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Paper 01. Efficacy and Safety of High-dose Tranexamic Acid Protocol in Adult Spinal Deformity – Analysis of 100 Consecutive Cases

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Background/Introduction: Adult spinal deformity (ASD) surgery is a massive undertaking that may involve a significant amount of blood loss, especially when various osteotomy techniques are utilized. Antifibrinolytic agents such as tranexamic acid (TXA) have been used in an attempt to reduce intraoperative blood loss. However, there is no universally accepted dosing protocol for TXA in spine surgery. Moreover, there are very few reports in the literature regarding high-dose TXA use in ASD, possibly due to concerns for thromboembolic or seizure risks. This study aims to investigate the safety profile and efficacy of using a high-dose (50mg/kg loading, 5mg/kg/hr infusion) TXA protocol during ASD surgery.

Materials/Methods: Consecutive patients undergoing spinal deformity correction over a 14-month period (September 1st 2015 – November 1st 2016) at a single institution were identified. Inclusion criteria were adults (age ≥ 18 years) who underwent posterior spinal fusion surgery of at least 5 levels. Our standard TXA protocol is 50 mg/kg intravenous loading dose followed by a 5 mg/kg/hr infusion until skin closure. Patient demographics, estimated blood time (EBL), post operative blood transfusion, and other procedure specific information were recorded and analyzed.

Results: A total of 100 adult patients were included in the study. Operative procedures were performed by a single surgeon. The mean age was 46.5 years, and 71% of patients were female. Average BMI was 24.7. The average fusion length was 14 levels. 46/100 patients had a primary surgical procedure while the rest were revisions. 61/100 of patients had pelvic fixation. Posterior column osteotomies were performed on 80/100 patients; pedicle subtraction osteotomy (PSO) was performed in 8 patients; and vertebral column resections (VCRs) were performed in 15 patients. Mean intraoperative blood loss among all patients was 1296cc. There was one PE was treated with a heparin drip, and two DVTs which developed in rehab which were treated with oral anticoagulation. There were no MIs, seizures, strokes, or renal complications.

Discussion/Conclusion: This study demonstrates that high dose TXA is effective and safe to use in well-selected ASD patients and lays the foundation for further studies on this important topic.

Paper 02. Comparison of Bleeding vs Clotting Complications after Lumbar Spine Surgery

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Background/Introduction: Unlike almost all other inpatient surgery, chemical anticoagulation after spine surgery is frequently withheld due to fear of bleeding complications. Unlike most other

surgeries, bleeding complications after spine surgery can result in neurological injury. The purpose of this study was to compare the incidence of bleeding and clotting complications in patients who have undergone spinal surgery without postoperative anti-coagulation, using a large national database.

Materials/Methods: A retrospective review of the Truven Health Marketscan® Research Databases was conducted for patients undergoing lumbar spine operations between 2003 and 2014. Patients were divided into 3 groups: anterior lumbar surgery, posterior lumbar fusion, and posterior lumbar laminectomy. The ICD-9-CM diagnosis codes for epidural hematoma, hematoma, seroma, deep vein thrombosis (DVT), and pulmonary embolism (PE) were used to calculate the incidence of these complications within three months of surgery in each group. The rate of operative intervention for the bleeding complications was assessed and compared to the rate of PE. The relative risks of these complications were calculated for surgical approach and fusion vs. decompression.

Results: 379,871 patients were included in the study. Overall, 8,609 (2.3%) patients developed bleeding complications (seroma+hematoma+epidural hematoma) while 13,384 (3.5%) developed clotting complications (DVT + PE). 1222 (3.2%) patients underwent surgical drainage for their bleeding complication, and 1,216 (0.32%) patients developed PE. While the rates of all bleeding complications were comparable to the rates of all thrombosis complications in all subgroups, the rate of PE was 5-7 fold higher than the rate of bleeding complication requiring operative intervention in all subgroups ($p < 0.001$) (Table 1). We observed a significantly higher risk of bleeding and thrombotic complications in posterior lumbar fusion as compared to anterior fusion (RR 1.43, 1.81 respectively). We also observed a significantly higher risk of bleeding and thrombotic complications in posterior lumbar fusion as compared to posterior decompression alone (RR 1.51, 1.48 respectively).

Discussion/Conclusion: We observed that PE rates were 5-7 fold higher than rates of bleeding complications requiring surgery. Given this large disparity in these complication rates, it may be worthwhile considering routine chemical anticoagulation after spine surgery.

Paper 03. Pharmacologic Prophylaxis for Venous Thromboembolism in Elective Spine Surgery

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Background/Introduction: Venous thromboembolism (VTE) is a known complication after spine surgery, but data and guidelines for prophylaxis are unclear for patients undergoing elective spine surgery. The current study examines VTE incidence, risk factors, and association of pharmacologic prophylaxis with VTE and postoperative hematoma in elective spine surgery patients.

Materials/Methods: Patients who underwent elective spine surgery, 2013-2016, were identified at a large academic medical center. A chart review was completed to examine for use of pharmacologic prophylaxis for VTE, history of prior VTE, and incidence of hematoma requiring reoperation. Additional demographic, comorbidity, intraoperative, and postoperative factors were available for each patient. The association of demographic,

comorbidity, intraoperative, and postoperative factors, including history of prior VTE and pharmacologic prophylaxis status, with VTE and postoperative hematoma requiring reoperation were tested with multivariate regression.

Results: The study included 2,855 patients. Pharmacologic prophylaxis was received by 56.3% of patients, and unfractionated heparin was the most frequently used agent (96.8%). The incidence of postoperative VTE was 1.23% (35/2,855), and independent risk factors for VTE included increasing age, male gender, higher BMI, perioperative blood transfusion, urinary tract infection, longer length of stay, and history of prior VTE. Pharmacologic prophylaxis did not significantly influence the rate of VTE (RR=0.68, P=0.424), even after controlling for patient risk factors and prescribing patterns. The incidence of postoperative hematoma requiring return to the operating room was 0.4% (11/2,855). Seven of the postoperative hematomas presented with significant neurological deficits (63.6%), three presented with pain or wound drainage (27.3%), and one presented with respiratory compromise (9.1%). Among 10 patients experiencing hematoma who received prophylaxis, nine received unfractionated heparin and one received enoxaparin. Pharmacologic prophylaxis was associated with significant increase in postoperative hematoma requiring return to operating room (RR=7.37, P=0.048).

Discussion/Conclusion: Contrary to expected findings, pharmacologic prophylaxis for VTE after elective spine surgery was not associated with a significant reduction in VTE that we could detect. Further, there was a significant increase in postoperative hematoma requiring reoperation among patients receiving prophylaxis, leading to questions about routine use of pharmacologic VTE prophylaxis for elective spine surgery.

Paper 04. Fever Following Lumbar Fusion Procedures

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Background/Introduction: Postoperative fever is a common occurrence following lumbar fusion surgery. While a postoperative fever can indicate underlying complications such as infection, it is often self-limited with no definitive cause. However, patients who develop transient postoperative fevers often undergo extensive workups, unnecessarily increasing costs and patient anxiety. In this context, this study aims to describe the incidence and timing of postoperative fever, the outcomes of fever workups, and the risk factors associated with fevers following lumbar fusion.

Materials/Methods: A retrospective review of a prospectively collected registry of patients undergoing transforaminal, posterior, anterior, or lateral lumbar fusion for degenerative disease was performed. For patients in whom postoperative fever (≥ 101.5 F) was documented, charts were reviewed for any fever workup or diagnosis. Additionally, multivariate regression was used to identify independent risk factors for the development of postoperative fever.

Results: 891 patients undergoing lumbar fusion met inclusion criteria, of which 107 (12.0%) exhibited at least one fever during their hospital course. Of these, 64 had only one fever, 15 had two fevers, and 28 had 3 or more fevers. 43.9% of first-documented fevers occurred during the first 24 hours, 53.3% during postoperative hours 24-48, and 2.8% following 48 hours. At least one component of a fever workup was conducted in 49 of the 107 patients who had fever (45.8%), resulting in fever-associated diagnoses in 4 patients prior to discharge. Additionally, 3 patients with fevers during the inpatient stay developed complications after discharge. On multivariate analysis, operations longer than 150 minutes (relative risk [RR]=1.66, p=0.015) and narcotic consumption greater than 85 oral morphine equivalents on postoperative day 0 (RR=1.69, p=0.015) were independently associated with increased risk of developing postoperative fever.

Discussion/Conclusion: The results of this study suggest that inpatient fever occurs in about 1 in 8 patients following lumbar fusion surgery. In most cases for which a fever workup is performed, no cause for fever is detected. Longer operative time and increased early postoperative narcotic use may increase the risk of developing postoperative fever. Fever workups following lumbar fusion are probably most effective when pursued with the guidance of an associated postoperative symptom suggesting a potential source.

Paper 05. Betadine Irrigation and Intrawound Vancomycin Powder Prevent Wound Complications Following Lumbosacral Tumor Surgery

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Background/Introduction: Surgical management of metastatic and primary spine tumors is associated with wound complication (infection, dehiscence) rates of up to 30%. The role of concurrent intrawound vancomycin powder (IVP) and betadine irrigation (BI) has not been examined in spine tumor surgery. Our objective was to evaluate wound complications following administration of IVP and BI for lumbar and sacral tumor surgery.

Materials/Methods: Patients undergoing spine tumor surgery by one surgeon at a regional cancer referral center from November 2012 to December 2016 were identified. Inclusion criteria were lumbar or sacral tumor surgery, minimum 30 days follow-up, administration of 1 to 2gm of IVP during wound closure and BI throughout the case. Demographic information (age, sex, race/ethnicity), location (lumbar, sacrum), histology (primary/metastatic), neurological status on presentation (ASIA motor scale), surgical data (EBL, instrumentation, approach), wound complications and radiation treatment status (pre and post-operative) were collected.

Results: 21 patients undergoing 23 procedures for lumbar and sacral tumors were enrolled. There were 8 females and 13 males with an average age of 55.1 (9 – 92) with 19 Caucasians, 1 African-American and 1 Native-American. 17 lesions were in the lumbar spine and 4 in the sacrum. Histology included 5 primary tumors (Chordoma 1, Angiolipoma 1, Aneurysmal bone cysts 3) and 16 metastatic tumors (Lung 7, Melanoma 2, Breast 1, Renal 1, Colon 1, Lymphoma 1, Hepatoid 1, Prostate 1, Squamous cell CA 1). Neurological status was 7 ASIA D and 14 ASIA E. Average EBL was 651ml (100 – 2500), with 19 posterior only and 2 anterior-posterior approaches. All patients had a decompression, 6 had a transpedicular decompression and 1 patient with chordoma underwent an en-bloc spondylectomy. 15 of 21 patients had instrumentation (average of 3 levels [3-6]). 3 had pre-operative radiation only and 12 had post-operative radiation only. There was a 0% rate of wound complications. 33% were deceased at latest follow-up.

Discussion/Conclusion: Intrawound vancomycin powder and betadine irrigation resulted in a 0% rate of wound complications in patients with lumbar and sacral spine tumors. IVP and BI are inexpensive modalities that can minimize the risk of wound complication in high-risk spine tumor patients.

Paper 06. Outcomes of Suprafascial Vacuum Assisted Closure Device in Spine Surgical Site Infections Management

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Background/Introduction: Many studies reported benefits using negative pressure wound therapy (NPWT) in surgical site infections (SSIs). Surgeons utilize NPWT in different ways. Some surgeons place the VAC (vacuum assisted closure) sponge into the open wound bed and allow the device to facilitate tissue granulation until ultimate

closure (Open VAC). Others believe a bed of muscle is beneficial and re-approximate the patient's paraspinal muscles and place the VAC device over the re-approximated muscle (Closed VAC). We compared the outcomes between open VAC and closed VAC procedures used in the management of SSIs occurring after spinal deformity surgeries.

Materials/Methods: This retrospective study included 23 consecutive patients (males-9, females-14) with an average age of 60 years with SSIs managed with NPWT following spinal procedures between 2012 and 2015. All patients received IV preoperative empirical antibiotics except two patients who received antibiotics after cultures were taken. Once growth cultures revealed the causative organisms, patients were placed on appropriate antibiotic therapy for at least 4 -6 weeks. A total of 33 wound VAC procedures in 23 patients were separated into two groups based on the type of wound closure: Group 1 (n=12, Open VAC) and Group 2 (n=21, Closed VAC). Complications after wound closure, duration of wound vac therapy (days) and re-operation rates were compared between groups. Statistical analysis was made using ANOVA and Chi Square tests for continuous variables. $P \leq 0.05$ was considered statistically significant.

Results: The re-operation rate was 63% in Group 1 and 19% in Group 2 during VAC therapy for persisted infections. Mean duration of wound VAC therapy was 77 days in Group 1 and 33 days in Group 2 (Table 1). In Group 2, one patient had re-infection after complete eradication of the initial infection and none were noticed in Group 1.

Discussion/Conclusion: Our study compared the outcomes between two techniques of placing a wound VAC in SSIs. The mean therapy duration and re-operative surgeries were less in closed wound VAC therapy. The small sample size was a limitation of the study. Management of spine SSIs with re-approximated suprafascial wound VAC reduces re-operation rates and duration of wound VAC therapy.

Paper 07. Can a surgeon's demographic factors predict postoperative complication rates after an elective spinal fusion?

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Background/Introduction: A surgeon's demographic factors have been shown to impact surgical decision-making in the management of degenerative disease of the lumbar spine. Complication rates are frequently reported outcome measurements that are used as quality-of-care indicators for surgical treatments. Thus, complication rates are used by healthcare systems to assess payments and reimbursements. However, there are few studies investigating the association between surgeons' demographic factors and complication rates. The purpose of this study was to determine whether surgeons' demographic factors – surgical specialty, years in practice, type of practice, medical degree earned, location of medical school, gender, and geographic region of practice – influence postoperative complication rates for elective spine fusion procedures.

Materials/Methods: A database of U.S. spine surgeons with corresponding postoperative complications data after elective lumbar (posterior approach) spine fusion was compiled utilizing publicly available data from the Centers for Medicare and Medicaid Services (CMS) from 2011-2013 and ProPublica Surgeon Scorecard from 2009-2013. Demographic data for each surgeon was manually collected, including surgical specialty (orthopaedic vs. neurological surgeons), years in practice, practice setting (private vs. academic), medical degree (M.D. vs. D.O.), medical school location (U.S. vs. foreign), gender, and geographic region of practice. General linear mixed models using a Beta distribution with a logit link and pairwise

comparison with post-hoc Tukey-Kramer were used to assess the relationship between surgeons' demographics and complication rates.

Results: 2,110 U.S. spine surgeons who performed spine fusions on 125,787 Medicare patients from 2011-2013 met the inclusion criteria. None of the surgeons' demographic factors analyzed were found to significantly affect the overall complication rates in lumbar (posterior approach) spine fusion (Table 1).

Discussion/Conclusion: Complication rates for an individual spine surgeon are being utilized by hospital systems and patients to assess the surgeon's aptitude and gauge expectations. The increasing demands for transparency will likely lead to an emphasis on these statistics and any measures instituted to improve outcomes. We conclude that none of the surgeons' demographic factors analyzed in this study are associated with the differences in the overall complications rates in patients undergoing elective spine fusion.

Paper 08. Adverse Events following Posterior Lumbar Fusion: A Comparison of Spine Surgeons Perceptions at LSRS and Reported Data for Rates and Risk Factors

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Background/Introduction: Post-operative complications and risks factors for adverse events play an important role in both decision-making and patient expectation setting. No recent study has examined the relationship between surgeons perceived understanding of these characteristics and nationally reported data. In this context, the purpose of the present study is to contrast surgeons' perceived and reported rates of post-operative adverse events following posterior lumbar fusion (PLF) and to assess the accuracy of predicting the impact of patient factors on such outcomes.

Materials/Methods: A survey investigating perceived rates of adverse events and the impact of patient risk factors on the occurrence of adverse events following PLF for degenerative conditions was distributed to spine surgeons at the Lumbar Spine Research Society (LSRS) 2016 annual meeting. For comparison, the corresponding rates and patient risk factors were assessed in patients undergoing elective PLF from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) data years 2011-2014.

Results: From the survey, there were 53 responses (response rate of 82%) from attending physicians at LSRS. From NSQIP, there were 16,589 patients who met the inclusion criteria. Adverse event rates estimated by the surgeons at LSRS were close to those determined by NSQIP data (no greater than 2.81% different, Figure 1). Surgeons overestimated the rate of 13 out of 17 (76%) post-operative adverse events by 0.17% to 2.81%. The largest differences were for deep vein thrombosis (overestimation of 2.81%, $P < 0.001$), anemia requiring transfusion (overestimation of 2.47%, $P = 0.018$), and urinary tract infection (overestimation of 2.29%, $P < 0.001$). Similarly, the estimated impact of patient factors was similar to the data (within relative risk of 2.02). The largest differences were for current smoking (overestimation of 2.02 relative risk, $P < 0.001$), insulin dependent diabetes (overestimation of 1.36, $P < 0.001$), and obesity (overestimation of 1.35, $P < 0.001$).

Discussion/Conclusion: The current study noted that surgeon estimates were relatively close to national numbers for estimating the adverse events and impact of patient factors on such outcomes after PLF for degenerative conditions. The estimates are roughly appropriate with a bias toward overestimation for planning and expectation setting.

Paper 09. Rates of Mortality Among Lumbar Spine Surgical Procedures and Factors Associated with its Occurrence Over a Ten Year Period: A Study of 803,949 Patients on the Nationwide Inpatient Sample

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Background/Introduction: Risk of death is important in counseling patients and improving quality of care. Incidence of death in lumbar surgery is not firmly established due to its rarity and limited sample sizes, particularly in the context of different surgeries, demographics, and risk factors. Particularly, different patient risk profiles may have varying degrees of risk in terms of surgeries, comorbidities, and demographics. This study aims to use a large patient cohort available on a national database in order to study the prevalence of death associated with lumbar spine surgery.

Materials/Methods: The Nationwide Inpatient Sample (NIS) database was reviewed from 2003-2012. 803,949 patients ages 18 years or older were identified by ICD-9CM procedure codes for spinal fusion or decompression of the lumbar spine. Incidence of mortality was assessed by chi-squared tests across different patient demographics and comorbidities, procedures performed, and concurrent in-hospital complications. Binary logistic regression identified significant increases or decreases in risk of death while controlling for comorbidities, BMI, race, sex, and Mirza invasiveness. Significance was defined as $p < 0.05$ differences relative to overall cohort

Results: Mortality for all patients requiring surgery of the lumbar spine was 0.13%. Mortality based on procedure type was 0.105% for simple fusions, 0.321% with complex fusions, and 0.081% for decompression only. Increased mortality was observed demographically in patients who were male (OR: 1.75 (95% CI: 1.51-2.03)), black race (OR: 1.40 (CI: 1.10-1.79)), and in the 65-74 (OR: 1.46 (CI: 1.25-1.70)) and 75+ age cohorts (OR: 2.70 (CI: 2.30-3.17)). Comorbidities associated with the greatest increase in mortality were mild (OR: 10.04 (CI: 7.76-13.01)) and severe (OR: 26.47 (CI: 16.03-43.70)) liver disease, and congestive heart failure (CHF; OR: 4.57 (CI: 3.77-5.53)). The complications with the highest mortality rates were shock (OR: 20.67 (CI: 13.89-30.56)) and pulmonary embolism (OR: 20.15 (CI: 14.01-29.00)).

Discussion/Conclusion: Rates and causes of mortality in adult patients undergoing different surgeries of the lumbar spine can be helpful to surgeons providing pre-operative counseling and for allocating resources to treat and prevent perioperative complications leading to mortality. Particularly concerning mortality rates of 1.42% in 16,693 patients with comorbid CHF, and 1.91% in 5,183 patients with mild liver disease.

Paper 10. Inaccuracies in ICD Coding for Obesity Bias Toward Higher Frequency of Coding in Patients with Increased Comorbidities and Correlate with Postoperative Complications: A Limitation for Spine Studies Using Administrative Databases

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Background/Introduction: There has been increased use of national databases in the spine surgery literature, much of which relies on International Classification of Diseases (ICD) codes. Past research has demonstrated that the sensitivity of ICD-9 codes for obesity is

poor. However, it remains unclear whether coding inaccuracies are biased toward certain patient subgroups and how potential bias may influence the outcomes of database research.

Materials/Methods: Patients who underwent elective posterior lumbar fusion from 2013-2016 at a large academic hospital were identified. All ICD-9 and ICD-10 codes assigned to the encounter were obtained. Height and weight at the time of surgery were measured, body mass index (BMI) was calculated, and other demographic, comorbidity, intraoperative, and postoperative factors were available for each patient. With the gold standard considered BMI ≥ 30 kg/m² for obesity and BMI ≥ 40 kg/m² for morbid obesity, the sensitivity of ICD coding for obesity and morbid obesity was calculated. Sensitivity was compared for subgroups defined by demographic, comorbidity, intraoperative, and postoperative variables (e.g. smokers versus nonsmokers). The association of obesity with various adverse events was tested using multivariate regression, controlling for age and American Society of Anesthesiologists (ASA) class.

Results: The study included 796 patients. Based upon calculated BMI, 50.25% of patients were obese (N=400), including 7.0% who were morbidly obese (N=56). The sensitivity of ICD coding for obesity was 42.5% and for morbid obesity was 60.7%. The sensitivity of ICD coding was significantly higher in patients with greater BMI, diabetes, ASA class $\geq$ III, increased length of stay, venous thromboembolism (VTE), a major adverse event, and any adverse event. In the multivariate analysis, assignment of obesity ICD coding was significantly associated with VTE, major adverse events, and any adverse event; however there were no associations when obesity was defined by calculated BMI.

Discussion/Conclusion: ICD codes for obesity have poor sensitivity and are applied significantly more often to patients with other comorbidities or postoperative complications. Obesity was associated with more postoperative complications when defined by ICD codes than by calculated BMI. Obesity coding in administrative databases may be skewed toward more complex patients, which may bias studies to overestimate the impact of obesity on adverse outcomes.

Paper 11. Is There Value in Retrospective 90-day Bundle Payment Models for Lumbar Spine Fusion Procedures?

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Background/Introduction: At our private practice, we implemented a Centers for Medicaid and Medicare Services (CMS) Bundled Payments for Care Improvement (BPCI) initiative retrospective payment model 2 in 2015 for a 90-day episode of care for lumbar fusions and other procedures. Under this model, CMS continues to make fee-for-service payments but reconciles total expenditures for the episode with a bundled payment reflecting the aggregate expenditures compared to the target price. The purpose of the study is to assess the value of the lumbar spine CMS bundle at our private practice.

Materials/Methods: We utilized data provided by CMS to compare the total expenditures of lumbar fusion DRGs 453-460. Medicare patients undergoing lumbar fusion surgery between January 2009-December 2012 were defined as non-BPCI (n=303) and compared to Medicare BPCI patients (n=200) undergoing surgery between January-December 2015. Post-acute events within the 90 day episode, including admission to an IRF or SNF, home health (HH), and readmission, were analyzed. Expenditures were converted to 2016 dollars and compared using bivariate and multivariate methods.

Results: The median expenditure for FFS and BPCI patients was \$24,782 (IQR \$24,088-\$25,542) and \$24,113 (IQR \$23,634-\$24,978; $p < 0.01$), respectively. Compared to FFS patients, BPCI patients had a

higher rate of SNF admissions (FFS 29.72% vs 38.46% BPCI; $p=0.36$) and HH (FFS 41.18% vs 53.67% BPCI; $p<0.01$). IRF admissions were lower for BPCI patients (FFS 4.64% vs 1.69% BPCI; $p=0.13$) as well as readmissions (FFS 14.24% vs 9.60% BPCI; $p=0.16$). At the multivariate level, there was no significant difference in total post-acute expenditures between patient groups ($p=0.87$), but all post-acute events were significant, independent drivers of increased cost. Admissions to an IRF, SNF, HH utilization, and 90-day readmissions increased cost 45% ($p<0.0001$), 28% ($p<0.0001$), 10% ($p<0.0001$), and 43% ($p<0.0001$), respectively.

Discussion/Conclusion: In spite of our best efforts to contain costs with practice guidelines, patient navigators, and a BPCI management team, expenditures were slightly higher for BPCI lumbar patients. With the low frequency and high variability of surgical complexity of these procedures, lumbar fusion bundles are challenging to manage. We discontinued our spine BPCI, but applied our lessons learned to other consumer bundles to include specific CPT codes.

Paper 12. Incidence of 90 Day Readmissions Following Posterior Lumbar Fusion

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Background/Introduction: Posterior lumbar fusion (PLF) is a commonly performed procedure. The evolution of bundled payment plans is beginning to require physicians to more closely consider patient outcomes for up to 90 days after an operation. Although the commonly used American College of Surgeons National Quality Improvement Program (ACS-NSQIP) database tracks readmissions for 30 postoperative days, it is difficult to know if readmissions have plateaued at the end of that tracking. The relatively new Healthcare Cost and Utilization Project National Readmissions Database (HCUP-NRD) database tracks patient linked hospital admissions data for up to a year.

Materials/Methods: PLFs performed in the first 9 months of 2013 were identified in the HCUP-NRD. Patient demographics and readmissions were tracked for 90 days after the discharge. To estimate an average admission rate in a matched population, the average daily admission rate in the last quarter of the year was calculated for a subset of PLF patients who had their operation in the first quarter of the year. Further, a general baseline daily admission rate for any cause in patients age 45-64 was estimated from the 2013 National Health Interview Survey.

Results: Of 26,727 patients undergoing PLF, 1,580 patients (5.91% of the study population) were readmitted within 30 days of discharge and 2,603 patients (9.74%) were readmitted within 90 days of discharge. Of those readmitted within 90 days, 54.58% occurred in the first 30 days. However, if only counting readmissions above the baseline admission rate of a matched population for the 4th quarter of the year (0.08% of population/day), 94.61% occurred within the first 30 days.

Discussion/Conclusion: Although the number of readmissions after PLF almost doubled between 30 and 90 days, accounting for a baseline rate of readmissions for this population significantly affected the perceived number readmitted due to the index operation. Determining baseline readmission rates will be an important consideration if healthcare continues to move in the direction of bundled payments.

Paper 13. 90-day bundled payment for primary single level lumbar discectomy/decompression: what does 'big data' say?

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Background/Introduction: Episode based bundling is likely to soon become the major form of reimbursement for many elective spine procedures. Assigning a uniform bundle amount will first require extensive scrutinizing of existing reimbursement data to give an estimate of previous payments and their distribution. This information is not known for a lumbar discectomy, which is the most common elective spine procedure done in the outpatient setting. In this context, we analyze the reimbursement data over the years from Commercial payers and Medicare for a primary single level lumbar discectomy/decompression and simulate a 90-day payment bundle for the same.

Materials/Methods: Administrative claims data was used to study reimbursements from Commercial payers (2007–Q2 2015), Medicare Advantage (2007–Q2 2015), and Medicare (2005–2012) for a primary single level lumbar discectomy/decompression. Distribution of payments among various service providers was studied and a 90-day bundle was simulated. In addition to descriptive analysis, variation between regions and payers was studied by a one way analysis of variance (ANOVA) and post-hoc Tukey test, as appropriate.

Results: Average facility costs constituted 59.7 % to 73.6 % of total payments, followed by surgeon's fees which accounted for 13.7 to 18.5 %. Post-acute services made up 8.8 to 15.8 % of the total reimbursement. The average 90-day bundle amount was estimated at \$11,091, \$6,571 and \$6,239 for Commercial payers, Medicare Advantage and Medicare, respectively. Overall, service providers in the Southern region were reimbursed the lowest from Commercial payers and Medicare, compared to other regions. Surgeries performed in the inpatient setting were significantly more expensive as compared to surgeries performed in the outpatient setting ($p<0.01$).

Discussion/Conclusion: Facility costs constitute the maximum share and variation in reimbursements. Surgery done as an inpatient is costlier than done in the outpatient setting. Commercial payers reimburse almost double the amount of what Medicare does for a single-level lumbar discectomy. There is regional variation in reimbursements for major clinical services, however not uniform.

Paper 14. National Trends for Spinal Deformity Surgery throughout the United States

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Background/Introduction: Advancements in spinal instrumentation and imaging modalities have given surgeons powerful new tools to achieve long construct fusions in spinal deformity surgery. With increasing biomechanical knowledge of long constructs and a focus on health care utilization and value-based care, it is essential to understand the demographic and economic data surrounding fusions involving 9 or more levels in the United States.

Materials/Methods: The National Inpatient Sample (NIS) database was queried for patients who underwent fusion or refusion of ≥ 9 vertebrae (ICD-9-CM 81.64) between 2004 and 2014 across 44 states. Demographic and economic data were obtained which

included the annual number of surgeries, age, sex, insurance type, location, and frequency of routine discharge. The NIS database represents a 20% sample of discharges from U.S. hospitals, excluding rehabilitation and long-term acute care hospitals, which is weighted to provide national estimates.

Results: In 2014, the estimated total number of fusions involving ≥ 9 vertebrae was 14,615 across the United States. The number of fusions involving 9 or more levels has increased 141% from 6,072 in 2004. The mean cost associated with these procedures is \$77,265 per case. The mean length of stay (LOS) is 7.4 days in the adult population and 5.3 days in the pediatric population. Based on payer, patients with private insurance comprised 44.1% of patients undergoing fusion of ≥ 9 levels and Medicare comprised another 28.0% of patients.

Discussion/Conclusion: Throughout the United States, there was a progressive increase in the number of long construct fusions involving ≥ 9 vertebrae. This trend is likely due to the improved safety of the procedure and evolution of spinal instrumentation systems. Further cost analyses are warranted to evaluate the overall societal impact of this increase in spinal deformity procedures.

Paper 15. A Predictive Nomogram for Clinical Outcomes following Surgical Correction of Adult Spinal Deformity

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Background/Introduction: Re-alignment surgery for patients with adult spinal deformity has been shown to improve quality of life outcome measures; however, large reconstructive surgery is associated with significant morbidity. We sought to create a preoperative predictive nomogram to determine which patients would benefit from surgery.

Materials/Methods: All patients aged 25-years-old with radiographic evidence of ASD and quality of life data that underwent thoracolumbar fusion between 2008 and 2014 were retrospectively identified. Demographic and clinical parameters were obtained. The EuroQol five dimensions questionnaire (EQ-5D) was used to measure health-related quality of life (HRQoL) preoperatively and at 12 months postoperative follow-up. A preoperative to postoperative decline of .04 or greater was used to indicate the presence of clinically relevant decline in HRQoL.

Results: Our sample included data from 191 patients. 63% of patients experienced clinically relevant postoperative decline in HRQoL. Seven variables were included in the final model: preoperative EQ-5D score, sex, dyslipidemia, diagnosis (degenerative, idiopathic, or iatrogenic), race, diabetes mellitus 2, and BMI. Female gender (OR 2.21, $p = .036$) and preoperative EQ-5D (OR = 1.531, $p < .0001$) each were independently associated with the poorer postoperative outcome.

Discussion/Conclusion: Lower preoperative EQ-5D scores and female gender were associated with a clinically significant decrease in postoperative EQ-5D scores, while race, diabetes mellitus type 2, and BMI showed no significant association with post-operative quality of life outcomes. The predictive nomogram that we developed using these data can improve preoperative risk counseling and patient selection for deformity correction surgery.

Paper 16. Frailty and Health Related Quality of Life Improvement Following Adult Spinal Deformity Surgery

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Background/Introduction: The Adult Spinal Deformity Frailty Index (ASD-FI) has been associated with longer hospital stay and increased complications in patients undergoing surgery for adult spinal deformity. The impact of frailty on postoperative changes in health-related quality of life (HRQoL) is unknown. This study investigates the relationship between ASD-FI scores and HRQoL scores measured at 2 years post-operatively.

Materials/Methods: This study was a retrospective review of a prospectively-collected multicenter database. Patients who underwent ≥ 4 level instrumented fusion for ASD and had minimum 2-year follow-up were stratified by ASD-FI score into the following categories: not frail 0-0.3 (NF); frail 0.3-0.5 (F); and severely frail >0.5 (SF). We analyzed baseline demographic, HRQoL, and radiographic parameters. The primary outcome measure was the proportion of patients who reached substantial clinical benefit (SCB) in terms of Oswestry Disability Index (ODI) score, SF-36 Physical Component Score (PCS), and numeric back and leg pain scores in each frailty group. Secondary outcomes included absolute values and 2-year post-operative changes in ODI, PCS, back and leg pain.

Results: There were 332 patients who met inclusion criteria: 135 NF, 175 F, and 22 SF. F and SF patients were significantly older, had more comorbidities, worse baseline HRQoL and pain scores, and worse radiographic deformity ($p < 0.05$). At 2-year follow-up, ODI, PCS, back pain, and leg pain were all worse in F/SF than NF patients. More NF than F patients reached SCB for back pain (63.4% vs. 57.5%, $p = 0.045$). However, more F than NF reached SCB for ODI (43.7% vs. 29.3%, $p = 0.025$), PCS (56.9% vs. 51.2%; $p = 0.03$), and leg pain (45.8% vs. 23.0%; $p = 0.03$).

Discussion/Conclusion: Despite higher preoperative risk stratification scores, worse baseline HRQoL scores, and greater complication rates, frail patients experienced greater improvement in most HRQoL measures and overall greater likelihood of reaching substantial clinical benefit than non-frail patients after undergoing surgery for adult spinal deformity.

Paper 17. Outcomes of Open Staged Corrective Surgery in the Setting of Adult Spinal Deformity

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Background/Introduction: Adult spinal deformity (ASD)

represents a constellation of complex mal-alignments affecting the spinal column. Corrective surgical procedures aimed at improving ASD can be equally challenging, and commonly require multiple index procedures and potential revisions prior to definitive management. There is a paucity of data comparing the outcomes of same-day (simultaneous) and two-day (staged) procedures for long spinal-fusions for ASD. The purpose was to compare intra-operative, peri-operative, and two-year outcomes of staged and simultaneous procedures correcting ASD.

Materials/Methods: Retrospective analysis of a prospective multicenter database. Inclusion criteria included ASD patients ≥ 18 yrs with 6-wk and 2 year follow-up. Propensity score matching identified similar patients undergoing staged (STA) or simultaneous (SIM) long spine fusions based on Surgical Invasiveness, Pelvic Tilt, and SVA. Complications, HRQLs (SRS22r, SF-36, ODI), and patient characteristics were compared across and within treatment groups at follow-up with ANOVA and paired t-tests at 3 surgical stages: intra-op, peri-op (6wk), and post-op (>6 wk).

Results: 142 patients were included (71 STA, 71 SIM). Matching staged and simultaneous groups based on degree of deformity and surgical invasiveness created two groups similar in overall correction of the surgery. STA patients underwent more ALIF and LLIF interbody procedures while SIM patients had longer fusions. Charlson Comorbidity Index and revision status were similar between groups ($p>0.05$). There were significantly more complications causing reoperation in STA procedures (STA: 47% SIM: 8%, $p=0.021$). STA had a greater number of peri-op complications requiring a return to the OR (STA: 9.9% SIM: 1.4% $p=0.029$). There was no difference in intra-op complications, mortality, or peri-op infection or wound complications ($p>0.05$). At 2 year follow-up, incidence of revision surgery was higher in STA (STA: 21.1% SIM: 8.5%, $p=0.033$).

Discussion/Conclusion: Staged spinal fusions which add ALIFs and LLIFs to the procedure, compared to similar-correction simultaneous procedures, result in similar intra-operative complication incidence, but significantly higher rates of peri- and post-op complications leading to revision. Functional outcomes, radiographic parameters, and mortality were similar. This will aid surgeons in their determination of optimal treatment for such complex procedures.

Paper 18. Visual Loss Following Spine Surgery: What Have We Seen Within the Scoliosis Research Society (SRS) Morbidity and Mortality Database?

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Background/Introduction: The Scoliosis Research Society (SRS) compiles surgeon-reported complications into a morbidity and mortality database, tracking particular postoperative complications including visual loss, instrumentation failure, neurological deficits, infections, and death. Limited literature exists on postoperative visual complications, a rare but devastating complication following spine surgery.

Materials/Methods: In this study, we utilized the SRS database to determine the patient profile, perioperative risk factors, and prognosis for visual related complications in deformity patients undergoing corrective spine surgery from 2009-2012.

Results: A total of 167,972 patients were identified with an overall visual acuity complication rate of 0.01%, or 12.5 per 100,000 patients. The visual acuity complication rates for patients with scoliosis, spondylolisthesis, and kyphosis were 0.01%, 0.01%, and 0.04% respectively. The 21 patients identified with visual complications had a mean age of 34.8 $\pm$ 24.3 years. Two patients (9.5%) had preoperative vision changes, 2(9.5%) were diabetic, 2(9.5%) had vascular disease,

1(4.8%) had a history of thromboembolic disease and 5(23.8%) had hypertension. Nineteen patients(90.5%) underwent a fusion procedure, 17(81%) of which were posterior. Seventeen patients(81.0%) were positioned prone during surgery with an average time in prone position of 264.2 $\pm$ 143.2 minutes. Average intraoperative blood loss was 1409.6 $\pm$ 988.6 mL's. The extent of visual loss was bilateral-partial in 4(19.0%), bilateral-total in 5(23.8%), unilateral-partial 8(38.1%), and unilateral-total in 3(14.3) patients. Four patients(19.0%) developed anterior ischemic optic neuropathy(AION), 4(19%) posterior ischemic optic neuropathy(PION), 5(23.8%) central retinal artery occlusion(CRAO), and 5(23.8%) cortical blindness(CB). Greater than 50% of the visual complications occurred on or before the first postoperative day. Ten patients(47.6%) recovered complete vision and 4(19.0%) experienced improvement. All patients with CB and 50% with PION experienced complete resolution. All patients that had intraoperative head support with a commercial head-holder and 3 (75%) with tongs/halo experienced complete resolution or improvement in vision. Trendelenburg and reverse Trendelenburg positions were associated with complete resolution, while only 5(42%) patients positioned flat experienced resolution.

Discussion/Conclusion: We conclude that visual complications occur in approximately 12.5 per 100,000 deformity patients, with a rate 4 times higher in patients with kyphosis. More than 50% of these complications occur within 24 hours postoperatively. Nearly half of these complications resolve completely, and another 20% improve postoperatively.

Paper 19. Outcomes of Lumbopelvic Fixation for the Treatment of Adult Deformity with a Modified Iliac Screw Starting Point

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Background/Introduction: Lumbopelvic fixation has been an important advancement in spine surgery. However, Iliac screws are not without complications including infection, screw prominence, and instrumentation failure(IF). Kasten et al. reviewed 78 patients treated with adult deformity found a 11.5% infection rate. Literature review demonstrates pseudoarthrosis failure rates between 5 and 15%. Our institution utilizes modified iliac screw starting points highlighted by more medial starting points, placing iliac screw heads in line with S1 pedicle screws. We hypothesize this technique is associated with decreased rates of elective screw removal secondary to prominence, infection and IF.

Materials/Methods: Retrospective review between 2006-2015 of 57 patients undergoing lumbopelvic fixation with a modified iliac screw starting site, for treatment of adult deformity secondary to degenerative scoliosis, posttraumatic kyphoscoliosis, and flat back syndrome. Primary outcome measure was rates of: 1) elective removal of Iliac screws, 2) infection, 3) IF (breakage of rods/pelvic screws/pedicle screws), 4) revision surgery for Pseudoarthrosis/IF. Secondary outcome measures: 1) EBL and 2) length of stay.

Results: Patient population consisted of 17.5% males and 82.5% females. The average age was 58.2 years old. Average follow-up was 22 months. Early infection rate (less than 1 month after primary procedure requiring surgical intervention) was 3.5% and late infection rate (greater than 1 month) was 12.2%. Overall infection rate was 15.7%. Elective removal of Iliac screws rate was 3.5% and IF via radiographic review was 35%, but revision surgery rate for pseudoarthrosis/IF was 5.2%. Revision surgery rate for proximal junctional failure/kyphosis was 3.5%. IF occurred below (N=15), above (N=2), and both above and below (N=3) the L5 pedicle screw. Time of diagnosis of broken instrumentation was 16 months. Average EBL was 172cc, with length of stay 8.6 days.

Discussion/Conclusion: Our modified LPF technique

demonstrated relatively low rates of elective screw removal (3.5%), likely from decreased screw prominence. Infection rates were similar to previously reported rates. The discrepancy between our relatively high rate of radiographic IF and much lower revision surgery rate demonstrates the low clinical significance of radiographic findings in isolation. The time to IF supports following patients with adult deformity reconstruction well past the 1-year benchmark.

Paper 20. Instrumentation Complication Rates Following Spine Surgery: A Report from the Scoliosis Research Society (SRS) Morbidity and Mortality Database

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Background/Introduction: Surgical databases, like the Scoliosis Research Society (SRS) database, have tremendous value in orthopaedic surgery. Beginning in 2004, the SRS has gathered surgeon-reported complications, tracking particular postoperative complications including instrumentation failure, blindness, new neurological deficits, infections, and death. To predict post-operative morbidity and mortality in a set of deformity and degenerative spinal conditions, we utilized the SRS database to assess demographic information and risk factors for instrumentation related complications from 2009-2012.

Materials/Methods: The SRS Morbidity and Mortality database was queried for occurrences of instrumentation complications in patients with a diagnosis of scoliosis, spondylolisthesis, and kyphosis from 2009-2012. Variables assessed included preoperative comorbidities, intraoperative and postoperative factors.

Results: A total of 167,972 patients were identified with an overall complication rate of 1.8% and an instrumentation complication rate of 0.19%. There were a total of 96,636 patients with a diagnosis of scoliosis, 54,901 with spondylolisthesis, and 16,435 with kyphosis and instrumentation complication rates of 0.21%, 0.11%, and 0.27%, respectively. There were 311 patients (0.19%) identified with instrumentation complications with a mean age of 38.5+/-25.5 years. Instrumentation complications occurred most commonly in scoliosis patients (66.2%), followed by spondylolisthesis patients (18.6%) and kyphosis patients (14.5%). The most common comorbidities included diabetes (10.7%), hypertension (23.5%), pulmonary disease (13.5%), smoking (8.7%) and vascular disease (7.1%). Scoliosis curve magnitudes larger than 50 degrees represented 42.4% of the cases that had an instrumentation complication. Fusion was performed in 86.2% and osteotomies in 29.3% of these patients. Instrumentation related complications included implant failure (23.3%), migration (28.3%), and malpositioned implants (48.6%). A new perioperative neurologic deficit was noted in 146 patients (46.9%) with an instrumentation complication.

Discussion/Conclusion: Overall, the rate of instrumentation complications in deformity patients was 0.19%, occurring more commonly in patients with a diagnosis of kyphosis with large curve magnitudes. The potentially avoidable malpositioning of the spinal implants represents nearly 50% of these complications. More attention to optimal intraoperative imaging or use of guidance, navigation or robotic, may be of some utility in potentially decreasing these instrumentation complications.

Paper 21. Bone Morphogenetic Protein Use in Lumbar Spine Surgery in The United States: How Have We Responded to The Warnings?

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Background/Introduction: Recombinant human bone morphogenetic protein-2 (rhBMP-2) has been widely adopted as a fusion adjunct in spine surgery since its approval in 2002. A number of concerns regarding adverse effects of rhBMP-2 use led to an FDA advisory issued in 2008. A separate warning about potential complications from rhBMP-2 was published by The Spine Journal in 2011. The objective of this cross-sectional database study was to compare trends of rhBMP-2 use in lumbar spine surgery after the FDA advisory in 2008 and The Spine Journal warning in 2011.

Materials/Methods: We conducted a retrospective cross-sectional study using the Nationwide Inpatient Sample (NIS) from 2002-2013. Using international classification of disease, ninth revision (ICD-9-CM) procedure codes, we identified lumbosacral spinal fusion procedures and identified the proportion that used rhBMP-2. The percentage of cases utilizing rhBMP-2 was plotted across time. A linear regression was fit to the data from quarter 3 of 2008 (FDA advisory) through quarter 1 of 2011, and a separate regression was fit to the data from quarter 2 of 2011 (Spine J warning) onwards. The slopes of these lines were statistically compared to determine differences in trends.

Results: A total of 2,185,114 lumbosacral spinal fusion were performed between 2002 and 2013. We observed a greater rate of decreased rhBMP-2 use after The Spine Journal warning (-1.13% cases/quarter) compared to the FDA advisory (-0.14% cases/quarter) for all lumbosacral fusions ($p=0.0008$) (fig. 1). Anterior lumbosacral procedures continued to increase rate of rhBMP-2 use after the FDA advisory (0.19% cases/quarter), but decreased rate of rhBMP-2 use after The Spine Journal article (-1.39% cases/quarter) ($p<0.0001$). Similarly, posterior procedures had an increased rate of rhBMP-2 use of 0.42% cases/quarter after the FDA advisory, and a decline in rate of rhBMP-2 use of -1.10% cases/quarter after The Spine Journal article ($p<0.0001$).

Discussion/Conclusion: Our results suggest that warnings sanctioned through the spine literature may have a greater influence on practice of the spine surgery community as compared to advisories issued by the FDA. The spine literature may be a valuable tool to establish comprehensive guidelines regarding safe and effective use of rhBMP-2.

Paper 22. National Trends in the Utilization of Intraoperative Neuromonitoring throughout the United States

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Background/Introduction: Intraoperative electrophysiological neuromonitoring is technique aimed at reducing neurologic morbidity during operative manipulations of the spinal column. The multimodal neuromonitoring technique has evolved over the past decade and may alert the surgeon to changes in the central nervous system prior to irreversible injury. Our group hypothesized that the use of intraoperative neuromonitoring during spine surgery has increased over the study period.

Materials/Methods: The National Inpatient Sample (NIS) database queried for the intraoperative monitoring of central nervous electrical activity (ICD-9-CM 00.94) between 2007 and 2014 across 44 states. Demographic and economic data were obtained which included the annual number of surgeries, age, sex, insurance type, location, and frequency of routine discharge. The NIS database represents a 20% sample of discharges from U.S. hospitals, weighted to provide national estimates.

Results: The estimated use of intraoperative neuromonitoring of central nervous electrical activity increased 3050% from 3,995 cases in 2007 to 125,835 cases in 2014. The greatest use of intraoperative neuromonitoring occurred in patients between the ages of 45 and 64 (44.5%). Based on payer, privately insured patients, rather than Medicare or Medicaid patients, were more likely to undergo intraoperative monitoring during spinal procedures (45.0% versus 36.8% versus 9.2%, respectively). When stratifying by median income for patient zip code, there was a substantial difference in the rate of monitoring for central nervous electrical activity between low and higher income groups (19.9% versus 78.1%, respectively). Moreover, monitoring of central nervous electrical activity was significantly more likely to be utilized at urban teaching hospitals rather than nonteaching hospitals or rural centers (72.9% versus 25.0% versus 2.2%, respectively).

Discussion/Conclusion: Over the past decade, there has been a shift in the practice of utilizing intraoperative monitoring of central nervous electrical activity. This is likely due to its proven benefit in reducing neurologic morbidity, without introducing additional risk. While neuromonitoring may improve patient care, it is still rather isolated to teaching hospitals and patients from higher income zip codes.

Paper 23. Circumferential Fusion: A Comparative Analysis Between ALIF and TLIF for the Indication of L5-S1 Isthmic Spondylolisthesis

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Background/Introduction: Circumferential fusions with either transforaminal lumbar interbody fusion (TLIF) with posterolateral fusion (PLF) or anterior lumbar interbody fusion (ALIF) with PLF offer significantly higher radiographic fusion rates than other fusion techniques for L5-S1 isthmic spondylolisthesis (IS). It is unclear which of the two procedures is optimal in the management of adult IS. No study to date has compared these techniques for treatment of L5-S1 IS. This study aims to provide evidence to guide spine surgeons towards the preferred surgical approach.

Materials/Methods: A retrospective review was performed of patients who underwent TLIF and PLF or ALIF and PLF for L5-S1 IS. Patient demographic data including age, gender, race, body mass index (BMI), medications, and smoking status/history were collected. Operative information including procedure time, blood loss and perioperative complications were also collected. Quality of life outcome scores, radiographic data, and financial data were collected with a minimum of 1-year follow up.

Results: A total of 66 patients met inclusion criteria. In the ALIF cohort, PDQ scores improved from 66.2±28.2 to 46.1±28.9 (p=0.01). In the TLIF cohort, PDQ scores improved from 66.3±26.6 to 44.2±38.9 (p<0.01). However, the ALIF group showed a significantly greater improvement in EQ5D scores at 1 year (0.2±0.2 vs. 0.1±0.2, p=0.03). Of note, neither group met the minimally clinical important

difference (MCID) for PDQ or EQ5D scores. Furthermore, segmental lordosis was only significantly increased in the ALIF cohort (20.5±5 to 25.9±6.5, p=0.002). The ALIF cohort showed a significantly greater improvement in disc height restoration compared to TLIF (4.0±2.4 vs. 6.9±3.3, p<0.01). No significant differences were found with regards to costs for both procedures.

Discussion/Conclusion: Our findings are in support of the ALIF technique as being the most reliable fusion procedure for the treatment of IS. We believe the superior radiographic outcomes achieved through ALIF, namely a greater restoration of segmental lordosis and disc height may have contributed to the greater clinical outcomes presented in the current study. These promising results can perhaps help clarify the contentious debate among the surgical community with regards to which surgical technique is most appropriate in the treatment of isthmic spondylolisthesis.

Paper 24. Treatment of Chronic Low Back Pain via Ablation of the Basivertebral Nerve: Results of the SMART Trial

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Background/Introduction: The basivertebral nerve (BVN) is a sensory nerve within the vertebral body, whose role in pain transmission is thought to be a source of chronic low back pain associated with degenerative changes. The use of a radiofrequency system (INTRACEPT TM System) for ablation of the BVN was tested in this trial.

Materials/Methods: 225 patients with chronic low back pain, 6 months of conservative care and no neurogenic leg pain were enrolled at 18 sites in the United States and Germany in this prospective, double blinded, randomized, sham controlled trial (147 active vs 78 sham arm). MRI had to demonstrate Type 1 or 2 Modic changes at <3 contiguous vertebral bodies. Follow-up was at 2 and 6 weeks, 3, 6 and 12 months. Patients and physicians providing postoperative care were blinded to allocation until the conclusion of the one year follow-up. For sham patients, there was an optional crossover after all 12-month evaluations.

Results: Targeting success (assessed by postop MRI) was achieved in 96.4% of the treated and evaluated vertebral bodies. Primary end point analysis in the per protocol population at 3 months showed that the ODI improvement in the active arm was superior to the sham arm (p=0.019) mean improvement was 20.5 points. This result was sustained through two years of follow-up. An analysis of ODI responder rates found that 75.6% of the RF ablation treated patients demonstrated a greater than 10-point clinically meaningful improvement in their low back pain and associated disability at 3 months. There were no adverse device effects and no device related serious adverse events. The rates of neurological events reported were low and comparable between treatment arms.

Discussion/Conclusion: BVN ablation with the INTRACEPTTM System proved to be safe and effective for the treatment of chronic low back pain in this patient population based on the primary end point results showing a significantly greater improvement in ODI for the arm.

Paper 25. Trend of Spine Surgeries In the Outpatient Hospital Setting vs. Ambulatory Surgical Center

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Background/Introduction: Recent studies have assessed the safety, satisfactory clinical outcomes, and increasing utilization of lumbar spinal surgeries performed in the outpatient setting. No studies have delineated between true ambulatory settings and outpatient hospitals when assessing the rates of these procedures. The aim of this study was to examine how often spine surgery is being performed in an outpatient hospital setting vs. a more “true” ambulatory setting, specifically ambulatory surgery centers (ASCs) where admission and discharge are required on the same calendar day.

Materials/Methods: A retrospective review of the Truven Health Marketscan® Research Databases was conducted for patients undergoing lumbar spine operations between 2003 and 2014. The frequency of each CPT code was identified per year, and then categorized into each of “inpatient hospital”, “outpatient hospital”, or “ASC” in states that clearly define ASCs as facilities where patients are discharged on the same calendar day of the operation, and do not stay overnight.

Results: The percentage posterior lumbar fusion 1st level performed as an inpatient procedure decreased from 98.9% in 2003 to 93.2% in 2014, while during the same time period, its percentage as an outpatient hospital and ASC procedure increased from 0.9% to 4.9%, and from 0.2% to 2%, respectively. The changes in trends for lumbar decompression laminotomy 1st level were more dramatic with the percentage performed as an inpatient procedure decreasing from 80.6% in 2003 to 20.9% in 2014, while during the same time period, its percentage as an outpatient hospital and ASC procedure increasing dramatically from 18.7% to 68.5%, and from 0.7% to 10.6%, respectively.

Discussion/Conclusion: “True” ambulatory surgeries are not increasing at the same rate as outpatient procedures with 23 hour observation capacity, and although prior studies have demonstrated the safety of outpatient spine surgery, this data suggests that most surgeons feel that this safety may not be comparable to that of other outpatient procedures.

Paper 26. Body Mass Index is Not Associated with Inpatient Pain Scores or Postoperative Narcotic Consumption following a Minimally Invasive Transforaminal Lumbar Interbody Fusion

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Background/Introduction: Current literature reports successful outcomes following minimally invasive transforaminal lumbar interbody fusion (MIS TLIF); however, inpatient pain scores across body mass index (BMI) category have not been previously reported. The purpose of this study is to examine patient-reported inpatient pain scores in the immediate postoperative period by BMI category following MIS TLIF.

Materials/Methods: A prospectively maintained surgical database of patients who underwent a primary, one-level MIS TLIF for degenerative spinal pathology between 2010-2015 was reviewed. Patients were stratified according to BMI: normal weight (<25 kg/m²), overweight (25-29 kg/m²), obese I (30-34 kg/m²), or obese II-III (≥35 kg/m²). The effect of BMI on surgical outcomes, narcotic

consumption, and inpatient pain scores was analyzed using Poisson regression with robust error variance or linear regression adjusted for patient demographics and preoperative characteristics.

Results: A total of 305 patients were included in the analysis, of which 56 (18.4%) were normal weight, 110 (36.1%) were overweight, 68 (22.3%) were obese I, and 71 (23.3%) were obese II-III. Normal weight and obese II-III patients had lower percentage of smokers (Normal: 8.9%; Overweight: 17.3%; Obese I: 27.9%; Obese II-III: 12.7%; $p=0.026$), while a greater BMI was associated with having an increased comorbidity burden (Normal: 1.9; Overweight: 2.6; Obese I: 2.5; Obese II-III: 3.2; $p=0.015$), increasing mean operative time (Normal: 113.2; Overweight: 116.3; Obese I: 119.4; Obese II-III: 136.7 minutes; $p=0.005$), and a trend towards increasing hourly inpatient VAS pain scores on POD 0 (Normal: 5.1; Overweight: 5.3; Obese I: 5.6; Obese II-III: 5.6; $p=0.322$), POD 1 (Normal: 4.5; Overweight: 4.9; Obese I: 4.9; Obese II-III: 5.3; $p=0.194$), and POD 2 (Normal: 4.6; Overweight: 4.7; Obese I: 5.0; Obese II-III: 5.4; $p=0.053$) as well as OME consumption (Normal: 2.6; Overweight: 2.6; Obese I: 2.7; Obese II-III: 3.1; $p=0.066$) on POD 2, although this result was not statistically significant.

Discussion/Conclusion: The results of this study suggest patients with a greater BMI do not report increased pain or require increased narcotic consumption in the immediate postoperative period despite prolonged operative times. As such, the postoperative analgesia protocol should not differ across BMI stratifications.

Paper 27. An Analysis of Robotic Assisted Pedicle Screw Placement

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Background/Introduction: The use of robotic assistance for the placement of pedicle screws continues to gain in popularity. Its proposed advantages are especially marked in instances of advanced scoliotic deformity or complex revision surgery. This study aims to evaluate the early experience at a single institution with the use of robotically assisted pedicle screw placement.

Materials/Methods: A retrospective review was performed on all patients who underwent spine surgery with use of a robotic assisted pedicle screw placement system. All surgeries were performed by three fellowship trained spine surgeons at a single institution from the time period of January 1st, 2016 to July 1st, 2016. Three independent researchers documented data from the operative reports, imaging modalities and technical notes of each surgeon. Screws were classified as A) successfully placed by robot, B) breach or malposition of screw placed by robot, or C) robot placement aborted in favor of manual instrumentation. Other data points recorded included percutaneous versus open screw placement, number of surgical levels instrumented as well as rates of screw complications which occurred during each attending's first ten cases versus all subsequent cases.

Results: Robotic assisted pedicle instrumentation was successfully utilized in 54 of 63 patients (85.7%) who met inclusion criteria. Of all patient's enrolled, 412 of an attempted 456 pedicle screws were successfully instrumented (90%). Thirty-eight screws were unable to be placed due to loss of registration (8.3%). Six screws were deemed to be placed in malposition based on intraoperative xray and/or CT scan and required removal and re-instrumentation (1.3%). Forty-two of the forty-four screws (95%) that were unable to be placed by the robot were in the open surgery group ($p=0.05$). There was no difference detected in unsuccessful screw placement during each operators' first ten cases versus subsequent cases. There was a statistically significant difference in screw malpositioning/registration errors occurring in spinal surgery greater than 3 levels. ($p=0.04$).

Discussion/Conclusion: Use of robotic assisted pedicle screw placement is a safe and effective means of instrumenting the spine when registration is achieved. Open surgery and cases greater than 3 levels typically involve more complex anatomy, which likely accounts for higher rates of registration failure.

Paper 28. Postoperative Outcomes Following Primary Minimally Invasive Transforaminal Lumbar Interbody Fusion with Unilateral or Bilateral Interbody Cages

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Background/Introduction: Controversy exists regarding the utilization of unilateral versus bilateral interbody cages in minimally invasive transforaminal lumbar interbody fusion procedures (MIS TLIF). Few studies have analyzed postoperative patient reported outcomes (PROs) as they relate to the use of unilateral versus bilateral cages. In this context, the purpose of this study is to determine differences in improvements in Oswestry Disability Index (ODI), Short Form-12 Physical Composite Summary (SF-12 PCS), and back and leg pain in patients undergoing MIS TLIF with unilateral versus bilateral interbody cages.

Materials/Methods: A prospectively maintained surgical database of patients who underwent a one-level, primary MIS TLIF for degenerative pathology with either unilateral or bilateral interbody cages between 2010-2016 was reviewed. Patients were excluded if there was incomplete preoperative PRO data. Improvements in PRO scores between instrumentation cohorts were compared using linear (continuous) or Poisson regression with robust error variance (categorical) adjusted for patient demographics, procedural characteristics, and preoperative PRO score.

Results: After exclusion of those with incomplete preoperative PRO data, 64 patients were included in this analysis. Of these, 44 (68.75%) underwent primary MIS TLIF with unilateral cages and 20 (31.25%) underwent MIS TLIF with bilateral cages. The unilateral cage cohort was older (53.02 vs 46.59 years, $p=0.031$), had a greater comorbidity burden (1.86 vs 1.00, $p=0.031$), and was more likely to have a preoperative diagnosis of degenerative spondylolisthesis (43.19% vs. 15.00%, $p=0.007$). The bilateral cage cohort exhibited a trend towards being more likely to have a preoperative diagnosis of isthmic spondylolisthesis (65.00% vs. 31.82%, $p=0.077$). There were no differences in operative time, estimated blood loss, or length of stay between cohorts ($p>0.05$ for each). Additionally, there were no significant differences in improvement in ODI, SF-12 PCS, VAS Back, or VAS Leg scores at 6-week, 12-week, and 6-month postoperative follow-up ($p>0.05$ for each).

Discussion/Conclusion: The results of this study suggest that patients undergoing MIS TLIF with bilateral cage instrumentation have increased disease severity. Despite this discrepancy in diagnosis, both cohorts experience similar improvements in PROs at all postoperative time points. Thus, practitioners and patients should expect similar improvements in disability and pain irrespective of necessity for bilateral cage instrumentation.

Paper 29. Lateral lumbar interbody fusion approach and relationship of the ureter: Anatomical study with application to minimizing complications

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Background/Introduction: Complications from lateral lumbar

interbody fusion procedures range from neurological deficits to damage to organs and blood vessels. Although apparently uncommon, damage to the ureter has been reported. To better understand the anatomical relationship of the ureter to this surgical approach, the present anatomical study was performed.

Materials/Methods: Eight adult cadavers (16 sides) were placed in the full lateral position. Next, an incision was made between the iliac crest and 12th rib. The retroperitoneal space was entered without disturbing the position of the kidney or ureter. The position of the ureter in relationship to the lumbar vertebrae was documented. Next, the distal ureter was cannulated with a metal wire, which was passed up to the kidney. Fluoroscopy was then obtained to note the position of the ureter in regard to the bony anatomy in this region.

Results: The ureter was easily identified on all sides and there were no signs or medical documentation of prior abdominal surgery or evidence of congenital malformations involving the kidney or ureters. From the direct lateral position and on all sides, the ureter was found to lie below the plane of the lumbar vertebral bodies and more so proximally. With the descent of the ureter, especially at L4 and L5, the ureter gradually moved to a more anterior position, i.e. closer to the anterior aspect of the vertebral body. On all sides, the ureter, from a lateral perspective, crossed the posterior third of the upper lumbar vertebrae, approached the middle third at L3, and reached the anterior third at L4/L5 before descending into the pelvis.

Discussion/Conclusion: Due to the proximity of the ureter to the lumbar vertebral bodies, it is imperative to verify that this structure is not in the surgical trajectory during lateral lumbar interbody fusion procedures, in order to avoid ureter damage.

Paper 30. Pain-Related Functional Changes in a Rodent Model of Intervertebral Disc Degeneration

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Background/Introduction: Surgical puncture of the lumbar intervertebral disc (IVD) in animal models induces structural damage and leads to IVD degeneration over time. Prior rodent IVD degeneration models have involved injury to multiple IVDs, which confounds the mechanism of pain generation. This study identifies a behavioral and pain-related sensitivity phenotype after puncture of one lumbar IVD.

Materials/Methods: Baseline functional assessments including static weight-bearing, gait analysis, site-specific algesia, and open field testing were done for Sprague-Dawley rats ($n=36$, 18 weeks old) the day before lumbar IVD puncture surgery (LDP). The L5-L6 IVD of the LDP group ($n=14$) was exposed and punctured with a 27 gauge needle. The sham group ($n=14$) had L5-L6 IVD visualization only and naïve animals ($n=8$) had no surgery. Animals repeated functional assessments on weeks 1, 4, 6, 8, 12, 16, 18, and 20 weeks post-surgery.

Results: Acute changes in the gait parameters of hind limb stride length, hind limb duty factor, stance-to-swing ratio, and stance width were observed in the LDP and sham groups following surgery; all of these gait changes resolved by post-operative week 6. In measures of static weight-bearing, acute changes in left hind limb weight-bearing of the LDP group similarly resolved by post-operative week 4. Animals in the LDP group presented with increased hind limb stride length at post-operative week 18 ($p<0.001$), and with decreased left hind limb weight-bearing ($p<0.05$) as shown in Figure 1.

Discussion/Conclusion: Our data indicate that rats do not fully recover from the soft tissue trauma and acute pain induced by LDP surgery until 4-6 weeks post-surgery. Gait and weight-bearing changes observed at post-operative week 18 may be more consistent with the presentation of a "chronic" degenerative disc disease. This timeline of acute injury and healing followed by a sustained pain-free period and subsequent development of sensitivity and gait changes

suggests that this model of IVD degeneration may have some relevance to the clinical development of discogenic pain in humans.

Paper 31. Comparison of the Efficacy of Adipose-Derived and Bone Marrow-Derived Stem Cells in a Rat Model of Spinal Fusion

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Background/Introduction: Bone marrow-derived stem cells (BMSCs) have been widely used in spinal fusion studies, however, adipose-derived stem cells (ADSCs) offer a number of key advantages, including larger available tissue volume, higher stem cell concentrations and reduced donor site morbidity. In this study we compare the efficacy of ADSCs and BMSCs in achieving successful spinal fusion when combined with a clinical-grade bone graft substitute in a rat model.

Materials/Methods: ADSCs were isolated from the inguinal fat pads, while BMSCs were isolated from the long bones of syngeneic female 6-8 week old Lewis rats and cultured in vitro until passage 2 for subsequent transplantation. The frequency of colony forming unit fibroblast (CFU-F) colonies for both ADSCs and BMSCs was assessed in vitro. Posterolateral spinal fusion surgery at L4-5 was performed on 36 female Lewis rats (6-10 wk old) divided into 3 experimental groups: [1] Vitoss (Stryker) bone graft substitute only (n=12); [2] Vitoss + 2.5×10^6 ADSCs/site (n=12); and [3] Vitoss + 2.5×10^6 BMSCs/site (n=12). Fusion was assessed 8 weeks post-surgery via micro-computed tomography (MicroCT) analysis and manual palpation. Manual palpation scoring was conducted by blinded researchers as follows: 0 = non-fused; 1 = partial fusion, some motion across operative joint; 2 = fused, no motion across the operated joint.

Results: MicroCT imaging analyses indicated that the average fusion volume in the ADSC group was significantly higher than in the BMSC and VO groups (44.3 mm³ vs. 27.6 and 30.0 mm³, respectively, $p < 0.01$). Similarly, average manual palpation score was the highest in the ADSC group compared with the BMSC and VO groups (1.5 versus 0.7 versus 0.8 $p = 0.03$). As in previous studies, ADSCs exhibited a faster proliferative rate and a higher CFU-F frequency than BMSCs in vitro.

Discussion/Conclusion: When combined with a clinical grade bone graft substitute in a rat model, ADSCs yielded increased fusion mass volume and rates of fusion than bone marrow-derived stem cells. Ongoing studies will explore whether freshly isolated ADSCs will yield similar results.

Paper 32. Intrawound Tobramycin Powder Eradicates Surgical Wound Contamination: An in Vivo Rabbit Study

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Background/Introduction: Implant-associated surgical site infections (SSI) remain a dreaded complication of spinal surgery. Currently, over 30% of all spine SSIs are secondary to gram-negative bacteria. The purpose of the present study was to assess the efficacy of intrawound tobramycin powder in terms of eradicating a known bacterial contamination in an Escherichia coli infected rabbit spinal implantation model.

Materials/Methods: Twenty New Zealand White female rabbits underwent simulated partial laminectomies and implantation of a 10mm titanium wire at L5-L6. All surgical sites were inoculated with 100uL of tobramycin-sensitive E. coli (EC ATCC 25922, 1×10^8 colony-forming units [CFU]/mL). Prior to closure, tobramycin powder (160mg) was placed into the wound of ten rabbits. The rabbits were sacrificed on postoperative day four. Tissue and wire samples were explanted for bacteriologic analysis. A Fisher exact test was used to assess differences in categorical variables and an independent samples t test was used to assess mean group differences.

Results: The experimental and control rabbits were similar in weight (mean [and standard deviation], 3.22 ± 0.12 kg and 3.22 ± 0.14 kg, respectively, $p = 1.0$), sex distribution and duration of surgery (13.1 ± 2.4 min and 11.6 ± 2.1 min, $p = 0.39$). Bacterial cultures of the tissue samples were negative for all ten tobramycin-treated rabbits and positive for all ten control rabbits ($p < 0.0001$). Bacterial growth occurred in thirty-nine of forty samples from control rabbits, but zero of the forty samples from the tobramycin group ($p < 0.0001$). Blood culture samples from all rabbits were negative. No rabbit had evidence of sepsis or tobramycin toxicity.

Discussion/Conclusion: In a rabbit spine-infection model, intrawound tobramycin eliminated E. coli surgical site contamination. All rabbits that did not receive intrawound tobramycin had persistent E. coli contamination.

Paper 33. Topical Intraoperative Antibiotic Administration and Fusion: A Comparison of Vancomycin and Tobramycin in a Rat Model

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Background/Introduction: Local intraoperative administration of antibiotics in spinal fusion procedures has become an increasingly common prophylactic measure in an attempt to reduce rates of post-surgical infection. The localized intraoperative use of vancomycin powder remains controversial in spinal fusion, although some clinical studies have suggested that it is safe and may reduce rates of infection (Khan et al, 2014, J Neurosurg Spine 21:974–983; Bakhsheshian et al, 2015, World Neurosurg. 83(5):816–823). We thus aim to examine the effects of local intraoperative delivery of vancomycin powder and tobramycin powder, an antibiotic commonly used in orthopaedic bone grafting surgeries, in a rat spinal fusion model.

Materials/Methods: Bilateral posterolateral intertransverse process lumbar spinal fusion surgery was performed at L4-L5 using syngeneic iliac crest allograft mixed with Vitoss (Stryker) bone graft substitute and varying concentrations of antibiotics. Sixty female Lewis rats (6-8 week old) were divided into five experimental groups: [G1] low concentration (14.3 mg/kg) vancomycin (n=12); [G2] high concentration (71.5 mg/kg) vancomycin (n=12); [G3] low concentration (28.6 mg/kg) tobramycin (n=12); [G4] high concentration (143 mg/kg) tobramycin; and, [G5] controls with no antibiotics (n=12). Eight weeks post-surgery fusion was evaluated via microCT analysis (CT scoring per side: 2 = robust fusion; 1 = some narrowing of fusion mass; and, 0 = discontinuity of fusion mass; total score = average of sum of both sides), manual palpation and histology.

Results: Preliminary microCT data indicated that the high-dose vancomycin group [G2] exhibited a significantly lower fusion score and fusion mass volume than controls (fusion scores: [G1]1.8, [G2]1.2, [G3] 1.6, [G4] 3.0, and [G5] 2.3, respectively, $p=0.045$; fusion volumes: [1]20.7, [2]15.5, [3]22.9, [4]34.9, and [5]31.5 mm³, respectively, $p=0.002$). Manual palpation and histological analysis are currently being performed.

Discussion/Conclusion: Preliminary data suggest that the intraoperative local application of vancomycin at supraphysiological

doses may have detrimental effects on spinal fusion rates, thus suggesting that caution may be required when considering the amount of intraoperative vancomycin powder to employ in certain fusion patients.

Paper 34. The Effectiveness of Personalized Electronic Patient Engagement Messaging Following Lumbar Spinal Fusion: A Pilot Study

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Background/Introduction: While much focus has been placed on preoperative patient optimization less attention has been given to immediate postoperative period and identifying potential means of motivating patients and directing behaviors. The field of population health management has attempted to understand the health of the individual patient and proactively utilize and connect the patient to optimal medical resources. Patients are routinely segmented by age, demographics and insurance however this provides detail on “what the patient is doing” and not “why the patient is behaving in a certain manner”. Previous research has identified 5 healthcare related patient psychographic segments each unique in its own motivations and communication preferences, i.e. voice mail, text messaging, etc.. The goal of this study was to apply psychographic segmentation to patients undergoing lumbar spine surgery and utilize a series of electronic, customized, automated messages designed to better prepare patients preoperatively and postoperatively and to monitor progress, proactively detect any recovery issues, and limit 30-day readmission while enhancing patient satisfaction.

Materials/Methods: We enrolled 69 consecutive patients undergoing posterior instrumented lumbar fusion surgery (60.48 years - 32-84). Patients received automated communication 5 and 2 days prior to surgery with prep videos and education. Each patient was also communicated with postoperatively on day 2, 4, 6, 10, 14 and 21.

Results: Each psychographic segment received specific messaging and responses were electronically sent back to the ancillary staff. Overall response rate to text, email or voice messaging was 87.5%. When responses were positive no further call back was necessary thus freeing up staff to assist other patients. However, if any negative response including pain control, mobility or wound issues, those patients received an immediate call back. The 30-day readmission rate during this pilot study was 1.45%.

Discussion/Conclusion: This study is unique in that we utilized consumer industry techniques and applied to specific lumbar spine patients. We have found that the psychographic segmentation tool is useful for engagement of patients and classified them per attitudes and beliefs. The pilot program has provided insights for deployment of medical resources to support patients and activate positive health behavior.

Paper 35. Preoperative Mental Health May Not Be Predictive of Improvements in Patient Reported Outcomes Following a Minimally Invasive Transforaminal Lumbar Interbody Fusion

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Background/Introduction: Prior literature has associated poor preoperative mental health with inferior patient-reported outcomes following spinal procedures. The purpose of this study is to test for an association of preoperative Short Form-12 (SF-12) Mental Health

Composite Score (MCS) with improvements in Oswestry Disability Index (ODI) and back and leg pain following a minimally invasive transforaminal lumbar interbody fusion (MIS TLIF).

Materials/Methods: A retrospective analysis of patients who underwent a primary, one-level MIS TLIF was reviewed. Patients were excluded if they did not have complete patient-reported outcome data for the preoperative or all postoperative visits. Preoperative SF-12 MCS was tested for association with preoperative ODI, back Visual Analog Scale (VAS), and leg VAS. Preoperative MCS was then tested for association with changes in ODI, back and leg VAS from the preoperative to postoperative visits. These tests were conducted using multivariate regression controlling for baseline characteristics as well as for the preoperative score for the patient-reported outcome being assessed.

Results: A total of 71 patients were included in the analysis. At baseline, higher preoperative MCS was associated with lower preoperative ODI (Coefficient: -0.62, $p < 0.001$), preoperative back VAS (-0.07, $p = 0.003$), and preoperative leg VAS (-0.06, $p = 0.019$). However, there was no association between preoperative MCS and improvement in ODI, back VAS, or leg VAS at any of the postoperative time points ($p > 0.05$ for each). The percent of patients achieving a minimum clinically important difference at 6 months did not differ between the bottom and top MCS quartiles ($p > 0.05$ for each).

Discussion/Conclusion: The results of this study suggest that better preoperative mental health is associated with lower perceived preoperative disability and with increased severity of preoperative back and leg pain. In contrast to other studies, the present study was unable to demonstrate that preoperative mental health is predictive of improvement in patient reported outcomes at any postoperative time point following an MIS TLIF.

Paper 36. Validation and Utility of the Patient Reported Outcomes Measurement Information System (PROMIS®) in Patients with Lumbar Stenosis with or without Spondylolisthesis

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Background/Introduction: Lumbar stenosis is a clinical syndrome caused by narrowing of the spinal canal characterized by back and leg pain. A subset of patients with lumbar stenosis have spondylolisthesis. Surgical decompression with laminectomy is a current standard of care with good outcomes, however, there is controversy regarding the results in patients with concomitant spondylolisthesis. Patient reported outcomes used in studies comparing these surgical procedures utilize legacy measures including but not limited to ODI (Oswestry Disability Index), VAS (Visual Analog Scale), ZCQ (Zurich Claudication Questionnaire), SF-12 (short form) etc., that are, administered on paper forms, time consuming, inaccurate and have floor/ceiling effects. PROMIS was created to improve on these limitations and uses a computer adaptive testing (CAT) model.

Materials/Methods: 69 patients with lumbar stenosis were included in this prospective study. Patients were administered outcomes questionnaires - PROMIS (pain behavior, pain interference, physical function) and legacy measures (ODI, ZCQ, SF-12) preoperatively, 6 weeks and 3 months post-operatively. Patients were divided into two groups depending on presence or absence of spondylolisthesis. Patients with spondylolisthesis were treated with an instrumented fusion in addition to laminectomy.

Results: 39 patients had spondylolisthesis, 30 had lumbar stenosis without spondylolisthesis. At baseline, both groups were comparable with no statistical difference between PROMIS scores and legacy measures. Patients with spondylolisthesis had slightly poorer scores at

baseline and this difference was maintained at all times. Both subsets of patients improved substantially at 3 month follow up. Change in scores in legacy measures was also comparable to PROMIS in both groups.

Discussion/Conclusion: Our study validates the utilization of PROMIS in lumbar spinal stenosis patients with or without spondylolisthesis. Longer term followup is needed to compare the results of treatment.

Paper 37. An Analysis of Conflicts of Interest in Lumbar Spine Surgery: The Effects of Industry Payments on Practice Patterns and Complication Rates

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Background/Introduction: Conflict of interest (COI) in medicine poses a potential threat to the quality of patient care and safety. Previous studies identified that orthopaedic and neurological surgeons receive among the highest payment amounts from the industry. With the recent increases in spine fusions and discrepancies regarding the surgical management of degenerative disc disease, a surgeon's decision to pursue lumbar fusion as a therapeutic option could be affected by the surgeon's financial interests. In this study, we aimed to determine whether financial relationships with industry have any impact on the practice patterns of spine surgeons or the complication rates for spine fusion.

Materials/Methods: A database of 2,110 orthopaedic (54%) and neurological spine (46%) surgeons with corresponding lumbar fusion recommendation rates, complication rates, and industry payments was compiled. Practice pattern data was derived from a publically available Medicare-based database, which included the total number of, and rate at which each spine surgeon recommended fusion from 2011-2012. Complication rates for each surgeon from 2009-2013 were extracted from the ProPublica Surgeon Scorecard database. A mixed-effects model adjusting for age and health-status of the patient along with hospital mortality and surgeon random-effects was used to risk-adjust each surgeon's raw complication rate. Data regarding industry payments from 2013-2014 were derived from the Open Payments website. Surgeons' performing fewer than 10 fusions from 2011-2012 and those without complications data were excluded. Pearson correlation coefficients and multivariate regression analyses were used to determine the relationship between industry payments, lumbar fusion recommendation rates, and complication rates.

Results: Pearson correlation analyses revealed a negligible relationship between the industry payments and lumbar fusion recommendation rates ($r = 0.07$; $p < 0.01$) (Figure 1). Multivariate regression analysis demonstrated no significant relationships among the industry payments, and lumbar recommendation or complication rates. Additionally, a comparison of 2007 surgeons receiving payments from the industry and 103 surgeons with undisclosed payments revealed no significant differences between fusion recommendations or complication rates the two groups.

Discussion/Conclusion: While spine surgeons receive the highest industry payment amounts among all subspecialties, conflict of interest does not appear to have a significant impact on the surgeons' practice patterns or complication rates.

Paper 38. Hospital Competitive Intensity Predicts Perioperative Outcomes Following Lumbar Spinal Fusion

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Background/Introduction: Increased hospital competition may improve health care delivery and outcomes. We investigated whether the level of local hospital competition affects perioperative lumbar spinal fusion outcomes.

Materials/Methods: Patients undergoing lumbar spinal fusion from the Nationwide Inpatient Sample from 2003, 2006, and 2009 were analyzed. The Herfindahl-Hirschman Index (HHI), a validated measure of a market's competitive intensity, was utilized to assess county-level hospital market competitiveness. Total charges were adjusted for inflation to 2015 dollars using the Bureau of Labor Statistics Consumer Price Index. Multivariate regression was performed to adjust for confounding variables, including: patient age, gender, primary payer, severity score, primary vs. revision fusion, national region, hospital bed size, location/teaching status, ownership, and year. Statistical significance set at $p < 0.05$, a priori.

Results: In total, 59,743 patients underwent lumbar spinal fusion and had county HHI data and were included in the analysis. After adjusting for confounding variables with multivariate regression, increased competitive intensity (as measured by county HHI) was associated with increased total complication rate (i.e., any complication) (OR=1.49 for county HHI=0 vs. county HHI=1, $p=0.0016$), increased total charges (ratio=1.39, $p=0.0025$), and increased hospital length of stay (LOS) (ratio=1.23, $p<0.0001$). No significant relationship was observed between HHI and inpatient mortality (OR=0.82, $p=0.6495$). Analysis of complication subtype revealed an association between increased competitive intensity and increased odds of gastrointestinal complication (OR=2.02, $p=0.0338$), infection (OR=3.28, $p=0.0005$), and neurologic complications (OR=2.09, $p=0.0050$).

Discussion/Conclusion: This investigation revealed an association between increased competitive intensity among hospitals and increased odds of complications, increased total charges, and prolonged LOS following lumbar spinal fusion. The cause of this disparity is unknown, however, highly competitive hospital markets may contain hospitals which provide relatively lower quality care due to suboptimal resource availability. Perioperative outcome disparities between highly competitive and minimally competitive geographies should be monitored and further studied.

Paper 39. Discriminative Ability of Commonly Used Comorbidity Indices: A Comparison of ASA, the modified Charlson Comorbidity Index, and the modified Frailty Index

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Background/Introduction: As research tools, ASA, the modified Charlson Comorbidity Index (mCC), and the modified Frailty Index

(mFI) have been associated with adverse outcomes following spine procedures. However, as clinical measures, no known study has compared their predictive performance. The purpose of the present study is to compare the discriminative ability of ASA, mCCI, and mFI as well as demographic factors for peri-operative adverse outcomes following posterior lumbar fusion.

Materials/Methods: Patients undergoing posterior lumbar fusion were extracted from National Surgical Quality Improvement Program (NSQIP) database 2011-2014. The discriminative ability of the ASA, mCCI, and mFI as well as demographic factors for general-health adverse outcomes were assessed using area under the curve (AUC) analyses from receiver operating characteristics curves.

Results: When considering comorbidity indices, ASA was equivalent to mFI for predicting any adverse event, severe adverse events, minor adverse events and discharge to higher-level care. ASA performed better than mFI for discrimination of an extended hospital length of stay. Regardless of outcome variable, the mCCI was the worst comorbidity index for predicting adverse outcomes. When considering demographic factors, age alone had the statistically significantly largest AUC for 4 out of 5 adverse events (any adverse event, minor adverse events, extended length of stay and discharge to higher level care). Age and BMI were equally discriminative for the occurrence of severe adverse events. A comparison of the most predictive demographic factor (age) and comorbidity index (ASA) resulted in age having the larger discriminative ability for 3 out of the 5 adverse events and ASA being more predictive for 1 out of 5 adverse events (Table 1). A combination of the most predictive demographic factor and comorbidity index, resulted in improvements in discriminative ability over the individual components for 4 out of the 5 outcome variables.

Discussion/Conclusion: For posterior lumbar fusion, ASA (a comorbidity index based upon physician gestalt) performed as well or better than formulaic indices (mCCI and mFI) for predicting peri-operative adverse outcomes. Patient age was the most powerful demographic predictor of adverse outcomes. In summary, easily obtained patient characteristics such as ASA and age have similar to better discriminative abilities than complex numerically tabulated indices.

Paper 40. Comparative Effectiveness between Primary and Revision Foraminotomy for the Treatment of Lumbar Foraminal Stenosis

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Background/Introduction: Foraminotomy has demonstrated clinical benefit for the management of lumbar foraminal stenosis. Although a substantial number of patients undergo more than one foraminotomy procedure, there is little data comparing primary foraminotomy (PF) and revision foraminotomy (RF) in terms of cost and quality of life (QOL) outcomes.

Materials/Methods: A retrospective cohort study was conducted among patients undergoing foraminotomy for the treatment of lumbar foraminal stenosis. QOL instruments (EQ-5D, PDQ, and PHQ-9) were prospectively collected between 2008 and 2016. The primary outcome measure was improvement in postoperative QOL. Secondary outcome measures included perioperative cost and QOL minimum clinically important difference (MCID).

Results: 703 procedures were eligible for study inclusion – 580 (83%) PF and 123 (17%) RF. There were no significant differences in demographics between the PF and RF groups. Preoperatively,

mean EQ-5D index (0.542 vs. 0.503, $p=0.15$), total PDQ (78.9 vs. 84.1, $p=0.20$), and total PHQ-9 (7.95 vs. 9.05, $p=0.22$) demonstrated marginally greater QOL in the PF cohort compared to the RF cohort. Postoperatively, EQ-5D index showed significant improvement in both the PF (0.542→0.636, $p<0.0001$) and the RF (0.503→0.645, $p<0.0001$) cohorts. Similarly, total PHQ-9 improved significantly in the PF cohort (7.95→5.99, $p<0.001$) and in the RF cohort (9.05→6.17, $p<0.01$). Total PDQ, however, showed a significant improvement only in the PF cohort (78.9→64.0, $p<0.0001$) and failed to reach significance in the RF cohort (84.1→72.5, $p=0.14$). QOL scores were also compared between groups preoperatively and postoperatively. The only significant difference between PF and RF was observed in postoperative PDQ score (64.0 vs. 72.5, $p=0.03$). Similarly, the proportion of patients achieving an MCID on the PDQ instrument was significantly greater in PF compared to RF (44% vs. 24%, $p=0.03$). Finally, perioperative cost did not differ significantly between cohorts (PF: \$62,386 vs. RF: \$68,300, $p=0.26$).

Discussion/Conclusion: Marginally poorer preoperative QOL was observed among patients undergoing RF compared to PF. PF yielded a statistically greater degree of improvement in total PDQ score and PDQ MCID compared to RF. PF therefore appeared to be more cost-effective relative to RF, since PF was associated with a lower perioperative cost but a significantly greater QOL improvement as measured by the PDQ instrument.

Paper 41. Decompression Versus Fusion for Grade I Degenerative Spondylolisthesis: A Meta-Analysis

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Background/Introduction: Degenerative spondylolisthesis (DS) remains one of the most common indications for spine surgery. Although large trials supported surgical treatment for this pathology and recent meta-analysis has compared different fusion techniques, the best surgical option for patients with only grade 1 disease has not been determined. The purpose of this study is to compare decompression and fusion with decompression alone for the treatment of grade 1 DS.

Materials/Methods: The MEDLINE, Embase, and Ovid electronic databases were systematically reviewed for studies evaluating patients with grade 1 DS published from January 1996 until July 2016. We stratified patients into two cohorts; the first group underwent a decompressive-type surgery and the second cohort underwent a fusion procedure. We looked at clinical outcomes, complications, reoperations, and surgical details such as blood loss. Descriptive statistics were used to describe both cohorts; then, random effect models were used to determine the rates of the specified outcome metrics, with its 95% confidence intervals.

Results: A total of 17 studies met our criteria. Nine studies (N=591 patients) who were part of the decompression cohort, with a mean age of 67 years, mean BMI of 24 kg/m², and 54% were women. The fusion cohort had 14 studies (N=434 patients) with a mean age mean 60 years, mean BMI of 24 kg/m² and 71% were female. In both cohorts, the pain (leg and low back) significantly decreased, the physical component of the Short Form 36 (SF-36), and overall increased the outcome metric scales. The decompression cohort had a 7.5% complication rate (95% CI of 2 to 16%) and the fusion had a 9.2% complication rate. In contrast, the reoperation rate was higher in the decompression cohort with a 6% rate than in the fusion cohort with a 4.4% rate.

Discussion/Conclusion: Patients undergoing decompression alone tended to be older and had a higher percentage of leg pain while fusion patients tended to be younger and have more low back pain. The decompression cohort had fewer complications but a higher

revision rate. Future studies specifically assessing patients with low grade DS are needed to determine the benefits and cost effectiveness of one procedure versus another.

Paper 42. Effect of Lumbar Fusion on Adjacent Segment Disc Deformation: an In-Vivo Pre and Post-Fusion Surgery Patient Analysis

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Background/Introduction: Up to 80% of patients develop adjacent segment degeneration (ASD) as early as one year after lumbar fusion, with 17-36% of patients requiring re-operation due to symptomatic ASD within 5-10 years. Kinematic changes at the adjacent segment after a spinal fusion have been assumed to be a causing factor for ASD, yet clear evidence is lacking. This study investigated adjacent segment disc deformation under weight bearing conditions before and after lumbar fusion surgeries.

Materials/Methods: Ten patients with disk degenerative disease at L4-S1 were MRI scanned and 3D anatomical models were constructed for each. Subjects were then imaged using a dual fluoroscopic imaging system at standing, flexion and extension positions before undergoing a fusion surgery at the L4-S1 segments. Five patients were imaged again 3 years after undergoing fusion surgery for post-op analysis. Deformations of the adjacent disc of L3-4 were calculated using the changes in geometry between the endplates of L3 and L4 segments, using the MRI disc as the reference. Patient data was compared with 8 healthy control subjects.

Results: Our data shows that a fusion surgery significantly increases tensile and shear deformations on the adjacent disc. Post-fusion, the disc height was reduced by 1.15mm, on average. On average, 13%, 15%, and 12% increase in shearing deformation was observed during standing, flexion and extension positions, respectively, after a fusion surgery. Lastly, greater tensile deformations were observed at flexion and extension positions post-op when compared to pre-op and normal control subjects. Specifically, on average, an increase in 9% compressive and 10% tensile deformations at flexion position, 15% in compressive and 7% in tensile deformations at extension position were observed.

Discussion/Conclusion: This study indicates that a fusion surgery increases the tensile and shear deformations at the adjacent disc. The data reveals that post-fusion, the anterior position of the disc experiences greater stresses than other positions. These increased stresses lead to disc deformations and degeneration of the adjacent segment discs. As fusion surgery can lead to ASD, it should be limited to when dynamic biomechanical and clinical evidence of instability is present to minimize reoperation rate.

Poster 01. Trends in Primary and Revision Laminectomy in the United States from 2006 to 2014

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Background/Introduction: Given the increasing focus on health care utilization and value-based care, it is essential to determine the number and trends in primary and revision laminectomies per year throughout the United States. Patient demographics and

economic data associated with primary and revision laminectomy cases is critical to understanding and improving optimal health care utilization.

Materials/Methods: The data utilized in this study was collected between 2006–2014 across 44 states from the National Inpatient Sample (NIS) database on patients who had undergone primary laminectomy (ICD-9-CM-03.09) or revision laminectomy (ICD-9-CM-03.02). Demographic and economic data were obtained which included the annual number of surgeries, age, sex, insurance type, location, and frequency of routine discharge. The NIS database represents a 20% sample of discharges from U.S. hospitals, which is weighted to provide national estimates.

Results: An estimated 1,430,987 and 49,998 patients underwent primary and revision laminectomy procedures, respectively, throughout the U.S. during the study period. The total number of primary laminectomy operations has progressively decreased slightly from 152,358 to 147,650 over the nine-year study period. In 2014 Medicare patients comprised 49% of those billed for primary laminectomy, and 22% of procedures were utilized in areas designated as not low income. Over 72% of primary laminectomies and 69% of revision laminectomies were performed at urban teaching hospitals. The calculated revision burden for laminectomy surgery over the nine year study period is 3.4%.

Discussion/Conclusion: Over the past nine years (2006–2014) there has been a slight decrease in primary and revision laminectomies in the U.S. despite an increase in the elderly U.S. population. One possibility for the decrease laminectomy procedures is the increasing rate of posterior interbody fusion procedures, which include a partial decompression in the ICD-9CM billing codes. Regardless more research is needed to determine the factors causing laminectomy surgery alone to decrease from 2006 to 2014. The revision burden for laminectomy is only 3.4%, which compares favorably to other orthopaedic surgeries such as total knee arthroplasty at 8.2% and total hip arthroplasty at 17.5%.

Poster 02. 90-day reimbursements for primary single level posterior lumbar interbody fusion from commercial and Medicare data

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Background/Introduction: Episode based bundled payments aim to align incentives of all health care providers towards the common goal of high quality and economic health care. Structuring such a payment model will require detailed analysis of previous year's reimbursements, which is currently not known for a primary single level posterior lumbar interbody fusion. In this context, we analyze the reimbursement data over the years from Commercial payers and Medicare for this common spine procedure.

Materials/Methods: Administrative claims data was used to study reimbursements from Commercial payers (2007–Q3 2015), Medicare Advantage (2007–Q3 2015), and Medicare (2005–2012) for a primary single level posterior lumbar interbody fusion. Distribution of payments among various service providers was studied. In addition to descriptive analysis, variation between regions and payers was studied by a one-way analysis of variance (ANOVA) and post-hoc Tukey test.

Results: Average hospital costs comprise 74.2 to 77 % of the total payments, followed by surgeon's fees which accounted for 12.8 to 13.7 %. Post-discharge services comprised 3.6 to 7.1 % of the total reimbursement. The national 90-day payment amount was \$51,465, \$26,234 and \$25,501 for Commercial payers, Medicare Advantage and Medicare, respectively. There was some regional variation, however not consistent among different payers. Inpatient surgery had higher facility costs than outpatient surgery.

Discussion/Conclusion: Facility costs constitute the majority

share in a 90-day bundle amount. Surgery done in the outpatient setting is associated with lower facility costs than inpatient surgery. Overall burden of readmissions/revisions was 2.1 to 2.7%, but for the readmitted patient they constitute 25 to 54 % of the 90-day payment.

Poster 03. Development of Common Language Descriptions Correlating with PROMIS

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Background/Introduction: The Patient Reported Outcome Measurement Information System (PROMIS) is a system of instruments that implements item response theory (IRT) and computerized adaptive testing (CAT) designing it to be precise, reliable, and versatile. PROMIS has been validated in the lumbar spine patient population and has been found to be more useful than other popular patient reported outcome measures. However, currently the use of PROMIS is limited in part because many clinicians lack a common language understanding of the meaning and the significance of PROMIS scores. The objective of this study was to develop rational plain language descriptions to apply to PROMIS Physical Function scores.

Materials/Methods: We retrospectively analyzed prospectively collected PROMIS Bank v1.2 Physical Function (PROMIS-PF) scores compiled in a database. Patients presenting for office visits (encounters) related to their back and/or lower extremity were included. Patients with missing scores, standard error >0.32, missing injury location, and assessments with <4 questions or more than 12 questions were excluded. PROMIS-PF scores from each encounter were grouped by scores to allow practical and rational application of common language descriptions based on the questions and answers for the scoring groups.

Results: In total, 12,712 encounters and 5,524 patients were included in the analysis. The mean PROMIS-PF score for all encounters was 37.2 (standard deviation 8.2). 90% of encounters were completed in 4 questions to generate the PROMIS-PF score. The frequency of question and answer occurrences was analyzed. The set of rationale was applied and used to develop common language descriptions of each PROMIS PF score group (Table 1). For example, a score of 35 ± 2 means someone is able to do chores such as vacuuming or yard work with much difficulty, can carry a laundry basket up a flight of stairs with much difficulty, can walk at normal speeds with some difficulty, and can run errands and shop with some difficulty.

Discussion/Conclusion: This study developed rational plain language descriptions to enhance the understanding and application of PROMIS Physical Function scores for patients presenting with back and lower extremity complaints in the clinical and research settings.

Poster 04. PROMIS Physical Function Outcomes in Diabetic Patients Undergoing Lumbar Spine Surgery

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Background/Introduction: PROMIS Physical Function (PF) Computer Adaptive Testing (CAT) is an NIH-funded, subjective measure of patient physical function, and has been validated in the spine population. Little is known about the effects of comorbidities on the outcomes of surgery as assessed by the PROMIS PF CAT. The purpose of this study was to compare the physical function outcomes

of diabetic patients and nondiabetic patients before and after lumbar spine surgery, as assessed by PF CAT.

Materials/Methods: PF CAT questionnaires were administered on electronic tablets to spine patients from October 1, 2013 to December 31, 2015 at a single university-based spine clinic. Patients were included if they had completed PF CAT questionnaires, were greater than 18 years of age, and had undergone any lumbar spine surgery within the aforementioned dates. Diabetic status of each patient was determined, and PF CAT scores were collected for the 3 months preoperative, and at 3, 6, and 12 month postoperative time points. Wilcoxon and Exact Wilcoxon tests were used to analyze median PF CAT scores and median age-adjusted PF CAT percentile ranks.

Results: Of 299 patients identified, 85 were diabetic (mean age 65, 58% male) and 214 were nondiabetic (mean age 55, 57% male). Median PF CAT scores were significantly different between diabetic and nondiabetic cohorts at the 3 months preoperative and 6 months postoperative time points. At 3 months preoperative, diabetic and nondiabetic scores were 31.4 and 34, respectively ($p=0.011$). At 6 months postoperative, diabetic and nondiabetic scores were 39.5 and 42.0, respectively ($p=0.015$). When looking at median age-adjusted PF CAT percentile ranks, rather than raw scores, no significant difference in percentile ranks between diabetics and nondiabetics was found at any of these time points (Figure 1).

Discussion/Conclusion: Patients with Diabetes Mellitus had significantly lower PROMIS Physical Function scores 3 months before and 6 months after lumbar surgery when compared with nondiabetic patients. However, when scores were adjusted for age this difference disappeared, highlighting the importance of this demographic when evaluating PROMIS Physical Function scores.

Poster 05. Radiographic and Clinical Outcomes of Anterior and Transforaminal Lumbar Interbody Fusions: A Systematic Review and Meta-Analysis of Comparative Studies

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Background/Introduction: ALIF and TLIF with pedicle screw fixation are two methods of achieving spinal arthrodesis. There are conflicting reports with no consensus on the optimal interbody technique to achieve successful radiographic and clinical outcomes. Given these findings, a systematic review and meta-analysis of the current literature was performed in order to better compare radiographic and clinical outcomes of ALIF and TLIF

Materials/Methods: A systematic search of multiple medical reference databases was conducted for studies comparing ALIF to TLIF. Studies that included stand-alone ALIFs were excluded. Meta-analysis was performed using the random-effects model for heterogeneity. Radiographic outcome measures included segmental and overall lumbar lordosis, and fusion rates. Clinical outcomes measures included Oswestry disability index (ODI) and visual analog scale (VAS) score for back pain.

Results: The search yielded 7 studies totaling 811 patients (ALIF = 448, TLIF = 363). ALIF was superior to TLIF in restoring segmental lumbar lordosis at L4-5 and L5-S1 ((L4-5; SMD = 4.655, 95% CI: 2.76 - 8.31, $p=0.013$), (L5-S1; SMD = 3.728, 95% CI: 1.710 - 5.746, $p<0.001$)). ALIF was also superior to TLIF in restoring overall (T12 or L1-S1) lumbar lordosis (SMD = 4.022, 95% CI: 2.71 - 5.333, $p<0.001$). However, no significant differences in fusion rates were noted between both techniques (OR = 0.905, 95% CI: 0.458 - 1.789, $p=0.775$). Additionally, ALIF and TLIF were comparable with regards to ODI and VAS scores ((ODI; SMD = 1.782, 95% CI: -0.849 - 4.413, $p=0.184$), (VAS; SMD = 0.00784, 95% CI: -0.732 - 0.748, $p=0.983$)).

Discussion/Conclusion: In patients with sagittal imbalance

whereby restoration of lumbar lordosis is paramount, ALIF is superior to TLIF. However, for patients with degenerative spinal pathologies without significant deformity, TLIF is comparable to ALIF with regards to fusion rate and clinical outcomes.

Poster 06. Open fixation and fusion versus percutaneous pedicle screw fixation for treatment of thoracolumbar flexion distraction injuries

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Background/Introduction: Flexion distraction injuries of the thoracolumbar spine describes a subset of fractures with posterior ligamentous complex disruption in response to a flexion and distraction moment imparted to the thoracolumbar spine. These injuries are mechanically and neurologically unstable and surgical stabilization is frequently necessary to prevent neurological deterioration and maintain sagittal alignment. Conventionally, open posterior fixation and fusion have been utilized as the standard surgical treatment. Recently, percutaneous techniques with pedicle screws insertion are becoming popular as they provide stabilization without the morbidity associated with the open approach. To date, our study remains the largest study directly comparing the two methods.

Materials/Methods: Patients with flexion distraction injuries who were treated surgically between July 2005 and August 2015 at our institute were prospectively followed. Patients were treated with either open posterior pedicle screw fixation and fusion or posterior percutaneous pedicle screw fixation. For all patients, the American Spinal Injury Association scores and radiographic sagittal plan parameters were recorded preoperatively, postoperatively and on subsequent follow ups. We compared the two treatment groups regarding intraoperative blood loss, operating room time, length of hospital stay and complications.

Results: 70 patients who underwent surgical stabilization for thoracolumbar flexion distraction injuries were identified. Open posterior pedicle screw fixation with posterolateral fusion was performed in 52 patients while 18 patients underwent percutaneous pedicle screw fixation. Neither groups showed a statistically significant difference in terms of American Spinal Injury Association scores or sagittal alignment. The percutaneous pedicle screw fixation group showed less blood loss and shorter operative time.

Discussion/Conclusion: Flexion distraction injuries of the thoracolumbar spine usually necessitate operative treatment. Percutaneous pedicle screw fixation allows for adequate stabilization with less intraoperative blood loss and avoids the morbidity associated with conventional open approach.

Poster 07. Hospital Ownership and Teaching Status Affects Perioperative Outcomes Following Lumbar Spinal Fusion

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Background/Introduction: Hospital ownership and teaching status may influence care quality. This study investigated how hospital ownership and teaching status affects perioperative outcomes following lumbar spinal fusion.

Materials/Methods: This investigation analyzed lumbar spinal fusion discharges in the Nationwide Inpatient Sample from 2002-2012. Hospital ownership was determined utilizing the AHA Survey of Hospitals. Teaching status was derived from the presence of AMA-approved residency program, Council of Teaching Hospitals membership, or a trainee/bed ratio of >0.25. In covariate-adjusted analyses, multivariate regression was used to account for confounding variables, including: patient age, gender, primary payer, severity score, primary vs. revision fusion, national region, hospital bed size, and year. Statistical significance was set at $p < 0.05$, a priori.

Results: In total, 453,761 lumbar spinal fusion discharges were analyzed. Compared to patients from for-profit hospitals, patients from non-profit hospitals exhibited increased odds of inpatient mortality (OR=1.55, $p=0.0009$), total complication rate (OR=1.14, $p=0.0020$), length of stay (LOS) (ratio=1.14, $p<0.0001$), and decreased total charges (ratio=0.75, $p<0.0001$). Discharges from urban non-teaching hospitals were associated with decreased odds of mortality (OR=0.73, $p=0.0003$), fewer total complications (OR=0.88, $p=0.0003$), and decreased LOS (ratio=0.88, $p<0.0001$) compared to discharges at urban teaching hospitals. Covariate-adjusted analysis revealed a significant association between discharge from non-profit hospitals and decreased total charges (ratio=0.76, $p<0.0001$) and increased LOS (ratio=1.04, $p=0.0249$) compared to discharge from for-profit hospitals. After covariate-adjusted analysis, patients discharged from urban non-teaching hospitals exhibited decreased odds of complications (OR=0.93, $p=0.0306$) and decreased LOS (ratio=0.90, $p<0.0001$) compared to patients discharged from urban teaching hospitals.

Discussion/Conclusion: Hospital ownership and teaching status may affect perioperative outcomes following lumbar spinal fusion, although these findings may largely reflect differing patient populations. After adjusting for patient severity and demographics, non-profit hospitals were found to have significantly lower charges and longer LOS compared to for-profit hospitals, and teaching hospitals had higher complication rates and longer LOS compared to non-teaching hospitals. Further examination of the mechanisms affecting complication rate, LOS, and charges based on hospital ownership and teaching status is warranted.

Poster 08. In Hospital Narcotic Usage Is Significantly Lower for Minimally Invasive Spine Surgery Versus Open Spine Surgery

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Background/Introduction: Minimally invasive surgery has been shown to be cost effective, have a shorter length of stay and decreased need for perioperative blood transfusion. Recent public awareness has focused on narcotic usage as detrimental to the public health. The focus of the present study was to examine length of stay and perioperative narcotic usage for open versus minimally invasive spinal surgery.

Materials/Methods: Institutional board approval was obtained for a retrospective review of patient data from 2014 to 2015. A retrospective analysis was performed for 40 patients that underwent minimally invasive spine surgery versus 70 that had open surgery. Data were collected on inpatient narcotic usage and length of stay.

Opioid use was standardized by using equi-analgesia chart and total dose was calculated. Average total dose was compared using statistical analysis and p values were calculated

Results: Average narcotic usage for minimally invasive versus open lumbar spinal surgery was statically significantly lower. Average equi-analgesic dose post operatively was 278 mg v. 423 mg (p 0.03). Intraoperative use showed a trend towards lower usage but was not statistically significant (26 mg v. 32 mg, p = 0.07). Average length of stay approached 1 day shorter for all minimally invasive cases versus open cases (p = 0.18).

Discussion/Conclusion: Open spinal surgery versus minimally invasive spine surgery requires approximately 2 times the amount of narcotics for management of post operative pain control. Intraoperative narcotic usage was not significantly different and length of stay approached one day shorter for minimally invasive cases.

Poster 09. Efficacy of Anti-fibrinolytics and When They Reduce Blood Loss During Spinal Deformity Surgery

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Background/Introduction: Adult spinal deformity correction surgery often involves significant intraoperative blood loss with numerous complications. Surgeons have begun administering peri-operative anti-fibrinolytic agents which significantly reduces intraoperative blood loss. The purpose was to determine which phase of surgery anti-fibrinolytics (antifib) will decrease blood loss compared to blood loss incurred without anti-fibrinolytic administration in adult thoracolumbar deformity surgeries.

Materials/Methods: Reviewed consecutive surgical case logs (2012-2015) from two spinal deformity surgeons. Inclusion criteria: age > 18 years, thoracolumbar surgeries, surgery duration between 6 and 9 hours, and levels of fusion > 7. Patients divided into two groups: 43 patients with no osteotomies (Group 1) and 22 patients with osteotomies (Group 2). We compared blood loss for every 2 hours in Groups 1 and 2 between patients receiving anti-fibrinolytic agents and no anti-fibrinolytics. ANOVA and Chi square analyses performed; p < 0.05 was considered statistical significant.

Results: Study consisted of 65 patients: mean age of 60±16 years. The number of levels fused and duration of surgery with and without antifib patients were not statistically significant in both Groups 1 and 2. In Group 1 (Table 1 and Graph 1): TBL was 1.8L & 2.2L (p=0.18) in patients without and with anti-fibrinolytics, respectively; blood loss in patients (no Fib vs with Fib) at first 2 hours (490 vs 620ml), between third and fourth hour (550 vs 682ml), fifth and sixth hours (512 vs 641ml), and seventh and eighth hour (500 vs 471ml). In Group 2: TBL was 1.5L and 2L (p=0.17) in patients without and with anti-fibrinolytics, respectively; blood loss in patients (no Fib vs with Fib) at first 2 hours (422 vs 550ml), between third and fourth hour (409 vs 716ml), fifth and sixth hour (407 vs 450ml), and seventh and eighth hour (264 vs 412ml). The TBL and blood loss at every 2 hours are not statistically significant between patients in Group 1 and 2.

Discussion/Conclusion: Antifibrinolytics started decreasing blood loss after 4 hours from the start of surgery. Antifibrinolytics patients had more TBL and blood loss at every time interval. Our low sample size failed to show any statistical significance between with and without antifibrinolytic patients.

Poster 10. The Use of Liberal Transfusion Triggers: Outcomes after Spine Surgery

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Background/Introduction: While blood transfusions are commonly used in spine surgery, they are associated with increased intra- and postoperative patient morbidity. No studies have examined the association between the reliance on liberal hemoglobin triggers—that is, an intraoperative hemoglobin level of ≥10 g/dL or a postoperative level of ≥8 g/dL—and perioperative morbidity in spine surgery patients. In this study, we examined the association between perioperative outcomes and a liberal transfusion strategy during spine surgery.

Materials/Methods: Institutional inpatient surgical records were queried for spine surgeries between 2008 and 2015. Included in this group were patients undergoing spinal fusion, tumor-related surgeries, and other spine surgeries. Variables analyzed included mortality, in-hospital morbidity, and length of stay associated with liberal transfusion triggers.

Results: A total of 6931 patients undergoing spine surgery were identified and separated into eight major procedural groups. For patients with an entire hospital stay hemoglobin nadir between 8 to 10 g/dL, transfused patients had longer in-hospital stays (median [IQR], 6 [5-9] vs. 4 [3-6] days; P<0.0001) and higher perioperative morbidity (n=145, [11.5%] vs. n=74, [6.1%]; P<0.0001) than those not transfused. Moreover, even after adjusting for potential confounders such as age, estimated blood loss, number of operated levels, ASA class, CCI score, and surgery type, patients with a hemoglobin nadir of 8-10 g/dL who were transfused had an independently higher risk of perioperative morbidity (odds ratio [OR] = 2.12; 95% confidence interval [CI], 1.24-3.64; P=0.006).

Discussion/Conclusion: Reliance on liberal transfusion triggers is associated with worse perioperative outcomes, even after adjusting for confounders. Clinicians may wish to consider alternative transfusion triggers for spine surgery patients to reduce patient morbidity.

Poster 11. Cigarette Smoke-Induced Inhibition of Osteogenesis Through Involvement of the Aryl Hydrocarbon Receptor

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Background/Introduction: Cigarette smoking significantly impairs bone regeneration and is associated with higher rates of pseudarthrosis after spine fusion procedures. However, the molecular mechanisms underlying these effects are unclear. Recent work has implicated the Ahr in mediating the inhibition of osteogenic differentiation by several ligands found in cigarette smoke. Our previous work with dioxin, a constituent of cigarette smoke and high-affinity ligand of the Ahr, has shown that dioxin exposure inhibits bone regeneration and spine fusion in vivo. The purpose of this study was to elucidate the mechanisms underlying the adverse effects of Cigarette Smoke Extract (CSE)—the Ahr ligand-containing fraction of cigarette smoke—on bone regeneration.

Materials/Methods: Bone marrow stromal cells (BMSC) were harvested from Long-Evans rats and cultured under standard or osteogenic conditions. CSE was prepared by drawing smoke from reference cigarettes through a 0.1 µm PTFE filter and washing the filter in DMSO to yield a concentration of 40 mg/mL. Factors critical to osteogenesis were then evaluated after BMSC were exposed to DMSO vehicle, 10 or 20 µg/mL CSE, or co-treated with Ahr antagonists (4 µM Resveratrol, Res; 2 µM α-Naphthoflavone, ANF; 10 µM 3'-Diindolylmethane, DIM). Endpoints included cell

viability (MTS assay), ALP activity, mineralization, and gene and protein expression of targets relevant to osteogenic differentiation.

Results: CYP1A1 mRNA was induced in CSE-treated BMSC, as was ethoxyresorufin-o-deethylase (EROD) activity, both of which are markers for Ahr activation. CSE reduced cell number and ALP activity, and also inhibited mineral deposition relative to vehicle control. Expression of ALP, OCN, RUNX2, CXCL12, PHEX, and OPN were also reduced. Co-treatment with each of the Ahr antagonists generally mitigated these effects.

Discussion/Conclusion: Our results suggest that Ahr activation may play a critical role in the adverse effects of cigarette smoke on bone healing, and that these effects may be reduced with Ahr antagonist co-treatment. Administration of natural and synthetic Ahr antagonists should be investigated as a therapeutic option to block these inhibitory effects.

Poster 12. Minimally invasive retroperitoneal anterolateral psoas-sparing (ATP) lumbosacral fusion: Is it safe?

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Background/Introduction: Lumbar fusion using the transpsoas technique is notorious for catastrophic neurovascular and visceral injuries. Therefore, psoas-sparing anterolateral technique has been gaining attention. However, the safety profile of this novice technique is not well investigated, particularly at the level of L5-S1. A minimally invasive anterolateral retroperitoneal psoas-sparing approach (anterior to the psoas: ATP) of the lumbosacral spine (T12-S1) has been adopted and finessed by the senior authors over the past 10 years.

Materials/Methods: Patients with degenerative lumbar disorders requiring a minimally invasive ATP lumbar fusion (between T12-S1) at our institution, between 2007 and 2011, were identified (396 subjects). (Figure 1) A retrospective chart review of the postoperative morbidity and mortality database was conducted and analyzed. (Table 1) A muscle splitting retroperitoneal ATP approach, including the L5-S1 segment, was performed in all identified patients.

Results: Overall, twelve patients (3%) were noted to develop postoperative complications. Surprisingly, the majority of the surgical complications (7 out of 12: 58%) were related to the posterior fusion rather than the anterior approach (2 out of 12: 16%). Neurologic deficits were only encountered in 2 patients, with complete resolution at final follow-up (2 years). There were no vascular or visceral injuries encountered with the ATP technique, however the noted complications in this series were technical in nature (Cage displacement due to adjacent vertebral body fracture, and anterior neural confusion with neurapraxia), did not involve the L5-S1 segment, and required revision surgeries.

Discussion/Conclusion: Minimally invasive ATP lumbosacral fusion, although technically demanding, is safe and feasible in patients with degenerative spinal disorders. Beside sparing the psoas muscle compartment and its contents, this technique allows for direct visualization, and therefore protection, of the peri-spinal neurovasculature and abdominal visceral structures between T12-S1. Direct and indirect neural decompression, as well as controlled anterior column release can be performed through a single muscle splitting approach between T12-S1. Despite a steep learning curve, the safety profile of this technique is favorable and promising.

Poster 13. Effect of Local Delivery of SDF-1 and Postoperative Stem Cell Mobilization on Bone Formation and Interbody Fusion in an Ovine Model

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Background/Introduction: Mesenchymal stem cell-based therapies represent an attractive approach for augmenting bone formation in spine fusion. MSC-based techniques have failed to gain widespread clinical adoption primarily due to time-, and labor-intensive ex vivo processing steps. We hypothesize that these steps can be eliminated by directing the recruitment of endogenous MSC populations. To this end, we evaluated the effect of local delivery of a chemotactic factor (SDF-1b) and post-operative administration of a stem cell mobilizing agent (AMD3100) on bone formation in an ovine model of interbody fusion.

Materials/Methods: Under an IACUC approved protocol, 20 Dorsett-Cross ewes underwent single-level ACDF. A PEEK cage filled with 1.0 cc of a commercially-available collagen/b-TCP/bioglass graft material and loaded with either SDF-1b (100 ng) or saline, was implanted at C4-C5. Following surgery, sheep were randomized to undergo a single subcutaneous injection of a stem cell mobilizing agent (AMD3100, 240 ug/kg) or saline. Four treatment groups were evaluated (n=5/group): Control, SDF-1b only, AMD3100 only, and SDF-1b+AMD3100. Blinded observers graded fusion status based on bone formation within the interbody cage observed on clinical CT, nondecalcified histology and backscattered electron imaging at the 16 week endpoint using a four-point ordinal scale adopted from Kandziora, et al.

Results: Clinical CT demonstrated at 60% fusion rate in the SDF-1b only group, 40% fusion in the AMD3100 and SDF-1b+AMD3100 groups, and 0% solid fusion in the Control group at 16 weeks. Both nondecalcified histology and backscattered electron imaging showed a 100% fusion rate in the AMD3100 only group, while 60% of the SDF-1b only animals were fused, and 40% of animals in both the SDF-1b+AMD3100 and Control group showed solid fusion. Quantitative histologic analyses showed that the AMD3100 only group had the greatest mean area fraction of mineralized tissue within the interbody cage.

Discussion/Conclusion: This study demonstrated that local delivery of a chemotactic factor (SDF-1b) and post-operative administration of a stem cell mobilizing agent (AMD3100) separately enhance bone formation. Quantitative analysis of nondecalcified histologic sections demonstrated that a single post-operative injection AMD3100 increased the mean area fraction of bone within the cage and promoted solid fusion in 100% of animals.

Poster 14. Preoperative Obesity Class III Designation as a Risk Factor for Major Postoperative Complications after Anterior Lumbar Fusion

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Background/Introduction: Introduction: Approach related complications have been well studied in adults undergoing anterior lumbar fusion (ALF). However, no study has been able to quantify risk of postoperative complications in patients with obesity class III (BMI>40) designation prior to surgery. It is important to understand which risk factors are independently associated with morbid obesity in order to treat these patients accordingly.

Materials/Methods: Methods: This was a retrospective analysis of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database between 2011 and 2014 for patients undergoing ASD surgery. Patients were included

based on Current Procedural Terminology (CPT) codes. Patients with age <18 years, non-elective surgery, emergency surgery, current pneumonia, current sepsis, current pregnancy, wound class >1 or a previous operation within 30 days of the principal operation were excluded from the study. Patients with a BMI equal to or over 40 were categorized into obesity Class 3 (OC3) and those with lower BMI were labeled as non-obesity Class 3 (NOC3). Multivariate logistic regression was utilized to uncover any associations between obesity classification and adverse outcomes.

Results: Results: 3,152 cases met the inclusion criteria for this study, and 190 (6.02%) of them were classified in OC3. Obesity classification was found to be an independent risk factor for mortality (OR=7.19, 1.42-44.17, p-value=0.018), wound complications (OR=3.01, 1.53-5.97, p-value=0.0015) sepsis (OR=3.76, 1.25-11.25, p-value=0.018), and unplanned readmission (OR=2.3, 1.4-4.0, p-value=0.0038) through multivariate logistic regression revealed comparing OC3 vs. NOC3.

Discussion/Conclusion: Conclusion: Patients with BMI over 40 had an obesity class III designation. This classification is significantly and independently associated with and increased risk of mortality, wound complications, sepsis, and unplanned readmission for patients undergoing ALF. Given the gravity of these postoperative complications, surgeons should counsel patients appropriately.

Poster 15. The Utility of In-hospital Postoperative Radiographs Following Surgical Treatment of Traumatic Thoracolumbar Injuries

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Background/Introduction: Previous studies have concluded that postoperative radiographs following lumbar fusion for degenerative conditions have limited clinical value, especially in the absence of changes in symptoms or examination. In order to obtain these radiographs, patients are subject to radiation and inconvenience at a cost to the healthcare system. Our hypothesis is that routine in-hospital postoperative radiographs following surgical treatment of traumatic thoracolumbar (TL) injuries are unnecessary in the absence of changes in symptoms or examination.

Materials/Methods: A retrospective review of patients who underwent surgical treatment of traumatic TL injuries between December 2006 and October 2015 at a Level I trauma center by four fellowship-trained spine surgeons was performed. Prior to discharge, postoperative upright AP and lateral radiographs were obtained and reviewed by one of the surgeons as per standard protocol. Those patients who subsequently underwent revision surgery were identified and further analyzed to identify demographic information, injury pattern, mechanism of injury, index and revision procedures, and reason for intervention.

Results: 500 patients (353 males and 147 females) were identified with a mean age of 44.6 years (range, 18-90). Only one patient, a 18 year-old male who sustained a L2 burst fracture, had revision surgery secondary to abnormal routine postoperative radiographs. Six other patients (five males and one female) with a mean age of 35.8 years (range, 18-75) underwent revision surgery due to worsening or continuing neurologic deficits or findings from advanced imaging. The injury patterns included 4 burst fractures and 3 flexion-distraction injuries. The index procedures included 5 percutaneous posterior stabilizations and 2 open posterior decompressions and instrumented fusions.

Discussion/Conclusion: Routine in-hospital postoperative radiographs following surgical treatment of TL injuries are of little value, especially in the absence of changes in examination or symptoms. The rate of revision surgery during the initial hospitalization was 1.4% (7/500) in our study. Only 0.2% (1/500) returned to the operating room for revision of instrumentation as a

result of an abnormality found on routine postoperative radiographs. With today's increasing emphasis on cost efficiency and evidence based practice, this study may contribute to a movement to discontinue routine postoperative radiographs following spine surgery.

Poster 16. How Does Case Type, Length of Stay, and Comorbidities Affect Medicare DRG Reimbursement for Minimally Invasive Surgery (MIS) for Deformity?

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Background/Introduction: We investigated Medicare DRG based reimbursement for MIS deformity procedures in our study group hospitals based on length of stay and presence of comorbid conditions (CC).

Materials/Methods: DRG based reimbursement was obtained for MIS anterior, posterior and circumferential 1-level and multi-level fusion for listhesis and deformity cases with and without CC from 12 institutions throughout the US. The 3 most common MIS procedures were analyzed to compare reimbursement based on DRG coding: 1. Fusion via anterior or posterior only; 2. Fusion anterior with fixation posterior percutaneous (no dorsal fusion); 3. Fusion Combined anterior and posterior.

Results: The number of levels fused does not affect the reimbursement for all cases. Cases 1 and 2 without CC, 3-day stay reimbursed \$41,404 vs 8-day reimbursed \$42,808. Cases 1 and 2 with CCs, 3-day stay reimbursed \$54,476 vs 8-day stay reimbursed \$55,881. Case 3 without CC, 3-day stay reimbursed \$47,992 vs 8-day stay reimbursed \$49,397. Case 3 with CC, 3-day reimbursed \$61,806 vs 8-day reimbursed \$63,212. The increased payment for an 8-day stay was \$1,405 or \$281 per day. If a deformity case 1 or 2 is coded incorrectly as a degenerative case the decrease in payment was \$9,769 lower (-24%) with no CC and \$22,841 lower (-42%) with CC.

Discussion/Conclusion: Regardless the direct costs, Medicare DRG based reimbursement was the same for single and multi-level MIS deformity cases. The use of posterior percutaneous fixation without dorsal fusion resulted in a 13-16% lower reimbursement compared with the addition of a posterior arthrodesis. Coding a deformity case as degenerative by the hospital resulted in 24-42% lower DRG based reimbursement. In today's challenging environment it is important that physicians and hospitals better understand procedure and coding issues in order to be able to continue to offer complex spinal surgeries cost effectively to our patients.

Poster 17. Do Former Smokers Exhibit a Distinct Profile Before and After Lumbar Spine Surgery?

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Background/Introduction: While smoking has been found to have myriad of deleterious effects on patients undergoing lumbar spine surgery, there has been little data evaluating those who have quit, i.e. former smokers. There are also no studies evaluating a dose-response relationship between number of pack years and duration of smoking cessation prior to lumbar surgery on patient reported outcomes (PROs). We hypothesized that former smokers undergoing

lumbar spine surgery have distinct baseline and post-operative PROs.

Materials/Methods: The prospective N2QOD database and electronic medical records were evaluated for smoking history and PROs: back and leg pain, Oswestry Disability Index and EuroQOL-5D scores, pre-operatively and at 3 and 12 months post-operatively in 483 patients who had lumbar spine surgery. Three cohorts, Never smokers, Former smokers and Current smokers were evaluated. Associations between pack years and duration of smoking cessation preoperatively with PROs were also assessed.

Results: 455 (94%) cases had complete smoking history with 12-month follow up. There were 209 Never, 171 Former, and 75 Current smokers. The distribution of diagnostic indication, workers' compensation, ASA grade and surgery type were similar among the cohorts. Baseline, 12 month, and improvement in PROs were significantly different with Current smokers having the worst scores, followed by Former smokers and Never smokers (Table 1). In Former smokers there was no significant correlation between pack years of smoking with baseline, 12 month, or change in PROs. Although there were significant negative correlations between the number of smoke-free days prior to surgery with baseline back and ODI, 12-month leg and ODI scores and improvement in ODI scores, the coefficients were small, indicating a low degree of correlation.

Discussion/Conclusion: Former smoking has detrimental effects on baseline health outcomes and the degree of their improvement.

Poster 18. Can Liposomal Bupivacaine Be Safely Utilized in Patients Undergoing Spine Surgery?

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Background/Introduction: Currently, there are many strategies utilized to control the pain level; however, most of these strategies are based on narcotics. Among these different strategies the multimodal use of liposomal bupivacaine (LB) has provided successful pain relief, the safety has never been evaluated in patients undergoing spine surgery. We attempted to report preliminary results on the side effect profile of LB in patients undergoing posterior laminectomy and instrumented spinal fusion procedures. Our secondary outcomes were to determine the readmission rates for pain (potential rebound pain phenomenon) and length of stay (LOS).

Materials/Methods: A retrospective review of posterior decompression and instrumented spinal fusion procedures from December 2015 through July 2016 in which LB was used for pain management was performed (N=33) and compared to a placebo cohort of patients who received sterile saline in similar procedures (N=21) from an ongoing prospective trial. The study cohort had a mean age of 60.8 years, equivalent to the mean age of 61.5 years in the control group (p=0.825) and the BMI was also equivalent (29.7kg/m² versus 31.1kg/m², p=0.402). Both cohorts were similar with the number of decompressed (3.30 versus 3.71; p=0.151), and number fused vertebrae (2.91 versus 2.38; p=0.053).

Results: We found no significant difference in the rates of complications between study and control groups including surgical site infections requiring antibiotics 6.1% versus 0% (OR=3.4, 95% CI of 0.2 to 74; p=0.4355), hypotension of less than 90mmHg systolic 21.2% versus 14.3%(OR=1.6, 95% CI of 0.37 to 7.1; p=0.53), or urinary retention requiring a straight catheter or replacement of Foley catheter 12.1% versus 14.3%(OR=1.3, 95% CI of 0.30 to 6.0; p=0.71), respectively. There was a significant difference between the study and control groups in regards to nausea and/or emesis: 36.4% vs 9.52%(OR=5.4, 95% CI of 1.1 to 27; p=0.041).

Discussion/Conclusion: The addition of LB for patients undergoing surgical procedures did not lead to increased rates of complication, with the exception of nausea and/or emesis. While

the increased rate of nausea and/or emesis was significant, further higher powered studies will be necessary to make more definitive conclusions on this significance given the large uncertainty seen in the CI.

Poster 19. A Comparison of Anterior and Posterior Lumbar Interbody Fusions—Complications, Readmissions, Discharge Dispositions and Costs

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Background/Introduction: Indications for anterior (ALIFs) vs posterior lumbar interbody fusions (PLIFs) can vary, though benefits of anterior approach surgery include full access to the anterior column and ability to place fusion devices. No large scale investigation has been conducted to understand medical complication rates, readmission rates, costs and discharge dispositions in ALIFs versus TLIF/PLIFs for lumbar degenerative disease.

Materials/Methods: The PearlDiver Database of Medicare records was utilized. A study group consisting solely of ALIF procedure patients was selected for. Similarly, a TLIF/PLIF group was selected for. Both groups were queried for comorbidities, 30 and 90-day complication and readmission rates. Additionally, discharge dispositions, and in-hospital/30-day/90-day Medicare reimbursements were determined.

Results: At both 30 and 90 days postoperatively odds of ileus, wound infection and lower extremity DVT were significantly increased in the ALIF. However, unadjusted rates and adjusted odds of transfusion or dural tear were significantly decreased in the ALIF patients. Odds of 30-day readmission were 4 times higher in ALIF patients. Additionally, 30 and 90-day total costs of care in ALIF patients were significantly increased by approximately \$4800 and \$5800 respectively, as compared to patients undergoing TLIF/PLIF.

Discussion/Conclusion: Despite higher initial routine discharge rates, readmissions and costs of postoperative care were significantly increased in ALIF procedures. It is necessary to evaluate etiology of degenerative pathology as ALIFs are successful solutions to anterior translational instability and anterior disc slippage, but may not have the best long-term outcomes and may not be cost-effective compared to a TLIF/PLIF. In light of our data, it is important to assess the risks and benefits of the varying approaches, and the necessity to access the anterior column, when deciding on surgical technique to treat lumbar degenerative pathology.

Poster 20. Postoperative Complications in Orthopaedic Spine Surgery- Is There a Difference Between Males and Females?

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Background/Introduction: Gender has previously been shown to have an impact on outcomes following surgical intervention. There is little data on the impact of gender on postoperative outcomes following spine surgery. Prior studies have utilized the National Surgical Quality Improvement Program (NSQIP) database to report outcomes of various spine surgeries. There are no studies that specifically look at the impact of gender difference across all spine procedures.

Materials/Methods: The NSQIP database was queried for patients undergoing spine surgery performed by an orthopedic surgeon from 2005-2014. Thirty-day postoperative data was analyzed to determine

the differences in outcomes and complications between genders.

Results: 41,315 patients (49.0% females) were included. Female patients were older than male patients (57.3 years vs. 56.1, $p<0.001$). Male patients were more likely to have diabetes (15.4% vs. 14.4%, $p=0.004$), require dialysis (3.8% vs. 2%, $p<0.001$), drink at least two alcoholic beverages a day (5.2% vs. 1.1%, $p<0.001$), have a history of cardiac surgery (5.6% vs. 2.1%, $p<0.001$), percutaneous coronary intervention (7.6% vs. 3.0%, $p<0.001$), and peripheral vascular disease requiring surgical intervention (1.2% vs. 0.6%, $p=0.001$). Females, however, were more likely to taking steroids for a chronic medical condition (4.3 vs. 3.0, $p<0.001$). Postoperatively, female patients were at increased risk for superficial surgical site infection (SSSI) (0.92% vs. 0.70%, $p=0.014$) and urinary tract infection (UTI) (1.96% vs. 0.89%, $p<0.001$), while males were at increased risk for pneumonia (0.92% vs. 0.71%, $p=0.018$) and unplanned intubation (0.60% vs. 0.41%, $p=0.007$). Females more frequently required transfusions (12.7% vs. 8.4%, $p<0.001$), and had longer hospital lengths of stay (LOS) (3.5 days vs. 3.0 days, $p<0.001$). This was confirmed by multivariate analysis. When controlling for preoperative comorbidities, female gender was an independent risk factor for postoperative transfusions ($p<0.001$), UTI ($p<0.001$), and SSSI ($p=0.045$).

Discussion/Conclusion: Present data finds that males and females have different preoperative co-morbidities and are at risk for different complications postoperatively (males - pneumonia, reintubation; females - UTI, SSSI, transfusions). Females had increased LOS, despite fewer preoperative comorbidities. With this knowledge, targeted preemptive strategies for males and females undergoing spine surgery can be effective in preventing postoperative complications and lead to reduced hospital LOS.

Poster 21. Operative Approaches for Lumbar Disc Herniation: A systematic review and multiple treatment meta-analysis of conventional and minimally invasive surgeries

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Background/Introduction: Since the late 1920s, many surgical procedures have been defined to operate on lumbar disc herniation, the Gold-Standard among them being open discectomy (OD) and Microdiscectomy (MD). In the last two decades, many minimally invasive procedures have been introduced such approaches have been defined which include percutaneous (PD), percutaneous endoscopic (PED) and tubular discectomy (TD).

Materials/Methods: Following the PICO approach, and PRISMA guidelines for literature search and conforming to GRADE guidelines for our outcome analyses, we identified 14 studies and performed a multiple treatment meta-analysis whereby we compared one surgical approach to 3 other approaches in the form of direct and indirect subgroup analysis.

Results: We found low-quality evidence that OD/MD is associated with significantly better post-operative disability as assessed by ODI score at Last follow-up (Mean Difference (MD) 2.61, 95% CI 0.88 to 4.35; $p=0.03$). Similarly, TD was found to be associated with significantly worse ODI scores at 1 year (MD 1.17, 95% CI 0.10 to 2.24; $p=0.03$). In terms of surgical outcomes, OD/MD was found to be associated with significantly longer duration of stay (MD 2.96, 95% CI 0.20 to 5.72; $p=0.04$) and more blood loss (MD 30.53, 95% CI 16.58 to 44.47; $p<0.00001$). In terms of complications, TD was found to be associated with significantly higher incidence of Dural tears (OR 1.72, 95% CI 0.99 to 2.97; $p=0.04$). Finally, OD/MD was found to be associated with significantly lower incidence of re-operation (OR 0.53, 95% CI 0.36 to 0.76; $p=0.0007$).

Discussion/Conclusion: OD/MD results in significantly improved post-operative disability, while TD and PED were found to be associated with shorter length of stay, less blood loss.

Poster 22. Comorbid Conditions as Predictors of Postoperative Outcome Following Lumbar Spine Surgery: a Survey of United States Orthopaedic and Neurological Surgeons

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Background/Introduction: There remains a lack of consensus among surgeons regarding the value of common comorbidities as predictors of poor postoperative outcome. The present study seeks to better characterize this discordance by eliciting surgeons' beliefs in the form of a nationally-distributed survey.

Materials/Methods: An electronic survey was distributed to 2366 orthopaedic and neurological surgeons throughout the United States. Respondents were asked to use a 5-point Likert scale to rate the value of five comorbidities in predicting poor postoperative outcome following lumbar spine surgery.

Results: 341 surgeons completed the survey (14.4%), including 254 orthopaedic surgeons and 86 neurological surgeons. Psychosocial complications and chronic narcotic use were deemed "strong" predictors of poor postoperative outcome, with mean Likert values of 4.2 and 4.1, respectively. Smoking and obesity were designated as "moderate" predictors, with mean values of 3.3 and 3.2, respectively. Diabetes was assigned a "weak" predictive value of 2.8 on the 5-point scale. Obesity was the greatest source of discrepancy between groups of responding surgeons. Orthopaedic surgeons assigned a significantly lower predictive value to obesity than neurological surgeons (3.1 vs. 3.4, $p=0.004$). Similarly, surgeons practicing in a hybrid setting deemed obesity significantly less predictive of postoperative outcome than surgeons in a private practice or academic center (2.9 vs. 3.2, $p=0.017$; 2.9 vs. 3.4, $p=0.002$). Fellowship-trained surgeons also rated obesity lower on the Likert scale than surgeons who were not fellowship-trained, although this difference did not reach significance (3.1 vs. 3.3, $p=0.074$). In addition to obesity, narcotics and diabetes generated significant disagreement among responding surgeons when stratified by level of experience. Less experienced surgeons assigned a significantly higher predictive value to narcotic use compared to their more experienced colleagues ($p=0.005$). Surgeons practicing for 10-20 years rated the predictive value of diabetes significantly lower than either their more experienced or less experienced counterparts ($p=0.023$).

Discussion/Conclusion: Surgeons showed consensus with respect to the role of smoking and psychosocial complications in predicting postoperative outcome, but opinions varied widely regarding obesity, diabetes, and narcotic use. Further studies are needed to determine whether the comorbidities with the highest Likert ratings are indeed the strongest predictors of poor postoperative outcome.

Poster 23. High Risk Subgroup Membership as a Risk Factor for Post-Operative Complications after Posterior Lumbar Fusion

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Background/Introduction: Posterior Lumbar Fusion (PLF) is a common procedure used to treat spinal deformities and degenerative disorders. It is unclear how specific subpopulations differ from the general surgical population in operative outcomes.

Materials/Methods: This is a retrospective analysis of data from the ACS-NSQIP database from 2010-2014 for patients undergoing

PLF. Demographic, comorbidity, and postoperative variables were collected on 6 subgroups: elderly (≥ 65 years), Caucasian vs. Non-Caucasian, obese (BMI ≥ 30 kg/m²), renal insufficiency, emergent, and cancer patients. Multivariate regression was utilized to determine whether subgroup membership was an independent predictor of complications.

Results: 24,202 patients met the study inclusion criteria, 42% of which were elderly, 84.2% of which were white, 48.5% of which were obese, 0.6% of which had cancer, 0.2% of which had renal insufficiency, and 0.7% of which were emergent procedures. Multivariate logistic regression (Table 1) found that the elderly subgroup was at increased risk for UTI (OR=1.99(1.57-2.51), $p<0.0001$), cardiac complications (OR=1.61(1.01-2.57), $p=0.047$), and unplanned readmission (OR=1.16(1.01-1.34), $p=0.041$). Advanced age was associated with a reduced risk for increased operative time (OR=0.84(0.783-0.896), $p<0.0001$), increased LOS (OR=0.791(0.841-0.973), $p=0.007$), and wound complications (OR=0.791(0.649-0.964), $p<0.020$). Non-Caucasian ethnicity was a predictor of increased operative time (OR=1.20(1.11-1.29), $p<0.0001$) and increased LOS (OR=1.55(1.42-1.68), $p<0.0001$). Obese patients had a greater risk of increased operative time (OR=1.27(1.20-1.35), $p<0.0001$), wound complications (OR=1.45(1.21-1.75), $p<0.0001$), renal complications (OR=2.60(1.45-4.68), $p=0.001$), reoperation (OR=1.17(1.00-1.36), $p=0.048$), and unplanned readmission (OR=1.14(1.00-1.30), $p=0.046$), as well as a reduced risk of postoperative blood transfusion (OR=0.922(0.854-0.995), $p=0.037$). Renal insufficiency was a predictor of increased LOS (OR=2.93(1.61-5.33), $p<0.0001$), renal complications (OR=4.90(1.02-23.6), $p=0.048$), blood transfusion (OR=2.22(1.22-4.05), $p=0.009$), sepsis (OR=3.51(1.18-10.5), $p=0.024$), reoperation (OR=3.07(1.35-6.99), $p=0.008$), and unplanned readmission (OR=2.53(1.17-5.45), $p=0.018$). Cancer was associated with greater risk for increased operative time (OR=1.73(1.21-2.46), $p=0.003$), increased LOS (OR=9.74(6.21-15.3), $p<0.0001$), wound complications (OR=2.18(1.07-4.43), $p=0.032$), postoperative blood transfusion (OR=2.90(2.02-4.16), $p<0.0001$), sepsis (OR=2.75(1.07-7.06), $p=0.036$), and mortality (OR=7.77(2.00-30.2), $p=0.003$). Emergent procedures associated with an increased risk of LOS (OR=3.74(2.68-5.23), $p<0.0001$), renal complications (OR=8.54(2.51-29.1), $p=0.001$), reoperation (OR=2.56(1.43-4.60), $p=0.002$), unplanned readmission (OR=2.44(1.43-4.15), $p=0.001$), and mortality (OR=5.73(1.17-28.1), $p<0.031$).

Discussion/Conclusion: This study found that advanced age, non-Caucasian ethnicity, obesity, renal insufficiency, cancer, and emergent procedures are independent predictors of postoperative morbidity and mortality following PLF. This demonstrates the importance of nested subgroup analysis within large populations for uncovering clinically relevant risks of selected patients and for identifying quality improvement goals.

Poster 24. Impact of sarcopenia on outcomes following elective lumbar fusion

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Background/Introduction: Sarcopenia, loss of skeletal muscle mass and function, has been measured by total psoas area (TPA). In other surgical specialties, significant associations were found between low TPA and increased postoperative complications.

Materials/Methods: From January 2007 to June 2011, adults undergoing elective lumbar fusion were included in a retrospective study aimed to assess the impact of TPA on their surgical outcomes. The axial series of each patient's lumbar CT scan was analyzed using 8 reference points with TPA calculated automatically, then divided by their height in meters squared. Primary endpoint was any

major complication within 30 days post-operative. Hospital length of stay (LOS) and ICU LOS were recorded. Baseline demographic characteristics were described in univariate analysis. Multivariable linear regression estimated the effect of TPA on post-operative complications, adjusting for potential confounders.

Results: Of 326 patients studied, most were female ($n=219$, 67%). Mean age: 59 (SD: 14.5). Average number of levels fused: 3.8. Median TPA/m² was 626.1 (IQR: 538.6, 769.2) mm²/m² in males and 465.9 (IQR: 392.0, 576.9) mm²/m² in females. Patients with below median TPAs were older for women ($p=0.06$), and significantly older for men ($p<0.01$). Women with low TPAs had significantly higher risk of arrhythmia ($p<0.01$). In analyses, women in the lowest TPA quartile had higher risk of overall complications ($p=0.06$). In multivariable logistic regression analysis, age was a significant predictor of complications, but TPA was not associated with complications. Hospital LOS (but not ICU LOS) was longer for women with lowest TPAs.

Discussion/Conclusion: This is one of the first studies looking at sarcopenia in spinal deformity patients. Median TPA was higher than previously reported sarcopenia thresholds, suggesting that women in the lowest TPA quartile have heightened risks for serious post-operative complications and prolonged hospital LOS. Further investigation should focus on interventions to improve postoperative outcomes.

Poster 25. The Impact of Sciatica on United States Medicare Recipients

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Background/Introduction: The Medicare Healthcare Outcomes Survey (HOS) is an annual demographic and patient outcomes survey used to monitor the performance of Medicare Advantage health plans in the U.S. The HOS consists of questions regarding baseline demographics, chronic medical conditions, and incorporates the Veterans Rand-12 (VR-12) patient-reported outcomes tool. The VR-12 is a health survey that is used to measure health related quality of life and to evaluate disease-specific impact. VR-12 outcomes are reported with two summary scores, the physical component score (PCS) and the mental component score (MCS). We analyzed the Medicare HOS data on over 1 million patients to evaluate the disease burden of sciatica on the U.S. Medicare population.

Materials/Methods: Medicare HOS data was obtained. Patients were placed into 2 categories based upon survey results: history of sciatica or no history of sciatica. Baseline demographics, chronic medical conditions, and average VR-12 scores were calculated for each group at baseline and at 2 years follow-up. All analysis was completed with significance set at $p < 0.0001$.

Results: The baseline cohort data of 1,000,952 patients yielded 250,869 (25%) patients who reported the diagnosis of sciatica. Patients with a history of sciatica tended to be younger, less educated, and with significantly more medical comorbidities. The VR-12 outcomes were significantly lower in patients with sciatica at both baseline and 2 year follow-up. PCS outcomes were approximately 8 units lower in the sciatica group at baseline and 7 units lower at 2 year follow-up. MCS outcomes were 6 units lower in the sciatica group at baseline and 5 units lower at 2 year follow-up. Validated literature on the VR-12 has shown a change as small as 1-2 units to be clinically and socially relevant.

Discussion/Conclusion: Medicare patients who report a diagnosis of sciatica have significantly more medical comorbidities and significantly lower VR-12 scores. Lower VR-12 outcomes have been shown to negatively impact health care costs, pharmacy expenditure,

and rate of healthcare utilization. This study illustrates that sciatica is a large health burden in the U.S. Medicare population. Early diagnosis and treatment of sciatica is needed to improve the health-related quality of life in this population.

Poster 26. Anemia as a Risk Factor for 30-Day Postoperative Complications Following Elective Anterior Lumbar Fusion Surgery

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Background/Introduction: Introduction: Approach related complications of anterior lumbar fusion (ALF) have been well-studied and are distinct from those of posterior approaches to the lumbar spine, and they relate to visceral or vascular injury. However, it is not clear how anemic characteristics in the patient affect adverse outcomes. The aim of this study is to elucidate the risk of mortality and serious postoperative morbidities in anemic patients undergoing ALF.

Materials/Methods: Methods: This was a retrospective analysis of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database between 2011 and 2014 for patients undergoing PLF surgery. Patients were identified by CPT code corresponding to PLF surgery. Patients with age <18 years, non-elective surgery, emergency surgery, current pneumonia, current sepsis, current pregnancy, wound class >1, or a previous operation within 30 days of the principal operation were excluded from the study. Patients were categorized as anemic if they had preoperative hematocrit <36.0 for females and <39.0 for males. Multivariate logistic regression models were employed, adjusting for patient demographic, preoperative and intraoperative variables, to determine the effect of patient anemia on 30-day postoperative complications.

Results: Results: 2,930 cases met the inclusion criteria for this study of which 406 (13.9%) displayed anemic characteristics. Univariate analysis showed the following characteristics in patients with anemia: < 65 years of age, diabetes, pulmonary, cardiac, and renal comorbidities, black, dyspnea, dependent functional status, bleeding disorders, preoperative RBC transfusion, and ASA Class $\geq$ 3. Multivariate logistic regression revealed anemia was a risk factor for increased length of stay (OR=1.64, 1.28-2.09), renal complication (OR=9.50, 1.58-57.01), and intraoperative or postoperative RBC transfusion (OR=3.29, 2.42-4.47).

Discussion/Conclusion: Conclusion: Anemia is significantly associated with a length of stay $\geq$ 5 days, postoperative renal complication, and intra or postoperative RBC transfusion. Consideration of these risk factors can help ensure appropriate evaluation and preoperative condition optimization leading to a decrease in the probability of a potentially fatal adverse outcome in patients.

Poster 27. Assessment of Demographic, Preoperative, and Intraoperative Risk Factors for Cardiac Arrest Following Elective Posterior Lumbar Fusion Surgery

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Background/Introduction: Introduction: Posterior lumbar fusion

(PLF) is indicated in a wide range of degenerative conditions. As the number of individuals undergoing PLF surgery increases every year, it is important to assess characteristics with the potential to cause adverse postoperative outcomes. This study seeks to assess demographic, preoperative, and intraoperative characteristics as risk factors for myocardial infarction following PLF surgery.

Materials/Methods: Methods: This was a retrospective analysis of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database between 2011 and 2014 for patients undergoing posterior lumbar fusion surgery. Patients were identified by CPT code corresponding to PLF surgery. Patients with age <18 years, non-elective surgery, emergency surgery, current pneumonia, current sepsis, current pregnancy, wound class >1, or a previous operation within 30 days of the principal operation were excluded from the study. Patients who suffered cardiac arrest necessitating CPR either during the surgical procedure or up to 30 days post-operation were included in the study. Multivariate logistic regression models were employed, adjusting for patient demographic, preoperative and intraoperative variables, to determine the effect of patient characteristics on cardiac arrest.

Results: Results: 22,911 cases met the inclusion criteria for this study of which 31 (0.14%) experienced cardiac arrest during or up to 30 days after undergoing PLF surgery. Multivariate logistic regression (c-statistic=0.646) revealed recent weight loss (OR=9.67, 1.18-79.42), bleeding disorder (OR=5.11, 1.51-17.25), preoperative RBC transfusion (OR=18.39, 2.21-152.75) and ASA classification $\geq$ 3 (OR=2.36, 1.07-5.19) to be predictive factors for cardiac arrest following PLF.

Discussion/Conclusion: Conclusion: ASA classification $\geq$ 3, preoperative transfusion of $\geq$ 1 unit of whole/packed RBCs, bleeding disorders, and weight loss of >10% of body weight within 6 months were associated with cardiac arrest during surgery or during the 30 days following a PLF procedure. Consideration of these risk factors can help ensure appropriate evaluation and preoperative condition optimization leading to a decrease in the probability of a potentially fatal adverse outcome in patients.

Poster 28. Metabolic Syndrome is Associated with Increased Wound Complications and Urinary Tract Infections after Lumbar Fusion: a Propensity Score-Matched Analysis

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Background/Introduction: Metabolic syndrome (MetS) is a distinct state of metabolic dysfunction, generally agreed on as a combination of visceral obesity, insulin resistance, hypertension, and hyperlipidemia. The syndrome is increasingly prevalent in patients undergoing spinal fusion. Understanding its independent effect on perioperative outcomes will optimize preoperative risk stratification and reduction in this high-risk cohort of patients. The purpose of this study is to quantify the independent effect of metabolic syndrome on rates of complications, readmissions, and prolonged length of stay (LOS) after elective lumbar spine fusion.

Materials/Methods: One- to three-level posterior spinal fusion cases were identified from the 2011-2014 ACS-NSQIP. To eliminate baseline differences between patients with and without metabolic syndrome, propensity scores based on demographics, comorbidities, presence of interbody fusion, number of levels, and diagnosis were used to match patients with and without metabolic syndrome in a 1:1 ratio. Outcomes of interest were compared between the cohorts. Logistic regression with propensity score adjustment was further utilized as a secondary method of reducing selection bias.

Results: Out of 18,605 patients that met criteria for inclusion, 1903 (10.2%) met our definition of metabolic syndrome. After matching, patients with MetS had a higher rate of wound complications (3.7% vs. 2.6%, $p=0.035$), urinary tract infections (3.1% vs. 1.7%, $p=0.004$),

and extended LOS (29.1% vs. 23.5%, $p < 0.001$). Logistic regression confirmed that patients with MetS were almost twice as likely to experience a UTI (O.R. 1.91, 95% C.I. 1.24-2.96) and one-and-a-half times as likely to experience a wound complication (O.R. 1.47, 95% C.I. 1.02-2.12). Rates of any medical complication and readmission were comparable between the two cohorts.

Discussion/Conclusion: Patients with metabolic syndrome who are considering elective spine surgery should be aware of a higher risk for wound complication, UTI, and long length of stay. Clinicians may want to consider medical optimization prior to elective surgery.

Poster 29. Safety and Outcomes Following Anterior versus Posterior Lumbar Interbody Fusion Procedures

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Background/Introduction: Controversy exists over the ability of various lumbar interbody fusion techniques to realign global and regional balance, as well as affect patient outcomes.

Materials/Methods: Our retrospective cohort utilizing the NSQIP database included 2372 (29.9%) single-level anterior/lateral interbody fusions and 5563 (70.1%) single-level posterior/transforaminal interbody fusions between 2013 and 2014. Emergent cases, fracture cases, and preoperative compromised wounds were not included in the analysis. Primary thirty-day outcomes included mortality, return to operating room, readmission, length of stay, and other major complications. Minor outcomes included urinary tract infection, superficial incisional site infection, and perioperative blood transfusion within 72 hours.

Results: Anterior/lateral fusion techniques were performed more often in patients with degenerative lumbar disc disease (31.0% vs. 13.9%, $p < 0.001$), whereas posterior techniques were utilized more for patients with spondylolisthesis (19.1% vs 24.4%, $p < 0.001$). Length of hospital stay and mean operation time were significantly longer statistically in the posterior group (3.6+ 4.3 days vs. 3.4 + 4.2 days, $p < 0.05$) and (200.2+ 94.4 minutes vs. 192.0 + 112.8 minutes, $p = 0.001$) though these differences are clinically insignificant. Thirty-day mortality was significantly higher for the anterior group (0.3% vs. 0.1%, $p = 0.021$). Significantly more patients in the posterior group required blood transfusions within 72 hours of surgery (9.6% vs. 7.6%, $p = 0.005$). Elevated American Society of Anesthesiologists (ASA) physical status classification, increased age > 60 , prior bleeding disorder, and preoperative anemia were significantly associated with the need for blood transfusion.

Discussion/Conclusion: Although numerous techniques can be utilized in the treatment approach to various lumbar pathologies, anterior approaches have an increased risk of early mortality. Transfusion risk is more strongly associated with elevated ASA class, increased age, preoperative anemia, and patients with bleeding disorders.

Poster 30. Association between Allogeneic Blood Transfusion and Postoperative Infection in Major Spine Surgery

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Background/Introduction: Postoperative infections increase

morbidity and mortality rates in spine surgery and generate additional costs for the healthcare system. It has been proposed that blood transfusions increase the risk of wound infection, urinary tract infection, pneumonia, and sepsis. The aim of this study was to determine the incidence of infection in patients who received blood transfusions in major deformity surgery involving at least eight levels, hypothesizing that transfusions are a risk factor for postoperative infection.

Materials/Methods: A retrospective cohort study conducted from 2012 to 2015 identified 56 patients meeting the study criteria who had received spine surgery involving the fusion of eight levels or more. Patient-specific characteristics, starting and ending hematocrits, number of units transfused, use of vancomycin powder, drain usage, and infections including urinary tract infection, wound infection, pneumonia, *Clostridium difficile*, and sepsis were documented. Differences in infection risk between those who did and did not undergo a transfusion and their 95% confidence intervals were calculated.

Results: Groups were similar with respect to baseline and surgical characteristics except for smoking status, operative time, estimated blood loss, and ending hematocrit. The overall infection rate was greater in patients who underwent transfusion than those who did not (36% versus 10%; $p = 0.03$). Wound infections ($n = 5$) were only observed in those who underwent a transfusion. Smokers were more likely to receive a transfusion and were also more likely to experience infection. A stratified analysis demonstrated an increased risk of infection associated with transfusion; however, the risk was greater in smokers, suggesting the effect of transfusion on infection could be modified by smoking. Patients undergoing transfusion experienced a significantly longer hospital stay ($p = 0.01$).

Discussion/Conclusion: Allogeneic red blood cell transfusion in major spine surgery could be a risk factor for postoperative infection. This increased risk seems to be magnified in those who smoke. Further studies are warranted, and risks of blood loss and transfusion-related complications in smokers also potentially merit exploration.

Poster 31. Predictors of Complications and Readmission following Spinal Stereotactic Radiosurgery

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Background/Introduction: Stereotactic radiosurgery (SRS) is increasingly used for treatment of spinal tumor. It is currently unclear what baseline demographic factors predict post-treatment outcomes. The objective of the present study was to identify preoperative factors associated with major morbidity, mortality, increase hospital length of stay (LOS), 30 day readmission and operation rates following SRS for spinal tumors.

Materials/Methods: The American College of Surgeons National Quality Improvement Program (NSQIP) was queried from 2012 to 2014 to identify all adult patients that underwent SRS for spinal tumors. Univariate analysis was used to identify potential predictive variables, multiple imputation was performed to account for missing data. Multivariable logistic regression was used to identify independent statistically significant predictors of post-treatment outcomes.

Results: 2714 patients were identified that met inclusion criteria. 184 patients (6.8%) had "major morbidity or mortality," 193 (7.1%) had a major morbidity, 186 (6.9%) were readmitted within 30 days, and 116 (4.3%) had a subsequent operation within 30 days. Age, BMI, and ASA class were predictive of LOS. Major morbidity was predicted by age greater than 80, BMI > 35 , high ASA class,

as well as pre-treatment functional dependence and other baseline comorbidities. Predictors of operation within 30 days included preoperative steroid use, renal failure, BMI>35, and if the treatment was non-elective.

Discussion/Conclusion: The data herein demonstrate that 4-7% of patients undergoing SRS for spinal tumors have morbidity following the procedure. A large percentage of this is likely attributable to baseline patient characteristics and severity of their oncologic disease. Factors that are independently predictive of morbidity, increased length of stay, and subsequent operation included age, BMI, and baseline comorbidities and functional status. Identification of preoperative patient-specific factors that are predictive of post-treatment outcome will aid in patient selection and patient counseling leading to greater patient satisfaction and hospital efficiency.

Poster 32. Evaluating the Effect of Growing Patient Numbers and Changing Data Elements in the National Surgical Quality Improvement Program (NSQIP) Database Over the Years: A Study of Lumbar Fusions

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Background/Introduction: The use of national databases in spinal surgery outcomes research is increasing. However, there has been limited study evaluating the effect that the addition of patients and evolving data elements in databases such as the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) may have on the results of outcomes studies. A number of variables collected by NSQIP changed between 2010 and 2011, coinciding with a rapid increase in the number of patients included per year. The current study aimed to investigate the effects of these changes on results of lumbar fusion studies.

Materials/Methods: The NSQIP database was retrospectively queried to identify 19,755 patients who underwent elective posterior lumbar fusion surgery +/- interbody fusion between 2005 and 2014. These patients were split into two groups based on year of surgery: 2,802 from 2005-2010 and 16,953 from 2011-2014. Preoperative characteristics and perioperative outcomes were compared between the era groups using bivariate analysis. As an example evaluation of the effect of such changing data elements, the association between age and postoperative outcomes in the two era groups was analyzed using multivariate Poisson regression.

Results: There were significant differences between the era groups for preoperative factors such as age, smoking status, alcohol use, ASA class, BMI, rates of cardiac and neurological comorbidity, and functional status. Postoperative events such as blood transfusion and deep vein thrombosis were also significantly different between the era groups. For the 2005-2010 cohort, age was significantly associated with septic shock by multivariate analysis. However, for the 2011-2014 cohort, age was significantly associated with septic shock, urinary tract infection, blood transfusion, myocardial infarction, and extended length of stay.

Discussion/Conclusion: The NSQIP database has undergone substantial changes between 2005 and 2014. Preoperative characteristics and perioperative outcomes have changed between older years (2005-2010) and newer years (2011-2014). These changes may contribute to different results in analyses such as the association between age and postoperative outcomes when using older versus newer data. Moving forward, it may be appropriate to limit NSQIP studies to later years.

Poster 33. Total Disc Arthroplasty and Anterior Interbody Fusion in the Lumbar Spine Have Relatively Similar Short-Term Outcomes

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Background/Introduction: Lumbar total disc arthroplasty (TDA) and anterior lumbar interbody fusion (ALIF) may be considered for similar degenerative indications. However, there have been few large-cohort comparison studies of short-term clinical outcomes for the two procedures. This study aimed to investigate the short-term general-health outcomes of TDA and ALIF in the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database.

Materials/Methods: The NSQIP database was retrospectively queried to identify 1,801 patients who underwent elective stand-alone ALIF and 255 cases of elective TDA between 2011-2015. TDA and ALIF cases were matched for nine preoperative characteristics using propensity scores, resulting in 255 pairs. The association of procedure type with adverse events was determined for the matched cohorts using McNemar's test. Operative time and postoperative length of stay were compared between procedures using bivariate and multivariate linear regression. Risk factors for adverse events in both procedures were determined using multivariate Poisson regression.

Results: There were no significant differences in the rates of any adverse event, serious adverse events or individual adverse events between the matched TDA and ALIF cohorts other than blood transfusion, which occurred more frequently in the ALIF cohort (3.92% versus 0.39%, $p = 0.007$). Operative time was not significantly different between the two cohorts, but postoperative length of stay was statistically significantly longer for ALIF cases (+0.28 days, $p < 0.001$). When evaluating ten preoperative variables as potential risk factors for any, serious, and minor adverse events after TDA and ALIF, the majority of predictors of adverse outcomes were similar.

Discussion/Conclusion: The only differences in perioperative outcomes between TDA and ALIF were a 3.53% higher incidence of blood transfusion and 0.28-day longer length of stay for the ALIF group. These results suggest that overall short-term general-health outcomes between the two groups were similar, and that the choice between two procedures for the appropriately selected patient should be based on longer-term functional outcomes.

Poster 34. Trends in Resource Utilization for Vertebral Fracture Repair Surgeries in the United States from 2006-2014

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Background/Introduction: The primary hypothesis of this study is that the annual volume of surgeries performed for vertebral fractures (VFX) has increased over the past nine year of the study period. Surgical trends over time for VFX operations as well as other economic outcomes provide valuable information for both surgeons and health policy makers. VFX surgeries and associated economic outcomes were analyzed throughout the United States from 2006-2014.

Materials/Methods: Patient data from the National Inpatient Survey (NIS) database for operative treatment of VFX from 2006-

2014 were included in this study. Demographic and economic patient data were determined for the procedure based ICD-9 CM code 03.53, which includes all forms of operative treatment of vertebral fractures except kyphoplasty and vertebroplasty. Outcomes included annual totals, hospital costs and charges, length of stay (LOS), and rate of routine discharge.

Results: An estimated 40,877 VFX repair surgeries were performed in the United States from 2006-2014. The number of procedures per year increased 76% during the course of the study period with a mean of 4,542 surgeries per year (range: 3,085-6,085). Mean LOS decreased 30% over the same period with an yearly LOS mean of 12.0 days per patient (range: 9.3-13.9 days). The mean percentage of patients with routine discharge was 39% (range: 34-46%). The mortality rate of operative intervention for VFX was 2.5% (range: 1.9-3.3%). The cost of VFX repairs peaked in 2012 at \$52,884, and increased 5.2% overall (mean: \$47,235; range: \$42,104-\$52,884). Charges have increased more rapidly with a 50.3% increase over the study period (mean: \$163,147; range: \$116,507-\$188,897).

Discussion/Conclusion: Operative management of vertebral fractures has increased by 76% in the United States from 2006-2014 to 6,085 surgeries per year in 2014. The exact cause of this increase is unclear but may be associated with increasing rates of osteoporosis in the aging population. LOS has decreased by 30% over the same time period, and yet both costs and charges have increased. On average 61% of patients were either discharged to a skilled nursing facilities or had home nursing, which represents a significant economic burden. Finally, inpatient mortality has remained relatively constant at 2.5% of all procedures.

Poster 35. Age as a Risk Factor for 30-Day Postoperative Complications Following Anterior Lumbar Fusion

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Background/Introduction: Surgical treatment and spinal fusion surgery is indicated for lumbar spinal diseases commonly observed in elderly patients. It is not clear whether rates of postoperative complications for anterior lumbar fusion (ALF) differ with age. Considering the steadily aging population, this study aims to elucidate if risk of mortality and other serious postoperative complications are associated with age.

Materials/Methods: This study analyzed data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database between 2011 and 2014 for patients undergoing ALF. Patients were included based on ALF specific diagnosis codes. Patients with age <18 years, non-elective surgery, emergency surgery, current pneumonia, current sepsis, current pregnancy, wound class >1 or a previous operation within 30 days of the principal operation were excluded from the study. Patients were categorically divided into four subgroups of age. Univariate and multivariate logistic regression models were employed to determine the effect of age on postoperative complications.

Results: A total of 3,184 patients met the inclusion criteria for the study. Age ranged from 19 years to 90 years old. The first age subgroup consisted of patients less than or equal to 45 years old, the second between 46 and 52 years, a third group consisted of those between 53 and 60 years, and finally, a group of patients 61 years old and over. Age Group 1, 2, 3 and 4 contained 905 (28.4%), 572 (17.9%), 614 (19.3%) and 1,093 (34.3%) patients respectively. Multivariate logistic regression revealed the groupings of age to be independent risk factors for increased length of stay in Group 3 (OR=1.95, 1.46-2.60) and Group 4 (OR=2.95, 2.28-3.82) relative to Group 1, transfusion Group 2 vs. Group 1 (OR=1.73, 1.06-2.83 p-value=0.028), and unplanned readmission in Group 2 vs. Group 1 (OR=2.31, 1.19-4.48, p-value=0.014) as well as Group 4 vs. Group 1

(OR=2.46, 1.32-4.56, p-value=0.004) (Table 1). All p-values <0.0001 unless otherwise noted.

Discussion/Conclusion: Age is significantly and independently associated with a variety of adverse postoperative outcomes including increased length of stay, transfusion, and unplanned readmission for patients undergoing ALF procedures. Providers should counsel elderly patients accordingly to mitigate age related risks of postoperative complications.

Poster 36. Differences in reported experience with hospital care in patients undergoing cranial and spinal operations

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Background/Introduction: Patient-centered outcomes have been increasingly mandated by the Centers for Medicare and Medicaid Services in order to evaluate hospital and physician performance and affect hospital reimbursement. The aim of this study was to investigate the differences in patient-reported experience of hospital care for a cranial or spinal operation in a single institution.

Materials/Methods: We sampled all patients who underwent inpatient, elective cranial and spinal procedures and completed the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey at a single institution between October 2012 and September 2015. Univariate analysis was employed to assess the association of the surgical procedure and diagnosis with various HCAHPS composite measures calculated across nine domains using standard top-box methodology.

Results: A total of 1484 patients met criteria and returned an HCAHPS survey. Overall, patients undergoing a cranial procedure gave top-box scores less often in Discharge Information (87.1% vs 93.1%, p-value < 0.001) but more often in Pain Management (66.3% vs 59.6%, p-value = 0.012) and Global, ie overall hospital rating and recommendation (88.7% vs 84.2%, p-value = 0.013) measures compared to those receiving a spinal operation. Moreover, patients with a primary diagnosis of brain or spinal tumor compared to those with degenerative spinal disease and those with other neurosurgical diagnoses, such as aneurysmal, normal pressure hydrocephalus and movement disorders, provided top-box scores more often regarding Communication with Doctors (82.7% vs 76.4% vs 75.2%, p-value = 0.039), Pain Management (71.8% vs 60.9% vs 59.1%, p-value = 0.002) and Global Rating (90.4% vs 84.0% vs 87.3%, p-value = 0.018).

Discussion/Conclusion: Significant differences in patient-reported experience of hospital care exist between the different cranial and spine surgery groups. Identifying weaker areas of hospital performance in target populations can stimulate quality initiatives that aim to increase the overall hospital score.

Poster 37. The Decussating Fibers of the Lumbar Thoracolumbar Fascia: A Landmark for Identifying the L5 Spinous Process?

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Background/Introduction: The thoracolumbar fascia has been well studied and is known to have crisscrossing fibers. Based on surgical experience, we hypothesized that the decussating fibers of this fascia might indicate a specific vertebral level. Therefore, the current anatomical study was performed.

Materials/Methods: Twenty adult fresh frozen cadavers, ages 72-84 years old at death, were placed in the prone position and the skin of the lumbar and upper sacrum was removed. Careful attention was given to the thoracolumbar fascia and any fibers of it that grossly crossed the midline to interdigitate with its contralateral counterpart. Once such decussations were identified, a metal wire was laid on them at their center and fluoroscopy performed to verify the vertebral level.

Results: Decussating fibers of the thoracolumbar fascia were found on all (95%) but one specimen. Of these, the central part of the decussation on the midline corresponded to the spinous process of L5 in 89% and the lower edge of the spinous process of L4 in the remaining two specimens (11%). No specimen was found to have had previous surgery in the area dissected or congenital anomalies of the spine such as a translational vertebra.

Discussion/Conclusion: Based on our cadaveric study, the decussating fibers of the thoracolumbar fascia in the lumbar region can help predict most often the L5 spinous process and less often, the spinous process of L4. This finding might be used as an adjunct to palpation and intraoperative imaging during surgical exploration of the lower lumbar region.

Poster 38. Predictors of Major Complications Following Anterior Lumbar Fusion

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Background/Introduction: Introduction: Anterior lumbar fusion (ALF) procedures are indicated in adult degenerative lumbar disorders and spondylolisthesis. This study seeks to identify the predictors of major complications following ALF.

Materials/Methods: Methods: This was a retrospective analysis of American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database between 2011 and 2014 for patients undergoing ALF. Patients with age <18 years, non-elective surgery, emergency surgery, current pneumonia, current sepsis, current pregnancy, wound class >1 or a previous operation within 30 days of the principal operation were excluded from the study. Two cohorts were created of patients who experienced 1 or more major complication and those that did not. Major complications included wound, pulmonary, cardiac and renal complications, venous thromboembolism, urinary tract infections, intra/postoperative transfusions, length of stays $\geq$ 5 days, reoperation, unplanned readmission and mortality. Multivariate logistic regression models were employed, adjusting for patient demographics, preoperative and intraoperative variables, to identify predictive factors for major complications.

Results: Results: 3,138 ALF patients met the inclusion criteria for the study and 32.5% of patients experienced one or more major complication. MVR (c-statistic=0.742) revealed total RVU (OR= 1.01, 1.01-1.02), male sex (OR=0.63, 0.53-0.74), white race (OR=0.61, 0.45-0.83, p-value=0.0017), age $\geq$ 65 years (OR=2.18, 1.80-2.64), independent functional status (OR=0.35, 0.19-0.65), cardiac comorbidity (OR=1.41, 1.18-1.69), preoperative transfusion (OR=20.92, 2.36- 185.24), operation time $\geq$ 4 hours (OR=3.12, 2.57-3.77) and ASA class $\geq$ 3 (OR=1.80, 1.50-2.14) were predictive factors for major complications following ALF. P-values are <0.001 unless noted otherwise.

Discussion/Conclusion: Conclusion: There are many clinically relevant predictive factors for major complications following elective ALF. Predictors for major complications include total RVU, sex, race, age, dependent functional status, cardiac comorbidity, preoperative transfusion, operation time and ASA class.

Poster 39. Correlation Between the Modic Changes and Facet Osteoarthritis in Lumbar Spine

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Background/Introduction: Modic changes (MCs) are detected on the MRI as bone marrow change within the vertebral body and endplate. Most of the studies in lumbar spine focused on the relationship between MCs and low back pain, but not with facet osteoarthritis. The aim of this study was to identify the correlation between Modic changes and facet osteoarthritis in lumbar spine using kinetic lumbar MRI images.

Materials/Methods: 425 patients who underwent kinetic lumbar MRI were reviewed. Total of 2,250 lumbar spinal segments in neutral position were evaluated for MCs, disc degeneration grading, and facet osteoarthritis. The chi-square test, Mann-Whitney U test, Pearson's correlation and linear regression were used to test for statistical significant difference between parameters.

Results: Modic changes were detected in 105 patients (24.7%). One-hundred fifty-seven (7.4%) lumbar segments from 2125 segments had MCs. Seventy-nine MCs were present at L5-S1, 44 at L4-5, 23 at L3-4, 7 at L2-3, and 4 at L1-2. Type 2 MCS was the most common (66.24%, n = 104 segments) followed by type 1 (24.2%, n = 38 segments). The presence of MCs was significantly correlated with advanced disc degeneration (grade 4-5, Odds ratio 6.29, 95% CI 4.48-8.83) and the presence of facet osteoarthritis (Odds ratio 9.50, 95% CI 6.18-14.62). The facet osteoarthritis grade was positively correlate with disc degeneration grade (r = 0.309, p-value < 0.001).

Discussion/Conclusion: Severe disc degeneration and the presence of facet osteoarthritis were significantly linked to the presence of MCs. The severity of facet osteoarthritis was correlated with the advanced disc degeneration grading but not with the presence of MCs. Presence of facet osteoarthritis is one of the important pathologies for evaluation of MCs.

Poster 40. Continued Inpatient Care After Posterior Lumbar Fusion Is Associated With Increased Post-Discharge Complications: A Propensity-Adjusted Analysis

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Background/Introduction: As bundled payment models become increasing prevalent in orthopaedics, hospitals will be required to consider post-discharge care and clinical outcomes after posterior lumbar fusion. There may be significant variations in post-discharge outcomes depending on discharge destination, either to an inpatient facility (i.e. subacute or acute rehabilitation) or home. The purpose of this study was to examine the 30-day post-discharge outcomes after lumbar fusion with regards to patient discharge destination following their acute hospital stay.

Materials/Methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried for all 1- to 3-level primary posterior lumbar fusion cases from 2011 to 2014. Multivariable propensity-adjusted logistic regressions were performed to determine associations between discharge destination and post-discharge complications, with adjusted odds ratios (OR) and 95% confidence intervals (CI). To account for selection bias in discharge destination, propensity scores were determined based on observable patient characteristics. For this study, the propensity score

was defined as the conditional probability of being discharged to an inpatient facility based on demographics, obesity class, modified Charlson Comorbidity Index (CCI), baseline functional status, American Society of Anesthesiologists (ASA) class, number of levels fused, and the occurrence of any pre-discharge complications.

Results: A total of 18,652 posterior lumbar fusion cases were identified, 15,234 were discharged home, and 3,418 were discharged to continued inpatient care. Multivariable propensity-adjusted logistic regressions showed that being discharged to continued inpatient care was independently associated with higher risk of any post-discharge complication (OR 1.24, 95% CI 1.06-1.46), deep vein thrombosis and/or pulmonary embolism (OR 1.79, 95% CI 1.13-2.85), and urinary complications (OR 1.79, 95% CI 1.27-2.51). Discharge destination was not significantly associated with wound complications, other systemic complications, readmission, or death (Table 1).

Discussion/Conclusion: Discharge to continued inpatient care versus home after primary posterior lumbar fusion is independently associated with higher odds of post-discharge complications. To optimize clinical outcomes as well as cost savings in an era of bundled payments, clinicians and hospitals should consider devoting resources toward facilitating home discharge after surgery whenever possible.

RF Paper 01. The Effectiveness of Bioskills Module for Simulated Lumbar Pedicle Screw Instrumentation

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Background/Introduction: To develop an inexpensive, user-friendly, and reproducible lumbar pedicle screw instrumentation bioskills training module and evaluation protocol that can be readily implemented into residency training programs to augment the clinical education of orthopaedic and neurosurgical physicians-in-training.

Materials/Methods: 19 participants comprised of senior medical students and orthopaedic surgical residents. Participants were randomized to control (n=9) or intervention (n=10) groups controlling for level of experience (medical students, junior resident, or senior resident). The intervention group underwent a 20-minute bioskills training module while the control group spent the same time with self-directed study. Pre- and post-test performance was self-reported by each participant (Physician Performance Diagnostic inventory scale, PPDIS). Total number of pedicle breaches were calculated pre- and post-test. Objective outcome scores were obtained from a blinded fellowship-trained attending orthopaedic spine surgeon using Objective Structured Assessment of Technical Skills (OSATS) and Objective Pedicle Instrumentation Score metrics. In addition, identification of pedicle breach and breach anatomic location was measured pre- and post-test in lumbar spine models.

Results: When compared to the control group, the intervention group had fewer breaches on post-test pedicle instrumentation (p=0.013). While the improvement in OSATS (p = 0.247) was not significant, there was mean improvement in PPDIS (p=.033475) scores in the intervention group. There was no statistically significant improvement in identification of pedicle breach or anatomic location of breach in both the control and experimental groups.

Discussion/Conclusion: We conclude that a concise lumbar pedicle screw instrumentation bioskills training session can be a useful educational tool to augment clinical education. Although no direct clinical correlation can be concluded from this study, the improvement in trainee's technical and procedural skills suggests that

Sawbones training modules can be an efficient and effective tool for teaching fundamental spine surgical skills outside of the operating room.

RF Paper 02. Resident Involvement as a Risk Factor in Anterior Lumbar Fusion Outcomes

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Background/Introduction: Introduction: Anterior lumbar fusion (ALF) procedures are indicated in adult degenerative lumbar disorders and spondylolisthesis. Residents simultaneously serve as both doctor and student. This study seeks to characterize resident involvement as a risk factor for 30-day postoperative outcomes following elective anterior lumbar fusions.

Materials/Methods: Methods: This was a retrospective analysis of American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database between 2011 and 2014 for patients undergoing ALF. Patients with age <18 years, non-elective surgery, emergency surgery, current pneumonia, current sepsis, current pregnancy, wound class >1 or a previous operation within 30 days of the principal operation were excluded from the study. Two cohorts were created of patients whose surgeries were performed only by an attending and those who were performed by an attending and a resident. Multivariate logistic regression models were employed, adjusting for patient demographics, preoperative and intraoperative variables, to identify outcomes impacted by resident involvement.

Results: Results: 340 ALF patients met the inclusion criteria for the study and 71.8 % of patients underwent surgeries performed solely by an attending. Multivariate logistic revealed the absence of a resident to be a predictor for decreased incidence of any major complication (OR=0.40, 0.23-0.70, p-value=0.0013, c-statistic=0.768), decreased incidences of length of stays ≥ 5 days (OR=0.29, 0.16-0.50, c-statistic=0.698), and decreased incidence of intra/postoperative transfusion (OR=0.24, 0.11-0.51, p-value=0.0002, c-statistic=0.822). Major complications are defined as wound, pulmonary, cardiac and renal complications, venous thromboembolism, urinary tract infections, intra/postoperative transfusions, length of stays ≥ 5 days, reoperation, unplanned readmission and mortality. P-values are <0.001 unless noted otherwise.

Discussion/Conclusion: Conclusion: The presence of a resident is a predictor for postoperative complications including length of stays longer than 5 days and intra/postoperative transfusions in ALF patients.

RF Paper 03. Assessing Online Patient Education Readability for Spine Surgery Procedures

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Background/Introduction: Increased patient reliance on Internet-based health information has amplified the need for comprehensible online patient education articles. As suggested by the American Medical Association (AMA) and National Institute of Health (NIH), spine fusion articles should be between a 4th and 6th grade readability level to increase patient comprehension, which may contribute to improved postoperative outcomes. The purpose of this study is to determine the average readability level of online healthcare education information relating to lumbar fusion and anterior cervical discectomy and fusion (ACDF) procedures.

Materials/Methods: Three popular search engines were utilized to access patient education articles for common cervical and lumbar spine procedures. Relevant articles were analyzed for readability using Readability Studio Professional Edition software (Oleander Software, Ltd). Articles were stratified by organization type as follows: General Medical Websites (GMW), Healthcare Network/Academic Institutions (HNAI), and Private Practices (PP). Thirteen common readability tests were performed with the mean grade level for each readability test compared between subgroups using analysis of variance (ANOVA) testing.

Results: Lumbar fusion and ACDF articles were determined to have a mean readability level of 11.3 ± 1.6 and 10.7 ± 1.5 , respectively. GMW, HNAI, and PP subgroups had mean readability levels of 10.9 ± 3.0 , 10.8 ± 2.9 , and 11.6 ± 2.7 for lumbar fusion and 10.9 ± 2.9 , 10.7 ± 2.8 , and 10.7 ± 2.5 for ACDF articles. Of 310 total articles, only 6 (3 lumbar fusion and 3 ACDF) were written below the 7th grade reading level.

Discussion/Conclusion: Current online literature from medical websites containing information regarding lumbar fusion and ACDF procedures are written at a grade level higher than the suggested guidelines. Therefore, current patient education articles should be revised to accommodate the average readability level in the United States and may result in improved patient comprehension and postoperative outcomes.

RF Paper 04. Is Physical Therapy Helpful After Lumbar Spine Surgery? A Multivariate Analysis of 1130 Patients

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Background/Introduction: There is conflicting evidence in the literature as to whether PT is helpful in patients recovering from lumbar spine surgery. There is no existing treatment algorithm to guide surgeons as to which patients should be referred for PT, when therapy should begin, and how long patients should undergo therapy.

Materials/Methods: 1130 patients who underwent PT following lumbar spine surgery were included. Pre- and post-PT scores on Oswestry Disability Index (ODI), activity Numeric Pain Rating Scale (NPRS) and resting NPRS were recorded. Logistic regression was used to identify risk factors associated with failure to reach the minimal clinical important difference (MCID). For each timepoint, patients referred to PT were compared to those who had not yet undergone PT to correct for the natural improvement in clinical outcome scores following surgery.

Results: The percentage of patients meeting the MCID for improvement following PT in ODI, activity NPRS, and resting NPRS was 32.1%, 55.0%, and 53.8% respectively. Workers' compensation status and the presence of nighttime symptoms were found to be associated with increased odds of failure to meet MCID for improvement for all three clinical outcomes. A non-significant trend was seen towards improved final outcomes in patients who began therapy in the first 20 days after surgery. When analyzing patients who finished at the same timepoint, an increased number of PT visits was associated with improved clinical outcomes.

Discussion/Conclusion: We conclude that in appropriately selected patients following lumbar spine surgery, post-operative PT is associated with improved clinical outcomes.

RF Paper 05. What Are the Differences in Medicare DRG Reimbursement for MIS Deformity Surgery in Academic vs Private Hospitals in Different Geographic Regions?

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Background/Introduction: While physicians are reimbursed based on CPT coding, hospitals are reimbursed based on Diagnosis Related Group (DRG) codes. This coding does not differentiate between number of levels fused but is impacted by approach (ant/post v ant or post only). The aim of this study is to investigate the impact of both geographic location and practice setting on reimbursement.

Materials/Methods: DRG based reimbursement for anterior, posterior and circumferential 1 or more level fusions for deformity at 12 institutions was collected. The reimbursement data was then categorized into academic (AC) vs private (PV) and urban (UR) vs suburban (SU) hospitals. The DRG was selected based off of coding for a deformity surgery.

Results: There were 3 PV and 9 AC practices' data available for review. AC reimbursement was \$45,353 while PV was \$29,585 (p=0.019). If significant CC were present AC received \$59,541 and \$39,281 for PV (p=0.022). With a major complication (MCC) reimbursement increased to \$78,188 AC and \$52,014 PV (p=0.024). There were 8 UR and 4 RU sites identified. In the UR setting, reimbursement was \$44,270 and \$35,672 (p=0.21) for RU. With CC the UR sites received \$58,182 and RU \$47,063 (p=0.21). With a MCC, UR received \$76,455 and UR \$62,024 (p=0.22). When comparing AC-UR (n=7) to PV-RU (n=2) the cost is 62% higher (\$28,530 vs \$46,066). When comparing a 3 vs 8 day stay no significant changes in reimbursement occurred. A hospital stay of 8 days vs 3 days increased reimbursement by \$355/day for AC and \$61/day for PV.

Discussion/Conclusion: Medicare DRG based reimbursement was highest for urban academic institutions. Private suburban hospitals must be more efficient to offset this reimbursement inequity. The number of levels fused and the length of hospital stay has minimal impact on DRG based reimbursement regardless of costs.

RF Paper 06. Prevalence of Pre-Operative Lower Urinary Tract Symptoms Among Patients Undergoing Elective Lumbar Spine Surgery

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Background/Introduction: Lower urinary tract symptoms (LUTS) are common in the adult population. Prevalence of LUTS is greater among adults with back pain compared to the adult population. However, LUTS prevalence and risk factors among patients undergoing elective lumbar spine surgery is unknown.

Materials/Methods: In this study, we used a validated questionnaire, the International Prostate Symptom Score (IPSS), to determine LUTS severity among elective lumbar spine surgery patients from 9/2015 to 9/2016 at Oregon Health and Science University. Data collected included IPSS scores and pre-operative clinic notes. Prevalence of moderate/severe LUTS, defined as IPSS

score 8-35 points. The 95% confidence intervals (CI) for LUTS prevalence were estimated using the normal approximation method for binomial parameters in Microsoft Excel. We compared LUTS prevalence in the study sample to prevalence estimates in the general population from the Boston Area Community Health Survey (BACH).

Results: Survey data was obtained from 81% of eligible patients. The sample included 259 patients (123 men, 136 women). No patients in the sample had cauda equina syndrome. Of these, 50% (95% CI: 42%, 58%) of women and 39% (95% CI: 30%, 48%) of men had moderate/severe LUTS. These prevalence estimates substantially exceed those of 19% of women and 19% of men observed in the BACH survey. The BACH survey included subjects ages 30-79 years. Therefore we repeated the analyses after restricting our sample to ages 30-79 years. The prevalence estimates of moderate/severe LUTS were essentially unchanged at 50% of women and 40% of men. The prevalence of moderate/severe LUTS was highest (56%) for patients with spondylolisthesis, in the middle (51%) for patients with stenosis, and lowest (34%) for patients with herniated nucleus pulposus.

Discussion/Conclusion: Although none of the patients had cauda equina syndrome, moderate/severe LUTS were highly prevalent in this population. In this sample of patients there is evidence to suggest that age, sex and diagnosis may influence these symptoms. Further analysis looking at medication use, psychological distress, quantification of sacral root compression, and eventually the ability to provide relief from these symptoms will augment this study's findings.

RF Paper 07. Risk of Surgical Site Infection and Mortality Following Lumbar Fusion Surgery in patients with Chronic Steroid Usage and Chronic Methicillin Resistant Staphylococcus Aureus (MRSA) infection

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Background/Introduction: Systemic immunosuppression by chronic steroid use and chronic MRSA infection carriers may pose an increased risk of SSI. Their association with SSI and mortality in posterior lumbar fusion surgery has not been studied in detail. Our study sought to determine the effects of chronic steroid use and chronic MRSA infection on rates of SSI and mortality in patients 65 years of age and older who were treated with posterior lumbar spine fusion.

Materials/Methods: A retrospective analysis was performed using an insurance based private database (PearlDiver database) to identify patients over 65 years of age who had undergone 1-2 level posterior lumbar spine fusion from 2005 to 2012. Study cohorts were created for patients who had been taking oral glucocorticoids chronically and those with a history of chronic MRSA infection amongst the fusion patients. The rates of 90 day surgical site infection (SSI) in these two mutually exclusive cohorts were compared to an age- and risk-factor matched control cohort and odds ratio was calculated.

Results: A total of 360,005 patients were identified to have 1-2 level lumbar fusion with chronic steroid usage and MRSA infection in 11,687 and 5,899 respectively. Chronic oral steroid use was significantly associated with increased risk of 1 year mortality (OR=2.06, 95%CI 1.13-3.78 p=0.018) and trended toward significantly increased risk of SSI at 90 days (OR=1.74, 95%CI 1.33-1.92 p<0.001) and 1 year (OR=1.88, (95%CI 1.41-2.01 p<0.001). Chronic MRSA infection was significantly associated with increased risk of SSI at 90 days (OR=6.99, 95%CI 5.61-9.91 p<0.001) and 1 year (OR=24.0, 95%CI 22.20-28.46 p<0.001) but did not significantly impact mortality

Discussion/Conclusion: In patients 65 years of age and older who underwent elective posterior lumbar fusion, our study found chronic oral steroid therapy to be associated with increased risk of 1 year mortality but not SSI, while chronic MRSA infection was associated with increased risk of SSI at both 90 and 1 year, but not 1 year mortality. These two risk factors should be important considerations during the perioperative period and may play a role in patient selection as well as preoperative planning and risk stratification.

RF Paper 08. The Risk of Postoperative Surgical Site Infection Following Lumbar Spine Surgery after Exposure to Steroids at the Time of Surgical Intervention

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Background/Introduction: Intraoperative corticosteroids are commonly used during lumbar spine surgery to potentially alleviate postoperative pain and limit autonomic reaction to general anesthesia. The efficacy of intraoperative steroid administration (topical or systemic) and any association with surgical site infections (SSI) remains controversial. The goal of this study was to evaluate the risk of postoperative SSI following lumbar spine surgery after exposure to steroids at the time of surgical intervention and whether there is a beneficial effect of steroids on postoperative length of hospital stay.

Materials/Methods: Retrospective review of patients who had surgery for degenerative lumbar spine disease at a single tertiary care center between 2005 and 2015. Inclusion criteria - lumbar spine surgery patients in this timeframe who had a postoperative SSI within 90 days that required a surgical intervention. The intraoperative steroids administered were classified as intravenous or topical after chart review. Demographic data, steroid administration and dosage, surgical details, and other patient characteristics were evaluated.

Results: Of the 1116 subjects who fit inclusion criteria, 79 patients had a SSI necessitating reoperation within 90 days while 1037 patients did not. 96 (8.60%) subjects were given intraoperative topical steroids (TS), while 276 (24.73%) subjects were given intraoperative intravenous steroids (IVS). 10 (10.42%) patients in the TS group had an SSI, while 69 (6.75%) patients in the non-TS group had a SSI. While the TS group had a higher rate of infection than the non-TS group, this difference was not statistically significant (p = .208, odds ratio: 1.6, 95% CI: .797 - 3.22). Additionally, 19 (6.88%) patients in the IVS group had a SSI, while 60 (7.14%) in the non-IVS group had a SSI. This difference was not statistically significant either (p = 1.000, odds ratio: .961, 95% CI: .563 - 1.64). Additionally, patients had shorter postoperative hospital stays in both the TS group (p < .001) and the IVS group (p=.0043) compared to patients who did not receive steroids.

Discussion/Conclusion: This study demonstrates no association between topical or intravenous intraoperative steroid administration and infection. In addition, we found that patients receiving topical steroids or intravenous steroids had shorter postoperative hospital stays.

RF Paper 09. Associations between Preoperative Hyponatremia and Perioperative Complications in Lumbar Spinal Fusion

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Background/Introduction: Several studies of surgical cohorts

have identified preoperative hyponatremia as an important risk factor for poor perioperative outcomes. However, this relationship has not been studied in lumbar spinal fusion patients. The purpose of this study is to investigate whether preoperative hyponatremia is a risk factor for 30-day major morbidity and mortality, increased hospital length of stay, and 30-day readmission and reoperation rates in patients undergoing lumbar fusion.

Materials/Methods: We used validated CPT codes for lumbar fusion to identify patients in the American College of Surgeons' NSQIP database, and identified hyponatremic ($[Na] < 135 \text{ mEq/L}$) and normonatremic ($[Na] 135\text{--}145 \text{ mEq/L}$) groups. We then performed a baseline univariate analysis to identify potentially predictive covariates (surgical approach and setting, patient demographics, and comorbidities) for each outcome. Missing data was addressed using a multiple imputation technique. Finally, multivariate logistic regression was used to identify significant associations between hyponatremia and several outcome measures, when compared to the normonatremic group.

Results: We identified 10,654 lumbar spinal fusion patients who were either hyponatremic or normonatremic. Multivariable analysis showed that preoperative hyponatremia was independently associated with major morbidity and mortality (OR 1.21; 95%CI 1.03–1.43), major morbidity (OR 1.22; 95%CI 1.03–1.44), and longer hospital length of stay (OR 1.14; 95%CI 1.02–1.27). However, we did not identify a statistically significant association between preoperative hyponatremia and mortality, 30-day readmission or 30-day reoperation.

Discussion/Conclusion: The present multi-institution study found that preoperative hyponatremia was independently associated with an increased risk of poor perioperative outcomes after controlling for numerous confounding covariates. As the U.S. transitions to a value and quality-based healthcare model, quantifying the association between modifiable risk factors and adverse outcomes has become increasingly important. The results of the present study can improve patient selection and preoperative risk counseling for lumbar spinal fusion operations, leading to improved healthcare delivery.

RF Paper 10. Thirty-Day Complications of Navigated Versus Conventional Single-Level Instrumented Posterior Lumbar Fusion: An ACS-NSQIP Analysis

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Background/Introduction: After the first navigated pedicle screw was implanted in 1995, the use of navigation in spinal instrumentation has slowly but steadily increased. The touted advantages of navigated surgery include better placement of pedicle screws and lower radiation exposure to the surgeon. Although multiple studies have investigated the accuracy of pedicle screw placement and radiation exposure with the use of navigation, no study has compared perioperative complications between navigated and conventional posterior lumbar fusion. The primary purpose of the current study was to compare perioperative outcomes between navigated and conventional single-level instrumented posterior lumbar fusion.

Materials/Methods: Patients who underwent navigated or conventional single-level instrumented posterior lumbar fusion in the 2010–2015 American College of Surgeons National Surgical Quality Improvement Database (NSQIP) were identified based on CPT codes. Patient characteristics and comorbidities were compared between the navigated and conventional cohorts. The usage of navigation throughout the years was characterized. Propensity score matched comparisons were performed for, operative time, hospital length of stay, thirty-day postoperative adverse events, and thirty-day readmissions between the navigated and conventional cohorts.

Results: Navigated cases have increased over time to be approximately 10% of reported posterior lumbar fusions in the NSQIP database. After propensity matching to control potential confounding factors, statistical analysis revealed no significant difference for most adverse events, including wound infection, return to the operating room, and readmission. There were significantly lower blood transfusions in the navigated cohort (2.84% versus 7.15%). Operative time was not different between the two cohorts. Patients who underwent navigated surgery did have a shorter mean hospital length of stay (0.2 day difference). Although this is statistically significant, it is probably not clinically significant.

Discussion/Conclusion: There are potential benefits of navigation such as better pedicle screw placement and reduced surgeon radiation exposure. The reduced blood loss and mildly reduced hospital length of stay identified for the navigated cases are probably markers of more minimally invasive surgery in the navigated cohort. The current study could not identify other differences such as wound infection (of concern due to bulky navigation technology) or return to the operating room (a potential functional difference in outcome).

RF Paper 11. The Prevalence of Spinal Epidural Lipomatosis On Magnetic Resonance Imaging

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Background/Introduction: Spinal epidural lipomatosis (SEL) refers to an excessive accumulation of fat within the epidural space. It can be idiopathic or secondary, resulting in significant morbidity. The prevalence of SEL, including idiopathic and secondary SEL, and its respective risk factors are poorly defined. We therefore sought to: (1) assess the prevalence of SEL among patients who underwent a dedicated Magnetic Resonance Imaging (MRI) scan of the spine—including: incidental SEL (i.e. SEL without any spine-related symptoms), SEL with spine-related symptoms, and symptomatic SEL (i.e. with symptoms specific for SEL), and (2) assess factors associated with overall SEL and subgroups. In addition, we assessed differences between SEL subgroups.

Materials/Methods: We retrospectively reviewed the records of 28,902 patients, aged 18 years and older with a spine MRI (2004 to 2015) at two tertiary care centers. Prevalence numbers were calculated as a percentage of the total number of patients. We used multivariate logistic regression analysis to identify factors associated with overall SEL and subgroups.

Results: The prevalence of overall SEL was 2.5% (731/28,902): incidental SEL 0.6% (168/28,902), SEL with symptoms 1.8% (526/28,902), and symptomatic SEL 0.1% (37/28,902). Factors associated with overall SEL in multivariate analysis were: higher age (OR: 1.02 95%CI: 1.01 – 1.02, $p < 0.001$), higher Modified Charlson Comorbidity Index (OR: 1.07, 95%CI: 1.03 – 1.11, $p < 0.001$), male sex (OR: 2.30, 95%CI: 1.85 – 2.87, $p < 0.001$), BMI 25–29.9 (OR: 2.28, 95%CI: 1.50 – 3.46, $p < 0.001$), BMI > 30 (OR: 7.45, 95%CI: 5.07 – 11.0, $p < 0.001$), Black/African American race (OR: 1.59, 95%CI: 1.06 – 2.36, $p = 0.023$), systemic corticosteroid use (OR: 3.26, 95%CI: 1.99 – 5.36, $p < 0.001$), and epidural corticosteroid injections (OR: 3.69, 95%CI: 2.77 – 4.90, $p < 0.001$).

Discussion/Conclusion: We found that about 1 in 40 patients undergoing a spine MRI had SEL; 23% of whom with no symptoms, 72% with spine-related symptoms, and 5% with symptoms specific for SEL. Our data help identify patients that might warrant an increased index of suspicion for SEL.

RF Paper 12. Validating The Clinical Significance of The CARDS Classification For Degenerative Spondylolisthesis Through Preoperative Outcome Measures

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Background/Introduction: The CARDS classification divides degenerative spondylolisthesis (DS) into 4 distinct groups using radiographic criteria of disc collapse, less than 5mm of translation, greater than 5mm of translation and segmental kyphosis. Though studies have shown reliability and reproducibility as a classification system, no study has looked at the 4 distinct CARDS group and how they vary in pain, physical function or disability. The purpose of this study is to classify patients with DS using the CARDS classification and compare the preoperative outcome measures between CARDS groups.

Materials/Methods: A retrospective review was done with all patients with the diagnosis of degenerative spondylolisthesis at a single level in the lumbar spine seen between October, 2013 and November, 2016. Multilevel surgery, prior laminectomy, prior discectomy, or scoliotic curve greater than 15 degrees were excluded, as were patients without preoperative outcome scores. The patients were divided into the CARDS classification groups. Preoperative PF CAT scores, ODI, VAS leg and back were reviewed and analyzed.

Results: From a total of 744 patients with DS, 102 met the inclusion and exclusion criteria. 20 (20%) patients had Type A, 39 (38%) patients had Type B, 40 (39%) had Type C, and 3 (3%) patients had Type D. Trend towards lower PF CAT score, higher VAS leg and higher VAS back in Type D, though not statistically different overall among CARDS groups ($p=0.3343$, $p=0.3881$ and $p=0.3836$ respectively). No difference in ODI score ($p=0.5892$) among different CARDS classification groups.

Discussion/Conclusion: CARDS classification is a reliable method for classifying DS. Measuring by PF CAT, ODI, VAS leg and back, neither disc space collapse (Type A), greater or less than 5mm of translation (Type B and C), nor kyphotic angulation (Type D) had a significant effect on patient presentation in DS. Trends however show that DS patient with segmental kyphosis (Type D) have lower PF CAT scores and higher VAS leg and back scores. Future studies will look at the clinical course, treatment received and subgroup analysis of each CARDS subtype.

RF Paper 13. Utility of Supine Lateral Radiographs in Assessment of Lumbar Segmental Instability in Degenerative Lumbar Spondylolisthesis

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Background/Introduction: The accurate evaluation of segmental instability is critical to the management of lumbar spondylolisthesis. Standing flexion-extension lateral radiographs are routinely obtained, as it is believed to precipitate the forward-backward motion of the segment; however recent studies with MRI and CT have shown that the relaxed supine position can facilitate the reduction of the anterolisthesed segment. Here, we show that inclusion of supine lateral radiographs likewise increases the amount of segmental instability seen in single-level lumbar spondylolisthesis when compared to traditional standing neutral/flexion/extension lateral radiographs.

Materials/Methods: Supine lateral radiographs were added to the routine evaluation (standing neutral/flexion/extension lateral radiographs) of symptomatic spondylolisthesis at our institution. In this retrospective study, 66 patients with this series of radiographs

were included. The amount of listhesis was measured and compared on each radiograph: Standing neutral lateral ("neutral"), Standing flexion lateral ("flexion"), Standing extension lateral ("extension"), and Supine lateral ("supine").

Results: 66 patients (56 female, 10 male), with a mean age of 60.9 years (+/- 11.8 years) were included in this study. The mean mobility seen with flexion-extension was 5.57%. The mean mobility seen with flexion-supine was 8.13%. This difference was significant in paired t-test ($p<0.001$), and independent of age and BMI. The maximal mobility was seen between flexion and supine radiographs in 40 patients, between neutral and supine radiographs in 14 cases, and between traditional flexion-extension studies in only 11 cases.

Discussion/Conclusion: The supine radiograph demonstrates more reduction in anterolisthesis than the extension radiograph. The supine radiograph is technically easy for both the facility and for patient comfort, and can be a valuable tool in the evaluation of spondylolisthesis. It is much less expensive than MRI or CT. This study suggests that the incorporation of a supine lateral radiograph, and possible replacement of the extension radiograph, can improve our understanding of segmental mobility when evaluating instability in a spondylolisthesis patient.

RF Paper 14. 2-5 Year Follow Up on S2AI Pelvic Fixation

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Background/Introduction: Sacropelvic fixation continues to be a challenge when performing long fusions to the pelvis. S2 alar-iliac (S2AI) screws have been found to provide solid biomechanical fixation and have been found to have good clinical results in short term follow up for pediatric and adult patients. However, longer follow up has yet to be presented. We have an established population and aim to report our results from 2 to 5 years post-operatively.

Materials/Methods: Cases were retrospectively reviewed at one institution in patients who had placement of S2AI screws for long fusions with at least a 2 year follow up. Demographic data as well as fusion, complications and reoperations were reviewed. Complications were broken into minor and major categories similar to previous series on sacropelvic fixation.

Results: There were 86 cases identified with at least 2 year follow up after S2AI fixation. Minor complications occurred in 32.6% of the study population with the majority being intraoperative dural tears. Major complications occurred in 19.8% of patients. These included primarily proximal junctional kyphosis and adjacent segment degeneration. Revision surgery for all causes was performed in 23% of the cohort. The rate of fusion at L5-S1 for patients without preoperative pseudarthrosis was 95.3%. Preoperative L5-S1 pseudoarthrosis was identified in 20 patients as an indication for surgery. Of these patients, 17 went on to fusion after one surgery, all went on to fusion after two surgeries. There was evidence of screw lucency in 10.4% of cases. However, the majority of these were asymptomatic. One patient had persistent SI pain, three patients had evidence of pseudarthrosis requiring revision surgery.

Discussion/Conclusion: Sacropelvic fixation using the S2AI technique provides safe, durable fixation with low rates of technique specific complications and limited need for hardware removal. Complication rates in this series were similar to other series on long fusions to the pelvis. Additionally, fusion rates were high at L5-S1 for both patients with and without preoperative L5-S1 pseudoarthrosis. It appears that the S2AI technique is a powerful option for patients with previous L5-S1 pseudoarthrosis.

RF Paper 15. Radiographic Analysis of Psoas Morphology and its Association with Neurovascular Structures at L4-5

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Background/Introduction: The direct lateral transpsoas approach, lateral lumbar interbody fusion (LLIF) procedures at the L4-5 level carry a significant risk of injury to the lumbar plexus. Previous small case series have introduced descriptions of anatomical psoas muscle variants that may indicate a greater risk of neurovascular injury during LLIF procedures. The objective of the present study was to utilize high-resolution magnetic resonance imaging (MRI) to expand the anatomical description of psoas morphology and its association with the neurovascular structures at the L4-5 intervertebral level.

Materials/Methods: Axial L4-5 sections of consecutive patients who obtained lumbar MRIs were analyzed. Teardrop psoas morphology was assessed qualitatively. MRI described psoas morphology and proximity of neurovascular structures, while plain radiographs were evaluated for lumbosacral transitional vertebrae (LSTV). Teardrop morphology was tested for associations with radiographic measurements using t-tests and chi-square analysis.

Results: 50 teardrop and 476 non-teardrop psoas muscles were identified. Teardrop morphology was associated with greater longitudinal length (53.1 vs. 49.3mm, $p=0.012$), and shorter transverse length (34.9 vs. 44.8mm, $p<0.001$) compared to non-teardrop. Teardrop morphology was associated with anterior and lateral migration of the psoas with greater distance between the anterior borders of the psoas and disc (13.5 vs. 6.3mm, $p<0.001$), and greater distance between the medial border of the psoas to the lateral disc border (1.6 vs 0.5mm, $p<0.001$). Teardrop morphology was associated with a higher incidence of the lumbar plexus migrating anteriorly adjacent to the middle-third of the disc (43.4% vs. 17.6%, $p<0.001$) and the iliac vasculature located adjacent to the anterior-third of the disc (43.4% vs. 30.0%, $p=0.047$). Teardrop morphology was not associated with presence of LSTV (3.8% vs 7.6%, $p=0.306$).

Discussion/Conclusion: The results of this study suggest that psoas muscles with teardrop morphology are more anteriorly and laterally displaced from the L4-5 disc space than normal psoas muscles. Furthermore, the lumbar plexus is more anteriorly displaced and the iliac vasculature is more posteriorly displaced from the L4-5 disc space in the presence of teardrop morphology. As such, the risk of intraoperative neurovascular injury during LLIF may be elevated in the setting of teardrop morphology at the L4-5 intervertebral level.

RF Paper 16. National Trends in the Utilization of Vertebroplasty and Kyphoplasty Procedures throughout the United States

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Background/Introduction: Double-blinded prospective randomized controlled trials have shown no benefit to the use of vertebroplasty over a sham procedure in the treatment of vertebral fractures. Contrastingly, kyphoplasty may be beneficial when appropriately indicated. Our group hypothesized that the use of vertebroplasty for vertebral fractures had decreased over the past decade, while the use of kyphoplasty remained relatively constant.

Materials/Methods: The National Inpatient Sample (NIS) database was queried for patients who underwent either kyphoplasty (ICD-9-CM 81.66) or vertebroplasty (ICD-9-CM 81.65) procedures between 2004 and 2014 across 44 states. Demographic and economic data were obtained which included the annual number of surgeries, age, sex, insurance type, location, and frequency of routine discharge. The NIS database represents a 20% sample of discharges from U.S. hospitals, excluding rehabilitation and long-term acute care hospitals, which is weighted to provide national estimates.

Results: In 2014, an estimated total number of 24,250 kyphoplasty and 6,615 vertebroplasty were performed across the United States. The number of vertebroplasty procedures has decreased 51% from 16,970 in 2008. Similarly, the number of kyphoplasty procedures has decreased 45% from 44,324 in 2007. Based on payer, Medicare patients comprised 81% of those billed for kyphoplasty and vertebroplasty, and 75% of procedures were utilized in areas designated as not low income. In 2014, patients in the South Atlantic region comprised 23% of vertebroplasty and 27% of kyphoplasty cases, far more than any other region. Additionally, kyphoplasty and vertebroplasty were more often performed in teaching facilities rather than community hospitals (61% and 68%, respectively).

Discussion/Conclusion: Since the publication of two double-blinded, prospective randomized controlled trials not showing any benefit of vertebroplasty over a sham procedure, there has been a significant decrease in both kyphoplasty and vertebroplasty procedures.

RF Paper 17. A Retrospective Study of Thoracolumbar Burst Fractures Treated with Fixation and Non-fusion Surgery of Intra-vertebral Bone Graft Assisted with Balloon Kyphoplasty

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Background/Introduction: Thoracolumbar fractures are common spinal injuries. Posterior fixation and fusion is the primary treatment, although this may sacrifice range of motion (ROM) to achieve stability, rather than treating the fracture itself. Two issues addressed when treating thoracolumbar fractures include: 1) replacing the fractured vertebrae, especially the upper endplate of the injured vertebrae, and 2) provide strong fixation with biomechanical stability and flexibility.

Materials/Methods: This retrospective study included 75 consecutive patients with thoracic or lumbar fractures treated from October 2010 to May 2014. A total of 61 patients met inclusion criteria. Patients were divided into one of two groups: group A, intra-vertebral bone graft with balloon kyphoplasty (non-fusion surgery); and group B, traditional posterior fixation and fusion surgery. The Visual Analog Scale (VAS) was done preoperatively as well as at three months, one year, and two years. X-ray, CT, and MRI were done preoperatively. X-rays were done postoperatively at three months and two years. Postoperatively at 3 months, CT was used to confirm healing of the vertebral fracture.

Results: Patient demographics and baseline characteristics were similar in the two groups. All fractures in both groups were reduced successfully, deformity was improved, and the more than 90% of anterior vertebral height (AHR) was restored. After removal of hardware in group A, ROM at the injury level recovered (mean ROM 8.57°), and at 2 years, there was no loss of vertebral height or recurrence of deformity. There was no hardware failure in group A, but there was evidence of screw loosening three screws in group B.

Discussion/Conclusion: Non-fusion treatment of intra-vertebral bone graft assisted with balloon kyphoplasty demonstrated good fracture reduction, deformity correction, fracture healing, and ROM maintenance. There were no complications associated with the implant. With the continued development of surgical techniques and materials, we believe that an increasing number of spinal fracture patients can avoid spinal fusion.

RF Paper 18. Radiographic Evaluation of Percutaneous Pedicle Screw Constructs Including Minimally Invasive Facet Fusions for Unstable Spinal Column Injuries

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Background/Introduction: The purpose of this study is to compare the maintenance of correction of unstable, operative spine fractures that underwent percutaneous fixation with and without facet fusion. A secondary outcome was to critically evaluate the hardware constructs for loosening and failure during a short-term follow-up period.

Materials/Methods: We conducted a retrospective review of all operative thoracic and lumbar spine fractures using our billing and coding database from 2006 to 2013. One-hundred and forty-one cases were obtained. Fifty-five cases were excluded for lack of post-operative radiographs and comorbidities. Eighty-seven had radiographs and operative reports available for review. Maintenance of correction was the primary outcome. One-week postoperative radiographs and available follow-up radiographs were analyzed for the Cobb angle to evaluate for progressive kyphosis and loss of correction. We also examined each radiograph for instrumentation fracture, loosening (greater than 2 mm radiolucency around any screw), or screw pullout.

Results: The mean follow-up of for all patients was 33 weeks. There average amount of kyphotic progression was 3.2 degrees. There were no cases of instrumentation fracture during this follow-up period. The rate of screw loosening was 24%. There was no significant difference in the rate of loosening or progression of kyphosis in patients with facet fusion (with or without bone morphogenetic protein [BMP]) and without facet fusion. There was no difference in the percentage of screw pullout between groups. A total of 19 patients (22%) eventually underwent instrumentation removal, of which, only 2 constructs were loose (10.5%).

Discussion/Conclusion: We did not demonstrate a significant difference in the progression of kyphosis postoperatively between patients with and without facet fusion. Additionally, no difference in kyphotic progression was noted when facet fusions were performed with or without BMP. In thoracic and lumbar spinal column injuries, where percutaneous fixation is indicated, the addition of facet fusion may be superfluous. Interestingly, we found a significantly higher rate of screw loosening (24%) than previously reported for percutaneous cases, but loosening was not significantly different between fused and non-fused groups. The clinical significance of this instrumentation loosening remains unclear, as only 2 of 19 instrumentation removals had loosening, and further clinical follow-up is needed.

RF Paper 19. Clinical and Radiographic Analysis of Expandable versus Static Lateral Lumbar Interbody Fusion Devices with One-Year Follow-up

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Background/Introduction: Use of static and expandable interbody spacers for minimally invasive lateral lumbar interbody fusion (LLIF) is widely accepted and offers favorable clinical results. However, complications such as implant migration and/or subsidence may occur if optimal interbody fit is unable to be obtained with a static implant. Expandable spacers allow in situ expansion to optimize fit and mitigate iatrogenic endplate damage during trial and impaction. This study sought to compare clinical and radiographic outcomes of static and expandable interbody spacers following LLIF and report device-related complications.

Materials/Methods: This multicenter clinical study included 25 patients (31 levels) who underwent LLIF with a static spacer and 25 (29 levels) with an expandable spacer manufactured from titanium alloy and radiolucent polyether-ether-ketone; all procedures were combined with supplemental transpedicular posterior stabilization. Patient self-assessment forms and radiographic records were used to assess clinical and radiologic outcomes.

Results: Mean patient age was 62.3 ± 10.8 years (62% female). Eighty percent of patients underwent one-level surgery, and 20% two-level surgery. Results showed no significant differences in estimated blood loss or length of hospital stay. However, operative time differed statistically between static (66.8 ± 35.1 min) and expandable (112.1 ± 58.8 min) groups ($P < 0.01$). Mean visual analog scale (VAS) and Oswestry Disability Index (ODI) scores improved significantly from preoperative to 12-month follow-up in both groups ($P < 0.05$). Mean intervertebral disc height ($\pm$ SD) increased significantly from 8.8 ± 2.7 mm preoperatively to 15.4 ± 2.5 mm at 12 months for static cages, and from 7.8 ± 2.3 mm preoperatively to 13.3 ± 2.5 mm at 12 months for expandable cages ($P < 0.01$). Neuroforaminal height also increased significantly from preoperative to 12-month assessment ($P < 0.01$). Fusion was observed in 96.3% (26/27) and 88.9% (16/18) of levels in static and expandable spacer groups, respectively. Subsidence was reported in 21.4% (6/28) of static and 3.7% (1/27) of expandable levels ($P < 0.01$). Postoperative radiographs showed no evidence of implant migration, and no cases required surgical revision at index or adjacent levels.

Discussion/Conclusion: LLIF using expandable spacers resulted in similar clinical and radiographic outcomes when compared with LLIF using static spacers and led to decreased subsidence.

RF Paper 20. National Treatment Trends and Perioperative Outcomes of Surgical Options for Degenerative Spondylolisthesis: An ACS-NSQIP study with comparison to prior LSRS survey results

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Background/Introduction: Surgical treatment for lumbar degenerative spondylolisthesis is common. Although most surgeries are performed with fusion, there is not consensus as to which fusion technique is best. The current study builds upon a Lumbar Spine Research Society (LSRS) survey on this topic for which the results were reported at the 2016 LSRS annual meeting. The primary purpose of the current study was to compare surgical practice patterns for degenerative lumbar spondylolisthesis utilized by spine surgeons at LSRS and surgeons captured by American College of Surgeons National Surgical Quality Improvement Program (NSQIP). The secondary purpose was to use NSQIP to compare perioperative outcomes of three common posterior surgical options for this pathology: uninstrumented posterior fusion, instrumented posterior fusion, and instrumented posterior fusion with interbody.

Materials/Methods: A survey was administered to surgeons who attended the LSRS meeting in 2014. Data was extracted from ACS-NSQIP from 2005-2014 to characterize the same responses. The two data sets were compared. Perioperative outcomes of those in the NSQIP posterior fusion sub-cohorts were characterized and compared.

Results: Posterior surgical approaches reported by the LSRS survey, which was previously presented, were similar to those captured by NSQIP, where 72% of those with degenerative spondylolisthesis were fused. Of those that were fused 8% had an uninstrumented posterior fusion, 33% had an instrumented posterior fusion, and 59% had an instrumented posterior fusion with interbody. On multivariate

analysis controlling for patient characteristics / comorbidities, there was no difference in risk of minor adverse events, serious adverse events, any adverse events, readmission, or length of stay to the treatment options studied.

Discussion/Conclusion: We had been surprised by the high rate of fusions performed with interbody for the diagnosis of lumbar degenerative spondylolisthesis in the prior LSRS survey. The national data, based on the NSQIP, revealed similar trends. Nonetheless, the current study could not detect perioperative differences in thirty-day outcomes between the techniques. These findings highlight that surgeon preference, patient experience, cost benefit considerations, and longer-term outcomes have to be the measures by which surgical technique is chosen for degenerative spondylolisthesis.

RF Paper 21. Combined Treatment with High-Dose Parathyroid Hormone (PTH 1-34) and Low Dose Bone Morphogenetic Protein 2 (BMP-2) in a Rabbit Spinal Fusion Model

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Background/Introduction: Previously, we demonstrated that, while low-dose (10 µg/kg) of parathyroid hormone (1-34) (PTH) yielded increased fusion mass volume in a rabbit model, it did not improve biomechanical stiffness nor improve fusion when combined with BMP-2 (Lina et al, Spine [Phila Pa 1976]. 2014; 39(5):347). However, research in rodent models has suggested that the effects of PTH are dose-dependent (Ming et al, Spine [Phila. Pa. 1976]. 2012; 37(15): 1275). We thus aim to evaluate whether increasing the dosage of PTH increases both the volume and biomechanical stiffness of the resulting fusion masses and/or exhibits synergistic effects with low-dose BMP-2 treatment.

Materials/Methods: Posterolateral intertransverse process lumbar spinal fusion surgery was performed on 60 male New Zealand White rabbits, divided into six experimental groups: [1] iliac crest autograft alone (n = 10); [2] autograft + 20 µg/kg PTH (n = 10); [3] autograft + 40 µg/kg PTH (n = 10); [4] BMP-2 alone (n = 10); [5] BMP-2 + 20 µg/kg PTH; and, [6] BMP-2 + 40 µg/kg PTH. Fusion was assessed 6 weeks post-surgery via manual palpation and volumetric CT analysis. Fusion mass stiffness was evaluated via four-point bending nondestructive biomechanical testing.

Results: When autograft was used, rabbits receiving PTH displayed an increased rate of fusion via manual palpation, with increasing doses yielding increased fusion mass volume as assessed via CT. However, increased mechanical stiffness was only observed in the 20 µg/kg group. All groups treated with BMP-2 fused. The highest dose of PTH in combination with BMP-2 yielded significantly increased fusion mass volume compared to treatment with BMP-2 alone, however, no significant differences in mechanical stiffness were observed.

Discussion/Conclusion: Treatment with PTH alone increased fusion rate and fusion mass volume in a dose dependent manner, when autograft bone is employed. However, there may be an optimal dose in the rabbit model, as significant increases in mechanical stiffness were only observed at a dosage of 20 µg/kg. While the effects of BMP-2 on fusion dominate, a significant increase in fusion mass volume at a dosage of 40 µg/kg over BMP-2 alone, suggests there may be some synergistic effects.

RF Paper 22. Intradiscal Injection of Polymethyl-Methacrylate/ Hyaluronic Acid in an Ovine Model of Degenerative Disc Disease: Long-Term Disc Appearance on MRI

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Background/Introduction: Degenerative disc disease (DDD) has been implicated as one of the pathophysiologic causes of chronic low back pain. Previous histopathologic and plain radiographic ovine studies have demonstrated that intradiscal polymethyl-methacrylate with hyaluronic acid (PMMA/HA) injection may interrupt an induced degenerative process and maintain intervertebral disc height after injury. The purpose of this study was to describe the magnetic resonance imaging (MRI) findings of treated versus untreated disc levels.

Materials/Methods: Two healthy, adult-aged, ovine subjects underwent a surgical exposure of five consecutive lumbar discs (L1-L6). An induced injury was accomplished via a left anterolateral annulotomy at 4 levels in each animal. Of the 4 injured discs, 2 underwent intradiscal injection of 100-300 microliters of PMMA/HA—this defined the treated/injured group. Two discs served as the untreated/injured control in each subject. The last disc space that was exposed, but did not undergo injury, served as the uninjured untreated control. On postoperative day 240, T1 and T2 weighted MRI sequences were obtained. An independent radiologist, blinded to the intervention, reviewed each level using the Modic and Thompson scores.

Results: Each subject tolerated PMMA/HA injection without any neurologic complications. After 240 days, in-vivo MRI demonstrated less DDD among treated/injured disc levels compared to injured/untreated levels (Figure 1). The untreated, uninjured disc levels had Modic scores of 2 at each disc level and Thompson scores that ranged from 2-4. Modic Scores for treated, injured disc levels were 0 for each disc level compared to scores ranging from 0 to 2.5 in untreated, injured discs. Thompson scores for treated, injured discs ranged from 1-2 compared to 1-4 in untreated, injured disc levels. These MRI findings suggest that PMMA/HA injection in injured intervertebral discs may confer some degree of disc preservation when compared to untreated, injured discs.

Discussion/Conclusion: In this pilot study of ten total intervertebral discs in two ovine subjects, we demonstrate the feasibility of PMMA/HA injection and observe a difference in the Modic and Thompson scores between injured and uninjured discs. Our findings suggest that this treatment may hold promise and that further research is warranted to establish the efficacy of PMMA/HA injection for the treatment of DDD.

RF Paper 23. Tissue Engineered Bone Graft with Hypertrophic Chondrocytes Prevents Fusion in an Athymic Rat Model

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Background/Introduction: Each year in the United States, over 200,000 spinal fusion surgeries are performed requiring bone grafts and bone graft substitutes. The current gold standard for posterolateral lumbar fusion is autogenous iliac crest bone graft (ICBG), but harvesting of this graft is associated with increased operative time and significant complications. Nonetheless, there continues to be a

high rate of pseudoarthrosis, particularly in long fusions and patients who smoke. This study sought to assess the efficacy of utilizing tissue engineered bone as an alternative bone graft source. We hypothesized that implantation of osteogenic cells cultured in a porous scaffold would increase fusion rates in an athymic rat spinal fusion model.

Materials/Methods: Bone cores harvested from bovine juvenile wrists were sterilized and decellularized for scaffold production. Human derived bone marrow mesenchymal stem cells (BMSC) were obtained and verified by tri-differentiation testing. BMSCs were applied to dried scaffolds at a concentration of 3×10^8 cells/mL. The seeded cores were expanded for six weeks in medium, mimicking endochondral ossification to produce hypertrophic chondrocytes. Single-level intertransverse fusions were performed at the L4-L5 level of 31 athymic rats. Fifteen rats were implanted with the hypertrophic chondrocyte seeded scaffold and sixteen had scaffold alone. Half of the study rats were sacrificed at 3 weeks and the other half at 6 weeks. Spinal fusion was analyzed using 2D and 3D micro-CT reconstructions.

Results: At 3 weeks, none of the hypertrophic chondrocyte rats had partial or complete fusion, while 62.5% of the control rats fused and another 12.5% had partial fusions ($p=0.013$). At 6 weeks, none of the hypertrophic chondrocyte rats fused and 50% had partial fusions, while 87.5% of the control rats fused ($p=0.002$). Manual palpation was of limited utility in determining fusion given inconsistent inter-observer and intra-observer reliability.

Discussion/Conclusion: This study demonstrates that certain tissue engineered bone grafts may actually prevent fusion in an athymic rat model. The hypertrophic chondrocyte scaffold used in this study does not represent a promising cost-effective bone graft substitute that could be useful in spine fusions.

RF Paper 24. The Role of Calcium Pyrophosphate Dihydrate Deposition in Postoperative Outcome of Lumbar Spinal Stenosis Patients

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Background/Introduction: Calcium pyrophosphate (CPP) associated arthritis is one of the most common types of arthritis. Induced inflammation and other related clinical outcomes in CPP associated arthritis and clinical-related outcomes are well-studied in CPP-associated arthritis of the appendicular joints. However, studies about spinal calcium pyrophosphate dehydrate deposition (SCPPD) remain scarce. Association among surgical interventions, inflammation in SCPPD, and clinical outcomes are not well-understood. The goal of the presented study is to investigate the association among surgical intervention, clinical and quality of life (QoL) outcomes in patients who underwent surgery for lumbar spinal stenosis (LSS) that had SCPPD versus LSS patients without SCPPD.

Materials/Methods: A single-institution database was reviewed, identifying LSS patients that were treated by posterior spinal surgery during the 2003 to 2011 study period. LSS patients were categorized as having or not having SCPPD. Diagnosis of SCPPD was confirmed by histologic identification. Clinical presentations and post-operative results were analyzed. Disability and QoL were assessed by using Oswestry Disability Index (ODI) and Short Form-36 Health Survey (SF-36).

Results: Thirty-four patients were enrolled, with 18 patients allocated to SCPPD group and 16 patients allocated to non-SCPPD group. Preoperative and postoperative pain scores were not significantly different between groups ($p=0.33$ and $p=0.48$, respectively). Average ODI score in SCPPD group was slightly higher than in non-SCPPD group preoperatively (57 vs. 51; $p=0.33$), but was significantly lower postoperatively (15 vs. 43; $p=0.01$). Postoperative physical function,

vitality, and mental health of SCPPD patients were also significantly improved ($p=0.03$, $p=0.022$, and $p=0.022$, respectively).

Discussion/Conclusion: Surgical intervention resulted in good clinical outcomes in SCPPD patients. According to our findings, total removal of CPP-involved tissue is not necessary. As such, surgery should be performed as indicated according to clinical presentation without concern regarding presence of CPPD.

RF Paper 25. Treatment of the Fractional Curve with Circumferential Minimally Invasive (cMIS) Interbody versus Open Surgery: An Analysis of Surgical Outcomes

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Background/Introduction: The fractional curve of adult scoliosis can cause significant radiculopathy. We sought to evaluate the outcomes of patients whose fractional curves were treated with either cMIS or open techniques.

Materials/Methods: A multicenter retrospective review of an adult spinal deformity database of MIS and open surgically treated patients, with the following inclusion criteria: age >18 years with fractional curves >10°, ≥ 3 levels of instrumentation, and one of the following: coronal Cobb angle (CCA) >20°, PI-LL >10°, PT >20°, SVA >5cm

Results: 118 patients had their fractional curves treated, 79 open and 39 cMIS. The fractional curves were similar pre-op (17 cMIS, 19.6 open) and post-op (7 cMIS, 8.1 open), but open had more levels treated (12.1 vs 5.7). cMIS had greater reduction in VAS leg (6.4 to 1.8) than open (4.3 to 2.5). When propensity matched for levels treated (6.6 cMIS and 7.3 open), 40 patients had their fractional curves treated with either cMIS ($n=20$) or with open ($n=20$) surgery. Both groups had similar fractional curve correction (18° in both groups before surgery, 6.9° in cMIS and 8.5° in open after). cMIS patients had a smaller postoperative coronal Cobb angle (12.5° vs 24.3°) and lower EBL (809cc vs 2299cc). Open patients had a higher SVA change (-19.6 vs +13.2), more pelvic fixation (55% vs 15%), and more direct posterior decompressions (80% vs 22.2%). Both groups had similar pre-op leg pain (VAS leg 6.1 cMIS and 5.4 open) and similar postop leg (VAS leg 1.6 cMIS and 3.1 open). All cMIS patients had interbody grafts whereas 35% of open did. The cMIS and open patients had similar reduction in leg pain (change VAS Leg -4.4 vs -2.2). There was no significant difference in change of Cobb angle, PI-LL, LL, ODI or VAS Back.

Discussion/Conclusion: In the treatment of the fractional curve of adult scoliosis with magnitude greater than 10 degrees, patients treated with cMIS achieved similar reduction in leg pain compared to those treated in an open fashion, even though significantly fewer cMIS patients underwent direct decompression of the fractional curve nerve roots.

RF Paper 26. Radiographic Sagittal Alignment in the Asymptomatic Elderly: What is Normal for Age?

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Background/Introduction: The purpose of this study is to define

“age normal” sagittal vertical axis (SVA) in asymptomatic individuals ranging 60 to 80 years in order to create an acceptable target for postop realignment in these patients.

Materials/Methods: 135 volunteers completed the Oswestry disability index (ODI) and Veterans Rand 12 (VR12) questionnaires and full-standing lateral radiographs were obtained. Patients were stratified into age cohorts of 60, 65, 70, 75 and 80 years. The primary outcome measure was SVA and several additional radiographic measures were recorded. Exclusion criteria included back pain history requiring medical attention within previous year, prior spinal surgery, neuromuscular condition, or compression fracture. Pearson correlations were used to evaluate associations. Analysis of Variance was used to determine differences in alignment across age-groups. Kruskal-Wallis tests were used to determine differences in patient reported outcomes across age-groups.

Results: All SVA measures were within normal range (<40mm). There was no overall significant ($p=0.1083$) difference in mean SVA for the 60, 65, 70, 75 and 80 year age groups. There were significant differences between age groups in L1-S1 ($p=0.0056$), and SS ($p=0.0113$), with a weak associations between age and alignment. The mean L1-were (57.32, 52.93, 53.4, 48.77, 45.39 degrees) for each respective age-group. Significant differences existed comparing 60 vs 75 year age-groups ($p=0.0382$), and 60 vs 75 year age-groups ($p=0.006$). Mean SS values for the age-groups were (39.18, 32.97, 34.33, 32.57, 32.17 degrees), respectively with significant differences between the 60 vs 70 year age-groups ($p=0.0354$), the 60 vs 75 year age-groups ($p=0.0194$) and the 60 vs 80 year age-groups ($p=0.0384$). ODI and VR-12 scores were not significantly different between age groups.

Discussion/Conclusion: In contrast to other studies, this study showed no statistically significant difference in SVA between the age groups in asymptomatic elderly individuals. We found that asymptomatic elderly individuals maintained a relatively normal SVA; however, full body radiography may better demonstrate other compensatory mechanism accounting for this. The need for restoration of normal sagittal alignment in the elderly population may still require further investigation given the frequency and severity of complications inherent in this population.

RF Paper 27. Effect of Lumbosacral Fusion Alignment on the Biomechanics of the Proximal Lumbar Segments in Standing and Sitting Postures

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Background/Introduction: L4-Sacrum is the most prevalent site of spinal fusions for painful degenerative conditions in adults. Lumbopelvic alignment in the standing posture is recommended as the ideal fusion alignment to avoid postoperative complications; even though, adults are spending increasing amount of time in sedentary activities involving sitting. In this study, we asked: (1) how do different sitting postures alter the lumbosacral spinal alignment, and (2) what impact will this have on the biomechanics of proximal lumbar segments adjacent to fusion?

Materials/Methods: Postural influence on lumbosacral sagittal alignment was assessed by analyzing full-length radiographs of 11

asymptomatic volunteers taken in three postures: (i) standing, (ii) erect-sitting, and (iii) slumped-sitting. For each subject, we calculated what would happen to the alignment of the lumbar (L1-S1) spine, in the absence of compensation, in erect- and slumped-sitting postures if the L4-S1 vertebrae were fixed to simulate L4-S1 fusion in the standing alignment (Figure 1A,B,C). Finally, we calculated the change in L1-L4 alignment necessary if the subject were to fully compensate to restore the L1 vertebra to its pre-fusion angular alignment (Figure 1D,E). Calculations were also made for the second scenario where the simulated L4-S1 fusion was performed in the erect-sitting alignment.

Results: Transitioning from standing to erect-sitting decreased L4-S1 lordosis (29° to 17°, $p<0.001$) and L1-L4 lordosis (18° to 16°). Transition from erect-sitting to slumped-sitting changed L4-S1 lordosis (17° to 13°) and L1-L4 from 16° lordosis to 2.5° kyphosis ($p<0.001$). Simulated L4-S1 fusion in standing alignment required significantly greater flexion of L1-L4 to accommodate erect- and slumped-sitting postures (13° and 36°). L4-S1 fusion performed in erect-sitting alignment distributed the postural compensation of L1-L4. Erect sitting to standing and erect to slumped-sitting required 13° extension and 23° flexion respectively.

Discussion/Conclusion: The increased demand on junctional segments to accommodate post-fusion standing and sitting postures may contribute to their mechanical breakdown. Biomechanical analysis suggests the importance of preoperatively assessing flexion-extension range of motion in the patient's upper (L1-L4) lumbar segments to arrive at a patient-specific decision regarding ideal L4-S1 fusion alignment.

RF Paper 28. Utility of Intraoperative Rotational Thromboelastometry in Thoracolumbar Deformity Surgery

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Background/Introduction: Blood loss during surgery for thoracolumbar scoliosis often requires blood product transfusion. Rotational thromboelastometry (ROTEM) has enabled more targeted treatment of coagulopathy, but its use in deformity has received limited study. We investigated whether the use of ROTEM reduces transfusion requirements in a case-control study of thoracolumbar deformity surgery.

Materials/Methods: Data were prospectively collected on all patients receiving ROTEM-guided blood product management during long-segment (7+ level) posterior thoracolumbar fusion procedures at a single institution from April 2015 to February 2016. Patients were matched according to age, fusion segments, number of osteotomies performed, and number of interbody fusion levels with a group of historical controls that did not receive ROTEM-guided therapy. Demographic, intraoperative, and postoperative transfusion requirements were collected on all patients. Univariate analysis of ROTEM status and multiple linear regression analysis of factors associated with total in-hospital transfusion volume were performed, with $p<0.05$ considered significant.

Results: Fifteen patients who received ROTEM-guided therapy were identified and matched with 15 non-ROTEM controls. The mean number of fusion levels was 11 among all patients, with no significant differences between groups in fusion levels, osteotomy levels, interbody fusion levels, or other demographic factors. Patients in the non-ROTEM group required significantly more total blood products during their hospitalization than patients in the ROTEM group (8.5±4.2 units versus 3.71±2.8 units, $p=0.001$). Multiple linear regression analysis showed that use of ROTEM ($p=0.016$) and a lower number of fused levels ($p=0.022$) were associated with lower in-hospital transfusion volumes.

Discussion/Conclusion: ROTEM use during thoracolumbar deformity correction is associated with lower transfusion requirements. Further investigation will better define the role of ROTEM in resuscitation during deformity surgery.

RF Paper 29. Cost Implications of Primary versus Revision surgery in Adult Spinal Deformity

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Background/Introduction: Adult spinal deformity (ASD) is an important problem to consider in the elderly. Though studies have examined the complications of ASD surgery and have compared functional and radiographic results of primary surgery versus revision, no studies have compared the costs of primary procedures to revisions. We assessed the in-hospital costs of primary versus revision surgery in adult spinal deformity patients.

Materials/Methods: The PearlDiver Database, a database of Medicare records, was used in this study. Mutually exclusive groups of patients undergoing primary or revision surgery were identified. Patients in each group were queried for age, sex and comorbidities. 30-day readmission rates, 30-day and 90-day complication rates and postoperative costs of care were assessed with multivariate analysis. For analyses, significance was set at $p < 0.05$.

Results: The average reimbursement of the primary surgery cohort was \$57,078±30,767. Reimbursement of revision surgery cohort was \$52,999±27,658. The adjusted difference in average costs between the two groups is \$4,178±1214 $p < 0.001$. The 30 and 90-day adjusted difference in cost of care when sustaining any of the major medical complications in primary surgery versus revision surgery was insignificant at \$5,522±4,840 $p=0.3$ and \$9,360±5,594 $p=0.1$ respectively. For wound infection cost of 30 and 90-day care was insignificant at \$7,402±8,624 $p=0.4$ and significant at \$17,340±8,366 $p=0.04$ respectively.

Discussion/Conclusion: Patients undergoing primary and revision corrective procedures for ASD have similar readmission rates, lengths of stays and complication rates. Our data demonstrated a higher cost of primary surgery compared to revision surgery though costs of sustaining postoperative complications were similar. This supports the decision to perform revision procedures in ASD patients when indicated as both outcomes and costs are not a hindrance to correction.

RF Paper 30. A Spine in Limbo: Does the Difference Between Standing and Supine Spino-Pelvic Measurements of Patients With Adult Spinal Deformity Affect Surgical Decision Making?

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Background/Introduction: Adult spinal deformity (ASD) surgery requires meticulous surgical planning to achieve proper sagittal and coronal alignment, especially if a corrective osteotomy is

required. Supine and standing preoperative radiographs may help to assess spinal flexibility and aid in surgical decision making.

Materials/Methods: Two independent observers retrospectively recorded spino-pelvic parameters by measuring standing and supine preoperative radiographs of ASD patients who underwent posterior spinal fusion (>5 levels fused extending to the sacrum) with corrective osteotomy. All patients were from a single surgeon at one institution. The difference between standing and supine spino-pelvic measurements were statistically compared. The patients were divided into cohorts that received either a 3-column osteotomy (3CO) or a posterior column osteotomy (PCO), and the change between standing and supine spino-pelvic measurements (Δ SPM) was statistically compared between the two cohorts. Statistical differences were assessed via a Student T-Test with a p value of < 0.05 set as significant.

Results: 48 patients with sagittal spinal deformity underwent posterior spinal fusion with corrective osteotomy (23 3CO vs. 25 PCO). The cohort consisted of 31 females and 17 males with an average age of 62.4 years. For all 48 patients, statistically significant differences were found between standing and supine positions in the following spino-pelvic measurements: pelvic tilt (mean supine angle 14.81° vs. mean standing angle 23.54°, $p < 0.0001$), thoraco-lumbar lordosis (14.13° vs. 26.53°, $p < 0.0001$), thoracic kyphosis (24.85° vs. 32.28°, $p = 0.0018$), pelvic incidence lumbar lordosis mismatch (13.10° vs. 22.57°, $p = 0.0057$). Δ SPM between osteotomy groups (3CO vs. PSO) yielded significantly higher Δ lumbar lordosis in the PCO group (21.05 vs. 10.58, $p = 0.0384$).

Discussion/Conclusion: A statistical difference in certain spino-pelvic measurements was found between supine and standing pre-operative radiographs of ASD patients undergoing PSF with corrective osteotomy. Further analysis revealed that patients receiving a PCO displayed a greater difference in standing vs supine lumbar lordosis compared to 3CO. These results suggest that a more flexible spinal deformity may require a less invasive corrective osteotomy. These measurements could be a useful preoperative tool to aid in planning for deformity correction surgery.

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