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Paper 01

Enhanced Risk Stratification for Short-term Complications Following Elective Vertebral Augmentation for Osteoporotic Vertebral Compression Fractures

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Background/Introduction: For patients with unremitting back pain due to osteoporotic vertebral compression fractures (VCF), vertebral augmentation remains the most utilized procedure. Despite the non-invasive nature of the procedure, studies in the past have reported readmission rates up to 10% and mortality rates up to 2%. Most such studies, however, combined VCFs due to pathologic etiology and osteoporosis and did not differentiate patients based on admission settings. These shortcomings altogether make it difficult for surgeons to stratify risks and to counsel patients for electively scheduled procedure.

Materials/Methods: This is a retrospective analysis of the NSQIP database years 2012-2014. Patients that underwent vertebral augmentations were identified using CPT codes. Those with disseminated cancer and those that underwent recent chemotherapy or radiotherapy were excluded. Patients were divided into three cohorts based on their admission settings: 1) outpatient – defined by those that underwent the procedure with same day discharge; 2) inpatient – those that were admitted inpatient on the day of surgery; 3) pre-procedure hospitalized – those that were already inpatient or were transferred from outside facilities. Patient characteristics and 30-day postoperative outcomes were analyzed and compared between the three groups. Multivariate analyses were used to assess admission settings as a risk factor for adverse outcomes.

Results: A total of 1,023 patients underwent the procedure on outpatient basis; 503 patients were admitted inpatient on the day of surgery; and 149 patients were already in-hospital or were transferred from other facility. Mortality rates were 0.68%, 0.60%, and 2.68%, and readmission rates were 6.26%, 6.76%, and 12.8%, for outpatient, inpatient, and pre-procedure hospitalization cohorts, respectively. Multivariate analyses identified pre-procedure hospitalization as an independent risk factor for UTI (OR=3.98, 95% CI=1.41-11.20, p=0.028), pneumonia (OR=19.69, 95% CI=3.81-101.65, p<0.001), readmission (OR=1.86, 95% CI=1.06-3.26, p=0.032), and mortality (OR=4.49, 95% CI=1.22-16.53, p=0.024).

Discussion/Conclusion: Our findings suggest that the patients who are being transferred from other facilities or those that are already hospitalized are at a higher risk for multiple 30-day postoperative adverse outcomes including readmission and mortality. Specifically, we show that a relatively healthy patient being offered outpatient same-day augmentation has a readmission risk 40% lower and a mortality risk three times lower than previously reported.

Paper 02

Does Day of Surgery Affect Length of Hospital Stay after Spine Surgery

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Background/Introduction: Day of surgery has recently been identified as a factor affecting hospital length of stay in patients undergoing some orthopedic procedures. Whether day of surgery affects length of stay in patients undergoing instrumented spine surgery is not characterized. We conducted a retrospective evaluation to study whether the day of the week the surgery is performed on may be predictive of increased length of stay in patients undergoing elective instrumented spine surgery.

Materials/Methods: A clinical practice database was interrogated for patients undergoing instrumented spine surgery at our single tertiary care hospital. Patients were excluded if they underwent surgery emergently or for a diagnosis of trauma, infection, or neoplasm. Patients were catalogued in seven groups based on the day of the week the surgery was performed, and the groups were compared with respect to hospital length of stay.

Results: A total of 706 patients underwent spine surgery with instrumentation during the selected time frame who met our inclusion and exclusion criteria. No patients underwent elective spine surgery with instrumentation on Sunday. Average age and gender were similar across the days of the week. BMI was slightly higher in patients undergoing surgery on Wednesday compared with other days of the week. Patients who underwent surgery on Saturday had an increased length of stay compared with those undergoing surgery on other days of the week (Monday LOS = 2.7 n=123, Tuesday LOS = 2.4 n=218, Wednesday LOS = 2.9 n=97, Thursday LOS = 2.5 n=180, Friday LOS = 3.1 n=72, Saturday LOS = 5.8 n=16, p = 0.004). When excluding patients who underwent surgery on Saturday, there was no statistically significant difference in length of stay (p=0.17).

Discussion/Conclusion: Average length of stay in patients undergoing elective spine surgery with instrumentation on Saturday is longer than length of stay in patients undergoing surgery on any other day. There is no statistically significant difference in length of stay among patients undergoing surgery on Monday through Friday.

Paper 03

6-month Outcomes for Patients Undergoing Posterior vs Circumferential Surgical Approach for Isthmic Spondylolisthesis

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Background/Introduction: There is no consensus on the optimal surgical approach in treating isthmic spondylolisthesis (IS). Both posterior and circumferential surgical approaches are used.

Materials/Methods: This is an interim analysis of a prospective, multicenter; observational, comparative study of surgically naïve patients with IS grade I-III at a single level between L4 and S1. Subjects are between 18 and 80 years of age, are enrolled at one of 12 sites in North America, and will be followed for two years. Patients with significant scoliosis or cauda equina syndrome are excluded. This interim analysis compares 6-month follow-up outcomes between posterior and circumferential surgical approaches.

Results: So far, 161 patients have been enrolled (115 posterior and 46 circumferential). The majority of patients were operated at L5/S1 (74.6% posterior and 95.7% circumferential). Six-month data is available for 112/126 subjects (84 posterior and 28 circumferential). At this time point, there are no differences in age, race, gender, or the baseline score values between the groups. There has been an improvement in all endpoints in both groups. While pain outcomes trend better in the circumferential group and EQ-5D scores in the posterior group, neither of these is significant. There are no differences between the posterior and circumferential groups in change in Oswestry Disability Index (ODI) (20.0 and 15.5 respectively, $p = 0.2277$); lumbar pain (2.6 and 3.0 respectively, $p = 0.5817$); buttocks and leg pain (3.1 and 3.5 respectively, $p = 0.4701$); EQ-5D Index (0.23 and 0.14 respectively, $p = 0.098$); SF-36 Physical Component Score (PCS) (10.7 and 11.3 respectively, $p = 0.7347$); and SF-36 Mental Component Score (MCS) (7.0 and 3.4 respectively, $p = 0.1855$).

Discussion/Conclusion: Patients in both treatment groups have improved in quality of life, pain, and functional outcomes. The extent of improvement is clinically meaningful. There are no differences in outcomes between the posterior and circumferential surgical approaches; however, this is an ongoing study and the current sample size is insufficient to provide confirmatory evidence.

Paper 04

Endplate Volumetric Bone Mineral Density Is a Predictor for Cage Subsidence following Lateral Lumbar Interbody Fusion: A Risk Factor Analysis

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Background/Introduction: Lateral lumbar interbody fusion (LLIF) is a common procedure used for various spinal conditions. One of the common complications of this procedure is subsidence. Emerging data suggests a lower endplate volumetric BMD (EP-vBMD) as measured by quantitative computed tomography is a risk factor for subsidence following LLIF. Additionally, there is interest in the role that patient factors, such as BMI and diabetes status, plays on bone quality. The purpose of this study is to investigate risk factors for subsidence following LLIF.

Materials/Methods: We reviewed the data of consecutive patients undergoing LLIF from 2014 to 2019 at a single academic institution who had radiological imaging between 5 and 14 months after surgery. We excluded levels with previous instrumentation, previous fractures, and poor imaging quality. Cage subsidence was measured using the grading system devised by Marchi et al. We collected preoperative body mass index (BMI) along with diabetes status. We measured both EP-vBMD and the trabecular vBMD (VB-vBMD). EP-vBMD was defined as the average of the upper and lower endplate vBMDs measured in cortical and trabecular bone with a 5 mm thickness region of interest beneath the cage contacting surfaces. Univariable analysis and multivariable logistic regression analyses with a generalized mixed model were conducted. For the multivariable analysis, we included BMI, diabetes status, EP-vBMD, VB-vBMD, and all trending ($p < 0.20$) factors in univariable analyses as explanatory variables.

Results: Patient demographics and subsidence rates are summarized in Table 1. After adjusting for age, American Society of Anesthesiologists Physical Status, Charlson comorbidity index, LLIF level, and VB-vBMD, standalone status ($p = 0.001$) and EP-vBMD ($p = 0.032$) were associated with subsidence. ROC curve analysis demonstrated a cutoff of 211 kg/m² for EP-vBMD. Ad hoc analysis demonstrated patients with no risk factors had subsidence at 18.3% of levels, 31.1% of levels with one risk factor, and 44.9% of levels with both risk factors ($p < 0.0001$).

Discussion/Conclusion: A decreased local EP-vBMD and the absence of posterior screws are risk factors for subsidence following LLIF. When performing LLIF, the preoperative EP-vBMD measurement should be considered, and in patients with a low EP-vBMD, the addition of pedicle screws could be included to limit the risk of subsidence.

Paper 05

Optimization of a Machine Learning Algorithm for Prediction of Complications After Lumbar Spinal Fusion

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Background/Introduction: Lumbar spinal fusion represents a large and growing fraction of the healthcare system, with a 15-fold increase in cases since 2002. Accurately risk-stratifying patients who undergo lumbar fusion would be of great utility, given the significant cost and morbidity associated with developing major perioperative complications. There is a paucity of accurate and validated prediction models that can be used to pre-operatively risk-stratify patients for lumbar fusion. We aim to develop an optimized machine learning (ML) algorithm for prediction of major perioperative complication after lumbar fusion as well as compare its performance against logistic regression (LR).

Materials/Methods: This is a retrospective cohort study of adult patients who underwent instrumented or non-instrumented lumbar spinal fusion at any California hospital between 2015-2017. The primary outcome was major perioperative complication (i.e. readmission within 30 days, myocardial infarction, pneumonia, systemic infection, surgical site bleeding, wound complications, venous thromboembolism). We utilize AutoPrognosis to develop ML models for prediction of major complications. AutoPrognosis employs an advanced Bayesian optimization algorithm to tune hyperparameters for four ML models: XGBoost, Gradient Boosting, AdaBoost, Random Forest. Discrimination and calibration were assessed using area under the receiver operating characteristic curve (AUROC) and Brier score, respectively. We ranked the contribution of the included variables to model performance.

Results: A total of 38,788 patients met inclusion criteria for this study. There were 4,470 major complications (11.5%). The optimized XGBoost algorithm demonstrates higher discrimination (AUROC: 0.687 ± 0.01) compared to LR (0.675 ± 0.01). It also outperforms the three other ML models. This model was well calibrated (Brier score: 0.094 ± 0.001). Variables important to model performance include angina pectoris, metastatic cancer, musculoskeletal infection, Charlson comorbidity score, and workers' compensation insurance (Table 1).

Discussion/Conclusion: We report an optimized ML algorithm for prediction of major perioperative complications after lumbar spinal fusion. The optimized XGBoost model is well-calibrated and demonstrates superior risk prediction to LR. This tool may identify and address potentially modifiable risk factors, helping to accurately risk-stratify patients and decrease likelihood of major complications. By automating the tuning of model hyperparameters, AutoPrognosis simplifies the development of ML algorithms for clinicians who may not possess expertise in these methods.

Paper 06

Predicting Disc Re-herniation After Lumbar Decompression: A Machine Learning Approach

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Background/Introduction: Surgical treatment of herniated lumbar intervertebral discs is a common procedure worldwide. However, re-herniated nucleus pulposus (re-HNP) may develop, complicating outcomes, and patient management. The purpose of this study was to utilize machine-learning (ML) to predict lumbar re-HNP, whereby a personalized risk factor scoring scheme can be developed as a clinical tool.

Materials/Methods: A retrospective study was conducted at a single center of 2,630 consecutive patients that underwent lumbar microdiscectomy (mean follow-up: 22 months). Various preoperative patient pain/disability/functional profiles, imaging parameters, and anthropomorphic/demographic metrics were noted. An Extreme Gradient Boost(XGBoost) classifier was implemented to develop a predictive model identifying patients at risk for re-HNP. The model was exported to a web application software for clinical utility.

Results: There were 1,608 males and 1,022 females, 114 of whom experienced re-HNP. Primary herniations were central (65.8%), paracentral (17.6%), and far lateral (17.1%). The XGBoost algorithm identified multiple re-HNP predictors and was incorporated into an open-access web application software, identifying patients at low or high risk for re-HNP. the XGBoost algorithm identified duration of symptoms (months), PI-LL mismatch, BMI, age, VAS leg, coronal angulation, and ODI as the top seven predictors of re-HNP. Validation of this model demonstrated excellent model discrimination through: precision (0.62), recall (0.80), accuracy (0.70), F-score (0.70), AUC (0.72), and brier score (0.22). The model is freely available at the following URL: <https://rad-manuscript-v1.herokuapp.com/>.

Discussion/Conclusion: Our predictive modeling via an ML approach of our large-scale cohort is the first study, to our knowledge, that has identified significant risk factors for the development of re-HNP after initial lumbar decompression. We developed the Re-herniation after Decompression (RAD) Score that has been translated into an online screening tool to identify low-high risk patients for re-HNP that would require reoperation. Additional validation is needed for potential global implementation.

Paper 07

Novel Artificial Intelligence Algorithm can Accurately and Independently Measure Spinopelvic Parameters

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Background/Introduction: Preoperative and postoperative sagittal plane assessment is crucial in both spinal deformity and degenerative pathologies. Sagittal malalignment is a well-established cause of poor patient reported outcomes. The currently available spine measurement software programs require users to identify several landmarks prior to calculating parameters, making them time consuming and more reliant upon user experience. There is a growing need for an automated analysis tool that measures pelvic parameters with speed, precision and reproducibility without relying on user identified landmarks. A new AI algorithm has been developed to measure important radiographic parameters independently. Hypothesis: The novel, fully automatic method will have a high agreement with human measurements for lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS).

Materials/Methods: From a total of 200 lateral lumbar radiographs (preoperative and postoperative images from 100 patients undergoing fusion) five independent observers (4 spinal surgeons, 1 senior researcher) digitally measured LL, PI, PT and SS. Their parameters were compared with AI algorithm generated parameters. Mean error (95% confidence interval, standard deviation) and inter-rater reliability were assessed using two-way mixed, single-measure intraclass correlation (ICC). ICC values larger than 0.75 were considered excellent (Cicchetti, Psychol. Assess. 1994).

Results: The novel algorithm's spinopelvic parameter ICC values were excellent in 98% of preoperative and in 95% of postoperative radiographs (PreOp range: 0.85–0.92, PostOp range: 0.81–0.87). Exemplarily, mean errors are smallest for the PI (PreOp: -0.5° (95%-CI: -1.5°–0.6°; Fig. 1); PostOp: 0.0° (-1.1°–1.2°)) and largest for LL (1.3° (0.3°–2.4°); 3.8° (2.5°–5.0°)).

Discussion/Conclusion: Novel AI algorithm automated spinopelvic parameter measurements from spine radiographs have a high degree of accuracy comparable to digital measurements by experts. This algorithm can improve physician workflow efficiency and reduce inter-rater and intra-rater measurement errors.

Paper 08

Effectiveness of Betadine wound Irrigation and Intrawound Vancomycin Powder to Reduce Surgical Site Infection in Posterior Lumbar Spine Surgery

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Background/Introduction: The most common complication of spine surgery is surgical site infection. The aim of this study was to compare the rate of infection with and without the use of Betadine Irrigation with Intrawound Vancomycin Powder to decrease surgical site infections (SSIs) following posterior lumbar spine instrumentation.

Materials/Methods: This a single-institution Prospective study from June 2016 to May 2018. All patients undergoing posterior lumbar spine decompression and instrumentation for spondylolysis, spondylolisthesis and multilevel lumbar canal stenosis. Patients were randomized into the following groups: Group A- Betadine irrigation and intrawound vancomycin powder (BIVP) and Group B-patients receiving no prophylaxis (NONE). Outcome of SSI/wound complication were recorded and analysed.

Results: A total of 224 patients included in this study as per inclusion and exclusion criteria. The BIVP group had 80 patients and 144 in NONE group. Both groups were statistically similar with regard to age, gender, body mass index and comorbidities. There was significant decrease in infection rate in the BIVP group-A (1.25%) compared with the NONE group-B (4.16%). No adverse events were noted in the intervention group associated with the use of betadine and vancomycin powder.

Discussion/Conclusion: Betadine Irrigation and Intrawound Vancomycin Powder led to a significant decrease in SSI rates following lumbar spine surgery. Administration of BIVP is not time consuming and decreased SSI rates.

Paper 09

Lower Hounsfield Units at the Upper Instrumented Vertebrae are Significantly Associated with Proximal Junctional Kyphosis and Failure

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Background/Introduction: Low bone mineral density (BMD) on dual energy x-ray absorptiometry (DXA) is likely a risk factor for proximal junctional kyphosis (PJK) and proximal junctional failure (PJF). However, prior instrumentation and degenerative changes can preclude a lumbar BMD measurement. Hounsfield units (HU) represent an alternative method to estimate BMD via targeted measurements at the intended operative levels. The objective of this study was to determine if patients with lower HU at the upper instrumented vertebrae (UIV) and vertebral body superior to the UIV (UIV+1) are at greater risk for PJK and PJF.

Materials/Methods: A retrospective chart review identified patients at least 50 years of age who underwent instrumented lumbar fusion with pelvic fixation, a UIV from T10 to L2, and a pre-operative CT encompassing the UIV. HU were measured at the UIV, UIV+1, and the L3-L4 vertebral bodies.

Results: One hundred and fifty patients (80 women and 70 men) were included with an average age of 66 years and average follow up of 32 months. Multivariable logistic regression analysis with an AUC of 0.89 demonstrated HU at the UIV/UIV+1 as the only independent predictor of PJK/PJF with an odds ratio of 0.94 (p-value=0.031) for a change in a single HU. Patients with HU at UIV/UIV+1 of <110 (n=35), 110-160 (n=73), and >160 (n=42) had a rate of PJK/PJF of 63%, 27%, and 12%, respectively (p-value <0.001).

Discussion/Conclusion: Patients with lower Hounsfield units at the UIV and UIV+1 were significantly associated with PJK and PJF, with an optimal cutoff of 120 HU that maximizes sensitivity and specificity.

Paper 10

Catastrophic Acute Failure of Pelvic Fixation in Adult Spinal Deformity Requiring Revision Surgery: A Multi-Center Review of Incidence, Failure Mechanisms, and Risk Factors

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Background/Introduction: There are few prior reports of acute failures of pelvic instrumentation. We report the incidence and risk factors for an under-reported cause of early revision surgery in adult spinal deformity.

Materials/Methods: 5 academic medical centers performed a retrospective review of 18 month's worth of consecutive adult spinal fusions extending 3 or more levels, and which included new pelvic screws placed at the time of surgery. Acute pelvic fixation failure was defined as occurring within 6 months of the index surgery and requiring surgical revision.

Results: Failure occurred in 24 of 409 cases (6%), and consisted of either slippage of the rods or displacement of the set screws from the screw tulip head, screw shaft fracture, screw loosening, and/or resultant kyphotic fracture of the sacrum (Figure 1). Reported revision strategies utilized placing new pelvic fixation, and/or multiple rod constructs spanning to the pelvis. 2 patients revised with less than 4 rods to the pelvis sustained a second acute failure, but no secondary failures occurred when at least 4 rods were used. In the univariate analysis, the magnitude of surgical correction was higher in the failure cohort (change in lumbar lordosis, and presence of a 3 column osteotomy, each <0.05). A 3 column osteotomy located at the lower lumbar segments between L4-S1, as opposed to correction at higher levels, particularly increased the risk (OR of 4.5, $P=0.004$). Screws less than 8.5mm in diameter were more likely to fail ($p<0.05$). In the multivariate analysis, either a previously solid L5-S1 fusion or the use of an interbody device at L5-S1 at the index surgery both significantly decreased the risk of acute pelvic fixation failure (OR of 0.32, $p=0.05$). Failures were observed across multiple implant manufacturers.

Discussion/Conclusion: Acute catastrophic failures involved large magnitude surgical corrections, particularly those with 3 column osteotomies located from L4-S1, and likely resulted from high mechanical strain on the pelvic instrumentation. Patients with large magnitude surgical corrections should have anterior structural support placed at the most caudal motion segment, and may benefit from multiple rods connecting to more than 2 pelvic fixation points. If failure occurs, salvage with a multi-rod construct can be successful.

Paper 11

Does Recall Bias Exist in Lumbar Spine Surgery Patients As Reported Through PROMIS Questionnaires?

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Background/Introduction: Surgical outcomes are being increasingly judged on patients' perceptions of the results. Despite the improved quantitative data provided by patient-reported outcomes (PROs), they remain susceptible to confounding factors on patients' interpretations such as recall bias: the inability to accurately recall prior impairment. No studies to date have reported the accuracy of patient recall using PROMIS outcomes after lumbar spine surgeries. The purpose of this study is to determine the presence and extent of recall bias in adult patients after elective lumbar spine surgery.

Materials/Methods: 98 patients who had undergone either lumbar decompression or lumbar decompression and fusion procedures at a single tertiary academic center were identified. All patients had prospectively completed PROMIS Physical Function (PF) CAT and Pain Interference (PI) CAT prior to surgery and at 3 months, 6 months, 1 year and 2 years. Patients, at least 2 years after their index surgery, completed a recall questionnaire comprised of the PF CAT and PI CAT as though it was a time immediately before their surgery. T tests were used to compare recalled PROs with actual baseline PROs. Correlation coefficients were calculated to evaluate the agreement between recalled PROs and baseline PROs. Regression analysis was performed to determine the impact of patient characteristics or clinical factors.

Results: Patient recollection of preoperative status at a minimum of 2 years postoperatively was significantly more severe than baseline preoperative status with mean difference in PF of -1.5 ($p < 0.05$) and PI of 2.1 ($p < 0.01$). There was only moderate correlation between recalled and baseline scores with regards to PF ($r=0.52$) and PI ($r=0.38$). No significant differences on recalled PROs were found based on age, gender, time between surgery and recalled outcomes, and duration of symptoms before surgery.

Discussion/Conclusion: Our data indicate that patient recall of preoperative status after lumbar surgery is significantly different than actual baseline preoperative status as measured by PROMIS PF and PI scores with only moderate correlation existing between the two. Patients' interpretations of improvement after surgery may be impacted by significant recall bias. This may have an impact on patient satisfaction and perceived value of lumbar spine surgery.

Paper 12

Retrospective Comparison of Patient Education and Reported Outcomes in Minimally Invasive Versus Open Spinal Procedures

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Background/Introduction: Minimally Invasive Spine (MIS) surgery has become increasingly prevalent and has advantages to open surgery. There is insufficient literature to evaluate how the availability of MIS surgery influences patients' decision-making process. The goal of this study was to analyze patients' understanding and preferences for a minimally invasive surgery as compared to individuals who underwent an open surgery for the same spinal disorders.

Materials/Methods: A survey was administered to patients who received a hemilaminectomy or transforaminal lumbar interbody fusion. All eligible patients were stratified into two cohorts based on the use of minimally invasive techniques. Each cohort was administered a survey that evaluated patient perceptions, preferences, understanding, and outcomes. The open surgery survey additionally asked if patients would prefer MIS over open if it had been an option. Data was evaluated using inferential statistics.

Results: 146 patients (81 MIS, 65 open) completed surveys. There was no difference in time from surgery to survey (2.2 vs. 2.0 years; $p=0.39$) or sex ($p=0.51$). The MIS group was younger (52.7 vs 60.7 years; $p<0.01$). More MIS patients reported that their technique influenced their surgeon choice ($p<0.01$) and increased their confidence ($p<0.00001$). There was a trend towards the MIS group being less informed about what their specific technique was used for in their surgery ($p=0.07$). The MIS cohort reported at least 1 advantage to their surgical technique ($p<0.00001$) and less reported any disadvantages ($p<0.00001$). Less MIS patients reported any negative impacts associated with their surgical technique ($p<0.00001$). If surgery was repeated, more MIS patients would desire the same technique ($p<0.00001$) and 98.8% of MIS and 86.2% of open cohorts reported a preference for MIS.

Discussion/Conclusion: Overall, patients have positive post-operative perceptions for MIS surgery. Patients who received a MIS approach more frequently sought out their surgeons, were more confident in their procedure, and reported less perceived negative impacts than those of the open surgery cohort. The MIS cohort was less likely to understand what the specific technique was used for in their procedure. Both groups would prefer MIS surgery in the future. Surgeons should emphasize operative differences in the techniques during consultation to enhance patient education.

Paper 13

Do Patients Accurately Recall Symptoms Pre- and Post-Lumbar Epidural Steroid Injection? A Cohort Study of Recall Bias in Patient-Reported Outcomes

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Background/Introduction: Although patient-reported outcomes (PROs) have become important in the evaluation of spine surgery patients, the accuracy of patient recall of pre or post-intervention symptoms following lumbar epidural steroid injection remains unknown. Our goal is to characterize the accuracy of patient recollection of back/leg pain following lumbar epidural steroid injection and identify factors that impact recollection.

Materials/Methods: We recorded numeric pain scores for patients undergoing lumbar epidural steroid injections. Baseline pain scores were obtained prior to injection, 4 hours and 24-hours post-injection. At least 2 weeks post-injection, patients were asked to recall their symptoms pre-injection, 4 hours, and 24-hours post-injection. Actual and recalled scores were compared using paired t-tests. Multivariable linear regression was used to identify factors that impacted recollection.

Results: Sixty-one patients with a mean age of 61.4 years (56% female) were included. Compared to their pre-injection pain score, patients showed considerable improvement at both 4 hours [Mean Difference (MD) = 2.18, 95% Confidence Interval (CI) 1.42 to 2.94)) and 24 hours (MD = 2.64, 95% CI 1.91 to 3.34) post-injection. Patient recollection of pre-injection symptoms was significantly more severe than actual (MD = 1.39, 95% CI 4.82 to 6.08). The magnitude of recall bias was moderate to severe and exceeded the minimal clinically important difference (MCID). Patient recollection of symptoms was also more severe than actual at 24 hours (MD = 0.63, 95% CI -1.17 to -0.07), mild magnitude of bias that did not exceed MCID. Patient recall of injection effect was also increased from actual effect. No significant recall bias was noted on patient recollection of post-injection symptoms at 4 hours (MD = 0.41, 95% CI -1.05 to 0.23). Linear regression models for differences between actual and recalled pain scores reveal that for recall at 4 hours post-injection, older patients were better at recalling pain.

Discussion/Conclusion: Relying on patient recollection does not provide an accurate measure of pre-injection status after lumbar epidural steroid injection. These findings support previous studies indicating that relying on patient recollection does not provide an accurate measure of pre-intervention symptoms. Patient recollection of post-intervention symptoms, however, may have some clinical utility and requires further study.

Paper 14

A Novel Lumbar Total Joint Replacement as an Alternative to Fusion for Degenerative Lumbar Conditions: A Comparative Analysis of Patient-Reported Outcomes at One Year

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Background/Introduction: Effective alternatives to degenerative lumbar fusion have remained elusive. Anterior total disc replacement does not address facet pathology or central/recess stenosis; thus indications are limited. There is a need for a posterior-based motion-preserving option that allows for neural decompression, facetectomy, and reconstruction of the disc and facets. The purpose of this study was to compare outcomes for a novel, all-posterior, lumbar total joint replacement (LTJR) against transforaminal lumbar interbody fusion (TLIF) for degenerative pathology.

Materials/Methods: Retrospective analysis was conducted on 148 adult TLIF patients who were propensity matched to the 52 LTJR patients for a total sample of 200. Oswestry Disability Index (ODI) and Numeric Rating Scale (NRS) for back and leg pain were compared preoperatively, 3 months and 1 year after surgery. Trauma, tumor, and infection were excluded. Multivariable regression was done to compare the one-year results as measured by three different standards to assess procedure success.

Results: At 3 months, both the LTJR and TLIF cohorts showed significant improvements in ODI and NRS back and leg pain. At one year, the LTJR cohort showed continued improvement in ODI, NRS back pain, and NRS leg pain, while the TLIF group showed a plateau for ODI and a worsening trend in back and leg pain. On multivariable regression, LTJR was shown to provide 4.0 times greater odds of achieving the minimal clinical symptom state in disability and pain (ODI < 20%, NRS back and leg pain < 2) and 3.6 and 2.6 times greater odds of achieving minimal clinically important difference (MCID) (30% reduction in ODI) and substantial clinical benefit (18% reduction in ODI) as compared to TLIF.

Discussion/Conclusion: Here we present a comparison of 52 patients undergoing a novel, posterior-based LTJR for the lumbar spine versus TLIF for degenerative pathology. At one year, the LTJR cohort showed significant improvement in ODI and NRS back and leg pain leg pain as compared to TLIF. These results suggest that motion preservation using this novel LTJR may be a potential improvement over TLIF for degenerative conditions. Longer term follow-up is underway to evaluate the durability of this procedure and its impact on adjacent segments.

Paper 15

Does rod attachment induce significant strain in lumbo-sacral fixation?

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Background/Introduction: The lumbosacral junction in long segment pedicle screw-rod instrumentation (PSR) is highly susceptible to fixation failure. Surface strain can be studied during loading conditions to evaluate stress and construct vulnerabilities. Rod attachment has the potential to induce significant rod and screw pre-strain which may predispose failure. However, this has not been previously studied.

Materials/Methods: 12 cadaveric specimens were instrumented with L2-Ilium PSR instrumentations. Contoured CoCr rods and sacral screws were instrumented with uni-axial strain gauges and used to record strains during sequential rod-to-screw tightening (pre-strains). The same instrumented constructs were then immediately tested in a 6DOF robot under continuous loading to 7.5 Nm in multidirectional bending, while recording instrumentation test strains. Absolute values of rod bending strains and sacral screw bending moments during 1st and 2nd rod attachment (pre-strains) and during in vitro loading (test strains) were compared using One-way RM-ANOVA followed by Holms-Sidak paired analysis. Statistical significance was set at $p < 0.05$.

Results: The mean first (171 uE) and second (322 uE) rod attachment pre-strains were comparable to the mean test strains during flexion (265 uE) and extension (315 uE, $p \geq 0.19$). Although the first and second rod pre-strains were not significantly different, the mean second rod attachment pre-strain was significantly greater than the mean test strains during lateral bending (51 uE, $p = 0.02$) and axial rotation (85 uE, $p = 0.03$). The mean sacral screw bending moments (screw pre-strains) during the first (1.03 Nm) and second (1.39 Nm) rod attachment were significantly greater than the screw strains during flexion (0.27 Nm), extension (0.24 Nm), and lateral bending (0.16 Nm, $p \leq 0.01$). There were no significant differences between sacral screw pre-strains during first and second rod attachment and screw test strains during axial rotation (0.79 Nm, $p \geq 0.25$).

Discussion/Conclusion: The magnitude of spinal rod and sacral screw pre-strains imposed during in vitro rod-screw attachment of seemingly well-contoured rods in lumbosacral fixation (L2-Ilium instrumentation) are comparable to, and at times, greater than strains experienced during in-vitro bending. Spine surgeons should be aware of the biomechanical consequences of rod contouring and attachment on construct vulnerability.

Paper 16

Posterior Thoracic Spine Construct Stiffness Under Cyclic Load: An In Vitro Biomechanical Comparison of Hooks vs. Pedicle Screws

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Background/Introduction: Proximal Junctional Kyphosis (PJK) is a well-recognized complication following long posterior thoracic spine (TS) construct instrumentation, however the mechanism of PJK is poorly understood. The purpose of this study was to investigate the effect of different fixation techniques in long TS constructs on the upper instrumented vertebra (UIV) and supra-adjacent level (UIV+1). Our hypothesis was that there would be increased motion supra-adjacent to the construct after cyclic load and that this would differ between constructs.

Materials/Methods: Twenty-seven thoracic functional spine units (FSUs), T3-T6, T7-T10 and T11-L2, were divided into three groups. The first group was instrumented with bilateral pedicle screws, the second group was instrumented with bilateral pedicle screws with bilateral transverse process (TP) hooks at the UIV, and the third group was tested with bilateral pedicle screws with sequential compromise of the posterior elements. Specimens were biomechanically tested intact, following a simulated long construct bilateral pedicle screw instrumentation, and after cyclic loading to 2Nm in flexion-extension for 20,000 cycles at 1Hz. FSUs were loaded in flexion-extension (FE), lateral bending (LB), and axial rotation (AR). 3-D kinematics were recorded to evaluate range of motion via motion capture. ROM at the SAL measurements were compared to intact specimens.

Results: There was no statistically significant difference in ROM between groups immediately following instrumentation. After cyclic motion testing, the hook group had a mean 29.4% increase in FE at UIV+1 whereas the pedicle screw group had an increase of 76.6% compared to intact anatomy ($p < 0.05$). The posterior element violation group showed an increased FE of 49.9% and 62.19% with sectioning of the facet joints and interspinous ligament compared to native anatomy respectively prior to cyclic testing.

Discussion/Conclusion: Bilateral pedicle screws at the UIV led to significantly increased motion at the UIV+1 compared to a construct with bilateral TP hooks at the UIV after cyclic loading. This is likely due to the increased rigidity of pedicle screws compared to TP hooks leading to a “softer” transition between the TP hook construct and the native anatomy at the UIV. Surgeons should consider TP hooks at the UIV to potentially decrease PJK risk.

Paper 17

Analysis of Vertebral Body Structure and Biomechanical Integrity in a Newly Developed Radiation-induced Vertebral Compression Fracture Model: Comparison of Single-dose and Hypo-fractionated Focused Radiation

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Background/Introduction: Vertebral compression fracture (VCF) is a common toxicity of spine stereotactic body radiation therapy (SBRT) often requiring invasive procedures. An in vivo model is crucial to fully understand how radiation treatment alters vertebral integrity and biology at various dose fractionation regimens. We present a clinically-relevant animal model to analyze the effects of localized, high-dose radiation on vertebral microstructure and mechanical integrity, utilizing the small animal radiation research platform (SARRP).

Materials/Methods: NZW rabbits were positioned inside the SARRP (Xstrahl) to administer the radiation treatment. A customized collimator was utilized to irradiate the L5 spine level exclusively. According to the applied radiation regimen, rabbits were divided into three experimental groups: [1] Single 24-Gy dose; [2] Hypofractionated in three 8-Gy doses on three consecutive days; and [3] Nonradiated or Control. Rabbits were euthanized at a 6-month time point post-irradiation, and their lumbar vertebrae harvested for radiological, histological, and biomechanical testing.

Results: Localized single-dose radiation led to loss of vertebral bone volume and decreased trabecular number and a subsequent increase in trabecular spacing and thickness at L5. Hypofractionation of the radiation dose similarly led to reduced trabecular number and increased trabecular spacing and thickness, yet preserves normalized bone volume at L5. Single-dose irradiated samples displayed lower fracture loads and stiffness compared to those receiving hypofractionated irradiation and controls. Hypofractionated and control groups exhibited similar means for fracture load and stiffness. For all samples, bone volume, trabecular number, and spacing were positively correlated with fracture loads and Young's modulus ($p < .05$). Hypocellularity was observed in both irradiated groups' bone marrow, but only the hypofractionated group conserved osteogenesis features.

Discussion/Conclusion: Single-dose radiation was detrimental to a greater degree than hypofractionation for the micro-architectural, cellular, and biomechanical characteristics of irradiated vertebral bodies. Correlation between radiological measurements and biomechanical properties supported the reliability of this animal model of radiation-induced VCF which can be applied to future studies of preventative measures.

Paper 18

Do Differences in Segmental Angle of Single Level Posterior Lumbar Fixation Affect Adjacent Level Biomechanics? Cadaveric Study of Range of Motion and Optical Disc Strain.

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Background/Introduction: Single-level lumbar fusion had been performed for years with little concern with final segmental angle. However, subtle changes on a segmental lordosis may mechanically impact adjacent level motion and stress triggering a domino effect of adult spinal deformity with sagittal imbalance and failed back fusion. The objective of this study was to quantify adjacent segment motion and disc surface strain changes with altered segmental angles.

Materials/Methods: Seven human specimens (L2-Sacrum) underwent L4-L5 pedicle screws and rods fixation and were tested in neutral angle (NEU), imposed +5° lordosis (LOR) and -5° kyphosis (KYP). Pure moments (7.5 Nm) were applied in flexion; extension; lateral bending (LB); axial rotation (AR) followed by 400 N of compression (C) alone, and combined with pure moments. Range of motion (ROM) and strain using digital image correlation (DIC) system were tracked. Principle maximum (E1) and minimum (E2) strains were analyzed within four quarters (Figure) on the lateral disc surface antero-posteriorly (Q1; Q2; Q3 and Q4). Data were analyzed using one-way RM ANOVA.

Results: At the upper adjacent level, significant increase in ROM was observed in both conditions KYP and LOR compared to NEU in flexion ($p=0.001$; $p<0.001$) and extension ($p=0.02$; $p=0.009$). Increased ROM was also observed in LOR compared to NEU ($p=0.026$) and compared to KYP ($p=0.004$) during compression. KYP had increased ROM compared to NEU and LOR ($p=0.031$; $p=0.025$) in C+EX. LOR had increased E1 in Q3 compared to NEU in RLB ($p=0.041$); LOR and KYP had decreased E1 in Q3 compared to NEU in C ($p=0.002$; $p=0.03$). LOR had decreased E1 in Q3 compared to NEU ($p=0.013$) while KYP had increased E1 in all quartiles and increased E2 in Q2 compared to LOR in C+FL ($p\leq 0.047$). KYP decreased E1 in Q3 ($p=0.021$) and E2 in Q1 ($p=0.006$) compared to NEU while LOR had decreased E1 in Q3 ($p=0.008$) compared to NEU in C+EX.

Discussion/Conclusion: Lumbar spine mono-segmental fixation with 5 degrees offset from neutral/native individual segmental angle increases the motion at adjacent level and can also induces disk strain in most direction of loads with final angle in kyphosis being worse than in lordosis.

Paper 19

Effects of Preoperative Lower Urinary Tract Symptoms on Risk of Postoperative Urinary Retention After Elective Lumbar Spine Surgery

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Background/Introduction: No study has examined the relationship between preoperative lower urinary tract symptoms (LUTS) and risk of postoperative urinary retention (POUR) in elective lumbar spine surgery patients. We investigated the extent to which POUR occurred among those with or without preoperative LUTS in patients undergoing elective lumbar spine surgery.

Materials/Methods: A prospective cohort study was performed on adult patients undergoing elective lumbar spine surgery at our institution between July 2017 and March 2020. Patients completed the 7-item International Prostate Symptom Score (IPSS) at their preoperative visit. LUTS was defined as an IPSS score ≥ 8 . The sample was restricted to patients discharged > 8 hours after surgery. The outcome of POUR was defined as the insertion of a Foley or straight catheter occurring between the anesthesia stop time and time of admission discharge. The association of LUTS and risk of POUR was estimated with risk ratios (RR) and 95% confidence intervals (CI) from multivariable Poisson regression with a robust variance estimate adjusted for age, sex, and intraoperative Foley catheter use.

Results: The analytic cohort included 476 patients ages 18-89 years, 296 undergoing lumbar fusion and 180 undergoing decompression. The mean (standard deviation) age was 60.5 (14.0) years and 251 (52.7%) were women. Preoperative LUTS prevalence was 50.0% in the cohort, 48.9% among men, and 51.0% among women. During the postoperative period, 25 (10.5%) of 238 without LUTS and 36 (15.1%) of 238 with LUTS developed POUR. For fusion surgery, the multivariable RR was 1.4 (95% CI: 0.8, 2.4). Separating by sex, the multivariable RR was 1.6 (95% CI: 0.6, 4.2) among men and 1.2 (95% CI: 0.6, 2.6) among women. Results for decompression surgery were obtained for men only because POUR occurred too infrequently among women for analysis. For decompression surgery, the multivariable RR was 1.6 (95% CI: 0.7, 3.8) among men.

Discussion/Conclusion: Among men but not women, preoperative LUTS seems to be associated with a higher risk of POUR for both lumbar fusion and decompression surgeries. These clinically significant results suggest that screening men for LUTS before elective lumbar spine surgery could help identify patients in need of additional postoperative management.

Paper 20

Body Mass Index Increases the Cost and Burden of Care in Pediatric Patients with Back Pain

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Background/Introduction: The prevalence of childhood obesity has rapidly increased over the last several decades, and chronic low back pain (LBP) is becoming more prevalent in the pediatric population. With clinic visits on the rise, the impact of pediatric obesity on the number of office visits and associated costs in chronic LBP patients remains unknown.

Materials/Methods: From 2009 to 2018, pediatric patients with a chief complaint of back pain were retrospectively examined. Demographic and clinical data was recorded from the electronic medical record. Patients between the ages of 10 and 19 were included, and patients treated for scoliosis, neoplasms, trauma, or infections were excluded. Total number of appointments was used as a proxy for burden of disease, and outliers for numbers of visits were removed. BMI was calculated using metrics at the last recorded visit, and age and gender adjusted weight-percentiles were calculated using CDC growth charts. Underweight, normal-weight, overweight and obese were defined as per CDC guidelines. Underweight and normal-weight individuals were grouped together for analysis. One-way ANOVA and Tukey post-hoc were used to assess the relationship between BMI and number of appointments.

Results: 289 patients met inclusion criteria, 53.3% (n=154) were female, and mean age was 15.7 ± 2.3 years. Individuals were classified as underweight 1.0%(n=3), normal-weight 65.4% (n=189), overweight 19.0% (n=55), or obese 14.5% (n=42). The mean number of office visits was 2.2 ± 1.8. Under and normal-weight patients had an average of 2.0 visits (SD=1.5), overweight patients averaged 2.1 (SD=1.7), and obese patients averaged 3.3 (SD=2.8). One-way ANOVA revealed a difference in number of appointments between weight classification groups (p<0.001), and Tukey post-hoc analysis revealed that the differences lie between the obese and under/normal-weight individuals (p=0.001) and between obese and overweight individuals (p<0.002).

Discussion/Conclusion: The number of visits to the orthopedist for back pain is correlated with CDC weight-percentiles. With a general lack of physical activity combined with restrictions associated with the COVID-19 pandemic, obesity among children will increase and further compound the physical and monetary costs of LBP. Future studies should target additional factors that influence the burden of LBP in the pediatric population and assess monetary costs.

Paper 21

Smoking Does Not Inhibit Meaningful Long-Term Improvement following Minimally Invasive Transforaminal Lumbar Interbody Fusion

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Background/Introduction: Implications of smoking for achieving meaningful improvement following lumbar fusion are unclear. Our study aims to assess the impact of smoking on achievement of a minimum clinically important difference (MCID) following minimally invasive transforaminal lumbar interbody fusion (MIS TLIF).

Materials/Methods: Data for this study was obtained via a retrospective review of a prospective surgical registry for primary, elective, single-level MIS TLIF procedures. Patient reported outcome measures (PROM) including visual analogue scale (VAS) for back and leg pain, Oswestry disability index (ODI), 12-item short form physical component summary (SF-12 PCS), and Patient-Reported Outcomes Measurement Information System physical function (PROMIS PF) were administered at preoperative and postoperative timepoints up to 2-years. Achievement of MCID was determined by comparing PROM improvement to the following previously established values: VAS back=2.2, VAS leg=5.0, ODI=8.2, SF-12 PCS=8.1, PROMIS PF=4.5. Patients were grouped according to their self-reported preoperative smoking status into smokers and non-smokers. Demographic and perioperative characteristics, mean PROM scores, and MCID achievement were compared between groups.

Results: A total of 587 TLIF patients were included with a mean age of 51.2 years. 104 identified as smokers and 483 as non-smokers, 37.1% were female, and 48.7% were obese. Age ($p<0.001$), insurance status ($p=0.001$), and recurrent herniated nucleus pulposus ($p=0.035$) were significantly associated with smoking status. PROM scores were significantly poorer for smokers for VAS back at 6-months ($p=0.012$) and 1-year ($p=0.006$), ODI at 6-weeks ($p=0.019$), 6-months ($p=0.011$), 1-year ($p=0.038$), SF-12 PCS at 6-months ($p=0.043$), and PROMIS PF at 2-years ($p=0.017$). MCID achievement was significantly associated with smoking status for VAS back at 6-weeks ($p=0.026$) and 6-months ($p=0.036$), and ODI at 1-year ($p=0.022$) only.

Discussion/Conclusion: Patients who smoked reported worse back pain, disability, and physical function at intermittent timepoints. However, overall rates of MCID achievement did not significantly vary based on smoking status. Smokers may be able to achieve meaningful improvement at similar levels as non-smokers following MIS TLIF.

Paper 22

Socioeconomic Neighborhood Characteristics of Patients who Underwent Spine Reoperation Between 90 Day - 2 Years Post-Op

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Background/Introduction: Socioeconomic status (SES) underlies three prominent determinants of health inequity: access and quality of care, environmental exposure, and health behavior. We sought to analyze how the qualities of a patient's community, their access to healthcare, and socioeconomic status affect their risk of readmission between post-operative day (POD) 90- and 2-years post-op.

Materials/Methods: Utilizing our prospectively collected institutional database, 3,079 patients undergoing spinal surgery between 2012 and 2018 were retrospectively identified. Readmission status was segregated into the following intervals: (1) no readmission; (2) readmission between post-operative day (POD) 90 and 180 (POD180); (3) readmission between POD 180 – 2 years. During the year that each patient underwent surgery, social and economic neighborhood determinants were calculated for each patient specific zip code using publicly available databases. Differences in socioeconomic measures when compared to non-readmitted patients were discerned using the Kruskal–Wallis test followed by Dunn's post-hoc tests.

Results: Patients readmitted between POD90-180 resided in neighborhoods where the GINI Income Inequality Index Score was 2.13% higher (0.48 vs 0.47; $P=0.03$) and families living below the federal poverty line (FPL) were 28.6% more prevalent (13.57% vs 10.55%; $P=0.01$). The racial distribution of those neighborhoods was 28.3% more non-white (39.2% vs 29.7%; $P=0.02$), and a significantly greater proportion of residents cited experiencing chronic physical distress ($P=0.04$), mental distress ($P=0.01$) and encountering chronic activity limitation due to infrastructural barriers ($P=0.04$). In addition to those same significant differences observed at POD180, patients readmitted by 2 years additionally had 15.7% lower surrogate incomes than those who were never readmitted (\$42,687.76 vs \$50,640.42, $P=0.0027$). In particular, at 180D, Black/African American readmitted patients had 20.9% lower surrogate income (\$48,078 vs \$38,007; $P=0.013$) and resided in neighborhoods with 159.9% higher prevalence of families residing below the FPL (23.7% vs 9.1%; $P<0.0001$), 53.8% lower median household value (\$132,527 vs \$287,137; $P<0.0001$), and 8.8% more patients per primary care provider (PCP) (1.36 vs 1.25; $P=0.0013$).

Discussion/Conclusion: Patterns of racial and ethnic segregation in urban environments have given rise to significant disparities in access and quality of care and environmental exposure. These findings suggest that socioeconomic manifestations impacts a patient's, holistic health and post-operative improvement.

Paper 23

The Effect of L5-S1 Degenerative Disc Disease on Outcomes of L4-L5 Fusion

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Background/Introduction: Increased motion of the adjacent caudal segment and greater biomechanical forces at the adjacent level in isolated L4-L5 fusion has led to concerns regarding a greater propensity towards revision surgery due to secondary adjacent segment disease (ASD). The objective of the study was to investigate the clinical relevance of pre-operative caudal adjacent segment disc degeneration in patients undergoing isolated L4-5 fusion to determine if there is a threshold of degeneration at which a primary L4-S1 fusion would be warranted.

Materials/Methods: A retrospective observational cohort study of patient who underwent isolated L4-L5 fusion between 2014 and 2019 was conducted. Those who did not have a minimum follow-up of 1 year were excluded. The ratio at the anterior, middle, and posterior disc of the rostral control disc height (DH) to caudal segment DH was used to quantify preoperative degenerative disc disease and to assess the influence of preoperative disk degeneration on functional disability. Patients were stratified based on who achieved Minimal, Moderate, and Severe ODI score on postoperative assessment and their preoperative disc height ratios (DHR) and Pfirrmann grades were compared. The same was done comparing patients who met the MCID for patient reported outcomes (PROM). An AUC curve was generated from preoperative disc degeneration ratio with each PROM to detect an inflection point.

Results: A total of 169 patients were studied with an average follow-up of 2.11 years. All patients demonstrated a significant improvement in all PROMs after surgery. When categorizing patients based on the severity of post-operative ODI scores, there were no pre-operative differences in the L5-S1 Pfirrmann grading (Minimal: 3.03, Moderate:2.88, Severe:3.00, $p=0.947$) or DH ratios (Minimal:1.50, Moderate:1.49, Severe:2.9, $p=0.156$). When categorizing patients-based achievement of the MCID, there were no radiographic differences in pre-operative L5-S1 Pfirrmann grade or DHR for ODI, VAS Back, VAS Leg, MCS-12, or PCS-12. AUC analysis was not able to identify a pre-operative DHR threshold that reflected worse MCID.

Discussion/Conclusion: The results of this study demonstrate that preoperative adjacent caudal segment degenerative disc disease does not significantly impact clinical outcomes of L4-5 fusion.

Paper 24

Effect of Advanced Age on Outcomes of Lateral Lumbar Interbody Fusion (LLIF)

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Background/Introduction: Lateral lumbar interbody fusion (LLIF) was developed to minimize soft tissue trauma and reduce the risk of vascular injury; however, there is little evidence regarding the effect of advanced age on outcomes of LLIF. The goal of this study was to assess the impact of advanced age on pain, disability, and complication and reoperation rates after LLIF.

Materials/Methods: LLIF cases between 2009 and 2019 from a single institution with minimum 6-month follow-up were reviewed. Patients <18 years and those undergoing surgery for tumor or trauma were excluded. Baseline demographics and comorbidities, number of levels fused, and adjacent level procedures were collected. The primary outcomes were the pre- to postoperative changes in Numeric Pain Rating Scale (NPRS) for back and leg pain and the Oswestry Disability Index (ODI). Operative time, estimated blood loss (EBL), length of stay (LOS), perioperative and 90-day complications, unplanned readmissions, and reoperations were also evaluated. Relationships with age were assessed both with age as a continuous variable and by segmenting by age <70 vs 70+.

Results: In total, 279 patients were included in the final cohort [age 68±13 years, 57% female, median follow up 15 months (interquartile range 12-34)]. Age was not related to the pre to postoperative improvements in back and leg NPRS and ODI. Operative time, EBL, LOS, perioperative and 90-day complications, unplanned readmission, and reoperation rates also showed no relationship with age. Older patients were more likely to be male, have higher CCI, and have more adjacent level procedures. After multivariable risk adjustment, increasing age was associated with greater improvements in back and leg NPRS but was not associated with rates of complication, readmission, or reoperation. For a 10-year increase in age, the decrease in back and leg NPRS were 0.71 (95% CI 0.16, 1.25; p=0.011) points and 0.89 (95% CI: 0.19, 1.59; p=0.013) points greater, respectively.

Discussion/Conclusion: LLIF is a safe and effective procedure in the elderly population. Advanced age is associated with larger improvements in postoperative back and leg pain. Surgeons should consider the benefits of LLIF and other minimally invasive techniques when evaluating elderly candidates for lumbar fusion.

Paper 25

Percutaneous Lumbopelvic Fixation for Sacral Fractures with Spinopelvic Dissociation - 2-Year Outcomes

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Background/Introduction: Sacral fractures with spinopelvic dissociation patterns are highly unstable injuries. Reestablishing the anatomic relationship of the pelvis to the axial spine and achieving mechanical stability, while preserving neurological function, are the main treatment goals. Lumbopelvic fixation is typically performed through a single posterior extensile midline incision from L4 to the pelvis. Surgery can be lengthy with major blood loss, and associated with wound complications. In an effort to minimize the morbidity of surgery while achieving stable fixation, we developed a percutaneous lumbopelvic fixation technique. The purpose of this study is to determine the 2-year outcomes and complications of percutaneous lumbopelvic fixation in the treatment of highly unstable sacral fractures with spinopelvic dissociation patterns.

Materials/Methods: Data were collected prospectively including blood loss, fluoroscopy time, screw accuracy, wound complications, neurological status including bowel and bladder function, fracture reduction, instrumentation failure, fracture healing, and patient functional status using established outcomes questionnaires (SF-12, ODI, and WHO-5).

Results: Clinical follow-up in 20 patients averaged 809 days (2.2 years) and radiographic follow-up averaged 679 days (1.9 years). Across all 20 patients surgical duration averaged 2 hours 24 minutes and blood loss averaged 195 mL, and there was 1 deep wound infection. Post-operative CT scans (N=18) assessed 135 screws and showed an intra-osseous screw accuracy rate of 98%. Fracture reductions were attempted in 10 patients and achieved in 8, including anatomic reduction of a completely displaced and shortened fracture (traumatic spondyloptosis). Kyphosis improved from 11° pre-operatively to 6° post-operatively, and displacement improved from 39% to 23% (Table 1). One fracture non-union occurred and was treated successfully with bone grafting and SI screw placement. One patient did not regain normal bladder function but no other patients developed neurogenic bladder dysfunction because of their injury. The SF-12v2 average Physical Composite Score averaged 44 (range 26-51) and the Mental Composite Score averaged 51 (range 30-68). The average ODI score was 17% (range 0%-44%). The average WHO score was 66% (range 8%-96%).

Discussion/Conclusion: Percutaneous lumbopelvic fixation is a safe and effective option for stabilization of highly unstable sacral fracture patterns with associated spinopelvic dissociation. Some residual disability is expected after these severe injuries.

Paper 26

A Biomimetic Bone Graft with Controlled Growth Factor Delivery: Creation of a Superior “Collagen Sponge” for Spinal Fusion

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Background/Introduction: Limitations of the Infuse™ Bone Graft (Medtronic; Memphis, TN) stem from its use of a simple collagen sponge, which has minimal bone-promoting capacity on its own and does little to control the delivery of recombinant human bone morphogenetic protein-2 (rhBMP-2). We developed a new scaffold (BiomimPDA) to overcome the limitations of the collagen sponge, and then directly compared it to the collagen sponge using different concentrations of rhBMP-2 in a rat model of spinal fusion.

Materials/Methods: A biomimetic bone graft comprising homogeneously dispersed extracellular matrix particles and calcium phosphates was created. This material was then activated with dopamine to confer controlled growth factor delivery. Sixty male Sprague Dawley rats were assigned equally and randomly to one of six groups, which differed by bone graft treatment: 1) collagen + 0.2 microgram rhBMP-2/side, 2) collagen + 2 microgram rhBMP-2/side, 3) collagen + 20 microgram rhBMP-2/side, 4) BiomimPDA + 0.2 microgram rhBMP-2/side, 5) BiomimPDA + 2 microgram rhBMP-2/side, and 6) BiomimPDA + 20 microgram rhBMP-2/side. All animals underwent posterolateral inter-transverse process L4-L5 spinal fusion using the assigned bone graft. Animals were euthanized at the 8-week postoperative time point, and their lumbar spines were examined by microcomputed tomography (micro-CT). Spinal fusion was defined as continuous bridging bone bilaterally across the fusion site via micro-CT.

Results: All 60 rats survived until the end of the study. The fusion rate was 100% (10/10 spines) in all groups, except for in Group 1 (70%) and Group 5 (90%). In Group 5, the single failed fusion was attributed to an intraoperative error on one side; a unilateral fusion was observed. Via morphometric analysis, significantly greater bone volume, percent bone volume, and trabecular number were observed among animals treated with BiomimPDA versus collagen at each of the three concentrations of rhBMP-2 ($p < 0.01$ for each).

Discussion/Conclusion: We developed a new scaffold that promotes bone formation on its own and offers controlled delivery of rhBMP-2, effectively overcoming the primary limitations of the Infuse™ Bone Graft. Our early data suggest that this new scaffold is at least as effective as the collagen sponge and may require lower doses of rhBMP-2 for spinal fusion.

Paper 27

Development of an Electroactive Composite for Use in Lumbar Fusion via Functionalization of an rh-BMP2 Loaded Absorbable Collagen Sponge Using Poly(3,4-ethylenedioxythiophene)

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³ **TO BE FIXED**

Background/Introduction: The prevalence and overall cost of spinal fusion procedures have continuously increased over recent decades. Implantation of absorbable collagen sponges (ACS) loaded with rh-BMP2 is a popular practice used to encourage fusion and enhance patient outcomes. While this technology has been successful, the efficacy of this approach may still be improved by increasing the biomimetic properties of ACS. One potential way to accomplish this is increasing material electroactivity. Although the collagen itself is non-conductive, identifying a method to instill electroactivity into these materials may dramatically enhance clinical outcomes. Conductive polymers (CPs) are electrically conductive organic materials increasingly explored in regenerative applications for their biomimetic mechanical properties and synthetic tunability. This study presents an approach to functionalize ACS with CPs by developing a novel electroactive composite. This material possesses significant potential to improve bone repair outcomes in a variety of clinical applications.

Materials/Methods: The conductive polymer poly(3,4-ethylenedioxythiophene) (PEDOT), a material with widely documented ability to augment functional outcomes in diverse tissue types, was synthetically modified to covalently bind to the amine groups in collagen. The amount of PEDOT loaded onto the scaffold was varied by incubating commercially available ACS for different time periods to generate composites with low, medium, and high loading doses of PEDOT. Alamar Blue cell viability and live/dead assays were performed to verify that these novel composites are not cytotoxic. Additionally, a differentiation assay was performed to screen the osteogenic potential of these scaffolds in vitro.

Results: The synthetically modified polymer effectively bound ACS, as evidenced by the visual color change of the material. Variations in structural characterization of these composites, each loaded with low, medium, or high doses of PEDOT, were analyzed using scanning electron microscopy. Alamar Blue and live/dead assays confirmed that these materials are not cytotoxic and promote cell viability when compared to ACS alone.

Discussion/Conclusion: In this study, an approach to functionalize collagenous materials with electroactivity for regenerative application was introduced, specifically with spinal fusion outcomes in mind. Because of the versatility of this functionalization approach, future use of this material may be expanded to bony applications beyond spinal fusion, such as fracture repair.

Paper 28

THE EFFECT OF PATIENT POSITION ON PSOAS MORPHOLOGY AND IN LUMBAR LORDOSIS

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Background/Introduction: Among the interbody fusions, the Lateral Lumbar Interbody Fusion (LLIF) allowed access to the lumbar spine through the major psoas muscle, which offers several advantages to the spine surgeon. However, some of its drawbacks cause surgeons to avoid using it as a daily practice. Therefore, to address some of these challenges, the Prone Transpsoas technique was proposed, differing mainly from the traditional technique on patient position – moving from lateral to prone decubitus, theoretically enhancing the lordosis and impacting the psoas morphology.

Materials/Methods: Twenty-four consecutive patients were invited to perform MRI exams in three different positions (Prone, Dorsal, Lateral). Two observers measured the following parameters, vertebral body size, psoas diameter, psoas anterior border distance, plexus distance, total lumbar lordosis, distal lumbar lordosis, and proximal lumbar lordosis. Values of $p < 0,05$ were deemed significant.

Results: The prone position yielded a significant increase in the lumbar lordosis, both L1S1 (57° vs., $46,5^\circ$) and proximal lordosis ($40,4^\circ$ vs. $36,9^\circ$) when compared to lateral position. Regarding the morphological aspects, the patients in prone presented lesser psoas muscles forward shift, but no difference was noted in the plexus position neither for L3L4 nor L4L5.

Discussion/Conclusion: The prone position results in a significantly increased lumbar lordosis, both distal and proximal, which may enable the spine surgeon to achieve significant sagittal restoration just by positioning. The prone position also produced a posterior retraction of the psoas muscle. However, it did not significantly affect the position of the plexus concerning the vertebral body.

Paper 29

Vancomycin-impregnated calcium sulfate beads compared with vancomycin powder in adult spinal deformity patients undergoing thoracolumbar fusion

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Background/Introduction: Surgical site infections (SSIs) constitute significant morbidity and financial burden on patients and healthcare systems. Adult spinal deformity (ASD) surgery patients are reported to be at particular risk for SSI due to large incisions, high blood loss, long surgical duration, and extensive use of instrumentation. The use of vancomycin powder, which can rapidly resorb, has demonstrated inconsistent results in ASD surgery. Antibiotic-impregnated calcium sulfate beads can lead to more sustained intra-wound antibiotic levels; their use in hip and knee arthroplasty and foot and ankle surgery has been reported with promising results. The purpose of this study was to compare SSI rates following ASD surgery with use of vancomycin-impregnated calcium sulfate beads versus vancomycin powder.

Materials/Methods: A retrospective chart review was performed for 95 consecutive surgical ASD patients at a tertiary care center from January 2017 until March 2020. Patients received either vancomycin powder (powder group) or placement of vancomycin-impregnated calcium sulfate beads (bead group) in the wound prior to closure. This was demarcated by a practice change: vancomycin powder was used prior to October 2018 and vancomycin-impregnated calcium sulfate beads were used thereafter. Patient demographics, operative course, and incidence of postoperative infections were recorded. A two-tailed chi-squared test was performed to compare the incidence of infection.

Results: Forty-two patients were in the powder group and 53 patients were in the bead group. The bead group was older (59.8 vs 67.8 years, $p < 0.01$). The two groups had similar BMI (28.9 kg/m² powder, 29.1 kg/m² bead) as well as rates of diabetes (11.9% powder vs 5.6% bead), smoking status (46% powder, 45% bead never smoked) and length of surgery (684 minutes powder vs 642 bead). There were four postoperative SSI in the powder group requiring operative irrigation and debridement and one SSI in the bead group (9.5% vs 1.9%, $p = 0.09$). All infections occurred in the first 90 days of the postoperative period.

Discussion/Conclusion: Use of vancomycin-impregnated calcium sulfate beads resulted in a lower, albeit not statistically significant, incidence of SSIs after ASD surgery. Prospective study is needed to determine if the differences found are maintained in a larger number of patients.

Paper 30

Can Lumbar Epidural Blood Patches Help Avoid Revision Surgery for Symptomatic Post-operative Dural Tears?

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Background/Introduction: Incidental durotomies resulting in symptomatic postoperative CSF leaks are a known sequelae of posterior lumbar and thoracolumbar surgeries. Common treatments include bedrest, subarachnoid lumbar drain, epidural blood patch, and most commonly surgical re-exploration for durotomy closure. Surgical re-exploration carries the inherent consequences of an additional surgical procedure. The theory behind epidural blood patches is to form a clot over the tear in a minimally invasive manner and allow the dura to heal without the need for an additional surgery. Our objective is to evaluate outcomes following epidural blood patches for symptomatic post-operative dural tears.

Materials/Methods: A retrospective analysis of the management of incidental dural tears and blebs in lumbar spine cases performed by a single surgeon at an academic institution between 11/2012 and 11/2020 was performed. Demographic variables, type of surgery, rate of dural tear, type of repair and use of blood patches post-operatively was recorded.

Results: Of 956 patients (478 males and 478 females) receiving thoracolumbar or lumbar surgeries (207 laminectomies, 458 fusions, and 291 micro-discectomies), with an average age of 58.4 (54-81), 65 (6.8%) patients (30 males and 35 females) were identified as having incidental dural tears or blebs. These were fixed primarily, or if they were inaccessible then treated with duraseal and/or a fat graft. 8 (12.3%) patients (4 males, 4 females) were found to have persistent leaks indicated by positive beta-2 transferrin or clinical symptoms of positional headaches and were referred for blood patches with interventional radiology. 7 of 8 patients had resolution of symptoms without reaccumulation of fluid (87.5%). One patient had a persistent pseudomeningocele after a blood patch and subsequently underwent primary repair with no relief. A second blood patch was then performed, which alleviated his symptomatic pseudomeningocele.

Discussion/Conclusion: The rate of dural tears/blebs in this series was 6.8%. Of the 8 patients with symptomatic post-operative CSF leaks, 7 of 8 (87.5%) were successfully treated with a blood patch. Targeted epidural blood patch is an effective option to treat symptomatic CSF leaks and minimizing the morbidity in surgical re-exploration.

Paper 31

Differences in Revision and Complication Rates Between Anterior and Posterior Interbody Fusion in Patients with Single-level Degenerative Spondylolisthesis

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Background/Introduction: There remains controversy about whether anterior or posterior interbody fusion for unstable single-level degenerative spondylolisthesis (DS) is superior. The purpose of this study was to compare 90-day revision and complication rates between them.

Materials/Methods: In this retrospective database study, patients with single-level DS who underwent anterior or posterior interbody fusion were queried through the PearlDiver Mariner Database, consisting of claims from 2010-Q2 2018. Primary outcome was 90-day revision rates. Secondary outcomes included 90-day transfusion rate, deep vein thrombosis (DVT), ileus, cauda equina, postoperative hematoma, wound complications, and major medical complications.

Results: Of 55,027 included patients 15,025 (27.3%) underwent anterior and 40,002 (72.7%) underwent posterior interbody fusion. At 90 days, rates of DVT [2.63 OR (95% CI 1.87–3.70), $p<0.0001$], ileus [1.64 OR (95% CI 1.45–1.86), $p<0.0001$], and major medical complications [1.12 OR (95% CI 1.02–1.22), $p=0.015$] were higher in the anterior population. Rates of transfusion [1.41 OR (95% CI 1.24–1.60), $p<0.0001$] and cauda equina [1.56 OR (95% CI 1.21 – 2.00), $p=0.0006$] were higher in the posterior population. There was no significant difference in post-op hematoma or wound complications. There was a higher rate of revision [OR 1.14 (95% CI 1.06 – 1.21), $p=0.0002$] and 90-day readmissions [OR 1.36 (95% CI 1.27 – 1.45), $p<0.0001$] with anterior compared to posterior.

Discussion/Conclusion: Single-level DS patients who undergo anterior interbody fusion have higher rates of revisions, 90-day readmissions, DVTs, ileus, major medical complications, whereas patients who undergo posterior interbody fusion have higher rates of transfusion and cauda equina.

Paper 32

Treatment of Painful Degenerated Lumbar Intervertebral Discs Using a Viable Disc Tissue Allograft. An Analysis of Minimum Clinically Important Differences in Outcomes at Twelve Months

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Background/Introduction: Discogenic pain, a common cause of chronic low back pain (CLBP) is one of the major causes of disability and has a major socioeconomic impact. Treatment modalities have included noninvasive treatments, regenerative modalities and surgical approaches such as fusion and disc replacement. A viable disc tissue allograft has been developed to supplement tissue loss associated with intervertebral disc degeneration and the subsequent development of chronic discogenic lower back pain.

Materials/Methods: Data from a prospective, multicentered, blinded randomized, clinical trial (RCT) for subjects with single level or two-level degenerative lumbar disc disease was analyzed. Inclusion criteria encompassed pre-treatment VASPI ≥ 40 mm, ODI Score ≥ 40 . Subjects were blinded and randomized to receive intradiscal injections of either viable disc allograft or saline or to continue with non-surgical management (NSM). The NSM group could cross over to the allograft group after 3 months. Patients were assessed at 6 and 12 months.

Results: At 12 months, improvements in mean VASPI and ODI scores were achieved in both the investigational allograft and saline groups. However, at one year in the investigational allograft group, pain improved 54% and was accompanied by a 53% improvement in ODI. NSM subjects following crossover attained a 65% improvement in pain at 12 months combined with a 64% improvement in ODI. A responder analysis demonstrated statistical significance when evaluating a MCID in ODI of ≥ 15 points at 12 months; 76.5% of subjects randomized to allograft were responders as compared to 56.7% in the saline group ($p = 0.03$). Higher responder rates of 66.7% and 91.3% of patients in the allograft and cross over to allograft groups versus 56.7% in the saline group were observed when evaluating a MCID of ≥ 20 points in back pain improvement ($p=0.022$). In the allograft group, 11 safety adverse events occurred in 141 subjects (3.5%).

Discussion/Conclusion: This large, prospective blinded RCT demonstrated outcomes suggesting that viable disc tissue allograft may be a beneficial non-surgical treatment for patients that have chronically painful lumbar degenerative discs. Subjects treated with viable disc tissue allograft exhibited MCID improvements in both functional and pain outcomes.

Paper 33

Prospective Randomized Control Trial of Tranexamic Acid Infusion During Elective Spine Surgery, Preliminary Results

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Background/Introduction: Current literature demonstrates that tranexamic acid (TXA) use during spine surgery is safe and effective at reducing intraoperative blood loss and blood transfusion. TXA use is increasing; yet, there is a paucity of literature comparing the effects of topical and intravenous (IV) TXA. This study aimed to compare the efficacy of topical and IV TXA in reducing blood loss and transfusions in adult patients undergoing elective lumbar spine surgery.

Materials/Methods: A prospective randomized control trial was performed. Patients undergoing elective decompressive lumbar laminectomy, with or without fusion, were prospectively enrolled and randomized into three groups: control (n=34), IV TXA (n=56), and topical TXA (n=35). Outcomes were collected and compared between groups. Primary outcomes included intraoperative blood loss, perioperative change in hematocrit, transfusion rates, and postoperative drain output. Secondary outcomes included operative time, hospital length of stay (LOS), postoperative complications, and postoperative visual analogue scale (VAS) pain scores with oral morphine milligram equivalents (MME) per day.

Results: No differences were found between the control, IV TXA, and topical TXA groups in intraoperative estimated blood loss ($211.2 \pm 152.5\text{ml}$ vs. $157.1 \pm 119.2\text{ml}$ vs. $175.6 \pm 153\text{ml}$, $p=0.207$), post-operative change in hematocrit (7.7 ± 2.9 vs. 6.2 ± 3.2 vs. 7.0 ± 2.9 , $p=0.176$), and blood transfusion rates (2.9% vs. 3.6% vs. 0%, $p=.5496$). Patient who received IV TXA and topical TXA both had significantly less drain output on post-operative day 1 (POD1) then the control group ($172 \pm 98.2\text{ml}$ vs. $72.8 \pm 52.9\text{ml}$ vs. $52.0 \pm 50.0\text{ml}$, $p = 0.0001$), however, there was no difference between the IV and topical groups ($p=0.089$). There was decreased oral MME requirements in the IV and topical TXA groups compared to controls. There were no significant differences in LOS, operative time, pain scores, and postoperative complications.

Discussion/Conclusion: There were significant decreases in POD1 drain output and pain medication requirements in IV and topical TXA patients, when compared to controls, in adult elective lumbar spinal patients. There were no observed differences between intraoperative blood loss, postoperative change in hematocrit, or transfusion rates. There were no major TXA-related complications.

Paper 34

Adoption of Enhanced Recovery After Surgery (ERAS) Protocol for Lumbar Fusion Decreases In-Hospital Post-operative Opioid Consumption

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Background/Introduction: Enhanced Recovery After Surgery (ERAS) is an evidence-based multidisciplinary perioperative protocol intended to reduce surgical morbidity and improve recovery. This single center prospective observational cohort study evaluated patients undergoing lumbar fusion surgery during the adoption of ERAS. We sought to assess the impact of ERAS on in-hospital and 90-day postoperative opioid consumption, length of stay, urinary catheter removal and post-operative ambulation after lumbar fusion for degenerative conditions.

Materials/Methods: We evaluated patients undergoing lumbar fusion surgery in the transition period prior to (N=174) and after (N=116) adoption of ERAS, comparing in-hospital and 90-day post-op opioid consumption in Morphine Milligram Equivalents (MME). Regression analysis was used to control for confounders. Secondary analysis was performed to evaluate the association between ERAS and length of stay, urinary catheter removal and ambulation after surgery.

Results: Mean age of the cohort was 52.6 years with 62 (47%) females. Demographic characteristics were similar between the Pre-ERAS and ERAS groups. ERAS patients had better 3-month pain scores, ambulated earlier, had urinary catheters removed earlier and decreased in-hospital opioid consumption compared to Pre-ERAS patients. There was no difference in 90-day opioid consumption between the two groups. Regression analysis showed that ERAS was strongly associated with in-hospital opioid consumption, accounting for 30% of the variability in MME. In-hospital opioid consumption was also associated with pre-operative pain scores, number of surgical levels, and insurance type (private vs government). Pre-op pain scores, but not ERAS were associated with 90-day opioid consumption. Secondary analysis showed that ERAS was associated with a shorter length of stay and earlier ambulation.

Discussion/Conclusion: This study showed ERAS has the potential to improved recovery after lumbar fusion for degenerative conditions with reduced in-hospital opioid consumption and improved postoperative pain scores.

Paper 35

Marijuana Use is Associated with Increased Use of Prescription Opioids Following Posterior Lumbar Spine Fusion Surgery

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Background/Introduction: Marijuana is an antinociceptive which has been evaluated as a possible adjunct or substitute for opioid use in the treatment of acute pain. The aim of this study was to evaluate the association between preoperative marijuana usage and consumption of narcotics for postoperative analgesia. We hypothesized that marijuana usage may be associated with decreased usage of opioid analgesics in postoperative pain relief in patients undergoing spine surgery.

Materials/Methods: This was a retrospective review of patients who underwent one- or two-level posterior lumbar fusion surgery between 2016 and 2020 at a single institution. Patients were categorized as marijuana users or non-marijuana users based on preoperative diagnoses of marijuana use. Total morphine equivalent dose (MED) was calculated for both in-house opioid consumption and postoperative prescription opioid usage. Patients who were on narcotics preoperatively were excluded. Age, ASA, BMI, depression, tobacco use, EBL, OR time, LOS, disposition to rehab, 30-day readmission, in-house opioid consumption and postoperative prescription opioid usage were compared between groups using ANOVA analysis.

Results: Of 221 total patients, 29 patients were identified as marijuana users while 192 were non-marijuana users. There were no significant associations between marijuana usage and age, ASA, BMI, tobacco use, EBL, OR time, LOS, or disposition to rehab. Marijuana users had greater association with depression (31% vs 12.5%, $p=0.032$) and 30-day readmission (17.2% vs 11.5% ($p<0.001$)). Marijuana users were found to have increased opioid consumption in-house (MED 236.49 vs 166.68, $p=0.005$), as well as increased postoperative prescription opioid usage (2415.62 vs 1391.54, $p=0.007$).

Discussion/Conclusion: Marijuana usage is associated with increased usage of opioids postoperatively, both while inpatient and post-discharge, after posterior lumbar spine fusion surgery.

Paper 36

The Impact of Preoperative Cross-sectional Area of Psoas Muscle on Postoperative Outcomes of Adult Spinal Deformity Surgery

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Background/Introduction: Proximal junctional kyphosis (PJK)/proximal junctional failure (PJF) is a critical challenge in adult spinal deformity (ASD) surgery. Decreased psoas cross-sectional area has been reported to have a negative impact on clinical outcomes after lumbar surgery, however, it is unclear whether it also impacts outcomes of ASD surgery. The objective of this study was to examine the impact of preoperative cross-sectional area of psoas muscle on postoperative outcomes of ASD surgery.

Materials/Methods: ASD patients who were over 18 years old and underwent posterior fusion surgery with more than 5 levels with 6 months follow-up were included in this study. The cross-sectional area of psoas muscle was measured on T2-weighted axial images at L3/4 of preoperative MRI. Normalized total psoas area (NTPA) was calculated as total psoas area normalized to patient height. Outcomes were patient reported outcome measures (PROMs) (ODI, SRS-22) and radiographic parameters (PT, PI, SS, LL, SVA, C2-C7 SVA, C2-T3 SVA, TS, TK, TPA and Cobb angle) and prevalence of PJK/PJF.

Results: The total of 65 patients were included in this study. When divided into 2 groups [low NTPA group (LG) and high NTPA group (HG)] at the point of the sex-specific lowest quartile of NTPA threshold (male 573 mm²/m², female 493 mm²/m²), there were no significant differences in PROMs between groups at all points. However, ODI and SRS-22 including all sub-items except for mental health were worse in the LG at 6 months, compared to the HG (Table 1). In radiographic parameters, C2-C7 SVA was significantly higher (LG 34.2±14.8 vs. HG 26.4±11.8, p=0.040 at pre-op; LG 34.5±17.4 vs. HG 26.9±10.3, p=0.044 at 6 months) and SS was significantly lower (LG 25.0±11.3 vs. HG 33.9±12.7, p=0.013 at pre-op; LG 30.9±7.9 vs. HG 37.9±10.8, p=0.025 at 6 months) in the LG. Prevalence of PJK was significantly higher in the LG (LG 50.0% vs. HG 18.4%, p=0.021) compared to the HG, while there were no patients with PJF in both groups.

Discussion/Conclusion: Decreased psoas cross-sectional area on preoperative MRI significantly increased prevalence of PJK. It was also associated with higher C2-C7 SVA and lower SS before surgery and at 6 months.

Paper 37

What Factors Are Associated With Normalization Of Pelvic Tilt Following Adult Spinal Deformity Surgery?

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Background/Introduction: Increasing pelvic tilt(PT) is the main compensatory mechanism in adult spinal deformity(ASD). Some patients improve in PT following ASD correction, while others are deemed non-responders. It remains unclear which preoperative factors contribute to PT normalization.

Materials/Methods: Operative ASD patients with pre-(BL), 6-week(6W), and 1-year(1Y) post-op pelvic tilt measurements were included. PT normalization was assessed at 6W and 1Y. Univariate analyses were used to compare normalized(PTNorm) and non-normal(NON) patients in terms of demographics, surgical and radiographic descriptors, postoperative alignment outcomes, and clinical outcomes. Binary logistic regression assessed the effect of baseline radiographic and surgical factors on PT normalization.

Results: 441 ASD pts included. Mean PT at BL: 23.8°, 6W: 19.4°, 1Y: 19.6°. By SRS-Schwab($PT \leq 20^\circ$), the following had normal PT at BL: 36%, 6W: 51%, 1Y: 51%. Of 282 pts with abnormal PT at BL, 86 normalized by 6W and another 20 by 1Y. 1Y PTNorm pts were more likely to have undergone osteotomy(80% vs. 1Y NON: 67%, $p=0.024$). 6W and 1Y PTNorm vs. NON pts did not differ in BL radiographic alignment by SRS-Schwab SVA and PI-LL or GAP score. 6W and 1Y PTNorm pts were more likely to have normal alignment by PI-LL and SVA, and to have ideal proportion by GAP score at 6W and 1Y, respectively (all $p<0.01$) 1Y PTNorm pts had lower reop rate(16% vs. 28%, $p=0.003$) and lower rate of X-ray showing PJK(2% vs. 16%, $p=0.020$). Controlling for age, levels fused, osteotomy, BL SRS-Schwab modifiers, BL GAP proportionality, and BL radiographic parameters, the following were independent predictors of 6W PTNorm: lower PT (OR: 0.882 [CI: 0.779–0.999], $p=0.048$) and lower SS (0.941[0.890–0.995], $p=0.032$). Independent predictors of 1Y PTNorm: higher levels fused (1.162[1.013–1.333], $p=0.032$), lower PT (0.778[0.663–0.912], $p=0.002$), and lower SS (0.933[0.877–0.993], $p=0.030$).

Discussion/Conclusion: PT normalization after ASD correction is associated with improved alignment outcomes, occurs most frequently within 6 weeks of index surgery, and can be predicted by preoperative radiographic parameters.

Paper 38

L3 Position Predicts Global Sagittal Imbalance in Multi-Level Tandem Degenerative Spondylolisthesis

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Background/Introduction: Multi-level adjacent, or tandem, degenerative spondylolisthesis (TDS) is commonly encountered in the clinical setting and is associated with both greater sagittal vertical axis (SVA), and larger pelvic incidence (PI) to lumbar lordosis (LL) mismatch compared to single-level degenerative spondylolisthesis. Greater SVA and PI-LL mismatch portend worse pain and function indices following fusion in the setting of TDS. However, little data exists on what radiographic metrics in TDS are associated with sagittal imbalance. The objective of this study was to correlate lumbar spine characteristics with SVA in patients with TDS.

Materials/Methods: Electronic medical records of patients with low back pain and/or neurogenic claudication were retrospectively reviewed between 2016 to 2020. Patients were included if they had TDS and both lumbar and full length standing spinal radiographs. Exclusion criteria were prior spinal trauma or surgery. LL, L3 sagittal distance (L3SD), and L3 flexion angle (L3FA) were compared in those with increased SVA versus those with a normal SVA (figure 1). Sagittal imbalance was defined as an SVA greater than 5 cm. Groups were compared via an unpaired two-tailed T-test.

Results: Twenty-six patients were included. Fifty-four percent had sagittal imbalance with an overall average SVA of 5.1 cm (range -1.3-13.6). LL, L3SD, and L3FA averaged 63.3 degrees (± 6.9), 2.9 cm (± 0.9), and -3.2 degrees (± 6.1), respectively, in patients with an SVA less than 5cm. In contrast, these measured 48.7 degrees (± 19.5), 54.5 mm (± 13.9), and 11.6 degrees (± 7.9) in patients with an SVA greater than 5 cm. All three measurements were significantly different between groups ($p = 0.018$, 0.00001 , and 0.00002 , respectively). An L3FA threshold greater than 2 degrees yielded a sensitivity and specificity of 93% and 92%, respectively, for predicting sagittal imbalance.

Discussion/Conclusion: In this series, greater than half of patients had sagittal imbalance with relative flexion and increased sagittal position of L3 strongly correlated with increased SVA. These measurements are simple to perform and may indicate when global sagittal alignment should be assessed in patients with TDS to better inform surgical management.

Paper 39

Facet Replacement Versus Standard TLIF for Degenerative Lumbar Spondylolisthesis: One-Year Results from an FDA-IDE Randomized Trial

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Background/Introduction: Posterior lumbar arthroplasty with facet replacement is a novel alternative to lumbar decompression and fusion. There are currently no FDA-approved devices for facet replacement. The TOPS System is a pedicle screw-based device intended to replace the posterior elements following aggressive decompression and preserve motion. We present data from an ongoing multicenter, prospective, randomized, US FDA-IDE trial evaluating the clinical and radiographic outcomes of a facet replacement device and standard TLIF.

Materials/Methods: The primary clinical outcomes measured from the IDE trial comparing facet replacement (TOPS) and lumbar interbody fusion (TLIF) in the treatment of Grade I degenerative spondylolisthesis and stenosis include the Oswestry Disability Index (ODI), visual analog scale (VAS), and re-operation rate. Patients were 2:1 randomized to artificial facet replacement versus TLIF and PEEK interbody spacer plus pedicle fixation. 12 months follow up was required for inclusion.

Results: 147 patients have been randomly assigned to either TOPS (n=104) or to TLIF (n= 43). 70 patients were available for one year follow up (TOPS=52, TLIF=18). Reoperation rate for revision, removal or supplemental fixation (for facet replacement and TLIF control was 6.5% and 12.8%, respectively. There was no significant difference between groups in baseline mean ODI (TOPS=57; TLIF=55) or VAS Back (TOPS=67; TLIF=68) and Leg scores (TOPS=84; TLIF=83). Both groups showed significant improvement in ODI (TOPS=11; TLIF=15) and VAS Back (TOPS=10; TLIF=13) and VAS Leg (TOPS=10; TLIF=13) from baseline to 12-month follow up (). At 12-month follow-up, 92% of TOPS patients and 83% of TLIF patients showed both a minimum of 15 point ODI improvement and no reoperation.

Discussion/Conclusion: Both groups have shown good clinical outcomes with low re-operation rates. There was a trend toward lower reoperation rates with lumbar arthroplasty that did not reach clinical significance, and a statistically significant level of improvement from baseline and last follow up in ODI and VAS (Back and Leg) in both treatment groups. Lumbar facet replacement and TLIF fusion appear to be viable options for treatment of one-level degenerative spondylolisthesis. Continued long term follow-up is required to validate these early findings

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SINGLE-POSITION PRONE TRANSPSOAS (PTP) LATERAL INTERBODY FUSION INCLUDING L4L5: EARLY POSTOPERATIVE OUTCOMES

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Background/Introduction: The LLIF was a revolutionary approach devised by Luiz Pimenta that allowed the surgeon to access the lumbar spine through the major psoas muscle. Although the traditional LLIF had enabled enormous advances, the technique has its drawbacks. Now a new concept to perform the traditional LLIF was proposed, with the patient in a prone decubitus and the slightly extended legs. The study aims to analyze the early outcomes of patients who had undergone the PTP for degenerative spine pathologies, including the L4L5 level

Materials/Methods: Multicentric, retrospective, non-randomized, non-comparative, observational study. Only were included in the study, participants that received PTP in L4L5, no more than three levels of intersomatics, fixation no further than S1. The primary outcomes were the onset of new neurologic deficits and postoperative complications. Also, surgery details, such as blood loss and surgery duration, were measured. The neurological deficits were accessed at the postoperative visit that ranged from 7 to 14 days after the surgery.

Results: Thirty-four patients fulfilled the inclusion and exclusion criteria, with the majority receiving PTP only in L4L5 (61,7%). The mean surgery time was 176, with 27min of mean Transpsoas time. Of the thirty-four patients, only one presented the onset of a motor deficit, while four patients presented a new sensory deficit. Six complications occurred, one intraoperative and five postoperative, with one being directly correlated with the access.

Discussion/Conclusion: The Prone Transpsoas is safe and feasible for approaching the L4L5 disc, presenting with a low rate of complication and new neurological deficits onset.

Paper 41

A Comparison of Fusion Rates for Transforaminal Lumbar Interbody Fusion using Cancellous Bone Chip Allograft versus Cellular Bone Matrices

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Background/Introduction: Transforaminal lumbar interbody fusion (TLIF) is an effective treatment in the management of degenerative lumbar spine disease. While iliac crest autograft has historically been the gold standard, there are many alternative graft options, including allograft bone preparations. Cellular bone matrices (CBM) containing live mesenchymal stem cells have seen increased clinical use, despite higher cost. The purpose of this study was to compare fusion rates and post-operative complications following TLIF between traditional allograft cancellous bone chips (CBC) versus cellular bone matrices.

Materials/Methods: A total of 149 patients who had undergone TLIF from July 2016 to October 2019 were included in the present study. Patients were divided into two cohorts based on whether CBM graft or CBC allograft was used. The patients' demographics, comorbidities, surgery performed, and surgical outcomes and complications were recorded. Postoperative fusion was assessed using plain radiographs. Multivariate statistical analysis was conducted to assess for any significant differences in rates of fusion between the two cohorts while controlling for demographic and operative variables. Postoperative complication rates were also compared.

Results: Fifty-three patients had a TLIF using CBM graft material, and ninety-six patients had TLIF using cancellous bone chip allograft. The rate of pseudarthrosis was significantly higher in patients who had CBM (13%) than those with CBC allograft (6%, $p < 0.05$) (Table 1). The rate of recurrent stenosis was also higher among those who received a TLIF with CBM (8%) versus CBC (2%, $p < 0.05$). There was no significant difference in revision rates, post-operative infection, hardware failure, hematoma, dural tear, ASD, or additional complications between the two cohorts.

Discussion/Conclusion: The present study found that patients who underwent TLIF with CBC allograft had higher fusion rates and less recurrent stenosis than those who received CBM. CBM is a newer graft technology with higher costs than traditional CBC or autograft. However based on the present study's results, CBM does not provide the benefit of increased rates of fusion over CBC.

Paper 42

Recurrent Dislocation Following Total Hip Arthroplasty is Associated with Previous Lumbar Fusion

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Background/Introduction: Lumbar fusion alters spinopelvic mechanics. History of lumbar fusion has been shown to increase dislocation risk following total hip arthroplasty (THA), but the effect of lumbar fusion on recurrent THA dislocation has not been investigated. The present study evaluates recurrent THA dislocation risk in patients with history of lumbar pathology or surgery. It is hypothesized that patients with lumbar pathology or surgery will have greater recurrent dislocation risk.

Materials/Methods: A retrospective review of a prospectively collected database was conducted on all patients presenting to a tertiary care center between 2009-2018 with a THA dislocation event. Patient records were reviewed for history of atraumatic lumbar pathology (stenosis, spondylolisthesis, degenerative disc disease) or surgery (fusion, laminectomy, discectomy) at the time of THA dislocation. Chi-squared tests with significance set at $p < 0.05$ were performed to examine if lumbar pathology, surgery, or fusion correlated with increased recurrent THA dislocation risk.

Results: 276 patients with THA dislocations were identified. 53 patients were excluded for THA dislocation secondary to infection or lack of treatment records. Of the 223 remaining patients, 103 (46.2%) experienced subsequent dislocations, 68 (30.5%) had diagnosed lumbar pathology, 44 (19.7%) had lumbar surgery, 30 (13.5%) had lumbar fusion, and 12 (5.3%) had lumbar fusion to sacrum. There was a significant association between recurrent dislocation and lumbar fusion ($p = 0.04$). There was no significant association between recurrent dislocation and lumbar pathology ($p = 0.48$), lumbar surgery ($p = 0.90$), or lumbar fusion to sacrum ($p = 0.18$).

Discussion/Conclusion: The present study is the first to assess the relationship between lumbar pathology and risk of recurrent THA dislocation. While lumbar pathology alone does not increase recurrent THA dislocation risk, previous lumbar fusion at the time of THA dislocation is associated with increased recurrent dislocation risk. This risk appeared to be independent of fusion to the sacrum. Decreased spine motion results in a compensatory increase in hip motion and has been identified as a possible etiology for THA dislocation, which may explain why lumbar fusion leads to an increased recurrent THA dislocation risk. Future research should identify the specific spinopelvic parameters altered by lumbar fusion that leads to increased recurrent THA dislocation risk.

Poster 01

Evaluation of Hydroxyapatite-Demineralized Bone Matrix Composite Scaffold for Spinal Arthrodesis

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Background/Introduction: Recombinant human bone morphogenetic protein-2 (rhBMP-2) is a potent stimulator of new bone formation utilized in spine fusion procedures to reduce the risk of pseudarthrosis, but it can also cause serious complications. To address these limitations, we developed a 3D-printed hydroxyapatite (HA)/demineralized bone matrix (DBM) scaffold as a recombinant growth factor-free bone graft substitute. Here, we evaluated the safety of the HA-DBM scaffold in a preclinical model of spine fusion, comparing it to rhBMP-2 in eliciting a host hyperinflammatory response.

Materials/Methods: This study employed a previously-established modified bilateral posterolateral lumbar spinal fusion (PLF) model whereby 0.5 g of tissue adjacent to the fusion bed was excised bilaterally and test implants were placed to bridge the transverse processes. Implants consisted of either (1) type I absorbable collagen sponge alone (ACS; negative control; n=20), (2) 10 µg rhBMP-2/ACS (positive control; n=20), or (3) HA-DBM composite scaffold (HA-DBM; n=20). Local soft tissue edema volume was quantified using MRI longitudinally out to eight weeks post-operative, and serum levels of inflammatory cytokines were quantified by ELISA.

Results: rhBMP-2 treatment resulted in significantly greater soft tissue edema volume on MRI relative to both ACS alone and HA-DBM treatment groups at post-operative day (POD) 2 (Fig. 1A-B). At POD 5, edema volume was also significantly greater in the rhBMP-2 group relative to the HA-DBM group. Similar trends in relative cytokine levels were also observed among treatment groups. At POD 2, the rhBMP-2 treatment group had significantly higher serum levels of TNF-α and MCP-1 expression, and higher IL-18 levels at POD 5 when compared with the ACS control. In contrast, HA-DBM treatment did not significantly induce any of the target cytokines (Fig. 1C).

Discussion/Conclusion: MRI analyses showed that rhBMP-2 treatment elicited a significant inflammatory response which peaked in the early post-operative period and decreased at later time points. In contrast, HA-DBM treatment resulted in no such local fluid collection. Similar trends were seen with rhBMP-2-mediated induction of IL-18, TNF-α, and MCP-1, with no such induction with HA-DBM treatment. This study demonstrates that the HA-DBM scaffold does not produce the same hyperinflammatory response associated with rhBMP-2 treatment.

Poster 02

Basal and Cytokine-Stimulated Biomarker Production by Degenerative Lumbar Discs from Microdiscectomy Versus Interbody Fusion Patients

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Background/Introduction: Intervertebral disc (IVD) degeneration is implicated in back pain, a leading cause of a spine-related disability. Both local and systemic inflammatory processes have been associated with IVD degeneration, though it is unclear if differences between these processes exist in degenerative IVDs of patients undergoing lumbar microdiscectomy versus fusion. This study was aimed to examine basal and cytokine-stimulated metabolic responses of degenerative lumbar IVD tissues with the hypothesis that tissues from patients undergoing fusion would produce significantly higher levels of degradative enzymes and inflammatory mediators under both basal and cytokine-stimulated conditions when compared to tissues from microdiscectomy.

Materials/Methods: Degenerative IVDs excised from lumbar microdiscectomy (n=3) or fusion (n=4) surgery, was obtained (n=7, mean age 53). Tissues comprised of nucleus pulposus (NP) was collected. Two explants per disc were randomly assigned to the 10ng/ml IL-1 β stimulation group (IL) or the untreated basal metabolism group (BASAL). Tissues were cultured for 3 days, after which media were collected for biomarker evaluation. Media Analyses: Media were tested for MMP-1, MMP-2, MMP-3, MMP-7, MMP-8, MMP-9, MMP-13, TIMP-1, TIMP-2, TIMP-3, TIMP-4, GRO- α , MCP-3, PDGF-AA, PDGF-AB/BB, IL-2, IL-4, IL-6, IL-8, MCP-1, MIP-1 α , MIP-1 β , RANTES, TNF- α , and VEGF using commercially available assays. Significant differences between groups were determined by t-test with significance set at p $\leq$ 0.05.

Results: In the BASAL group, only the production of MMP-8, TIMP-4 and PDGF AA was significantly higher in the IVD tissues from the fusion cohort compared to that from the microdiscectomy group. In response to cytokine stimulation with IL-1 β , tissues in the fusion group responded with significantly greater production of TIMP-2, TIMP-4, PDGF-AA, IL-6, IL-8, MIP-1 β , and VEGF when compared to the response by the tissues from the microdiscectomy patients.

Discussion/Conclusion: Basal inflammatory and degradative metabolism of degenerative lumbar IVD tissues collected from microdiscectomy versus fusion patients was not significantly different, since MMP-8 and TIMP-4 were the only biomarkers significantly different between the two patient groups. Tissues from the lumbar fusion patients do appear to be more sensitive to cytokine stimulation compared to those from the microdiscectomy. The biochemical processes and clinical significance require further study. A deeper understanding of this phenomenon may provide insight into potential therapies for prevention and treatment of lumbar intervertebral disc degeneration.

Poster 04

The Impact of Degeneration on Bone Densitometry and CT Hounsfield Unit Measurements in a Spine Patient Population

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Background/Introduction: The purpose of this study was to determine the impact of degeneration on bone densitometry measurements and CT Hounsfield units (HU) in a spine patient population, to govern the applicability of such measurements for patients with lumbar spine pathology.

Materials/Methods: A retrospective study of 63 spine surgery patients was performed. Patients with a dual-energy x-ray absorptiometry (DXA) scan, and a CT containing the lumbar spine within 18 months of each other were included. Individual vertebra containing surgical hardware were excluded. DXA scan data were collected and analyzed by lumbar level. Accepted cutoff values for T-score, trabecular bone score (TBS), and HU were applied to categorize patients into groups. Individual vertebrae were assessed for degenerative changes by qualitative evaluation of the anterior and posterior elements. Degeneration grades were compared to patient T-scores, TBS, CT HU, and to International Society of Clinical Densitometry (ISCD) criteria for excluding vertebrae from diagnostic consideration.

Results: The mean patient age was 67.2 years old and 79.4% were female. The mean lowest T-scores of the hip spine, and lowest overall T-score were -1.3 ± 1.4 , -1.7 ± 0.9 , and -1.9 ± 1.0 , respectively. Osteoporosis was diagnosed in 38% of the patients, and osteopenia in 52%. The mean degeneration score of individual vertebrae was 4.1 on a 0-6 scale. T-score correlated moderately with degeneration score (Spearman's rho: 0.484, P-value <0.001), whereas TBS (rho: 0.022, P: 0.61) and HU (rho: -0.211, P: 0.097) showed no correlation to degeneration score. ISCD excluded vertebrae had a significantly higher degeneration score than included vertebrae (P-value = <0.001).

Discussion/Conclusion: In a spine population, TBS and CT HU are insensitive to lumbar degenerative changes. Additionally, our data reinforce the ISCD criteria for exclusion a lumbar vertebra from diagnostic consideration if its T-score is >+1 SD than adjacent vertebrae.

Poster 05

A Novel Comprehensive Model to Describe Vertebral Body Motion Following Interbody Fusion

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Background/Introduction: Subsidence of interbody fusion spinal implants occurs in up to 30% of interbody fusions. Previous methods to quantify subsidence of interbody implants have focused on quantifying changes in disc height or magnitude of erosion of the implant into the vertebral body. These studies focus on the description of subsidence in a cranial-caudal direction. A comprehensive description of subsidence should report cranial-caudal shift, anterior-posterior shift and angular shift of one vertebra with respect to its adjacent vertebra. We developed a novel method that describes the motion of one vertebral body with respect to its adjacent vertebral body in terms of translation and rotation, and we hypothesize this method would have satisfactory inter-observer reliability.

Materials/Methods: A retrospective review of lateral lumbar spine radiographs was performed by seven physicians (3 residents, 2 fellows, and 2 attendings). The review included radiographic analysis of 10 patients that underwent L4-5 or L5-S1 anterior interbody fusion. Preoperative, postoperative (day 1), and 12-month postoperative radiographs were analyzed. Each vertebra was defined in two-dimensional space by 4 peripheral points at the corners of the vertebral body and a centroid. The upper vertebra was designated as a reference plane by which the motion of the lower vertebra was measured. We measured the movement of the lower vertebra in terms of anterior-posterior translation, cranial-caudal translation, and angular change immediately following lumbar interbody fusion and 12 months postoperatively to detect translational and rotational subsidence.

Results: A model was successfully developed to describe the angular and translational change of one vertebral body with respect to its adjacent segment. The intraclass correlation coefficients of anterior-posterior, cranial-caudal, and angular change were calculated to be 0.75, 0.90, and 0.86, respectively. The average standard deviations of translational and rotational change were 3.3% and 2 degrees, respectively.

Discussion/Conclusion: A model to comprehensively describe vertebral body motion as a method of characterizing subsidence was successfully developed. The model had good to excellent reliability. Further refinement of the protocol may yield improved intraclass correlation coefficients. This method of measuring vertebral body motion is applicable to measuring modes of failure beyond subsidence such as fracture or delayed fusion.

Poster 06

Pre-operative Modified Zung Depression Index Scores are Risk Factors for Worse Short-Term Post-Operative Function After Posterior Lumbar Laminectomy

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Background/Introduction: Pre-operative mental health disorders like anxiety and depression have been correlated with worse post-operative functional improvement in patients after spine surgery. In this study, we investigated the effects of pre-operative depression per the Modified Zung Depression Index (MZDI) on pre- and post-operative Oswestry Disability Index (ODI) scores.

Materials/Methods: An institutional review board approved database of a consecutive series of patients who underwent lumbar spine decompression for management of neurogenic claudication and/or radiculopathy between November 2015 and December 2018 at a single academic institution were included in this study. Baseline variables included gender, age, body mass index (BMI), primary diagnosis, procedure performed, estimated blood loss, hospital length of stay, opioid consumption (defined as morphine milligram equivalents (MME) within the first 24 hours after surgery), preoperative visual analog scale (VAS) pain, and MZDI scores. Postoperative variables included ODI scores, presence of complications, and need for revision surgery. MZDI scores were measured at patient's first pre-operative visit; scores ≥ 33 were categorized as depressed. Statistical analysis was performed with SPSS 27.0 with a significance level of 0.05. Independent samples t-test and Chi-square tests were used as applicable. Pearson correlation analysis was performed to determine the relationship between MZDI scores and different studied parameters.

Results: A total of 114 patients were included in this study. The average age was 57.1 years, 59.1% of patients were male, and 12% of patients were depressed. There was no significant difference amongst any baseline variables between depressed and non-depressed patients and post-operative complication and revision rates were similar between the two groups. Female patients had significantly greater pre-operative MZDI scores than males. There was a significant positive correlation between pre-operative MZDI scores and pre-operative ODI scores and post-operative ODI scores at the 2-4 week and 1-3 month follow-up periods (Table 1). There was no statistically significant correlation between pre-operative MZDI score and age, BMI, pre-operative VAS pain score, post-operative MME, ODI score improvement, and ODI scores at all other follow-up time points.

Discussion/Conclusion: Pre-operative MZDI scores are associated with worse post-operative function shortly after surgery but is not associated with long-term impaired function after posterior lumbar laminectomy.

Poster 07

The Influence of Cognitive Behavioral Therapy on Lumbar Spine Surgery Outcomes: A Systematic Review and Meta-Analysis

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Background/Introduction: Novel interventions are needed for lumbar spine patients who do not respond to traditional rehabilitation techniques. Although behavioral and psychosocial interventions have demonstrated efficacy in postoperative rehabilitation, few studies have evaluated their impact on patients' perception of clinical improvement. This study aims to conduct a systematic review and meta-analysis of current randomized control trials (RCTs) that evaluate the influence of cognitive behavioral therapy (CBT) on patient reported outcomes (PROs) among lumbar spine surgery patients.

Materials/Methods: Relevant studies for this systematic review were found using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to search the following databases: PubMed/MEDLINE, Scopus, CINAHL, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, PsycINFO, and Google Scholar. A total of 241 unique articles were identified and screened by two independent reviewers. Articles were excluded if they did not include lumbar spine surgery, if they were in a language other than English, if they were not RCTs, if they were study protocols, and if they were not full manuscripts.

Results: After the 241 articles were screened, 29 full-text studies were assessed for eligibility, and 11 were ultimately included. These 11 studies were conducted between 2003-2019 and included a total of 1,128 patients who underwent lumbar spine surgery. Seven studies evaluated lumbar fusion, three assessed lumbar disc surgery, and one observed patients undergoing laminectomy. Only four of the studies utilized a CBT intervention preoperatively, while ten employed postoperative CBT interventions. Total CBT sessions ranged from three to 18 sessions. The most frequent outcomes observed were disability (82%, Oswestry Disability Index), pain (55%, Visual Analog Scale), quality of life (55%, European Quality of Life 5 Dimensions, 55% Short Form-36), pain catastrophizing (45%, Pain Catastrophizing Scale), and kinesiophobia (45%, Tampa Scale of Kinesiophobia). Of the 11 studies, six had findings supporting CBT as a superior rehabilitation intervention when analyzing improvements in PROs.

Discussion/Conclusion: The majority of the reviewed studies observed that CBT had better outcomes compared to postoperative rehabilitation control groups. Further research is needed to address appropriate assessments before undergoing CBT and to refine the ideal pre- and postoperative CBT frequencies, durations, and settings.

Poster 08

Establishing a Two-Year Minimal Clinically Important Difference (MCID) Threshold for Minimally Invasive Lumbar Decompression

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Background/Introduction: Improvement of patient-reported outcome measures (PROM) can quantify the success of minimally invasive lumbar decompression (MIS LD) surgery. Few studies evaluate the clinical significance of patient health questionnaire-9 (PHQ-9) with spine surgery. This study establishes a minimal clinically important difference (MCID) for PHQ-9 among patients undergoing MIS LD.

Materials/Methods: A retrospective study of a surgical registry was performed for MIS LD patients from November 2015 to August 2017. Inclusion criteria was primary, MIS LD for degenerative spinal pathologies. Exclusion criteria were incomplete pre- or postoperative 2-year PHQ-9 survey, surgery indicated for infectious, traumatic, or metastatic etiologies. PROMs included PHQ-9, Short Form and Veterans RAND 12-Item Health Survey (SF-12 and VR-12). Mental Component Summary (MCS) scores were recorded preoperatively, and 6-weeks, 12-weeks, 6-months, 1-year, and 2-year postoperatively and mean scores calculated. Preoperative and 2-year scores were used to calculate MCID values using both anchor- and distribution-based methods. The SF-12 mental health self-perception item acted as an anchor. MCID calculation methods included the minimum detectable change within 95% Confidence Interval (MDC95), mean delta, change difference, and receiver operating characteristic (ROC) curves. MCID achievement rates were calculated from our selected MCID value.

Results: Our cohort was 173 patients with a mean age of 45.3 years, 28% female, and 44% obese. Three most common preoperative spinal diagnoses were radiculopathy (92%), herniated nucleus pulposus (76%), and central/spinal stenosis (69%). The range of values for each MCID calculation method were: PHQ-9 (2.0-2.8), SF-12 MCS (4.6-6.1), and VR-12 MCS (4.7-7.3). The MDC95 was greater than mean values of unimproved patients for PHQ-9 (2.3), SF-12 MCS (5.7), and VR-12 MCS (6.0). MCID achievement at 2-years was 97.7% (PHQ-9), 94.8% (SF-12 MCS), and 94.8% (VR-12 MCS). PHQ-9 had the highest MCID achievement rate at each period.

Discussion/Conclusion: Our MCID analysis at 2-year postoperative follow-up is the first mental health calculation from an MIS LD cohort with a PHQ-9 of 2.3, an SF-12 MCS value of 5.7, and a VR-12 value of 6.0. Mental health MCID threshold values will assist in describing and quantifying patient psychological status before and after MIS LD.

Poster 09

Risk Factors Associated with a Failure of Achieving a Minimum Clinically Important Difference Following Lumbar Decompression

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Background/Introduction: Clinically important postoperative changes can be best evaluated through the minimum clinically important difference (MCID). Risk factors for failure to meet MCID have yet to be investigated in patients undergoing lumbar decompression (LD). The purpose of this study is to evaluate risk factors associated with failure to achieve MCID following LD.

Materials/Methods: Patients undergoing primary, elective LD were retrospectively reviewed in a prospective surgical database. Demographic, perioperative, and patient reported outcome measures (PROM) for pain (Visual Analogue Scale; VAS), disability (Oswestry Disability Index; ODI), and physical function (12-Item Short Form Physical Component Score; SF-12 PCS and Patient Reported Outcome Measurement Information System; PROMIS) were collected. PROMs were collected at preoperative and postoperative timepoints through 1-year. Differences in baseline characteristics and PROM improvement were evaluated. MCID achievement was calculated using previously established values. Relative risk of demographic and perioperative characteristics for failure to meet MCID for all PROMs was calculated. Least absolute shrinkage and selection operator (LASSO) was used to estimate individual risk factors and postestimation logistic regression was performed.

Results: The study cohort included 811 patients with a mean age of 44.6 years, 70.1% male, and 60.4% non-obese (<30 kg/m²). Majority (81.7%) underwent a single level procedure, with a mean operative length of 45.7 minutes, average blood loss of 31.4mL, and length of postoperative stay of 5.7 hours. Operative levels or duration was associated with failed MCID for VAS leg, SF-12 PCS, and PROMIS-PF. Preoperative spinal pathology was associated with failed MCID for VAS leg, ODI, SF-12 PCS, and PROMIS-PF. Additional risk factors included insurance, age, and body mass index. LASSO selected insurance, age, ageless CCI, EBL, operative length, and central or foraminal stenosis as significant risk factors for failure to reach MCID.

Discussion/Conclusion: Failure to reach MCID was greatest for VAS back. Age, comorbidity burden, and prolonged procedures were significantly associated with risk for failure to reach MCID for the majority of PROMs. Comorbidity burden combined with operative outcomes may place patients at increased risk for failure to achieve an MCID for pain, disability, and physical function following LD.

Poster 10

**Does transforaminal lumbar interbody fusion (TLIF) induce lordosis or kyphosis?
Radiographic evaluation with minimum 2-year follow-up**

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Background/Introduction: Conflicting reports exist about whether transforaminal lumbar interbody fusion (TLIF) induces lordosis or kyphosis, ranging from decreasing lordosis by 3.71° to increasing it by 18.8°. To identify factors that result in kyphosis or lordosis from TLIF.

Materials/Methods: A single center, retrospective study of open TLIF without osteotomy for spondylolisthesis with minimum 2-year follow-up was undertaken. Pre- and post-operative clinical and radiographic parameters and cage specifics were collected. TLIFs were lordosing if post-operative induction of lordosis was >0° and kyphosing ≤0°.

Results: 137 patients with an average follow-up of 52.5 months (24-130) were included. The overall post-operative disc angle, segmental lordosis increased by 1.96°, 1.88° (p=0.003, p=0.038), whereas overall lumbar lordosis remained unchanged (p=0.133). 79 patients had lordosing TLIFs with segmental lordosis increase of 5.73 ±3.97°, while 58 patients had kyphosing TLIFs with a decrease of 3.17 ±2.98°. Multivariate analysis showed that a lower pre-operative disc angle, lower pre-operative segmental lordosis, and anterior cage placement were correlated with the greatest increase in post-operative segmental lordosis (p=0.040; p<0.001; p=0.035). There was no difference in demographics, cage type or height, or spinopelvic parameters between groups (p>0.05). Linear regression showed the pre-operative disc angle and segmental lordosis correlated with segmental lordosis after TLIF (R² =0.198, p<0.001; R² =0.2931, p<0.001).

Discussion/Conclusion: Whether a TLIF induces kyphosis or lordosis depends upon the pre-operative disc angle, pre-operative segmental lordosis, and cage position. Less lordotic segments became more lordotic post-operatively, and highly lordotic segments may lose lordosis after TLIF. More anterior cage position was associated with more lordosis.

Poster 11

Is there a relation between the number of levels fused and decompressed and functional outcomes in lumbar spine fusions?

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Background/Introduction: To evaluate the impact of length of fusion and degree of decompression on lumbar fusion patient outcomes, by objective patient-reported outcome measures (PROM).

Materials/Methods: A retrospective observational cohort study of all elective lumbar fusions patients from, March 2018 -until August 2019 , with a minimum of 6 months follow-up, was completed. Patients were categorized based on the proportion of number of levels fused to the number of levels decompressed. The length of fusion was quantified in the number of levels fused (i.e., L1-L2; 1 level) while the degree of decompression in segments decompressed (i.e., L1 and L2; 2 levels). In order to assess if there was a significant difference in functional outcomes associated with the ratio of levels fused to decompressed, the threshold of two segments decompressed for each level fused was established to compare both cohorts. Baseline Oswestry Disability Index (ODI), along with baseline characteristics, were collected. The substantial clinical benefit (SCB) was defined as a reduction of ≥ 10 points in ODI. Univariate logistic regression identified the Odds Ratio (OR) of ≥ 2 levels decompressed/fused with the achievement of SCB 6-months postoperatively. Multiple logistic regression was used to determine the associations between independent variables and the functional outcomes.

Results: A total of 309 patients met inclusion criteria. The mean number of levels fused was greatest in the ≥ 2 levels decompressed /fused ratio cohort ($p < 0.01$), although the mean number of levels decompressed was not significantly different ($p = 0.96$). The ODI improvement was greater in ≥ 2 levels decompressed/fused group ($p = 0.024$). Multivariate analysis demonstrated that a ratio of decompression/fusion ≥ 2 was the greatest independent predictive factor associated with an OR of 2.08 to achieve a SCB ([CI]:1.17-3.07, $p = 0.01$). Three other variables analyzed were also significantly associated with better functional outcomes: the pre-operative ODI (OR, 1.09; [CI]:1.06-1.13, $p < 0.01$), degenerative spondylolisthesis indication for fusion (OR, 1.83; [CI]:1.03-3.22, $p = 0.03$), and the presence of discogenic pain (OR, 4.06; [CI]:1.35-12.25, $p = 0.01$).

Discussion/Conclusion: In lumbar spinal decompression and fusions procedures, the PROM are more closely associated with the relation between the number of levels decompressed and fused. Our results suggest that patients whose surgeons minimize fusion and favor decompression fare better.

Poster 12

Range of Motion of the Spine and Hips Following Short and Long Spinal Fusions

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Background/Introduction: Data on range of motion (ROM) of the hips and spine following short and long fusions is limited. Spinal parameters for success have been based on static imaging. The purpose of the study was to measure ROM of the thoracic spine, lumbar spine and hips following short and long spinal fusions.

Materials/Methods: Patients who had undergone 3 level fusions, 7 level fusions and 12 level fusions were recruited to the study along with patients without fusion and healthy volunteers. ROM of the spine (thoracic segments, lumbar segments) and hips was measured using an optoelectronic marker-based system (Motion Analysis) throughout a flexion and extension cycle. VAS, EQ5D, ODI scores and radiographic parameters (LL, PI, PI-LL, SVA) were obtained at the time of analysis. Statistical methods included Chi square tests for categorical variables and ANOVA were used for continuous variables.

Results: Sixty-seven patients were included (Healthy volunteers = 8, No fusion = 14, 3-level fusion = 17, 7-level fusion = 17, 12-level fusion = 11). No statistical differences between gender, age, mean VAS, EQ5D scores, ODI scores and radiographic parameters were identified among different patient groups ($p > 0.05$). 75,923 points of data were captured and analyzed. The mean hip ROM of in the volunteer group was measured at 186.43° compared to 89.99° in the 12-level fusion group ($p < 0.001$). Mean difference in hip ROM between the 3-level and 7-level compared to the 12-level group was 15.7° and 23.3° ($p > 0.05$). ROM of each spinal segment are shown in Figure 1.

Discussion/Conclusion: Significant lower hip and spine ROM was measured following fusion compared to unfused patients and healthy volunteers. No significant differences in hip ROM between short and long fusions was found. 3-level and 12-level fusion groups had statistically less spinal ROM than the 3-level group, no fusion group and healthy volunteers. Less ROM was measured for 7-level and 12-level group compared to the 3-level group and unfused group.

Poster 14

Living in a Socio-economically Distressed Community is Associated with Greater Complications following Elective Spinal Fusions

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Background/Introduction: Socio-economically disadvantaged individuals are known to experience inequities in healthcare. Despite a growing concern over these disparities, current evidence assessing the impact of socioeconomic status on outcomes following spinal fusions is limited by the availability of comprehensive community-level socioeconomic data.

Materials/Methods: The 2012-2014 100% Medicare Standard Analytical Files (SAF100) was used to identify patients undergoing elective 1- to 3-level anterior cervical fusions or posterior lumbar fusions for degenerative spine pathologies. Socio-economic status of individuals was determined by linking the residential ZIP code with a nationally validated Distressed Community Index (DCI) score. Multi-variate logistic regression analyses were used to assess the independent impact of increasing DCI score on 90-day complications and readmissions while controlling for other factors (age, gender, region, co-morbidity burden, procedure type, and hospital-level characteristics).

Results: 121,840 patients were included in the study. Following adjustment for baseline demographics, procedural characteristics and hospital-level factors, patients living in a highly distressed community (i.e. DCI score >80 vs. DCI score 0-20), were more likely to experience higher rates of surgical site infections (OR 1.27 [95% CI 1.14-1.41]; p<0.001), cardiac complications (OR 1.07 [95% CI 1.01-1.15]; p=0.042), urinary tract infections (OR 1.08 [95% CI 1.01-1.15]; p=0.032) and emergency department visits (OR 1.08 [95% CI 1.03-1.13]; p<0.001) within 90-days of the procedure. There were no significant association between the DCI score of a patient's residence and 90-day readmissions, renal complications, sepsis and thromboembolic complications.

Discussion/Conclusion: Patients belonging to distressed communities are at a higher risk of experiencing complications following spinal fusions. Addressing or incorporating socioeconomic/living status of an individual, by improving access to and/or availability of appropriate healthcare resources, has the potential to mitigate the risks of adverse outcomes in these vulnerable patient populations. Furthermore socio-economic status of a patient would be an invaluable tool for risk-adjusting value-based payments, to ensure that physicians taking care of vulnerable patients are adequately compensated to ensure a higher level of care may be provided.

Poster 15

Minimally Invasive Unilateral Laminotomy with Bilateral Decompression Versus Minimally Invasive Transforaminal Lumbar Interbody Fusion for Treatment of Low-Grade Lumbar Degenerative Spondylolisthesis: A Single-Surgeon Retrospective Series

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Background/Introduction: The objective of this study is to compare perioperative outcomes, radiographic parameters, and patient reported outcome measures (PROMs) between minimally invasive unilateral laminotomy with bilateral decompression (MIS-ULBD) versus MIS transforaminal lumbar interbody fusion (MIS-TLIF) for treatment of low-grade lumbar degenerative spondylolisthesis. While lumbar degenerative spondylolisthesis is a common condition, optimal surgical treatment remains controversial.

Materials/Methods: Consecutive patients with low-grade (Meyerding grade I or II) lumbar degenerative spondylolisthesis treated with single-level MIS-ULBD or MIS-TLIF were identified retrospectively from a prospectively collected registry from April 2017 – March 2020. Perioperative outcomes, radiographic data, and PROMs were assessed

Results: 92 patients underwent either MIS-ULBD or MIS-TLIF (23 MIS-ULBD and 69 MIS-TLIF). Mean follow-up was 33 weeks, and 40 patients had at least 1 year follow-up. Patients who underwent MIS-ULBD tended to be older, had higher Charlson Comorbidity Index, lower mean percentage back pain, shorter operative time, lower estimated blood loss, and lower postoperative pain ($p < 0.05$). In the MIS-ULBD group, there were significant improvements at 1 year for three out of the six PROMs studied: Oswestry Disability Index (ODI), visual analog scale (VAS)-back pain, and VAS-leg pain ($p < 0.05$). In the MIS-TLIF group there were significant improvements at 1 year for five out of six PROMs studied: ODI, VAS-back pain, VAS-leg pain, Short Form 12 Physical Component Score (SF12-PCS) and Patient-Reported Outcomes Measurement Information System (PROMIS) ($p < 0.05$). In multivariate analysis, MIS-ULBD was associated with higher rates of achieving minimal clinically important difference (MCID) in VAS-back pain at 1 year ($p < 0.05$). No other associations between procedure type and achieving MCID in other PROMs were identified.

Discussion/Conclusion: Both MIS-ULBD and MIS-TLIF result in significant improvements in pain and function for patients with low-grade lumbar degenerative spondylolisthesis. The current study suggests that MIS-ULBD is associated with higher rates of achieving MCID in back pain.

Poster 16

Static vs. Expandable PEEK Interbody Cages: A Comparison of One-Year Clinical and Radiographic Outcomes for One-Level TLIF

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Background/Introduction: Transforaminal lumbar interbody fusion (TLIF) can help stabilize the spine while improving patient neurologic symptoms. Recently, focus has shifted on improving the design of interbody cages to achieve superior fusion rates and lead to better restoration of spinal alignment. This study examines the effect of static versus expandable polyetheretherketone (PEEK) cages on patient-reported outcomes (PROMs) and radiographic outcomes.

Materials/Methods: A retrospective cohort study was conducted on patients who underwent a one-level transforaminal lumbar interbody fusion (TLIF) with either a static or expandable PEEK cage. Patient outcomes were obtained from chart review and radiographic outcomes were measured using standing, lateral radiographs. Univariate data was analyzed using mean sample t-tests or categorical chi-squared tests. Multivariate linear regression analysis was performed to determine the effect of cage type on the change in PROMs, controlling for age, sex, BMI, smoking status, Charlson Comorbidity Index (CCI), and perioperative diagnosis.

Results: A total of 240 patients (137 Static, 103 Expandable) were included in the final analysis. Significant improvement was seen in both groups at 3 and 12 months postoperatively. Δ PCS-12 scores at 3 months were significantly greater for the Static group (16 vs. 10.5, $p=0.026$). However at 1 year, Δ PCS-12 scores were significantly greater for the Expandable group (-0.68 vs. 9.72, $p<0.001$) with a significantly greater proportion of patients meeting the MCID (53.6% vs. 72.5%, $p=0.034$). At 1 year, the Expandable group experienced greater improvement in Δ MCS scores (-8.96 vs. 1.09, $p<0.001$). Multivariate regression showed that cage type was an independent predictor of Δ PCS-12 ($\beta: 9.11$, $p=0.007$), Δ MCS-12 ($\beta: 10.79$, $p=0.008$), and Δ ODI ($\beta: -7.82$, $p=0.048$) at 1 year. All spinopelvic alignment measures showed no significance differences perioperatively within or between groups at 1 year. Subsidence rates failed to show any statistically significant difference between the two groups.

Discussion/Conclusion: TLIF with an expandable PEEK cage was an independent predictor of improved ODI, PCS-12, and MCS-12 scores at 1 year. Our study showed no significant difference in subsidence rates or spinal alignment between static and expandable PEEK cages.

Poster 17

The Value of Enhanced Recovery After Surgery (ERAS) in Lumbar Spine Surgery

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Background/Introduction: Providers across multiple specialties are constantly looking at processes and protocols to improve patient outcomes in lumbar spine surgery. ERAS protocols have been successfully demonstrated in the gastrointestinal surgical patient population to improve outcomes in the acute care phase. This study was designed to determine if the implementation of an ERAS protocol, customized for patients undergoing lumbar spine surgery, could improve outcomes including length of stay, opioid use, estimated blood loss, and transfusion rate, while evaluating the possible effect on readmission rates during this implementation phase.

Materials/Methods: An anesthesia designed ERAS protocol specific for joint replacement patients, was then implemented for all patients undergoing lumbar spine surgery at a single hospital. Charts from this cohort of patient were reviewed to include patients one year prior to and after implementation of ERAS. Data included length of stay (LOS) in both days and hours, daily and cumulative opioid usage converted into milligram morphine equivalents (MME), blood loss, transfusion amount (per unit pRBC) and readmissions data 0-90 days post-operatively. Student T-tests were used for statistical analysis.

Results: 231 patient charts reviewed in all, 135 prior to implementation and 96 post implementation. LOS (days) and LOS (hours) decreased significantly from 3.04 to 2.5 ($p=0.06$) for days and 74.1 to 63.9 hours ($p=0.1$). Average opioid consumption decreased for the overall hospital stay from 108.2 MME to 95.8 MME ($p=0.6$). Estimated blood loss significantly decreased as well from 357.3 mL to 250.7 mL ($p=0.05$), which correlated with a decrease in transfusion rate of 8.65 units to 4.5 units ($p=0.08$). Overall the 90 day readmission rate decreased significantly from 38 to 24 ($p=0.29$). The overall complication rate was similar between both groups.

Discussion/Conclusion: The ERAS protocol in our patients demonstrated a significant improvement in outcomes and can be implemented safely with collaboration with anesthesia providers and patient education.

Poster 18

Change in Patient Reported Outcome Measures as Predictors of Revision Lumbar Decompression Procedures

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Background/Introduction: Studies have highlighted specific demographic or radiographic risk factors for revision of lumbar decompression (LD) procedures. Few have elucidated the predictive utility of patient reported outcome measures (PROMs) for requirement of a revision LD. We aim to assess the extent that changes in PROMs act as potential predictors for a revision procedure following LD.

Materials/Methods: A surgical database was retrospectively reviewed for patients who underwent primary, elective, single or multilevel LD from May 2008 to January 2020. Exclusion criteria were procedures indicated for trauma, infection, or malignancy. Primary outcomes were visual analogue scale (VAS), Oswestry Disability Index (ODI), Short-Form 12-Item and Veterans RAND 12-Item Physical Component Score (SF-12 PCS and VR-12 PCS), and Patient-Reported Outcome Measurement Information System physical function (PROMIS PF). PROMs were collected from the primary procedure preoperatively and at 6-weeks, 12-weeks, 6-months, and 1-year follow up. Patients were categorized based on whether they underwent revision of LD within 2 years of the primary procedure. Score differences between subsequent timepoints were calculated as delta-PROM and evaluated for intergroup differences. Regression analysis of delta-PROM as a risk factor for revision of primary LD procedure was also conducted.

Results: Our cohort included 91 patients who underwent a primary LD procedure only and 44 undergoing a primary and revision procedure. Propensity score matched patients did not demonstrate significant differences in demographics. PROMs significantly differed between groups preoperatively for VAS back ($p=0.020$) and at preoperative, 6-week, 6-month, and 1-year (all $p<0.05$) for PROMIS PF. Delta values for all PROMs did not demonstrate significant associations for risk of undergoing a revision procedure except for at the 6-month timepoint for PROMIS PF ($p=0.024$).

Discussion/Conclusion: Patients who went on to undergo a revision procedure demonstrated significant improvements following their primary procedure at intermittent timepoints. As compared to patients who only received a primary procedure, revision patients demonstrated significant differences in physical function, but this was largely not a predictive factor for a revision procedure. These results suggest that patient reported outcomes may not be useful as potential predictors for undergoing a revision procedure following LD.

Poster 19

Does Degree of Cage Lordosis Affect Radiographic Outcomes in Patients Receiving Single Level Transforaminal Lumbar Interbody Surgery?

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Background/Introduction: Restoring or maintaining lumbopelvic sagittal alignment in lumbar fusion surgery has been shown to be important for successful lumbar fusion surgery. Various angles of cages in interbody fusion have been used, however the relationship between cage lordotic angle and radiographic measures achieved postoperatively has not been investigated. Therefore, the purpose of this study was to determine the effect of the interbody cage lordosis on radiographic measures after single-level transforaminal lumbar interbody fusion (TLIF).

Materials/Methods: A retrospective review was performed on patients who underwent single level TLIF between January 2010 to September 2020. Seventy-five patients with a 12° cage and 51 patients with a 5° cage were analyzed intraoperatively, at one month postoperatively, and at final follow up. Lumbar lordosis angles, segmental lordosis, disc height, centre point ratio (CPR), cage position, and cage subsidence were measured on standing lateral radiographs.

Results: A total of 126 patients were included in final analysis. There were no differences in Δ lumbar lordosis (0.73° loss with 12° cage vs. 0.19° loss with 5° cage, $p = 0.791$) or Δ segmental lordosis (1.67° loss with 12° cage vs. 1.77° loss with 5° cage, $p = 0.945$) at 1 month follow up. There were no differences in Δ lumbar lordosis (2.11° gain with 12° cage vs. 4.07° gain with 5° cage, $p = 0.511$) or Δ segmental lordosis (1.69° loss with 12° cage and 0.81° gain with 5° cage) at final follow up as well. Multivariable linear regression failed to show demographic factors, cage position, CPR or cage characteristics to be independent predictors of change in lordosis.

Discussion/Conclusion: Increasing cage lordotic angle was not found to be associated with radiographic changes in patients receiving a single-level TLIF procedure.

Poster 20

Comparison of Outcomes of Primary and Revision Minimally Invasive Lumbar Microdiscectomy

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Background/Introduction: Although revision surgery carries a higher risk of complications due to dissection through scarred tissue planes, minimally invasive (MIS) techniques are increasingly being utilized to avoid scar tissue from previous approaches. However, it is not known whether there are differences in outcomes between primary and revision MIS lumbar microdiscectomy. Thus, the purpose of this study was to compare outcomes of primary and revision MIS lumbar microdiscectomy.

Materials/Methods: A retrospective review of prospectively collected data of patients who underwent 1-2 level MIS lumbar microdiscectomy was performed. Patient demographics, operative data, clinical outcomes and patient-reported outcomes [PROMs– ODI, VAS back& leg pain, SF-12 and PROMIS] of primary and revision surgery were compared.

Results: 195 patients (Primary=166, Revision=29) were included. The revision cohort was younger (42 vs 48yrs for primary, $p=0.033$), had a lower Charlson Comorbidity Index (0.06 vs 0.36, $p=0.006$) and shorter operation time (42 vs 48mins, $p=0.033$). There were no differences in post-operative narcotic consumption ($p=0.927$) or length of stay ($p=0.968$). 90% of patients in both cohorts were discharged on the day of surgery. The only operative complication was 1 dural tear (0.6%) and the only in-hospital complication was urinary retention ($n=3$, 1.8%), all in the primary cohort. During the follow-up period, the revision cohort had a higher rate of complications managed non-operatively ($p=0.035$), but there was no difference in reoperation rates ($p=0.472$). Both groups showed significant improvement in all PROMs with no difference in the achievement of MCID (Primary vs revision: 2 weeks 50 vs 55.2%, $p=0.606$; 90 days 62.7 vs 65.5%, $p=0.774$; last follow-up 68.7 vs 65.5%, $p=0.733$).

Discussion/Conclusion: Patients undergoing revision surgery were younger, had lower comorbidity burden and slightly shorter operative times. There was no difference in narcotic consumption, length of stay, or intra-operative and in-hospital complications. Although the revision cohort had a higher rate of complications managed non-operatively, there was no difference in reoperation rates. Both groups showed significant improvement in PROMs, with no difference between groups. These findings suggest that revision MIS microdiscectomy is a safe and as effective treatment option for patients with recurrent herniation, and can provide outcomes equivalent to primary surgery.

Poster 21

Is Postoperative Loss of Reduction after Minimally Invasive Transforaminal Lumbar Interbody Fusion for Degenerative Spondylolisthesis Clinically Meaningful?

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Background/Introduction: Minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) is the workhorse minimally invasive treatment for patients with degenerative lumbar stenosis and spondylolisthesis refractory to nonoperative care. While the basic tenets of surgical treatment do not differ between minimally invasive and open techniques, surgeons performing MI-TLIF are more likely to attempt reduction of spondylolisthesis in order to optimize restoration of canal dimensions due to a greater reliance on indirect decompression, which has been shown to be effective. While intraoperative reduction is often successful, postoperative loss of reduction and slip recurrence can be seen. The purpose of our study was to determine the rate and clinical impact of slip recurrence after MI-TLIF with expandable cage technology.

Materials/Methods: Patients undergoing MI-TLIF for degenerative spondylolisthesis using articulating, expandable cages from 2017-2019 were retrospectively studied. Lateral radiographs were reviewed and evaluated for the presence or absence of spondylolisthesis preoperatively, intraoperatively, and at follow-up times including 2 weeks, 6 weeks, 12 weeks, 6 months, and 1 year postoperatively. Spondylolisthesis was measured from the posterior inferior corner of the cephalad vertebra to the posterior superior corner of the caudal vertebral, with any measurement >1mm classified as spondylolisthesis, and Meyerding grade was noted. Intraoperative reduction was measured, and loss of reduction was defined as >1mm increase in spondylolisthesis comparing follow-up imaging to intraoperative films. ODI, VAS for back/leg pain, SF-12, and PROMIS Physical Function, were recorded at the preoperative and follow-up time points.

Results: A total of 63 patients and 70 levels were included, with mean age 59.8 yrs (SD,13.8). 19 levels (27.1%) had complete reduction intraoperatively, 40 (57.1%) had partial reduction, and 11 (15.7%) had no reduction. Of the 30 levels with loss of reduction (50.8%), 20 (66.7%) occurred by 2 weeks postoperatively and 28 (93.3%) occurred by 12 weeks postoperatively. At 6 months, there were significant differences between those who had loss of reduction and those who did not in VAS back pain (3.0 vs. 0.9, p=0.017) and SF-12 PCS (41.5 vs. 50.0, p=0.035).

Discussion/Conclusion: While a majority of patients demonstrated reduction intraoperatively, 51% had loss of reduction, most commonly in the acute postoperative period.

Poster 24

Impact of Operative Time on Adverse Events Following Elective Single Level Posterior Lumbar Fusion

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Background/Introduction: Independent of other risk factors, increased operative time has been associated with post-surgical adverse events across a spectrum of orthopedic surgeries. The purpose of our study is to quantify the risk of postoperative adverse events associated with each increasing operative time interval in patients undergoing a single-level posterior lumbar fusion.

Materials/Methods: The American College of Surgeons National Surgical Quality Improvement Quality Improvement Program (ACS-NSQIP) Participant Use File was queried from 2009 to 2018. We identified all patients undergoing elective single-level posterior lumbar fusions utilizing Current Procedural Terminology codes (22612, 22630, 22633) and excluding codes for additional levels and deformity. Demographic information, medical comorbidities, and adverse events within 30 days were compared in relation to operative time, including infection, venous thromboembolism, cardiopulmonary complications, reoperation, and mortality. Univariate analysis compared operative time and postoperative outcomes; variables with a p-value of less than 0.05 were considered significant and included in the multivariate analysis. The strength of the correlation was considered strong if the area under a receiver operating characteristic analysis was above 0.7 and moderate if above 0.6.

Results: A total of 12,173 patients were identified from 2009-2018 who underwent an elective single level posterior lumbar fusion. Approximately half (53.3%) were female with an average age of 60.3 years old. The distribution of operative times was positively skewed, with a median operative time of 175 minutes (IQR 125 to 241). The median length of hospitalization was 3 days (IQR 2 to 4) also with a positive skew. Each additional 15 minutes of operative time resulted in an increased risk of requiring a transfusion by 12% ($p < 0.001$, AUC = 0.76) and extended ventilation for >48 hours postoperatively by 10% ($p < 0.001$, AUC = 0.79). Moderate but still significant risk of venous thromboembolism increased by 8% for every additional 15 minutes of operative time ($p < 0.001$, AUC = 0.64).

Discussion/Conclusion: We found statistically significant correlations between increased operative time and increased risk of post-operative adverse events after one-level lumbar fusion, including extended ventilation requirements, VTE and transfusion. Our findings suggest that intra-operative efficiency may yield incrementally patient outcomes in the short term.

Poster 25

Healthcare Resource Utilization: Lumbar Disc Herniation

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Background/Introduction: Healthcare as an industry has experienced exponential inflation of cost, with national expenditure exceeding 17 percent of GDP. To combat resource overutilization, it may be efficient to address common pathologies, such as lumbar disc herniations (LDH). As one of the driving causes of low back pain in the US, a \$100 billion market, LDH comprise a significant healthcare expenditure. Our purpose was to identify patterns of health resource utilization after elective lumbar disc herniation surgery.

Materials/Methods: All patients undergoing surgery for lumbar disc herniation at a single tertiary care center were identified by CPT code. Retrospective review of records was performed to obtain data on patient-specific characteristics, including demographic data (age, BMI), medical comorbidities including Charlson Comorbidity Index (CCI), preoperative opioid use, and American Society of Anesthesiologists (ASA) classification. Outcomes were measures of post-operative healthcare utilization, including complications, number of clinic and telephone visits, use of advanced imaging, referrals to other healthcare providers, ED and urgent care visits, and opioid prescriptions. Multivariate analysis was used to identify trends in resource utilization, and ANOVA analyses compared differences between groups. Statistical significance was set at $p < 0.05$.

Results: 204 patients met inclusion criteria, with mean age 54 and BMI 28.5. 58 (28.4%) patients were ASA class 1, 123 (60.3%) patients were ASA class 2, and 23 (11.3%) patients were ASA class 3-5. 132 (64.7%) patients had a CCI < 3 , and 60 (29.4%) patients had a CCI of 3 or 4. Multivariate analysis compared healthcare utilization outcomes against patient characteristics of age, ASA class, CCI score, BMI, and pre-operative opioid use. Results demonstrate a statistically significant relationship with age, ASA class, and CCI score ($p < 0.05$). ANOVA analyses looking at ASA class and CCI score reaffirm significant relationships with markers of resource utilization including opioid prescriptions, complications, outpatient referrals, ED visits, and advanced imaging ($p < 0.05$).

Discussion/Conclusion: This study illustrates that patient-specific characteristics can be associated with significant differences in healthcare utilization after elective surgery. We identify different utilization rates between patients grouped by age and CCI score, indicating potential targets for peri-operative intervention to improve quality and reduce resource utilization.

Poster 26

Not Frail and Elderly: How Invasive Can We Go In This Different Type of Adult Spinal Deformity Patient?

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Background/Introduction: Frailty has been described as a dynamic measure transcending age, encompassing a patient's sum deficits in health. Frailty indices have been utilized in adult spinal deformity(ASD) to characterize the influence of preop health state on postop outcomes. There is paucity in the literature investigating the surgical profile and outcomes of operative adult spinal deformity (ASD) patients who present as elderly and not frail.

Materials/Methods: Included: ASD patients ≥ 18 years of age, undergoing ≥ 4 levels fused with baseline(BL) and follow up data. Patients were categorized by the ASD frailty index: Not Frail[NF], Frail[F], Severely Frail [SF]. An elderly patient was defined as a patient ≥ 70 (Caterino, Am J Emerg Med). The patients were grouped into patients who were NF/elderly and F/elderly. Baseline SRS-Schwab modifiers were assessed at baseline and 1-year(0, +, ++). Logistic regression analysis assessed the relationship between increasing invasiveness (Mirza et al), no reoperations or major complications and improving in SRS-Schwab modifiers[Good Outcome]. Decision tree analysis assessed thresholds for an invasiveness risk/benefit cutoff point.

Results: 598 ASD pts included(55.3yrs, 60%F, 28.3kg/m²). 29.8% of patients were elderly. At baseline, 51.3% of patients were classified as NF, 37.5% F and 11.2% SF. 66(11%) of patients were NF and elderly. Surgical characteristics of the NF-elderly: 3% anterior, 84.9% posterior, and 12.1% combined approach; levels fused: 4.8; 28.8% Ponte osteotomy, 9.1% PSO, invasiveness: 14.6; reoperations in 18.2% of patients. 24.2% of patients improved in SRS-Schwab by 1-year and had no reop or complication postop in the NF-Elderly. Binary regression analysis found a relationship between worsening SRS-Schwab, postop complication and reoperation with invasiveness score(1.056[1.013-1.102], p=0.011). Risk/benefit cut-off was 10(p=0.004). Patients below this threshold were 7.9[2.2-28.4] times more likely to have a Good Outcome. 156 patients were elderly and MF/SF with 16.7% having Good Outcome[as 33.3% had a complication and 25% reoperation]. Their risk/benefit cut-off point was found to be (< 8), 4.4[2.2-9.0], p<0.001.

Discussion/Conclusion: ASD patients who are not frail and elderly present with a broad range of deformity severity. Not frail/elderly patients do better in invasive procedures compared to the frail/elderly. Surgeons should consider the patient's overall health profile(frailty) over elderly age in an adult spinal deformity population.

Poster 27

Achievement of Optimal Clinical Outcomes in Adult Spinal Deformity Surgery Requires Prioritizing Realignment Goals and Varies Based on Pelvic Incidence

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Background/Introduction: Many patients are unable to undergo a major adult spinal deformity (ASD) corrective surgery due to deformity severity, age, comorbidities, and overall frailty status. In order to optimize quality of life in patients with ASD there may be alignment ratios to be prioritized across different presentations of spinal shape.

Materials/Methods: Included: Patients >18yrs undergoing surgery for ASD (scoliosis $\geq 20^\circ$, SVA $\geq 5\text{cm}$, PT $\geq 25^\circ$, or TK $\geq 60^\circ$) with full baseline (BL) and 2-year (2Y) radiographic parameters and HRQL scores. Patients were stratified by baseline pelvic incidence: Low PI ($<45^\circ$), High PI ($\geq 45^\circ$). Ratios of SRS-Schwab radiographic parameters (PI-LL, SVA, PT) were assessed for quartiles of correction: minimal ($<0\%$), 0-25%, 25-50%, 50-75%, and 75-100%. Target quartiles of correction were assessed within the PI severity groups for achievement of 2Y Best Clinical Outcome as defined by Smith et. al: SRS-22 scores ≥ 4.5 and ODI ≤ 15 [BCO] through correlations and stepwise linear regression analysis.

Results: 165 ASD patients included (56.7 ± 16.3 yrs, 80.3% female, $25.8 \pm 5.3 \text{kg/m}^2$). By baseline PI: 24.3% Low PI, 75.7% High PI. (47 patients) of patients met the criteria for BCO, which was evenly distributed amongst the Roussouly types ($p=0.115$). For Low PI patients, a combination of correcting the PI-LL from 0-25%, SVA 75-100%, and PT 0-25% significantly predicting acquiring the BCO ($R^2 = 0.622$, $p=0.002$). For BCO in High PI patients, a 25-50% correction in PI-LL, SVA minimal, and PT 75-100% ($R^2 = 0.297$, $p=0.021$). Low PI patients who met the 3 ratios of correction (PI-LL, SVA and PT) had less major complications (11.1% vs 23.1%) compared to other Low PI patients. High PI patients who were corrected to the Schwab quartile of ratios underwent less reoperations (6.1% vs 23.3%) and had less PJK occurrence by 2-years postop (20.4% vs 40%), all $p < 0.05$.

Discussion/Conclusion: Certain ratios of correction of the SRS-Schwab modifiers contribute to improving clinical outcomes and vary by preoperative spinal shape. Prioritization of global realignment relative lumbo-pelvic mismatch depends on the theoretical contour of the individual patient. Importantly, certain subgroups experience the most clinical benefit from the initial percentages of realignment, which may obviate more aggressive corrections on an individual basis.

Poster 28

Pre-Operative Modified Zung Depression Index Scores are Not Predictive of Worse Post-Operative Functional Outcome in Adult Spinal Deformity Patients.

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Background/Introduction: Pre-operative mental health status is a known risk factor for worse post-operative outcomes after lumbar spine surgery. However, few studies have investigated the effect pre-operative mental health has on patients after surgery for adult spinal deformity (ASD). We investigated the effects of pre-operative depression, as measured by the Modified Zung Depression Index (MZDI), on post-operative Oswestry Disability Index (ODI) scores after corrective surgical treatment for ASD.

Materials/Methods: An institutional review board approved database consisting of a consecutive series of patients with ASD from 2014 to 2019 treated at a single academic institution was used for this study. All patients were 18 years or older, underwent long-segmental spinal fusion from the thoracic spine to the pelvis, and had at least 6 months of follow-up. MZDI scores were measured at patient's first pre-operative visit; scores ≥ 33 were categorized as depressed. ODI scores were measured at both the first pre-operative visit and final post-operative visit. Statistical analyses were performed using SPSS 27.0. Comparison of means was conducted using Student's t-test. Variables with a P-value less than 0.200 on univariate linear regression analysis were included in the multivariate analysis to determine the correlation between MZDI scores and patients' baseline variables and ODI scores. Statistical significance was defined as $P < 0.05$.

Results: A total of 51 patients were included in this study. The average age was 62.2 years, 33% of patients were male, and 43% of patients were depressed. BMI and pelvic tilt were significantly less in depressed patients but all other demographic and radiographic variables were not significantly different between groups. There was no significant difference in pre-operative ODI, post-operative ODI, nor percent change in ODI in depressed vs. non-depressed patients. Univariate linear regression revealed increased BMI to be significantly associated with decreased absolute and percent change in post-operative ODI. Multivariate analysis revealed only increased BMI to be significantly associated with decreased percent change in post-operative ODI (Table 1).

Discussion/Conclusion: Our study suggests that increased BMI, not MZDI score nor depression status, is a significant risk factor for worse improvement in ODI after long-segment spinal fusion with pelvic fixation in patients with ASD.

Poster 29

Evaluation for Healthcare Disparities in PROMIS scores after 1- and 2-level TLIF and PLIF Procedures

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Background/Introduction: Socioeconomic disparities are known to affect health outcomes. Existing research has highlighted the health challenges for patients with fewer socioeconomic resources. However, there is a paucity of literature on the effects of socioeconomic status on elective spine surgery outcomes.

Materials/Methods: A single center retrospective cohort study was conducted including adults who underwent 1- and 2-level TLIF and PLIF procedures with baseline and minimum 3 month post-operative PROMIS scores from 2017-2020. Demographics and payor type were collected. Median income was approximated by 5-digit zip codes and data from the U.S. Census Bureau and American Community Survey 2018. Relationships between socioeconomic factors, demographics, and PROMIS scores were determined using chi-square analyses and one-way ANOVA (p=0.05).

Results: This study includes 130 patients, 50% female, average age 61.2 years, 63% Caucasian, 85% Privately Insured, average BMI 29, 7% current smokers, and average median income of \$84,190. When comparing by Low, Middle, and Upper Class, Pain Interference (PIf) decreased with increasing median income at 6-12 months (81.5+20.4 vs. 77.5+21.0 vs 39.0+53.7, p=.048) and the change from baseline to 6-12 months was approaching significance (-7.4+13.7 vs. -12.5+22.3 vs. -48.5+61.5, p=.069). When comparing by gender, Physical Function was worse for women at baseline (8.8+10.4 vs. 13.9+11.2, p=.01), and trending towards significance at 6-12 months (21.5+21.9 vs. 31.9+20.5, p=.084). Comparing by payor type, Publically Insured patients had a higher CCI (3.4+2.8 vs. 2.4+1.5, p=.02). Comparing by race, PIf was significantly higher for non-Caucasians at baseline (58.0+5.8 vs. 55.6+6.8, p=.044), and there was no difference in the change from baseline to later time points; there were also more women in the non-Caucasian cohort (66% vs. 43%, p=.01).

Discussion/Conclusion: While our patient cohort is predominantly Caucasian, Privately Insured, and Middle to Upper Middle Class, when evaluating for healthcare disparities there were no consistent differences in PROMIS scores at post-operative time points. There was a significant difference in Pain Interference scores at 6-12 months and the change from baseline to 6-12 months was trending towards significance, when stratifying by Pews Group income brackets and by payor type. This suggests that patients with lower socioeconomic resources may have less pain improvement at 6-12 months post-op.

Poster 30

Influence of Obesity on Achievement of Minimum Clinically Important Difference After Transforaminal Lumbar Interbody Fusion

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Background/Introduction: Obesity is a proven risk factor for poorer outcomes following minimally invasive transforaminal lumbar interbody fusion (MIS TLIF). Few studies investigated the impact body mass index (BMI) on achievement of a minimum clinically important difference (MCID) for physical function outcomes. This study aims to evaluate the impact of BMI on postoperative outcomes and achievement of MCID following MIS TLIF.

Materials/Methods: A prospective surgical database was retrospectively reviewed from 2011 to 2020 for primary, single level MIS TLIF. Patients were grouped based on BMI: Non-Obese (<30 kg/m²); Obese I (≥30 and <35 kg/m²); Severe (≥35 and <40 kg/m²); Morbid (≥40 kg/m²). Visual Analog Scale (VAS) back and leg, Oswestry Disability Index (ODI), 12-Item Short Form (SF-12), and PROMIS-PF were collected preoperatively and postoperatively. The impact of BMI on outcome measures was determined using simple linear regression. Achievement rates of MCID were evaluated using pre-established values: 1.2 (VAS Back); 1.6 (VAS Leg); 12.8 (ODI); 4.0 (SF-12); 8.0 (PROMIS PF). Intergroup differences in MCID achievement were evaluated using Chi-square analysis.

Results: The study cohort included 162 patients with 88 categorized as normal weight, 37 Obese I, 25 Severe, and 12 Morbid. Mean age was 50.9 years with 63.4% being male and 62.0% having a spinal pathology of degenerative spondylolisthesis. The BMI groups differed in diabetes status (p=0.015), hypertension (p=0.002), and American Society of Anesthesiologists score (p=0.006). Regression analysis revealed ODI, SF-12, and PROMIS-PF significantly differed by BMI group at all timepoints. BMI only affected VAS back at 6- and 12-weeks and VAS leg at preoperative through 12-weeks (all p<0.05). MCID achievement for PROMIS-PF significantly differed at 12-weeks (p=0.011). Overall MCID achievement for all outcomes did not differ by BMI group.

Discussion/Conclusion: BMI demonstrated a significant effect on disability and physical function scores throughout the 1-year postoperative period. The effect of BMI on MCID achievement was also demonstrated for PROMIS PF. While obesity may be a significant risk factor for poorer outcomes, it may only impact achievement of an MCID for physical function.

Poster 31

Racial Differences in Discharges Against Medical Advice of Lumbar Vertebral Fracture Patients in U.S. Emergency Departments (2011-2019)

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Background/Introduction: Troubling disparities exist in the quality of care for racial minorities and the socioeconomically disadvantaged. In particular, differences in emergency disposition among races are of clinical interest as cohort studies have shown that the expected time to leave against medical advice (AMA) is 20% shorter for Black Americans than White Americans (Tawk et al., 2016). Leaving the emergency department AMA predisposes Black patients to significant morbidity and may be underlaid by distrust of medical professionals or dissatisfaction with received care (Armstrong et al., 2007). We sought to understand differences in discharges AMA for patients with lumbar vertebral fractures using a nationally representative cohort.

Materials/Methods: This was a cross-sectional, descriptive investigation that identified cases of adult lumbar vertebral fractures from 2011 to 2019 using the National Electronic Injury Surveillance System (NEISS) database, a publicly available and nationally representative probability sample of hospital emergency departments in the United States. Cases were stratified by the size of the hospital, disposition in the emergency department, and recorded race.

Results: This national investigation has revealed that 0.65% percent of Black and 0.57% percent of Hispanic patients left AMA, while 0.31% percent of White and 0.32% percent of all patients left AMA. There was a statistically significant difference in these proportions (p-value = 0.002). This difference is most evident in “very large” metropolitan hospitals where 1.2% of Black and 3.7% of Hispanic fracture patients left AMA. In chi-squared analyses of independence, it was thus found that both hospital size (p-value < 0.001) and race (p-value < 0.001) were both significantly associated with the incidence of fracture patients leaving AMA.

Discussion/Conclusion: The data illustrate how racial differences in lumbar fracture discharges AMA exist. Past literature has shown that leaving AMA is associated with poor communication between patient and provider (Windish et al., 2008). This is consistent with the established distrust of healthcare systems by racial minorities (Armstrong et al., 2007). In order to improve healthcare outcomes for historically marginalized communities, having identified these differences in emergency department disposition by race presents an opportunity to ensure that these communities have access to higher quality care.

Poster 32

Intraoperative Ketamine on Intermediate and Long-Term Opioid Use After Spine Surgery

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Background/Introduction: Management of chronic postoperative pain and opioid dependence pose significant challenges for spine surgeons. Ketamine has come to attention as an intraoperative analgesic that may reduce opioid consumption in the immediate postoperative period, but its long-term opioid sparing abilities remain poorly characterized. This study investigates whether intraoperative ketamine administration reduces opioid consumption in the intermediate to long-term outpatient setting after spine surgery.

Materials/Methods: A retrospective review was performed of 434 patients (118 ketamine, 316 control) who underwent spine surgery between August 2016 and June 2018. Opioid scripts filled between January 2013 and August 2019 were collected from the PDMP, and opioid consumption was quantified using cumulative MMEs over time. Propensity score analysis was used to evaluate association between ketamine administration and net outpatient opioid consumption at 1, 3, 6, and 12 months postoperatively. Patients were further stratified into subgroups based on their exposure to opioids preoperatively (naïve vs episodic vs chronic use), as well as the magnitude of their preoperative usage (40-60th percentile, 60-80th percentile, 80th+ percentile, <90 MME/day, >90 MME/day). The association between intraoperative ketamine exposure and postoperative opioid consumption was examined in all subgroups.

Results: There were no differences in net MME outpatient opioid consumption between the ketamine (k) and control (c) groups at 1 month (k=2442, c=2081), 3 months (k=4219, c=2548), 6 months (k=6337, c=3191), or 1 year (k=10352, c=5002). Exposure to intraoperative ketamine was not associated with lower incidence of long-term postoperative opioid use (OR=1.06). Subgroup analysis did not demonstrate differences in opioid consumption between the ketamine vs control groups regardless of preoperative opioid consumption patterns. Notably, ketamine exposure was not associated with reduced mean opioid consumption in patients with chronic preoperative opioid use (k=4552, c=6011 at 3 months), the demographic theorized to benefit most from this intervention.

Discussion/Conclusion: Intraoperative ketamine is not associated with decreased outpatient opioid consumption or lowered incidence of long-term opioid use after spine surgery. While ketamine has been theorized to exert greater opioid-sparing benefits in patients with long-term or high-dose preoperative opioid use, this was not observed in this study. Management of chronic postoperative opioid dependence remains a challenging topic that requires further research.

Poster 33

Healthcare Resource Utilization: Lumbar Spinal Stenosis

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Background/Introduction: Low back pain and sciatica contribute to a \$100 billion problem in the US, with worsening expenditure and resource consumption. Lumbar spinal stenosis is a key clinical and radiographic diagnosis associated with these symptoms, with a prevalence of 25% in the general population over age 50. The purpose of this study is to identify patterns of resource utilization after elective surgery for lumbar spinal stenosis.

Materials/Methods: All patients undergoing surgery for lumbar stenosis at a single tertiary care center were identified by CPT code. Retrospective review of records was performed to obtain data on patient specific characteristics, including demographic data (age, BMI), medical comorbidities including Charlson Comorbidity Index (CCI), preoperative opioid use, and American Society of Anesthesiologists (ASA) classification. Outcomes data included measures of post-operative healthcare utilization, ranging from complications, number of clinic and telephone visits, use of advanced imaging, outpatient referrals, ED and urgent care visits, and opioid prescriptions. Multivariate analysis was used to identify trends in resource utilization, and ANOVA analyses compared differences between patient groups. Statistical significance was set at $p < 0.05$.

Results: 233 patients met inclusion criteria, with mean age 55 and BMI 30.1. 17 (7.3%) patients were ASA class 1, 140 (60%) patients were ASA class 2, and 76 (32.6%) patients were ASA class 3-5. 127 (54.5%) patients had a CCI < 3 , 65 (27.9%) patients had a CCI of 3 or 4, and 41 (17.6%) patients had a CCI > 4 . Multivariate analysis demonstrated a significant relationship between utilization outcome measures and patient-specific CCI score ($p < 0.05$). ANOVA analyses demonstrate similar patterns, with statistically significant differences between patients grouped by CCI score or ASA class in association with utilization measures of opioid prescriptions, outpatient referrals, post-operative complications, advanced imaging, and ED and clinic visits ($p < 0.05$).

Discussion/Conclusion: These analyses identify patient-specific characteristics that may be associated with significant differences in healthcare utilization after elective lumbar stenosis surgery. We found patients with higher ASA class or CCI score consume relatively more healthcare resources, suggesting that peri-operative intervention may help improve quality of care and address the evolving issues of healthcare resource overutilization.

RF 01

Evaluation of the Basal Metabolism of Degenerative Lumbar Intervertebral Discs Based on Pfirrmann Grade and Presence of Instability

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Background/Introduction: Intervertebral disc (IVD) degeneration is implicated in back pain, a leading cause of spine-related disability. It may also cause segmental instability. Both local and systemic inflammatory processes have been implicated in the pathophysiology of IVD degeneration, though it is unclear if Pfirrmann grade severity or presence of instability affects degenerative IVD metabolism. These differences have not previously been investigated. This study was aimed to examine the basal metabolism of degenerative lumbar IVD tissues collected from patients undergoing lumbar microdiscectomy or fusion with the hypothesis that tissues from patients with higher Pfirrmann grades with instability would produce significantly higher levels of degradative enzymes and inflammatory mediators.

Materials/Methods: Degenerative IVD tissue was obtained from patients (n=7, mean age 53) being treated for symptomatic degenerative lumbar disease. Pfirrmann grading (1-5) of the IVD was determined by evaluation of MRI (grade 3 n=3, grade 4 n=4), and for instability as defined by the presence of a spondylolisthesis. Tissues comprised of degenerative nucleus pulposus (NP) was collected and explants were created. Cultured for 3 days, after which media were collected for biomarker evaluation. Media Analyses: Media were tested for MMP-1, MMP-2, MMP-3, MMP-7, MMP-8, MMP-9, MMP-13, TIMP-1, TIMP-2, TIMP-3, TIMP-4, GRO- α , MCP-3, PDGF-AA, PDGF-AB/BB, IL-2, IL-4, IL-6, IL-8, MCP-1, MIP-1 α , MIP-1 β , RANTES, TNF- α , and VEGF using commercially available assays. Statistical analysis: Significant differences between groups were determined by t-test with significance set at $p \leq 0.05$.

Results: No significant differences between basal biomarker production by degenerative IVD tissues of Pfirrmann grade 3 versus 4 discs. However, tissues from degenerative IVDs with instability were found to produce significantly higher levels of MMP-8, and significantly lower levels of MMP-1, MMP-2, and MMP-13 compared to tissues from stable spine.

Discussion/Conclusion: No significant difference in the metabolism of IVD tissues with a Pfirrmann grade of 3 or 4. However, the presence of instability in the degenerated lumbar IVD resulted in a significant increase in the production of MMP-8, but the production of other degradative enzymes was significantly decreased. Further study is aimed to provide potential therapies for prevention and treatment of lumbar intervertebral disc degeneration.

RF 02

Adjacent Segment Biomechanics Modeling T10-Pelvis Spinal Fusion*Rodriguez Christian, BS¹, Kumar Rachit, BS¹, Saifi Comron, MD¹**¹ University of Pennsylvania, Philadelphia, Pennsylvania, United States*

Background/Introduction: Proximal junctional kyphosis (PJK) and failure (PJF) are challenging complications of long fusion constructs for the treatment of adult spinal deformity. Few studies have investigated the biomechanics of long spinal fusions, none of which accounted for anatomical variation. This study seeks to use a large cohort to understand the biomechanical stresses proximal to the upper instrumentation of a T10-pelvis fusion.

Materials/Methods: The pre-fusion models were subject-specific thoracolumbar spine models that incorporate the height, weight, spine curvature, and muscle morphology measurements of 250 individuals from the Framingham Heart Study Multidetector CT Study. To create post-fusion models, the subject-specific models were further modified to eliminate motion between the intervertebral joints from T10 to the pelvis. Simulated motion included neutral standing, axial rotation, trunk flexion, and 'pushing a force'. Both increased segmental mobility and unchanged segmental mobility were modeled for each simulated motion. OpenSim analysis tools were used to calculate the medial lateral shear force, anterior posterior shear force, and compressive force on the T9 vertebra during the simulated motions.

Results: Anterior-posterior shear force significantly increased from 23.16 N to 204.2 N ($p < 0.001$) during trunk flexion and significantly increased from 93.35 N to 143.7 N ($p < 0.001$) during axial twist. During trunk flexion, medial lateral shear force significantly increased from 115.8 N to 157.1 N ($p < 0.001$). During trunk flexion, compression decreased from 1583 N pre-fusion to 1170 N post-fusion ($p < 0.001$). Axial twist had a compression decrease from 889.2 N to 735.4 N ($p < 0.001$). Standing ($p < 0.001$) and 'pushing a force' ($p < 0.001$) motions also saw significant decreases in compression.

Discussion/Conclusion: This computational study provided the first use of subject-specific models to investigate the biomechanics of long spinal fusions. Patients undergoing T10-Pelvis fusion were predicted to have increased shear forces and decreased compressive force at the T9 vertebra, independent of change in segmental mobility. The results suggest that more research is needed to understand how shear forces affect vertebral body integrity. Despite its limitations, this computational model shows potential for the investigation of spinal fusion biomechanics in order to reduce the risk of PJK or PJF.

RF 03

Finite Element Model for Spinal Metastatic Disease

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Background/Introduction: Introduction: Spinal metastasis is common among cancer patients. It may result in fractures with instability and neurological complications. Understanding spine biomechanics with metastasis may be helpful to advise cancer patients about their physical limits. This study investigates the biomechanics for different degrees of metastatic involvement under pure compressive and combined (compressive and bending) loading.

Materials/Methods: A validated T12-sacrum FEM was used. The L3 vertebra was subjected to 6 clinical scenarios: (1) healthy (2) osteoporotic, (3) 40% metastasis in the VB, (4) 80% metastasis, (5) 4cc PMMA in 40% metastasis, (6) 4cc PMMA in 80% metastasis. All were subjected to pure compression (1kN), and combined compression (1kN) and bending moment (1Nm) in flexion and extension. The loading was representative of ADL's (carrying /lifting weight (10 kg) from ground or tying shoes) The load was applied at T12 and sacrum constrained. 18 cases were simulated and ROM, VB forces, and disc pressures analyzed.

Results: Healthy and osteoporotic models showed similar responses. The metastasis at L3 decreased the spine stiffness, increased the ROM under all loading conditions. The decrease in stiffness was greater in 80% metastasis case: higher ROM, higher potential for fracture and instability. PMMA increased the stiffness in tumor models, reducing the ROM. Spinal forces were higher (up to 25%) in pure compression as compared to combined loading. In cases with metastasis, the VB forces at L3 reduced more than 90%. PMMA in 40% metastasis, the L3 vertebral body forces reached within 15% of the healthy model. Whereas in 80% metastasis, the L3 VB forces were unchanged (not clinically significant) with the injection of PMMA.

Discussion/Conclusion: Increase metastasis increases instability of the spine (higher ROM, lesser vertebral forces at L3). Pure compression loading resulted in higher VB forces and disc pressures. Thus, the activities which result in pure compression of the spine (carrying / lifting) are more severe than activities which involve flexion or extension. PMMA may be effective in vertebrae with 40% metastasis, and patients may be able to perform ADL's safely. With 80% metastasis the patients may not be able to perform ADLs without risking pathologic fractures with instability.

RF 04

Intervertebral Foramen Narrowing in Compression Fractures of the Lumbar Spine: Biomechanical and Clinical Considerations.

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Background/Introduction: Lumbar spine fractures occur in military environments, falls, and vehicle crashes. Each event encompasses pelvis acceleration/deceleration contributing to compressive loads as force transmitted through the pelvis compress the lumbar spine against the torso mass, leading to tissue deformation and injury. Even in the absence of severe vertebral body injury, persistent back and radicular pain may persist. The clinical evidence of the effect of vertebral wedge/burst fracture on the intervertebral foramen (IVF) parameters, however, is relatively sparse. This study evaluates IVF measurements associated with vertebral body fracture after traumatic axial loading.

Materials/Methods: A series of 30 isolated human cadaver lumbar spines underwent vertical dynamic loading using a drop tower. Axial CT scan was performed on the specimens, before and after the impact. Foraminal height (IVF_Ht) and posterior disc height (PD_Ht) were measured. Fractures were graded for presumed clinical significance using Abbreviated Injury Scaling (AIS) 2015 (AAAM 2016) scoring. Statistical analysis was done using one sample t-test with $p < 0.05$.

Results: There was a significant decrease ($p < 0.05$) in the post-test IVF measurements compared to the pre-test. Furthermore, 45% of the total 22 less-severe (AIS 2) cases and 88% of the total 8 more-severe (AIS 3) cases had IVF values below the clinical literature reported thresholds (IVF_Ht < 15 mm and PD_Ht < 4 mm).

Discussion/Conclusion: As expected, majority of the more-severe cases had IVF measurements below the threshold. However, it was surprising to find that half of the less-severe cases also had an IVF measurement below the critical values, indicating a potential occurrence of nerve root compromise even in the minor fracture cases. In a companion clinical study, the senior author reviewed records of 950 patients with compression fractures. Eleven of 24 patients with isolated radiculopathy (no spinal cord injury) had AIS 1 or 2 injuries, six had not undergone CT scanning initially. Nine required surgical decompression. Thus, the preliminary experimental and clinical finding would suggest the need to look at IVF measurements more closely for patients with even minor fractures.

RF 05

Adjacent disc height should be considered in choosing between anterior versus posterior lumbar fusion approach

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Background/Introduction: Generally, lumbar fusion approach (anterior versus posterior) is chosen based on the index level anatomical considerations and surgeon/patient preference. There is increasing evidence for sagittal balance and lumbar/pelvic mismatch considerations during decision-making. We set out to investigate how anatomical factors at the adjacent levels influence the spine biomechanics that may, in turn, favor a particular technique.

Materials/Methods: A L3-sacrum osteoligamentous finite element model was developed and validated with cadaveric experiments. This model was modified at L4-5 to simulate: 1) standalone anterior lumbar interbody fusion (ALIF) (Globus Medical Monument); and 2) traditional posterior lumbar interbody fusion (PLIF) (Globus Medical Sustain RT). Using Latin hypercube sampling, 300 models were created by modifying adjacent level disc height and lumbar lordosis. The models were constrained at S1 and simulated for a combined bending moment of 5 Nm in flexion and compression of 400 N at L3. Range of motion, disc stresses and vertebral body forces were measured. Pearson's coefficient and sensitivity analyses were performed.

Results: ALIF models were sensitive to the changes in inferior adjacent (L5-S1) disc height – decreased inferior disc height led to elevated superior (L3-4) and inferior (L5-S1) disc stresses. In contrast, PLIF models were sensitive to the changes in superior adjacent (L3-4) disc height – decreased superior disc height led to elevated superior and inferior disc stresses.

Discussion/Conclusion: When considering ALIF, the inferior adjacent disc height should be inspected. For PLIF, superior adjacent disc height should be inspected. ALIF is a biomechanically favorable option if there are early signs of disc degeneration at the superior adjacent level. PLIF is a more favorable option if there is early disc degeneration at the inferior adjacent level.

RF 06

Comparison of Lumbar Fusion Techniques ALIF,TLIF,PLIF for Spondylolisthesis Using Finite Element Analysis

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Background/Introduction: Adjacent segment disease following lumbar fusion is common involving 20-25% of cases resulting in revision surgery. This is costly with the patient experiencing the costs of additional surgery and financial losses due to perioperative down time. This study uses finite element analysis to determine the biomechanical stresses involved using 6 different interbody fusion techniques at the L4-5 level for degenerative spondylolisthesis. This study is aimed at determining the biomechanical effects of commonly performed lumbar spine interbody fusion procedures and the effects on adjacent segments to aid in surgeon decision making in efforts to minimize adjacent segment disease and the need for additional surgeries.

Materials/Methods: A validated T12-sacrum lumbar FEM was used to simulate fusion of the L4-5 segment using stand-alone ALIF, ALIF with posterior instrumentation, PLIF with 1 and 2 cages with posterior instrumentation, and TLIF 1 cage with unilateral and bilateral posterior instrumentation. The intact model and 6 interbody fusion models were simulated under physiological pure moment (10Nm) and combined moment and follower compressive loads (10Nm and 2kN) in flexion and extension. The ROM, vertebral body forces, intervertebral disc pressure, and endplate stresses were analyzed to investigate the biomechanical effects of different fusion techniques.

Results: The PLIF with 2 cages and posterior instrumentation, bilateral TLIF with posterior instrumentation, and ALIF with posterior instrumentation were stiffer and comparable in decrease ROM with flexion and extension. The stand-alone ALIF, and unilateral instrumented TLIF resulted in the least decrease in ROM compared to the other fusion techniques. Vertebral body forces and intervertebral disc pressures followed an inverse trend with respect to ROM. VB cross sectional forces and intervertebral disc pressures were higher cephalad to the fusion. Endplate stresses were higher at the caudal aspect of the fusion with a direct correlation with the surface area of the cages in contact with the vertebral body.

Discussion/Conclusion: Adjacent segment stenosis would be predicted to be higher in cephalad segments and subsidence of implants higher in the caudal endplates as seen clinically and in the literature. Using FEM can help determine optimal surgical procedure selection in efforts to minimize the need for subsequent surgery due to adjacent segment disease.

RF 07

Post-operative Analgesics Associated with Increased Risk for Revision Lumbar Fusion

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Background/Introduction: Over the years, data has suggested NSAIDs have an inhibitory effect on healing following spinal fusion despite its analgesic benefits. Likewise, opioids have been associated with worse outcomes in spine surgery yet remain the most common method of postoperative pain control following spine surgery. As medicine moves closer to a value and outcomes-based form of reimbursement along with national pressures to reduce narcotic use, there is sustained interest in determining the optimal postoperative analgesic regimen. The purpose of this study is to assess whether the use of nonselective NSAIDs, selective COX-2 inhibitors, Tramadol or opioids within the immediate postoperative period is associated with increased risk for revision lumbar fusion.

Materials/Methods: A commercially available claims data set utilizing the PearlDiver Research Program was used to query patients undergoing primary lumbar fusion from 2010-2016 who had at least one year of available follow up data. Using multivariable logistic regression models, we examined associations between COX-2 inhibitor, NSAID, Tramadol and opioid prescription fills within the 30-day postoperative period following primary lumbar arthrodesis to assess the risk of revision fusion surgery for presumed pseudarthrosis.

Results: Overall 220,890 patients [58.8% female] underwent primary lumbar fusion with an average cost/claim of \$51,512.39. Of these patients, 3,557 (1.6%) required revision arthrodesis within one year of the index procedure. Multivariable regression models identified patients with a new active COX-2 inhibitor (N=2,878) were at an increased risk for revision arthrodesis (OR=1.47; P=0.002). Similarly, patients prescribed NSAID's (N=11,902; OR=1.17; P=0.02) and opioids (N=114,519; OR=1.23; P<0.001) within the 30-day postoperative period were also at increased risk for revision surgery. Those with a new active Tramadol prescription were not at an increased risk (N=14,245; OR=0.91; P=0.18), however this finding was not statistically significant.

Discussion/Conclusion: Like opioid use, new nonselective NSAID and selective COX-2 inhibitors prescribed in the postoperative were associated with increased risk for revision surgery within one year of the index procedure. Conversely, Tramadol was not strongly associated with increased rates of revision surgery. This study suggests Tramadol may be an effective analgesic with lower risk of revision surgery than other pain relief modalities.

RF 08

Reoperation and Long-Term Clinical Consequences Following Single-Segment Surgery for Meyerding Grade 1 Degenerative Lumbar Spondylolisthesis

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Background/Introduction: There is conflicting evidence whether surgical approach (decompression alone versus decompression with fusion) impacts reoperation rates following surgery for lumbar spondylolisthesis.

Materials/Methods: We studied 608 patients undergoing elective single-segment spine surgery for degenerative grade 1 lumbar spondylolisthesis using the prospective QOD registry. Baseline through latest follow-up data (at least greater than 2 years) were collected. Reoperations were recorded that were deemed related to the index surgery.

Results: Four-hundred sixty eight (77.0%) patients underwent fusion [140 (23.0%) underwent decompression alone]. The overall reoperation rate was 6.9% (42 of 608 patients with 44 reoperations). There were a similar proportion of reoperations for decompression and fusion cohorts (9.3% vs. 6.2%, $p=0.21$). There were significantly more reoperations within 30 days for the fusion cohort ($p=0.02$), whereas there were significantly more reoperations from 30 days to 1 year for the decompression cohort ($p=0.01$). There were no significant differences at other time points ($p>0.05$). In adjusted analyses, reoperations were independently associated with a decreased odds of reaching ODI MCID (defined as 14.3 improvement) (adjusted OR=0.4, 95%CI(0.2-0.7), $p=0.003$), inferior change in ODI (adjusted $\beta = 10.1$, 95%CI(4.5-15.7), $p<0.001$), NRS-BP (adjusted $\beta = 1.1$, 95%CI(0.1-2.1), $p=0.03$), NRS-LP (adjusted $\beta = 1.6$, 95%CI(0.6-2.5), $p<0.001$), EQ-5D (adjusted $\beta = -0.07$, 95%CI(-0.14- -0.003), $p=0.04$), and NASS Satisfaction (adjusted OR = 3.1, 95%CI(1.7-5.5), $p<0.001$) at latest follow up. For those receiving decompression and fusion, reoperations remained independently associated with a decreased odds of reaching ODI MCID (adjusted $p=0.001$), lower NASS satisfaction (adjusted $p=0.003$), and inferior change in ODI (adjusted $p<0.001$), NRS-BP (adjusted $p=0.006$), NRS-LP (adjusted $p<0.001$), and EQ-5D (adjusted $p=0.001$). For those receiving decompression alone, reoperation occurrence was not associated with significantly different outcomes at 24 months (adjusted $p>0.05$, all comparisons).

Discussion/Conclusion: Twenty-four months following surgery, decompression alone was associated with a higher reoperation rate (9.3% vs. 6.2%) compared to decompression with fusion, though the result was not statistically significant. Fusions had a higher rate of reoperation 30 days following surgery, whereas decompression surgery had a higher rate between 30 days and 1 year. Reoperations, particularly when they occur for patients receiving decompression and fusion, negatively impacted patient satisfaction.

RF 09

The Inclusion of Frailty Improves Predictive Modeling for Postoperative Outcomes in the Surgical Management of Primary and Secondary Lumbar Spine Tumors

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Background/Introduction: Malignant spinal tumors common, continually increasing in incidence as a function of improved survival times for patients with cancer. Until recently, age has been popularly analyzed as an independent predictor of postoperative complications. However, frailty has been shown to be superior in predicting patient outcomes in spine surgery for several indications. Using predictive analytics and propensity score matching, we evaluated the influence of frailty on postoperative complications compared to age in patients with malignant neoplasms of the lumbar spine.

Materials/Methods: We used the Nationwide Readmissions Database from 2016 and 2017 to identify patients with malignant neoplasms of the lumbar spine who received a fusion procedure. Patient frailty was queried using the Johns Hopkins Adjusted Clinical Groups (JHACG) frailty-defining diagnosis indicator. Propensity score matching for age, sex, CCI, surgical approach, and number of levels fused was implemented between frail and non-frail patients, identifying 533 frail patients and 538 non-frail patients. Receiver operating characteristic (ROC) curves were created following creation of logistic regression models for relevant postoperative complications using both age and frailty status as predictor variables. The area under the curve (AUC) of each ROC served as a proxy for model performance.

Results: Despite matching, frail patients reported significantly higher inpatient lengths of stay (LOS), costs, infection, posthemorrhagic anemia, and urinary tract infections ($p < 0.05$). In addition, frail patients were more often discharged to skilled nursing facilities and short-term hospitals compared to non-frail patients ($p < 0.0001$) when demographics and surgical variables were held constant. Regression models for mortality (AUC=0.644), nonroutine discharge (AUC=0.600), and acute infection (AUC=0.666) were all improved when using frailty as the primary predictor compared to models using age. These models were also improved using frailty when predicting 30-day readmission and 90-day hardware failure.

Discussion/Conclusion: Frailty demonstrated a significant relationship with increased postoperative patient complications, LOS, costs, and acute complications in patients receiving fusion following resection of a malignant neoplasm of the lumbar spine region. Frailty also demonstrated a superior predictive validity of outcomes compared to patient age. The assessment of frailty is an important consideration in evaluating the risks in the surgical management of patients with lumbar spinal neoplasm.

RF 10

Relative Safety of Lumbar Drains for Management of Postoperative Cerebral Spinal Fluid (CSF) Leaks in Thoracolumbar Spine Surgery

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Background/Introduction: Cerebrospinal fluid (CSF) leaks after spinal surgery pose a danger to patients. Early recognition and proper management help prevent potential and long-term associated complications. Lumbar drain placement is one method of symptomatic dural tear management occurring during/after spinal surgery. We detailed safety and efficacy of lumbar drains placed either primarily or secondarily in dural tear management by analyzing the incidence of potential complications occurring postoperatively with and without lumbar drain placement.

Materials/Methods: In a retrospective chart review, 61 consecutive patients (age >18 years) who had dural tears after spinal surgery were included during 4-year study period. Reviewed and documented demographic data, surgical data and postoperative charts for complications. Patients divided into 2 groups: Group 1 (patients without lumbar drain placement (n=48)) and Group 2 (patients managed with lumbar drain placement (n=13)). Calculated rate of complications in immediate postoperative period following surgery and analyzed the types of complications.

Results: Patient demographics and comorbidities were similar between groups. Group 1 had a 10% complication rate and Group 2 had a 7.7% complication rate; difference of complications was not statistically different ($p = 0.63$). Duration of hospitalization was significantly longer in Group 2 versus Group 1 (17 days vs. 11 days, $p=0.002$). (Table 1)

Discussion/Conclusion: Based on this retrospective single center series, lumbar drain placement to manage dural leaks, regardless of the indication and when placed, is a relatively safe option. Complications reported in literature appear to be attributed to excessive CSF leakage or drainage from a large and controlled/uncontrolled aggressive CSF lumbar drainage.

RF 11

Postoperative Urinary Retention Is Not Associated With Increased 90-Day Readmission Or ER Visits In Patients Undergoing Lumbar Spine Surgery

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Background/Introduction: Postoperative urinary retention (POUR) is a relatively common complication following spine surgery which can result in significant comorbidities such as UTI, sepsis, and prolonged length of hospitalization. Prior studies have examined rates and risk factors for POUR following spine surgery, but data on its effect on patient outcomes remains limited. This study aims to analyze the impact of POUR on 90-day hospital readmission and cost of hospitalization following lumbar spine surgery

Materials/Methods: After institutional review board approval, the electronic medical record was used to identify all patients who underwent lumbar spinal surgery between January 2017 and December 2019 at one institution. Patients were followed for complications out to 90 days postoperatively. Patients were divided into groups based on the presence of POUR at the time of discharge from the index procedure.

Results: There were 2529 patients who underwent lumbar surgery with 175 patients developing POUR. There was no difference between non-POUR and POUR patients in terms of length of stay (54.7 vs 58.4 hours), length of surgery (138 vs 143 minutes), age (58 vs 56 years) or gender. There was no statistically significant difference between the groups in 90-day readmission or emergency center visits. Sub analysis of patients undergoing laminectomy/laminotomy with or without instrumented fusion did show a correlation between POUR and readmission in the instrumented fusion group.

Discussion/Conclusion: Patients with POUR at the time of discharge were not more likely to have a 90-day readmission or emergency center visit following lumbar spinal surgery. There was a correlation between POUR and readmission with laminectomy and instrumented fusion compared to laminectomy/laminotomy alone.

RF 12

Acute Failure of S2-Alar-Iliac Pelvic Fixation Following Adult Deformity Correction

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Background/Introduction: Pelvic fixation with S2-alar-iliac (S2AI) screws is a widely accepted technique in adult deformity surgery, with few descriptions of complications.

Materials/Methods: We performed a retrospective review of all fusion surgeries extending from L2 or higher with instrumentation to the pelvis in which S2AI screws were placed with at least 6 months follow-up between 3/2017 and 6/2019. We excluded patients under 18 years of age and non-ambulatory patients. Acute instrumentation failure was defined as any case requiring revision of the pelvic fixation within 6 months from the index surgery. We reviewed the demographic and surgical characteristics of each patient, and reviewed pre-operative and 6 week post-operative radiographs to document the change in their deformity parameters as well as for the presence of a transitional lumbo-sacral segment.

Results: Failure occurred in 6 of 125 cases (5%), and consisted of either slippage of the rods or displacement of the set screws from the S2AI tulip head, with resultant kyphotic fracture. All occurred within 6 weeks post-operatively. Revision with a minimum of 4 rods connecting to 4 pelvic fixation points was successful. 2 of 3 (66%) patients revised with less fixation sustained a second failure. Failure patients were younger (56.5 years v. 65 years, $p=0.03$). The magnitude of surgical correction was higher in the failure cohort (number of levels fused, change in lumbar lordosis, change in T1-Pelvic Angle, and change in coronal C7 vertical axis, each $p<0.05$). In the multivariate analysis, younger patient age and change in lumbar lordosis were independently associated with increased failure risk ($p<0.05$ for each). There was a trend towards the presence of a transitional S1-2 disc being a risk factor (OR=8.8, 95% CI 0.93-82.6). Failure incidence was the same across implant manufacturers ($p=0.3$).

Discussion/Conclusion: All failures involved large magnitude correction and resulted from stresses that exceeded the failure loads of the set plugs in the S2AI tulip, with resultant rod displacement and kyphotic fractures. Patients with large corrections may benefit from four total S2AI screws at the time of the index surgery, particularly if a transitional segment is present. Salvage with a minimum of 4 rods and 4 pelvic fixation points can be successful.

RF 14

Autocorrection of Cervical Malalignment Following Thoracolumbar Deformity Surgery

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Background/Introduction: Adult spinal deformity(ASD) severity may coincide with deformity of the cervical spine. It is unknown if certain preoperative factors allow for postop cervical correction after surgical intervention on the thoracolumbar spine.

Materials/Methods: Inclusion criteria were met by operative ASD patients (coronal Cobb angle $\geq 20^\circ$, SVA $\geq 50\text{mm}$, pelvic tilt $\geq 25^\circ$, and/or thoracic kyphosis $> 60^\circ$) $> 18\text{yrs}$ and with baseline(BL) and 1-year(1Y) radiographic data. Patients with fusion construct extending above T1 were excluded. Cervical deformity (CD) was defined as ≥ 1 of the following radiographic criteria: C2-C7 sagittal kyphosis $< -15^\circ$, T1S-CL $> 35^\circ$, cSVA $> 4\text{cm}$, chin brow vertical angle (CBVA) $> 25^\circ$, McGregor's slope (MGS) $> 20^\circ$, or segmental C2-T1 cervical kyphosis $> 15^\circ$ across any 3 vertebra. If patients met CD criteria at BL but not postoperatively (6W and/or 1Y), they were considered autocorrected[AC]. If BL CD patients did not meet autocorrected cervical criteria, they were noted as maintained/worsened[MW]. Univariate analyses assessed baseline factors and postoperative complications associated with AC. Conditional inference tree (CIT) determined BL radiographic thresholds that were associated with autocorrection of cervical malalignment.

Results: 683 ASD patients included. 33.8%(n=231) had preop CD. By 6W postop, 86 patients(37.3%) with preop cervical malalignment no longer met radiographic CD criteria. 46.8%(n=108) of preop CD patients were AC by 1Y. 6W and 1Y AC patients had lower BL SVA, cSVA, CL, and C2-T3, and higher T2-T12 TK (all $p < 0.05$). AC patients were more likely to have ideal SVA by SRS-Schwab criteria at BL(52% vs. MW: 36%, $p = 0.025$). AC patients were less likely to have severe disproportion by GAP score at 1Y(5% vs. 36%, $p = 0.041$). AC patients had lower rates of overall postop complication, major complication, and PJK at 6W and 1Y(all $p < 0.05$). CIT identified BL radiographic thresholds for 6W autocorrection: T2-T12 TK $> 0.3^\circ$, CL $\leq 3.34^\circ$, cSVA $\leq -4.487\text{ mm}$, C2-T3 $\leq 19.1^\circ$, SVA $\leq -30.502\text{ mm}$, and T1S $\leq 47.165^\circ$. Thresholds for 1Y AC were: T2-T12 TK $> -7.8^\circ$, TS-CL $> 0.665^\circ$, CL $\leq 3.34^\circ$, cSVA $\leq -3.107\text{mm}$, C2-T3 $\leq -5.4^\circ$, SVA $\leq -8.282\text{mm}$, T1-C2 $\leq 21.371^\circ$, and T1S $\leq 26.837^\circ$.

Discussion/Conclusion: Autocorrection of cervical deformity following thoracolumbar ASD correction occurred in 37% of pts, and was more common among those meeting age-adjusted TL alignment and with CD less than certain radiographic thresholds.

RF 15

EFFECT OF TERIPARATIDE ON TRANSFORAMINAL LUMBAR INTERBODY FUSION IN LUMBAR DEGENERATIVE DISEASE PATIENTS WITH OSTEOPOROSIS

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Background/Introduction: Osteoporosis is a progressive metabolic bone disease that is characterized by a decrease in bone mass and density. TLIF is biomechanically a better technique for the treatment of degenerative lumbar disease. Teriparatide (rPTH) is the only anabolic agent that has been approved for the treatment of osteoporosis. The study aim was to evaluate the efficacy of teriparatide for TLIF in osteoporotic women.

Materials/Methods: A total of 94-osteoporotic patients underwent TLIF surgery for degenerative lumbar spine disease. Patients were divided into two groups. The calcitonin group (n = 48) was administered nasal calcitonin (200 IU) for 2-months. The teriparatide group (n=46) was injected subcutaneously with teriparatide (20 ug/daily) for 3-month cycles. Serial plain x-rays, computed tomography, and bone mineral densitometry (BMD) evaluations were performed. Fusion rate, bony fusion duration, and T-score changes were evaluated. VAS and ODI were evaluated.

Results: The teriparatide group showed earlier fusion than the calcitonin group. The mean bone fusion period was 5.8 ± 4.7 months in the teriparatide group but 9.4 ± 5.2 months in the calcitonin group. The bone fusion rate in the teriparatide group was higher than that in the calcitonin group at 5-months; however, there was no difference after 12 and 24 months surgery. Pain scores and ODI were not significantly different between groups. BMD scores in the teriparatide group were significantly improved compared with the calcitonin group 2 years after surgery.

Discussion/Conclusion: There was no significant improvement in overall fusion rate and clinical outcome in our patients after injection of teriparatide, but the teriparatide group showed early bony union and highly improved BMD scores.

RF 16

Multimodality Intraoperative Neuromonitoring in Lateral Lumbar Interbody Fusion. A Review of Alerts in 628 Patients

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Background/Introduction: Lateral Lumbar Interbody Fusion (LLIF) is a minimally invasive procedure that can cause injury to the to the lumbar plexus and its associated nerve branches. The purpose of this study was to review neuromonitoring alerts in a large series of patients undergoing LLIF and determine whether alerts occurred more frequently when more lumbar levels were accessed and if alerts occurred more frequently at particular lumbar levels

Materials/Methods: Intraoperative neuromonitoring (IONM) databases were reviewed and patients were identified undergoing LLIF between L1 and L5. All cases in which at least one IONM modality was used (motor evoked potentials (MEP), somatosensory evoked potentials (SSEP), evoked electromyography (EMG)) were included in this study. The type of IONM used and incidence of alerts were collected from each IONM report and analyzed. The incidence of alerts for each IONM modality based on number of levels at which at LLIF was performed and the specific level an LLIF was performed were compared.

Results: A total of 628 patients undergoing LLIF across 934 levels were reviewed. EMG was used in 611 (97%) cases, SSEP in 561 (89%), MEP in 144 (23%). The frequency of IONM alerts for EMG, SSEP and MEPs did not significantly increase as the number of LLIF levels accessed increased. No EMG, SSEP, or MEP alerts occurred at L1-L2. EMG alerts occurred in 2-5% of patients at L2-L3, L3-L4, and L4-L5 and did not significantly vary by level ($P=0.34$). SSEP and MEP alerts occurred more frequently at L4-L5 versus L2-L3 and L3-L4 ($P<0.03$) (Figure 1).

Discussion/Conclusion: It may be that IONM provides the greatest utility at L4-L5, particularly MEPs, and may not be necessary for more cephalad procedures such as at L1-L2. Future studies should investigate the selective use of IONM during LLIF with the hypothesis that SSEPs and MEPs have low utility at upper lumbar segments and added utility at lower lumbar segments.

RF 17

Early Surgery for Thoracolumbar Extension Type Fractures in Geriatric Patients with Spinal Ankylosing Disorders Decreases Perioperative Patient Complications and Mortality.

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Background/Introduction: The treatment of patients with spinal ankylosing disorders (SAD) continues to pose a unique challenge for the practitioner. This population is especially susceptible to vertebral column fractures, specifically unstable extension type fractures even from minor trauma. An increase in geriatric patients with unstable extension type vertebral fractures may be especially anticipated due to change in patient demographics including an increase in age and prevalence of associated comorbidities. In the geriatric population, studies have shown that early surgery for other injuries such as hip fractures may reduce patient complications and mortality. These studies have changed patient care protocols in many medical centers worldwide. In this study, we aim to assess the relationship between the timing of surgery for vertebral fractures in this population and patient complications, rehospitalization rates, length of hospital stays and mortality.

Materials/Methods: We searched our department's database for all SAD patients diagnosed with thoracolumbar extension type fractures. Patients included were those over 65 years old, following minor trauma and with no prior spinal instrumentation. Difference in patient outcomes that underwent early surgery of less than 72 hours from diagnosis as opposed to those that underwent later surgery was assessed.

Results: A total of 85 patients were diagnosed with extension type thoracolumbar fractures at our institution between 2016-2020. Of these, 47 met the inclusion criteria for this study. 19 patients underwent surgery less than 72 hours from diagnosis and 28 more than 72 hours from diagnosis. There was a statistically significant difference in perioperative patient complications and mortality between the early and the late groups ($p < 0.002$). There was no statistically significant difference between the groups when comparing surgical site infections, length of hospital stays and rehospitalization within a month.

Discussion/Conclusion: Time to surgery may affect perioperative complications and mortality in patients of the elderly population with spinal ankylosing disorders presenting with unstable hyperextension type thoracolumbar fractures. Early surgery in this patient population should be considered.

RF 18

Assessing the Performance of Single Assessment Numeric Evaluation (SANE) score in Predicting Long-Term Outcomes of Patients Undergoing Surgery for Low Grade Spondylolisthesis

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Background/Introduction: The Single Assessment Numeric Evaluation (SANE) is a patient-reported outcome measure (PROM) consisting of one question, in which a patient is asked to rate overall function on a scale of 0 to 100. The SANE has been increasingly utilized in other orthopedic disciplines but has not been evaluated after spinal surgery. In this study, we sought to assess the performance of the SANE score in predicting outcomes of patients undergoing routine lumbar surgery.

Materials/Methods: The Quality Outcomes Database (QOD) lumbar module was queried for patients undergoing 1 or 2 segment fusion for grade I lumbar spondylolisthesis. Using multivariable logistic regression models, the performance of SANE score was assessed relative to Oswestry Disability Index (ODI) in predicting patient satisfaction, and change in quality of life (assessed using Euro-QOLD 5-D or EQ5D) at 3 and 12 months.

Results: At 3 months, 2,712/6,138 (44.3%) achieved MCID-change in EQ5D, a total of 4,059 (66.2%) achieved MCID change in ODI, and 3,043 (49.6%) achieved MCID change in SANE. A total of 4,110 patients (67%) achieved 30% change in ODI at three months, 3,081 patients (50.4%) achieved 30% change in EQ5D and 2356 (38.4%) achieved a 30% change in SANE score. A total of 90.6% (n=5,562) were satisfied at 3 months. At 12 months follow up, 2,191/4,817 (45.6%) achieved MCID change in EQ5D, 3,426 (71.2%) achieved MCID change in ODI, and 2,407 (50%) achieved MCID change in SANE. A total of 3,484 patients (72.3%) achieved 30%-change in ODI, 2,469 patients (51.25%) achieved 30% change in EQ5D and 1935 (40.2%) achieved a 30%-change in SANE score at twelve months. A total of 87% (n=4,193) were satisfied 12 months. The R² for 3 month and 12 month correlations between the SANE and ODI were found to be 0.35 (p<0.001) and 0.40 (p<0.001), respectively. Upon comparing the model performance using Area Under the Curve (AUC) values, models using MCID change and 30% change in SANE scores were found to be only slightly lower relative to models employing ODI.

Discussion/Conclusion: Our results demonstrate that the single-question SANE score can be utilized to obtain clinically important information about patient outcomes after 1-2 level lumbar-fusion.

RF 19

Greater Increase in Foraminal Height and Area After Anterior Lumbar Interbody Fusion (ALIF) at L5-S1 Compared to Other Levels as Measured by Computed Tomography

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Background/Introduction: Anterior lumbar interbody fusion (ALIF) can induce lordosis and indirectly decompress the nerve roots by foraminal distraction. The objective of this study was to evaluate the foraminal height and area change by CT analysis after ALIF by level.

Materials/Methods: Forty-eight patients who underwent ALIF for degenerative conditions with minimum 1-year follow up were retrospectively analyzed using computed tomography (CT). Demographics, cage parameters, disc height, foraminal height, and foraminal area were measured. Only patients with pre- and post-operative CT scans were included. Paired t-tests and analysis of variance (ANOVA) were used for statistical analysis. Post-hoc Scheffe tests were used for significant variables.

Results: The average age was 63.32 years, and mean follow up was 3.84 years (range 1 to 12). The implant heights ranged from 7 to 21mm. By CT analysis, the L5-S1 post-operative foraminal heights (right: 12.46 to 16.74mm, $p < 0.01$; left: 13.00 to 16.83mm, $p < 0.01$) and foraminal areas (right: 98.22 to 152.43mm², $p < 0.01$; left: 102.20 to 144.44mm², $p < 0.01$) significantly increased. At L4-5, there was no significant increase in foraminal heights ($p \geq 0.05$) but there was an increase in foraminal area (right: 99.11 to 152.43mm², $p = 0.01$; left: 109.77 to 138.19mm², $p = 0.02$). There were no significant increases in foraminal height ($p \geq 0.05$) or area ($p \geq 0.05$) for L3-4. The disc height significantly increased at L5-S1 (3.43 to 7.10mm, $p < 0.01$) and at L4-5 (3.73 to 6.02mm, $p < 0.01$), but not at L3-4 ($p = 0.11$). At L5-S1, implant heights ≥ 16 mm significantly increased the right foraminal height (2.41 to 6.02mm; $p = 0.02$) and area (28.19 to 82.70mm²; $p = 0.01$) but not the left foraminal height (2.42 to 5.26mm, $p = 0.10$) or area (30.76 to 72.71mm², $p = 0.07$). At L4-5, there was no correlation between implant height and foraminal height ($p \geq 0.05$) or foraminal area ($p \geq 0.05$). There was no correlation between implant lordosis and pre- and post-operative foraminal disc heights or areas for L3-4, L4-5, and L5-S1 ($p \geq 0.05$).

Discussion/Conclusion: ALIF significantly increases foraminal height, foraminal area, and disc height at L5-S1 more than L3-4 and L4-5 by CT analysis. Implant height was positively correlated with larger foraminal size at L5-S1 but not at L4-5. Increased lordosis did not correlate with increased foraminal size.

RF 21

Physical Therapy on Postoperative Day Zero Following Lumbar Spine Surgery Decreases Length of Stay

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Background/Introduction: Postoperative length of stay (LOS) is a major factor in overall cost for lumbar spine surgery, and its duration often depends on discharge clearance from physical therapy (PT). The study goal was to compare postoperative LOS for lumbar spine surgery patients who initiated formal PT on postoperative day (POD) 0 versus POD 1.

Materials/Methods: A retrospective review was conducted of 1,870 patients who underwent elective 1-2 level laminectomy+/-posterior lumbar fusion+/-instrumentation by 13 spine surgeons at 1 institution from 2011-2019. Patients were categorized by postoperative PT timing, with POD 0 defined as within 24 hours after surgery. Patients were excluded if they had incomplete data, admitted under trauma visit, admitted to ICU between surgery and discharge for observation or complications, did not see PT before discharge, or had qualifying surgery at >2 levels. Demographics, perioperative variables, and postoperative variables were collected. Statistical methods for categorical bivariate analysis included Chi-square test of independence or Fisher's Exact test. For continuous outcomes, normality was tested using Shapiro-Wilk test; and two-sample t-test or Wilcoxon Rank Sum test was used to determine differences across POD groups. Data were analyzed using R with two-sided $p < 0.05$ considered significant.

Results: Of 1,870 patients, 336 met inclusion criteria. Formal PT was initiated on POD 0 for 202 patients, and POD 1 for 134 patients. As Table 1 demonstrates, there was no significant difference between POD 0 and POD 1 groups regarding: age($p=1.00$), gender($p=0.28$), insurance type($p=0.58$), BMI($p=0.23$), or discharge destination($p=0.61$). The difference in LOS (9.9 hours) was large enough to be of statistical and clinical significance($p < 0.0001$) (Table 1). The difference in distribution of postoperative nights spent in the hospital was also clinically and statistically significant between POD 0 and POD 1 groups($p < 0.0001$) (Table 1).

Discussion/Conclusion: Early initiation of PT has been proposed to facilitate discharge following lumbar spine surgery. In our study, lumbar spine patients who initiated PT on POD 0 demonstrated clinically and statistically significant earlier discharge than patients who initiated PT on POD 1. Given the role of LOS in quality metrics and reimbursement, a multidisciplinary approach including physical therapists and early formal postoperative PT may facilitate discharge following lumbar spine surgery.

RF 22

Robotic vs. Freehand Screw Placement: A Comparison of One-Year Clinical and Surgical Outcomes for Lumbar Fusion

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Background/Introduction: Studies have shown robotically-assisted surgery demonstrates increased pedicle screw accuracy and safety when compared to conventional freehand surgery. However, little research has been done to determine if this increased accuracy and safety translates to improved clinical outcomes. The purpose of this study is to compare patient reported outcome measures (PROMs) for patients undergoing 1-3 level lumbar fusion using robotically-assisted vs. freehand screw placement.

Materials/Methods: A retrospective review was performed on patients who underwent either robotically-assisted or freehand 1-3 level lumbar fusion surgery from January 1, 2014 to August 31, 2020 at a single academic institution. Clinical and surgical outcomes were compared between groups. Recovery Ratios (RR) and the number of patients achieving the Minimally Clinically Important Difference (MCID) were calculated for ODI, PCS-12, MCS-12, VAS Back, and VAS Leg at 1 year. Surgical outcomes included complication and revision rates.

Results: A total of 262 patients were included in the study, 85 robotically-assisted and 177 freehand. No significant differences were found in Δ PROM scores, RR, or MCID between patients who underwent robotically-assisted vs. freehand screw placement. No significant differences in the rates of revision (1.70% in freehand group vs. 1.18% in robotic group, $p = 1.000$) and complications (1.10% in freehand vs. 1.18% in robotic group, $p = 1.000$) were found between groups. Controlling for demographic factors, procedure type (robot vs. freehand) did not emerge as a significant predictor of Δ PROM scores on multivariate linear regression analysis.

Discussion/Conclusion: Robotically-assisted screw placement did not result in significantly better clinical or surgical outcomes compared to conventional freehand screw placement.

RF 23

Minimally Invasive Spinal Surgery Techniques Demonstrate Greater Post-Operative Function Compared to Open Spinal Surgery After Lumbar Spine Decompression

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Background/Introduction: Minimally invasive spine surgery (MISS) is an emerging field of spine surgery with high appeal. However, one concern regarding MISS is its steep learning curve with complication rates being initially greater than traditional open surgery. Therefore, the purpose of this study is to investigate the differences in post-operative outcomes after lumbar spine decompression utilizing MISS versus traditional open surgery approaches.

Materials/Methods: An institutional review board approved database consisting of a consecutive series of patients who underwent discectomy, facetectomy, foraminotomy, laminotomy, and/or one or two-level laminectomy for neurogenic claudication and/or radiculopathy from 2015 to 2019 treated at a single academic institution was used for this study. Exclusion criteria included: history of acute spine trauma, spinal tumor, spinal infection, and/or previous lumbar spine surgery. Demographic variables included age, gender, BMI, and visual analog scale pain scores. Peri-operative variables included operative time, estimated blood loss (EBL), hospital length of stay, post-operative opioid consumption (defined as morphine milligram equivalents (MME) within the first 24 hours after surgery) and complications and revisions (defined as repeat decompression or conversion to fusion). Oswestry Disability Index (ODI) scores were collected at the first pre-operative clinic visit and at each post-operative visit. All statistical analyses were performed using IBM SPSS 22.0. The Student's t-test or Chi-squared test were wherever applicable. Statistical significance was defined as $p < 0.05$.

Results: A total of 114 patients were included in this study, with 51 and 63 patients undergoing MISS and open lumbar decompression, respectively. The mean age was 55.4 years and 59% of patients were male. Post-operative MME use and EBL were significantly greater in the open group compared to the MISS group; all other demographic and peri-operative variables were not significantly different. Absolute ODI scores were significantly less in the MISS group compared to the open group at 1 year; all other time points revealed no significant difference in absolute ODI scores nor change in ODI scores with respect to pre-operative scores (Table 1).

Discussion/Conclusion: MISS for lumbar spine decompression demonstrates significantly greater post-operative ODI scores after 1-year compared to open surgery while maintaining similar operative times and complication and revision rates.

VA 01

Computed tomography analysis of L5-S1 fusion rates in symptomatic patients after transforaminal (TLIF) and anterior lumbar interbody fusion (ALIF) with minimum 2-year follow-up

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Background/Introduction: To evaluate computed tomography (CT) arthrodesis rates of L5-S1 anterior (ALIF) and transforaminal lumbar (TLIF) interbody fusion in symptomatic patients.

Materials/Methods: Patients who underwent L5-S1 fusion for degeneration were retrospectively evaluated. Fusion was independently evaluated by two radiologists using the Brantigan-Steffee-Fraser (BSF) grade in symptomatic patients. Spino-pelvic parameters, segmental measurements, revision surgeries, and bone morphogenetic protein (BMP) use were analyzed.

Results: Ninety-six patients were evaluated (48 ALIF, 48 TLIF), with mean follow up of 37.5 months (24 to 51). Radiographic fusions were higher in ALIF than in TLIF at last follow-up (75% vs 47.9%, $p=0.006$). TLIF radiographic pseudarthrosis was four times that of ALIF (16.7% vs 4.16%) ($p=0.045$). Indeterminate fusion occurred in 20.8% (10/48) of cases in ALIF and 35.4% (17/48) of cases in TLIF ($p=0.112$). In subgroup analysis of patients without BMP, the solid fusion rate was significantly higher in ALIF than TLIF (78.6% vs 45.5%) ($p=0.037$). There was no difference in sex, age, body mass index (BMI), Meyerding grade, spondylolysis, smoking status, and follow-up times between two groups ($p>0.05$). ALIF had more improvement in disc height (7.8mm vs 4.7mm), disc angle (5.2° vs 1.5°), segmental lordosis (7.0° vs 2.5°), and overall lumbar lordosis (4.7° vs 0.7°) compared to TLIF ($p<0.05$). Overall revision rates were similar between TLIF and ALIF (14.5%vs 10.4%) ($p=0.552$).

Discussion/Conclusion: With minimum 2-year CT analysis of arthrodesis by radiologists in symptomatic patients, fewer than 50% of TLIFs have a radiographic solid fusion compared to 75% of ALIFs. TLIF also had a four-fold higher rate of clear pseudarthrosis compared to ALIF, and this difference held up even when excluding BMP use.

VA 02

Obesity is Correlated with Functional Disability and Depression Following Lumbar Spinal Deformity Surgery in the Early Postoperative Period Despite Improvement in Spinopelvic Parameters

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Background/Introduction: Major spine surgery for the treatment of adult lumbar spinal deformity (ASD) is an inherently high-risk endeavor that is fraught with potential complications, particularly in obese patients. Published outcomes after ASD surgery in obese patients have been inconsistent, therefore, a better understanding of the unique impact of body mass index (BMI) is needed. Therefore, we examined the influence of pre-operative BMI on perioperative complications, length of stay (LOS), 30-day readmission, proximal junctional kyphosis (PJK), and quality of life (QOL) as measured by standardized patient reported outcome instruments.

Materials/Methods: We retrospectively reviewed patients who underwent ASD surgery at the Cleveland Clinic between the years 1999-2019. Major spine surgery was defined as any patient who underwent ≥ 2 posterior column osteotomies or ≥ 1 pedicle subtraction osteotomy combined with posterior segmental instrumentation and fusion. Obesity was defined as a preoperative BMI ≥ 30 . Multivariate analysis was performed to determine whether BMI was independently correlated with postoperative QOL and surgical complications.

Results: A total of 600 patients were included in the final analysis: 358 (64.4%) were females. Mean age was 59.8 ± 16.7 years and mean preoperative ODI was 52. 47% of patients had BMI ≥ 30 ; 6% had BMI ≥ 40 . 34% had a history of prior spine surgery. Obesity was correlated with worse postoperative ODI (47.3 (SD 34.1) vs 53.9 (SD 15.4), $p=0.026$) and poorer PHQ9 scores (6.5 (SD 6.2) vs 7.6 (SD 6.3), $p=0.003$) at three months; however, these differences no longer became significant at one-year. There was no significant difference in the pre- and post-operative spinopelvic parameters between non-obese and obese patients. Mean follow-up was approximately 1.5 years after surgery. Obesity was not correlated with a higher incidence of post-surgical complications.

Discussion/Conclusion: The role of obesity in predicting outcomes after ASD surgery appears to be substantially more complex and multi-factorial than previously believed. This study found obese patients seemed to experienced increased functional disability and depression despite satisfactory correction of radiographic spinopelvic parameters shortly after surgery. Further prospective studies will be required to elucidate the reasons behind these findings and develop patient-specific treatment strategies.

VA 03

Preoperative Factors Associated with Outpatient Lumbar Decompression

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Background/Introduction: Spine surgery in the outpatient setting has become increasingly common, and has been associated with increased patient satisfaction, a decrease in length of stay, and a decreased financial burden on the healthcare system. The purpose of this study was to create a predictive calculator using machine learning models to accurately and precisely evaluate successful candidates for outpatient surgery.

Materials/Methods: Patients with primary 1- to 4-level lumbar decompression procedures were retrospectively identified. Outpatient surgery was defined as procedures that involved same-day patient discharge or one overnight stay, while a LOS of 2+ days was categorized as inpatient surgery. Eighty percent of the total cohort, randomly chosen, was used as a training cohort to create a risk calculator for having an inpatient procedure. Univariate analysis of patient demographic and medical data was performed to determine differences between inpatient and outpatient cohorts. Multivariate logistic regression was performed to identify independent risk factors for being classified as inpatient. Results from the regression were used to develop a novel scoring system to predict having an inpatient stay.

Results: A total of 1202 outpatient and 187 inpatient patients were included in the training cohort. Patients with inpatient surgery were older (64.3 vs. 54.0 years, $p<0.001$), had a higher BMI (31.0 vs. 29.3, $p<0.001$), higher ASA (35.3% with ASA >2 vs. 17.6%, $p<0.001$), more levels decompressed (25.7% with >2 levels decompressed vs. 3.8%, $p<0.001$), and more often had hypertension (50.3% vs. 32.3%, $p<0.001$) and diabetes mellitus (23.0% vs. 11.1%, $p<0.001$). Age (OR=1.04 [1.02, 1.05], $p<0.001$), ASA >2 (1.51 [1.10, 2.08], $p=0.01$), and >2 levels decompressed (6.67 [4.16, 10.74], $p<0.001$) were found to be independent risk factors for having an inpatient procedure. The AUC of the predictive calculator was 0.77, with an optimal cutpoint of 84 points. The relationship between score and likelihood of having an inpatient stay is demonstrated in Figure 1.

Discussion/Conclusion: Increasing age, ASA classification, and levels decompressed are independently associated with an increased likelihood of inpatient lumbar decompression. This novel calculator assists in the prediction of successful risk stratification of patients undergoing lumbar decompression to the inpatient or outpatient setting.

VA 04

An Analysis of Workers' Compensation Patients: Risk Factors Associated With Delayed Return to Work Following Lumbar Discectomy

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Background/Introduction: Workers' compensation (WC) patients often experience poorer postoperative outcomes, leading to losses in productivity and wages, and increasing the cost burden on the medical system. In this study, we examined WC patients that did and did not return to work (RTW) within six months of lumbar microdiscectomy (LMD) for primary lumbar disc herniation (LDH) in order to evaluate the risk factors for failure to RTW.

Materials/Methods: This study retrospectively assessed patients with WC undergoing LMD for LDH with one of three fellowship-trained spine surgeons from 2004 to 2019. Two cohorts were stratified as RTW and Non-RTW, with a third cohort of non-WC patients matched to RTW patients. Imputation and cohort matching was performed using the k-Nearest Neighbors algorithm. Differences in patient demographics, comorbidities, and patient-reported outcome measures (PROMs) were evaluated via univariate statistics. Predictive factors for failure to RTW were determined using multinomial logistic regression. Statistical significance for all tests was established at $p < 0.05$.

Results: Overall, 181 WC patients returned to work within 6 months following LMD while 48 did not. Factors associated with delayed RTW included elevated BMI (OR: 1.44, $p=0.036$), diabetes (OR: 2.21, $p=0.018$), psychiatric history (OR: 1.55, $p=0.004$), motor weakness (OR: 1.34, $p=0.049$), prior spine surgery (OR: 5.28, $p=0.008$), recurrent herniation (OR: 2.32, $p=0.043$), opioid usage (OR: 2.5, $p=0.024$), and heavy labor (OR: 1.56, $p=0.032$, Table 1). Analysis of PROMs demonstrated worse preoperative VAS Back scores among non-RTW patients ($p=0.020$), in addition to a greater decline in the VR12 mental component postoperatively ($p=0.045$). Comparisons between the matched non-WC and WC cohorts (RTW, non-RTW) demonstrated worse PROMs and worse improvement among WC patients in most preoperative and postoperative surveys.

Discussion/Conclusion: Factors predicting a decreased propensity to RTW among WC patients following LMD included history of psychiatric disorders, diabetes, elevated BMI, preoperative motor weakness, re-herniation, prior spine surgery, opioid usage, and heavy labor work. These patients were also more likely to experience higher levels of preoperative back pain and a greater decline in postoperative mental health status. These findings suggest a significant disparity among patients who return to work following surgery and those who do not.

VA 05

The Minimally Invasive Interbody Selection Algorithm for Spinal Deformity

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Background/Introduction: Minimally invasive surgery (MIS) for spinal deformity use interbody techniques for correction, indirect decompression, and arthrodesis. We created the minimally invasive interbody selection algorithm (MIISA) to provide a framework for rational decision making in MIS deformity surgery.

Materials/Methods: A retrospective dataset of 100 circumferential minimally invasive surgeries (cMIS) for lumbar adult spinal deformity (ASD) with 338 interbody devices over a five-year period was analyzed by level to identify preferences and evaluate segmental lordosis outcomes. This data was used to inform a Delphi session of MIS deformity surgeons from which the algorithm was created. The algorithm lead to the following interbody approaches: anterior lumbar interbody fusion (ALIF), anterior column release (ACR), lateral lumbar interbody fusion (LLIF), and transforaminal interbody fusion (TLIF). Preoperative and 2 -year postoperative radiographic parameters and clinical outcomes were compared.

Results: The surgeons generally preferred LLIF for L1-L2 (91.2%), L2-L3 (85.2%), and L3-L4 (80.7%). ACR was most commonly performed at L3-L4 (8.4%) and L2-L3 (6.2%). At L4-L5, LLIF (69.5%), TLIF (15.7%), and ALIF (9.8%) were most commonly utilized. TLIF and ALIF were the most selected approaches at L5-S1 (61.4% and 38.6%, respectively). Segmental lordosis at each level varied based upon approach with greater increases reported using ALIF, especially at L4-5 (9.2 degrees) and L5-S1 (5.3 degrees). Substantial increase in lordosis was achieved with ACR at L2-L3 (10.9 degrees) and L3-L4 (10.4 degrees). Lateral interbody arthrodesis without the use of an ACR did not generally result in significant lordosis restoration. There were statistically significant improvements in PI-LL mismatch, coronal Cobb angle, and ODI at 2-year follow-up.

Discussion/Conclusion: The use of the MIISA provides consistent guidance for surgeons who plan to perform MIS deformity surgery. For L1-L4, the surgeons preferred lateral approaches to TLIF and reserved ACR for patients who needed the greatest increase in segmental lordosis. For L4-L5, the surgeons' order of preference was LLIF, TLIF, and ALIF, however TLIF failed to demonstrate any significant lordosis restoration. At L5-S1 the surgeon team typically preferred an ALIF when segmental lordosis was desired and preferred a TLIF if preoperative segmental lordosis was adequate.

VA 06

Patient Characteristics and Risk Factors in Elderly Patients Developing Surgical Site Infections Following Lumbar and Thoracolumbar Surgery

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Background/Introduction: Surgical site infections (SSIs) following spine surgeries are associated with worse outcomes. Elderly patients may be more vulnerable to adverse outcomes following SSIs due to higher prevalence of comorbidities. The objective of this study was to identify risk factors for elderly patients (≥ 65 years old) undergoing lumbar and thoracolumbar spine surgery.

Materials/Methods: This is a retrospective study of patients ≥ 65 years old undergoing lumbar and thoracolumbar spine surgery between November 2012 and March 2019 at a single academic center. Bivariate analyses and step-wise multivariable logistic regression analysis were used.

Results: 164 elderly patients met the inclusion criteria, of which 4 (2.4%) developed a SSI. Patients with SSIs were more likely to be smokers (50% vs. 6.9%, $p=0.03$) and have rheumatoid arthritis (RA) (25% vs. 0.6%, $p=0.048$). More elderly patients with SSIs underwent thoracolumbar fusion (50% of procedures for patients with SSIs vs. 10.6% of procedures for patients without SSIs) and lumbar discectomy (25% vs. 7.5%) ($p=0.04$ for all). Less patients with SSIs underwent lumbar posterior spinal fusion (25% vs. 52.5, $p=0.04$). Patients with SSIs were also more likely to be undergoing surgery for deformity (50% vs. 8.8%, $p=0.11$). Patients with SSIs had a higher average Vit D level of 51 ng/mL compared to 36.1 ng/mL for non-SSI patients and were more likely to have potentially harmful high (>60 ng/mL) Vit D levels (50% vs. 3.1%) ($p=0.02$ for all). Patients who had RA had significantly greater odds ($p=0.02$) of developing SSI.

Discussion/Conclusion: Limited evidence exists that can inform SSI risk stratification and preoperative counseling in elderly patients, which are a high risk cohort undergoing lumbar and thoracolumbar spine surgery. Our study found that in elderly patients, diagnosis of RA and potentially harmful high Vit D levels are associated with greater risk of SSI. Spine surgeons should be mindful of these risk factors when selecting elderly surgery patients, which are growing due to an aging population.

VA 07

Risk of Adult Spinal Deformity (ASD) Surgery Can Equal or Exceed that of Surgery for Metastatic Spinal Disease (MSD)

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Background/Introduction: Comorbidity status of patients with MSD influences their outcome after spinal surgery. Qualities of an ASD cohort that would intersect with complication rates of MSD patients are under-investigated.

Materials/Methods: Included: Elective ASD and MSD patients >18 years with demographic data in the American College of Surgeons' National Surgical Quality Improvement Program (ACS-NSQIP) database from 2005-2016. Excluded: Patients with infections or emergent surgeries. Means comparison tests and logistic regression analysis compared complication rates. Propensity score matching (PSM) controlled age, sex, and BMI. American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Results: Criteria included 11,949 patients - 9,392 ASD and 2,655 MSD. MSD had higher rate of any perioperative complications (49.9% vs. 33.7%, $p<0.001$) and complications with surgery and hospital stay (TABLE). ASD had higher home discharge (71.4% vs. 56.3%, $p<0.001$) and lower LOS (5.82 days vs. 11.02 days, $p<0.001$). After PSM for age, CCI, invasiveness, and levels fused, MSD had higher Clavien II (59.6% vs. 26.7%, $p<0.001$) and Clavien V complications (7.3% vs. 0.2%, $p<0.001$). ASD patients with $mFI\geq 0.4$ and 6+ levels fused had a complication rate (43.2%) similar to MSD. $mFI\geq 0.5$ caused the rate of any complication (60.9%) to surpass MSD. Osteotomy increased their complication rate to 79.7%. ASD with invasiveness scores 10+ after PSM had similar rates of any complication (ASD: 49.8%, Metastatic: 54.7%, $p>0.05$) as well as integumentary, pulmonary, renal, and neurological complications (all $p>0.05$). Modified CCI and mFI score did not affect incidence of any complication in this high invasiveness cohort ($p>0.05$).

Discussion/Conclusion: Increasing ASD levels fused, invasiveness, instance of osteotomy, and mFI score saw complication rates similar to or beyond MSD. Thus, these factors are important to consider as they are influential in patient outcomes despite comorbidity status.

VA 08

Correlation between Number of Spinal Levels Involved in Surgery and the Amount of Analgesia Required for Pain Control

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Background/Introduction: Patients who undergo lumbar spinal fusion surgery often experience significant postoperative pain. One of the most common medications used for treating pain is opioids. We investigated if a greater number of levels of lumbar fusion surgery was associated with more opioid usage.

Materials/Methods: In a retrospective study of posterior open lumbar spinal fusion surgery patients obtained surgery case logs and ICD-9 codes. Inclusion criteria: patients with lumbar stenosis, neurogenic claudication, and greater than 18. Exclusion criteria: lumbar fractures, lumbar infections, lumbar tumors and revision surgeries. Surgical, demographic and postoperative records reviewed and documented. Anesthesia and ISTOP (Internet System for Over-Prescribing) records used for dosage amounts. Patients categorized based on number of levels of lumbar fusion. Sub-groups formed based on interbody fusions. Total morphine equivalents (TMEs) from 30 days preoperatively, 1,3 and 6 months postoperatively analyzed. All patients received the same type of postoperative opioid after surgery.

Results: Sample size =58 consecutive patients. Mean age 59 years; gender (males= 35, females=23); mean number of operated levels = 3.3; mean Charlson Comorbidity score = 0.7 and ASA score = 2.6. 17 patients received interbody fusions. No statistical difference found in preoperative TMEs among groups ($p=0.21$), but patients using more TMEs preoperatively used more TMEs postoperatively. Postoperatively, the 3-level group had higher opioid dosages than 4- or 5-levels at 1-month follow-up. At 3 and 6 months postoperatively, TMEs reduced significantly in each group. No statistical difference of TMEs between operated levels groups seen postoperatively. At 6 months, interbody fusion patients had significantly higher TMEs in 5-level vs. other groups, $p<0.001$. With no interbody fusion, there was a slight difference ($p=0.06$) in preoperative TMEs between groups. No difference in hospital stay or estimated blood loss among groups ($p>0.05$), but EBL without interbody fusion increased as more levels fused ($p=0.06$). Hospital stay was shorter for less operated levels. (Table 1)

Discussion/Conclusion: There is no current evidence postoperative opioid use is correlated to number of levels fused. Patients using more TMEs preoperatively tend to use more TMEs postoperatively. It is important to reduce opioid use and seek alternative therapies after undergoing multilevel lumbar fusion surgery.

VA 09

Evaluation of Sacral Table Angle in Adolescent Idiopathic Scoliosis Patients with Spondylolisthesis

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Background/Introduction: Sacral table angle (STA) is a proposed sacral parameter for the prediction of spondylolisthesis (Spondy) progression. There is a negative correlation between STA and degree of spondylolisthesis slippage in skeletally immature patients. However, such STA changes have been poorly studied in skeletally mature patients. This study analyzes the changes in STA over time between adolescent idiopathic scoliosis (AIS) with spondylolisthesis patients (AIS+Spondy) and AIS patients without spondylolisthesis cohorts.

Materials/Methods: Retrospectively analyzed matched cohorts (aged, 10-21 yrs.) who were surgical treated between 2001 and 2007. Matching was done based on age, gender and preoperative major coronal Cobb angle (MCC). STA and other sacropelvic parameters were analyzed between groups at preoperative, postoperative and final follow-up (FFU).

Results: Total study sample, N=22 patients: AIS cohort(Group 1, n=11), AIS + Spondy(Group 2, n=11). In Group 2: preoperatively, 2 patients had high grade isthmic slips (Meyerding Grade 3 or 4), 1 patient had Grade 2, and 8 had Grade 1; all slips occurred at L5-S1. Age, female gender, preoperative and postoperative MCC, FFU lumbar lordosis (LL), and average follow-up were similar between groups (Table 1). Mean STA was significantly lower in Group 2 at preop (94° vs. 100°, p=0.03), postop (91° vs. 100°, p=0.01) and FFU (90° vs. 98°, p=0.02), respectively. Mean STA decreased by 4° at FFU (p=0.60) in Group 2 and by 2° (p=0.60) in Group 1 from preoperatively, respectively. Mean PI was significantly higher in Group 2 at preoperative (66° vs. 49°, p=0.01) and FFU (77° vs. 55°, p=0.04), respectively. In Group, 2 at FFU slip grades did not change for 9 patients (Grade 1), 1 patient had slip progression to Grade 2 (patient had surgery for spondylolisthesis in FU), and unknown in 1 patient.

Discussion/Conclusion: STAs were significantly smaller in AIS+Spondy. However, STA decrease over time was not significantly different between AIS and AIS+Spondy in young skeletally mature patients. In skeletally immature spondylolisthesis patients, the negative correlation between STA and degree of spondylolisthesis slippage might be the result of secondary anatomic changes related to remodeling of the upper sacrum as a result of slippage, rather than the cause.

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Pedicle Subtraction Osteotomy in Adult Spinal Deformity Correction: Clinical and Radiographic Risk Factors for Early Instrumentation Failure

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Background/Introduction: Early instrumentation failure (EIF) after pedicle subtraction osteotomy (PSO) is a known complication of adult spine deformity (ASD) correction. In contrast to the more common failure that occurs secondary to pseudarthrosis, early instrumentation failure (<6 months after surgery) and its risk factors are not as well understood. The aim of the current study is to identify and present the risk factors for early instrumentation failure (EIF) in patients undergoing pedicle subtraction osteotomy (PSO) for ASD correction.

Materials/Methods: Patients with ASD who underwent correction with PSO at a single institution from 2003 to 2018 were retrospectively reviewed. Demographic characteristics, number of rods, spinopelvic parameters, bone density derived from computed tomography (CT) attenuation in Hounsfield units (HU), Global Alignment and Proportion (GAP) score, and type of instrumentation failure were evaluated. Potential risk factors for EIF were analyzed.

Results: 9 out of 46 (19.5%) patients who underwent PSO had EIF. All 9 patients with EIF had 2-rod constructs and failed secondary to rod fracture. The number of rods used in the EIF group was significantly lower than the non-EIF group ($2.00 \pm .00$ vs $2.81 \pm .995$, $p = .000$). The EIF group demonstrated a significantly higher pre-op pelvic incidence (77.33 ± 13.23), $p = .022$, pre-op pelvic tilt (37.22 ± 6.46), $p = .012$, and post-op sagittal vertical axis (89.96 ± 23.85), $p = .028$ compared to the non-EIF group. There was no significant association found between pre-op GAP score and EIF.

Discussion/Conclusion: The overall rate of early instrumentation failure after PSO in ASD surgery was 19.5%. Patients with EIF had a lower number of rods 2.00 vs 2.81. High pre-op pelvic incidence, pre-op pelvic tilt, and post-op sagittal vertical axis were significant risk factors associated with EIF after PSO. These results suggest that when considering PSO for the treatment of ASD, patients with a higher sagittal spinal malalignment may have a higher rate of early instrumentation failure and using multiple rods may help decrease early failure.