. The choice of surgical approach was at the discretion of the surgeon. Outcome measures were the Modified Japanese Orthopedic Assessment Scale (mJOA), the Nurick scale, the Neck Disability Index (NDI) and the SF36 Physical (PCS) and Mental (MCS) Component Scores.

**Results:** Average age was 60.2 years (SD 10.8), 29.8% were female. Subjects treated with laminectomy and fusion had more levels operated (5.0 vs. 4.4,  $P < .01$ ), shorter length of stay (7.7 vs. 15.7 days,  $P < .01$ ) and, less severe neurologic impairment measured by mJOA (12.6 vs. 11.2,  $P < .01$ ). There were no differences in age, and baseline NDI, SF36v2 PCS and SF36v2 MCS. At 12 month follow-up, there were no differences in neurologic and functional outcomes for laminoplasty compared to laminectomy and fusion; mJOA (3.0 and 2.3, respectively,  $P = 0.15$ ). Moreover, there were no differences in NDI (13.3 and 12.0, respectively,  $P = 0.71$ ), SF-36v2 PCS (8.5 and 7.7, respectively,  $P = 0.66$ ) and SF-36v2 MCS (7.9 and 6.9, respectively,  $P = 0.56$ ).

**Conclusion:** Patients undergoing laminectomy and fusion and laminoplasty surgery for CSM show similar improvements in generic and disease specific outcome measures allowing for baseline differences in clinical presentation between the two groups of patients. Longer term follow-up will be required to determine whether any differences in outcome between the two forms of treatment emerge.

### 212. Defining the Relative Utility of Lumbar Spine Surgery: A Systematic Literature Review of Common Surgical Procedures and Their Impact on Health States

Cyrus Chi-Ho Wong MD BSc (Vanderbilt University), Scott L. Parker MD, Saniya S. Godil MD (Vanderbilt University), Marcus J. Gates (Mayo Clinic), Joseph S. Cheng MD MS (Vanderbilt University Medical Center), Matthew McGirt MD (Vanderbilt University Medical Center)

**Introduction:** Recently, the importance of measuring quality of life gains after surgical procedures has been revealed, as it will prove critical for health policy makers to assess relative effectiveness and value of various surgical procedures and help direct health care expenditure in an efficient and cost effective manner. We conducted this systematic review to compare the baseline and postoperative EQ-5D utility scores for common surgical procedures reported in the literature to obtain post-operative quality-adjusted life year (QALY) gains and establish the relative utility of lumbar spine surgery as compared to other surgical procedures commonly performed in the U.S. healthcare system.

**Methods:** A systematic literature review was conducted to identify all studies reporting preference-based general health state instrument EuroQol-5D (EQ-5D) after surgical procedures. Studies reporting preoperative/baseline EQ-5D scores as well as post-operative EQ-5D scores were included. For each study, the number of patients included and baseline/preoperative and follow-up mean EQ-5D index score was recorded. Mean quality-adjusted life year (QALY) gain for each intervention was calculated.

**Results:** A total of 67 studies comprising 95,014 patients were identified. Patients with lumbar spondylosis had the lowest preoperative EQ-5D score (0.36), followed by knee osteoarthritis and hip osteoarthritis, Table 1. The greatest QALY gain was seen in patients undergoing hip arthroplasty (0.38), knee arthroplasty (0.35) and lumbar spine surgery (0.32), nearly 2.5-fold greater QALY gained than for all other surgical procedures, Table 1 and Figure 1.

**Conclusion:** Patients with lumbar spondylosis have the worst reported HRQOL at baseline compared to other surgical cohorts in the literature. This, coupled with the high prevalence of lumbar spondylosis, incurs a detrimental impact on the overall health of U.S. population. Lumbar spine surgery leads to significant QALY gains compared to other surgical procedures, highlighting the high utility and value of lumbar spine surgery compared to other common surgical procedures.



**213. Use of a Prospective Web-based Registry to Determine the Relative Value of Surgical and Medical Treatments of Degenerative Spine Disorders: Proving the Real-world Value of Surgical Care**

Scott L. Parker MD, Saniya S. Godil MD (Vanderbilt University), Oran Aaronson MD (Vanderbilt University Medical Center), Clinton J. Devin MD, Joseph S. Cheng MD MS (Vanderbilt University Medical Center), Matthew McGirt MD (Vanderbilt University Medical Center)

*Introduction:* Current healthcare reform calls for the reduction of healthcare procedures that are less effective, more costly, and of little “value”. However, the methodology and infrastructure to guide value-based purchasing of the reform era have yet to be devised. We developed a novel, web-based, prospective registry that generates risk-adjusted evidence on the comparative effectiveness, quality, cost, and value of spine care at our comprehensive spine center.

*Methods:* A novel web-based electronic registry was designated as quality improvement, funded by the hospital system, and introduced as standard of care into the practice of a multidisciplinary spine center to record and follow all surgically treated patients and a representative sampling of medically managed patients. Data was collected at baseline, 3-months and 12-months, Table 1.

*Results:* An average of 28 patients per week received surgical spine care at our center, 98% of which were captured into the registry at baseline. A sample of six medically managed patients were enrolled per week. One-year follow-up was available in 83% of patients. A significant ( $p < 0.05$ ) improvement in all outcome measures occurred after surgery in all diagnosis groups, Figure 1. Data on 12-month surgical quality, effectiveness, patient satisfaction, return to work, cost, and value for the seven most common surgical procedures and three medical treatment groups are given in Table 2, Figures 2&3. Medical management ranked best in cost but last in value (cost per effect), Figure 4.

*Conclusion:* Web-based registries incorporating cost measures and validated patient reported outcome instruments allow for a feasible method of measurement of quality, effectiveness, and value of “real-world” spine care. Value (effect per cost) versus cost alone assessment markedly influenced the measured worth of treatment options and will likely aid in value-based decision analysis on reduction of waste in spine care reform.

**214. Pharmacokinetics and Safety of Intraspinal Vancomycin**

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*Introduction:* Rising rates of resistant microbes as well as recent changes in CMS payment policy highlight the need for new research to reduce surgical wound infection rates. Intraspinal antibiotic application (intraoperative placement of antibiotics within the wound) is rapidly growing but little researched practice that offers great potential.

*Methods:* Thirty adult posterior spinal fusion patients undergoing their first procedure were assigned to receive one of three escalating doses of intraspinal lyophilized Vancomycin. Vancomycin concentrations in blood and wound seroma fluid (via wound drain) were measured immediately after surgery and every morning until drains were removed to determine pharmacokinetic parameters.

*Results:* Mean area under the curve (AUC) Vancomycin concentrations in blood and seroma fluid for each dose group was determined. In the lowest dose group AUC remains greater than 400 times the minimally inhibitory concentration for standard MRSA strains for at least 4 days after surgery. Blood Vancomycin concentrations were undetectable in this group of subjects. No adverse events were noted.

*Conclusion:* A single intraspinal Vancomycin application at all three studied doses results in antibiotic levels within the wound which

vastly exceed maximal kill concentrations for even partially resistant MRSA strains continuously for at least 4 days after surgery. This method of antibiotic usage likely entails a lower risk of renal toxicity than IV administration due to undetectably low blood concentrations throughout treatment.

**215. Garbage In, Garbage Out: A Spinal Neurosurgeons Report Card as a Measure of Quality Patient Care and Outcomes. The Importance of Data Fidelity in Calculating Quality Metrics Utilizing University Health System Consortium (UHC) Clinical Database**

John J Knightly MD FAANS (Atlantic Neurosurgical Specialists), Charlotte Cosgrove, Bonnie B Weiss MSN RN (Atlantic Neurosurgical Specialists), Rami Bustami PhD MBA (Atlantic Health System), Scott A. Meyer MD (Atlantic Neurosurgical Specialists), John J Halperin MD FACP FAAN (Atlantic Health System)

*Introduction:* Surgeon report cards derived from administrative databases are becoming the normative assessment of physician quality and efficiency. Mortality index and 30-day readmission rates are common metrics used by hospitals, insurers and health care policy makers to evaluate the quality of health care. The validity of reports derived from an administrative database is directly related to the accuracy of clinical and coding data assigned at the time of admission and discharge. The data fidelity is key to accurately creating a surgeon’s report card.

*Methods:* A retrospective review of data accuracy was performed for a single neurosurgeon utilizing UHC Database for 2011. The physician role was classified as primary attending or other. Mortality index and 30-day readmission rate were calculated by physician role and statistical comparisons of these two measures were made using the z approximation test and Fisher’s exact test, respectively. Patient charts were reviewed to assess for improper documentation of physician role and coding errors.

*Results:* 152 patients were included in the original report card; 61 (40%) with primary attending physician role and 91 (60%) with “other” role. The original report card gave a mortality index of 0.79; however when the physician’s defined role was primary only, this dropped to 0.46. The rate of 30-day readmission was lower when the physician’s defined role was primary attending (3%) compared to other role (12%). In a review of 20 randomly selected charts from the “other” role group, there were 14 cases (70%) in which the physician had no significant role or was erroneously assigned. Also out of 10 deaths attributed to the physician in the role of “other”, 4 cases (40%) showed similar errors in assignment.

*Conclusion:* Inaccurate data entry used in calculating patient and clinical outcomes can lead to high error rates when a large administrative database is used to assess physician quality measures.

**216. Smoking Associated With Increased Health-Care Costs and Worse Outcomes in Spine Surgery**

Christian Bowers MD (University of Utah Hospital), Erica Fay Bisson MD (University of Utah Health Care), Meic H. Schmidt MD (University of Utah Health Center)

*Introduction:* The cost of spine surgery and care is growing exponentially, and cost-effectiveness is a critical consideration. Smoking has been shown to increase hospital costs in general surgery, but this impact has not been reported in spinal surgery patients.

*Methods:* We performed a retrospective cross-sectional analysis of all non-obese patients admitted for spine surgery to the University HealthSystem Consortium (UHC) hospitals from 2005 through 2011. The patients were identified using ICD-9 codes and grouped according to pathology type: dorsopathy, congenital, fracture. The entire cohort was divided by smoking status into smokers and non-smokers.

The outcomes were length of stay, intensive care unit (ICU) admission, total cost, complication rates, and 14, and 30-day readmission rates. The data were reviewed using univariate analysis to identify significant differences between smoking and non-smoking patients.

**Results:** We identified 231,509 UHC patients admitted for spine surgery during the study period. Of these, 205,689 patients were non-smokers and 25,820 patients were smokers. Smoking was associated with longer hospital stays, more ICU admissions, higher total cost, higher complication rates, and higher 14, and 30-day readmission rates for patients with spinal disorders, including dorsopathy and fracture. The congenital group did not demonstrate a significant difference across all outcomes, although the 30-day readmission rate, total direct cost, and length of stay were significantly higher in smokers.

**Conclusion:** In spinal surgery patients admitted to UHC hospitals from 2005 through 2011, smoking was significantly associated with longer hospital stays, more ICU admissions, higher overall costs, higher complication rates, and higher 14, and 30-day readmission rates across the fracture and dorsopathy spinal pathologies. The congenital pathology group had significantly higher 30-day readmission rates, more total cost, and longer length of stay for smokers. In the current health-care climate focused on cost-effectiveness, smoking represents a potentially modifiable area for cost reduction, particularly for elective spinal surgery patients.

### 217. Rate of Anterior Cervical Discectomy and Fusion Following Initial Posterior Cervical Foraminotomy

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**Introduction:** In select patients, posterior cervical foraminotomy (PCF) and anterior cervical discectomy and fusion (ACDF) have been shown to lead to similar clinical outcomes when used to treat cervical radiculopathy. Nonetheless, ACDF is performed more frequently, in part because of a belief among spine surgeons that PCF requires operative revisions more frequently. The present study investigates the rate of ACDF re-operation following initial PCF.

**Methods:** Demographic, operative, and reoperation information was collected from the electronic medical records for all patients who underwent PCF at Cleveland Clinic between 2004 and 2011. All patients were subsequently contacted by telephone to more conclusively determine whether any revision operation was performed and identify complications.

**Results:** One hundred seventy-eight patients were reviewed, with an average follow-up of 31.7 months. Nine (5%) patients required ACDF revision operation at the index level. The reason for reoperation in these patients included cervical radiculopathy, foraminal stenosis, disc herniation, and cervical spondylosis. Patients who had ACDF revision were significantly younger (35 versus 25 years;  $p=0.03$ ), had lower BMI (29 versus 25;  $p=0.01$ ), and were more likely to take anxiolytic (22% versus 56%;  $p=0.04$ ) or antidepressant medication (27% versus 67%;  $p=0.02$ ), as compared to those that did not have a revision operation. The revision cohort also spent significantly less time in the hospital after their first operation (1.1 versus 0.4 days;  $p=0.05$ ). Postoperative complication rates did not differ between the groups.

**Conclusion:** This is the first study to determine conversion to ACDF following PCF. The present study demonstrates that PCF has a relatively low reoperation rate, similar to the historical reoperation rate for ACDF. Moreover, the reasons for reoperation were similar to those found following an initial ACDF. Accordingly, spine surgeons can operate via a PCF approach without putting patients at increased risk for ACDF revision surgery at the index level.

### 218. The Significance of Sagittal Alignment on Outcomes Following 3-Level Anterior Cervical Discectomy and Fusion

*Michael Mumert MD (University of Utah Hospital), Marcus D. Mazur MD (University of Utah), Meic H. Schmidt MD (University of Utah Health Center), Lubdha Shah, Erica Fay Bisson MD (University of Utah Health Care)*

**Introduction:** Regional and global sagittal alignment has become increasingly stressed for its vital role in promoting improved patient health status and function. This study evaluates the role of multiple radiographic analyses and their relationship to postoperative outcome for patients undergoing 3-level ACDF.

**Methods:** From 2000-2010, a retrospective analysis of patients who received 3-level anterior cervical discectomy and fusions for cervical stenosis, myelopathy, and kyphosis were evaluated for cervical sagittal alignment changes and its effect upon patients health related quality of life measures (HRQOL). Further inclusion criteria required pre-, 6-months post, and 1-year post-operative x-ray follow-up as well as corresponding visual analog pain scale (VAS) documentation. X-ray radiographic measurements evaluated preoperatively, at six-months and one-year postoperatively included (1) C1-C2 lordosis, (2) C2-7 Cobb angle, (3) C1-C7 sagittal vertical axis (C1-7 SVA), (4) C2-C7 SVA, C2-7 tangent, effective lordosis, and fusion status. The radiographic measurements and changes were then compared using a t-test to determine significance in relation to VAS score changes. Twenty-nine patients were identified who met the above inclusion criteria.

**Results:** 89% of patients reported improvement of VAS scores or remained the same at the 6-month follow-up compared to pre-op scoring this increased to 93% at 1-year follow-up. Increased C1-2 lordosis measured at both the 6-month and 1-year interval correlated with a higher change in VAS improvement ( $p<0.04$ ,  $p<0.01$ ). Increased Cobb change at the 1-year mark was also significantly associated with a greater change in VAS scores ( $p<0.03$ ).

**Conclusion:** Our initial hypothesis that establishment or maintenance of cervical lordosis following a multilevel anterior cervical fusion would positively impact patient reported postoperative pain scores was confirmed by this study as judged by the 6-month and 1-year C1-2 lordosis, and 1-year Cobb angle.

## MAYFIELD BASIC SCIENCE AWARD

### 219. Tissue-engineered Intervertebral Discs: Long Term Outcome in the Rodent Spine

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**Introduction:** Tissue-engineered intervertebral discs (TE-IVD) are a potential biological approach for the treatment of degenerative disc disease. Compared to conventional implants, TE-IVDs have the potential to mimic physiological properties of native discs. Prior in vivo studies by our group showed that biological discs have a similar biochemical composition and comparable mechanical properties as native discs. In this study we evaluated the long-term outcome of TE-IVDs implanted into the rat-tail spine according to radiological and histological parameters.

**Methods:** Eight animals underwent disc implantation, another 8 simple discectomy as control. The animals were sacrificed after 8 and 5 months, respectively. MRIs were obtained at 1, 5, and 8-month time points to study the disc height and the morphological appearance of TE-IVDs. T2-relaxation time (RT) measurements were performed to assess the water content and volume of the Nucleus Pulposus

(NP), T1 roh-RT measurements to assess its proteoglycan content. Segments were harvested for histology.

**Results:** Over 8 months the disc height of TE-IVDs remained constant between 68-74% of healthy control discs. MRIs showed a TE-IVD morphology comparable to native discs. T2-RT measurements revealed a similar NP water content with a lower NP volume compared to healthy discs. T1 roh-RT measurements indicated proteoglycan synthesis in TE-IVDs. Micro CTs showed no bridging bone formation. Histological slides showed an annulus fibrosus consisting of an organized fiber structure encapsulating the NP. The NP matrix appeared amorphous, stained for proteoglycans and contained chondrocyte resembling cells. The discectomy group showed complete collapse and no signs of viable disc tissue.

**Conclusion:** TE-IVDs remained viable over the life span of rats and maintained a structure similar to native discs. Biological discs showed evidence of dynamic adaptation to the host environment with matrix production and cell proliferation. Our experiments provide evidence that TE-IVDs are a viable option for the potential treatment of DDD and should be explored further in larger animal studies.

## 220. Tonsillar Ectopia is Not an Indicator of Symptom Severity in Chiari

Michael J. Rosner MD FCCM, Royce K. Bailey MD, Ian A Rosner (Michael J Rosner MD PA)

**Introduction:** Currently, 3-5mm of cerebellar tonsillar ectopia defines Chiari malformation (ACM), impairing autonomic and somatic functions by brainstem distortion. The assumption has been that symptom severity correlates with the degree of ectopia, but little supportive evidence has been presented.

**Methods:** 115 neurologically abnormal patients (exams consistent with ACM) were evaluated pre- and 12 months post-operatively; they rated severity of 57 symptoms (0=none to 3=severe). Tonsillar ectopia was classified as "Chiari 0", "minimal" (1-4mm ectopia), or "classical" (>5mm ectopia). The brainstem and upper cord were surgically decompressed by craniectomy, usually C1 laminectomy, often undercutting C2 and duraplasty. Tonsils resection extended to the exit of IX X and XI.

**Results:** Pre-operatively there was only one instance of 9 prevalent symptoms (figure 1), varied in severity by degree of ectopia: headache in "classical" Chiari patients was greater than "Chiari 0" patients (2.69±0.09 vs. 2.37±0.13, p=0.037), but not in "minimal Chiari". Post-operatively, pain with exertion in "minimal Chiari" was less than in "Chiari 0" (0.97±0.24 vs. 1.86±0.25, p=0.014) or "classical Chiari" (0.97±0.24 vs. 1.84±0.25, p=0.017). Additionally, symptoms were grouped into six organ systems: somatic NS, GI, CV, GU, pain and misc. (table 1&2). Pre-operatively, symptom severity did not vary with ectopia. Post-operatively, 7 differences in symptom group severity related to ectopia: 6 revealed slightly better results for "minimal" Chiari and 1 showed greater improvement in "classical" Chiari.

**Conclusion:** 1. Tonsillar ectopia on the midline sagittal MR correlates poorly with symptom severity, but may be a minor factor in long-term outcome. These statistical differences may not be clinically important. 2. ACM causes a wide variety of symptoms and dysfunction in most organ systems which are completely compatible with the anatomy and function of the brainstem and upper cervical cord. 3. With minimal to no tonsillar ectopia, surgical decisions are dependent upon the history and neurological exam.

## 221. Prevalence of Osteoporosis and Necessity of Measurement of Bone Mineral Density in Patients Requiring Spine Surgery

Insoo Kim MD PhD (Keimyung University Dongsan Medical Center)

**Introduction:** The purpose of this study is to investigate the prevalence of osteoporosis in the patients with back pain and the necessity

of pre-operative measurement of bone mineral density (BMD) in patients requiring spine surgery.

**Methods:** From March 2005 to February 2012, we measured 1310 patients of BMD by the dual-energy X-ray absorptiometry in the patient with back pain. According to each age group of a decade, we compared BMD of the patients among the conservative treatment group (group A), spine surgery group (group B) and major spine surgery group except vertebroplasty and kyphoplasty (group C). We also evaluated the prevalence of osteoporosis and osteopenia of the three groups.

**Results:** Among 1217 patients older than 50 years old, 483 patients (332 female, 151 male) had undertaken spine surgery. Out of the 332 female patients, there were 222(66.9%) with osteoporosis, and 82(24.7%) with osteopenia. Among the 151 male patients, there were 55(36.4%) with osteoporosis, and 56(37.1%) with osteopenia. 276 patients (171 female, 105 male) had undertaken major spine surgery except vertebroplasty and kyphoplasty. Out of 171 female patients, there were 83(48.54%) with osteoporosis, and 63(36.8%) with osteopenia. Among 105 male patients, there were 22(21%) with osteoporosis, and 45(42.9%) with osteopenia. The prevalence of osteoporosis over 50 years old was respectively 54.6% in conservative treatment group, 57.3% in whole spine surgery group, and 38.2% in major spine surgery group.

**Conclusion:** The patients over 50 years old who have back pain symptom often have osteoporosis. We recommend pre-operative evaluation of osteoporosis for patients requiring spine surgery, especially over 50 years old in female patients.

## 222. Intraoperative Radiographic Localization is Superior to Pre-incisional X-ray for Lumbar Microdiscectomy

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**Introduction:** For spine surgeons, wrong level surgery remains a significant concern. In the case of one of the most frequently performed procedures, the lumbar microdiscectomy, anatomical exposure is minimal, and therefore use of X-ray has been advocated to assure correct localization. The goal of this study is to evaluate the accuracy of preincisional and intraoperative radiographs for confirmation of correct spinal level during lumbar microdiscectomy.

**Methods:** After positioning and before incision, all patients undergoing microdiscectomy had one or more spinal needles placed percutaneously and a localizing X-ray performed. The surgical incision was then planned according to the results of this X-ray. After exposure of bony landmarks, a second radiograph was obtained with a radiopaque marker on the lamina to confirm correct spinal level. The level of the pre-incisional localizing marker, the intra-operative marker, and the intended level of surgery were recorded.

**Results:** Two hundred and seventy six patients had available radiographs for review. The pre-incision X-ray marker indicated the correct level in 207 cases (75%). The intraoperative X-ray indicated the correct level in 238 cases (86%). When the pre-incision marker showed the incorrect level, despite adjusting the incision and approach, 14 of 69 (20%) of the intraoperative X-rays still showed the incorrect level. When the pre-incision X-ray showed the correct level, 24 of 207 (12%) of the intraoperative X-rays showed the incorrect level. There was one case of a wrong level surgery performed due to misinterpretation of poor quality pre-incision and intra-operative radiographs.

**Conclusion:** Pre-incisional X-ray for localization of the target level for lumbar microdiscectomy is associated with a 12-20% rate of wrong lamina identification. Surgery based on pre-incisional X-rays alone would potentially lead to a far higher number of negative disc space explorations or potentially wrong-level surgery. Even with multiple X-ray localization, wrong level surgery may still occur due to misinterpretation of the X-rays due to poor quality imaging.



**223. A Clinical Prediction Rule to Determine Outcomes in Patients with Cervical Spondylotic Myelopathy undergoing Surgical Treatment: Data from the Prospective, Multicentre AOSpine North America CSM Study**

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**Introduction:** Cervical spondylotic myelopathy (CSM) is a degenerative spine disease and the most common cause of spinal cord dysfunction worldwide. Surgery is an effective and common treatment option for mild to severe CSM. The objective of this study is to develop a clinical prediction rule relating a combination of clinical and imaging variables to surgical outcome in patients with CSM, based on data from a large multi-center prospective study.

**Methods:** Two hundred and seventy eight patients diagnosed with cervical myelopathy treated surgically were enrolled in the CSM-North American multicenter trial. Patients were consented at twelve sites from December 2005 to September 2007. Univariate analyses were performed to evaluate the relationship between outcome, assessed by the modified Japanese Orthopaedic Association (mJOA) score, and various clinical and imaging predictors. A set of important variables for the final model was selected based on author consensus and statistical findings. Logistic regression was used to formulate the final prediction model and assess the impact of each variable on outcome.

**Results:** The dependent variable, mJOA at 1-year, was dichotomized for logistic regression: a “successful” outcome was defined as a final mJOA greater than or equal to sixteen and a “failed” outcome was a score less than sixteen. The final model included age ( $p=0.0017$ ), duration of symptoms ( $p=0.048$ ), smoking status ( $p=0.043$ ), impairment of gait ( $p=0.020$ ), psychological co-morbidities ( $p=0.0035$ ) and baseline severity score ( $p=0.0084$ ) and transverse area of the cord on MRI ( $p=0.19$ ). The area under the receiver operator (ROC) curve was 0.79, indicating excellent model prediction.

**Conclusion:** Based on this study, we have identified a list of the most important predictors of surgical outcome for cervical spondylotic myelopathy. This model will allow clinicians to estimate the likely outcome of surgery, provide this valuable prognostic information to their patients and implement appropriate treatment programs.

**224. Outcomes Following 3 Column Spinal Osteotomies: Impact of HRQOL and Age on Two Year Followup**

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**Introduction:** Major osteotomies for adult spinal deformity include resection of all 3 spinal columns such as pedicle subtraction osteotomy (PSO) and vertebral column resection (VCR). The relationship between patient age and health-related-quality-of-life-outcomes (HRQOL) for patients undergoing major spinal deformity correction with PSO or VCR has not been well characterized.

**Methods:** 228 patients underwent a 3 column osteotomy (158PSO/70VCR) from two major institutions. Patients were stratified by age into groupings of =45, 46-64, and =65 years. HRQOL

outcome included; ODI, SF36/SF12 and SRS22 at standard time points: preoperative, 1 month, 3 month, 6 month, 1 year, and 2 years. Differences and correlations between age and HRQOL were investigated.

**Results:** Age significantly correlated with preop ODI ( $r=0.26$ ,  $p=0.0011$ ) and 6 months ODI (0.28,  $p=0.097$ ). A stratification by age (36pts =45yrs, 107pts 46-64yrs, 84pts =65yrs) revealed that the <45 yrs group had significant lower pre-operative ODI scores (39.2) than both 46-64yrs (51.3,  $p=0.0052$ ) and =65yrs (53.0,  $p=0.0017$ ) with no significant difference between 46-64yrs and =65yrs ( $p=0.6$ ). Immediate postop ODI scores were not significantly different between age groups. At 3 months, the >65yrs had significantly greater ODI scores (44.6) than the 46-64yrs group (36.4,  $p=0.03$ ). The 6month ODI scores for the >65yrs group were significantly greater (45.2) than for the 46-64yrs (36.1,  $p=0.0495$ ) and =45 (26.2,  $p=0.006$ ). At 1yr and 2 years, the ODI scores were not significantly different for all age groups.

**Conclusion:** The results suggest that patients over age 65 have greater preoperative disability and recover more slowly after 3 column osteotomy than younger age groups. Patients over age 65 experience a greater improvement after 3CO than younger patients but this improvement occurs more slowly over the course of 1 year.

**225. Reoperation Rates and Impact on Outcome in a Large Prospective Multicenter Adult Spinal Deformity Database**

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**Introduction:** Adult spinal deformity is historically associated with relatively high rates of complications and need for reoperation. Reoperation within 30 days and 1 year may be important quality metrics that will require baseline rates at centers of excellence to set acceptable occurrence standards of these events. Analysis of the rates, timeframe and reasons for reoperation, and impact on clinical outcomes may identify potential areas for care improvement.

**Methods:** The rates of reoperation within 30 days and 1 year were assessed based on a large multicenter adult deformity database of 316 operative patients, 205 of which had minimum 1 year follow-up. Reasons for reoperation and its impact on the Oswestry Disability Index (ODI) and Scoliosis Research Society (SRS) outcomes measures at 1year were assessed. Smoking history, Charlson, and ASA scores were also assessed.

**Results:** 45/316 patients (14%) had required reoperation at any time(11>1yr). 34(17%) required reoperation within 1yr of initial surgery, including 13(6%) within 30 days following initial surgery. Reoperation indications included: instrumentation malposition/fracture( $n=16$ ), proximal junction failure( $n=9$ ), neurological compromise( $n=6$ ), pseudarthrosis( $n=4$ ), coronal imbalance( $n=3$ ), infection( $n=3$ ), distal junction failure( $n=2$ ), adjacent segment degeneration( $n=1$ ), and hematoma( $n=1$ ). Patients requiring reoperation were significantly older than those not requiring reoperation within the first year of surgery(62.6 vs 57.4 years,  $p=0.03$ ). Compared with patients not requiring reoperation, those needing reoperation had worse outcomes measure at 1 year follow-up, including ODI(36 vs 23,  $p=0.017$ ) and SRS total score and all subscores( $p<0.05$ )(Table). There were no significant differences between reop and nonreop pts for Charlson, ASA, or smoking hx.

**Conclusion:** The results show age may have an effect on the reop-

eration rate and that reoperation within 1yr does have an effect on health-related quality of life at 1 year. The most common indications for reoperation (instrumentation complications and radiographic failure) reinforce the importance of preoperative planning, intraoperative imaging and surgical technique.

**226. Likelihood of Reaching Minimal Clinically Important Difference (MCID) in Health Related Quality of Life (HRQOL) Measures: Prospective Analysis of Operative and Non-operative Treatment of Adult Spinal Deformity (ASD)**

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**Introduction:** Few reports have examined threshold improvements of HRQOL by MCID for treatment of ASD. Our hypothesis was that operative (OP) treatment would be more likely to achieve MCID threshold improvement compared with nonoperative (NONOP) care.

**Methods:** Multicenter, prospective, consecutive case series. Inclusion criteria: ASD, age>18 years, baseline and min 1 yr. HRQOL measures (Oswestry Disability Index [ODI], SRS-22 and SF-36). Percentages of patients achieving established MCID thresholds were compared between OP and NONOP groups.

**Results:** The 391 patients included 189 OP and 202 NONOP patients. Demographic differences were noted, with OP patients having a higher rate of prior surgery (40% vs 19%,  $p<0.001$ ), greater BMI (27.7 vs 25.7,  $p<0.001$ ) and greater baseline disability across all HRQOL measures ( $p<0.001$ ). There were no significant age or gender differences. NONOP patients had only minimal improvement in one HRQOL measure (SRS-22 activity), while OP patients had improvement across all measures ( $p<0.001$ ). Regarding MCID for ODI, NONOP patients had threshold improvement in 26% and threshold deterioration in 22% of cases. OP patients had threshold improvement in 51% and threshold deterioration in 5% of cases. Regarding MCID for SRS-22 activity, NONOP patients had threshold improvement in 46% and threshold deterioration in 28% of cases. OP patients had threshold improvement in 72% and threshold deterioration in 8% of cases. Regarding MCID for SRS-22 pain, NONOP patients had threshold improvement in 35% and threshold deterioration 27% of cases. OP patients had threshold improvement in 76% and threshold deterioration in 4% of cases. All differences between OP and NONOP groups in terms of reaching MCID thresholds were significant ( $p<0.05$ ).

**Conclusion:** While OP treatment offered significantly greater HRQOL improvement and likelihood of reaching threshold MCID than NONOP treatment, there was a subset of patients that had significant benefit from NONOP care.

**227. Change in Classification Grade by the Schwab-SRS Adult Spinal Deformity (ASD) Classification Predicts Impact on Health Related Quality of Life (HRQOL) Measures: Prospective Analysis of Operative and Nonoperative Treatment**

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**Introduction:** ASD has traditionally been described using pediatric classifications that neglect sagittal spinopelvic parameters. Our hypothesis was that the Schwab SRS classification, a validated system to classify ASD, will be responsive to and predict changes in HRQOL measures from baseline to 1 yr. follow-up for operatively (OP) and nonoperatively (NONOP) treated ASD patients.

**Methods:** Multicenter, prospective, consecutive case series. Inclusion criteria: ASD, age>18, baseline and min 1 yr x-rays and HRQOL measures (Oswestry Disability Index [ODI], SRS-22 and SF-36). The Schwab-SRS classification includes 3 sagittal modifiers, each with 3 grades (normal, moderately poor and poor). These modifiers are sagittal vertical axis (SVA: <4, 4-9 or >9cm), pelvic tilt (PT: <20, 20-30 or >30°), and pelvic incidence/lumbar lordosis mismatch (PI-LL: <10, 10-20 or >20°). Changes in modifiers at 1 yr were assessed for impact on HRQOL from pre-treatment values.

**Results:** 391 patients met criteria (mean age=54 yrs.; 85% women; OP, n=189; NONOP, n=202). Change in SVA modifier at 1 yr. was associated with changes in ODI, SF36 physical component score (PCS) and SRS-22 total and all subscores ( $p<0.03$ ), but not the SF-36 mental component score (MCS). Change in PI-LL modifier at 1 yr. was associated with changes in SF-36PCS, SRS-22 total score and 4 of the SRS-22 subscores ( $p<0.03$ ). Changes in SVA and PI-LL modifiers were associated with likelihood of achieving minimal clinical important difference for ODI and SRS subscores ( $p<0.03$ ). Changes in PT modifier were not significantly associated with changes in HRQOL measures.

**Conclusion:** The Schwab-SRS classification of ASD provides a validated language and has significant association with HRQOL measures. The current study demonstrates that the classification modifiers are responsive to changes in disease state and reflect significant changes in patient reported outcomes.

**228. The Posterior Pedicle Screw Construct: 5 Year Results for Thoracolumbar and Lumbar Curves**

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**Introduction:** The purpose of this paper is to analyze the radiographic and clinical outcomes at 5 years of patients with thoracolumbar and lumbar adolescent idiopathic scoliosis (AIS) curves treated with posterior pedicle screw (PS) constructs.

**Methods:** A multicenter database was retrospectively queried to identify patients with AIS who underwent spinal fusion for Lenke 3C, 5C, and 6C curves. Radiographic analysis was compared between preoperative, first follow-up, 1 year follow-up, 2 year follow-up, and 5 year follow-up time points. Chart review included scoliometer measurements, SRS-22 questionnaires, and complications requiring return to the operating room.

**Results:** 26 patients were identified with Lenke 3C, 5C, and 6C curves with a mean age of  $14.6 \pm 2.1$  years. There was a statistically significant improvement of the mean coronal lumbar and thoracic Cobb angles from the preoperative radiographs to the radiographs at 5 years after surgery ( $p<0.0001$ ), and the lumbar and thoracic curves remained stable from the first postoperative radiograph to 5 years after surgery ( $p=0.14$ ,  $p=0.10$  respectively). The thoracic kyphosis (T5-T12) remained stable from the first postoperative visit to 5 years after surgery ( $p=0.10$ ), and the lumbar lordosis (T12 to top of sacrum) remained stable from the preoperative radiographs to 5 years after surgery ( $p=0.44$ ). The coronal balance improved significantly from preoperative to 5 years after surgery ( $p<0.05$ ), and remained stable

from the first postoperative to 5 years after surgery ( $p=.20$ ). The SRS-22 total scores improved significantly from preoperative to 5 years after surgery ( $p<0.0001$ ). No patients suffered complications requiring reoperations.

**Conclusion:** At the 5 year follow-up period, patients with thoracolumbar and lumbar AIS curves treated with PS constructs demonstrate maintenance of their coronal, sagittal, and axial plane corrections from their first follow-up measurements, and show improved SRS-22 total scores compared to their preoperative measurements.

### 229. Health Impact Comparison of Different Disease States and Population Norms to Adult Spinal Deformity (ASD): A Call for Medical Attention

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**Introduction:** ASD is a cause of poor health related quality of life (HRQOL), however, health policy providers often underestimate ASD-associated disability. Purpose: compare ASD Standard Form Version 2 (SF-36) scores to age-specific normative data and disease-specific norms.

**Methods:** Multi-center, prospective analysis of consecutive patients, no prior history of spine surgery, treated operatively (OP) or nonoperatively for ASD. ASD demographic and SF-36 physical component scores (PCS) and mental component scores (MCS) were compared to US normative values, age generational values and disease specific norms. ASD SF-36 data reported as norm-based score (NBS) with standard deviations (sd), compared to NBS means and reported based upon minimally important difference (MID) values for PCS and MCS (3 NBS points).

**Results:** 497 ASD (mean age=50.4) met inclusion criteria. Mean ASD PCS was 3 MID values (9 NBS points) below the mean general population norm (ASD=41 sd 11; US mean=50). ASD MCS (49 sd 11) was similar to US mean MCD (50). ASD age generational PCS declined more rapidly with age than US age generational norms. Minimum one MID decline in PCS between generations occurred at an earlier age for ASD than US norms. All ASD generational PCS values were minimum one MID lower than US generational values. ASD MCS values were not MID compared to US generational norms, except for 55-64 age group. Comparing ASD PCS to disease specific PCS norms, mean ASD PCS was 4 MID values below mean PCS for healthy population (55), and had similar MID impact as cancer (41), diabetes (41), heart disease (39), and rheumatoid arthritis (40).

**Conclusion:** ASD can be a debilitating disease that impacts physical function to a similar degree as diabetes and heart disease. The impact of ASD worsens with age and warrants similar research and health policy attention as other diseases such as cancer and diabetes.

### 230. Prevalence and Risk Factors for Proximal Junctional Kyphosis (PJK) Following Realignment Surgery by Pedicle Subtraction Osteotomy: A Multicenter Review

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**Introduction:** This study analyzes the prevalence and risk factors for the development of PJK following lumbar PSO. The hypothesis was that PJK would develop early in the post-operative period at high rates in this population undergoing dramatic sagittal plane realignment, and that risk factors based on baseline and follow-up radiographs would emerge.

**Methods:** This multi-center, consecutive retrospective analysis was based on patients undergoing PSO surgery for ASD. The rate of patients developing PJK was identified based on 54 cases with 2-year follow-up standing radiographs and at least 1 follow-up at 6 months or 1 year. Risk factors of developing PJK were investigated in 75 patients with 6-month follow-up and short fusion (T10-L2). PJK was radiographically defined as post-operative kyphosis of  $>10^\circ$  (between UI and UIV+2) and change in alignment from pre-op of  $>10^\circ$ .

**Results:** The analysis of patients with 2-year radiographs revealed a high rate of PJK (39%), without significant difference between short and long fusions. In 82% of PJK cases, PJK was present at earlier follow-up points. The rate of surgical revisions was 15%, with 4% occurring due to PJK. For patients with 6-month follow-up and short fusion, significant risk factors for PJK were identified: neutral/kyphotic alignment at UIV/UIV+2, age  $>55$ , lumbar lordosis ideal correction or overcorrection. For patients with at most one of these risk factors, 0% PJK was noted, while patients with 3 risk factors developed PJK in 42%.

**Conclusion:** New appearance of PJK after 6 months seems uncommon. The prevalence of PJK following PSO occurs at a high rate radiographically (39% at 2 years) but few require surgical revision (4%). Risk factors for PJK following short fusion that have emerged include UIV alignment, age and lumbar lordosis correction. Future studies will assess the impact of radiographic PJK on health-related quality of life.

### 231. Diffusion Tensor Imaging Offers Correlation with Severity of Experimental Models of Spinal Cord Injury

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**Introduction:** Spinal cord diffusion tensor imaging (DTI) may be an important technique for assessing severity of spinal cord injury (SCI). However, DTI has not been well explored for assessment of SCI. We compared DTI tractography in hemisection and transection SCI rat models with histology and manganese (Mn)-enhanced MRI (MEMRI). We have shown direct correlation between MEMRI T1-weighted signal and degree of SCI.

**Methods:** Nine rats underwent spinal cord complete transection ( $n=3$ ), hemisection ( $n=3$ ), or were normal (sham) controls ( $n=3$ ) with SCI performed at T9. MRI was performed at T7 using DTI sequences as well as T1-weighted spoiled gradient-echo pulse sequences 60 hours after Mn injection (80 hours post SCI). Values for fractional anisotropy (FA) were acquired 1cm rostral to SCI. The percent difference between the lesion area with decreased FA was normalized to lateral area that showed no change in FA. Histological analysis of myelin load was performed. MEMRI signal intensity ratio for above and below SCI level was calculated.

**Results:** In transection, hemisection, and normal control groups, FA decreased 67.5%, 40.1%, and 6.1% respectively ( $p<0.05$ ). Transection and hemisection groups showed 67.1% and 50.6% decreases, respec-



tively, in myelin load compared to controls ( $p < 0.05$ ). Transection, hemisection, and normal control groups, showed MEMRI ratios of 61-64%, 82-84% and 98-99% respectively ( $p < 0.05$ ). Pearson's correlation coefficient between FA, myelin load and MEMRI ratio changes was 0.99.

**Conclusion:** FA differs among experimental complete transection and hemisection groups, correlating to the severity of SCI and correlated with assessments of myelin load MEMRI ratios. DTI may be a useful in vivo MR imaging technique allowing evaluation and quantitation of SCI that directly reflects severity of SCI, and can be correlated to other new techniques of MR imaging (such as MEMRI), and importantly, can be used in serial, noninvasive fashion.

### 232. Return to Play after Spine Trauma: A Review of the Current Guidelines

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**Introduction:** Concussion and brain injury in sports are gaining widespread attention. Return to play after spinal trauma is equally important, and a synthesis of the existing evidence and guidelines is warranted. The goal of this work was to review the current literature and provide an updated report on return to play guidelines after spinal injuries.

**Methods:** Articles were identified by querying the Cochrane Collaboration, Educus journal search, PubMed, and Google Scholar databases using the following phrases: "spine injury return to play," "cervical spine injury athletes," and "return to play thoracolumbar." Additionally relevant references from these articles were reviewed.

**Results:** All recommendations represent level III evidence. Absolute contraindications for return to play include atlantoaxial fusions, occipitalcervical fusions, atlantodental interval  $> 3\text{mm}$  adult ( $> 4\text{mm}$  child), acute herniated discs, discs with pain and neurologic deficits, reduced ROM,  $> 2$  level ACDF, ligamentous injuries  $> 3.5\text{mm}$  subluxation or  $> 11^\circ$  of angulation, burst fractures with retropulsion, lateral mass fractures with incongruity, delayed cervical instability, junction spanning instrumentation. Patients who are pain free, without neurologic deficit, have full ROM, radiologic evidence of a healed axis lateral mass fractures, odontoid fractures, non-displaced Jefferson fractures,  $< 2$  level ACDF, single level corpectomies, Jefferson fractures, fractures without retropulsion, chronic discs, fully fused, asymptomatic, non-junctional thoracic and lumbar decompressions and fusions may resume play with caution.

**Conclusion:** No level I or II evidence exists to dictate return to play standards after spinal injuries. Data collection efforts such as the national football head and neck injury registry could become a source of level II data if physicians document their decision making and use existing published guidelines. Providers should consider nature of injury, stability, location, and neurological status before making recommendations. Across existing guidelines certain types of injuries consistently constitute absolute contraindications to resuming play. Familiarity with current evidence is mandatory.

### 233. Cervical Pedicle Fractures: Surgical vs Conservative Treatment

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**Introduction:** Pedicle fractures in the cervical spine are not uncommon. They may occur in isolation or in combination with other con-

comitant fractures. Multiple classification systems have been introduced to provide a clinical framework when approaching these types of fractures; yet do not provide guidelines for the optimal treatment. Data regarding decision making is limited. The conservative treatment with orthoses may result in subluxation and instability requiring further treatment. Surgery may not be required in all instances as many of these injuries may heal non-operatively.

**Methods:** We retrospectively reviewed all cervical fractures treated at our institution over a 5 year period. Those with pedicle fractures were further evaluated. Sixty-seven cases managed either with or without surgery were identified. Presenting history, neurologic examination, imaging findings, comorbidity, method of treatment, complication rate and length of hospital stay were collected. Clinical examination, fusion rate and fracture displacement were assessed by plain radiographs and computed tomography scans at follow-up.

**Results:** Forty eight patients received non-surgical immobilization treatment while 16 patients received early surgical fixation. In non-surgically treated group, 8 patients developed progressive listhesis and subsequent neurological deficits. Four required surgical fixation in a delayed fashion. No patients initially managed surgically demonstrated further listhesis nor delayed neurologic findings. This difference was statistically significant. Associations were sought that would help predict failure of non-operative management. Only pedicle fracture located at C7 was associated with delayed listhesis.

**Conclusion:** The data demonstrate that cervical pedicle fractures may be managed with and without surgery. Progression was seen in 16% of those treated in a rigid collar with half of these requiring further surgery. This was greatest with fracture location at C7.

### 234. Comparative Effectiveness of Anterior versus Posterior Approach for Treatment of Thoracolumbar Burst Fractures Without Neurological Deficit

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**Introduction:** The optimal surgical approach for thoracolumbar burst fractures without neurological deficit remains debated. Anterior corpectomy and fusion allows shorter segment fusion but often requires more invasive dissection of the chest and diaphragm. Posterior approaches avoid chest wall invasion but often require longer fusion constructs. We performed a comparative effectiveness analysis to determine the differences in the outcomes of these two surgical approaches in real-world care.

**Methods:** All patients with unstable thoracolumbar burst fractures (T10-L2) without neurological deficit, managed at a single institution over a 2-year period were entered into a prospective registry. Data collected on all patients included demographics, clinical, radiological and treatment variables. One-year patient reported outcomes including numeric rating scale (NRS-BP, NRS-LP), ODI, SF-12 PCS, SF-12 MCS and EQ-5D were prospectively assessed via telephone interview, and compared between the two treatment groups.

**Results:** A total of 43 patients (28 posterior approach and 15 anterior approach) underwent surgery for burst fractures. All patients were Grade E (neurologically intact) at presentation based on ASIA Impairment Scale. Baseline characteristics and pre-injury functional status were statistically similar between the two treatment groups, Table 1. Significantly higher number of motion segments were fused in posterior approach (4.2 vs. 2.2;  $p < 0.001$ ). There was no significant difference in 90-day morbidity or patient reported pain, disability, or quality of life between the two groups one year after surgery: NRS-BP ( $p = 0.25$ ), NRS-LP ( $p = 0.71$ ), ODI% (0.74), SF-12 PCS ( $p = 0.14$ ), SF-12 MCS ( $p = 0.26$ ), EQ-5D ( $p = 0.35$ ) and Zung Depression ( $p = 0.26$ ), Table 1.

**Conclusion:** Our study demonstrates that there is no difference in one year outcomes or peri-operative morbidity after anterior versus posterior approach for treatment of unstable thoracolumbar burst

fractures without neurological deficit. While the posterior approach required fusion of greater motion segments, this had no consequence on one year physical function and quality of life.

**235. Initiation of a Pre-Operative “Spine Camp” Significantly Decreases Hospital Length of Stay following Elective Spine Surgery**

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*Introduction:* Patient education and coordination of care are obstacles to hospital discharge planning following elective spine surgery. In an effort to decrease hospital length of stay, a comprehensive pre-operative regimen called “Spine Camp” was established to provide patient education regarding details of surgery, hospital stay, discharge planning, exercise regimen, spinal precautions, pre-operative brace fitting, and need for rehabilitation following elective spine surgery.

*Methods:* All patients undergoing elective spine surgery at a single institution over an 18 month time period (October 2010 - March 2012) were reviewed. During the initiation of the “Spine Camp” program, patients were referred pre-operatively based on surgeon preference, allowing a time-matched control cohort of patients not enrolled in the program. The “Spine Camp” educational program consisted of 1) individual assessment by a Program Navigator, 2) pre-operative physical therapy evaluation, 3) laboratory testing and brace fitting as needed, and 4) a group educational session. Hospital length of stay was measured and compared between the two cohorts.

*Results:* Overall, 497 patients underwent elective spine surgery during the 18 month time period. Of these, 334 were enrolled in the “Spine Camp” program compared to 163 in the control group. Mean length of stay for patients enrolled in “Spine Camp” was  $2.6 \pm 1.8$  days, compared to  $3.1 \pm 1.9$  days in the control cohort ( $p < 0.05$ ). There were no statistically significant differences in age or type of procedure between the two groups ( $p > 0.05$ ).

*Conclusion:* Adoption of a comprehensive pre-operative educational and coordination of care program can significantly decrease hospital length of stay following elective spine surgery. With growing concerns related to the rising cost of health care, this program offers the potential benefit of substantial cost-savings in the care of degenerative spine disease.

**236. Distraction, Compression and Extension Reduction of Basilar Invagination And Atlanto-Axial Dislocation: A Novel Technique**

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*Introduction:* To describe a new innovative method to reduce basilar invagination (BI) and atlanto axial dislocation (AAD) through a single stage posterior approach surgery only.

*Methods:* 35 patients with irreducible BI and AAD (May, 2010 - April, 2012, underwent surgery using this technique. Investigation included pre- and postoperative dynamic cervical x-rays, computed tomographic scans, 3-dimensional reconstruction views and MRI. In all patients, reduction of the AAD and BI was achieved using a new innovative method of distraction, spacer placement, followed by compression and extension. A C1 lateral mass/C2 trans-laminar screw was performed in cases where the C1 arch was not assimilated and occipito-C2 trans-laminar screw fixation was performed in cases where the C1 arch was assimilated.

*Results:* 32/35 (94%) patients improved clinically and 2 patients had stable symptoms (mean Nurick’s post op score 1.4 compared to 3.7 pre op). AAD reduced completely in 33/35 patients and >50% in

the other 2. BI improved significantly in all patients. Solid bone fusion was demonstrated in all 24 patients with at least 6 months follow up. The duration of the operation ranged from 80 to 190 minutes, and blood loss ranged from 90 to 500 mL (mean:  $170 \pm 35$  ml). There was 1 death because of cardiac etiology and 1 morbidity due to wound infection.

*Conclusion:* Distractive compressive extension reduction of BI and AAD is an effective, simple, fast, and safe method for the treatment of BI with AAD and may prove to be a better alternative to transoral odontoidectomy and posterior fixation.

**237. Timing of Tracheostomy after Anterior Cervical Discectomy and Fusion**

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*Introduction:* Frequently, spine surgeons encounter a patient who requires an emergent anterior cervical spinal fusion for instability as well as a tracheostomy for airway protection. Some have advocated delaying the tracheostomy because they believe that creating a contaminated wound so close to a fresh anterior cervical fusion may increase the risk of infection. Unfortunately, there are scarce data to guide the timing of tracheostomy.

*Methods:* We used the Nationwide Inpatient Sample (NIS) from the years 1998 to 2008 to create our cohort. Our cohort was formed by all admissions in which the procedure code for anterior fusion (ICD-9 code: 81.02) and tracheostomy (ICD-9 code: 31.1 and 31.29) were used. We determined whether the patient had a wound infection with ICD-9 codes 998.5, 998.51, and 998.59. Logistic regression was used to determine which factors significantly changed a patient’s risk of developing a post-operative wound infection.

*Results:* Our final cohort was composed of 1093 hospital admissions in which the patient had both ACDF and tracheostomy performed. Postoperative wound infection was diagnosed in 41 (3.75%) patients. The median interval between ACDF and tracheostomy was 8 days (interquartile range: 5-14 days). A t-test revealed that those with post-operative infections had longer delays before their tracheostomy (14 vs 10 days,  $p < 0.0001$ ). Logistic regression revealed that every additional day of delay between ACDF and tracheostomy increased the risk of wound infection by 5% (OR: 1.05, 95% CI: 1.02-1.08,  $p < 0.001$ ). Waiting more than six days before tracheostomy increased the risk of infection by more than 300% (OR: 3.27, 95% CI: 1.16-9.30,  $p < 0.05$ ).

*Conclusion:* Contrary to our initial hypothesis, our data demonstrate that delaying tracheostomy is associated with an increased risk of wound infection after ACDF.

**238. Targeting Brachyury Using A Lipid-based Nanoparticle Delivery System for shRNA Inhibits Chordoma Cell Growth In Vitro**

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*Introduction:* Chordoma is a rare neoplasm arising from notochordal remnants. Studies demonstrate that Brachyury knockdown using shRNA results in premature cell senescence and reduced tumor growth in vitro. Lipid nanoparticles consisting of dioleoyltrimethylammoniumpropane (DOTAP) and cholesterol has been shown to induce RNA interference in vitro and in vivo, but whether these nanoparticles can deliver shRNA targeting Brachyury is unknown. The aim of this study is to determine if lipid nanoparticles can be used

to deliver shRNA targeting Brachyury to chordoma cells and inhibit cell growth in vitro.

**Methods:** A constructed Brachyury shRNA/protamine complex was coated with cationic liposomes consisting of DOTAP and cholesterol to produce liposome-polycation-DNA (LPD) nanoparticles. Agarose gel electrophoresis was used to test the efficiency of LPD formulations. The effect of LPD formulations (2µg/ml shRNA for 24hrs) on cell proliferation and apoptosis in two different chordoma cell lines (JCH7 and UCH1) were measured by MTS and caspase 3/7 activity, respectively. Gene expression of e-cadherin, slug, and snail, which are believed to be critical to epithelial-mesenchymal transition (EMT), were detected by quantitative RT-PCR.

**Results:** Agarose gel electrophoresis showed a strong binding capacity of liposome and Brachyury shRNA. LPD nanoparticle-delivered Brachyury shRNA reduced Brachyury expression at gene and protein levels (80% and 63% lower relative to controls for JCH7 and UCH1 cells, respectively) and led to growth inhibition in vitro [64% and 37% lower relative to controls for JCH7 and UCH1 cells, respectively]. Liposome-encapsulated Brachyury shRNA also increased caspase 3/7 activity in both cell lines [2.9- and 1.5-fold increases for JCH7 and UCH1 compared with controls, respectively]. Brachyury shRNA/nanoparticles led to upregulation of E-cadherin and downregulation of slug and snail expression, which suggest inhibition of EMT.

**Conclusion:** Brachyury inhibition using a lipid-based nanoparticle delivery system for shRNA inhibits growth, induces apoptosis and alters regulation of factors critical to EMT in two chordoma cell lines.

### 239. Improving Quality: Establishing Standard Performance Measures for Adult Patients with Spinal Column Tumors

*Daniel J. Hoh MD (University of Florida), Dan Neal MS, Brian Lim Hoh MD (University of Florida)*

**Introduction:** The federal government has adopted quality-based reimbursement to incentivize better performance. Adverse events like hospital-acquired conditions (HACs) and those occurring after surgery (PSIs) are the basis for nonpayment. Neurosurgical advances have expanded capabilities for treating complex conditions like spinal column tumors (SCTs). SCTs are high risk even with optimal care, yet nationwide incidences of HACs and PSIs have not been previously reported. It is essential to establish baseline incidences as these are the metrics by which neurosurgeons are being measured, and to serve as the basis for further quality improvement. To obtain the best generalized data, we utilized the Nationwide Inpatient Sample (NIS) to determine the incidence and predictive factors of adverse events for patients with SCTs.

**Methods:** The NIS was queried from 2002-2010 for primary (pSCT) or secondary (sSCT) spinal column tumor admissions >18 years old. Reported HACs and PSIs were recorded. Comorbidity Scores were assigned by summing the recorded Elixhauser comorbidities. Statistical models assessed associations between patient and hospital characteristics for each HAC, PSI.

**Results:** There were 3,817 pSCT and 473,006 sSCT admissions. Mean ages were 39.4(pSCT) and 64.8(sSCT) years. 45.7% (pSCT) and 48.8%(sSCT) were female. 72.3% (pSCT) and 50.8%(sSCT) were admitted to teaching hospitals. Among pSCTs, there were 684(17.9%) PSIs and 108(2.8%) HACs. Leading adverse events were: pressure ulcer (3.67%), postoperative respiratory failure(3.67%), sepsis(3.64%), DVT(2.41%). Adverse events were associated with age, male gender (pressure ulcers, sepsis), hospital-type, and Comorbidity Score. Among sSCT, there were 125,611(26.6%) PSIs and 14,149(3.0%) HACs. Leading adverse events were: postoperative respiratory failure (6.78%), sepsis(6.18%), pressure ulcer(3.68%), DVT(4.58%), PE(2.71%). Adverse events were associated with age (pressure ulcer, postoperative hip fracture), male gender (pressure ulcer, postoperative hip fracture, postoperative respiratory failure, sepsis), hospital-type, and Comorbidity Score.

**Conclusion:** By establishing baseline standard performance mea-

asures for minimizing adverse events for SCTs, we may further improve overall patient quality and safety.

### 240. Influence of Preoperative Chemo and Hormonal Therapy and/or Spinal Radiotherapy on Postoperative Complications in Patients with Prostate Cancer Metastases to the Spine

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**Introduction:** Prostate cancer metastases to the spine cause significant morbidity and decreased quality of life. Many patients require surgical intervention, but chemotherapy and spinal radiation are still instrumental in treating spinal metastases. However, these therapies may predispose patients to postoperative complications. We sought to determine the association between preoperative chemotherapy, spinal radiotherapy, and post-operative complications.

**Methods:** We retrospectively reviewed records of 327 consecutive patients who underwent surgical treatment for spinal metastases at a single institution. All electronic records were reviewed to determine the status of preoperative chemo/hormonal therapy and radiotherapy. Student's paired t-tests were performed to determine associations with preoperative oncologic treatment and postoperative major complications.

**Results:** Twenty-seven patients with prostate cancer metastases to the spine were identified. Twenty patients underwent preoperative chemo/hormonal therapy, 11 underwent preoperative spinal radiotherapy, and 8 had combination chemo/hormonal therapy and spinal radiotherapy. Seven patients (26%) suffered major complications in the immediate postoperative period (2 wound infections, 1 sacral decubitus ulcer, 1 pulmonary embolism, 1 hydropneumothorax, 1 spinal epidural hematoma, and 1 hardware failure). Preoperative chemo/hormonal therapy was significantly associated with postoperative complications (p=0.003). However, there were no significant associations between preoperative radiotherapy (p=0.3) and both chemo/hormonal therapy and radiotherapy (0.8) with postoperative complications.

**Conclusion:** In our review, postoperative complications were significantly associated with the administration of preoperative chemo/hormonal therapy. However, postoperative complications were not significantly associated with the use of preoperative radiation, or combined chemo/hormonal therapy and radiotherapy. This underscores the importance of maintaining meticulous wound management and vigilance in patients who have received preoperative chemo/hormonal therapy.

### 241. Survival Following Surgical Resection of Spinal Sarcoma: A Report of Twenty-five Consecutive Cases

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**Introduction:** Sarcoma of the spine is a devastating and rare disease. This study investigated the survival and outcomes of twenty-five consecutive cases of spinal sarcoma, including osteosarcoma and chondrosarcoma, treated at a single academic medical center.



**Methods:** Patient medical records were reviewed in accordance with the University Institutional Review Board. Twenty-five consecutive patients were identified with pathology-proven spinal sarcoma treated with surgical excision from 2002-2012. Data collection included hospital data, outcomes, survival and exposure to adjuvant therapy.

**Results:** Spinal sarcomas presented most often in middle-aged adults (average age 42 years) and predominantly in women (56%). Median clinical follow-up time was 11.8 months. Five year mortality in this cohort was 44%, with 75% of osteosarcoma patients dying within five years. There was no statistically significant difference in survival between chondrosarcoma and osteosarcoma patients ( $p = 0.07$ ). A majority of patients (56%) received adjuvant therapy in the form of chemotherapy or radiation. Patients undergoing en bloc resection survived significantly longer than patients who underwent intralesional resection ( $p=0.02$ ). The sacrum was the most common site of the lesion (40%) and 56% of patients underwent a posterior approach for resection.

**Conclusion:** Sarcomas of the spine represent an aggressive form of bone cancer resulting in high morbidity and poor quality of life. Advances in surgery and adjuvant treatment have demonstrated benefits to patients while often times extending their survival. Our results have shown that osteosarcoma patients have the highest rates of mortality within five years after surgery, and that en bloc resection is preferable to an intralesional resection.

#### 242. Independent Predictors for Local Recurrence Following Surgery for Spinal Metastasis

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**Introduction:** The recurrence of spinal metastasis after surgical resection is relatively common and can result in spinal instability and nervous compression. The risk factors and predictors for metastatic recurrence are unclear, as there are few studies in the literature that have examined this.

**Methods:** Patients that underwent surgery for spinal metastasis from June 2005 to June 2011 were identified. Demographic and clinical variables were collected. The primary outcome of interest was local recurrence. Chi-square tests were performed to identify significant associations between covariates of interest and categorical outcomes. Multivariable logistic regression models for recurrence risk were fit and adjusted for potential confounders.

**Results:** 106 patients who underwent surgery for spinal metastasis were included. The mean time to metastatic recurrence was 9.8 months. 32 patients (30.2%) had recurrence of their metastatic disease following their initial surgery. Patients younger than 40 years old had higher rates of recurrence (53.8%) compared to patients aged 40-65 (28.2%) and patients greater than 65 (22.7%) ( $p = 0.124$ ). Recurrence rate significantly decreased as more contiguous levels were involved ( $p=0.008$ ). Extraspinal metastasis was significantly associated with recurrence ( $p = 0.036$ ). Patients who received chemotherapy ( $p = 0.044$ ) or radiotherapy ( $p = 0.023$ ) had significantly higher rates of recurrence. Melanoma was the only cancer type that was independently associated with higher odds of recurrence (OR 10.61, CI 1.62-69.43,  $p = 0.014$ ).

**Conclusion:** Chemotherapy and radiotherapy were associated with higher risk of recurrence, which likely reflected increased survival time. Similarly, there was a trend toward increased recurrence in younger patients. A decreased risk for recurrence was seen in patients with multi-level disease; however, this finding potentially reflected decreased survival. Of the 10 cancer types included in the study, melanoma was the only one with an increased odds ratio for recurrence.

#### 243. Differential Cost and Rates of Readmission in Surgical Treatment of Primary and Metastatic Spinal Tumors at a Large Tertiary Referral Center

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**Introduction:** Resection of spinal tumors can greatly improve the quality of life for metastatic disease and facilitate cure of primary spine tumors. With the rise in healthcare costs there is increasing effort to maximize the value of care provided. Unplanned hospital readmissions are costly and may not be reimbursed in the future. Baseline rates from high volume centers are necessary to help establish quality standards. This study investigates readmission rates and risk factors for readmission after spine surgery for neoplastic disease.

**Methods:** This retrospective single-center study included patients from 2005 to 2010 with resection of metastatic or primary tumor of the spine. All patients underwent chart review to identify unplanned hospital readmissions, causes, and risk factors for readmission. Patients were grouped by primary or metastatic tumor, and by Tokumashi primary site subscore (0=worst prognosis, 5=best prognosis). Death within one year was identified using the social security number death database. Readmission rates were estimated using Kaplan-Meier time-to-failure analysis; patients were censored after readmission or death. True costs were calculated from our hospital billing records, and averaged on a per-patient basis.

**Results:** 185 patients included: 38 with primary, 147 with metastatic tumor. Forty-six (24.9%) of patients died within one year (5.3% primary, 29.9% metastatic). The one-year unplanned readmission rate estimate was 23.9% for primary tumor patients and 39.3% for metastatic tumor patients (Figure 1a,  $p = 0.089$ ). Readmissions related to spine surgery accounted for 70.1% of readmissions. Metastatic tumors with a worse Takahashi primary site subscore showed higher readmissions (Figure 1b,  $p = 0.002$ ). Finally, the index hospitalization cost for primary tumors was 79.3% greater than for metastatic tumors ( $p=0.026$ ), while the average cost of readmissions was similar ( $< 5\%$ ,  $p = 0.907$ ).

**Conclusion:** Treatment of metastatic spine tumors is associated with higher mortality and unplanned readmission compared to primary spine tumor. However, surgical treatment of primary spine tumor was associated with significantly higher cost than metastatic tumor. This information may be useful in setting baseline quality metrics and counseling patients and their families.

#### 244. Preventing Spinal Cord Deficits in Adult Spinal Surgery with Intraoperative Monitoring: A Single Institution Experience

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**Introduction:** Neurophysiologic Intraoperative Monitoring (NIOM) of the Spinal Cord (SC) is widely but not universally utilized during spine surgery. This study aims to better characterize SC monitoring events from a large database, to determine the reversibility of the data loss, interventions utilized, and long term neurologic outcomes associated with NIOM events during adult spinal surgery.

**Methods:** From a database of 8,993 patients, 157 were identified with warning criteria for somatosensory evoked potential (SSEP), descending neurogenic evoked potential (DNEP), and/or transcranial motor evoked potentials (TCEP). The etiology of the NIOM changes were categorized into SC vs. cauda equina/peripheral nerve events. 77/157(49%) were attributed to loss of function of the SC. Further analysis was completed to characterize the interventions and neurologic outcomes.

**Results:** The 77 patients with SC events were grouped into 5 etiologic categories: SC compression ( $n=30$ ); Hypotension ( $n =$

22); Deformity correction (n=15); Implant placement (n=8); and Miscellaneous (n=2). 56/77 (73%) patients with SC NIOM events recovered data after interventions. Only 3/56 (5%) emerged from anesthesia with neurologic deficits, and all 56 ultimately regained normal function. However only 9/21 (43%) without return of NIOM data emerged at neurologic baseline, and only 15/21 (71%) ultimately recovered to normal function. Deformity correction, hypotensive patients, and misc patients (n=39) had 100% return to normal function, compared to only 84% in the cord compression and implant placement groups (32/38),  $p=0.01$ .

**Conclusion:** In 73% of cases (56/77), NIOM alerted the surgeon to SC issues that were corrected leading to restoration of NIOM data and normal neurologic outcomes. Return of NIOM data following interventions, especially when due to deformity correction and hypotension, universally correlated strongly with baseline neurologic outcome. Although it is difficult to calculate the cost effectiveness of NIOM, it is highly likely that the cost to monitor 126 surgeries is less than the cost of 1 spinal cord injury.

#### 245. Major Perioperative Complications after Surgery for Cerebral Palsy: Assessment of Risk Factors

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**Introduction:** The purpose of this study is to determine the incidence, consequences, and risk factors of major perioperative complications in patients with cerebral palsy treated with spinal fusion for neuromuscular scoliosis.

**Methods:** A prospectively collected multicenter dataset was retrospectively queried to identify consecutive patients with cerebral palsy treated with spinal fusion. All major perioperative complications (within 90 days of surgery) were stratified into categories including: Pulmonary, Gastrointestinal, Medical, Wound Infection, Neurologic, Instrumentation Related, and Unplanned Staged Surgery. Univariate and multivariate analyses were performed to identify various risk factors for major perioperative complications.

**Results:** 127 patients were identified with a mean age of 14.3 years. Overall, 39% of the patients had a major perioperative complication; of the complications: Pulmonary 30%, Gastrointestinal 19%, Medical 12%, Wound Infection 5%, Instrumentation Related 2%, Unplanned Staged Surgery 2%, Neurologic 1%. Occurrence of a complication (NC= no complication, YC= yes complication) resulted in a significantly increased intensive care unit (NC=3.2 days, YC=7.8 days,  $p<0.05$ ) and hospital stay (NC= 7.7 days, YC= 15.6 days,  $p<0.05$ ). Risk factors identified for perioperative complications included estimated blood loss (NC=1656 cc, YC= 2843 cc,  $p<0.001$ ), kyphosis (NC=40°, YC=48°,  $p=0.05$ ), staged procedure (NC=27%, YC=73%,  $p=0.02$ ), antifibrinolytic use (NC=70%, YC=30%,  $p=0.05$ ), supplemental postoperative nutrition (NC=45%, YC=55%,  $p<0.001$ ), and a trend toward lower body mass index ( $p=0.08$ ). Multivariate regression analysis revealed estimated blood loss and postoperative supplemental nutrition as independent predictors of a major perioperative complication.

**Conclusion:** 39% experienced a major perioperative complication, with Pulmonary being the most common. Complication occurrence lengthened both ICU and hospital length of stay. Risk factors for complications included greater kyphosis, staged procedures, lower body mass index, no antifibrinolytic use, the need for supplemental postoperative nutrition, and increased estimated blood loss, with the latter two being independent predictors of a major perioperative complication.

#### 246. Proximal Junctional Failure (PJF) Classification and Severity Scale: Development and Validation of a Standardized System

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**Introduction:** Confusion exists regarding the consequences of post-operative proximal junctional kyphosis (PJK). PJF, defined as failure of the structures stabilizing the upper instrumented vertebra (UIV) region, is a severe form of PJK that is a potentially catastrophic complication. No validated classification exists for PJF. Purpose: develop and validate a PJF classification and severity scale.

**Methods:** 14 surgeons participated in a modified Delphi approach to identify clinical and radiographic features of PJF. A classification assigning severity of 6 distinct PJF characteristics was agreed upon (Neurological Deficit, Focal Pain, Instrumentation Problem, Kyphosis/PLC Integrity, UIV/UIV+1 Fracture, and Level of UIV) and a total PJF severity score (PJFSS) created. 15 case examples were graded by 14 surgeons in 2 separate grading sessions; time between grading sessions= 7 days. Intra and inter-rater reliability of 6 PJF severity features and PJFSS was calculated. Correlation with recommended treatment (observation, cement augmentation or revision surgery) was assessed.

**Results:** Mean kappa intra-rater (0.74) and inter-rater (0.71) agreement for severity scores of all 6 PJF characteristics was substantial (kappa intra-rater range; UIV/UIV+1 Fracture =0.43 to Neuro status=0.89; kappa inter-rater range; UIV/UIV+1 Fracture =0.31 to Neuro status=0.89). Mean PJFSS intra-rater (kappa=0.47) and inter-rater (kappa= 0.42) agreement was moderate. All 6 PJF features significantly correlated with treatment recommendation (mean R value=0.3;  $p<0.01$ ). Mean R values for PJF features and recommended treatment ranged from level of UIV (0.13) to Pain (0.44). Total PJFSS score strongly correlated with recommended treatment (mean R value=0.63;  $p<0.01$ ). PJFSS =7 uniformly resulted in recommendation for revision surgery.

**Conclusion:** PJF requires accurate diagnosis. The proposed PJFSS classification has good reliability and repeatability and correlates strongly with recommended treatment. Pain, kyphosis, neurological status, and instrumentation failure were the strongest predictors for recommendation for surgical revision. Further validation of the PJFSS classification using a prospective cohort is needed and underway.

#### 247. Health Related Quality Of Life Outcomes With Minimally Invasive Transforaminal Lumbar Interbody Fusion Based On Long-Term Analysis Of 318 Consecutive Patients

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**Introduction:** Long-term prospective outcomes in patients undergoing minimally invasive transforaminal lumbar interbody fusion (MITLIF) for debilitating back pain has not been well studied.

**Methods:** 318 patients (mean age 63, range 19-94) who underwent MITLIF with an average 5 year follow-up (range 1 to 7 years), treated for spondylolisthesis (236, 74%) or degenerative disc disease (82, 26%) causing intractable back pain. Health care quality of life mea-

tures included visual analog scale (VAS), Oswestry disability index (ODI), and short form (SF-36).

**Results:** 196 females and 122 males were treated. Levels fused included L1-2 (n = 3, 1%), L2-3 (n = 19, 6%), L3-4 (n = 34, 11%), L4-5 (n = 163, 51%), L5-S1 (n = 89, 28%), or multi-level instrumentation (n = 10, 3%). Estimated blood loss and hospital stay were 128.4 ml and 4.37 days, respectively. VAS scores decreased significantly starting at 6 weeks post-op. ODI scores declined from 44.1 preoperatively to 28.1 (p < .05) at one year, and 30.4 (p < .05) at 2-7 year period. SF-36 physical component scores increased from 30.3 preoperatively to 39.6 (p < .05) at one year, and 38.7 (p < .05) at 2-7 year period. SF-36 mental component scores increased from 43.7 preoperatively to 48.5 (p < .05) at one year, and 49.1 (p < .05) at 2-7 year period. Fusion rate was greater than 95% at 2-year follow up. Re-operation rate for adjacent level disease was less than 2% over the 7 year period.

**Conclusion:** This study presents a large long-term prospective outcomes analysis of MITLIF revealing statistically significant outcome improvements out to seven years post-operatively. MITLIF resulted in a high rate of spinal fusion and very low rate of adjacent segment disease requiring re-operation. These results highlight the importance of focused surgery and attention to proper indications when selecting patients.

#### 249. Minimally Invasive Laminectomy through Tubular Retractors for Lumbar Spinal Stenosis in Patients With and Without Pre-operative Spondylolisthesis: Clinical Outcome and Re-operation Rate

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**Introduction:** Surgical decompression is widely performed as the treatment of choice for lumbar spinal stenosis (LSS). A minimally invasive laminectomy through tubular retractors has been introduced as an alternative to open laminectomy technique, with the potential advantage of preserving stabilizing structures of the spine. The aim of our study was to evaluate the clinical outcome of this procedure for LSS in patients with or without pre-operative spondylolisthesis.

**Methods:** Patients with isolated LSS on MRI, who had undergone minimally invasive laminectomy through tubular retractors between 2004 and 2011, were included. Follow-up radiographic studies were evaluated for changes in the degree of spondylolisthesis. Clinical outcome was evaluated by Oswestry Disability Index and Visual Analogue Scale scores, as well as by MacNab's criteria.

**Results:** A total of 110 patients with a mean age of 68.5 years, underwent minimally invasive laminectomy through tubular retractors. Pre-operative spondylolisthesis was present in 52.5% of the patients. ODI and VAS pain scores at a mean 28.8 months follow up revealed median improvement of 16 % in the ODI, 2.75 in VAS back pain, 2.25 in VAS buttock pain and 3 in VAS leg pain scores, as compared to the pre-operative baseline (p values <0.0001). A Macnab of excellent or good was reported by 71.6% of the patients. The re-operation rate requiring fusion was 3.5%. Comparisons between the patients with and without pre-operative spondylolisthesis showed no significant differences in any of the clinical outcome variables or the reoperation rate. The procedure was found not to be associated with an increase in the amount of listhesis.

**Conclusion:** Minimally invasive laminectomy through tubular retractors is an effective procedure for treatment of LSS, yielding similar results in patients with and without pre-operative spondylolisthesis and with a low re-operation rate. The clinical outcome of this technique is comparable to that reported for open laminectomy in the literature.

#### 250. Measuring Surgical Outcomes in Subaxial Degenerative Cervical Spine Disease Patients: Minimum Clinically Important Difference as a Tool for Determining Meaningful Clinical Improvement

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**Introduction:** The evaluation of clinical impact of cervical spine surgery on quality of life currently draws from PRO (Patient Reported Outcome) measures. The concept of minimum clinically important difference (MCID) has been used to calculate the threshold by which the effect of a treatment can be considered clinically meaningful. A range of MCID threshold values have been reported. We compare MCID values obtained by different distribution-based and anchor-based approaches and determine the clinically meaningful and statistically significant MCID for patients undergoing cervical spine surgery.

**Methods:** 88 patients undergoing surgery for subaxial degenerative cervical spine disease were selected from a prospective registry. Preoperative, 3 and 6 months postoperative PRO's were collected (Neck Disability Index, Short Form 36 Physical and Mental Components, Visual Analog Scale). Blinded Surgeon Ratings (SR) were collected at 3 and 6 months post-surgery. Four well-established distribution-based and anchor-based MCID calculation approaches were used to calculate MCID threshold values: average change, change difference, minimum detectable change (MDC) and receiver operating characteristic curve (ROC). Three anchors were used to evaluate meaningful improvement postoperatively: HTI (SF-36 Health Transition Item), Patient Overall Rating and SR.

**Results:** All patients had statistically significant improvement (p<0.001) postoperatively for NDI (27.42 to 19.42), PCS (33.02 to 42.23), MCS (44 to 50.74) and VAS (2.85 to 1.93). The four MCID approaches yielded a range of values for each PRO: 2.23-16.59 (PCS), 0.11-16.27 (MCS), 2.72-12.08 (NDI). Area under the ROC curve was consistently greater for the SR anchor compared to other anchors for all PRO's. MDC values were not affected by choice of anchor.

**Conclusion:** With 4 currently used approaches for MCID calculation, we provide a range of MCID values for 4 patient reported outcome measures in patients undergoing degenerative cervical spine surgery. The practical value of MCID as an outcome standard needs further investigation and validation.

#### 251. Anterior versus Lateral Extra-cavitary Approach for Thoracic Corpectomy: A Retrospective Review of Consecutive Cases.

*Matthew Frank Gary MD (Emory University SOM), Christopher M. Holland (Emory University), Daniel Refai MD (Emory University Orthopaedics and Spine Center)*

**Introduction:** There are several surgical approaches to anterior thoracic pathology. The technique utilized by an individual neurosurgeon is influenced by training, availability of a competent thoracic co-surgeon and/or the presence of concomitant posterior pathology (Lubelski et al. 2011). The lateral extracavitary approach has become a very important tool in the spine surgeon's armamentarium. Its benefits include not requiring a thoracic surgeon and the ability to place 360-degree instrumentation. On the other hand, the anterior approach gives a better view of anterior pathology and allows for the placement of larger cages. It is unclear, however, if there is a difference in such factors as length of ICU care, length of post-operative hospital stay, and degree of kyphosis correction with these approaches. Understanding the outcomes, efficacy, and complications associated would assist the neurosurgeon in selecting the optimal approach.

**Methods:** We performed a retrospective review of consecutive tho-



racic corpectomy cases by a single neurosurgeon from October 2010 to July 2012. Cobb angles were measured on CT scan.

**Results:** Twenty-four consecutive patients, mean age 58 (Range 30-78) underwent thoracic corpectomy by either transthoracic (n = 11) or lateral extracavitary (n = 13) approach. There was no significant difference in age or gender distribution. Patients undergoing a transthoracic approach had a significantly longer length of stay (LOS) and post-op ICU days. However, there was no significant difference in pre- or post-operative local or regional cobb angles, nor was the change in cobb angle different ( $p > 0.05$ ).

**Conclusion:** In this small cohort, similar correction of kyphosis was obtained via both anterior transthoracic and lateral extracavitary corpectomy. However, patient's undergoing the lateral extracavitary approach had significantly shorter ICU and overall hospital stays.

### 253. Incidence and Risk Factors for the Development of Post Operative Urinary Retention in Neurosurgery Patients

*Azam Basheer MD (Henry Ford Hospital), Mohammed Alsaïdi MD (Henry Ford Hospital), Joanne Guanio RN, Lonni Schultz PhD, Muwafak Abdulhak, Mokbel K. Chedid MD FACS (Henry Ford Hospital), Donald M. Seyfried MD (Henry Ford Hospital)*

**Introduction:** Post-operative urinary retention (POUR) is a commonly encountered problem in many surgical specialties. Its exact incidence and etiology in neurosurgical patients are not well-established. POUR can potentially lead to urogenital damage, prolonged hospital stays, higher costs, and infections.

**Methods:** 136 neurosurgical patients were prospectively followed between 5/2010 and 3/2011 for the development of POUR. POUR was defined as a post void residual (PVR) > 250 ml 6 hours after the removal of the Foley catheter. For any patients with PVR > 250, straight catheterization was performed. For those with PVR > 250 ml on the third check, a Foley catheter is reinserted. Subsequently, patients' records were reviewed for age, gender, BMI, length of surgery, type of surgery, diabetes, usage of selective alpha blockers, and hospital stay.

**Results:** There were 136 patients included in the following first PVR (PVR1) analyses. One patient had missing information for PVR1. There were 67 (49%) males and the mean age was 57.5 (s.d.=14.1) with a range from 26 to 95. The differences for gender, age (<60 vs >=60) and surgery type (cranial vs spine) were significant. Furthermore, the difference between cranial and cervical/thoracic surgery types was significant. Trends were also seen for surgery time (<=200 vs >200 minutes), diabetes, beta blockers, lumbar vs cervical/thoracic and lumbar vs cranial. Table 1 When considering all patient characteristics (except selective alpha blockers), the three variables that remained significant were gender, surgery time and surgery type. Table 2 In addition, PVR1 was positively associated with longer length of stay ( $r=0.176$ ,  $p=0.04$ ). In our protocol, for any PVR > 250 ml, straight-catheterization was performed. Table 3 shows the number of patients based on gender who underwent catheterization or re-insertion of the Foley catheter.

**Conclusion:** POUR is a prevalent condition in the neurosurgical patients. Its overall incidence is about 40%. Males, > 60 years of age, and undergoing cervical or thoracic surgery > 200 minutes have the highest risk for developing POUR.

### 254. Radiologic Outcomes of Static Versus Expandable Titanium Cages After Corpectomy: Analysis of Subsidence

*Paul Park MD (University of Michigan, Department of Neurosurgery), Darryl Lau, Yeohan Song, Zhe Guan BS, Frank La Marca MD (University of Michigan)*

**Introduction:** Commonly, mesh cages have been used for reconstruction after corpectomy. Recently, expandable cages have become

a popular alternative. Regardless of cage type, a concern following cage placement is subsidence. This study assesses whether subsidence rates differ between static and expandable cages, and identify independent risk factors for subsidence and extent of subsidence when subsidence is present.

**Methods:** A consecutive population of patients who underwent corpectomy between 2006 and 2009 was identified. Subsidence was assessed based on x-ray imaging at 1-month and most recent follow-up visits. In addition to cage type, demographic, medical, and cage-related covariates were recorded. Multivariate models were employed to assess for independent associations with rate, odds, and extent of subsidence.

**Results:** Of 98 patients, 41.8% had an expandable and 58.2% had a static cage. Subsidence rate at 1 month was 37.8% and at last follow-up was 56.0%. Expandable cages were independently associated with higher rates and odds of subsidence compared to static cages. Infection, trauma, and footplate-to-vertebral body endplate ratio of less than 0.5 were independent risk factors for subsidence. Presence of prongs on cages had lower rates and odds of subsidence. Age >65 years, infection, and cage placement in the thoracic or lumbar region had greater extent of subsidence when subsidence was present.

**Conclusion:** Expandable cages had higher rates and risk of subsidence compared to static cages. When subsidence was present, expandable cages had greater magnitudes of subsidence. Other factors including footplate-to-vertebral body endplate ratio, prongs, spinal region, and diagnosis also impacted subsidence.

### 255. Radiation Use During Minimally Invasive Lateral Interbody Fusion: How Much and How to Reduce?

*Jacob H. Bagley BS (Duke University Division of Neurosurgery), Vijay Agarwal MD (Duke University Hospital), Scott Tyler Brigeman BSE (Duke University), Andrew Hall Marky MD (Duke University Medical Center), Jian Xi, Chris Brown MD, Robert E. Isaacs MD (Duke University Medical Center)*

**Introduction:** While several studies have demonstrated that the extreme lateral interbody fusion (XLIF) procedure is well-tolerated and produces a high rate of arthrodesis, the procedure requires more intraoperative fluoroscopy than open approaches. However, no study has yet quantified the amount of radiation to which the patient and surgeon is exposed during XLIF.

**Methods:** Radiation dosage data was prospectively collected from 80 consecutive patients, who underwent XLIF between April, 2010 and January, 2012. An OEC 9900 Elite C-arm that measured total absorbed dose and exposure time was used to provide fluoroscopic imaging in both the AP and lateral planes. When necessary, surgeons used magnification to improve image quality. In smaller patients, pulsed imaging could be used to reduce radiation exposure at the expense of image resolution. ANOVA was used to compare the normal, pulsed, and magnified imaging groups.

**Results:** A total of 228 vertebral levels were treated with minimally invasive XLIF, ranging from T9-T10 to L4-L5. Mean fluoroscopy time was 2.96 minutes (1.04 min/level) and mean absorbed dose was 107.9 mGy (37.9 mGy/level). The Mag group (N=44), NoMag group (N=28), and Pulse group (N=8) were statistically similar in age, male-to-female ratio, BMI, and levels treated. Differences between the total fluoroscopy time per level (1.64 min/level Mag, 0.75 min/level NoMag, 0.34 min/level Pulse,  $p<0.001$ ) and absorbed dose per level (64.5 mGy/level, 20.7 mGy/level, 12.2 mGy/level,  $p<0.001$ ) were statistically significant.

**Conclusion:** Patients undergoing the XLIF procedure absorb a moderate but safe amount of ionizing radiation during fluoroscopy. Pulsed imaging was associated with an almost 50% reduction in radiation exposure per level compared to normal fluoroscopy. The use of magnification during was associated with a 300% increase in the amount of radiation over normal fluoroscopy.

**256. Safety and Efficacy of an Ultrasonic Bone Curette in Reduction of Intraoperative Durotomies: Outcomes in 337 Patients**

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**Introduction:** Unintended durotomies are an anticipated complication of spine surgeries and may be correlated with an increased risk of perioperative complications and possible worse neurologic outcome. Recently, ultrasonic bone curettes have been introduced in spine surgery as a potential alternative to the conventional high-speed drill, offering the potential for greater bone-cutting precision and less damage to surrounding soft tissues. To date, however, few studies have investigated the safety and efficacy of the ultrasonic bone curette in reducing the rates of incidental durotomy compared to the high-speed drill.

**Methods:** We retrospectively reviewed 337 consecutive patients necessitating posterior cervical or thoracic decompression at a single institution between January 2009 and September 2011. Preoperative pathologies, the location and extent of spinal decompression, and the use of an ultrasonic bone curette versus the high-speed drill were noted. The rates of incidental durotomy, as well as lengths of hospital stay and perioperative outcomes were compared between patients who received the ultrasonic bone curette versus those who experienced the high-speed drill.

**Results:** Amongst 88 patients who experienced the BoneScalpel™ and 249 who experienced the high-speed drill, 5 (5.7%) and 9 (3.6%) patients had an unintentional durotomy, respectively, which was not statistically significant ( $p=0.40$ ). No patients in either cohort experienced statistically higher rates of perioperative complications, although patients experiencing the BoneScalpel™ tended to have a longer length of hospitalization. In thirteen patients, the dural defect was repaired intra-operatively and none of these patients required any additional treatment. However, in one high-speed drill case where decompression was necessitated by a metastatic thoracic extradural lesion, the patient's post-operative course was complicated with pulmonary embolism and methicillin-resistant *Staphylococcus aureus* empyema. After a second operation for dural defect repair and lumbar drain placement, the patient subsequently recovered without any additional complications. No other patients who experienced an incidental durotomy had new-onset or permanent neurologic deficits postoperatively.

**Conclusion:** The safety and efficacy of ultrasonic bone curettes in spine surgery has not been well established. Here, we show that the ultrasonic bone curette use has a similar safety profile compared to the high-speed drill, although both are capable of causing iatrogenic dural tears during spinal surgery.

**257. Improving Benchmarking in Spine Surgery: Suggested Modifications of the UHC Algorithm for Calculating Readmission Rates following Spine Surgery**

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**Introduction:** We have previously published the pitfalls of using the UHC all-cause readmission algorithm to calculate readmission rates following spine surgery. The all-cause readmission rate algo-

rithm overestimated our readmission rate by 25%. The purpose of this study is to develop an algorithm for calculating a more clinically relevant readmission rate.

**Methods:** We performed a retrospective analysis of 5780 consecutive patient encounters by 10 spine surgeons at UCSF between October 2007 and June 2011 with a primary endpoint of readmission within 30 days. This data was abstracted from the UHC dataset using the Clinical Database/Resource Manager. We performed an independent chart review on all readmission cases.

**Results:** 281 (4.9%) patients were readmitted within 30 days from the previous discharge date according to the UHC database. Based on our manual chart review, 69 cases should not have been included in our readmission rate calculation. These cases included planned readmissions for staged procedures, cancelled or rescheduled cases on the index admission due to unpreventable reasons, and readmissions unrelated to the initial spine surgery. We devised modifications to the all-cause readmission algorithm to omit these cases. Specific filters using clinically relevant variables have been created. The index encounter DRG must equal the readmission encounter DRG to eliminate unrelated cases. Staged procedures will have a "p" next to the repeat encounter number to indicate it is a planned readmission. Accurate coding using clinically relevant variables such as DRGs is important.

**Conclusion:** Readmission rates are one metric used for quality of care. It will likely be used by payers to determine reimbursement rates and guide policy makers in their quest for effectiveness and value in healthcare. Improving readmission algorithms in spine surgery is necessary for accurate benchmarking and our reorganized algorithm is more clinically relevant than the prior UHC all-cause version. Its validity will be tested in a pilot study.

**258. Accurately Measuring the Quality and Effectiveness of Cervical Spine Surgery in Registry Efforts: Determining the most Valid and Responsive Instruments**

Saniya S. Godil MD (Vanderbilt University), Scott L. Parker MD, Scott L. Zuckerman MD BS (Vanderbilt University School of Medicine), Stephen Mendenhall BS, Matthew McGirt MD (Vanderbilt University Medical Center)

**Introduction:** Prospective registries have emerged as a feasible way to measure real-world effectiveness and value of care. However, the proven validity of more robust patient reported outcomes instruments (PROi) must be balanced with feasibility. We set out to establish the relative validity and responsiveness of common PROi in accurately determining effectiveness of cervical surgery in registry efforts.

**Methods:** Sixty-one patients undergoing ACDF for neck and arm pain were entered into a web-based prospective registry. Baseline and 3-month patient-reported outcomes [VAS-NP, VAS-AP, NDI, SF-12 PCS, SF-12 MCS and EQ-5D] were assessed. A level of improvement that met patient expectations was defined as meaningful effectiveness. To assess the validity of PROi to discriminate between effective and non-effective improvements, receiver operating characteristic (ROC) curves were generated. The difference between standardized response means (SRM) in patients reporting meaningful improvement versus not was calculated to determine relative responsiveness of each PROi.

**Results:** For pain and disability, NDI was the most accurate discriminator of meaningful effectiveness (AUC: 0.79) and most responsive to post-operative improvement, Table 1 & Figure 1. For general health and quality of life, SF-12 PCS ( $r=0.56$ ,  $p<0.001$ ) and EQ-5D ( $r=0.53$ ,  $p<0.001$ ) correlated highly with disease-specific NDI, suggesting both as valid measures. SF-12 PCS (AUC: 0.73) was an accurate discriminator but was least responsive compared to EQ-5D and SF-12 MCS, Table 1 & Figure 1.

**Conclusion:** For pain and disability, NDI is the most valid and responsive measure of effectiveness after surgery for neck and arm pain. For health-related quality of life, both SF-12 PCS and EQ-5D were valid measures, but only SF-12 PCS could accurately dis-

criminate meaningful improvement after cervical surgery. Large scale registry efforts replacing the 10-item NDI with more feasible 2-item VAS LP/BP and the 12-item SF-12 with more feasible 5-item EQ-5D will not represent an accurate measure of effectiveness or quality of spine care.

### 259. Improving Quality: Establishing Standard Performance Measures for Patients with Adult Spinal Deformity

Daniel J. Hoh MD (University of Florida), Dan Neal MS, Brian Lim Hoh MD (University of Florida)

**Introduction:** There is increasing local and national emphasis on improving patient quality. The federal government is pursuing quality-based reimbursement and pay-for-performance strategies to incentivize better performance. Various adverse events such as hospital-acquired conditions (HACs) or those occurring after surgery (PSIs) have been earmarked as surrogate measures of quality. Current nationwide incidences of these HACs and PSIs for various neurosurgical conditions have not yet been reported, which is of particular relevance for complex conditions like adult spinal deformity (ASD) in which significant complications can occur even with optimal medical care. Knowledge of national incidences of HACs and PSIs and factors predictive of their occurrence are essential, as they are the metric by which neurosurgeons are being measured. Further, these standards may serve as a baseline for further patient quality improvement. To obtain the best generalized data, we utilized the Nationwide Inpatient Sample (NIS) to determine the incidence and predictive factors of adverse events for patients with ASD.

**Methods:** The NIS was queried from 2002-2010 for all ASD admissions >18 years of age. Reported HACs and PSIs were recorded. Comorbidity Scores were assigned by summing the Elixhauser comorbidities. Statistical models were used to assess associations between patient and hospital characteristics for each HAC and PSI.

**Results:** There were 265,789 ASD admissions. The mean age was 58.4 years. 74.3% were female. 50.6% were admitted to teaching hospitals. There were 43,385 (16.3%) PSIs and 20,456 (7.7%) HACs. Leading reported adverse events were: falls/trauma (6.47%), postoperative respiratory failure (6.34%), sepsis (2.37%), pressure ulcer (2.23%), and postoperative hip fracture (1.51%). Adverse events were associated with increased age, male gender (inverse for postoperative hip fracture), hospital-type, and higher Comorbidity Score.

**Conclusion:** By establishing baseline standard performance measures for minimizing adverse events for ASD, we may further improve overall patient quality and safety.

### 260. Economic Value of ACDF—Analysis of a 5 Year Follow-up Cohort from FDA Trials

Praveen V. Mummaneni MD (University of California San Francisco Spine Center), Paul A. Anderson MD (University of Wisconsin), Vincent C. Traynelis MD (Rush University Medical Center), Steven D. Glassman, Leah Y. Carreon MD MSc

**Introduction:** Economic value is increasingly important in health-care policy decision making. This study presents the cost/QALY gained for single-level instrumented Anterior Cervical Discectomy and Fusion (ACDF) over five years.

**Methods:** Control ACDF patients with complete five year follow-up data that were part of the IDE trials for cervical disc arthroplasty were identified. Direct costs for each intervention reported were determined using the 2012 Medicare Fee schedule. Health utility was determined using the SF-6D.

**Results:** There were 352 patients (182 females, 170 males), mean age 44.6 years (22 to 73). Over five years 41 repeat ACDFs, 15 posterior fusions, 6 foraminotomies, 2 implant removals, 2 hematoma evacuations and 1 esophageal fistula repair were performed. Mean QALY

gained in each year follow-up was 0.16, 0.18, 0.17, 0.18 and 0.18 for a cumulative 0.88 QALY gain over five years. The resultant cost/QALY gained at one year was \$104,831; \$53,074 at year two; \$37,717 at year three; \$28,383 at year four; and \$23,460 at year five. Eleven nerve releases and 26 rotator cuff repairs were done within five years after the index ACDF. The cost/QALY gained at one year including upper extremity procedures was \$106,256, \$54,622 at year two, \$38,836 at year three, \$29,454 at year four and \$24,479 at year five.

**Conclusion:** This study indicates that at five year follow-up, single-level instrumented ACDF is both effective and durable resulting in a favorable cost/QALY gained as compared to other widely accepted healthcare interventions such as total hip arthroplasty.

### 261. Accurately Measuring the Quality and Effectiveness of Lumbar Surgery in Registry Efforts: Determining the most Valid and Responsive Instruments

Saniya S. Godil MD (Vanderbilt University), Scott L. Parker MD, Scott L. Zuckerman MD BS (Vanderbilt University School of Medicine), Stephen Mendenhall B.S., David Shau BS, Matthew McGirt MD (Vanderbilt University Medical Center)

**Introduction:** Prospective registries have emerged as a feasible way to measure real-world effectiveness and value of care. However, the proven validity of more robust patient reported outcomes instruments (PROi) must be balanced with feasibility. We set out to determine the relative validity and responsiveness of common PROi in accurately determining effectiveness of lumbar fusion for lumbar spondylolisthesis in registry efforts.

**Methods:** Fifty-eight patients undergoing primary TLIF for degenerative lumbar spondylolisthesis were entered into an institutional registry and prospectively followed for two years. Baseline and two-year patient-reported outcomes [VAS-BP/LP, ODI, SF-12, Zung Depression and EQ-5D] were assessed. A level of improvement that met patient expectations was defined as meaningful effectiveness. To assess the validity of PROi to discriminate between effective and non-effective improvements, receiver operating characteristic (ROC) curves were generated. The difference between standardized response means (SRM) in patients reporting meaningful improvement versus not was calculated to determine relative responsiveness of each PROi.

**Results:** For pain and disability, ODI was an accurate discriminator of meaningful effectiveness (AUC: 0.94) and most responsive to post-operative improvement (SRM difference: 2.18), Table 1 and Figure 1. For general health and quality of life, SF-12 PCS, Zung and SF-12 MCS were all accurate discriminators of meaningful effectiveness, however, EQ-5D was most accurate (AUC: 0.97) and most responsive, Table 1 and Figure 1.

**Conclusion:** For pain and disability, ODI is the most valid and responsive measure of effectiveness of lumbar fusion. For health-related quality of life, EQ-5D is the most valid and responsive measure of effectiveness of lumbar fusion. Large scale registry efforts can utilize the more feasible 5-item EQ-5D rather than 12-item SF-12 or 18-item ZUNG, but cannot replace the 10-item ODI with the more feasible 2-item VAS LP/BP without sacrificing validity. Registry efforts using only VAS pain may not represent an accurate measure of effectiveness of quality of spine care.

### 262. Analysis of the Cost-Effectiveness of Surgical Treatment for Adult Spinal Deformity

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(Institute for Health Care Research & Improvement, Baylor Health Care System), Justin S. Smith MD PhD (University of Virginia Health System), Rajiv Saigal MD PhD (University of California, San Francisco), Sigurd Berven MD (University of California, San Francisco), Vedat Deviren MD (University of California San Francisco), International Spine Study Group

**Introduction:** The average cost-effectiveness ratio (ACER) is the cost of care relative to the improvement in HRQOL. In a value-based health care economy, the ACER is an important consideration for resource allocation. This analysis concerns the estimation and statistical analysis of ACERs of surgical treatment for patients diagnosed with one of four categories of ASD: Primary Idiopathic Scoliosis (PIS), Primary Degenerative Scoliosis (PDS), Primary Sagittal Plane Deformity (PSPD), and Revision (R).

**Methods:** Multi-center, retrospective analysis of 323 consecutive ASD patients (ages 18 to 85, with an average age of 54). Patients were assigned to one of four diagnostic categories of ASD: PDS (n=59, 18%), PIS (n=102, 32%), PSPD (n=39, 12%), and R (n=123, 38%). HRQOL measures were based on the Medical Outcomes Study Short Form 36 (SF-36), the Oswestry Disability Index (ODI), and the Scoliosis Research Society (SRS) questionnaires after at least one year following surgery. SRS scores were translated to a 100 point scale. Costs were collected from hospital data and included direct costs (DC) incurred for the episode of surgical care. Confidence intervals were calculated using nonparametric bootstrap methods.

**Results:** For all categories of ASD, point estimates and 95% confidence intervals were estimated for the following measures: ACER MCS=\$26,028 (\$15,661 to \$66,645); ACER PCS=\$12,174 (\$9,089 to \$17,919); ACER ODI=\$7,833 (\$5,928 to \$12,074); ACER SRS(Function)=\$9,006 (\$6,437 to \$14,567); ACER SRS(Self-Image)=\$3,405 (\$2,936 to \$4,021); and ACER SRS(Pain)=\$4,198 (\$3,508 to \$5,135). ACERs and confidence intervals were also estimated for specific diagnostic categories of ASD.

**Conclusion:** The CE of care is an important determinant of resource allocation. This study establishes a baseline range of the cost of incremental improvement in HRQOL for patients undergoing surgical treatment for ASD. Further analysis will measure ACERs based on QALYs, allowing comparisons to other medical and surgical interventions.

### 263. A Novel Mouse Model of Cervical Spondylotic Myelopathy: An Opportunity to Identify New Targets

Spyridon K Karadimas MD PhD (Toronto Western Hospital), Wenru Yu, Eun Su Moo, Madhav Bole, Michael G. Fehlings MD PhD FRCS FACS (Toronto Western Hospital)

**Introduction:** In this study we have developed a novel model of CSM.

**Methods:** Following the resection of ligamentum flavum at C5-6, C6-7 the spinal cords of C57BL mice were slowly and progressively compressed introducing a piece of aromatic polyether underneath the C6 lamina. Compression animals were sacrificed at 5 and 10 weeks post-surgery. In control animals a sham operation was performed. The extent of compression was evaluated using MRI. Gait analysis was performed weekly using a computerized kinematic assessment (Catwalk). Demyelination was assessed by HE&LFB. The loss of neuronal cell, the extent of gliosis, axonal degeneration, and inflammation were measured by NeuN, GFAP and Iba-1 immunohistochemistry and by Western blot analysis. The expression of cytokines and chemokines were evaluated by multiplex ELISA. ANOVAs with Bonferroni post-hoc analysis were used for statistical analysis.

**Results:** MRI quantification at 10 weeks revealed  $46.1\% \pm 3.4$  compression ratio in the compression group. Compression animals had a broad-based, ataxic, hesitant and spastic gait compared to the smooth rhythmic gait of controls. There was statistically significant

decrease in front and hind paw stride length between the compression and sham group ( $p<0.001$ ) and between the compression groups ( $p<0.005$ ). In addition, statistically increases ( $p<0.001$ ) were observed in hind paw base of support. The protein levels of Iba-1 were significantly ( $p=0.039$ ) higher at 5 weeks compressed animals compared to controls. The expression levels of MCP-1, M-CSF and MIG were significantly ( $p=0.042$ ,  $p=0.002$ ,  $p=0.008$ ) higher in the 5 weeks compressed animals compared to controls. Moreover, there was a statistically significant increase ( $p=0.036$ ) in GFAP immunoreactivity in the compression compared to control animals.

**Conclusion:** The development of this mouse CSM model offers the opportunity to exploit for the first time the power of mouse genetics in CSM.

### 264. Incidence of Vitamin D Deficiency in Patients Undergoing Elective Spine Surgery

Vijay Ravindra MD (University of Utah Hospital), Wilson Zachary Ray MD (Washington University School of Medicine), Andrew T. Dailey MD (University of Utah Hospital)

**Introduction:** Decreased bone density secondary to osteoporosis and osteomalacia represents a significant risk factor for both bony fracture and spinal instrumentation failure. We investigate the incidence of vitamin D deficiency or insufficiency in patients undergoing elective spinal fusion procedure. Although there is a clear link between bone mineral density and the risk of osteoporosis, it is not clear whether aggressive treatment of low vitamin D levels would lead to improved spinal fusion and decreased incidence of instrumentation failure.

**Methods:** Postoperative serum 25-OH vitamin D levels were measured in adults (>18 years) with the diagnosis of degenerative spondylosis who underwent spinal fusion procedures. Anterior and posterior, lateral, and flexion and extension radiographs are to be obtained at 6 weeks, 3 months, 6 months, and 1 year after surgery.

**Results:** 172 patients (99 male, 73 female) who underwent elective spinal fusion from November 2011 through September 2012 were reviewed. The mean age of the study group is 59 years (range 22-90 years). 57 patients underwent fusion from an anterior approach, 107 from a posterior approach, and 8 patients underwent a combined procedure. The average 25-OH vitamin D level was 25.2 (range 6-77 ng/mL; reference 30-80 ng/mL). 123 (72%) patients had laboratory confirmed vitamin D insufficiency (20-30 ng/mL) or deficiency (<20 ng/mL). 56 patients (33%) patients in the series had laboratory confirmed vitamin D deficiency (<20 ng/mL).

**Conclusion:** The incidence of vitamin D insufficiency is alarmingly high in patients with degenerative spondylosis requiring spinal fusion. Future progress will focus on postoperative nonunion, pseudarthrosis, hardware failure, and subsequent time to fusion in the setting of clinically proven vitamin D deficiency.

### 265. Intraoperative Monitoring Does NOT Improve Outcomes in Cervical Spine Surgery

Sanjay S. Dhall MD (Emory University School of Medicine), Daniel J. Hoh MD (University of Florida)

**Introduction:** The use of intraoperative monitoring (IOM) during spinal surgery has gained widespread popularity despite a paucity of studies on its efficacy at preventing neurologic injury. We set out to determine the impact of IOM in the surgical treatment of cervical spondylotic myelopathy (CSM).

**Methods:** Medical records of consecutive patients undergoing posterior surgery for CSM by 2 surgeons over a 2 year period were retrospectively reviewed. IOM was used exclusively by one surgeon, and not used by the other. Charts were reviewed for patient demographics, procedure performed, intraoperative IOM data, and post-

operative neurologic outcome. Patients that had surgery with IOM (+IOM group) were compared to those without IOM (-IOM group).

**Results:** 52 patients underwent posterior surgery with IOM; 44 patients without IOM. There was no significant difference in age, gender, indication for surgery, or number of levels treated between groups. All patients had instrumentation placed during the procedure (lateral mas screws or laminoplasty plates). The number of levels treated ranged from 3 to 8. 4.5% (n=2) of -IOM patients had delayed temporary C5 nerve root palsy postoperatively. 1.9% (n=1) of +IOM patients had delayed temporary C5 nerve root palsy postoperatively (p=0.23). No patient in either group had a new permanent postoperative neurologic deficit. None in the +IOM group had an intraoperative change in SSEP or MEP that directly impacted the surgical procedure, intraoperative decision-making, or resulted in a postoperative neurologic change.

**Conclusion:** Postoperative neurologic deficits after posterior surgery for cervical spondylotic myelopathy are rare. The routine use of IOM during surgery does not predict neurologic outcomes, significantly reduce the incidence of complications, or impact the surgical procedure. While further prospective investigation is needed, these findings suggest that IOM during posterior surgery for CSM is not standard of care.

#### **266. Outcome Following Unilateral versus Bilateral Instrumentation in Patients Undergoing Minimally Invasive Transforaminal Lumbar Interbody Fusion: A Single Center Randomized Prospective Study**

Nader S. Dahdaleh MD (Department of Neurosurgery at Northwestern), Albert Wong MD (Northwestern University), Richard G. Fessler MD (Northwestern University)

**Introduction:** Minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) is widely used for a variety of degenerative spinal disorders. The outcome of bilateral instrumentation versus unilateral instrumentation for unilateral MIS TLIF has never been explored.

**Methods:** A prospective study was conducted on patients undergoing single level unilateral MIS TLIF. The patients were randomized into two groups, one that received unilateral instrumentation (2 pedicle screws and one rod) and included 16 patients and the other received bilateral instrumentation (4 pedicle screws and 2 rods) and included 20 patients. Preoperative and postoperative clinical outcomes at the last follow up visit as well as radiographic data were collected and analyzed.

**Results:** The baseline characteristics of both groups are summarized in table 1. There were no differences in baseline preoperative Visual analogue scale for back pain (VAS-BP), VAS leg pain (VAS-LP), Oswestry disability index (ODI), and short form 36 (SF-36) physical component between both groups (Table 1). Within each group, there were statistically significant improvements in all postoperative outcome measures except for SF-36 mental component compared to preoperatively (Figures 1, 2, 3, 4, and 5). There were no significant differences in all clinical outcome measures between the bilateral and unilateral instrumentation groups. Blood loss was lower in the unilaterally instrumented group, whereas average hospitalization was lower in the bilaterally instrumented group. No postoperative complications were encountered in both groups.

**Conclusion:** The clinical outcome following unilateral instrumentation for unilateral MIS TLIF is similar to bilateral instrumentation. Further studies are warranted to compare cost-effectiveness of both procedures.

#### **267. A Review of 295 cases of Spinal Epidural Abscess: What is chance that medical management alone will fail?**

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**Introduction:** A spinal epidural abscess (SEA) is a rare disease with potentially devastating morbidity if not adequately treated. Early diagnosis and treatment is essential in preventing neurologic deficits. If the patient's exam is normal, we often attempt to treat SEA medically, without surgical intervention. There is minimal information on how frequently SEA patients who are initially managed medically end up requiring surgical intervention.

**Methods:** Institutional Review Board approval obtained to search the hospital computer database. Retrospective search performed to identify inpatients that had a discharge diagnosis code of 'spinal abscess' over a 6 year period. We examined 295 SEA cases to determine which were treated initially with medical management, and what percentage ultimately required surgery. Various prognostic factors were assessed.

**Results:** 295 adult inpatients were diagnosed with spinal abscess. Of these, 168 patients were initially managed medically. Out of these 168, 83 (49.4%) patients ended requiring surgical intervention. Various prognostic factors were assessed to determine which factors lead to increased risk of converting to operative treatment.

**Conclusion:** There is an approximately 50% chance that medical management of spinal abscesses will fail, ultimately requiring surgical intervention. Patients who are treated medically need to be warned about the high chance that operative intervention will be required, especially when risk factors are present.

#### **268. Unplanned Return to the Operating Room in Patients with AIS: Are We Doing Better with Pedicle Screws?**

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**Introduction:** This study seeks to define the incidence, reason, timing, and risk factors for reoperation in patients with adolescent idiopathic scoliosis (AIS) treated with pedicle screws (PS) compared to hybrid (Hb) constructs.

**Methods:** A multicenter database was retrospectively queried to identify consecutive patients with AIS who underwent posterior spinal fusion with either PS or Hb constructs with a minimum 2 year follow-up. All reoperations were stratified into an early group (<60 days) or a late group (>60 days), and were further categorized by reason for return. Univariate and multivariate logistical analyses were performed to identify potential risk factors causing complications requiring reoperation in the patients treated with PS.

**Results:** 627 patients met the inclusion criteria (PS=540, Hb=87). There was a statistically significant difference in the rate of reoperations between the PS and Hb groups (3.5% versus 12.6%, p<0.001). Early returns to the operating room occurred in 2.0% of the patients with PS, compared to 3.4% in the Hb group. Reasons for an early reoperation were malpositioned instrumentation (PS=1.7%, Hb=1.1%) and infection (PS=0.4%, Hb=2.2%). Reasons for a later reoperation were infection (PS= 1.1%, Hb=1.2%), pseudarthrosis (PS=0.2% S, Hb=2.3%), malpositioned instrumentation (PS=0%, Hb=2.3%), and prominent instrumentation (PS=0.2%, Hb=3.4%). Multivariate analysis revealed longer operating time as an independent risk factor for an unplanned reoperation in patients with AIS treated with PS.

**Conclusion:** Patients with AIS treated with PS constructs appear to have decreased rates of reoperation compared to those treated with Hb constructs. Patients with PS constructs mostly have reoperations in the early postoperative period for misplaced pedicle screws. Patients with Hb constructs mostly have reoperations in the late postoperative period for pseudarthrosis and prominent instrumentation. Longer operating times were found to increase the risk of an unplanned reoperation in patients with AIS treated with PS.

**270. Surgical Manifestations of Thoracic Arachnoid Pathology: Case Series of Twenty-Eight Patients and Review of the Literature**

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**Introduction:** Thoracic arachnoid pathology manifests as thoracic myelopathy with or without syrinx formation, and may present a significant management dilemma. This pathology includes traumatic tethering, dural duplication, spinal cord herniation, arachnoid bands and adhesions, arachnoid cysts, and infectious arachnoiditis.

**Methods:** We have managed and followed twenty-eight patients with thoracic myelopathy from thoracic arachnoid pathology over the last seventeen years. Twelve patients had short-segment thoracic arachnoid pathology, sixteen patients presented with long-segment arachnoid pathology. A chart review and contemporary follow-up of these patients was performed, followed by a systematic review of patients with thoracic arachnoid pathology using the MEDLINE and PubMed databases.

**Results:** There are multiple manifestations of thoracic arachnoid pathology causing thoracic myelopathy. Etiology of this pathology includes trauma, infection, intraspinal hemorrhage, epidural anesthesia, intrathecal contrast injections, and congenital malformations. Short-segment thoracic arachnoid pathology often responds favorably to detethering/lysis and is less likely to recur. Long-segment thoracic arachnoid pathology responds poorly to detethering/lysis procedures only, and typically requires CSF diversion for recurrent cystic loculations or syrinx formation. Overall, 75% of patients with symptomatic thoracic arachnoid pathology are improved or are stabilized with surgical treatment when indicated. Twenty-five percent of patients decline long term despite aggressive management.

**Conclusion:** Thoracic arachnoid pathology causing thoracic cord dysfunction and myelopathy is varied, has multiple etiologies, and can be difficult to treat long-term. Surgical management, when indicated, is case specific. Serial long-term follow-up is essential to document enduring clinical and radiographic success.

**271. Predictors of Loss of Kyphotic Deformity Correction and Scoliosis after Anterolateral Vertebrectomy and Spinal Fusion for Thoracolumbar Burst Fractures**

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**Introduction:** Anterolateral vertebrectomy and spinal fusion is a described treatment for burst fractures of the thoracolumbar junction. Controversy remains as to the best method of treating these difficult and highly unstable fractures.

**Methods:** Patients who underwent single stage anterolateral vertebrectomy and fusion for burst fractures of the thoracolumbar junction from January 2000 through April 2012 were identified from our institutional case log. Clinical and radiographic data were obtained from the hospital medical records. Scoliosis of greater than 5° at the time of final follow up was considered significant. Loss of kyphotic deformity correction by 5° at the time of final follow up was also considered significant.

**Results:** Ninety-six patients were followed for greater than one month, mean follow up was 6.6 (2-36) months. Forty-two patients (42.7%) had an expandable titanium cage graft and 54 (56.3%) had a bone strut graft. Five patients (5.2%) subsequently failed during follow up and required posterior instrumentation. Thirty-nine patients (40.6%) demonstrated scoliosis during follow up. Thirty-five (36.5%) had loss of kyphotic deformity correction by a mean of 10.0° (±3.6, Range: 5-20). In a univariate analysis, BS graft ( $p = 0.01$ ), tilt in graft position ( $p = 0.005$ ), end plate damage ( $p < 0.0001$ ), and graft to endplate width ratio of =45% on AP x-ray ( $p = 0.02$ ) were associated with loss of kyphotic deformity correction at follow up. Graft location towards the left of midline ( $p < 0.0001$ ), tilt in graft position ( $p = 0.01$ ), and end plate damage ( $p = 0.0001$ ) were also associated with scoliosis at the time of final follow up.

**Conclusion:** Use of a bone strut graft, graft location, tilt in graft position, presence of end plate damage, and width of the graft on AP x-ray may be associated with loss of kyphotic deformity correction after single stage anterolateral vertebrectomy and spinal fusion. Graft location, tilt in graft position and presence of end plate damage may also be associated with post-operative scoliosis in these patients.

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