Abstracts of the 2021 AANS/CNS Joint Section on Disorders of the Spine and Peripheral Nerves Annual Meeting San Diego, California • July 28 - 31, 2021

(DOI: 10.3171/2020.8.SPINE.DSPN2021abstracts)

Disclaimer: The Journal of Neurosurgery Publishing Group (JNSPG) acknowledges that the preceding abstracts are published as submitted and did not go through JNSPG's peer-review or editing process.

Thursday, July 29, 2021 Kuntz Scholar Oral Abstract Presentations Concurrent Session 1

3:15 - 3:20 pm 100 Dorsal Root Entry Zone Lesioning for Chronic Neuropathic Pain Secondary to Brachial Plexus Avulsion

Daniel Lubelski, MD; Zach Pennington, BS; Arinze Ochuba; Allan J. Belzberg, MD, FAANS

Introduction: Many patients who suffer brachial plexus avulsion (BPA) go on to develop chronic deafferentation pain secondary to electrical hyperactivity in the spinal cord dorsal horn. Dorsal root entry zone (DREZ) lesioning can be a beneficial last line intervention for those with intractable, debilitating pain.

Methods: All patients who underwent DREZ lesioning by the senior author for medically refractory BPA-related deafferentation pain between 2016 and 2020 were retrospectively identified. Details were gathered on patient demographics (age, sex), preoperative symptoms, mechanism of injury, operative details, pre- and postoperative pain scores on the numeric rating scale (NRS), and outpatient medication regimen. Statistical analyses were performed using R version 3.6.3.250 (R Studio).

Results: Nineteen patients were identified (16/19 male; mean age 52.1; 10/19 left-sided injuries) with a mean follow-up of 3.9-months. Motorcycle accident was the most common mechanism of injury (12/19). Average time to symptom onset was 3.8 months and mean time from symptom onset to DREZ lesioning was 16.8 years. Preoperatively 11/19 had paroxysmal pain episodes, 8/19 endorsed only constant pain, 8/19 endorsed sensory deficits (paresthesias, dysesthesias, anesthesia), and 19/19 demonstrated motor deficits. Fourteen of sixteen patients seen at 2-months postoperatively endorsed continuous relief of \geq 85% of their baseline pain; all patients with preoperative paroxysmal pain endorsed \geq 85% relief. Mean NRS score improved from 8.6±0.5 preoperatively to 0.5±0.5 by last follow-up (p<0.05). At last follow-up, 15/16 patients reported satisfaction with their pain relief. Only one patient developed mild hip flexor weakness, requiring cane with ambulation.

Conclusion: DREZ lesioning may be an effective option for pain relief for patients with intractable upper extremity neuropathic pain secondary to BPA. Additional studies are needed to elucidate the robustness of pain relieve and identify the optimal lesion depth.

3:25 - 3:30 pm

101 Characterization of Intervertebral Disc Inflammation Following Discectomy for Treatment of Lumbar Disc Herniation

Daniel Myers, MD; Isaac Swink; Brett Phillips; Chen Xu, MD; Yesica Garcia-Fiueroa; Boyle C. Cheng, PhD; Nick Giannoukakis; Alexander Kwong-Tak Yu, MD

Introduction: Lumbar Disc degeneration has been historically characterized as a disease of mechanical stress. More novel literature suggests that this stress is a catalyst for degeneration and that the inflammatory response may play a major role in disc degeneration. This study aims to characterize the presence of inflammatory cells and mediators that may be involved in lumbar degenerative disc disease.

Methods: Tissue was acquired from patients undergoing lumbar discectomy with no deviations from standard of care treatment. Disc tissue was prepared and assess for the presence of various inflamatory cells as well as various inflammatory mediators including TNFa. Patient characteristics were extracted from the medical record IRB approved.

Results: 20 subjects with 18 samples were enrolled. 3 samples were cadaveric controls. Inflammatory cells including neutrophils and macrophages were detected in degenerative disc tissue, both sources of TNFa production. Patients who received physical therapy and epidural steroid injections had a significantly lower level of TNFa in tissues at time of discectomy as compared to patients who did not. There was a positive correlation between TNFa levels and length of symptoms.

Conclusion: Our study confirms that there is evidence of inflammatory cells and inflammatory mediators in degenerated intervertebral disc tissue. Furthermore, the trend of TNFa increase with length of symptoms provides molecular bases as to why DMARDs may improve discogenic back pain. Further study is needed to further delineate the complex interplay between mechanical stress and inflammation as drivers for degenerative disc disease to improve therapies to be delivered in a more minimally invasive and efficacious way.

3:35 - 3:40 pm 102 Surgical Approaches to Tumors of the Occipito-cervical, Subaxial Cervical, and Cervicothoracic Spine

Zach Pennington, BS; Erick M Westbroek, MD; Sheng-fu L. Lo, MD; Daniel Sciubba

Introduction: Vertebral body tumors of the cervicothoracic spine can be approached using a combination of via anterior-only, posterior-only, or staged approaches. The aggressiveness of the adopted approach varies significantly depending upon the goals of surgery and anatomic location, up to and including transmandibular and transsternal approaches for primary lesions.

Methods: All patients treated for vertebral column tumors involving the occipito-cervicothoracic spine (occipitocervical junction-T4) over a 10-year period at a comprehensive cancer center were reviewed. Tumor pathology and morphology were recorded, and surgical approach was classified according to the use of staging and the use of invasive bony work i.e., transmandibular approach or manubriotomy/sternotomy. For tumors extending above the plane of the inferior mandibular border, angle of attack was defined as the angle inscribed by the inferior mandibular plane and line connecting the superior tumor pole and mandibular angle. For those extending below the thoracic inlet, angle of attack was defined as the angle inscribed by the plane of the inferior mandibular notch and inferior tumor pole.

Results: One hundred fifteen patients were included. Mean age was 56.7yr, 56% were male, average tumor size was 26.5cm³, and 34% were primary tumors. Sixty percent of patients had single-stage procedures (49.6% posterior-only, 10.5% anterior-only), 30.4% had two-stage procedures, and 8.7% had three- or four-stage approaches. Lesions requiring a combined transmandibular-transcervical approach all involved the C2 and C3 levels and had a significantly steeper angle of attack (42.5±9.5 vs 6.1±13.3°; p=0.01) and higher superior tumor extent (3.69±2.18 vs 0.33±0.78; p=0.002). extent above the inferior plane of the mandible. Lateral tumor extent, tumor size, nor inferior angle of attack differed significantly between approach groups.

Conclusion: Here we present a preliminary decision-making algorithm for the management of vertebral column tumors of the cervicothoracic spine. Based upon this single center experience, we suggest which patients, assessed via a combination of tumor histology and regional anatomy, may benefit from extended anterior surgical access.

3:45 - 3:50 pm

103 Differences between Anterior and Posterior Approaches for Treatment of Cervical Spondylotic Myelopathy

Brandon Sherrod, MD; Christopher G. Wilkerson, MD; Mohammed A. Alvi, MD, MS; Anthony L. Asher, MD, FAANS, FACS; Domagoj Coric, MD; Michael S. Virk, MD, PhD; Kai-Ming G. Fu, MD, PhD, FAANS; Kevin T. Foley MD, FAANS; Paul Park MD, FAANS; Cheerag D. Upadhyaya, MD; John J. Knightly, MD, FAANS; Mark E. Shaffrey, MD, FAANS; Eric A. Potts, MD, FAANS; Christopher I. Shaffrey, MD, FAANS; Michael Y. Wang MD, FAANS; Praveen V. Mummaneni, MD, FAANS; Andrew Kai-Hong Chan, MD; Mohamad Bydon, MD, FAANS; Luis M. Tumialán, MD; Erica F. Bisson, MD, FAANS

Introduction: Selection of the optimal approach for treatment of cervical spondylotic myelopathy (CSM) remains challenging in some patients, and differences in patient outcomes between anterior and posterior approaches remain unclear.

Methods: Patients with symptomatic CSM treated at 14 high-volume sites were identified from the NeuroPoint Quality Outcomes Database. Demographic, comorbidity, socioeconomic, and PRO measures were retrospectively compared between anterior and posterior approach groups at baseline and 3 and 12 months postoperatively.

Results: Significant baseline differences between approaches were observed for age, comorbidities, myelopathy severity, unemployment, and hospital stay in 1151 patients (791 [68.7%] anterior and 360 [31.3%] posterior approach). Postoperatively, anterior approach patients had a significantly lower Neck Disability Index (NDI) (p<0.001 for both time points) and more anterior approach patients achieved a minimal clinically important difference (MCID) in NDI (p=0.002 for both time points), which remained significant on multivariate analysis. Anterior approach patients' modified Japanese Orthopaedic Association (mJOA) scores were higher at 3 and 12 months (p<0.001 and p=0.022, respectively), although no differences were seen in mJOA MCID or change from baseline. A greater improvement in EQ-5D at 3 months (p=0.024) for anterior approach patients was not sustained at 12 months and was insignificant on multivariate analysis.

Conclusion: In the largest analysis to date of CSM surgery data, significant baseline differences existed between anterior and posterior approach patients. Adjusting for these differences, patients undergoing anterior surgery were more likely to achieve clinically significant NDI improvement at short- and long-term follow-up.

3:55 - 4:00 pm 104 Involvement of mTOR Pathway Modulates Autophagy and Immune Response in Recovery from Spinal Cord Injury

Tolga Sursal, MD; Ingrid Vargova; Lucia Machova Urdzikova; Kristyna Karova; Chirag D. Gandhi, MD, FACS, FAANS; Pavla Jendelova; Meena Jhanwar-Uniyal

Introduction: Spinal cord injury (SCI) is the most frequent cause of disability. SCI consists of primary mechanical injury followed by a secondary inflammatory cascade that hinders recovery. Autophagy is inhibited in SCI, contributing to secondary injury. Modulation of autophagy is therefore a potential treatment for SCI. The mTOR pathway regulates numerous cellular mechanisms via two functionally distinct complexes mTORC1 and mTORC2, and is considered as a major negative regulator of autophagy through multiple pathways. Therefore, mTOR pathway inhibition may lead to neuroprotection and functional recovery from SCI by stimulating autophagy and reducing inflammation. Here we studied the effects of Rapamycin (RAPA), an mTORC1 inhibitor, and pp242, a dual inhibitor of both mTORC1 and mTORC2 on autophagy, immune response, and recovery from SCI.

Methods: In a balloon-compression model of SCI, rats (n=52) were randomized into four treatment groups: RAPA, pp242, vehicle-treated controls, and no-lesion no-treatment controls. Treatments were administered intraperitoneally daily, starting from the second day and repeated until the sixth day after the SCI. Rats were sacrificed on day 7 post-SCI. Behavioral testing (BBB) was performed to assess recovery status. IHC, Western Blot, and ELISA were used to analyze the effects of mTOR pathway inhibition on inflammatory and autophagic markers.

Results: RAPA or pp242 downregulated downstream mTORC1 target, pS6, and mTORC2 target, Akt. Another mTORC1 target, 4EBP1 was hyperphosphorylated following treatment with RAPA or pp242. Expression of autophagic marker, LC3B, was elevated after SCI and further potentiated by RAPA or pp242 treatment. RAPA or pp242 treatment altered cytokine production in SCI. Pro-inflammatory cytokines were increased by pp242 treatment and reduced by RAPA treatment. Both RAPA and pp242 induced downregulation of cytokines IL-1 β , MIP-1 α , and IL-10. Lastly, mTOR inhibition led to increased functional recovery as shown by higher BBB scores.

Conclusion: Our results suggest that mTOR inhibition via mTORC1 suppresses inflammation and upregulates autophagy leading to an improved functional recovery in a rat model of SCI.

4:05 - 4:10 pm 105 Abaloparatide Increases Bone Mineral Density in Potential Spine Surgery Candidates with Osteoporosis

Nikita Lakomkin, MD; Anthony L. Mikula, MD; Adip G. Bhargav; Jeremy L. Fogelson, MD, FAANS; Mohamad Bydon, MD, FAANS ; Arjun Sebastian, MD; Kurt Kennel; Brett Freedman; Paul A. Anderson, MD; Benjamin D. Elder, MD, PhD, FAANS

Introduction: Osteoporosis is a common condition in patients undergoing spine surgery and has been shown to negatively impact postoperative outcomes. Abaloparatide is a parathyroid hormone-related protein analog that is a novel anabolic treatment for osteoporosis. Hounsfield units (HU) are a metric of bone mineral density (BMD) that can be obtained via standardized measurements on routine computed tomography (CT) scans.

Methods: Adult patients who were potential spine surgery candidates and underwent a minimum of 6 months of abaloparatide therapy were identified. Patients underwent either DXA or CT imaging before and after treatment. Patients with instrumentation in the L1-L4 spine were excluded. Demographics, duration of treatment, the use of other osteoporosis medications, and metabolic laboratory studies were collected. Hounsfield units were measured in the vertebral bodies from L1 to L4. Pre- and post-treatment DXA of the lumbar spine, hip, and femoral neck were collected. Bivariate statistics were employed to examine the relationship between abaloparatide treatment and objective metrics of bone quality in the context of treatment duration and other variables.

Results: A total of 55 patients were included in the analysis, with a mean age of 65 years and a BMI of 25. The average pre-treatment lumbar BMD by DXA was 0.84 g/cm2 (+/- 0.10) which increased to 0.91 g/cm2 (+/- 0.09) after abaloparatide therapy (+8.5%, P<0.001). The mean pre-treatment HU was 98.5 (+/- 40.0), compared to 133.5 (+/- 50.5) following treatment (P=0.028). Average hip T-score increased from -2.23 to -2.01 (P<0.001). The mean time between the start of treatment and follow-up imaging was 525 days for DXA and 344 days for CT. Significant increases in BMD were observed by 6 months of treatment.

Conclusion: Abaloparatide improved both HU and BMD on DXA in the lumbar spine and therefore may have utility in pre-operative bone strength optimization in osteoporotic patients undergoing spine surgery. Further studies are needed to examine the relationship between abaloparatide use and postoperative outcomes.

4:15 - 4:20 pm 106 Non-surgical Management of Shoulder Subluxation after Nerve Reconstruction for Neonatal Brachial Plexus Palsy

Whitney Muhlestein, MD; Sean McKale; Kate Chang; Lynda Jun-San Yang, MD, PhD, FAANS; Brandon Smith

Introduction: A subset of children with neonatal brachial plexus palsy (NBPP) fail to develop normal shoulder anatomy, which can lead to posterior subluxation of the humeral head, limiting external rotation. This can progress to an internal rotation contracture, limiting functional outcomes long term. Management of NBPP-associated shoulder subluxation ranges from early orthopedic surgery to non-surgical management(bracing +/-botox injection). The optimal treatment strategy is debated.

Methods: We performed a retrospective case series of 14 consecutive children with NBPP and ultrasoundproven shoulder subluxation who underwent non-surgical management of shoulder subluxation with SPICA brace +/- botox after nerve reconstruction. Pre and post-operative shoulder passive external rotation range of motion was measured by a trained occupational therapist. Clinical outcomes including progression to secondary shoulder surgery were analyzed.

Results: All children in this series were placed into a custom SPICA brace for 6 weeks after brachial plexus reconstruction. 9 of 14 children had botox injection at time of surgery. All children resumed occupational therapy after bracing. Average follow up was 31.8 months. There was no significant decrease in shoulder passive external range of motion preoperatively to postoperatively (average 79.3 degrees vs 77.8 degrees, p=0.8). Only one child (7.1%) ultimately progressed, requiring surgical management of shoulder deformity.

Conclusion: Shoulder subluxation in the context of NBPP can persist even in the setting of nerve recovery. Treatment is thus indicated to avoid permanent functional deficit caused by chronic subluxation and internal rotation contracture. While some advocate for early orthopedic surgery, superiority of surgical over conservative management has not been demonstrated, and surgery in young children is not without risk. We present a series of children with shoulder subluxation treated by bracing that shows no significant difference in shoulder passive external rotation at an average of 31.8 months postoperatively. Only one child out of 14 progressed to require shoulder surgery. These findings suggest that a non-surgical approach to shoulder subluxation in NBPP does not lead to excess internal rotation contracture, and only 7.1% of these patients progress to shoulder surgery.

Thursday, July 29, 2021 Kuntz Scholar Oral Abstract Presentations Concurrent Session 2

3:15 - 3:20 pm 107 Lower Hounsfield Units at the Upper Instrumented Vertebrae are Associated with Proximal Junctional Kyphosis and Failure

Anthony L Mikula, MD; Jeremy L. Fogelson, MD, FAANS; Nikita Lakomkin, MD; Patrick M. Flanigan, MD; Zachariah Pinter; Matthew Doan; Mohamad Bydon, MD, FAANS; Ahmad Nassr, MD; Brett A. Freedman; Arjun Sebastian MD; Kingsley O. Abode-Iyamah MD; Paul A. Anderson MD; Benjamin D. Elder MD, PhD, FAANS;

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.

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).

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.

3:25 - 3:30 pm 108 Spontaneous Recovery in Patients with an ASIA A Spinal Cord Injury: Analysis of Multicentre Data in 943 Cases

Ali Moghaddamjou, MD; Jefferson R. Wilson, MD, PhD; Michael G. Fehlings, MD, PhD, FAANS, FRCS

Introduction: Predicting spontaneous recovery after traumatic Spinal Cord Injury (tSCI) is important for the expectation setting of patients and clinical trial design. Spontaneous recovery needs to be accounted for in trial design to prevent type 1 errors through erroneous randomization. It is recognized that the prediction of patients with an American Spinal Injury Association (ASIA) Impairment Scale (AIS) A that converts is challenging. A better understanding of the natural history of ASIA A patients is required to understand disease trajectory and to decipher treatment effect in trials from spontaneous recovery.

Methods: Patients with ASIA A injury were identified from 3 prospective, multi-center datasets (NACTN, STASCIS, and SYGEN). All follow-up examinations for each patient were included and transitions with their respective time from injury in hours were tabulated. A-priori we identified age (<60yrs and =>60), injury region (cervical, thoracic, and lumbar), and early surgery (surgery <24hrs vs >24hrs) as covariates in our analyses. We also tabulated the number of muscle groups below the neurological level of injury from baseline at each examination point. The mstate statistical package in R was utilized to develop flexible Markov models of disease progression. Covariate effects were estimated using Cox regression without any proportionality assumption.

Results: We identified 943 patients with 384 total transitions. On average patients recovered 2.7 muscle groups below their level of injury at the 52-week mark. The cumulative hazard ratio plot over time reveals an exponential relationship in all transition groups illustrating the time-dependent impact on transition intensities. Dynamic prediction probabilities revealed a total conversion of 34.36% from ASIA A. Cervical injuries showed a statistically significant increase in spontaneous transition probabilities.

Conclusion: We model spontaneous recovery in ASIA A tSCI patients showing a time-dependent overall conversion rate of 34.36% with an average gain of 2.7 muscle groups gained at the 1-year follow-up. These results show a higher potential for spontaneous recovery than previously thought which further supports early surgical treatment for ASIA A tSCI patients.

3:35 - 3:40 pm 109 Use of the Relative Citation Ratio as a Measure of Academic Neurological Spine Surgeon Productivity

Dayton Grogan; Vamsi Reddy; Arjun Gupta; Yue-Fang Chang, PhD; Daryl Fields; Nitin Agarwal

Introduction: Publication metrics such as the author-level h-index are often used to evaluate and compare research productivity in academia. The h-index, however, is not a field-normalized statistic and has been criticized as inappropriate for comparison of authors from different fields. The NIH has developed a new, field-normalized article-level metric called the relative citation ratio (RCR) that can be used to more accurately compare author productivity between fields. However, this metric has yet to be applied to subspecialties in the field of Neurological surgery.

Methods: The mean RCR is the total citations per year of a publication divided by average citations per year received by NIH-funded papers in the same field. A value of 1 is the normal NIH-funded standard. iCite database searches were performed for all physician faculty members affiliated with ACGME-accredited neurological surgery programs who have sub-specialized in spine as of November 1, 2019. Gender, career duration, academic rank, additional degrees, total publications, mean RCR, and weighted RCR were collected and analyzed for 358 academic spine surgeons from 125 institutions. RCR and weighted RCR were compared between variables to assess patterns of analysis

Results: Neurological spine surgeons had exceptional research productivity, with a median RCR of 1.38 [IQR = 0.94 - 1.95] and a weighted median RCR of 25.28 [IQR = 6.87 – 79.93]. Overall, gender and academic rank were associated with increased mean RCR and weighted RCR values. Career duration and Ph.D. acquisition were not. All subgroups analyzed had an RCR value above 1.0, with professor-level faculty or department chair having the highest mean and weighted RCR values overall.

Conclusion: Current academic spine neurosurgeons have high median RCR values relative to the NIH standard value. Relative to the field of neurosurgery overall, RCR values for the spinal subspecialty are comparable. These data offer a more accurate means for evaluation of faculty by institutional and departmental leaders.

3:45 - 3:50 pm

110 Decisional Regret Among Older Adults Undergoing Corrective Surgery for Adult Spinal Deformity

Owoicho Adogwa, MD, MPH; James Caruso, MD; Cody M. Eldridge; Ravinderjit Singh; Sai Chilakapati; Palvasha Deme; Sonja Stutzman, PhD; Salah G. Aoun, MD; Aanand Naik; Carlos A. Bagley, MD; Una Makris

Introduction: Among older adults (> 65 years old), adult spinal deformity (ASD) is a leading cause of disability, with a population prevalence of 60%-70%. Surgical referral for deformity correction is common despite the high rates of postoperative complications.

Methods: Older adults with a diagnosis of ASD who underwent spinal surgery at a quaternary medical center from January 2016 to March 2019, were enrolled in this study. Patients were categorized into medium/high or low-decisional regret cohorts based on their responses to the Ottawa decision regret questionnaire 24 months after surgery. The primary outcome measure was prevalence of decisional regret after surgery. Factors potentially associated with high decisional regret were analyzed by multivariate logistic regression with inclusion of covariate terms for gender, depression, ASA score, invasiveness of surgery, and presence of a postoperative complication.

Results: A total of 155 patients (mean, 69.5 years) met the study inclusion criteria. Of the 155 patients, 91 consented to participate (response rate, 59%). There were no differences in demographics, comorbidities, invasiveness of surgery, or severity of baseline functional disability, between patients consenting to study participation and those that declined. Overall, 80% agreed that having surgery was the right decision for them, and 77% would make the same choice in future. A total of 21% regretted the choice that they made, and 21% responded that surgery caused them harm. Comparing patient cohorts reporting medium/high- versus low-decisional regret, there were no differences in baseline demographics, comorbidities, invasiveness of surgery, length of hospital stay, discharge disposition, or extent of functional improvement 12-months after surgery. After adjusting for gender, ASA score, invasiveness of surgery, and presence of a postoperative complication, older adults with pre-operative depression had a 4.0 fold increased odds of high-decisional regret (p=0.04). Change in HRQOL measures were similar between all groups at 12-months after surgery.

Conclusion: While the majority of older adults were appropriately counselled and satisfied with their decision, one-in-five older adults regret their decision to undergo surgery. Preoperative depression was associated with medium/high decisional regret on multivariate analysis.

3:55 - 4:00 pm 111 Risk Factors for Not Reaching MCID at 90 days and 1 year after Elective Lumbar Spine Surgery

Seokchun Lim, MD; Kylie Springer; Sameah A. Haider, MD; Mohamed Macki, MD; Travis M. Hamilton, MD; Richard Easton, MD; Mick J. Perez-Cruet, MD, FAANS; Ilyas Aleem, MD, Msc, FRCSC; Muwaffak Abdulhak,, MD, FRCS; Jason M. Schwalb, MD, FAANS, FACS; Victor W. Chang MD, FAANS

Introduction: Patient perceived functional improvement is a core metrics in lumbar surgery for degenerative disease. It is important to identify modifiable risk factors that can be optimized prior to elective surgery.

Methods: We queried Michigan Spine Surgery Improvement Collaborative (MSSIC) database to identify elective lumbar surgeries with PROMIS-PF scores. Cases were divided into two cohorts based on whether patients achieved MCID at 90 days and 1 year after surgery. Patient characteristics and operative details were analyzed as potential risk factors.

Results: We captured 10,922 patients for 90-day follow up and 4,453 patients (40.8%) did not reach MCID. We also identified 7,780 patients for 1-year follow up and 2,361 patients (30.3%) did not achieve MCID. Significant adjusted relative risks are included in bracket next to individual item. At 90 days after surgery, significant factors include: less than high school education (1.20), African American descent (1.25); chronic opiate use (RR 1.23); current smoking (1.14); chronic obstructive pulmonary disease (COPD) (1.13); morbid obesity (1.15); scoliosis (1.06); history of DVT (RR 1.08); depression (1.09); anxiety (1.06); symptom duration more than 1 year (1.34); ASA class >2 (1.15); previous spine surgery (1.25); baseline PROMIS (1.06); surgery invasiveness (1.02). Independent ambulatory status (0.83) and private insurance (0.83) were associated with higher likelihood of reaching MCID at 90 days.

At 1 year after surgery, significant factors include: age (1.01), African American descent (1.20), less than high school education (1.34); chronic opiate use (1.25); current smoking (1.21); chronic obstructive pulmonary disease (COPD) (1.09); morbid obesity (1.30); history of DVT (1.12); depression (1.10); symptom duration more than 1 year (1.41); ASA class >2 (1.18); previous spine surgery (1.30); baseline PROMIS (1.06). Independent ambulatory status (0.88) and private insurance (0.85) were associated with higher likelihood of reaching MCID at 90 days.

Conclusion: Our case control study identified relevant risk factors for patients not reaching MCID after elective lumbar spine surgery. This study may assist clinicians in identifying high risk patients and optimizing patients prior to surgery.

4:05 - 4:10 pm

112 Effect of Morbid Obesity on Complications, Readmission, and PROs after MIS TLIF: An Inverse Propensity Score Analysis

Chad F. Claus, DO; Michael H Lawless, DO; Evan J. Lytle, DO; Doris Tong; Matthew Bahoura, BA; Lucas Garmo; Joseph Gabrail; Peter L. Bono, DO; Prashant Sudhir Kelkar, DO; Boyd F. Richards, DO; Daniel A. Carr, DO; Clifford M. Houseman, DO; Teck-Mun Soo, MD, FAANS

Introduction: Obesity remains a serious public health concern. Obese patients who undergo lumbar fusion have historically thought to be at higher risk for complications and fare worse regarding quality-of-life outcomes. However, recent literature may demonstrate comparable risk and outcomes in obese patients. An increasing number of patients are categorized as morbidly obese (BMI > 40 kg/m2). Perioperative and patient-reported outcomes (PROs) are lacking in this patient population.

Methods: The authors retrospectively reviewed a prospectively collected database of all morbidly obese and non-obese patients that underwent MiTLIF between 2015 to 2018 for degenerative conditions who had a minimum of 1-year follow-up for outcome assessment. An inverse propensity/probability of treatment weighting was utilized to create a synthetic weighted sample in which covariates were independent of obesity designation to adjust for the imbalance between groups. Generalized estimating equations (GEE) were used to estimate the association of morbid obesity and complications and 1-year PROs.

Results: A total of 292 patients were analyzed with 234 non-obese patients and 58 morbidly obese patients. Multivariate analysis failed to demonstrate any significant association between morbid obesity and achieving MCID for ODI, VAS, or SF-12 physical component score. However, morbid obesity was associated with a significantly decreased odds of improving MCID for SF-12 mental component score (p=.001) and a significantly increased odds of prolonging surgery duration (p=.001). Morbid obesity was not independently associated with postoperative complications, readmission, pseudarthrosis, or ASD.

Conclusion: Morbidly obese patients who undergo MiTLIF can achieve meaningful clinical improvement comparable to nonobese patients. Morbid obesity was independently associated with longer surgical times but was not associated with increased risks for postoperative complications, readmission, or ASD.

4:15 - 4:20 pm 113 Injury Volume Extracted from MRI Predicts Neurologic Outcome in Acute SCI: A Prospective TRACK-SCI Pilot Study

John F. Burke, MD; Nikhil Mummaneni; Anthony M. DiGiorgio, DO, MHA; Leigh H. Thomas, BA; Xuan Duong Fernandez, BA; Mark Harris; Lisa Pascual; Ferguson Adam, PhD; J Russell Huie, PhD; Jonathan S. Pan; Debra P. Hemmerle, RN, MSN; Vineeta Singh; Abel Torres; Nikolaos Kyritsis, PhD; Philip R. Weinstein, MD, FAANS(L); William Whetstone, MD; Geoffrey T. Manley, MD, PhD; Jacqueline Bresnahan, PhD; Michael Beattie, PhD; Sanjay S. Dhall, MD, FAANS; Jason Talbott, MD, PhD

Introduction: Conventional MRI measures of traumatic spinal cord injury severity largely rely on 2-dimensional injury characteristics such as intramedullary lesion length and cord compression. Recent advances in spinal cord imaging have led to the development of a robust anatomic atlas incorporated into an open-source platform called the Spinal Cord Toolbox (SCT), which allows quantitative volumetric injury analysis.

Methods: This IRB-approved prospective cohort study involved the image analysis of 60 patients who had cervical spinal cord injury due to blunt trauma. These 60 patients were enrolled in the TRACK-SCI clinical research protocol. Axial T2w MRI data obtained within 24 hours of injury were processed using the SCT. The MRIs were automatically segmented using Deepseg tool in the SCT and manually corrected by a neuro-radiologist. The PAM50 anatomical template was then registered to the MRI data, and a lesion mask was manually created and used to calculate the probabilistic volume of the lesion. Lesion volume data were used as predictor variables for correlation with patient's lower extremity motor scores at discharge.

Results: The mean lesion volume was 536.6 mm3, with values ranging from 27.2 mm3 to 3533.7 mm3. Volumetric MRI measures of T2-hyperintense lesions accurately predict lower extremity motor scores at discharge (Pearson's coefficient: -0.499, p-value: 0.01). Similarly, 3-dimensional MRI measures of injury volume significantly correlated with motor scores to a greater degree than standard 2-dimensional metrics.

Conclusion: The 3-dimensional volume of total cord injury on T2w MRI is significantly and independently associated with neurologic outcome at discharge after injury. Lesion volume could be a valuable prognostic tool for physicians treating patients shortly after injury.

Thursday, July 29, 2021 Kuntz Scholar Oral Abstract Presentations Concurrent Session 3

3:15 - 3:20 pm 114 Comparison of C5 Palsy Incidence in Laminectomy and Fusion Versus Laminoplasty

Yaroslav J. Gelfand, MD; Yagmur Muftuoglu, MD; Anwesha Dubey; Ien Li; Michelle Hong; Daniel C. Lu, MD, PhD, FAANS; Langston T. Holly MD, FAANS

Introduction: C5 palsy is a well known complication in posterior cervical spine surgery. Prior studies have conflicting evidence on whether C5 nerve root palsy rates are different between two most common posterior procedures for degenerative cervical myelopathy.

Methods: A retrospective chart review was conducted of all patients from 2014-2019 treated for degenerative cervical myelopathy who underwent laminoplasty or posterior cervical laminectomy and fusion. Patients for whom there was no reliable pre-op exam, post-op exam, or sufficient follow up were excluded. Patients who had pre-operative shoulder and/or biceps weakness were excluded from the analysis as were patients with neurodegenerative, rheumatologic or other diagnoses that could explain their C5 distribution weakness. Univariate analysis, followed by multivariate regression model was used to compare the differences between the groups.

Results: A total of 123 patients met the inclusion criteria. Of those 76(62%) underwent laminectomy and fusion and 47(38%) underwent laminoplasty. Patients in laminoplasty group were slightly older, and more likely to be male. Other than that, there were no significant differences between the groups. There was no statistically significant difference between those with C5 palsy in laminectomy and fusion group(9.2%) compared to laminoplasty group (6.4%) on univariate analysis (p=0.577), or multivariate regression(p=0.501). Those in the laminectomy and fusion group seemed to have a slightly delayed onset of symptoms (5.9 vs 2 days), but the difference was not statistically significant (p=0.319). While it did not reach statistical significance (p=0.092) there was a trend towards less amount of time to recovery for C5 palsy after laminoplasty (median of 2 weeks vs 26 weeks).

Conclusion: This study did not find significant difference between occurrence of C5 palsy between laminoplasty and laminectomy and fusion patients. The onset of symptoms was within 1 week after the operation on average, and while not statistically significant, there was a trend towards faster resolution of symptoms in those who have undergone laminoplasty.

3:25 - 3:30 pm

115 Outcomes of Anterior Cervical Discectomy and Fusion Correlate with the Specialty of the Surgeon Performing the Procedure

Safwan Alomari; Brendan F. Judy, MD; Jon Weingart; Sheng Fu L. Lo, MD, FAANS ; Daniel M. Sciubba, MD; Nicholas Theodore, MD, FAANS, FACS; Timothy F. Witham, MD, FAANS; Ali Bydon, MD, FAANS

Introduction: Comparative effectiveness research has a vital role in recent health reform and policies. Specialty training is one of these provider-side variables and surgeons who were trained in different specialties may have different outcomes upon performing the same procedure.

Methods: A retrospective, 1:1 propensity score-matched cohort study. 21,211 patients were reviewed from ACS-NSQIP database. Propensity score matching and subgroup analysis were utilized.

Results: In both groups (single/multi-level ACDF), patients operated on by neurosurgeons had longer operation time (133 vs 104 minutes/ 164 vs 138 minutes), shorter total hospital stay (24 vs 41 hours/ 25 vs 46 hours), and lower rates of return to operating room (0.7% vs 2.1%/ 0.6% vs 2.4%), non-home discharge (1.2% vs 4.6%/ 1.0% vs 4.9%), discharge after postoperative day 1 (6.7% vs 11.9%/ 10.1% vs 18.9%), perioperative blood transfusion (0.4% vs 2.1%/ 0.6% vs 3.1%) and sepsis (0.2% vs 0.7%/ % 0.1 vs 0.7%), (p<0.05). In the single-level ACDF group, patients operated on by neurosurgeons had lower readmission (1.9% vs 4.1%) and unplanned intubation rates (0.1% vs 1.1%), (p<0.05). Other outcome measures and mortality rates were similar among the 2 cohorts in both groups.

Conclusion: Our analysis found significant differences in early perioperative outcomes of patients undergoing ACDF by neurosurgeons and orthopedic surgeons. These differences might have significant clinical and cost implications for patients, physicians, program directors, payors and health systems.

3:35 - 3:40 pm

116 Single Position Lateral Lumbar Fusion with Robot-assisted Pedicle Screws: Analysis and Comparison to Prone Screws

Islam Fayed, MD; Alexander X. Tai, MD; Matthew Triano, BS; Anousheh Sayah; Jean-Marc Voyadzis, MD, FAANS; Faheem A. Sandhu, MD, PhD, FAANS

Introduction: Single position lateral lumbar interbody fusion (SP-LLIF) has recently gained significant popularity due to increased operative efficiency, but it remains technically challenging. Robot-assisted percutaneous pedicle screws (RA-PPS) can facilitate screw placement in the lateral position.

Methods: We reviewed prospectively collected data from our first 100 lateral position RA-PPS. We graded accuracy of screws on CT imaging and compared to all prone position RA-PPS placed during the same time period. We analyzed the effect of various demographic and perioperative metrics, as a whole and specifically for lateral position RA-PPS.

Results: We placed 99 lateral position RA-PPS in the first 18 consecutive SP-LLIF cases with postoperative CT imaging using the ExcelsiusGPS robotic platform, which we compared to 346 prone position RA-PPS in the first consecutive 64 cases during the same time period. All screws were placed at L1 to S1. Overall, the lateral group had 14 breaches (14.1%), and the prone group had 25 breaches (7.2%) (p=0.032). When looking at breaches greater than 2mm (grade C or worse), the lateral group had five breaches (5.1%), and the prone group had four breaches (1.2%) (p=0.015). Operative level had an effect of breach rate, with breach rates (grade C or worse) of 7.1% at L3 and 2.8% at L4. Within the lateral group, multivariate regression analysis demonstrated that BMI affected accuracy, but the side positioned up or down did not.

Conclusion: RA-PPS can aid in the feasibility of SP-LLIF. Spine surgeons should be cautious and selective with this technique given the decreased accuracy in the lateral position, particularly in more obese patients. Further studies should compare SP-LLIF techniques in the prone and lateral positions.

3:45 - 3:50 pm

117 The Effects of Connexin Inhibitors on the Outcomes of a Porcine Spinal Cord Injury Model

Khaled Alok, MD; Ibrahim Omeis; Wassim Baassiri; Charbel Moussalem; Mohamad Nabih El Houshiemy; Shadi Bsat; Safwan Alomari

Introduction: Connexin inhibition has demonstrated promising results in rodents spinal cord injury models (SCI) as a neuroprotective strategy that improves SCI outcomes. However, it has not been tested in a larger animal yet, a necessary step before conducting a human clinical trial.

Methods: SCI was induced using a compression/contusion weight drop model in three groups of pigs with 2 animals per group. Group A: sham, Group B: Nonselective gap junctions blocker (Carbenoxolone) treated, Group C: Connexin-43 memetic peptide (Gap26) treated. The medication was delivered intrathecally at the time of injury. The locomotor development of the animals was assessed over 11 weeks. After which the animals were euthanized and their spinal cords were harvested for histological and immunofluorescence assessment.

Results: In terms of locomotion recovery, Groups B and C regained the stepping ability in their hind limbs, whereas the control group did not. Second, the histological damage was limited in Gap 26-treated group (C). Third, groups B and C exhibited a decreased level of astrocytes activation at the injury site. Finally, PGE2 serum levels remained low in the two treated groups.

Conclusion: We translated the positive neuroprotective effect of a connexin-43 mimetic peptide and gap junction blockers in a porcine SCI model. This study provides further evidence supporting the potential role of these agents in improving SCI outcome.

3:55 - 4:00 pm 118 Surgical Timing of TLICS 4 Fractures Impacts Long-term Pain Outcomes

Daryl Fields; Stephanie Casillo; Xiaoran Zhang, MD; Nima Alan, MD; Nitin Agarwal, MD; Peter C. Gerszten, MD, MPH, FAANS; Adam S. Kanter, MD, FAANS; David Hamilton; David O. Okonkwo, MD, PhD, FAANS

Introduction: Thoracolumbar injury classification and severity (TLICS) guides early clinical management of thoracolumbar spinal fractures. TLICS 4 fractures represent a grey zone without clear directive for surgical versus non-surgical management. While severe back pain is a common indication for early surgery, it is not considered within the TLICS classification. To date, there has been limited exploration into how management decisions influence pain outcomes for neurologically intact patients with TLICS 4 fractures.

Methods: A retrospective review of spine trauma patients from January 1, 2010 to January 1, 2019 was performed. Inclusion criteria were neurologically intact patients with TLICS 4 fractures who were prescribed opioids for pain management. Patients with pre-existing spinal fractures, confounding pain from non-spinal injuries, or recent (within 6 months of injury) opioid pain prescriptions were excluded. Opioid and non-opioid pain medication use was determined through Prescription Drug Monitoring Program (PDMP) records and inpatient records. Long-term outcomes were based on clinic notes, pharmacy records, EHR and PDMP.

Results: Fifty-nine patients from the study period were identified. Neurologically intact patients presenting with severe back pain and TLICS 4 fractures had approximately a 50% chance of developing chronic pain, defined as persistent pain medication use or an inability to perform activities of daily living 6 months following injury. Patients who received early surgical intervention (< 1 week post injury) were less likely to develop chronic pain (odds ratio = 0.26) with fewer patients reporting disability (p < 0.01) or opioid medication use (p < 0.0001) when compared to patients undergoing delayed surgery (> 1 week after injury; odds ratio = 1.79) or no surgery (odds ratio = 1.42).

Conclusion: For neurologically intact patients with severe back pain and TLICS 4 fractures, early surgery improved pain control at 1 year post-injury when compared to delayed surgery and non-surgical management. These data support early surgical intervention for TLICS 4 fractures with severe back pain. Further work is needed to clarify if severe pain, independent of TLICS score, warrants early surgery.

4:05 - 4:10 pm

119 Rate of Pseudarthrosis Following Anterior Cervical Discectomy and Fusion using Allograft Cellular Bone Matrix

Timothy Y. Wang, MD; Stephen M. Bergin; Christine Park, BA; Shashank Rajkumar; C. Rory Goodwin, MD, PhD; Isaac O. Karikari, MD, FAANS; Muhammad M. Abd-El-Barr, MD PhD; Christopher I. Shaffrey MD, FAANS; Chester Yarbrough, MD; Khoi D. Than MD, FAANS

Introduction: Usage of osteobiologics is becoming increasingly common for spinal fusion procedures, but the efficacy of certain products is unclear.

Methods: The medical records across three medical centers and 12 spine surgeons were retrospectively queried for patients undergoing single-level ACDF utilizing Osteocel. Pseudarthrosis was determined based on computed tomography (CT) or x-rays of the cervical spine. Patients were determined to have radiographic pseudarthrosis if they met any of the following criteria: 1) lack of bridging bone on CT obtained >300 days postoperatively, 2) evidence of instrumentation failure, or 3) motion across index level as seen on flexion/extension cervical spine x-rays. Univariate and multivariate analyses were then performed to identify independent preoperative or perioperative predictors of pseudarthrosis in this population.

Results: A total of 326 patients met inclusion criteria. 43 (13.2%) patients met criteria for pseudarthrosis, of which 15 underwent revision surgery (34.9%). Age (54.1 vs 53.8 years), sex (34.9% vs 47.4% male), race, prior cervical spine surgery (37.2% vs 33.6%), tobacco abuse (16.3% vs 14.5%), chronic kidney disease (2.3% vs 2.8%), and diabetes (18.6% vs 14.5%) were not significantly different between patients with or without pseudarthrosis, respectively (p>0.05). Presence of osteopenia or osteoporosis (16.3% vs 3.5%) was associated with pseudarthrosis (p<0.001). Implant-type was also significantly associated with pseudarthrosis, with a 16.4% rate of pseudarthrosis for patients with polyetherethereketone (PEEK) implants versus 8.4% for patients with allograft implant (p=0.04). Average length of follow-up was 27.6 and 23.8 months for patients with and without pseudarthrosis, respectively. Multivariate analysis demonstrated osteopenia or osteoporosis (OR: 4.97, 95% CI [1.51-16.4], p<0.01) and usage of PEEK implant (OR: 2.24, 95% CI [1.04-4.83], p=0.04) as independent predictors of pseudarthrosis.

Conclusion: The usage of Osteocel in single-level ACDF is associated with a higher rate of pseudarthrosis compared to the literature-reported fusion rates for alternative osteobiologics. This is especially true when Osteocel is combined with a PEEK implant.

4:15 - 4:20 pm

120 Carbon Ion Radiotherapy for Sacral Chordomas: An Institutional/National Comparison of Outcomes with Surgery and RT

Yagiz U. Yolcu, MD; Jad Zreik, BS; Waseem Wahood; Atiq Bhatti; Mohamad Bydon, MD, FAANS; Matthew Houdek; Peter Rose; Anita Mahajan, MD; Ivy Petersen; Michael Haddock; Safia Ahmed; Nadia Laack, MD; Krishan Jethwa; Elizabeth Jeans; Reiko Imai; Shigeru Yamada; Robert L. Foote, MD

Introduction: Chordomas are rare tumors that arise from notochordal remnants. Although maximal safe resection is preferred initial management, radiotherapy is used in the adjuvant setting or primarily when surgical resection is not preferred. Carbon ion radiotherapy (CIRT), as an alternative to surgery alone or conventional radiotherapy modalities, has shown promising results to date.

Methods: Following IRB approval, baseline and tumor-related characteristics from two institutional cohorts were collected for contemporary patients diagnosed with sacral chordomas. Univariable logistic regression was performed to evaluate the association between treatment type and oncologic and toxicity outcomes. Overall survival (OS) and progression-free survival were estimated using the Kaplan-Meier method and compared using the Cox proportional hazards model. The National Cancer Database (NCDB) was also queried for sacral chordoma patients and included in OS analyses. Additionally, a comparison of cost between surgery and CIRT therapy was performed.

Results: A total of 919 patients were included in the study. Comparison of the institutional cohort (en bloc resection) to CIRT showed similar oncologic and toxicity outcomes, despite larger tumors in the CIRT group. The CIRT group experienced lower rates of peripheral motor neuropathy (OR: 0.13 [95% CI 0.04-0.40], p<0.001). In a comparison of NCDB to CIRT, significantly higher overall survival (OS) was found for CIRT when compared to margin-positive surgery without adjuvant radiotherapy (p=0.029) and primary photon radiotherapy alone (p<0.0001). There was no difference in OS between patients treated with CIRT or proton radiotherapy. Mean total procedure and 2-year costs for CIRT are less than surgery.

Conclusion: These findings suggest that CIRT is a safe and effective treatment for older patients with high performance status and sacral chordoma in which surgery in not preferred. Moreover, the use of CIRT might provide additional benefit for patients who undergo margin-positive resection or who are candidates for conventional radiotherapy alone.

Thursday, July 29, 2021 Minimally Invasive/Motion Preservation Abstract Breakout Session

3:15 - 3:17 pm 200 Lordotic vs. non-Lordotic Static Cage in MIS Transforaminal Lumbar Fusion: A Longitudinal Comparative Cohort Study

Michael H. Lawless, DO; Chad F. Claus, DO; Doris Tong; Noah J. Jordan, BS; Amarpal Dosanjh, BS; Connor Hanson; Clifford M. Houseman, DO; Daniel A. Carr, DO

Introduction: Minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) is increasingly used to treat lumbar degenerative pathology. Its effect on sagittal parameters remaining controversial. Static and expandable lordotic interbody devices (cages) were developed to improve segmental and overall lumbar lordosis. The effectiveness of which remains unproven.

Methods: We reviewed consecutive eligible patients who underwent 1-2 level MI-TLIF (7/2017-11/2019) at a single institution by multiple surgeons. We prospectively collected standing X-rays at preoperative, 1-month, and 6-month postoperative; PROs at preoperative, 6-month, and 12-month postoperative. Our primary outcome is lumbar lordosis. Our secondary outcomes include PI–LL mismatch, pelvic tilt, sacral slope, segmental lordosis, anterior/posterior disc height, and cage subsidence; PROs include Visual analog scale (VAS), Oswestry disability index, and Short-Form 12. Using univariate analyses, we compared the two cohorts regarding confounders, radiographic parameters, and proportions of patients reaching minimal clinically important difference (MCID) for PROs. Multivariate analyses modeling postoperative PRO were performed to adjust for confounders. P < 0.007 was considered significant after Bonferroni correction.

Results: One-hundred-twenty-five patients were reviewed. Forty-seven had lordotic and 78 non-lordotic cages. The lordotic cohort was significantly younger than the non-lordotic (55.9 y vs. 60.7 y, p= 0.042). The baseline radiographic parameters were not significantly different between cohorts. At the preoperative-6-month interval, the lordotic cohort had significant improvement in lumbar lordosis versus non-lordotic ($2.95^{\circ} \pm 7.2^{\circ}$ vs. $-0.3^{\circ} \pm 7.1^{\circ}$, p=.024). Both cohorts showed improvement in segmental lordosis, anterior and posterior interspace height, and low subsidence grade with no significant difference between cohorts at all intervals. Overall, 69.1-83.8% of patients achieved MCID in all PROs with no significant difference between cohorts. Multivariate analysis demonstrated that pelvic tilt was independently and significantly associated with inverse risk of postop VAS back (β -0.09, -0.16 - -0.03 95% CI, p = 0.003).

Conclusion: This study demonstrated that static lordotic titanium cages led to significantly greater lumbar lordosis increases at 6-month follow-up than non-lordotic cages. Increasing pelvic tilt was independently associated with significantly less risk with back pain.

3:17 - 3:19 pm 201 Higher Paraspinal Muscle Density Effect on Outcomes after ACDF

Zachariah Pinter; Scott Wagner; Ashley Xiong; Brett Freedman; Benjamin D. Elder, MD, PhD, FAANS; Ahmad Nassr

Introduction: Studies in the lumbar spine suggest a correlation between sarcopenia and worse patient outcomes. To our knowledge, no studies have investigated whether an association exists between fatty degeneration of the cervical paraspinal musculature and cervical disability in the perioperative period.

Methods: We performed a retrospective review of a prospective cohort of patients undergoing 1 to 3 level ACDF at a single institution between the years 2011-2014. We utilized preoperative MRI's to classify patients into Goutalier grades. Patient-reported outcomes including neck disability index (NDI), RAND score, and EQ-5D score were collected and analyzed according to patients' Goutalier grade. We utilized Student's t-test and ANOVA to compare all means between groups. The mid-P exact test was used to compare proportional differences between groups.

Results: We identified 69 patients for inclusion. The cohort was 47.3% male. 29 patients were classified as Goutalier 0-1 (Group 1), 29 were Goutalier 1.5-2 (Group 2), and 11 were Goutalier 2.5-4.0 (Group 3). Determination of Goutalier grade by the two reviewers resulted in 82.8% agreement with correlation coefficient of 0.69 (Pearson, r2), demonstrating moderate interrater reliability. All Goutalier groups experienced significant improvement in all three outcome scores. Average post-operative NDI scores were 25.3 in Group 1, 13.9 in Group 2, and 25.1 in Group 3 (p=0.02). The percentage of patients in each group reporting worse disability after surgery was 17.2%, 3.3% and 9.1%, respectively (p=0.05) No statistically significant difference was seen between groups in postoperative EQ-5D (p=0.07) or RAND scores (p>0.05).

Conclusion: The present study is the first to assess the association between cervical paraspinal muscle Goutalier grade and patient reported outcomes following ACDF. Based upon our study, patients with worse cervical paraspinal degeneration may benefit from improved symptom relief in comparison to patients with a lesser degree of degeneration undergoing ACDF.

3:19 - 3:21 pm 202 Robotic-Assisted Trajectory into Kambin's Triangle during Percutaneous Transforaminal Lumbar Interbody Fusion (percLIF)

Tara Elizabeth Dalton; Dustin James Donnelly, MD, PhD; Timothy Y. Wang, MD; Khoi D. Than, MD, FAANS; Isaac O. Karikari, MD, FAANS; C. Rory Goodwin, MD, PhD; Dhanesh K. Gupta MD; Walter Wiggins; Muhammad M. Abd-El-Barr MD PhD;

Introduction: Minimally invasive spine surgery (MISS) has the potential to advance even further with the use of robot-assisted techniques. While there has been extensive investigation of robot-assisted MISS for pedicle screw placement, there is a lack of literature in the use of the robot for other purposes. Here, we discuss a seven-patient case series of patients receiving robot-assisted placement of an expandable cage via Kambin's triangle during percutaneous lumbar interbody fusion (percLIF).

Methods: From November 2019 to December 2020, patients undergoing robot-assisted percLIF were eligible for enrollment. Baseline health and demographic information were collected. For the discectomy and cage placement, a robot trajectory was planned through Kambin's triangle. The annulus of the intervertebral disc was accessed via an incision 6cm to the right or left of midline by placing a Kirschner wire down a dilator and into the disc space. Once the disc space was accessed, the discectomy and placement of expandable cage was completed using standard percLIF methods. The dimensions of each patient's Kambin's triangle were measured using source CT images with Visage 7 multiplanar reformat (MPR) viewer.

Results: Seven patients (four female) and eight levels with spondylolisthesis were retrospectively reviewed. The mean age was 63 years old. Each patient was treated with a percLIF using the ExcelsiusGPS (Globus Medical, Audubon, PA) robot. Patient 1 and Patient 7 underwent the operation with awake anesthesia. The mean EBL was 75ml and operative times ranged from 163 to 347 minutes. The size of each patient's Kambin's triangle varied within the group (range 51- 84mm2), but all were smaller than the average of 108mm2 reported in the literature. No cases were aborted and all patients were neuro-intact post-operatively with no motor or sensory deficits.

Conclusion: We present a case series of seven patients who underwent percLIF using the novel technique of robot-assisted expandable cage placement via Kambin's triangle. Our success demonstrates the need for future development of innovative robot-assisted techniques in the field of MISS.

3:21 - 3:23 pm

203 Functional Ability Classification based on Kinesiophobia and Demoralization Scores in Degenerative Spine Patients

Ram Haddas; Cezar Sandu; Varun Sambhariya; Domingo Molina; Isador H. Lieberman, MD; Andrew Block

Introduction: Fear avoidance and demoralization can significantly impact outcomes in spine surgery. While scales such as the Tampa Scale for Kinesiophobia (TSK) and Demoralization Scale (DS) assess these factors, interpreting their effect on patient function remains challenging. Understanding this relationship can help identify patients whose altered mechanics may have a significant component of underlying psychologic distress.

Methods: We conducted a prospective cohort study of 405 adult patients with symptomatic spine pathology. Patients were given the TSK and DS questionnaires. Primary gait measures and functional balance were tested with a full body reflective marker set. TSK score of 41 and DS score of 30 were chosen as cutoffs to classify moderate vs severe dysfunction based on literature and statistical analysis.

Results: Higher TSK scores correlated with worse walking speed (p<0.001), longer stride time (p=0.001), decreased stride length (p=0.001) and wider step width (<0.001) during gait as well as increased head sway across planes (p=0.001) during standing balance. Similarly, higher DS scores correlated with worse walking speed (p=0.001), longer stride time (p=0.008), decreased stride length (p=0.048), and increased head sway across planes (p=0.001). When classified by TSK scores > 41, patients with severe fear avoidance had slower walking speed (p<0.001), longer stride time (p=0.001), shorter stride length (p=0.004), increased step width (p<0.001) and increased head sway (p=0.001) compared to lower scoring counterparts. Similarly, patients with severe demoralization (DS > 30) had slower walking speed (p=0.012), longer stride time (p=0.003) compared to lower scoring counterparts.

Conclusion: This study demonstrates that fear avoidance and demoralization directly correlate with worsening gait mechanics and balance. Furthermore, patients with TSK >41 and DS >30 have more severe underlying psychosocial factors that contribute to significantly worse function compared to lower scoring peers. Using these guidelines can help identify and treat patients whose mechanical dysfunction may have a more severe component of psychologic distress.

3:23 - 3:25 pm 204 TLIF using a Novel Minimally Invasive Expandable Interbody Cage: PROs and Radiographic Parameters

Richard G. Fessler, MD, PhD, FAANS; Josha Woodward, MD; Christopher D. Witiw, MD; John P. George Kolcun, MD; Mena G. Kerolus, MD; Brian T. David, PhD; R. David Fessler

Introduction: Low back pain (LBP) represents one of the most common causes of chronic pain and disability in the United State1-3. Although the majority of LBP resolves spontaneously, nearly 10% of patients progress to a chronic state that often requires operative intervention1,2. With the aging American population and associated projected growth in degenerative lumbar disease in this patient population, surgical solutions to improve clinical outcomes and patient satisfaction while mitigating healthcare costs are of increasing interest1. To meet this demand, a multitude of surgical approaches to the lumbar spine, each with a unique set of advantages and limitations have been developed. Herein, we describe the clinical and radiographic outcomes of a novel MIS TLIF cage capable of multidirectional in situ expansion to enhance the axial fusion footprint as well as promote restoration of normal lumbar alignment

Methods: A retrospective analysis of 69 consecutive patients undergoing a 1- or 2-level MIS TLIF using an expandable cage was performed over a 2-year period. Standard MIS operative techniques with pedicle screw fixation were used in all cases. Upright lateral dynamic flexion/extension radiographs were reviewed prior to and at 1-year after surgery. Clinical metrics included Numeric Rating Sacle for back and leg pain, Owestry Disability Index and the SF12 and VR12 physical and mental health surveys. Radiographic parameters included anterior and posterior disc height, neuroforaminal height, spondylolisthesis, segmental lordosis, lumbar lordosis and fusion rate.

Results: 69 patients representing 75 operative levels met study inclusion criteria. Mean patient age at surgery was 63.4±1.2 years, with a female predominance of 51%. Average radiographic and clinical follow-up were 372 and 368 days, respectively. 63 patients (91%) underwent 1-level and 6 patients (7%) underwent 2-level surgery. Significant reduction of NRS scores for back and leg pain were observed from 6.1±0.7 to 2.5±0.3 (p<0.0001) and 4.9±0.6 to 1.9±0.2 (p<0.0001). A similar reduction in ODI from 38.0±4.6 to 20.0±2.3 (p< 0.0001) was noted. Likewise, SF12 and VR12 scores all showed statistically significant improvement from baseline (p<0.001). Mean anterior and posterior disc height improved from 8.7±1.0mm to 13.4±1.5mm (p< 0.0001) and 6.5±0.8mm to 9.6±1.1mm (p<0.0001). Foraminal height improved from 17.6±2.0mm to 1.9±2.5mm (p<0.0001). When present, spondylolisthesis was, on average, reduced from 4.3±0.5mm to 1.9±0.2mm (p<0.0001). Lumbar lordosis improved from 47.8±5.5° to 58.5±6.8° (p=0.2687), no change in segmental lordosis was observed. The overall rate of radiographic fusion was 93.3% at 1-year. A single instance of cage migration requiring operative revision was encountered, no instances of cage subsidence or hardware malfunction were observed.

Conclusion: In this series of MIS TLIFs, use of this novel interbody cage was shown to be safe and effective. Significant improvements in pain and disability were observed. Effective and durable restoration of disc height, foraminal height and reduction of spondylolisthesis were obtained with concurrent gains in lumbar lordosis. Taken together, this device offers excellent clinical and radiographic outcomes through a MIS approach.

3:25 - 3:27 pm

205 A New Bibliometric Index: The Top 100 Most Disruptive Publications in Neurosurgery Journals

Owoicho Adogwa, MD, MPH; Rachyl Shanker; Sai Chilakapati; Palvasha Deme; Syed I. Khalid ; Elizabeth Khusid; James Caruso, MD; Michael DeCuypere; Sandi Lam, MD, MBA; Adan Becerra

Introduction: Numbers of publications and citation count are measures of assessing research productivity widely used in academic medicine. However, absolute number of publications or citations may not capture the significance and impact of research in a scientific field. The disruption score, a measurement of the degree to which a publication disrupts its field by supplanting its cited literature, is a recently published metric proposed to highlight innovation and development.

Methods: The disruption score for a publication ranges between -1 and +1, with -1 representing identification of publications that develop known science and +1 identifying publications that disrupt existing science. The PMIDs from a PubMed query of the eight top neurosurgery journals were merged with a publicly available, published and validated dataset of disruption scores for all papers with PMIDs published between 1954-2014. We ranked the publications by disruption score and selected the top 100 most disruptive articles for descriptive analysis.

Results: We identified 43,809 articles published in Journal of Neurosurgery (n=16,436), Neurosurgery (n=10,949), Acta Neurochirurgica (n=6,222), World Neurosurgery (n=5,835), Journal of Neurosurgery: Spine (n=1,664), Neurosurgical Review (n=1,024), Journal of Neurosurgery: Pediatrics (n=951), and Neurosurgical Focus (n=728) for analysis. The top 100 most disruptive publications in these journals were classified as more disruptive than 99.9% of all PubMed papers. 1980-1989 was the most disruptive decade in neurosurgery, with 25 of the top 100 disruptive papers published during that period. While citation count is a practical metric, it may fail to capture evidence of change to established practice when used alone.

Conclusion: This study is the first to identify the top 100 most disruptive publications in eight neurosurgery journals published between 1954-2014 utilizing a novel bibliometric index. In an era in which innovation is receiving increasing emphasis, this review describes research that has influenced ensuing publications of the neurosurgical community over the past several decades using the disruption score as a metric.

3:27 - 3:29 pm

206 Intraoperative Monitoring in Lateral Lumbar Interbody Fusion is Not Associated with Improved Patient Outcomes

Jianning Shao, BA; Arbaz Momin; Jonathan J. Rasouli, MD; Jacob Enders, BSE; Derrick Obiri-Yeboah; Edward C. Benzel, MD, FAANS; Michael P. Steinmetz MD, FAANS

Introduction: Lateral lumbar interbody fusion (LLIF) is a relatively new minimally invasive technique with expanding indications and increasing traction since its introduction. While LLIF has been correlated with favorable long-term outcomes and relatively low risks for intraoperative complications, iatrogenic injury resulting in motor and sensory deficits can still occur with this approach. Intraoperative multimodal monitoring (IOM) is often utilized to provide real-time feedback regarding spinal tract and nerve root integrity in an attempt to minimize iatrogenic injury. However, there is no consensus on the efficacy of IOM monitoring in LLIF with respect to postoperative complications and quality of life (QOL).

Methods: All patients who underwent LLIF at our institution from 2010 to present were retrospectively reviewed, and data on patient demographics, operative levels, usage of IOM, specific IOM modalities utilized, short-term (3-months) and long-term (12 months) postoperative complications, along with postoperative quality of life were collected. Specifically, QOL was evaluated in two domains: functional and mental, measured utilizing the modified Oswestry Index (ODI) and Patient Health Questionnaire-9 (PHQ9), respectively. Multivariable regression analyses were performed to identify any independent significant associations between IOM usage and development of postoperative complications and postoperative QOL.

Results: A total of 190 patients were included in the final analysis: 73 (38.4%) male and 117 (61.6%) female, with an average age of 62.7 \pm 12.16 years. 166 patients (87.4%) had IOM guidance. Multivariable logistic regression indicated no significant association between IOM usage and development of either short-term (p=0.91) or long-term complications (p=0.53). Additionally, multivariable linear regression analyses showed no significant association between IOM usage and improvements in postoperative ODI at either 3 (p=0.39) or 12 months (p=0.46). Similarly, no association was identified between IOM usage and postoperative PHQ-9 at either 3 (p=0.42) or 12 months (p=0.37).

Conclusion: While IOM is undoubtedly a useful tool in several complex spine operations, our results do not show a significant association between its usage and improved patient outcomes following LLIF.

3:29 - 3:31 pm

207 Utility of the 5-item Modified Frailty Index for Predicting Adverse Outcomes Following Elective ACDF

Jad Zreik, BS; Mohammed A. Alvi, MD, MS; Yagiz U. Yolcu, MD; Abdul Karim Ghaith, MD; Brett Freedman; Mohamad Bydon, MD, FAANS ;

Introduction: Frailty is an increasingly studied tool for preoperative risk stratification, but its prognostic value for anterior cervical discectomy and fusion (ACDF) patients is unclear.

Methods: The National Surgical Quality Improvement Program was queried from 2016-2018 for patients undergoing elective ACDF for degenerative diseases. Outcomes of interest included 30-day complications, extended length of stay (LOS), non-home discharge, and unplanned readmissions. Unadjusted/adjusted odds ratios were calculated. The discriminatory performance of the 5i-mFI compared with age, American Society of Anesthesiologists (ASA) classification, and body mass index was computed using the area under the receiver operating characteristic curve (AUC).

Results: A total of 23,754 patients were identified. On adjusted analysis, an index of 1 was significantly associated with extended LOS, non-home discharge, and unplanned readmissions (P < 0.001, P = 0.023, P = 0.003, respectively), but not complications (all P > 0.05). An index =2 was significantly associated with each outcome (all P < 0.001). The 5i-mFI was found to have a significantly higher AUC than body mass index for each outcome, a similar AUC compared with ASA classification and age for complications and unplanned readmissions, and a significantly lower AUC than ASA classification and age for extended LOS and non-home discharge.

Conclusion: The 5i-mFI was found to be significantly associated with 30-day adverse outcomes following ACDF but had similar or lesser predictive performance compared with more universally available and easily implemented metrics, such as ASA classification and age.

3:31 - 3:33 pm

208 Safety and Accuracy of Robot-Assisted Placement of Pedicle Screws Compared to Conventional Free-Hand Techniques.

Nida Fatima, MBBS; John H. Shin, MD, FAANS

Introduction: The introduction and integration of robot technology into modern spine surgery provides surgeons with millimeter accuracy for pedicle screw placement. Coupled with computer-based navigation platforms, robot-assisted spine surgery utilizes augmented reality to potentially improve the safety profile of instrumentation.

Methods: We conducted a systematic review of the electronic databases using different MeSH terms from 1980 to 2020. The present study measures pedicle screw accuracy, complication rates, proximal-facet joint violation, intra-operative radiation time, radiation dosage, and length of surgery.

Results: A total of 1,525 patients (7,379 pedicle screws) from 19 studies with 777 patients (51.0% with 3,684 pedicle screws) in the robotic-assisted group were included. Perfect pedicle screw accuracy, as categorized by Gerztbein-Robbin Grade A, was significantly superior with robotic-assisted surgery compared to FH-technique (OR: 1.68, 95%CI:1.20-2.35; p=0.003). Similarly, clinically acceptable pedicle screw accuracy (Grade A+B) was significantly higher with robotic-assisted surgery versus FH-technique (OR: 1.54, 95%CI:1.01-2.37; p=0.05). Furthermore, the complication rates and proximal-facet joint violation were 69% (OR: 0.31, 95%CI:0.20-0.48; p<0.00001) and 92% less likely (OR: 0.08, 95%CI:0.03-0.20; p<0.00001) with robotic-assisted surgery versus FH-group. Robotic-assisted pedicle screw implantation significantly reduced intraoperative radiation time (MD: -5.30,95%CI:-6.83--3.76; p<0.00001) and radiation dosage (MD: -3.70, 95%CI:-4.80--2.60; p<0.00001) compared to the conventional FH-group. However, the length of surgery was significantly higher with robotic-assisted surgery (MD: 22.70, 95%CI:6.57-38.83; p=0.006) compared to the FH-group.

Conclusion: This meta-analysis corroborates the accuracy of robot-assisted pedicle screw placement.

3:33 - 3:35 pm 209 How to Perform, and Bill for, a Spine Specific Neurologic Strength Exam Using Telehealth in the COVID-19 Era

Alexander F. Haddad, BS; John F. Burke, MD; Praveen V. Mummaneni, MD, FAANS; Andrew Kai-Hong Chan, MD; Michael Safaee, MD; John J. Knightly, MD, FAANS; Rory R. Mayer, MD; Brenton H. Pennicooke, MD MS; Anthony M. DiGiorgio, DO, MHA; Philip R. Weinstein, MD, FAANS(L); Aaron J. Clark MD, FAANS; Dean Chou, MD, FAANS; Sanjay S. Dhall, MD, FAANS

Introduction: The use of telemedicine has dramatically increased due to the social distancing measures associated with the COVID-19 pandemic. As a result, many neurosurgeons are now faced with using, and billing for, telemedicine technologies for preoperative evaluations and routine outpatient visits. However, there is little evidence on how to perform a telehealth neurologic examination for a patient who is at home and without the aid of an assistant. Developing an evidence-based standard neurologic exam is crucial to facilitate telemedicine patient care and accurate billing.

Methods: We identified a 12-member panel composed of spinal surgeons, fellows, and senior residents. We created an initial telehealth strength examination protocol based on published data and developed 10 agree/disagree statements summarizing the protocol. A blinded Delphi method was utilized to build consensus for each statement, defined as >80% agreement and no significant disagreement using a two-way binomial test (significance threshold of p<0.05). Any statement that did not meet consensus was edited and iteratively resubmitted to the panel until consensus was achieved. In the final round, the panel was unblinded and the protocol was finalized.

Results: After the first round, 4/10 statements failed to meet consensus (<80% agreement, and p=0.031, 0.031, 0.003, and 0.031 statistical disagreement, respectively). The disagreement pertained to grading of strength in the upper (3/10 statements) and lower extremities (1/10 statement). The amended statements clarified strength grading, achieved consensus (>80% agreement, p>0.05 disagreement), and were used to create the final telehealth strength examination protocol. We also provide billing codes associated with telehealth visits.

Conclusion: The resulting protocol was implemented in our clinic and was used effectively to diagnose neurologic deficits during video telehealth visits. Our protocol should also aid neurosurgical clinics with billing for telemedicine visits by providing a standard telemedicine neurologic examination. Future studies should further validate the specificity and sensitivity of specific exam maneuvers over a video/audio communication system.

3:35 - 3:37 pm

210 Transforaminal Lumbar Interbody Fusion with a Novel Minimally Invasive Expandable Interbody Cage

Josha Woodward, MD; Hani Malone, MD; Christopher D. Witiw, MD; Lacin Koro; John Paul G. Kolcun MD; Shahjehan Ahmad; Brian T. David, PhD; Richard D. Fessler, MD; Richard G. Fessler, MD, PhD, FAANS

Introduction: Chronic lumbar back pain represents the most common indication for lumbar surgery in the United States. In response to the increasing incidence of degenerative pathology and growing number of operative candidates, MIS approaches to the lumbar spine continue to evolve. In an effort to enhance axial fusion surface area without compromise to fusion rates, in situ expandable TLIF cages have gained popularity

Methods: A retrospective analysis of 69 consecutive patients undergoing a 1- or 2-level MIS TLIF for degenerative pathology with an expandable cage was performed over a 2-year period. Standard MIS operative techniques with pedicle screw fixation were used in all cases. Preoperative and 1-year post surgery radiographic parameters were assessed with upright lateral flexion/extension xrays and clinical outcomes with serial confidential surveys.

Results: 69 patients representing 75 operative levels were included. 63 patients (91%) underwent 1-level and 6 patients (7%) underwent 2-level surgery. Significant reduction of NRS back and leg pain scores and ODI were observed from 6.1 ± 0.7 to 2.5 ± 0.3 and 4.9 ± 0.6 to 1.9 ± 0.2 and 38.0 ± 4.6 to 20.0 ± 2.3 (all p< 0.0001), respectively. Likewise, SF12 and VR12 scores showed significant improvement from baseline (p<0.001). Mean anterior and posterior disc height improved from 8.7 ± 1.0 mm to 13.4 ± 1.5 mm and 6.5 ± 0.8 mm to 9.6 ± 1.1 mm (both p<0.0001). Foraminal height improved from 17.6 ± 2.0 mm to 21.9 ± 2.5 mm (p<0.0001). When present, mean spondylolisthesis was, on average, reduced from 4.3 ± 0.5 mm to 1.9 ± 0.2 mm (p<0.0001). Lumbar lordosis improved from $47.8\pm5.5^{\circ}$ to $58.5\pm6.8^{\circ}$ (p=0.2687), no change in segmental lordosis was observed. The overall rate of radiographic fusion was 93.3% at 1-year. A single instance of cage migration at 3 months required operative revision.

Conclusion: In this series of MIS TLIFs, use of this novel interbody cage was shown to be safe and effective. Significant improvements in pain and disability were observed. Effective and durable restoration of disc height, foraminal height and reduction of spondylolisthesis were obtained with concurrent gains in lumbar lordosis. Taken together, this device offers excellent clinical and radiographic outcomes through a MIS approach.

3:37 - 3:39 pm

211 Anterior Lumbar Interbody Fusion: Single Institutional Review of Complications

Armin Mortazavi; Ehsan Dowlati, MD; William Mualem; Hepzibha Alexander, MD; Juliana Rotter, MD; Jean-Marc Voyadzis, MD, FAANS

Introduction: With an increasing number of patients undergoing single and multi-level anterior lumbar interbody fusion (ALIF), it is critical to understand associated complications. Approach-related injuries remain the predominant complication, though minimally invasive techniques may mitigate these risks. The rate of these reported complications and associated risk factors, such as patient and surgical factors, however, vary widely across studies.

Methods: A single-center retrospective review of prospectively collected data of 362 patients who underwent ALIF between 2017 and 2019 was performed. Outcomes were characterized categorically with either ALIF only or ALIF with posterior instrumentation. Subgroup analysis of surgical complications of "No Complications," "Minor Complications," and "Major Complications" were performed either by nonparametric One-Way ANOVA or Chi-square tests.

Results: Within the entire cohort, 91 (25.1%) experienced at least one complication. Within the ALIF only group, patients who experienced any complication were of higher age (p=0.0001), higher Physical ASA status (p<0.0001), and greater BMI (p=0.0477). Those who experienced complications had a longer length of stay (LOS) (p<0.0001) and were less likely to return to home without PT or rehabilitation following surgery (p<0.0001). Additionally, those with complications were more likely to undergo readmission (p<0.0001), experience hardware failure (p=0.0084), and return to the operating room (ROR) (p=0.0002). Within the ALIF with posterior instrumentation group, complications in this cohort were associated with greater ASA classification (p=0.0171) as well as DM (p<0.0001). Patients who experienced complications in this cohort had greater LOS (p<0.0001), require more intensive care and rehabilitation (p=0.0001), more likely to be readmitted (p<0.0001), and more likely to return to the OR (p<0.0001).

Conclusion: ALIF is increasing in popularity in the treatment of pathologies of the lumbosacral spine and is widely applicable. Our study reveals variables associated with complications, most strikingly, age of the patient and ASA classification, which resulted in greater length of stay, higher readmission rates, and disposition to higher skilled facilities. Patients more likely to experience complications should be counseled and close monitoring postoperatively.

3:39 - 3:41 pm 212 The Minimally Invasive Interbody Selection Algorithm for Spinal Deformity

Praveen V. Mummaneni, MD, FAANS; Ibrahim Hussain, MD; Christopher I. Shaffrey, MD, FAANS; Robert Eastlack, MD; Gregory M. Mundis; Juan S. Uribe, MD, FAANS; Richard G. Fessler, MD, PhD, FAANS; Paul Park, MD, FAANS; Leslie Robinson, MD, PharmD, MBA; Joshua Rivera; Dean Chou, MD, FAANS; Adam S. Kanter, MD, FAANS; David O. Okonkwo, MD, PhD, FAANS; Pierce D. Nunley, MD; Michael Y. Wang MD, FAANS; Frank La Marca, MD, FAANS; Khoi D. Than MD, FAANS ; Kai-Ming G. Fu, MD, PhD, FAANS

Introduction: Minimally invasive surgery (MIS) for spinal deformity use interbody techniques for correction, indirect decompression, and arthrodesis. Selection criteria for choosing a particular interbody approach is lacking.

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.

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.

3:41 - 3:43 pm

213 Patterns and Impact of EHR- defined Depression Phenotypes in Spine Surgery

Mayur Sharma, MD, MPH; Maxwell Boakye, MD, FAANS; Shawn W. Adams, MD; Thomas Chandler; Dengzhi Wang, MS; Beatrice Ugiliweneza, MSPH; Doniel Drazin, MD, MA

Introduction: Preoperative depression is a risk factor for poor outcomes after spine surgery.

Methods: Using IBM's MarketScan Database, we identified 52,480 patients who underwent spinal fusion. Retained patients were classified into 6 depression phenotype groups based on ICD-9/10 codes and use/nonuse of antidepressant medications: Major Depressive Disorder (MDD), Other depression (OthDep), Antidepressants for Other Psychiatric Condition (PsychRx), Antidepressants for Physical (non-psychiatric) Condition (NoPsychRx), Psychiatric condition only (PsychOnly), No Depression (NoDep). We analyzed baseline demographics, comorbidities, healthcare utilization/payments and chronic opioid use.

Results: Breakdown of groups in our cohort: MDD (15%), OthDep (12%), PsychRx (13%), NonPsychRx (15%), PsychOnly (12%), NoDep (33%). Post-surgery: increased outpatient resource utilization, admissions, medication refills at 1, 2 and 5 years in NoDep, PsychOnly, NonPsychRx, PsychRx, OthDep groups, and highest in MDD. Postoperative opioid usage rates remained unchanged in MDD (44%) and OthDep (36%), reduced in PsychRx (40%), NonPsychRx (31%), PsychOnly (20%), with greatest reduction in NoDep (13%). Reoperation rates: 1-year after index procedure, MDD, OthDep, PsychRx, NonPsychRx, PsychOnly had more reoperations compared to NoDep; same at 2-years and 5-years. In NoDep patients, 45% developed new depressive phenotype post-surgery.

Conclusion: EHR-defined classification allowed us to study in depth the effects of depression in spine surgery. This increased understanding of the interplay of mental health will help providers identify cohorts atrisk for high complication rates, and health care utilization.

3:43 - 3:45 pm

214 Comparison of Complications and 90 Day Readmissions Between Open and MIS Surgery for Adult Spine Deformity

Juan S. Uribe, MD, FAANS; Shashank V. Gandhi, MD; Paul Park, MD, FAANS; Christopher I. Shaffrey, MD, FAANS; Robert Eastlack, MD; Dean Chou, MD, FAANS; Richard D. Fessler, MD; Gregory M. Mundis; Shay Bess, MD; Adam S. Kanter, MD, FAANS; David O. Okonkwo, MD, PhD, FAANS; D. Kojo Hamilton, MD, FAANS; Neel Anand, MD; Michael Y. Wang, MD, FAANS; Khoi D. Than, MD, FAANS; Kai-Ming G. Fu, MD, PhD, FAANS; Frank La Marca, MD, FAANS; Pierce D. Nunley, MD; Virginie Lafage, PhD; Renaud Lafage; Praveen V. Mummaneni, MD, FAANS

Introduction: Surgical management of ASD improves HRQoL. However, these procedures carry 40-86% risk of perioperative complications, resulting in readmissions and increased burden to patients and health systems.

Methods: Assessment of patients who underwent either open or MIS treatment for ASD with inclusion criteria: age>18years, major coronal Cobb=20°, SVA=5cm, PT=25° and/or TK>60°, with 1 year follow up. The open and MIS groups were propensity score matched based on age, BMI, preoperative sagittal and coronal alignment parameters, date of surgery, and previous surgery. The matched cohorts were analyzed for differences in surgical techniques, HRQoL, complications, readmission, revisions, alignment correction, and length of stay.

Results: 260 patients were matched, 130 in each. Operative time was similar (p=0.220). Open had greater EBL (p<0.001), number of levels fused (p<0.001), PCOs (p<0.001), LOS (p=0.001), and ICU admissions (p<0.001). MIS had more interbody fusions (p<0.001) and ACRs (p<0.001). Open had higher major (p=0.028), neurological (p=0.029) and overall (p=0.012) complications. There was a trend toward greater overall readmissions in the open group (19.23% vs 12.31%, p=0.126) but no difference in 90-day-readmissions (p=0.790). There was no difference in revision rates (p=0.118). Both had significant improvements in ODI and SRS-22, with greater appearance (p=0.006) and mental health (p<0.001) in open. Open had greater postop TK (p=0.013) and change in PJA (p<0.001).

Conclusion: For the same preoperative deformity, there were similar 90 day readmissions between open and MIS surgery. However, open surgery is associated with larger constructs, more EBL, LOS, ICU admissions, and complications, achieving similar spinal alignment and overall HRQoL.
3:45 - 3:47 pm

215 Long-Term Analysis of Adjacent Level Pathology in Minimally Invasive Transforaminal Lumbar Interbody Fusion

Mick J. Perez-Cruet, MD, FAANS; Lee Ong Chieng; Wissam M. Elfallal, DO; Eric Mong, MD; Aaron Rapp, MD; Esam Elkhatib

Introduction: Adjacent level pathology can result in less than optimal outcomes and increasing cost of spine care.

Methods: A retrospective analysis of 405 consecutive patients (245 (60.8%) female, 160 (39.2%) male), mean age 64.1 +/- 12.5 years old (22-90 years) after MI-TLIF between November 2011 and March 2017. Variables analyzed included adjacent level pathology requiring reoperation, surgical time, complications, autograft harvested, fusion rate, cost savings, disc and foraminal height restoration, and patient outcomes including visual analogue scale (VAS), Oswestry disability index (ODI) and Short Form 36 version 2 (SF36v2). Pre- and post-operative MRI analysis was conducted and post-operative computer tomography was preformed.

Results: Eight patients (2%) underwent reoperation for adjacent level pathology over the 6 year average follow-up period. The majority of MI-TLIF cases were one-level (n = 369, 91.6%), EBL 98 ml. Operative time averaged 203 +/- 27 minutes, with disc and foraminal height restoration of 41.3%, 37.43% (P = .0001 for each) respectively.Restoration of sagittal allignment in spondylolisthesis was achieved in 86% of patients. No major surgical complications occurred. VAS improved from 6.9 +/- 2.2 pre-operative to 2.3 +/- 1.99 (P = .0001) at one year and 2.8 +/- 1.6 at 5 years (P=.0026).ODI decreased from45.9 +/- 16.4 pre-operative to 21.9 +/- 17.8 (P = .0001) at one year and 22.3 +/- 17.6 (P = .012) at 5 years. The physical component of SF-36 increased from 17.5 +/- 11.9 pre-operative to 58.4 +/- 26.5 (p = 0.17) at one year and 83.3 +/- 10.3 (P=.003) at 5-year follow-up. The emotional component of the SF-36 increased from 43 +/- 4.1 pre-operative to 85.9 +/- 15.4 (P = .08) at one year, and 87.5 +/- 19.5 (P = .03) at five years. A 97% fusion rate was achieved at 6 month follow-up. Post-operative MRI and CT revealed preservation of spinous process, paraspinal muscle anatomy, and complete interbody fusion.

Conclusion: MI-TLIF is an excellent procedure for reducing adjacent level pathology while treating debilitating back pain disorders.

3:47 - 3:49 pm

216 Surgical Treatment of Sacroiliac Joint Pain: Patient-reported Outcomes Through 2-year Follow-up

Louis H. Rappoport, MD; Alex Mohit, MD, PhD, FAANS; Kim Helsper; Torrey J. Shirk, BA

Introduction: Dysfunction in the sacroiliac joint (SIJ) may be often overlooked source of chronic low back pain and subsequently undertreated. Even when diagnosed correctly, conservative treatment must be repeated regularly and may be ineffective for some patients. A more stable and long-lasting surgical solution may be sought by the patient's physician. This report describes the outcomes of patients treated with a screw-type SIJ fusion device at two sites by two surgeons.

Methods: Patient data was collected prospectively at one study site, and retrospectively at the second study site. Both surgeons used the same screw-type SIJ fusion device. Similarly collected data was combined for a total analysis. Patient reported outcomes included a visual analog scale for pain and the Oswestry Disability Index, and these were collected preoperatively, and at 3, 6, 12 and 24 months postoperatively. Changes in these scores were compared using paired samples t-tests.

Results: Average preoperative VAS low back pain scores was 6.8 (\pm 2.3) and average ODI score was 53.4 (\pm 13.5). At 24-month follow-up average VAS low back pain score was 1.6 (\pm 1.6) and average ODI score was 17.7 (\pm 15.6). These improvements from preoperative scores were significant at all follow-up time points.

Conclusion: Significant reductions in patient reported pain and disability by 3 months postoperatively and through 24-month follow-up were found in patients treated with a screw-type system for SIJ fusion in the current study.

3:49 - 3:51 pm 217 Saphenous SSEP Monitoring of Femoral Nerve Health During Prone Transpsoas (PTP) Lateral Lumbar Interbody Fusion (LLIF)

Antoine Tohmeh; Cheri Somers; Kelli Howell

Introduction: Post-op quadriceps weakness is a known challenge of LLIF. To date, attempts at continued monitoring of the plexus after safe transpsoas approach and during subsequent retractor exposure haven't correlated with outcomes.

Methods: Detailed intraoperative notes were captured prospectively in 52 consecutive LLIF-PTP surgeries at a single institution. tEMG was used during the approach; saphSSEP was monitored throughout using a novel system that enables acquisition of difficult signals, and provides real-time actionable results making intra-op intervention possible. Post-op motor/sensory function was correlated with intraoperative findings.

Results: Patients were 62% female, with a mean age 64, and mean BMI 32. PTP was performed at 82 total levels, inclusive of L4-5 in 73%, and fixated via percutaneous pedicle screws (80%) or lateral plate, with direct decompression in 42%. Total OR time averaged 148 minutes. Psoas retraction time averaged 15 minutes/level. Baseline SSEPs were unreliable in 3 due to comorbidities in 2 and anesthesia in 1; one of those resulted in transient quadriceps weakness, fully recovered at 6 weeks. In 25/49 no saphSSEP changes occurred, and none had postoperative femoral nerve deficits (100% true negatives). In 20/27 with saphSSEP changes, responses recovered intraoperatively following intervention (considered presumed positives), with normal postoperative function in all but one with ipsilateral anterior thigh pain and one with delayed quadriceps weakness, improved at 4 months and recovered at 9 months. In the remaining 7/27, saphSSEP changes persisted to close, and resulted in 2 isolated anterior thigh numbness and 2 combined sensory and motor femoral nerve deficits. From these data, the sensitivity of saphSSEP to predict postoperative deficit is 100% (95% CI: 85.8-100.0%), and the specificity is 88% (95% CI: 68.8-97.5%), with a positive predictive value of 89% (95% CI: 73.5-95.9%) and negative predictive value of 100%.

Conclusion: SaphSSEP was reliably monitored in most cases and provided actionable feedback that correlated with postoperative neuromotor expectations and allowed for intervention that may have mitigated complications in others.

3:51 - 3:53 pm

218 The Impact of Erector Spinae Plane Block on Postoperative Opioid Use in Minimally Invasive Lateral Lumbar Spine Fusions.

Clifford Crutcher, MD; Hans Zhang; Hari Mitra; Brian Nevitt; Jeffrey Gadsden; Muhammad M. Abd-El-Barr, MD PhD; Peter M. Grossi, MD

Introduction: Erector spinae plane (ESP) blocks were first described in 2016 for the treatment of thoracic neuropathic pain secondary to rib fractures. Recently, this form of regional anesthesia has started to gain traction in the spine surgery community. Unfortunately, the majority of the data regarding ESP regional block in spine surgery is limited to case reports and small case series.

Methods: We performed a retrospective analysis of 66 consecutive adult patients undergoing 1 -2 level minimally invasive lateral lumbar interbody fusions with percutaneous instrumentation from January 1 2018-December 31, 2020 at a single institution. We collected data for each patient regarding the use of a preoperative ESP block, time spent in PACU, PACU Visual analogue scale (VAS), 24-hour post -operative opioid use, hospital length of stay (LOS), and documented distance ambulated on post-operative day (POD) 1.

Results: The average 24-hour postoperative opioid use in the ESP group was 139 mg oral morphine equivalents (OME) vs 194 mg OME in the non-ESP group (p<.05). The average time spent in the PACU was 1.7 hours vs 1.7 hours (p= .82). The average PACU VAS was 6.3 vs 7.4 (p=.12), The average distance ambulated on POD 1 was 130 vs 129 feet (p=.97). The average LOS was 53.5 vs 54.8 hours (p=0.8).

Conclusion: The use of ESP block anesthesia in minimally invasive lateral lumbar interbody fusion is associated with reduced postoperative opioid consumption in the first 2 hours after surgery. On average, patients receiving ESP anesthesia consumed 55mg OME less than those not undergoing ESP. Larger prospective studies are needed to further evaluate the impact of ESP blocks on perioperative outcomes in minimally invasive spine surgery.

3:53 - 3:55 pm

219 Ambulation within 8 Hours of Elective Cervical And Lumbar Spine Surgeries are Associated With Improved Outcome

Seokchun Lim, MD; Michael Bazydlo, MS; Sameah A. Haider, MD; Mohamed Macki, MD; Travis M. Hamilton, MD; Richard Easton, MD; Ilyas Aleem, MD, Msc, FRCSC; Michelangelo Perez-Cruet; Jason M. Schwalb, MD, FAANS, FACS; Muwaffak Abdulhak, MD, FRCS; Victor W. Chang, MD, FAANS

Introduction: Early postoperative mobilization is a common element in ERAS protocols for spine surgery. The evidence supporting this practice suffers from heterogeneity in methodology, surgical procedures, and patient selection. There has yet to be a large multi-center study evaluating the benefits of ambulation within 8 hours of spine surgery, and whether this is advantageous compared to ambulation within 24 hours of surgery.

Methods: The Michigan Spine Surgery Improvement Collaborative (MSSIC) database was queried to track all elective cervical and lumbar spine surgery for degenerative disease between July 2018 and July 2020. 18,071 cases were divided into three cohorts based on time to ambulate after surgery: <8 hours; 8-24 hours and >24 hours. All cases with cerebrospinal fluid leak were excluded from the study.

Primary outcomes included: any type of complication following surgery; urinary retention; surgical site infection; readmission within 30 days or 90 days; home discharge; patient satisfaction; and percentage of patients who achieved minimum clinically important difference (MCID) of the PROMIS Physical Function 4-item Short Form (PROMIS-PF). General estimated equations were used for multivariate regression to account for baseline differences between cohorts.

Results: Our multivariate analysis demonstrated that <8 hour ambulation was associated with significantly improved outcome when compared to >24 hour ambulation cohort. Patients were less likely to have any complication (aOR 2.07); 30-day (aOR 1.94) or 90-day readmission (aOR 1.62); urinary retention (aOR 2.76); had shorter hospital stay (aOR 1.60); were more likely to be discharged home (aOR 0.18) and had higher proportion of patients achieve PROMIS MCID at 90 days after surgery (aOR 0.89).

When compared to 8-24 hour group patients ambulated <8 hour had lower risk of any complication (aOR 1.28); urinary retention (aOR 1.29); shorter hospital stay (aOR 1.24) and were more likely to be discharged home (aOR 0.54).

Conclusion: <8 hour ambulation after spine surgery is associated with significant improved outcome after elective cervical and lumbar spine surgery, and potentially has greater benefit than ambulation within 24 hours.

3:55 - 3:57 pm

220 Comparison of Single-Position Robot-Assisted Surgery Versus Conventional Minimally Invasive Surgery Following LLIF

Themistocles Protopsaltis, MD; Robert Brady, MD; Jeffrey J. Larson; Richard F. Frisch, MD; Kade Huntsman; Todd Lansford, MD; Chris Maulucci; Gerald Hayward; Jonathan Harris; Jorge Gonzalez; Brandon Bucklen, PhD

Introduction: Lateral lumbar interbody fusion (LLIF) provides indirect decompression of the neural elements and a large surface area for fusion. Posterior fixation may be applied as conventional minimally invasive surgery (CMIS), which requires patients to be repositioned prone to provide access to both pedicles. Conversely, robot-assisted navigation (RAN) of pedicle screws may be utilized from a single position without flipping patients. RAN is theorized to reduce patient surgical time, radiation, and blood loss due to positioning and workflow effects.

Methods: Twelve unembalmed human torsos were implanted with 2 level static LLIF cages, followed by posterior bilateral pedicle screw fixation using either CMIS (n=6) or RAN (n=6). Preoperative computed tomography (CT) RAN workflow utilized CT scans of the specimen taken offsite and transferred to the robotic system during setup. Screw planning was performed using these CT scans, and then was merged with intraoperative fluoroscopy. Surgical times, surgeon radiation exposure, and screw accuracy were measured. Patient flip time from a consecutive patient series was included.

Results: Significant differences in surgical times and radiation dosages were found between groups. Surgical time for preoperative RAN and CMIS was 64.7 min±4.1 min and 123.0 min±13.7 min, respectively. Time per screw for RAN and CMIS workflows was 2.7±0.6 min and 4.3±1.3 min, respectively. RAN resulted in significantly lower total operative time and time per screw in comparison to CMIS (p<0.05). Radiation dosages and times were separated into interbody and posterior fixation procedures, and sorted by imaging workflow. RAN and CMIS radiation dosages during posterior fixation were 0.4±0.2rad and 2.7±1.6, respectively (p<0.05). Screw accuracy was as follows: CMIS resulted in 4 breaches (11% breach rate), while RAN resulted in a single breach (3% breach rate).

Conclusion: Significant differences were found in both surgical time and radiation exposure between CMIS and RAN, with RAN resulting in shorter surgical times and less surgeon radiation exposure than CMIS. Consideration should be given to single-position LLIF procedures that utilize RAN to instrument the spine with bilateral pedicle screws.

3:57 - 3:59 pm

221 Management of Single-level Thoracic Disc Herniation via a Modified Transfacet Approach: A Review of 86 Patients

Samir Kashyap, DO; E.(Lisa) A. Friis, PhD; Andrew Webb; Paul M. Arnold, MD, FAANS, FACS

Introduction: Symptomatic thoracic disc herniation is rare and does not typically resolve with conservative management. The gold standard in surgical management is the transthoracic approach, however, this approach carries significant risk. Posterolateral approaches are less invasive, but no single approach has proven to be more effective than the other. The results are dependent on surgeon experience with the approach, the location and characteristics of the disc herniation, and the health of the patient.

Methods: This was a retrospective review of a prospectively collected database. Eighty-six patients with TDH treated surgically via the modified transfacet approach were reviewed to evaluate for improvement in their pain, Nurick grade, and neurological symptoms for up to 12 months postoperatively. Their estimated blood loss, length of hospital stay, hospital course, and postoperative complications were also assessed.

Results: All attempts at disc resection were successful. Most patients reported improvement in pain, sensory involvement, and strength. Seventy-nine patients had complete resolution of their symptoms while three patients had unchanged symptoms. Three patients experienced mild neurologic worsening postoperatively, but this resolved back to baseline. One patient experienced myelopathy during the postoperative period that resolved with steroid administration. The procedure was well tolerated with minimal complications.

Conclusion: Thoracic disc herniation can be managed surgically through a variety of approaches. The selection of approach is dependent on surgeon experience with an approach, the patient's health, and the location and type of disc. The transfacet approach is safe and efficacious.

3:59 - 4:01 pm

222 Global Coronal Malalignment after MIS ASD Surgery: Multicenter Assessment of 141 Patients with Min 1-Yr Follow-up

Thomas Buell, MD; Vivian Le; Dean Chou, MD, FAANS; Robert Eastlack, MD; Kai-Ming G. Fu, MD, PhD, FAANS; Juan S. Uribe, MD, FAANS; Gregory M. Mundis ; neel anand MD; Pierce D. Nunley MD; David O. Okonkwo MD, PhD, FAANS; Richard G. Fessler MD, PhD, FAANS; Paul Park, MD, FAANS; Michael Y. Wang, MD, FAANS; Adam S. Kanter, MD, FAANS; Christopher I. Shaffrey, MD, FAANS; Praveen V. Mummaneni, MD, FAANS; Khoi D. Than, MD, FAANS; International Spine Study Group

Introduction: Few reports focus on global coronal malalignment (GCM; C7PL-midsacrum=3cm) after minimally invasive surgery (MIS) for adult spinal deformity (ASD).

Methods: Prospective multicenter data was reviewed. After minimum 1-year follow-up, malaligned patients (GCM=3cm) were compared to aligned patients (GCM<3cm).

Results: Of 198 patients, 141 (71.6%) achieved minimum 1-year follow-up and were included (age=68.4±10.5yrs, 68.1% women, BMI=28.8±6.3 kg/m2). Index operative data included: anterior-posterior (82.4%), posterior fused levels (5.3 ± 3.4), decompression (31.2%), number of IBFs (3.2 ± 1.5), type of IBF (50.4% ALIF, 10.4% MIS-TLIF, 80.0% LLIF), operative duration (6.8 ± 3.7 hrs), and EBL (0.5 ± 0.6 L). Overall, 1-year postoperative alignment improved significantly (p<0.05): maximum coronal Cobb 28.6±14.5° to 19.2±12.9°, SVA 6.0±6.2 to 3.7 ± 4.9 cm, PT 23.4±9.8° to 21.6±8.9°, PI-LL 15.2±17.2° to $6.4\pm13.1°$, lumbar lordosis 39.7±20.8° to 48.4±16.6°. HRQL improved significantly (p<0.05): ODI 46.4±14.0 to 26.4±18.1, PCS 29.2±7.0 to 39.9±9.5, SRS22r-Total 2.8±0.6 to 3.5 ± 0.7 . Incidence of baseline GCM was 34.8% (n=49), which was corrected in 15.6% (n=22) or persisted/worsened in 19.1% (n=27). Incidence of iatrogenic GCM was 16.3% (n=23) and 1-year postoperative GCM was 35.5% (n=50).

Of assessed baseline and operative variables, the postoperative GCM group (vs. GCA) was associated with significantly older age, greater CCI, worse baseline deformity (global coronal offset, coronal Cobb, SVA), and longer posterior fusions with proximal extension to the thoracic spine. On multivariable analysis, greater baseline coronal Cobb and SVA were significant predictors of postoperative GCM. Postoperative GCM was not associated with statistically inferior HRQL nor increased rates of other complications.

Conclusion: Like open surgery, thesd results suggest postoperative GCM is also common after MIS ASD treatment, with similar overall incidence at baseline and 1-year postoperatively (~35%). Multivariable analysis identified greater baseline coronal Cobb and SVA as significant predictors of postoperative GCM. In this study, postoperative GCM was not associated with worse clinical outcomes.

4:01 - 4:03 pm 223 Segmental Lordosis Gain: PTP vs. LLIF

Luiz Pimenta; Rodrigo A. Amaral, MD; Gabriel Pokorny; Rafael Moriguchi; Fenando Melo Filho

Introduction: The LLIF is an established surgery procedure in the literature to treat a wide range of spinal pathologies from degenerative to deformity cases. Despite its outstanding results, a recent meta-analysis reported that the mean increase of segmentar lordosis with LLIF varied from 2.9° - 4.0°.

To solve this gap, a new approach to the lateral lumbar interbody fusion was devised. Its principal difference from the standard LLIF relies on positioning the patient in a prone decubitus, leading to an increase in the intradiscal lordosis.

Methods: Retrospective, singlecentric, comparative, and non-randomized study. The inclusion criteria: Patients undergoing single-level prone transpsoas or LLIF surgery; and the exclusion criteria as follows: patients with low-quality X-rays that do not allow adequate measurements and those receiving cages with more than 12° angulation. The following measures were taken: the index level segmentar lordosis (IsL) of the patients in the X-rays, Preop IsL and Postop IsL, Pelvic Incidence (PI), Lumbar Lordosis(LL). The gain of segmental lordosis was set as Preop IsL-Postop IsL (IsL Gain). Moreover, the Pelvic Mismatch was derivated as PI-LL, and three categories for PI were established small(<40°), medium(40-65°), high(> 65°). The patients were divided into two groups, PTP, and LLIF groups. Finally, a propensity-matched score analysis was used to pair the patients by the following variables (PI Category, Pelvic Mismatch, Pathology, and Preoperative Segmental Lordosis).

Results: Fifty-eight levels were included in the LLIF group and Seventeen (17) in the PTP group. LLIF group showed an IsL of 2,6°(±6,2°), while the PTP group presented with an IsL gain of 6,2° (±6,2°) p=0.03. After the propensity-matched score model, 17 levels of LLIF and 17 levels of PTP were included. Now the Preop IsL of the become similar 8,2° (±4,1°) vs. 7,9° (±6,3°), p = 0.77, in this scenario, the LLIF group presented a mean IsL of 1°(±5.3) and the PTP 6,6° (±6,8°), p = 0.02

Conclusion: The PTP technique showed a higher capability to increase the index level segmental lordosis when compared with standard LLIF.

4:03 - 4:05 pm 224 An Analysis of Perioperative Complications of LLIF in Patients with a History of Colonic Inflammatory Disease

Edward M. Barksdale; Mina Huerta; Karrington Seals; Arbaz Momin; Nicholas M. Rabah, BS; Vikram Chakravarthy, MD; Michael P. Steinmetz, MD, FAANS; Thomas E. Mroz, MD

Introduction: Minimal access lateral lumbar interbody fusion (LLIF) carries inherent risks such as injury to the lumbar plexus, abdominal viscera, and vasculature. Mobilization of viscera can become further complicated if there is a history of inflammatory bowel disease or prior abdominal surgeries which may induce retroperitoneal fibrosis and/or scarring, increasing the risk of perioperative complications.

Methods: Patients who underwent interbody fusion via a retroperitoneal approach at our institution from 2008-2019 were retrospectively selected to be included in this study. Patient demographics, date of surgery, IBD/other pathology of the bowel as well as other significant medical comorbidities, and prior abdominal surgeries were all collected. Along with this, operative notes were reviewed to collect the type of surgical approach (Ante-Psoas vs. Trans-Psoas), side of operation (left vs right), use of intraoperative navigation, intraoperative complications, blood loss, length of surgery, length of hospital stay, indication for surgery and surgical levels. Postoperative complications, length of hospital stay and readmissions were determined from clinical notes. Risk factors for perioperative complications were analyzed using multivariable logistic regression.

Results: Our population included 257 patients who underwent spine surgery with a retroperitoneal approach, 37 (14.3%) had a history of bowel disease and 44 (17.1%) had a prior abdominal surgery. A history of bowel disease was significantly associated with perioperative complications (OR 2.00, CI 1.01-3.99, p<.05) while a history of prior abdominal surgery was not significantly associated with perioperative complications (OR 2.00, CI 1.01-3.99, p<.05) while a history of prior abdominal surgery was not significantly associated with perioperative complications (OR 1.40, CI 0.77-2.52 p>.05). Other factors associated with an increased likelihood of perioperative complications were multilevel surgery (OR 1.77, CI 1.01-3.11, p<.05) and ante-psoas surgical approach (OR 2.05, CI 1.01-4.18, p<.05)

Conclusion: To the authors' knowledge, this study is the first to identify that patients undergoing lumbar interbody fusion by a retroperitoneal approach with a history of inflammatory conditions of the bowel are at an increased risk for perioperative complications.

4:05 - 4:07 pm

225 Early Assessment of Cost-effectiveness in the FDA Pivotal Study of the TOPS Motion Preserving Device

Jared Ament, MD; Bart Thaci, MD; Amir A. Vokshoor, MD, FAANS; Kee Kim; J. Patrick Johnson, MD, MS, FACS, FAANS

Introduction: Given the increased attention to functional improvement in spine surgery as it relates to motion preservation, activities of daily living, and cost, it is critical to fully understand the healthcare economic impact of new devices being tested in large FDA randomized controlled trial (RCT). The purpose of this analysis was to comprehensively evaluate the cost-effectiveness of the novel Total Posterior Spine (TOPS[™]) System investigational device compared to the trial control group, standard transforaminal lumbar interbody fusion (TLIF).

Methods: The study patient population was extracted from a multi-center randomized controlled trial (RCT). Analysis was conducted in accordance with the Second Panel on Cost-Effectiveness Health and Medicine. Health-related utility was expressed in quality-adjusted life years (QALYs). The base case analysis utilized SF-36 data from the RCT. Both cost and QALY outcomes were discounted at a yearly rate of 3% to reflect their present value. A cohort Markov model was constructed to analyze peri- and post-operative costs and QALYs for both TOPS and control groups. Cost-effectiveness was calculated as the incremental cost-effectiveness ratio (ICER). Scenario, probabilistic, and threshold sensitivity analyses were conducted to determine model discrimination and calibration.

Results: The primary time horizon used to estimate cost and health utility was 2-years following index surgery. From a health system perspective, assuming a 50:50 split between Medicare and Private payers, the TOPS cohort is cost-effective at 2-years post-operatively (60,084 \$/QALY) compared to control assuming a willingness-to-pay (WTP) threshold of 100,000 \$/QALY. At 6-years and beyond, TOPS becomes dominant, irrespective of payer mix and surgical setting. At willingness-to-pay (WTP) thresholds of 100,000 \$/QALY, 63% of all 5,000 input parameter simulations favor TOPS. While testing thresholds, the most conservative estimate limits the device upcharge versus TLIF to \$9,500.

Conclusion: The novel TOPS device is cost-effective compared to TLIF and becomes the dominant strategy over time. In the emerging and rapidly expanding field of value-based medicine there will be an increased demand for these analyses, ensuring surgeons are empowered to make the best, most sustainable, solutions for their patients and for society.

4:07 - 4:09 pm

226 Minimally Invasive Multiple-Rod Constructs with Robotics Planning in Adult Spinal Deformity Surgery: A Case Series

Vrajesh Shah; Martin H. Pham, MD; Luis D. Diaz-Aguilar; Ronald A. Lehman, MD

Introduction: Multiple rod constructs (MRCs) are often used in adult spinal deformity correction for increased stability and rigidity1. There are currently no reports showing minimally invasive robotic multi-rod long-segment posterior fixation and its technical feasibility through preoperative software planning.

Methods: Data was collected retrospectively from medical records of 6 consecutive patients who underwent minimally invasive multiple-rod constructs with robotics planning by a single surgeon at an academic center between March-August 2020.

Results: A total of 6 patients (4 females, mean age 69.7 years) underwent minimally invasive long-segment (6+) posterior fixation with multiple rods (3+) using the Mazor X Stealth Edition robotics platform. Average follow-up was 9.3 months. All patients underwent oblique lumbar interbody fusion as a first stage, followed by second stage posterior fixation in the same day. The mean number of levels posteriorly instrumented was 8.8. One patient underwent 3 rod fixation (1 iliac, 2 S2AI) and 5 patients underwent quad rod fixation (2 iliac, 2 S2AI). The mean time to secure all rods was 8 minutes 36 seconds. Mean improvement in spinopelvic parameters was -4.9 cm sagittal vertical axis, 18.0° lumbar lordosis, and -10.7° pelvic tilt with an average pelvic incidence of 62.5°. Mean EBL was 200 cc with no blood transfusions, and all but one patient ambulated on postoperative day 1 or 2.

Conclusion: The preoperative software planning required of spinal robotics allows for not just the accurate placement of each pedicle screw in isolation, but the fine-detailing of an entire spine construct design. This concept is demonstrated in this case series where rod placement in a minimally invasive approach depends upon the preoperative design of the whole construct. Spinal robotics brings us into this new era of minimally invasive construct design. To our knowledge, this is the first description of the technical feasibility of multiple-rod constructs in minimally invasive adult spinal deformity surgery.

4:09 - 4:11 pm

227 OLIF vs LLIF: A Comparative Analysis of Postoperative Complications and Quality of Life

Jianning Shao, BA; Arbaz Momin; Jonathan J. Rasouli, MD; Jacob Enders, BSE; Derrick Obiri-Yeboah; Edward C. Benzel, MD, FAANS; Michael P. Steinmetz, MD, FAANS;

Introduction: Oblique lateral lumbar interbody fusion (OLIF) was an approach developed with the aim of alleviating some of the complications associated with a transpsoas approach (LLIF), such as motor and sensory deficits following surgery. Due to the relative recent introduction of both techniques, there is currently no consensus on the association between oblique vs transpsoas surgical approach and postoperative complications and quality of life (QOL).

Methods: All patients who underwent LLIF and OLIF at our institution from 2010 to present were retrospectively reviewed. We collected data on patient demographics, operative levels, operative approach (LLIF vs OLIF), both short-term (3-months) and long-term (12 months) postoperative complications including sensory and motor deficits, and postoperative QOL measures. Specifically, we evaluated both functional and mental QOL utilizing the modified Oswestry Index (ODI) and Patient Health Questionnaire-9 (PHQ9), respectively. Multivariable regression analyses were performed to identify any independent significant associations between surgical approach and development of postoperative complications and postoperative QOL.

Results: A total of 190 patients were included in the final analysis: 73 (38.4%) male and 117 (61.6%) female, with an average age of 62.7 \pm 12.16 years. 161 (84.7%) patients underwent LLIF and 29 (15.3%) patients underwent OLIF. Multivariable logistic regression analyses showed no significant association between oblique vs transpsoas surgical approach and either short-term (p=0.26) or long-term complications (p=0.508). Multivariable linear regression analyses showed significant correlation between oblique vs lateral surgical approach and postoperative ODI at 3 (p=0.48) or 12 months (p=0.87). However, the oblique approach was correlated with a statistically higher PHQ9 score at 3 months (b=3.54, p=0.04), though this effect disappears at 12 months (p=0.41).

Conclusion: Patients who undergo OLIF are at risk for higher degrees of depression at the 3-month postoperative time point, in comparison with LLIF, though this effect is not present at 12 months. There is no significant difference in postoperative complications or functional disability with respect to oblique vs transpsoas surgical approach in our cohort.

4:11 - 4:13 pm 228 Progression to Spinal Instability Requiring Fusion Following Lumbar Decompression Surgery

Jacob Enders, BSE; Nicholas Bank; Ryan McNassor; Precious Oyem; Michael Ryan; Nicholas M. Rabah, BS; Michael P. Steinmetz, MD, FAANS; Thomas E. Mroz, MD

Introduction: Long term complications of decompressive laminectomy may include spinal instability. Patients may experience worsening symptoms that fail to improve or worsen with primary intervention. Few studies have examined the indications for lumbar spine reoperation with a follow-up time of at least five years' post-decompression, and such studies are often limited by small sample sizes.

Methods: All patients who underwent lumbar laminectomy at our institution from 2009 to 2014 were retrospectively reviewed. We collected data on patient demographics, operative levels and approach, preoperative patient comorbidities, postoperative complications including infection and durotomy, and reoperation data including date and type of reoperation. Patients were excluded if they had spinal malignancy or did not have at least one office visit with a spine or internal medicine provider five years following index decompression. A random forest classifier was used to identify associations between preoperative complications, and reoperation.

Results: A total of 929 patients were included in the final analysis: 591 (63.6%) male and 338 (36.4%) female with an average age of 63.5 ± 12.4 years. Of the 258 (27.7%) patients that underwent a reoperation, 121 (46.9%) underwent a fusion. Forty-eight patients of the 258 (18.6%) underwent a fusion for an indication of iatrogenic spondylolisthesis. Forty-two patients of 258 (16.3%) underwent reoperation for persistent foraminal stenosis. The median time to reoperation was 1.8 years (IQR 0.6-4.2). The random forest classifier was 71% accurate in determining reoperation status and showed blood loss, length of index surgery, and BMI were most useful in predicting reoperation.

Conclusion: Roughly one in four patients who have an index laminectomy in our study underwent a reoperation, and of patients who underwent reoperation, about one-fifth underwent a fusion for iatrogenic spondylolisthesis. Factors associated with a higher risk of reoperation by a random forest model were blood loss and length of index surgery, and BMI.

4:13 - 4:15 pm

229 Robotic-Assisted Cervical Pedicle Screw Placement with Computer Navigation: Feasibility Study in a Cadaveric Model

Tim O'Connor, MD; Mary O'Hehir; Lauren Levy; Isador H. Lieberman, MD; Brandon Mariotti; Jennifer Mao, MBA; John Pollina, MD, FAANS; Jeffrey P. Mullin, MD, MBA

Introduction: With robotic advancements and increasing technological innovation, highly accurate instrumentation can be placed more reliably than ever before. Subaxial cervical pedicle screws offer significant pull-out strength compared to lateral mass screws, however there are potential challenges to accurately placing cervical pedicle screws. These challenges include the added complexity due to the smaller diameter of these pedicles, the highly cortical nature of these pedicles, the relative mobility of the cervical spine, and the slim margin for error with the closely surrounding vascular and neural structures.

Methods: Using a combination of robotic guidance and navigation, cervical pedicle screws were placed from C2-C7. In this study, robotic registration method was used. The robot was attached to the bedframe and secured to an explanted cadaveric cervical spine with a single spinous process clamp. Intraoperative navigation was viewed as a necessity to confirm safe and accurate placement of instrumentation given the inherent mobility of the cervical spine and the small and highly cortical cervical pedicle. As a result, a secondary spinous process clamp was placed superiorly on the spinous process of C2, and a navigation array was fixated to this clamp to allow for intraoperative navigation. Two surgeons independently evaluated the accuracy of the cervical pedicle instrumentation using the Gertzbein-Robbins scale.

Results: Cervical pedicle screws were placed from C2-C7 using robotic assistance with computer navigation with 100% grade A accuracy on the Gertzbein-Robbins scale.

Conclusion: Robotic advancements and navigation technology have continued to progress in the last decade. Using a combination of robotic guidance and navigation, cervical pedicle screws were placed from C2-C7 with 100% grade A accuracy on the Gertzbein-Robbins scale, confirmed on postoperative CT imaging. The navigated robotic techniques described here allow for accurate placement of cervical pedicle screws in a cadaveric model. Further studies are needed to document how these techniques can be translated to clinical practice.

4:15 - 4:17 pm 230 Prone transpsoas fusion (PTP) for treatment of adjacent segment disease: A multicenter case series

Timothy Y. Wang, MD; Vikram Mehta, MD; Eric W. Sankey, MD; Khoi D. Than, MD, FAANS ; William R. Taylor, MD; Luiz Pimenta, MD, PhD; John Pollina, MD, FAANS; Muhammad M. Abd-El-Barr, MD, PhD

Introduction: Prone transpsoas fusion (PTP) is a novel minimally invasive technique for lumbar interbody fusion that allows for single-position lateral access interbody surgery and prone posterior instrumentation. This is theorized to be particularly efficacious solution to cases of adjacent segment disease as discectomy and interbody fusion performed from a lateral corridor avoids the scar tissue from previous posterior-only surgery.

Methods: From May 2020 through January 2021, adult patients undergoing prone transpsoas lumbar interbody fusion for treatment of lumbar adjacent segment disease across four hospitals were retrospectively enrolled. Demographic information, comorbid conditions, and operative data were recorded. Radiographic measurements including segmental and global lumbar lordosis, pelvic incidence, pelvic tilt, sacral slope, and sagittal vertical axis were recorded both pre- and immediately post-operatively. Length of stay and the presence of any postoperative complications were also recorded.

Results: Twenty-four patients (29 spinal levels) met criteria for inclusion. Average age was 60.4±10.4 years and average BMI was 31.5±5.0 kg/m2. Levels fused included L1-2 (n=1), L2-3 (n=10), L3-4 (n=12), and L4-5 (n=6). Total operative time was 204.7±83.3 minutes with blood loss of 187.9±211.9mL. The anterior longitudinal ligament was inadvertently released in one patient. Titanium interbody cage heights ranged from 9 to 13mm in height. Two patients suffered pulmonary embolism, and two patients had transient lumbar radiculopathy. All patients were discharged home with an average length of stay of 3±1.3 days. There were no emergency department visits or inpatient admissions within the 30-day postoperative period. Radiographically, lumbar lordosis improved by an average of 10.1±9.0degrees, segmental lordosis by 10.1±13.3 degrees, and sagittal vertical axis by 3.2±3.2cm.

Conclusion: Prone transpsoas lumbar interbody fusion is a novel technique that can address adjacent segment disease following index posterior lumbar fusions. Future work should focus on intermediate and long-term clinical and radiographic outcomes following this approach.

4:17 - 4:19 pm

231 Comparison of Early "Prone Lateral" Experience vs "PTP" Proceduralization: Learnings, Efficiencies, and Peri-op Outcomes

Gene Massey; Antoine Tohmeh; Tyler Smith; Muhammad M. Abd-El-Barr, MD, PhD; Isaac Moss; David G. Schwartz, BS, MD, MBA; Samuel Joseph

Introduction: Recently prone-position lateral interbody fusion has shown feasibility and efficiencies related to single-position surgery. Learnings from early experience led to development of procedure-specific technologies and technique details that differentiate the newly proceduralized "prone transpsoas (PTP)" from prior attempts at "prone lateral" using traditional lateral systems.

Methods: The pre-proceduralization cohort (ProneLat) included the early multi-center clinical experience wherein procedural details and perioperative outcomes were prospectively captured to assess feasibility, efficiencies, and challenges. That experience informed the development of procedure-specific tools reflecting the demands of operating laterally with the patient prone. Following commercialization of these systems and the post-proceduralization technique (PTP), similar perioperative data was collected across an expanded cohort of patients; the results were compared between groups.

Results: The ProneLat and PTP cohorts included 120 patients/176 levels and 65 patients/101 levels, respectively. The number and distribution of levels per patient were not different between groups; procedures spanned from T12-L1 to L4-5, most inclusive of L4-5 (68% vs. 63%, p>0.05). BMI was similar between groups; no procedure was abandoned due to body habitus. The PTP group saw significant time savings in the following: average positioning time decreased by 19 min (p<0.0001); time to target/dock the retractor decreased from 18 to 10 min (p<0.0001); psoas retraction time decreased by 5.6 min (p=0.0019). Initial retractor docking was at the posterior 33% in the ProneLat group vs. 45% in the PTP group (p<0.0001). All of the PTP cases used saphSSEP monitoring; alerts were identified in 39% of cases, prompting interventions including adjusting positioning, closing the retractor, and/or finishing expeditiously. Other intraoperative challenges included inadvertent ALL release in 2 of the ProneLat group, none in the PTP group. Blood loss and length of stay were similar between groups (p>0.05).

Conclusion: The comparison of pre- and post-proceduralization cohorts further identifies the efficiencies gained by the introduction of a procedure-specific systems that have measurably streamlined patient positioning, targeting, exposure, and interbody time requirements, while enabling single-position circumferential fusions. "PTP" has advantages over "prone lateral" procedures performed using systems designed for lateral decubitus LIF.

4:19 - 4:21 pm

232 SpineTrak: The First Randomized Control Trial Using the Apple Watch to Objectively Track Spine Surgical Patients

Christopher Leung; Parastou Fatemi, MD; Ketan Yerneni, BA; Atman Desai; Christy Tompkins-Lane; Corinna Clio Zygourakis, MD

Introduction: Early post-operative mobilization reduces complications and is associated with improved survival, decreased hospitalization, and improved well-being. Current methods for evaluating mobility and outcomes of spine surgery are limited, relying on subjective patient-reported outcome measures (PROMs) that may be influenced by psychiatric comorbidities or chronic pain.

Methods: Eligibility: Adult patients undergoing elective spine surgery at Stanford Hospital. Patients randomized 1:1 to intervention vs control group. Intervention patients receive Apple Watch, download study-specific HIPPA-compliant application to collect all health measures from Apple Watch. Visual reports (showing steps, distance, flights, standing time, pain, and PROMs), are provided to intervention patients and surgeons at each follow-up.

All patients complete PROMs (SF-36, EQ-5D, PROMIS, NDI, ODI, VAS Pain) pre-operatively and at 6 weeks, 3 months, 6 months, and 1 year post-operatively. All patients complete study-specific questionnaire regarding satisfaction and understanding of surgical recovery.

Results: Participants (n=39 enrolled; 20 intervention) have worn their Apple Watch 91.8% of days and for an average 12.5(+/-5.1) hours/day. At their 6-week post-operative visit, 80% patients said it was helpful to see their Apple Watch data. 80% were satisfied with the Apple Watch's use in their care. 80% of surgeons stated the Apple Watch data helped them understand how their patient was doing postoperatively.

Conclusion: Preliminary results of early participants indicate patients are highly compliant with wearing the Apple Watch, and both patients and surgeons have been satisfied with its use in their spine care. Initial analyses do not show a correlation between subjective PROMs and objective measures after spine surgery. This emphasizes the need for a novel metric that combines objective and subjective measures to better track our patients in real-time after spine surgery.

4:21 - 4:23 pm 233 Awake Spine Surgery Reduces Length of Stay and Enhances Recovery in Transforaminal Lumbar Interbody Fusion

Jared Heinze; Holley Spears; Kyle Brena; Ernest E. Braxton, MD

Introduction: Prolonged hospitalization has been cited as a significant driver of costs associated with spine fusion surgery in the United States. Awake surgery protocols have emerged to Enhance Recovery After Surgery (ERAS) and specifically to reduce length of stay. A novel awake spine surgery protocol has been put into place at three healthcare institutions since 2017. The authors sought to assess the efficacy of their awake spine surgery protocol in patients undergoing elective minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF).

Methods: A retrospective observational study of 79 adult participants ages 34-81, who underwent elective, single-level MIS-TLIF surgery between 2017-2021. All surgeries were performed by one senior spinal/neurosurgeon at one of three locations, including two regional hospitals and one Ambulatory Surgical Center (ASC). Outcomes were compared between cases utilizing the awake spine surgery protocol for ERAS and cases where general anesthesia was used. The primary outcome measure was length of stay. Postoperative opioids, opioids prescribed at discharge, and frequency of 30-day readmissions were analyzed as secondary outcomes.

Results: Among 79 adult study participants, 34 (43%) received the awake spine surgery protocol and 45 (57%) received general anesthesia. There was a significant difference in the average length of stay in the awake spine surgery protocol group (1.31 days, SD=0.88 days), compared to the general anesthesia group (1.80 days, SD=1.01 days, [p=0.03, 95% CI; 0.06-0.92]). No difference was found in the amount of postoperative or prescribed opioids upon discharge between groups. Only 3 30-day readmission were identified (awake, n=2; general anesthesia, n=1).

Conclusion: This study suggests that using an awake spine surgery procedure for MIS-TLIF may lead to reduced lengths of stay following surgery. More research is required to understand what other patient factors may allow for further implementation of this protocol to facilitate increased use of outpatient settings for spine fusion, and to assess if awake spine surgery independently improves patient reported outcomes while decreasing healthcare cost.

4:23 - 4:25 pm

234 Navigated Robotic Assistance Improves Pedicle Screw Accuracy in Minimally Invasive Surgery of the Thoracolumbar Spine

Arnold B. Vardiman, MD, FAANS; David Wallace; Neil Crawford; Jessica Riggleman; Samantha Greeley; Charles Ledonio; Grant Jamgochian; Torrey J Shirk BA; Brandon Bucklen, PhD

Introduction: As robotic systems were introduced into the surgical field approximately twenty years ago, they continually need to be verified and improved. Advances in medical imaging and technology have improved pedicle screw placement accuracy especially in the setting of minimally invasive surgical (MIS) procedures.

Methods: A retrospective, Institutional Review Board-exempt review of 354 navigated robot-assisted spine surgery cases was performed. Radiographic evaluation of screw tip and screw tail offset distance and angulation from preoperative plan to actual final placement based on intraoperative computerized tomography (CT) images was analyzed and calculated. Additionally, pedicle screw malposition, reposition, and return to operating room (OR) rates were reviewed. A CT-based Gertzbein and Robbins System (GRS) was used to classify pedicle screw accuracy.

Results: In the 354 cases analyzed, 2023 thoracolumbar pedicle screws were placed. Thirty-one screws (6 patients) did not use from robotic guidance due to surgeon discretion leaving the remaining 1992 to be analyzed. The average age was 66.8 years, and 47% of the patients were male. Average body mass index was 29.25 kg/m2. The average offset from preoperative plan to actual final placement was 1.7±1.3mm from the tip, 1.6±1.0mm from the tail, and 2.0±1.4 degrees of angulation. Based on the GRS CT-based grading, 97.7% (1947/1992) screws were graded A or B, 2.1% (42/1992) screws were graded C, and 0.2% (3/1992) screws were graded D. Complications reported included interbody removal, deep wound infection, and wound vacuum-assisted closure. None were related to robotic guidance or pedicle screws.

Conclusion: This study demonstrated a high level of accuracy (97.7%) in the clinical use of navigated, robot-assisted surgery when placing 1992 pedicle screws.

General Spine Surgery 1/Trauma/Spinal Cord Injury Abstract Breakout Session Saturday, July 31

7:30 - 7:32 am 300 Preop Symptom Duration and PROs after ACDF in Non-myelopathic Patients: Michigan Spine Surgery Improvement Collaborative

Michael H. Lawless, DO; Chad F. Claus, DO; Doris Tong; Connor Hanson; Lucas Garmo; Chenxi Li; Clifford M. Houseman, DO; Peter L. Bono, DO; Boyd F. Richards, DO; Prashant S. Kelkar, DO; Muwaffak Abdulhak MD FRCS; Paul Jin-Young Park, MD; Teck-Mun Soo, MD, FAANS

Introduction: Preoperative symptom duration (PSD) is predictive for patient-reported-outcomes (PRO) in surgeries for lumbar radiculopathy. However, data on PSD and patient-reported-outcomes (PRO) after surgery for cervical radiculopathy are lacking.

Methods: The Michigan Spine Surgery Improvement Collaborative (MSSIC) is a quality improvement collaborative with 26 hospitals. The MSSIC registry was queried between 3/2014-7/2019 for patients who underwent ACDF for cervical spondylosis without myelopathy and PRO (baseline, 90-d, 1-yr). PROs were measured by VAS neck/arm, PROMIS, EQ5D, and NASS patient satisfaction index. Univariate analyses were used to evaluate the proportion of patients reaching minimal clinically important differences (MCID) for PRO by PSD. The PSD was divided into <3 mo, >3 mo-1 yr, >1 yr. Multiple imputation (MI) was used to generate complete predetermined covariate datasets. Multiple logistic regression models were used to estimate the association between PSD and PRO reaching MCID. Bonferroni correction was used. P<0.005 was considered significant.

Results: We included 2,233 patients who underwent ACDF with PSD <3 mo (278, 12.4%), 3 mo-1 yr, (669, 30%), and >1yr (1,286, 57.6%). Patients with PSD >3 mo suffered from a significantly higher rate of anxiety (p = 0.003) and depression (p < 0.001). On univariate analyses of PROs, the proportion of patients achieving MCID progressively decreased with longer PSD at 90-d and 1-yr postoperative for VAS Neck (p = .005/.016), VAS Arm (p = .001/.035), and PROMIS-PF (p = .006/.002); at 1-yr postoperative for EQ-5D (p = .028), and at 90-d for satisfaction (p = .004). On multivariate analyses, there was a significant increased odds of achieving MCID for PSD < 3-month vs >1yr for VAS Neck (OR 0.30, CI 0.14-0.67, p = .003), VAS Arm at (OR 0.25, CI 0.10-0.62, p = .003), and PROMIS-PF (OR 0.24, CI 0.11-0.51, p < .001).

Conclusion: Longer symptom duration (> 3 months) in patients who underwent ACDF for non-myelopathic cervical disease is associated with a worse rate of achieving MCID for multiple PROs. Early surgical intervention for cervical radiculopathy may be associated with improved pain and functional outcomes.

7:32 - 7:34 am 301 Impact of Spinal Cord Injury on Intestinal Microbiome: A Yucatan Mini Pig Study

Mayur Sharma, MD, MPH; Richa Singhal; Jay Ethridge; Caitlin Moorman; Manicka Vadhanam, PhD; Leslie Sherwood; Steven Davison; Shirish Barve, PhD; Maxwell Boakye, MD, FAANS

Introduction: Spinal cord injury (SCI) is associated with severe disturbances of gastrointestinal system. Although, it has been shown that the SCI induces profound changes in gut microbiomes in rodents, the impact of SCI on intestinal microbiomes in the Yucatan minipig (YMP), in an increasingly used large animal model has not been elucidated.

Methods: Following approval by the University of Louisville (UofL) Institutional Animal Care and Use Committee (IACUC), six healthy YMPs underwent thoracic SCI. Genomic bacterial DNA was extracted from fecal samples using MagAttract Power Soil Kit (Qiagen) at baseline and 2-13 weeks post-SCI. The 16S rDNA V4 region is amplified by PCR and sequenced on the MiSeq platform (Illumina). 16S rRNA gene sequences are assigned into Operational Taxonomic Units (OTUs) or phylotypes at a similarity cutoff value of 97% using the UPARSE algorithm. OTUs are then mapped to an optimized version of the SILVA Database containing only the 16S v4 region to determine taxonomies. A custom script constructs an OTU table from the output files generated in the previous two steps, which is then used to calculate alpha-diversity, beta-diversity. Linear discriminate analysis effect size (LEfSe) and nonparametric Kruskal Wallis test with corrections (Dunn's multiple comparisons adjusted p-value or Bayesian q-value) were used.

Results: Our preliminary data showed that SCI leads to a decrease in microbial diversity and initiates perturbations in the microbial composition as early as 2-5 weeks which continues to alter over a period of 10-13 weeks. Compared to baseline, significant decrease in Shannon index (measuring species richness and abundance) was observed at 6-9 weeks. Overall, the alpha diversity indicated that the SCI could decrease the microbial diversity indices that showed a trend for attenuation between 10-13 weeks. Beta diversity was assessed to examine the dissimilarity of the microbial taxa after SCI. This analysis showed that microbial composition is distinct for each animal and within each biological replicate composition is different at baseline, 2-5 weeks, 6-9 weeks and 10-13 week respectively. Taxonomic profiling revealed that phylum Firmicutes, harboring beneficial butyrate producing Blautia, Ruminococcaceae_GQPBa105 and Anaerostipes genera were significantly enriched at baseline and showed a trend for reduction after SCI. At 2-5 weeks following SCI, there was an expansion of Peptococcus and pathobiont Helicobacterand at 10-13 weeks there was an expansion of Parabacteroides.

Conclusion: Although the current sample size limits our ability to identify statistically significant alterations in microbiome, these metagenomic studies highlight impact of SCI on the intestinal microbiome in the early postinjury phase using a large animal model. Increase in sample size and further investigations are necessary to understand the mechanism and clinical implications of these alterations

7:34 - 7:36 am

302 Effect of Improvement in mJOA Scores on Patient Satisfaction after Surgery for CSM: An Analysis of the QOD

Jesna SM Sublett, MD; Anthony L. Asher, MD, FAANS, FACS; Erica F. Bisson, MD, FAANS; Mohamad Bydon, MD, FAANS ; Kai-Ming G. Fu, MD, PhD, FAANS; John J. Knightly, MD, FAANS; Praveen V. Mummaneni, MD, FAANS; Paul Park, MD, FAANS; Eric A. Potts, MD, FAANS; Mark E. Shaffrey, MD, FAANS; Khoi D. Than, MD, FAANS ; Luis M. Tumialán, MD; Cheerag D. Upadhyaya, MD; Michael Y. Wang, MD, FAANS; Kevin T. Foley MD, FAANS

Introduction: To date, few studies exist that evaluate the association between mJOA scores and patient satisfaction following surgery for cervical spondylotic myelopathy (CSM).

Methods: The Quality Outcomes Database was queried for all patients enrolled between 2016 and 2018 who underwent elective surgery for CSM. Correlation between change in mJOA score and patient satisfaction was evaluated using univariate and multivariable proportional odds logistic regression analysis. Patient satisfaction was analyzed as an ordinal variable (NASS score 1-4). Improvement in mJOA was analyzed both as a continuous variable and as a binary outcome (stable or improved vs worsened score) with similar results.

Results: Of 1151 patients, 958 patients had complete 3 month data while 819 had complete 12 month data. Mean baseline mJOA was 12, with an average improvement of 1.91 (+/- 2.67) points 3 months after surgery and 1.74 (+/- 2.88) points 12 months after surgery. Although mJOA scores did not significantly change from 3 to 12 months (mean decrease: 0.112 points, 95% CI: -0.270 to 0.046, p-value=0.1643), patient satisfaction (NASS score 1-2) decreased in the same time period (binary satisfaction 87% and 84.2% respectively, p<0.00001). Univariate analysis showed a positive correlation between improvement in mJOA score and higher patient satisfaction at both 3 and 12 months after surgery (p<0.001). Multivariate analysis showed that improvement in mJOA correlates strongly with satisfaction at 3 (OR:1.097, 95% CI: 1.007 to 1.195, p-value=0.0333) and 12 months after surgery (OR:1.151, 95% CI: 1.054 to 1.257, p-value=0.0017), independently from baseline mJOA, other patient-reported outcomes, anxiety, depression, BMI, age, gender, race, education, unemployment, type of insurance, ASA grade and surgical approach.

Conclusion: Improvement in mJOA scores after surgery for CSM is independently associated with higher patient satisfaction. Although no single method provides a perfect measurement of quality of spine surgery, patient satisfaction may be used in conjunction with change in mJOA to assess the quality of spine surgery for CSM from a patient perspective.

7:36 - 7:38 am

303 Alignment and Junctional Failure in Posterior Cervical Fusion: A Multicenter Comparison of Two Surgical Approaches

Zachariah Pinter; Brian A. Karamian, MD; Jad Bou Monsef; Jennifer Mao; Ashley Xiong; Rachel L. Honig; Bradford L. Currier, MD; Ahmad Nassr; Brett Freedman; Mohamad Bydon, MD, FAANS ; Benjamin D. Elder, MD, PhD, FAANS; David Kaye; Chris Kepler; Gregory Schroeder; Alex Vaccaro; Scott Wagner; Arjun Sebastian MD

Introduction: PCF is successfully used to treat cervical spondylotic myelopathy, multilevel cervical stenosis, and cervical deformity. However, limited evidence exists regarding the appropriate level of proximal and distal extension of PCF constructs. Further investigation is required to understand the effects of construct endpoint on fusion rate, junctional failure, and sagittal deformity correction.

Methods: A multicenter retrospective cohort study of patients who underwent PCF between 2012 and 2020 was performed. Surgical and radiographic outcomes were compared between those who had C3-T1 or C2-T2 constructs.

Results: A total of 155 patients were included in the study (C2-T2: 106 patients, C3-T1: 49 patients). There were no significant differences in demographics or preoperative symptoms between cohorts. Fusion rates were significantly higher in the C2-T2 (93%) than the C3-T1 (80%, p=0.040) cohort. When comparing the C2-T2 to the C3-T1 cohort, the C3-T1 cohort had a significantly greater rate of proximal junctional failure (2% vs. 10%, p=0.006), distal junctional failure (1% vs. 20%, p<0.001) and distal screw loosening (4% vs. 15%, p=0.02). Although Δ C2-7 Sagittal vertical axis increased significantly in both cohorts (C2-T2: 6.2°, p=0.04; C3-T1: 8.4°, p<0.001), correction did not significantly differ between groups (p=0.32). The C3-T1 cohort had a significantly greater increase in Δ C2 Slope (8.0° vs 3.1°, p=0.03) and Δ C0-C2 Cobb angle (6.4° vs 1.2°, p=0.04).

Conclusion: In patients undergoing PCF, a C2-T2 construct demonstrated lower rates of pseudarthrosis, DJF, PJF, and compensatory upper cervical hyperextension compared to a C3-T1 construct.

7:38 - 7:40 am

304 The Use Of Vancomycin Powder To Prevent Surgical Site Infections In Lumbar Spine Surgery: An Institutional Experience

Ahmed Albayar, MD; Rachel Blue, MD; Rachel Welch; Jang W. Yoon, MD, MS; Ali Ozturk, MD; William C. Welch, MD, FAANS, FACS

Introduction: The use of vancomycin powder in spine surgery has become a wide-spread practice, particularly after multiple reports confirming its efficacy to decrease the rates of surgical site infections (SSIs). However, other studies have reported an associated increase in vancomycin-resistant, gram-negative, and polymicrobial SSIs. Additionally, few animal and in-vitro studies reported inhibitory changes in dural fibroblasts and osteoblast activity when exposed to high vancomycin concentration.

Methods: The electronic health records of patients who underwent lumbar spine decompression ± fusion from January 2017- December 2019 were reviewed. Further, the intraoperative use of vancomycin powder was determined, and cases were categorized into "Vancomycin" and "No Vancomycin" groups. Demographic data, preoperative medical and surgical history, operative details, and postoperative complications were identified. Pearson Chi-square test and independent-sample t-test were used to determine statistically significant differences between the two groups. Statistical findings were deemed significant when P<0.05.

Results: A total of 1,436 (mean age: 65.4 ± 12.5 years, 54.4% females) patients were included in the study. This cohort was divided into vancomycin group (n=775, 54%) and no vancomycin group (n=661, 46%). There were no significant differences between the two groups in age, Body mass index (BMI), length of stay (LOS), blood loss, or operative time. There was no significant difference in the total SSIs rate (21 (2.7%) vs. 17 (2.6%)), gram-positive infections (11 (50%) vs. 11 (64.7%)), staph. aureus infections (7 (31.8%) vs. 5 (29.4%)) and gram-negative (3 (13.6%) vs. 1 (5.9%)). Of note, 13 (8 (36.4%) vs. 5 (29.4%)) patients were diagnosed with SSI but did not undergo wound culture, or records were unavailable.

Conclusion: In contrast to the general belief, our institution's experience shows no additional prevention of SSIs with the application of vancomycin powder intraoperatively. Additionally, vancomycin did not significantly shift the rates of gram-positive or negative infections.

7:40 - 7:42 am

305 Radiographic Comparison of Lordotic and Hyperlordotic Implants in L5-S1 Anterior Lumbar Interbody Fusion

Samuel H. Farber, MD; Jake Godzik, MD, MSc; James Zhou, MD; Corey T. Walker, MD; Kaveh Khajavi, MD; Jay D. Turner, MD, PhD, FAANS; Juan S. Uribe, MD, FAANS

Introduction: Anterior lumbar interbody fusion is used at the lumbosacral junction to provide arthrodesis and provide restoration of lumbar lordosis. With the advent of hyperlordotic ALIF implants, there are now several options which may be employed to obtain the desired lordosis.

Methods: All patients undergoing L5-S1 ALIF over a 4-year interval were included. Patients <18 years or those with any posterior decompression or osteotomy were excluded. ALIF implants in the lordotic group had 8 and 12 degrees of inherent lordosis, while those in the hyperlordotic group had 20 or 30 degrees of lordosis. Upright standing radiographs were used to determine all radiographic parameters. A separate analysis was performed for patients who underwent single segment fixation at L5-S1 and for the overall cohort.

Results: A total of 204 patients were included (n =93 hyperlordotic, n =111 lordotic). Single segment ALIF at L5-S1 was performed in 74 patients (n =27 hyperlordotic, n =47 lordotic). The average age was 61.9 (12.3) years and 58.3% (n= 119) were females. The average number of total segments fused was 3.2 (2.6). Overall, 66.7% (n=136) of patients had supine surgery and 33.3% (n=68) had lateral surgery. Supine positioning was more common in the hyperlordotic group (83.9% vs. 52.3%), p < 0.0001.

Adjusting for differences in positioning, the change in lumbar lordosis was greater for hyperlordotic versus lordotic implants (3.6° [7.5] vs. 0.4° [7.5], p= 0.048) in patients with single level fusion. For patients receiving hyper-lordotic versus lordotic implants, changes were also significantly greater for segmental lordosis (12.4° [7.5°] vs. 8.4° [4.9°], p= 0.03) and disc space lordosis (15.3° [5.4°] vs. 9.3° [5.8°], p<0.001) after single-level fusion at L5-S1. The change in disc space height was similar for these 2 groups (9.0mm [3.9] vs. 7.8mm [2.8], p= 0.233).

Conclusion: Hyper-lordotic implants provided a greater degree of overall lumbar lordosis restoration as well as L5-S1 segmental and disc space lordosis restoration than lordotic implants. The change in disc space height was similar. Differences in lateral and supine positioning did not affect these parameters.

7:42 - 7:44 am 306 Segmental Alignment Impacts Adjacent Segment Strain after Single Level Lumbar Fusion: A Cadaveric Study

Bernardo De Andrada, MD; Piyanat Wangsawatwong; Anna Sawa; Jennifer Lehrman; Luke O'Neill; Jakub Godzik; Samuel H. Farber, MD; Juan S. Uribe, MD, FAANS; Brian Kelly; Jay D. Turner, MD, PhD, FAANS

Introduction: Single-level lumbar fusion has been performed for years with little concern over final segmental angle. However, there is mounting evidence that inadequate restoration of segmental lordosis may contribute to adjacent segment degeneration and failure. Very little work has been completed to evaluate the influence of segmental lordosis on adjacent segment biomechanics.

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 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=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.

Conclusion: Segmental angle changes in single level lumbar fusion significantly impacts adjacent segment motion and disc strain in a cadaveric model. These findings may provide a biomechanical basis for failures that are often observed with inadequate restoration of segmental lordosis after lumbar fusion.

7:44 - 7:46:00 AM

307 Predictors of Long-term Outcomes and Survival Following 3-Column Injuries in Patients with Ankylosing Spinal Disorders

Nikita Lakomkin MD; Anthony L. Mikula, MD; Elizabeth Wellings; Zachariah Pinter; Mohammed A. Alvi, MD, MS; Jeffery St. Jeor; Benjamin D. Elder, MD, PhD, FAANS

Introduction: Patients with ankylosing spinal disorders (ASD), including ankylosing spondylitis (AS) and diffuse idiopathic skeletal hyperostosis (DISH), represent a unique population of spine trauma patients with increased risks of perioperative adverse events. However, very few studies have explored long-term functional outcomes and mortality in this group.

Methods: All adult patients with a documented history of AS or DISH who experienced a traumatic 3-column fracture between 2000 and 2020 were identified. Those with at least 2 years of follow-up were included in the analysis. An array of perioperative variables, including demographics, level/location of injury, mechanism of trauma, initial imaging, symptoms, and neurologic exam at presentation were collected. Baseline functional status, including the use of a walker, aide, or other assistance, was obtained for all patients. Operative factors, including time to surgery, approach, and number of fused segments was recorded. The primary outcomes of interest included ambulatory status at long-term follow-up and prolonged survival (= 75th percentile). Bivariate statistics and multivariable logistic regression modeling were employed to identify predictors of independent functional status and long-term survival at least two years following the initial injury.

Results: A total of 43 patients were included in the analysis, with a mean follow-up of 4.7 (+/-) 2.4 years. Of these, 16 (37.2%) died at a mean of 6.7 (+/- 3.4) years following the initial injury. Twenty-one patients (48.8%) experienced a delay of at least one day from the time of their injury to diagnosis. More than one third of patients (37.2%) did not undergo full imaging of the cervical, thoracic, and lumbar spine during their initial evaluation. After controlling for potential known confounders, increased age (OR: 1.12, 95%CI: 1.02-1.23, P=0.013) and the number of days from injury to diagnosis (OR: 1.06, 95%CI: 1.00-1.11, P=0.036) were significantly associated with decreased rates of prolonged survival. Independent functional status prior to the injury was the only significant predictor of good long-term functional status (OR: 21.4, 95%CI: 1.6-281.4, P=0.02).

Conclusion: A significant proportion of patients with ASD may experience delays in diagnosis following traumatic injury, which is significantly predictive of decreased long-term survival. Prompt evaluation and careful selection of appropriate imaging studies may be important in improving outcomes in this high-risk group.

7:46 - 7:48 am **308 Optimal Number of Interbodies and Fusion Length: Impact on Complications**

Juan S. Uribe, MD, FAANS; Shashank V. Gandhi, MD; Paul Park, MD, FAANS; Robert Eastlack, MD; Dean Chou, MD, FAANS; Richard D. Fessler, MD; Gregory M. Mundis ; Adam S. Kanter, MD, FAANS; David O. Okonkwo, MD, PhD, FAANS; D. Kojo Hamilton, MD, FAANS; Neel Anand, MD; Michael Y. Wang, MD, FAANS; Khoi D. Than, MD, FAANS ; Kai-Ming G. Fu, MD, PhD, FAANS; Frank La Marca, MD, FAANS; Pierce D. Nunley, MD; Virginie Lafage, PhD; Praveen V. Mummaneni, MD, FAANS

Introduction: Minimally invasive spinal surgery (MIS) for adult spinal deformity (ASD) has been shown to have reduced complication rates when compared to open techniques. Amongst MIS surgery, there is an inflection point with regards to construct length and number of interbody levels where complication rates increase drastically.

Methods: Assessment of patients who underwent either circumferential MIS treatment for ASD with inclusion criteria: age>18years, major coronal Cobb=20°, SVA=5cm, PT=25° and/or TK>60°, with 1 year follow up. The patients were divided based on length of construct: thoracic to sacrum/pelvis, lumbar only, and lumbar to sacrum/pelvis. Surgical metrics, complications, and reoperation rates were compared.

Results: 159 patients were evaluated. There were significantly higher all-complication rates with increasing construct length 30% lumbar only, 47.1% lumbar-sacrum, and 57.8% thoracic-sacrum (p=0.036). There were no differences in reoperation and major complications (p=0.252). There were increasing minor complication rates: 12.5% lumbar only, 20.6% lumbar-sacrum, and 35.6% thoracic-sacrum (p=0.039). Operative time (p<0.001), blood loss (p<0.001), and length of stay (p<0.001) significantly increased as construct length increased. Multivariate analysis controlling for posterior construct length revealed that number of interbody levels did not impact complication rates.

Conclusion: For patients with ASD undergoing circumferential MIS surgery, the length of posterior construct length increased complication rates without impact of number of interbody levels fused. There is an inflection point as the construct crosses the thoracolumbar junction, suggesting that in select cases there may be a benefit stopping a long construct in the proximal lumbar spine for reduced complication rates.

7:48 - 7:50 am

309 Intra-operative Hypotension Diminishes Functional Recovery in Patients Following Acute Traumatic Spinal Cord Injury

Maclean Cook; Kristopher Patterson; Jason Barber; Vikas O'Reilly-Shah; Arman Dagal; Christine Fong; Hannah Weaver; Rajiv Saigal, MD, PhD, FAANS;

Introduction: Current guidelines recommend providers maintain a mean arterial blood pressure (MAP) between 85 - 90mmHg in patients following spinal cord injury (SCI). However, a paucity of high-quality data exists to support these guidelines in the perioperative period.

Methods: A retrospective cohort analysis was conducted using patients who suffered an acute traumatic SCI that was surgically treated between 2017-2019 at a single high-volume level I trauma center. Patients were excluded if, there was >48 hours from injury to surgery, age <16 years, incomplete ASIA motor exams, and/or incomplete MAP data. MAP measurements were obtained on a minute by minute basis via arterial line measurement during surgery. Intra-operative MAP exposure was characterized using an area-under-the-curve approach. The total bounded area below 85mmHg was calculated over the entire surgical period, then divided by surgery duration to achieve a normalized "hypotension exposure" MAP value. Single variable linear regression was used to examine the relationship of intra-operative MAP with the change in motor score at two time points.

Results: After inclusion criteria were met, n=122 and n=88 patients were identified with complete motor exams at hospital discharge and rehab discharge, respectively. Average duration of surgery was 5.26 hours (SD 1.74). Average length of stay was 16 days (SD 16) for hospital and 37 days (SD 41) for rehabilitation. No statistically significant association was found between intra-operative MAP and change in motor score at the earlier time point: hospital discharge. However, an increase of 1mmHg in intra-operative average MAP corresponded to an average motor score increase of 0.94 points (p=.022; 95% CI = 0.14, 1.74) by the second time point: rehab discharge.

Conclusion: Intra-operative MAP correlates with neurologic recovery following SCI at rehab discharge but not at the earlier timepoint of hospital discharge. Particularly, patients with lower and more frequent intra-operative MAP values (<85mmHg) had a significantly smaller overall improvement in ASIA motor score following SCI.

7:50 - 7:52 am

310 Percutaneous Lumbar Interbody Fusion is Associated with Reduced Opioid use When Compared with Minimally Invasive TLIF

Clifford Crutcher, MD; Hari Mitra; Hans Zhang; Peter M. Grossi, MD; Muhammad M. Abd-El-Barr, MD, PhD

Introduction: Percutaneous transforaminal lumbar interbody fusion (percLIF) is gaining increased utilization in the United States. It is widely accepted that minimally invasive and percutaneous approaches to the spine are associated with decreased estimated blood loss, and shorter hospital LOS.

Methods: We performed a multi-surgeon single institution retrospective analysis on consecutive patients undergoing 1 or 2 level percLIF or miTLIF from January 1, 2018- December 31, 2020. We collected data for each patient regarding time spent in PACU, PACU Visual analogue scale (VAS), 24-hour post -operative opioid use, hospital length of stay (LOS), and documented distance ambulated on post-operative day (POD) 1.

Results: There were 37 patients that underwent perLIF and 70 patients that undwerwent miTLIF. The average postoperative 24-hour oral morphine equivalent utilization for percLIF and miTLIF patients was 90 mg and 149 mg respectively (p<0.01). Time spent in PACU, PACU VAS, distance ambulated on POD1, and LOS were similar between the two groups.

Conclusion: Percutaneous LIF was associated with a 40% reduction in 24-hour postoperative oral morphine equivalent utilization. A larger prospective study may be helpful in evaluating differences between these two groups

7:52 - 7:54 am

311 Comparison of Adjustable Lordotic Expandable & Static Lateral Interbody Spacers on Endplate Loading, Lordosis Correction

Ripul R. Panchal, DO; Dhara Amin; May Allall; Jonathan Harris; Brandon Bucklen, PhD

Introduction: For restoration of sagittal alignment, hyperlordotic lateral lumbar interbody fusion spacers are available as expandable or static spacers to maximize lordosis when used with ALL resection. However, angular mismatch between the implant and endplates may play a role in subsidence due to asymmetric loading of the anterior implant edge. The relationship between implant size and their effect on segmental lordosis correction and anterior-posterior endplate loading is poorly understood.

Methods: Fourteen L4–L5 cadaveric segments were used. A 55 lb axial load was applied to L4 to simulate intraoperative loads. Segments were instrumented with bilateral pedicle screws and a sequence of expandable spacers with anterior fixation (n=7) or static spacers (n=7) at varied heights and lordosis matched between spacers (nine constructs per spacer), including (A) three height and lordosis combinations with intact ALL; and (B) six height and lordosis combinations after ALL resection. Segmental lordosis and endplate force maps were collected. An equivalent loading ratio (ELR=anterior load/total load*100%) was calculated.

Results: No significant differences in lordosis were observed between spacers (p>0.752). Prior to ALL resection, the 0° and 20° expandable spacer had a significantly larger ELR than the 9 mm 0° (p=0.001) and 9 mm 10° (p=0.013) static spacer, respectively. Following ALL resection, the 20° expandable at 11.5mm and 17.4mm heights and 30° at 17.8mm and 20.4mm heights had significantly larger ELRs than the 11mm 10°, 13mm 20°, 19mm 25°, and 21mm 25° static spacers (p<0.037). However, the expandable spacers had a significantly larger area of contact with the superior endplate (p=0.011), spreading the load over a larger surface area.

Conclusion: This study suggests that expandable and static spacers result in comparable lordosis correction; however, more consistent endplate loading over a larger spacer-endplate contact area was observed with the expandable spacers.

7:54 - 7:56 am

312 Predicting Adverse Events Following Anterior Cervical Discectomy and Fusion: ACDF Scoring System

Nida Fatima, MBBS; John H. Shin, MD, FAANS

Introduction: Preoperative prognostication of the adverse events (AEs) in patients undergoing anterior cervical discectomy and fusion (ACDF) can improve the risk stratification, thus can guide in implementing targeted treatment to minimize these events.

Methods: The patient cohort was identified from the American College of Surgeons, National Surgical Quality Improvement Program (2005-2016). We developed six machine learning algorithms, and the algorithm with the best performance across discrimination, calibration and overall performance was used for predicting the overall risks of AEs.

Results: The overall 30-d AEs of the 12, 574 patients who underwent ACDF were 3.4% (n=432). The median age of our cohort was 54.0 years (range, 16-89 years). The model with 11-predictive factors which include, age, BMI, ASA grade, hypertension, congestive heart failure, chronic steroid use, preoperative serum hematocrit, preoperative serum albumin, preoperative serum white blood cell count, preoperative serum alkaline phosphatase and preoperative serum creatinine —performed well on the discrimination, calibration, Brier score and decision analysis to develop a machine learning algorithm. Logistic regression showed higher AUCs than least absolute shrinkage and selection operator across these different models. The predictive probability derived from the best model was uploaded on an open access web application which can be found at: https://spine.massgeneral.org/drupal/Anterior-Cervical-Discectomy.

Conclusion: Machine learning algorithms provide promising results for prediction of postoperative outcome in spine surgery. Hence, these algorithms can provide useful factors for patient-counselling, accurate risk adjustment, and accurate quality metrics.

7:56 - 7:58 am

313 Fixation Strength of Modified Iliac Screw Trajectory Compared to Traditional Iliac and S2 Alar-Iliac Trajectories

Alexander von Glinski; Clifford A. Pierre, MD; Jonathan Mahoney; Jonathan Harris; May Allall; Brandon Bucklen, PhD; Rod J. Oskouian, MD; Jens Chapman, MD

Introduction: Traditional iliac screws have drawbacks including screw prominence, removal of cortical bone, and the typical use of offset connectors prone to mechanical failure. S2 alar-iliac (S2AI) screws mitigate some of these concerns, but cross the sacroiliac joint and may experience greater biomechanical stress. A modified iliac fixation technique follows a similar trajectory as the traditional iliac screw without crossing the sacroiliac joint, but has a significantly more medial starting point, reducing screw prominence and the need for offset connectors.

Methods: Eighteen human cadaveric sacropelvic spines were divided into three groups (n=6): traditional iliac (TI), S2AI, and modified iliac (MI). Each specimen was fixed unilaterally with an S1 pedicle screw, and pelvic fixation according to its group. Screws were loaded at ±10Nm at 3Hz for 1000 cycles. Screw loosening of S1 and iliac screws was measured by using motion analysis software to calculate the motion of each screw relative to the bone in which it was anchored. The difference between maximum translations of the screw in each direction of loading was reported as screw toggle.

Results: Toggle of the S1 screw was 0.26±0.07mm for the TI group, 0.39±0.26mm for the S2AI group, and 0.39±0.20mm for the MI group, but there were no significant differences between groups (p=.421). Toggle of the iliac screw relative to the pelvis was 0.26±0.23mm for the TI group, 0.43±0.16mm for the S2AI group, and 0.28±0.08mm for the MI group, but there were no significant differences between groups (p=.179). The S2AI screw also toggled 0.54±0.43mm relative to the sacrum.

Conclusion: The S1 screw toggled similarly across all three groups. While not statistically different, the S2AI screw had greater toggle relative to the pelvis than both the TI and MI screws. Further, the S2AI screw also toggled relative to the sacrum at a magnitude greater than that relative to the pelvis. MI screws performed similarly to TI screws, but with the anatomical advantages of the S2AI screw.

7:58 - 8:00 am **314 Parkinson's Disease, Dysphagia and Cervical Spine Surgery**

Mauricio J. Avila, MD, MHPE; Travis M. Dumont, MD

Introduction: Cervical Spondylotic myelopathy (CSM) is an increasingly common problem in the aging population. Several surgical options exist to treat this condition including anterior, posterior and combined surgical approaches. Each approach carries it own set of postoperative complications with the anterior approach carrying a known risk of postoperative dysphagia. Some co-morbid condition may increase further the risk of these complications. Little is known of the of clinical outcomes after cervical spine surgery in Parkinson's disease.

Methods: The National Inpatient sample was queried 1998-2016 and all elective admissions with cervical spondylotic myelopathy were identified. Surgical treatments were identified as either: ACDF, posterior laminectomy, posterior cervical fusion or combined anterior/posterior surgery. Pre-existing Parkinson's disease and advance age were identified. Endpoints included mortality, length of stay, swallowing dysfunction measured by placement of feeding tube and post-procedure pneumonia.

Results: A total of 73 088 patients underwent surgical procedures for CSM during the study period. Of those, 552 patients had concomitant Parkinson's disease. The most common procedure overall was ACDF. Patient's with Parkinson's disease who underwent ACDF, Posterior laminectomies or Posterior cervical fusion had a longer length of stay compared to those who did not have PD (p<0.001). There was no difference in LOS for patients who underwent front and back surgery. Inpatient death has higher in patients who underwent front-back surgery and had PD (p<0.001). Patients with PD had a higher rate of needing a Nasogastric tube after surgery (swallowing dysfunction) vs. those who did not have PD (p<0.001). Multiple regression analysis showed that PD patients had a higher change of having NG Tube or pneumonia (OR 2.98 [1.7-5.2], p<0.001) after surgery.

Conclusion: While anterior discectomy and fusion is most commonly performed procedure for cervical spondylotic myelopathy, for patients with Parkinson's disease it is associated with longer length of stay, higher incidence of postoperative swallowing dysfunction and post-procedural pneumonia, and a higher inpatient mortality compared with posterior cervical procedures.

8:00 - 8:02 am

315 Does Discharge Destination Increase Risks of Readmissions and Complication after Lumbar Spine Surgery?

Christine Park, BA; Chad Cook, PT, PhD, MBA; Alessandra Garcia, PT, PHD; Oren N. Gottfried, MD

Introduction: For individuals with severe disability requiring spine surgery, appropriate discharge destination is a challenging and complex decision. Juxtaposing concerns regarding lack of oversight and iatrogenic infections are important considerations.

Methods: This was an observational study using the Quality Outcomes Database (QOD) Spine Registry. Subjects were limited to age =18 years, primary lumbar spine surgery, and severe disability at baseline [Oswestry Disability Index (ODI) =50%]. Discharge destination was dichotomized to home or healthcare institution. Demographics, preoperative characteristics, and postoperative outcomes (three-month hospital readmission and revision surgery and 30-day return to operating room and complication rates) were included.

Results: A total of 13,050 patients were included in the study. Of this, 11,859 patients (90.9%) were discharged home and 1,191 (9.13%) patients were discharged to a healthcare institution. Individuals who were discharged to a healthcare institution were older (68.56±10.20 vs 56.88±13.97, p<0.01) and had worse baseline characteristics (higher ASA score, presence of back pain, and prevalence of comorbidities, all p<0.01) compared to those who were discharged home. In both univariate and multivariate analysis after controlling for significant demographics and baseline characteristics, the home discharge cohort had lower rates of hospital readmission (OR=0.68, 95% CI 0.55-0.84) and revision surgery (OR=0.56, 95% CI 0.37-0.85) within three months and return to operating room (OR=0.46, 95% CI 0.34-0.63) and complications (i.e. deep vein thrombosis, pulmonary embolism, surgical site infection, new neurological deficit, urinary tract infection, duratomy) within 30 days than institution discharge cohort.

Conclusion: In a cohort of severely disabled patients who received lumbar spine surgery, those discharged to home have lower risk for worse postoperative outcomes compared to those discharged to healthcare institutions.
8:02 - 8:04 am 316 Effects of Patient Transfer on Total Cost of Posterior Cervical Decompression and Fusion Surgery

Theodore Hannah, BA; Emily K Chapman, BA; William Shuman; Colin Lamb; Sean N. Neifert, BS; Frank Yuk, MD; Robert J. Rothrock, MD; Jonathan S. Gal, MD; John M. Caridi, MD, FAANS

Introduction: Posterior cervical decompression and fusion (PCDF) is a common surgical approach to treat various cervical spine diseases. Surgical patients transferred from other departments or hospitals tend to have increased comorbidity burdens, however, the this effect on the cost of PCDF surgery has yet to be studied.

Methods: All patients who underwent PCDF surgery between January 2008 and November 2016 at a single institution were included. Patients were split into four cohorts based on whether it was elective surgery (CT) or a transfer (emergency department transfer (ED), intra-hospital transfer (TI), inter-hospital transfer (TO)). Differences between the cohorts were assessed using one-way ANOVA. Multivariate regressions were used to evaluate the risk of various adverse outcomes and total cost based on transfer status.

Results: Cohort demographics differed only in comorbidity burden (p<0.0001). ED and TI patients, in comparison to CT, had higher direct cost (\$32,872 and \$31,677 v. \$19,921, p<0.0001) and LOS (12.0 days and 13.2 days v 3.8 days, p<0.0001) following PCDF surgery. There were also significant differences between transfer patients and CT in rates of delayed extubation (p<0.0001), required ICU stay (p<0.0001), non-home discharge (p<0.0001), and 30- and 90-day readmissions (p<0.0001). Multivariate linear regressions confirmed that transfer status independently affected cost for ED (β =\$11,335, 95% CI: \$7,877-\$14,793, p<0.0001) and TI (β =\$8,818, 95% CI: \$4,659-\$12,977, p<0.0001) patients. Regression analysis also demonstrated that total LOS was significantly elevated as a result of transfer status in ED (β =8.0, 95% CI: 6.4-9.6, p<0.0001) and TI (β =8.9, 95% CI: 7.0-10.8, p<0.0001) patients.

Conclusion: Transfer status at the time of operation may significantly influence cost and the likelihood of adverse outcomes following PCDF surgery. Thus, initiatives designed to avoid unnecessary transfers may improve patient outcomes. Moreover, transfer status is likely an important variable for cost prediction models especially in bundled payment systems.

8:04 - 8:06 am

317 RCT Trial Comparing PEEK and Allograft Spacers in Patients Undergoing Transforaminal Lumbar Interbody Fusion Surgeries

Alan T. Villavicencio, MD, FAANS; Ewell L. Nelson, MD; Sharad Rajpal, MD; Kara D. Beasley, DO, MBe; Sigita Burneikiene MD

Introduction: Allograft and polyether-ether-ketone (PEEK) radiographic, biomechanical, histological properties have been extensively studied and both spacers have their advantages and shortcomings, but there are no comparative randomized controlled or double-blinded spinal fusion clinical trials reported to date.

Methods: A prospective, randomized, controlled, double-blinded clinical trial was initiated at a single center. All patients were followed for 2 years \pm 2 months; radiographic and clinical outcomes were assessed at 3, 6, 12 and 24 months with an additional follow-up at 3 weeks for radiographic assessment.

Results: A total of 138 patients undergoing transforaminal lumbar interbody fusions (TLIF) were enrolled, randomized to receive either femoral cortical allograft or PEEK interbody lordotic spacers. (1:1) and 121 patients finished the study. Although no differences were detected between the allograft and PEEK patient groups at any of the follow-up time points, there was a highly significant (p<0.0001) improvement in all clinical outcome measures. Overall, evidence of radiographic fusion was achieved in 118 (97.5%) patients at the 24 months follow-up. Three patients, all in the allograft group had pseudoarthrosis and underwent revision surgeries. Postoperative improvement of sagittal alignment, anterior (ABH,) or posterior body height (PBH) was achieved initially, it was mainly lost or reduced at the final follow-up and there were no statistically significant differences between the groups.

Conclusion: Although allograft-assisted surgeries may have reduced fusion rates, the study findings demonstrated that TLIF surgery with two different types of cages had a similar effect on radiological or clinical outcomes and there was a highly statistically significant improvement in all clinical outcome measures at end of the study regardless of the randomization group.

8:06 - 8:08 am

318 Postoperative SVA >4 cm Has No Impact on Neck Pain after C2-T2 Fusion for Myelopathy: Results from a Multi-center Study

Zachariah Pinter; Jad Bou Monsef; Joshua Kolz; Bradford L. Currier, MD; Ahmad Nassr; Brett Freedman; Mohamad Bydon, MD, FAANS; Benjamin D. Elder, MD, PhD, FAANS; Chris Kepler; Gregory Schroeder; Alexander R. Vaccaro, MD; Scott Wagner; David Kaye; Arjun Sebastian, MD

Introduction: The C2-7 SVA has been utilized as a measure of global cervical alignment, and previous work has suggested that achieving a postoperative SVA of 4 cm or less is ideal with regards to patient outcomes.

Methods: We performed a retrospective review of a multicenter prospective cohort of patients undergoing posterior cervical laminectomy and fusion from C2-T2 for subaxial cervical stenosis and degenerative cervical myelopathy from 2011-2018. We assessed cervical alignment on standing radiographs performed preoperatively as well as at 6 months or greater postoperatively. The cohort was divided into 2 groups based on a postoperative SVA of less than 4 cm or 4 cm or greater. We then examined differences between the groups with regards to alignment, demographics, and neck pain.

Results: In this cohort of 173 patients, 70 were identified with a postoperative SVA less than 4 cm and 103 were identified with an SVA of 4cm or greater. In both groups, the change in SVA showed a worsening of alignment from preoperative to postoperative. This was higher in the SVA >4 cohort compared to the SVA <4 cohort (-11.6 vs -3.3, p<.001). Of the 173 patients, 108 (62.4%) had VAS neck pain scores recorded at greater than 6 months postoperatively. With regards to VAS neck pain scores, they improved in both groups with long-term follow-up. There was no significant difference between the cohorts with respect to neck pain scores at any time point. Using the established minimal clinically important difference for VAS neck pain following cervical surgery, we found that 61.9% of the SVA <4 cohort and 52.9% SVA >4 cohort achieved MCID with no significant difference between the groups (p=.432).

Conclusion: While previous work has established the importance of SVA alignment in treatment of cervical deformity, in this multi-center cohort of patients undergoing C2-T2 posterior cervical fusion for degenerative myelopathy, postoperative SVA >4 cm was not associated with a significant difference in long-term patient reported outcomes with regards to neck pain.

8:08 - 8:10 am

319 Outcomes for 139 Patients Seen in Person for the First Time on the Day of Surgery Compared to Historical Controls

Alex C. M. Greven; Beau McGinley; Gerald E. Rodts, MD, FAANS; Daniel Refai, MD, FAANS; Matthew F. Gary, MD, FAANS

Introduction: Telemedicine is a powerful technology that has the potential to increase access to specialty care and decrease healthcare costs for patients, providers, and hospital systems. COVID-19 has accelerated the use of telemedicine in all aspects of healthcare delivery, including spine surgery. There is no existing literature that investigates the safety and efficacy of telemedicine to preoperatively evaluate spine surgery candidates.

Methods: The previously stated metrics were collected for 278 patients, 139 who were exclusively evaluated preoperatively with telemedicine during the COVID-19 pandemic (4/1/2020-9/15/2020), and 139 age- and case-matched historical controls (4/1/2019-9/15/2019) who were evaluated preoperatively in person. Chi-square and the Mann Whitney non-parametric test were used to determine significance.

Results: A total of 278 patients were included in this study (139 telemed preop, 139 in-person preop). The median preop VAS score was 6.0 for both the telemed preop and in-person preop groups. There were no significant differences in the median change for postop VAS scores (-2.0 vs. -2.0, p=.420), surgical time (2.1 hrs vs. 2.0 hrs, p=0.525), EBL (113 cc vs. 100 cc, p=0.828), or LOS (3.0 days vs. 2.0 days, p=0.280). In addition, there were no significant differences in intraoperative complication rates (0.7% vs. 1.4%, p=0.530), readmission rates (11.5% vs. 5.8%, p=0.092), or reoperation rates (9.0% vs. 4.4%, p=0.116).

Conclusion: Our results suggest that preoperative evaluation of spine surgery candidates with telemedicine alone is both safe and effective.

8:10 - 8:12 am 320 Single Assessment Numeric Evaluation (SANE) Can Reliably Predict Quality of Life for Patients Undergoing ACDF

Scott C. Wagner; Mohammed A. Alvi, MD, MS; Arjun Sebastian, MD; Abdul K. Ghaith, MD; Ryan Jarrah; Andrew Kai-Hong Chan, MD; Praveen V. Mummaneni, MD, FAANS; Erica F. Bisson, MD, FAANS; Regis W. Haid, MD, FAANS; John J. Knightly, MD, FAANS; Anthony L. Asher, MD, FAANS, FACS; Clinton J. Devin, MD; Mohamad Bydon, MD, FAANS ;

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 recently been used by several surgical specialties, but its utility has not been studied for cervical spine surgery.

Methods: The Quality Outcomes Database (QOD) cervical module was queried for patients undergoing 1 or 2 segment ACDF. Using multivariable logistic regression models, the performance of SANE score was assessed relative to neck disability index (NDI) in predicting patient satisfaction, and change in quality of life (assessed using Euro-QOLD 5-D or EQ5D) at 3 and 12 months.

Results: A total of 11,292 patients had available PROM data at 3 months, and 4,817 patients had data out to 12 months post-surgery. A total of 2,712 (44.3%) achieved MCID change in EQ5D, a total of 4,059 (66.2%) achieved MCID change in NDI, and 3,043 (49.6%) achieved MCID change in SANE. A total of 4,110 patients (67%) achieved 30% change in NDI 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) had a NASS satisfaction score of 1 or 2 at 3 months. At 12 months follow up, a total of 2,191 (45.6%) achieved MCID change in EQ5D, a total of 3,426 (71.2%) achieved MCID change in NDI, and 2,407 (50%) achieved MCID change in SANE. A total of 3,484 patients (72.3%) achieved 30% change in SANE score at twelve months. A total of 87% (n=4,193) had a NASS satisfaction score of 1 or 2 at 12 months. The R2 for 3 month and 12 month correlations between the SANE and NDI 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 NDI.

Conclusion: This study is the first to assess the one-question SANE score after spine surgery. Our results demonstrate that the single-question SANE score can be utilized to obtain clinically important information about patient outcomes after ACDF. Furthermore, the SANE performs similarly to more burdensome legacy PROMs, and may offer the quickest and easiest method by which spinal surgeons can assess patient outcomes after anterior cervical fusion surgery.

8:12 - 8:14 am **321 Impact of Obesity on Posterior Cervical Fusion for Cervical Myelopathy**

Eli Perez; Royce Woodroffe, MD; Brian Park, MD; Logan Helland, MD; Patrick W. Hitchon, MD, FAANS

Introduction: Obesity is a prevalent condition in patients with cervical spondylotic myelopathy (CSM) and presents unique challenges in treatment strategies and obtaining optimal outcomes. Previous studies have shown worse postoperative sagittal alignment and higher reoperation rates in patients with high body mass index (BMI) undergoing anterior decompression and fusion. Obtaining ideal sagittal balance has been shown to improve patient outcomes. Similar evidence for the impact of obesity in postoperative sagittal alignment for patients with CSM undergoing posterior cervical decompression and fusion (PCF) is lacking.

Methods: A retrospective analysis of patients with CSM undergoing PCF was performed. Demographics, need for reoperation, and perioperative radiographic parameters were collected. Cervical lordosis, C2-7 sagittal vertical axis (SVA), and T1 slope was measured on standing lateral radiographs.

Results: Of the 198 patients that met inclusion criteria, 53 had BMI normal (<25), 65 were overweight (25-30), and 80 were obese (=30). SVA increased in all groups; 4mm in the normal group, 13mm in the overweight group, and 13mm in the obese group (p=0.0026). There was no significant difference in the postoperative change of cervical lordosis or T1 slope between the groups. Multivariate analysis demonstrated fusions involving the cervicothoracic junction and those involving 5 or more levels significantly affected alignment parameters. There were 27 complications (14%) with no significant differences among the groups stratified by BMI (p=0.386).

Conclusion: Overweight patients with CSM undergoing PCF had greater increase in C2-7 SVA than normal weight patients. Patients with BMI >25 had significantly greater changes in SVA than those below this cutoff. BMI is an important factor to consider when attempting to optimize sagittal alignment and patient outcomes.

8:14 - 8:16 am 322 In-situ VBR Cage Assembly for 360 Degree Repair of Severe Traumatic L5 Burst Fractures: 3 Case Reports

Shahriar Daneshfar; Joey Grochmal, MD, PhD, FAANS; Jason A. Felton, MD, FAANS

Introduction: We present three case studies of severe burst fractures of the fifth lumbar vertebra, and a novel surgical technique to treat this uncommon, but complex injury.

Methods: Three patients with severe, operative L5 burst fractures underwent posterior L5 corpectomy, with L3-S2 instrumented fusion. Following lumbopelvic screw fixation, posterior L5 corpectomy was performed to 90% completion, leaving intact both an anterior shelf of cortical bone as well as the ALL. Using an Ulrich-style VBR cage system, the central core and each end cap were individually passed between the nerve roots then assembled and expanded in-situ, reconstructing the anterior column and facilitating arthrodesis. We report operative time, blood loss, and patient-specific recovery with radiographic follow up.

Results: Patient one: Total operative time 7:01hrs, EBL 1000mL. He initially presented with 3/5 bilateral dorsiflexion weakness and L5 hypoesthesia that resolved by 6-month follow up. CT and X-ray results were good post-op and at 6 months. At final follow up (32 months) radiography demonstrated a unilateral broken S2 alar-iliac screw at the sacroiliac joint, with no other evidence of failure, no subluxation, loss of height, or cage subsidence, with good demonstration of fusion and no symptoms.

Patient two: Total operative time 5:38hrs, EBL 1000mL. Initial neurological exam was limited with extensive long-bone fractures, 3-month follow-up demonstrated bilateral APF/ADF (4+/5) strength and altered left L5 sensation. Final follow up at 3 months demonstrated adequate alignment and intact instrumentation.

Patient three: Total operative time 8:15hrs, EBL 500mL. Intact initial neurologic exam preserved at three-month follow-up. Stable radiographic follow-up at three months.

Conclusion: In-situ assembly of the vertebral body replacement cage can allow preservation of the eloquent lumbosacral nerve roots during posterior corpectomy and instrumentation for severe lumbar burst fracture. In particular, this posterior only approach to three-column stabilization in severe L5 burst fractures is a viable treatment option for an otherwise difficult to treat condition.

8:16 - 8:18 am

323 Analysis of Complication and Failure to Rescue Rates in Spinal Cord Injury Patients from a National Database (TQIP)

William Shuman; Lea Scherschinski; Alex J. Schupper; Sean N. Neifert, BS; Emily K. Chapman, BA; Michael L. Martini, BA; Jeffrey Gilligan, MD; Jeremy Steinberger, MD; Konstantinos D. Margetis, MD; John M. Caridi, MD, FAANS ;

Introduction: A major aspect of treating spinal cord injury (SCI) is preventing complications. Failure to rescue (FTR), defined as the failure to prevent mortality after a complication, has been used to study hospital treatment efficacy following various interventions.

Methods: The Trauma Quality Improvement Program (TQIP) national database from 2010-2015 was queried for SCI patients. Patients with polytrauma or unsurvivable injury severity, those who expired in the ED, and those under 16 years old were excluded. Demographics, injury location, injury severity, and complication history were recorded. In-hospital mortalities were also identified. FTR was calculated for the overall cohort, by injury location, and by number of complications. For complications with over 0.1% prevalence, FTR for that complication was also calculated. Logistic regression models assessed odds of mortality for these complications, controlling for age, sex, injury location, injury severity, and hospital size. Rates of co-incidence of complications were calculated and represented pictorially as a heat map.

Results: There were 23,663 patients included. Mean age was 51.1 years (±19.5), 72.2% of patients were male, 73.9% of patients were hospitalized at large centers with over 350 beds, and 70.2% of patients had cervical injuries. Approximately 37% of patients experienced complications. Overall FTR rate was 6.9%, and rates gradually increased with higher spine regions (p<0.0001) and number of complications (OR=1.77, 95%CI=1.67-1.87, p<0.0001). The most common complications included pneumonia (6.7%), UTI (4.8%), decubitus ulcers (2.5%), and other complications (24%). Among these, pneumonia had the highest FTR, at 12.9%. Pneumonia (OR=2.97, 95%CI=2.43-3.62, p<0.0001) and other complications (OR=1.80, 95%CI=1.53-2.11, p<0.0001) were associated with increased odds of mortality.

Conclusion: FTR for SCI patients was calculated to be 6.9%. Higher FTR was associated with higher injury region and larger complication burden, with each complication nearly doubling odds of mortality. Pneumonia was the single most common complication and had a FTR at 12.9%. These data can inform care to prevent common complications and mortality following SCI.

8:18 - 8:20 am

324 Comparison of Intra-operative Positioning Techniques on Cervical Sagittal Parameters after Posterior Cervical Fusion

Asad Akhter, MD; Andrew J. Grossbach, MD, FAANS; Ryan Eaton, MD; Nathaniel Toop, MD; Stephanus Viljoen, MD

Introduction: Recent papers have highlighted the importance of cervical sagittal alignment in functional outcome after cervical spinal fusion. Posterior cervical fusion often result in loss of lordosis, therefore, patient positioning during operating becomes a critical factor on post-opeartive outcomes. In our study, we compare the use of Gardner-Wells tongs with bi-vector traction and the Mayfield skull clamp with intra-operative extension in regards to pre- and post-operative spinal alignent parameters.

Methods: Methods: After institutional review board (IRB) approval, retrospective chart review of a total of 54 patients who underwent posterior cervical fusion from July 2017 to December 2019 was conducted. The patients were divided into two cohorts based on their intra-operative positioning, those who were affixed to a three-point fixation system, and those who were placed in bi-vector traction. Pre- and post-operative cervical alignment parameters were measured.

Results: Results: There was no difference in post-operative sagittal parameters between the two groups. Each group showed a statistically significant difference in T1-slop when comparing pre- and post-operative measurements.

Conclusion: Conclusions: In our study we did not find that any of our techniques including bi-vector traction, static Mayfield positioning, or dynamic Mayfield positioning were very effective in adding lordosis during posterior cervical fusion surgeries. Interestingly, we also found a statistically significant increase in T1 slope and resulting trend towards increased cervical SVA.

8:20 - 8:22 am

325 Paraspinal Muscle Density Effect on Outcomes After Posterior Cervical Fusion

Zachariah Pinter; Adan Omar; Harold Salmons; Sarah Townsley; Bradford L. Currier, MD; Brett Freedman; Ahmad Nassr; Benjamin D. Elder, MD, PhD, FAANS; Scott Wagner; Arjun Sebastian, MD

Introduction: Studies in the lumbar spine suggest a correlation between sarcopenia and worse patient outcomes.

Methods: We performed a retrospective cohort study of patients undergoing PCF at a single institution between the years 2015 and 2020. We utilized preoperative magnetic resonance images to classify patients into Goutalier grades. Radiographic parameters including bone mineral density (BMD), longus colli and multifidus size, and cervical deformity measurements including but not limited to C2 SVA, C2 slope, C2-C7 lordosis and thoracic kyphosis were obtained. Patient-reported outcomes, including Neck Disability Index (NDI), RAND score, and EQ-5D scores and surgical complications were recorded. These parameters were analyzed according to the patients' Goutalier grade.

Results: We identified 99 patients for inclusion. A total of 36 patients were classified as Goutalier 0-1 (group 1), 39 were Goutalier 2 (group 2), and 24 were Goutalier 3-4 (group 3). Goutalier groups 1 and 2 experienced significant improvement in all 3 outcome scores. Goutalier group 3 did not experience a significant improvement in NDI. Average postoperative NDI scores were 12.7 in group 1, 14.3 in group 2, and 21.6 in group 3. The percentage of patients in each group reporting worse disability after surgery was 0% in Group 1, 17.9% in Group 2, and 41.6% in Group 3 (p<.01).

Conclusion: The present study is the first to assess the association between cervical paraspinal muscle Goutalier grade and patient-reported outcomes following PCF. Based on our study, patients with worse cervical paraspinal degeneration preoperatively were less likely to experience improvement after surgery.

8:22 - 8:24 am 326 Effects of Military Personal Protective Equipment on Spinal Column Loads from Underbody Blast Loading

Jamie Baisden, MD, FAANS; Sagar Umale, PhD; Hoon Choi, MD, PhD, FAANS; Narayan Yoganandan

Introduction: Combat-related injuries from improvised explosive devises are attributed to vertical loading transmitted from the seat to the pelvis to the torso and head and neck regions of mounted soldiers. Field data shows spine injuries from IED's in Military members. The presence of body armor (personal protective equipment, PPE) adds to the weight of the torso and influences load transmission within the vertebral column.

Methods: The detailed mid-sized global body model consortium was used. The simulation environment consisted of positioning the model on a rigid seat and using a 5-point seatbelt as a restraint typical of military harnesses. The model was updated with PPE using 1.5kg military helmet and 12kg body armor vest. The model was positioned in a upright seated soldier position as if in a military vehicle. Acceleration profiles were obtained for at T1, T5, T8,T12, and the pelvis both with and without PPE for 50ms.

Results: The kinematics, forces, moments and accelerations for cervical, thoracic and lumbar spine were compared +/- PPE. In both cases the cervical spines extended, thoracic spines flexed, upper lumbar spines extended and lower lumbar spines underwent flexion. Compressive forces decreased from caudal to cephalad. Due to PPE, forces increased in the cervical and thoracic spines and remained relatively constant in the lumbar spine. Spinal accelerations peaked earlier with PPE;however, their peak and morphologies were unchanged.

Conclusion: Increases in the compressive forces and flexion moments in t thoracic spine suggest compression-flexion mechanism of injury as seen in burst fractures of the thoracic spine. Both thoracic and lower lumbar spine went into flexion while upper lumbar spine went into extension. We anticipate this is due to the lumbar lordosis. Lower lumbar fractures may also occur under compression-flexion mechanism. Spine accelerations peaked earlier with PPE and this may be attributed to added mass from body armor that acts to constrain the torso. This modeling study delineates the kinematics across all spinal levels from an underbody blast loading and delineates the role of PPE and potential spine injury mechanisms.

8:24 - 8:26 am 327 Short Segment Pedicle Fixation of Traumatic Low Lumbar Fractures (L3-L5): Report of 30 Cases

Christina Moawad; Paul M. Arnold, MD, FAANS, FACS

Introduction: Low lumbar fractures are relatively uncommon. Limited data exists regarding the management of these injuries. No previous studies have specifically examined the surgical management of L3-L5 fractures exclusively with pedicle fixation in a large series. Multiple studies have reported on thoracolumbar and lumbosacral injuries, but few studies exist specifically regarding the lower lumbar region.

Methods: We reviewed prospectively collected data of 30 patients who underwent short-segment pedicle fixation for low lumbar fractures at our institution between 1993 and 2020. The average age at presentation was 38.62 ± 17.5 SD, (14-70 years). There were 18 patients with L3 fractures, 8 patients with L4 fractures, and 5 patients with L5 fractures. Follow-up was scheduled at 3-month intervals for 12 months after surgery. At each visit, radiographs were obtained, and patients were evaluated for pain, neurologic function, wound healing, spinal alignment, and evidence of fusion.

Results: There was no worsening of neurologic status following surgery, and three patients regained motor or sphincter function. Twenty-four (85.7%) patients went on to successful fusion. Five (16.7%) patients required reoperation and 1 for planned hardware removal. Four (13.8%) patients had surgical complications. Eighteen patients (64.3%) reported no pain at final follow-up, five patients (17.9%) reported pain as mild, and five patients (17.9%) reported moderate pain.

Conclusion: This large series provides information regarding the safety and efficacy of surgical management of low lumbar fractures with pedicle fixation. Following surgery, there was no neurological worsening and some patients regained neurologic function. Low complication rates, low reoperation rates, and low pain levels at final follow-up provide evidence that the surgical management of low lumbar fractures utilizing short-segment pedicle fixation is safe and efficacious.

8:26 - 8:28 am 328 Randomized study examining return to work after surgery for cervical spondylotic myelopathy

Zoher Ghogawala, MD, FAANS; Janis Breeze; Melissa Dunbar; Adam S. Kanter, MD, FAANS; Praveen V. Mummaneni, MD, FAANS; Erica F. Bisson, MD, FAANS; Frederick G. Barker, MD, FACS; James S. Harrop, MD, FAANS; Subu N. Magge, MD, FAANS; Robert F. Heary, MD; Michael G. Fehlings, MD, PhD, FAANS, FRCS; Todd Albert, MD; Paul M. Arnold, MD, FAANS, FACS; K. Daniel Riew, MD; Michael P. Steinmetz, MD, FAANS; Marjorie C. Wang, MD, MPH; Robert G. Whitmore, MD; John Heller; Edward C. Benzel, MD, FAANS;

Introduction: Cervical spondylotic myelopathy (CSM) is the most common cause of spinal cord dysfunction worldwide. It remains unknown which of three surgical approaches - ventral decompression with fusion (VF), dorsal decompression with fusion (DF), or dorsal laminoplasty (DL) - provides the best results. Return to work is a priority for patients considering surgery for CSM.

Methods: We conducted a multi-center prospective, randomized controlled trial (CSM-S) for patient aged 45-80 years with multi-level CSM enrolled over a 4-year period (2014-2018) from 15 sites. Patients were randomized (2:3) to ventral or dorsal surgery. Type of dorsal surgery (fusion or laminoplasty) was at surgeon's discretion. For patients who were working before surgery, time to return to work was recorded at 30 days, 3 months, 6 months, and 1 year after surgery.

Results: CSM-S randomized 163 patients - 63 (39%) to ventral and 100 (61%) to dorsal surgery. Mean age was 62 years (49% male). Baseline characteristics were comparable. One -year follow-up was 95%. 67/163 patients were working at baseline. The proportion of patients who returned to work within 1 year (76.5%) did not significantly differ depending upon surgical strategy (P=0.35); however, the time to return to work was different depending on surgical approach (P=0.02). Median time to return to work was 30 days for DL, 90 days for VF, and 180 days for DF. Surgeons recommended collar for VF and DF (26 and 28%) more frequently than for DL (0%) (P=0.015). However, collar usage>6 weeks was not a significant predictor of time to return to work (P=0.73). Patient who underwent DL returned to work sooner than DF (P=0.01) and VF (P=0.025) patients.

Conclusion: Of those working before CSM surgery, 75% returned to work. Dorsal laminoplasty was associated with quicker retrun to work compared with ventral and dorsal fusion surgery for CSM.

8:28 - 8:30 am

329 Subsidence and Loss of Lordosis With Stand-Alone Cages for Multilevel Anterior Cervical Fusions

Shashank V. Gandhi, MD; Daniel Toscano, MD; Peter Hollis, MD, FAANS; Ahmad Latefi, DO

Introduction: Recently, stand-alone cages have become more prevalent for anterior cervical fusions. However, there has been little direct comparison to traditional plated anterior cervical fusions.

Methods: Patients who underwent multilevel anterior cervical discectomy and fusion (ACDF) at a single institution from 2016-2019 were assessed. Immediate postoperative x-rays and follow-up x-rays or CT scans were evaluated assessing for regional cervical lordosis, subsidence, pseudoarthrosis, and hardware failure. The type of diet was also noted to assess development of dysphagia.

Results: A total of 185 patients were assessed: 154 in the stand-alone group and 31 in plated group, with a mean follow-up of 9.5 months. There was no significant difference in subsidence rates between stand-alone and plated groups (40.9% vs. 38.7%, p=0.82). There was no difference in pseudoarthrosis rates (5.9% stand-alone vs. 12.9% plated, p=0.164). There was a lower rate of adjacent segment disease with stand-alones (0% vs 21.4%, p=0.002). There was no difference in postoperative dysphagia (21.4% stand-alone vs. 6.5%, p=0.266). A multivariate logistic regression analysis revealed that longer constructs had higher risk of subsidence (2-levels 35.5%, 3-levels 38.5%, 4-level 63.0%, p=0.032). There was a significant loss of regional lordosis across the fused segments in the stand-alone group (61.3% vs. 20.4% loss from immediately postoperative, p=0.018). Presence of subsidence was significantly correlated with loss of lordosis (p<0.001) and pseudoarthrosis (p<0.001). Age, gender and race did not impact subsidence or pseudoarthrosis rates.

Conclusion: There was no difference in subsidence between stand-alone and plated constructs; however, patients with multilevel stand-alones had greater loss of regional cervical lordosis. Longer fusion segments are at a higher risk of subsidence and loss of lordosis. Surgeons should consider long term alignment goals when choosing constructs for anterior cervical fusions.

8:30 - 8:32 am 330 Allograft Subsidence has Minimal Effect on Cervical Alignment following ACDF

Zachariah Pinter; Anthony L. Mikula, MD; Ashley Xiong; Arjun Sebastian, MD; Brett Freedman; Bradford L. Currier, MD; Benjamin D. Elder, MD, PhD, FAANS; Mohamad Bydon, MD, FAANS; David Kaye; Chris Kepler; Ahmad Nassr; Scott Wagner

Introduction: Studies investigating the impact of interbody subsidence in ACDF suggest a correlation between subsidence and worse radiographic and patient-reported outcomes. To date, no studies have investigated whether allograft subsidence is associated with worse postoperative cervical alignment.

Methods: We performed a retrospective review of a prospective cohort of patients undergoing 1 to 3 level ACDF with an allograft interbody and anterior plating at a single institution between the years of 2011-2017. We collected demographic information and assessed cervical alignment on standing radiographs performed preoperatively and greater than 6 months postoperatively. Cage subsidence was assessed on CT scan performed at least 6 months postoperatively. Patients with at least one level demonstrating greater than 4mm of cage subsidence were classified as severe subsidence, while patients with less than 4mm of subsidence at each level were classified as non-severe subsidence. Student's t-test was used to compare all means between groups.

Results: We identified 66 patients for inclusion. The cohort was 43.9% female. 56 patients were classified as non-severe subsidence with an average subsidence of 1.80mm, while 10 patients were classified as severe subsidence with an average subsidence of 3.28mm across all levels, with the difference in subsidence being statistically significant between groups (p=.006). Preoperative cervical alignment parameters including C2 SVA, C2 slope, C2-7 lordosis, C1-occiput distance, and T1 slope were not significantly different between groups (p>0.05). On assessment of radiographs obtained greater than 6 months postoperatively, there was no significant difference in cervical alignment parameters between the severe subsidence and non-subsidence groups (p>0.05). While 46 of the non-subsided patients achieved arthrodesis (82.1%), none of the patients in the severe subsidence group did (p<.001). Linear regression analysis demonstrated no significant correlation between subsidence and C2-7 lordosis or C2 SVA.

Conclusion: The present study is the first to assess the impact of allograft subsidence on cervical alignment following ACDF. Based upon the results of this study, structural allograft subsidence has minimal impact on overall cervical alignment following ACDF.

8:32 - 8:34 am

331 Is There Value to Flexion-Extension Radiographs for Degenerative Spondylolisthesis?

Aidin Kashigar; Joseph Laratta; Leah Carreon; Erica F. Bisson, MD, FAANS; Zoher Ghogawala, MD, FAANS; Andrew Y. Yew, MD; Tino Mkorombindo; Praveen V. Mummaneni, MD, FAANS; Steven D. Glassman, MD

Introduction: Supine MRI and upright neutral radiographs are routinely performed in patients with for degenerative spondylolisthesis. Flexion-Extension radiographs are frequently used to assess motion in patients with degenerative spondylolisthesis. However, they expose patients to additional radiation and increase cost. It is unclear if additional flexion- extension views play a significant role in surgical planning for this patient population.

Methods: From the Quality Outcomes Database, patients who had surgery for grade 1 degenerative spondylolisthesis were identified. Magnitude of slip on pre-op supine MRI, upright neutral, flexion and extension radiographs were measured. Additional motion was defined as =3mm slip difference between radiographs. For the purpose of this analysis, patients with a slip =7mm on upright neutral radiographs were assumed to require a fusion.

Results: 191 patients were identified. Mean age was 61.6 years (114 females, 60%). Only 31 patients (16%) had additional motion on flexion-extension views not seen on upright neutral x- rays versus supine MRI. Of these 31 patients, 19 had slips <7mm on upright x-ray, generating equipoise for fusion.

Conclusion: Flexion-extension radiographs may play a limited role in management of degenerative spondylolisthesis. The subset of patients for which flexion-extension views were most likely to provide value were patients with smaller slips (<7mm) with no evidence of motion on standing radiographs versus MRI. In 90% of spondylolisthesis cases, information utilized for surgical planning may be ascertained by comparing motion between supine MRI and upright lateral radiographs.

8:34 - 8:36 am

332 Impact of Timing of Surgical Decompression for Acute Spinal Cord Injury: A Pooled Analysis of Individual Patient Data

Jetan Badhiwala; Jefferson R. Wilson, MD, PhD; Christopher D. Witiw, MD; James S. Harrop, MD, FAANS; Alexander R. Vaccaro, MD; Bizhan Aarabi; Robert G. Grossman, MD; Fred Geisler; Michael G. Fehlings, MD, PhD, FAANS, FRCS

Introduction: Although there is a strong biological rationale for early decompression of the injured spinal cord, the influence of timing of surgical decompression for acute spinal cord injury (SCI) remains hotly debated.

Methods: A pooled analysis of data derived from four independent, prospective, multicentre sources of acute SCI data was undertaken. Patients were stratified into early (<24 h after SCI) and late (=24 h after SCI) decompression groups. Neurological outcomes were assessed by American Spinal Injury Association (ASIA) standards. The primary endpoint was change in total motor score from baseline to 1 year after SCI. Secondary endpoints were ASIA grade and change in upper-extremity motor, lower-extremity motor, light touch, and pin prick scores after 1 year. One-stage meta-analyses were done by hierarchical mixed-effects regression adjusting for key covariates. Effect sizes were summarised by mean difference (MD) for sensorimotor scores and common odds ratio (cOR) for ASIA grade. Change in total motor score was regressed against time to surgical decompression (h) as a continuous variable.

Results: 1548 eligible patients were analyzed. Patients who underwent early surgery (n=528) experienced greater recovery than those with late decompression (n=1020) at 1 year after SCI; total motor scores improved by 23·7 points (95% CI 19·2–28·2) in the early group versus 19·7 points (15·3–24·0) in the surgery group (MD 4·0 points [1·7–6·3]; p=0·0006), light touch scores improved by 19·0 points (15·1–23·0) vs 14·8 points (11·2–18·4; MD 4·3 [1·6–7·0]; p=0·0021), and pin prick scores improved by 18·3 points (13·7–22·9) versus 14·2 points (9·8–18·6; MD 4·0 [1·5–6·6]; p=0·0020). Patients who had early decompression also had better ASIA grades at 1 year after surgery (cOR 1·48 [95% CI 1·16–1·89]; p=0·0019). Regression analysis showed that there was a steep decline in change in total motor score with increasing time during the first 24–36 h after injury (p<0·0001).

Conclusion: Surgical decompression within the critical time window of 24 h after acute SCI is associated with improved sensorimotor recovery.

8:36 - 8:38 am 333 Does Rod Attachment Induce Significant Strain in Lumbosacral Fixation?

Anna Sawa; Piyanat Wangsawatwong; Bernardo De Andrada, MD; Jakub Godzik; Juan S. Uribe, MD, FAANS; Jay D. Turner, MD, PhD, FAANS; Brian Kelly

Introduction: Rod attachment has the potential to induce significant pedicle screw and rod (PSR) pre-strain that may predispose the instrumentation to failure.

Methods: Twelve cadaveric specimens were instrumented with L2-ilium PSR. Contoured cobalt-chrome 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 6-degree-of-freedom apparatus 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 the first and second rod attachment (pre-strains) and during in vitro loading (test-strains) were compared using one-way repeated-measure analysis of variance followed by a Holm-šidÁk paired analysis. Statistical significance was set at P<0.05.

Results:

The mean first (171 μ E) and second (322 μ E) rod attachment pre-strains were comparable to the mean teststrain during flexion (265 μ E) and extension (315 μ E, P=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 μ E, P=0.02) and axial rotation (85 μ E, 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=0.01). Sacral screw pre-strains during first and second rod attachment and screw teststrains during axial rotation (0.79 Nm) did not differ (P=0.25).

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) is 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.

8:38 - 8:40 am 334 Correlation Between the Motor Component of the ISNCSCI with the Bedside Neurosurgical Examination: a TRACK-SCI study

John F. Burke, MD; Anthony M. DiGiorgio, DO, MHA; Leigh H. Thomas, BA; Xuan Duong Fernandez, BA; Mark Harris; Lisa Pascual; Ferguson Adam, PhD; J. Russell Huie, PhD; Jonathan S. Pan; Debra P. Hemmerle, RN, MSN; Vineeta Singh; Abel Torres; Cleopa Omondi; Nikolaos Kyritsis, PhD; Jason Talbott, MD, PhD; William Whetstone, MD; Geoffrey T. Manley, MD, PhD; Jacqueline Bresnahan, PhD; Michael Beattie, PhD; Sanjay S. Dhall, MD, FAANS

Introduction: The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) assessment is the gold-standard for evaluation of neurologic function after spinal cord injury (SCI). However, it can be impractical to obtain routinely on all patients.

Methods: We collected prospective data on all consecutive patients with SCI presenting to a level-1 trauma center. Institutional Review Board (IRB) approval was obtained at this site for all study procedures. ISNCSCI exams were performed for all patients during the initial admission, either as part of clinical care if the treating provider completed InSTEP training, or separately for the research study if the ISNCSCI was not performed for clinical examinations from the neurosurgery treatment team were obtained from chart review of the consult note and daily progress note.

Results: We retrospectively reviewed ISNCSCI scores and neurosurgical exams for 60 patients. The regression coefficient was 0.9956 with an overall R2 value of 0.989 (p<0.001), and the Pearson's coefficient was 0.9946 (p<0.001). This correlation persisted when the upper and lower extremities were examined as subgroups. Upper extremity regression coefficient was 0.9860 with an overall R2 value of 0.961 (p<0.001), and the Pearson's coefficient was 0.980 (p<0.001). Lower extremity regression coefficient was 1.011 with an overall R2 value of 0.991 (p<0.001), and the Pearson's coefficient was 0.995 (p<0.001).

Conclusion: The ISNCSCI motor score and clinical neurosurgery motor examination are highly correlated. When conducting SCI research, the neurosurgery motor examination can be used as a reliable surrogate for the ISNCSCI motor score.

8:40 - 8:42 am 335 Addition of Fusion to Decompression Improves Patient-Reported Outcomes for Grade I Degenerative Lumbar Spondylolisthesis

Brandon Sherrod, MD; Erica F. Bisson, MD, FAANS; Jian Guan, MD; Mohamad Bydon, MD, FAANS; Mohammed A. Alvi, MD, MS; Anshit Goyal, MBBS; Steven D. Glassman, MD; Kevin T. Foley, MD, FAANS; Eric A. Potts, MD, FAANS; Christopher I. Shaffrey, MD, FAANS; Mark E. Shaffrey, MD, FAANS; Domagoj Coric, MD; John J. Knightly, MD, FAANS; Paul Park, MD, FAANS; Michael Y. Wang, MD, FAANS; Kai-Ming G. Fu, MD, PhD, FAANS; Jonathan Slotkin, MD; Anthony L. Asher, MD, FAANS, FACS; Michael S. Virk, MD PhD; Andrew Y. Yew, MD; Regis W. Haid, MD, FAANS; Andrew Kai-Hong Chan, MD; Praveen V. Mummaneni, MD, FAANS

Introduction: Extensive prior investigations have not ascertained the ideal surgical management of grade 1 lumbar spondylolisthesis. This study was intended to bridge the gap between the findings of previous randomized trials and the more heterogeneous population treated in typical practice by using the large, multicenter, prospectively collected Quality Outcomes Database (QOD).

Methods: The primary outcome measure was 24-month Oswestry Disability Index (ODI) change. The minimal clinically important difference (MCID) in ODI change, as well as 30% change in ODI at 24 months was also evaluated. Multivariable linear regression and logistic regression, after adjusting for patient specific and clinical factors, were employed to evaluate the impact of addition of fusion on primary outcomes of interest. Furthermore, to account for differences in age, sex, body mass index (BMI), and baseline-listhesis, a sensitivity analysis was performed using propensity score analysis to match patients undergoing decompression-only to those undergoing decompression and fusion. Secondary outcomes included 24-month change in EQ-5D and changes in numerical rating scale back and leg pain scores compared with baseline values. Patient satisfaction values at 24-months were also assessed using the North American Spine Society satisfaction questionnaire.

Results: Six hundred eight eligible patients who had grade 1 lumbar spondylolisthesis were identified (85.5% with at least 24-month follow-up); 140 (23.0%) underwent decompression alone and 468 (77.0%) underwent decompression and fusion. The 24-month change in ODI was significantly greater in the fusion group than the decompression-only group (-25.8±20.0 vs. -15.2±19.8, p<0.001). Upon multivariable linear and logistic regression, fusion remained independently associated with 24-month ODI change (B=-7.05, 95%CI -10.70 to - 3.39, p=0.001), with achieving MCID (12.8 points) for ODI at 24-months (OR 1.767, 95%CI 1.058 to 2.944, p=0.029) and 30% change in ODI at 24-months (OR 2.371, 95%CI 1.286 to 4.371, p=0.005). Propensity score analysis, using age, sex, BMI and baseline listhesis, resulted in 94 patients in the decompression-only grouped matched 1:1 to 94 patients in the fusion group. Upon multivariable regression, addition of fusion remained a significant predictor of 24 month change in ODI (B=2.796, 95%CI 2.228-13.275, p=0.006), of achieving 24-month MCID ODI (OR 2.898, 95% CI 1.214=6.914, p=0.016) and 24-month 30% change in ODI (OR 2.300, 95%CI 1.014-5.216, p=0.046).

Conclusion: The results of our study suggest that decompression plus fusion may offer superior outcomes to decompression alone in patients with grade 1 lumbar spondylolisthesis at 24 months, both in reduction of disability as well as achieving clinically meaningful improvement. Longer-term follow-up is warranted to assess whether this effect is sustained.

8:42 - 8:44 am 336 Isolated Traumatic Occipital Condyle Fractures: Is External Cervical Orthosis Even Necessary?

Enyinna L. Nwachuku, MD; Confidence Njoku-Austin; Austin Anthony; Kevin Patel; David Hamilton; Adam S. Kanter, MD, FAANS; Peter Gerszten; David O. Okonkwo, MD, PhD, FAANS

Introduction: Occipital condyle fractures (OCF) have been reported in up to 4% of individuals presenting with traumatic brain injuries (TBI). In 1988, Anderson and Mantesano developed a classification system dividing the injury into 3 categories based on the type of injury-causing force. However, this classification does not offer much guidance regarding the clinical management of OCF. Current practice guidelines supports management of patients irrespective of injury isolation with a C-collar for approximately six weeks or longer. We analyzed the rate of acute and delayed surgical intervention (occipitocervical fusion) in patients with isolated OCF managed with a cervical right collar over a 10-year period of time.

Methods: A retrospective analysis reviewed all patients admitted to Presbyterian hospital as trauma from 2008 to 2018 who suffered traumatic isolated occipital condyle fractures managed with external cervical orthosis. Radiographic imaging was reviewed by senior neurosurgical resident and confirmed by read of board-certificed neuro-radiologist. Demographic data was collected including need for occipito-cervical fusion with 12 months post-trauma.

Results: There was an incidence rate of 4% (60/1536) of isolated OCF during the 10 year period of review. The median age was 49 years old (range: 18-86) with 92% being Caucasian race and 58% of male gender. Falls accounted for the main reason for injury in 47% of the patient cohort. Type I OCF was the most common type encounted at 47%. Of the 60 patients who suffered isolated OCF and managed with external cervical orthosis, 0% required occipito-cervical fusion with 12 months post trauma. 90% of that patient cohort presented and were discharged as an ASIA E with the remaining 10% suffering traumatic brain or orthopedic injury that accurately limited their ASIA assessment.

Conclusion: A 4% incidence rate of isolated occipital condyle fractures in our 10 year research cohort correlates with the current literature rate. Our data reviewed revealed a 0% delayed occipital-cervical surgical fusion rate. This result suggests that external cervical orthosis does not change the stability profile after isolated OCFs, and thus may be unnecessary.

8:44 - 8:46 am

337 Biomechanical Effect of Facet Joint Violation on Adjacent Segment Motion and Disc Strain Following Lumbar Fusion

Brian Kelly; Piyanat Wangsawatwong; Anna Sawa; Bernardo De Andrada, MD; Luke O'Neill; Juan S. Uribe, MD, FAANS; Jay D. Turner, MD, PhD, FAANS

Introduction: Facet joint violation (FV) is a complication occurring while placing pedicle screws at the uppermost level using an entry point and trajectory too close to the superior facet joint. The incidence of FV has been reported up to be as high as 50%. However, little is known about how FV affects superior adjacent level spinal stability and especially intervertebral disc (IVD) strain after lumbar fusion.

Methods: 14 human cadaveric L3-S1 specimens were divided into two equal groups. L4-5 pedicle-rod fixation was performed in a different fashion in each group i.e. facet joint preservation (FP) and facet joint violation (FV). The violation of the facet joint was defined by denuding the facet joint capsule and removing of the external cortical surface of the superior articular process with a 3 mm Leksell-rongeur. The entry point of these pedicle screws was located at the junction between the inferolateral aspect of the facet joint. All specimens were tested multi-directionally under pure moment loading (7.5Nm). DIC was performed with cameras positioned laterally (left side) to capture the change in principal disc strains (Pmax and Pmin) at the upper adjacent level (L3-4) under peak load. Optical motion tracking was simultaneously performed on the right side. The IVD region was divided into four similar sized quarters and included upper and lower endplates. Analysis of variance of upper adjacent level range of motion (ROM) and disc strain, normalized to intact, was performed between the groups. Statistical significant was set at P=0.05

Results: Normalized ROM was significantly greater with FV than FP at upper adjacent level (L3-4) during right axial rotation (1.22 vs. 0.99, 23% difference, p=0.047). Normalized IVD Pmax strains at the upper adjacent level (L3-4) were significantly greater with FV than FP in the anterior quadrant during right axial rotation (1.80 VS 0.83 (ratio to intact), 97% difference, p=0.003). However, there were no significant differences in ROM and disc Pmax or Pmin strains during flexion, extension, and lateral bending.

Conclusion: Facet violations at the uppermost level of fusion construct during pedicle screw-rod fixation were associated with adjacent level torsional instability and the increase of IVD strain. This study suggested that the preservation of uppermost facet joint of fusion segment was helpful for alleviating adjacent segment mobility and stress concentrations of the IVD above the fusion segment.

8:46 - 8:48 am 338 Navigated Robot Assistance in the Placement of 726 Pedicle Screw: A Quantitative Accuracy Assessment

Carlo Alberto Benech, MD; Rosa Perez; Franco Benech; Torrey J. Shirk, BA; Brandon Bucklen, PhD

Introduction: Traditional minimally invasive pedicle screw placement techniques utilize fluoroscopic guidance, which can require many fluoroscopic shots. The introduction of computed tomography navigation resulted in more accurate screw placement. The use of robotic surgery seeks to take these benefits a step further, by establishing the access and trajectory with greater accuracy through robotic assistance.

Methods: Demographic data, preoperative/postoperative computerized tomography (CT) scans, and complication rates of 127 patients who underwent lumbosacral pedicle screw placement with minimally invasive navigated robotic guidance using preoperative CT were analyzed. A CT scan of the operative spinal levels was taken prior to the patient entering the OR, and screw placement planning was completed based on that scan. A CT-based Gertzbein and Robbins System (GRS)1 was used to classify pedicle screw accuracy. Additionally, quantitative 3-dimensional screw tip, screw tail, and screw angulation accuracies were determined using CT scans and image overlay analysis to compare preoperative planned trajectories to actual postoperative screw placement.

Results: Graded according to the GRS scale, there were 97.9% (711/726) of screws graded A or B, 1.7% (12/726) of screws graded C, 0.4% (3/726) of screws graded D, and 0% graded E. The average offset from preoperative plan to final screw placement was 1.9 ± 1.5 mm from the tip, 2.2 ± 1.4 mm from the tail and $2.9\pm2.3^{\circ}$ of angulation. Tip, tail and angular offset was not correlated to BMI (tip offset: R=0.16, p=0.25; tail offset: R=0.10, p=0.47; angular offset: R=0.03, p=0.83).

Conclusion: Robotic assisted surgery utilizing preoperative CT workflow with intraoperative fluoroscopy based registration improves the accuracy of pedicle screw placement within the patient's pedicles and according to preoperative planning. Screw placement accuracy is unaffected by patient BMI, a potential benefit of this procedural approach.

8:48 - 8:50 am

339 Frailty Predicts Complications Better Than Age after Surgery for Cervical Myelopathy: A NSQIP Database Study

Jamie R. F. Wilson, BM.BCh.BA; Jetan H. Badhiwala, MD; Jefferson R. Wilson, MD, PhD; Albert Yee; Michael G. Fehlings, MD, PhD, FAANS, FRCS

Introduction: The effect of frailty on the perioperative outcomes for patients undergoing surgery for degenerative cervical myelopathy (DCM) patients is poorly understood.

Methods: The modified frailty index 11- and 5-point (MFI-11, MFI-5), modified Charlson Co-morbidity index (mCCI) and ASA grade were calculated for patients with a diagnosis of DCM from the NSQIP database 2010-2018. The MFI-11 and MFI-5 scores were stratified into "Not Frail", "Pre-Frail", "Frail" and "Severely Frail". Univariate analysis was performed to assess the risk of mortality and adverse events by index. Multivariable modelling of age and frailty with a base model (type of surgical approach, number of operated levels and gender) was performed, with receiver operating characteristic area under the curve analysis (AUC) to define discriminative ability of each measure.

Results: 41,369 patients were included. Increasing frailty correlated significantly with increased risk of mortality, adverse events, longer hospital stay and risk of non-home discharge destination. Comparing age and the other indices, the MFI-5 had the largest effect size for all variables (odds ratio 8.37 [Frail] - 27.70 [Severely Frail]). MFI-5 and mCCI have the best discriminative ability at predicting adverse events with multivariable modelling, but the base model with MFI-5 and age had the best predictive value (AUC=0.84). The effect size of frailty was greater than age alone for all outcomes, and MFI-5 had a categorical assessment correlation with MFI-11 of 0.988 (p<0.001).

Conclusion: Frailty has a larger effect size and better discriminative value compared to age alone to predict adverse events after surgery for DCM. A multivariable regression model using MFI-5 produced the most robust predictive tool, which substantiates the use of the MFI-5 in preference to the MFI-11 in clinical practice.

8:50 - 8:52 am

340 ¬The Role of Instrumentation in the Surgical Treatment of Spondylodiscitis and Spinal Epidural Abscess

Jonathan J. Lee, MD; Saeed S. Sadrameli, MD, MS; Suraj Sulhan, MD; Virendra R. Desai, MD; Sean M. Barber, MD

Introduction: Spondylodiscitis is an infection of the intervertebral disc with associated osteomyelitis of the adjacent vertebral body endplates and variable involvement of the spinal canal and the paraspinal structures. An abundant arterial anastomotic system allows for hematogenous spread of infection to the vertebral metaphysis and cartilaginous endplates, and can destroy the structural integrity of the spine. Despite the high incidence of spinal infections that require a neurosurgical operation, there is no definite consensus on the most appropriate initial surgical management for these patients in regards to decompression with versus without instrumented fusion.

Methods: Records of patients undergoing operative intervention for spondylodiscitis with spinal epidural abscess at the authors' institution between 2011 and 2018 were reviewed. Two cohorts were created: patients who underwent decompression alone and patients who underwent decompression with instrumented fusion as the initial operation. Patient demographics and primary outcomes were analyzed and compared.

Results: A total of 74 patients with spinal infection were reviewed and 47 patients met the inclusion criteria. There were 27 (57.4%) patients who underwent decompression alone and 20 (42.6%) patients who underwent decompression and fusion. There were no significant differences in the comorbidities, level and/or extent of infectious involvement between the decompression alone cohort and the decompression with fusion cohort. The reoperation rate was significantly higher in the patients who underwent decompression alone (51.9% vs 10%, p = 0.004). No significant difference was seen between groups with regards to complication rates or neurological outcomes.

Conclusion: Decompression with instrumented fusion delivers neurological outcomes and complication rates similar to those seen with decompression alone in patients with spondylodiscitis. The results of this study suggest that reoperation rates are significantly lower after decompression and fusion, however, when compared with decompression alone.

8:52 - 8:54 am

341 6-month Outcomes for Patients Undergoing Posterior vs Circumferential Surgical Approach for Isthmic Spondylolisthesis

Paul M. Arnold, MD, FAANS, FACS; Steven C. Ludwig, MD; Alexander R. Vaccaro, MD; Darrel S. Brodke, MD; Justin S. Smith, MD, PhD, FAANS; Jens Chapman, MD; James S. Harrop, MD, FAANS; Thomas E. Mroz, MD; Michael G. Fehlings, MD, PhD, FAANS, FRCS; Daniel M. Sciubba, MD; Branko Kopjar, MD, PhD, MS; Sarah Woodrow, MD, FAANS; Zack Ray, MD, FAANS

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

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 15 sites in North America, and will be followed for two years. Patients with significant scoliosis or cauda equina syndrome are excluded.

Results: So far, 174 patients have been enrolled (125 posterior and 49 circumferential). The majority of patients were operated at L5/S1 (75.0% posterior and 95.9% circumferential). Six-month data is available for 141/174 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 2.6 and 3.2 respectively, p = 0.3834); buttocks and leg pain (3.2 and 3.6 respectively, p = 0.4437); EQ-5D Index (0.23 and 0.15 respectively, p = 0.0693); SF-36 Physical Component Score (PCS) (10.7 and 10.5 respectively, p = 0.9354); and SF-36 Mental Component Score (MCS) (7.2 and 3.9 respectively, p = 0.1642).

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.

8:54 - 8:56 am

342 Do Safety-net Hospitals Provide Equitable Care after Decompressive Surgery for Acute Cauda Equina Syndrome?

Archis R. Bhandarkar; Mohammed A. Alvi, MD, MS; James Naessens; Mohamad Bydon, MD, FAANS

Introduction: Safety-net hospitals provide care to a substantial share of disadvantaged patient populations. Whether disparities exist between safety-net hospitals and their counterparts in performing emergent neurosurgical procedures has not yet been examined.

Methods: The NIS from 2002 to 2011 was queried for patients with a diagnosis of acute CES who received decompressive surgery. Hospital safety-net burden was designated as low (LBH), medium (MBH), or high (HBH) based on the proportion of inpatient admissions that were billed as Medicaid, self-pay, or charity care. Etiologies of CES were classified as degenerative, neoplastic, trauma, and infectious. Significance was defined at p < 0.01.

Results: A total of 5607 admissions were included in this analysis. HBHs were more likely than LBHs to treat patients who were Black, Hispanic, on Medicaid, or had a traumatic CES etiology (p < 0.001). After adjusting for patient, hospital, and clinical factors treatment at an HBH was not associated with greater inpatient adverse events (p = 0.611) or LOS (p = 0.082), but was associated with greater inflation-adjusted admission cost (p = 0.001).

Conclusion: Emergent decompressive surgery for CES performed at SNHs is associated with greater inpatient costs, but not greater inpatient adverse events or LOS. Differences in workflows at SNHs may be the drivers of these disparities in cost and warrant further investigation.

8:56 - 8:58 am 343 Early Decompression and Short Transport Time after Traumatic Spinal Cord Injury are Associated with Improved Outcomes

Robert Sterner; Nathaniel Brooks

Introduction: Traumatic spinal cord injury (tSCI) is a catastrophic event that may result in permanent disability or loss of function. To date, there remains significant controversy over the optimal time for surgical decompression in tSCI patients.

Methods: Data from 84 patients with tSCI requiring surgical decompression was collected. Regression analysis was used to establish time to decompression classification cutoffs. Patients were classified into the following subgroups: 0-12 or <12 hours as a factor of the total or admitting hospital time to decompression. The change in American Spinal Injury Association Impairment (AIS) Grade from admission to discharge was determined. Additionally, the effect of transport time on conversion of AIS grade was assessed as patients were grouped into transport times of <6 or >6 hours.

Results: Among the time to decompression subgroups there were no significant differences (P>0.05) in baseline confounding factors such as age, injury severity, and AIS grade. Patients who received decompression within 0-12 hours were associated with significantly (P<0.0001) higher average improvements in ASIA grade (0.76). Patient transport times <6 hours were associated with significantly (P=0.004) higher conversion of AIS grade to less impaired states.

Conclusion: The present study suggests an association of decompression within 12 hours and short transport times (<6 hours) with significant improvements in neurological outcomes.

8:58 - 9:00 am 344 Postoperative Quality of Life in Young, Early- and Late Elderly Patients with Cervical Myelopathy

Davide M. Croci, MD; Brandon Sherrod, MD; Erica F. Bisson, MD, FAANS

Introduction: Cervical spondylotyc myelopathy (CSM) is a common progressive spine disorder affecting predominantly the middle-aged and elderly population. With the continuously increasing life expectancy, the incidence of CSM is further estimated to rise. However, the outcome of elderly patients undergoing CSM surgery and especially their quality of life (QOL) postoperatively remains unclear.

Methods: The NeuroPoint Quality Outcomes Database (QOD) was queried for CSM patients treated surgically from January 2016 to December 2018. Data from the 14 highest-volume cervical QOD sites were included. Patients were divided into three groups: young (<65 years old), early elderly (65-74 years) and late elderly (>75 years). Demographic and PRO measures (NDI, mJOA, EQ-5D-VAS, EQ-5D) were compared between the groups at baseline, 3 and 12 months postoperatively.

Results: A total of 1151 patients in the cervical QOD register underwent surgical treatment for CSM. 691 patients (60%) were included in the "young-", 331 patients (28.7%) in the "early-elderly" and 129 (11.2%) in the "late-elderly-group". At baseline, younger patients presented worse NDI (p<0.001), lower baseline EQ-5D VAS (p=0.004) and EQ-5D (p<0.001) scores. No differences were found in the mJOA. An improvement of all QOL scores was noted in all age groups, however younger patients presented worse NDI (p<0.001), lower EQ-5D vas baseline at 3 and 12 months. At 3 months, younger patients presented worse NDI (p<0.001), lower EQ-5D scores (p<0.001) but no significant differences were found in the mJOA and EQ-5D VAS, compared to the elderly. At 12 months, younger patients still had worse NDI score (p<0.001) and lower EQ-5D-VAS but no significant difference in EQ-5D and mJOA was found.

Conclusion: Our results indicate that elderly patients undergoing CSM surgery achieved equal QOL outcomes to younger patients at 12 months follow up.

9:00 - 9:02 am

345 External Validation of a Predictive Model of Postoperative Complications and Correlation with Patient Reported Outcomes

Parastou Fatemi, MD; Yi Zhang; Summer Han; Natasha Purington; Corinna C. Zygourakis, MD; Anand Veeravagu, MD, FAANS; Atman Desai; Jon Park, MD, FRCS(C); John K. Ratliff, MD, FAANS, FACS

Introduction: Existing models that predict 30-day adverse events (AEs) following spine surgery lack external validation. Additionally, the relation between postoperative complications and long-term patient-reported outcomes are unknown. We previously developed the Risk Assessment Tool for Adverse Events after Spine Surgery (RAT-Spine), a predictive model of 30-day postoperative AEs following spine surgery using a cohort of approximately one million from Medicare and MarketScan databases.

Methods: A prospective cohort of adults undergoing spine surgery at a tertiary academic institution between April to October 2018 were enrolled. No exclusion criteria were applied. Incidence of observed AEs was compared with predicted AEs. The RAT-Spine generated a patient-specific overall risk score ranging from 0 to 1 representing the probability of occurrence of any AE. The predicted risks were presented as absolute percent risk and divided into low (<17%), medium (17-28%), and high (>28%). Additionally, Oswestry Disability Index (ODI) and Patient Health Questionnaire-2 (PHQ-2) scores were assessed pre- and at 1-year postoperatively.

Results: Among the 276 patients followed prospectively, 76 experienced at least one 30-day postoperative AE. The median age was slightly lower in the non-AE cohort (63 vs 66.5). Patients with Medicaid comprised 2.5% of the non-AE cohort and 6.6% of the AE cohort. Spinal fusion was performed in 59.1% of cases, which was comparable across cohorts. There was good agreement between the predicted AE and observed AE rates. The incidence of observed AEs in the prospective cohort was 17.8% among the low-risk group, 23.0% in the medium-risk group, and 38.4% in the high risk group (p = 0.003). Mean ODI decreased by approximately 15 points one year after surgery (p < 0.001), and this did not differ significantly between the cohorts (p = 0.33).

Conclusion: We externally validated a model for postoperative complications following spine surgery (RAT-Spine). The results are presented as low-, moderate-, and high-risk designations. We also correlated postoperative complications with 1-year patient reported outcomes and found that adverse events did not appear to impact these long-term outcomes, though due to small sample size this relationship merits further study.

9:02 - 9:04 am 346 Patient Risk Factors and Hospital Drivers for Exorbitant Cost after Elective ACDF for CSM

Andrew B. Koo, MD; Aladine A. Elsamadicy, MD; Margot Sarkozy; Mani Sandhu; Astrid Hengartner; Christopher S. Hong, MD; Daniel M. Sciubba, MD; Luis Kolb, MD; Maxwell S.H. Laurans, MD, MBA

Introduction: There remains a poor understanding of the epidemiological risk factors portending increased cost and health care utilization for patients undergoing elective anterior cervical discectomy and fusion (ACDF) for cervical spondylotic myelopathy (CSM).

Methods: The National Inpatient Sample (NIS) database was queried using the International Classification of Diseases, 10th revision, Clinical Modification Coding system to identify all adult (=18 years) patients with a primary diagnosis of cervical spondylotic myelopathy undergoing an elective ACDF for years 2016 and 2017. Discharge weight and cost-to-charge ratios were used to estimate national demographics, Elixhauser comorbidities, complications, length of stay (LOS), discharge disposition and total cost of admission. Multivariate regression was used to determine the odds ratio for risk-adjusted exorbitant cost, as defined as a total cost greater than the 75th percentile for the entire cohort (>\$23,164). The primary outcome was the degree to which patient comorbidities or postoperative complications correlated with exorbitant cost.

Results: We identified 17,260 patients, of which 4,315 (25.0%) encountered an admission of exorbitant cost (Normal Cost: 12,945; Exorbitant Cost: 4,315). The exorbitant cost cohort had a significantly greater number of comorbidities compared to the normal cost cohort. Patients with exorbitant cost had a significantly greater proportion of intraoperative electrophysiological monitoring (p=0.013), two level or more fusion (p<0.001), and blood transfusion (p<0.001). There were greater intraoperative CSF leak and/or dural tear encountered in the exorbitant cost cohort (p<0.001). Compared to the normal cost cohort, the overall complication rates were greater in the exorbitant cost cohort (Normal Cost: 8.3% vs. Exorbitant Cost: 19.4%, p<0.001). On average, the total cost incurred by the exorbitant cost cohort was more than twice than that of the normal cost cohort (Normal Cost: \$15,307 ± 4,229 vs. Exorbitant Cost: \$33,815 ± 14,749, p<0.001) and had a longer LOS (Normal Cost: 1.6 ± 1.3 days vs. Exorbitant Cost: 3.4 ± 4.1 days, p<0.001). A greater proportion of patients in the exorbitant cost cohort encountered a non-routine discharge location (Normal Cost: 13.7% vs. Exorbitant Cost: 30.5%, p<0.001). In multivariate regression analysis, several covariates were associated with exorbitant cost, including: female sex, 51-75th and 76-100th patient median household income guartile, and U.S. census bureau West hospital region. The odds ratio for exorbitant cost after two levels or more fusion was 3.66 [95% CI: (2.82, 4.75), p<0.001] compared to one level fusion, and 1.48 [95% CI: (1.36, 1.61), p<0.001] for length of hospitalization.

Conclusion: Our study suggests that hospital admissions encountering exorbitant cost are driven by multiple patient demographic, inpatient and hospital-related risk factors following elective anterior cervical discectomy and fusion for cervical spondylotic myelopathy.

9:04 - 9:06 am

347 Relation of Prehospital Hemodynamic Status and SpO2 to Neurologic Recovery After Acute Traumatic Spinal Cord Injury

Kristopher Patterson; Maclean Cook; Jason Barber; Vikas O'Reilly-Shah; Arman Dagal; Christine Fong; Hannah Weaver; Rajiv Saigal, MD, PhD, FAANS;

Introduction: Current treatment of traumatic spinal cord injury (SCI) targets secondary neurological injuries, such as hypoperfusion and ischemia, that underlie much of the pathophysiology following a traumatic SCI. However, there is a paucity of data available to suggest that early modulation of blood pressure or optimizing tissue oxygenation in the prehospital setting yields better long-term neurologic outcomes.

Methods: In this retrospective cohort study, conducted at a large level 1 trauma center, acute traumatic SCI patients from 2017-2019 were assessed for neurologic recovery at discharge from hospital and inpatient rehabilitation. Neurologic outcomes were measured as the change in the American Spinal Injury Association (ASIA) motor score at the outcome time points. Major exclusionary criteria included: greater than two days from time of injury to spinal decompression surgery, age <16 years old, insufficient prehospital data, and missing/incomplete motor exams. Prehospital MAP exposure was characterized for each subject using an area-under-the-curve approach. The total bounded area below 85mmHg was calculated over the entire monitoring period, then divided by the duration of monitoring to achieve a normalized "average hypotensive burden" value. A similar analysis was performed with prehospital SpO2 data, utilizing a threshold of 92% to yield an "average hypoxemic burden" value. Linear regression was used to examine the relationship of both prehospital MAP and SpO2 values with the change in motor score.

Results: The chart review identified n=109 patients at hospital discharge and n=79 at rehab discharge. Linear regression analysis demonstrated a non-significant (p>0.05) relationship between average hypotensive burden and change in the motor score at both hospital discharge and rehab discharge. Prehospital SpO2 analysis also yielded a non-significant relationship.

Conclusion: Prehospital MAP values below the current clinical recommendations of 85mmHg did not show a significant association with motor score change in traumatic SCI patients. Similarly, prehospital oxygenation status did not demonstrate a significant relationship with neurologic recovery following SCI. Further work is necessary to adjust for confounders as well as validate these findings in additional settings.

9:06 - 9:08 am 348 FDA IDE Study of Decompression and Paraspinous Tension Band for Degenerative Spondylolisthesis: 24-Month Outcomes

Alan T. Villavicencio, MD, FAANS; Rick Sasso, MD; Barrett Boody; William F. Lavelle; S. Tim Yoon, MD, PhD; Ravi Bains; Calvin Kuo; Hyun Bae, MD; Kee D. Kim, MD, FAANS; Khalid Ahmed Sethi, MD, FAANS; Jeffrey Fischgrund; Harel Deutsch, MD; Elizabeth Yu, MD; William C. Welch, MD, FAANS, FACS; Michael Stauff; Reginald J. Davis, MD, FAANS, FACS; Harvinder S. Sandhu, MD, MBA; Matthew Mermer; Zack Ray, MD, FAANS; Dennis G. Crandall, MD; Umesh Metkar; Richard D. Guyer, MD; Sigurd Berven, MD; Jens Chapman, MD; Hamid Hassanzadeh, MD; Jeffrey L. Gum MD; Sigita Burneikiene, MD; Mick J. Perez-Cruet, MD, FAANS; Todd Alamin; Louis Fielding; Michael Y. Wang, MD, FAANS

Introduction: Symptomatic degenerative spondylolisthesis (DS) is commonly treated with decompression and fusion (D+F). D+F has been shown to have superior outcomes to decompression alone, however, D+F is an invasive procedure commonly associated with adjacent segment degeneration. A paraspinous tension band (PTB) was developed to provide sagittal plane stability without fusion for patients with DS undergoing decompression.

Methods: Patients with Grade 1 DS were enrolled in the FDA IDE study comparing D+PTB and D+F (NCT03115983). Operative and patient-reported outcomes were recorded at baseline and 6w, 3m, 6m, 12m and 24m follow-up. All prospectively enrolled patients in the IDE study due for 24m follow-up were included in this analysis.

Results: 118/124 patients (76 D+PTB/42 D+F) due had 24m follow-up (95%) and were included in this analysis. Mean characteristics of D+PTB/D+F groups were: age 64.8/63.6yrs; BMI 28.4/29.7; 48(61%)/34(76%) female. Mean operative outcomes for D+PTB/D+F were: OR time 113/176 min; EBL 41/262 ml; LOS 0.6/3.4 nights (all p<0.01). 32/79 D+PTB patients (41%) had their procedures in an ambulatory or outpatient surgery center. Overall, 53/79 D+PTB patients (67%) were discharged the same day of surgery. There were no significant differences between groups in VAS or ODI scores at baseline. Both groups demonstrated significant improvement in VAS and ODI scores at 24m compared to baseline (all p<0.01). The D+PTB group had significantly lower ODI outcomes at 6w and 24m follow-up. 24 months postoperatively, 95% of D+PTB and 74% of D+F patients had a 15-point ODI improvement vs baseline. During the 24m follow-up, 3 D+PTB patients (3.8%) and 5 D+F patients (11.1%) had reoperations at index or adjacent segments.

Conclusion: Both groups demonstrated significant clinical improvement through 24m follow-up. The D+PTB group had shorter procedure time, less blood loss and shorter length of stay vs. the D+F group, and lower ODI during initial recovery and at 24m follow-up. If these results are durable and generalizable, the D+PTB may offer an alternative to fusion for patients with symptomatic DS. Further study will include longer-term follow-up with propensity score-selected and matched subgroups.

9:08 - 9:10 am 349 Surgical Decompression for Cervical Spondylotic Myelopathy in Patients with Associated Hypertension

Alexander Perdomo-Pantoja, MD; Alejandro Chara ; Ann Liu, MD; Yike Jin, MD; Maritza N. Taylor ; Nagat El Demerdash; Ali Karim Ahmed, MD; Zach Pennington, BS; Erick M. Westbroek, MD; Ali Bydon, MD, FAANS; Nicholas Theodore, MD, FAANS, FACS; Timothy F. Witham, MD, FAANS

Introduction: The relationship between spinal cord compression and hypertension is still unclear. A few clinical studies recently reported blood pressure (BP) improvement in cervical spondylotic myelopathy (CSM) patients with concomitant hypertension after undergoing surgical decompression.

Methods: A single-institution retrospective review of consecutive CSM patients who underwent cervical decompression between 2016 and 2017 was conducted. Baseline clinical and imaging characteristics, preoperative and postoperative BP readings, heart rate, functional status, and pain scores were collected. Additionally, a PRISMA guidelines-based systematic review of the literature was performed.

Results: We identified 264 patients with CSM treated surgically; 149 (56.4%) of these had hypertension. The degree of spinal canal compromise and spinal cord compression, preoperative neurological examination, and the presence of T2-signal hyperintensity on MRI were associated with hypertension. Overall mean arterial pressure (MAP) decreased at one and 12 months after surgery.

In those with hypertension, MAP decreased postoperatively at one month (mean [SD] difference: -3.3 [13.2] mmHg, p = 0.01) and 12 months (mean [SD] difference: -2.7 [16.2] mmHg, p = 0.04). At 12 months after surgery, 24 (24.7%) of 97 patients with initially uncontrolled hypertension had controlled BP values with reduction of MAP (mean [SD] difference: -13.5 [10.1] mmHg, p < 0.001), systolic BP (mean [SD] difference: - 20.8 [13.9] mmHg, p < 0.001) and diastolic BP (mean [SD] difference: -9.9 [9.4] mmHg, p < 0.001).

Patients without T2-signal hyperintensity on imaging showed a MAP reduction at 12 months postoperatively while those with T2-signal hyperintensity showed a transient MAP reduction at one month postoperatively before returning to preoperative values.

Including the present study, five articles were eligible for systematic review, with all reporting a BP decrease in CSM patients after decompression.

Conclusion: Cervical surgical decompression reduced BP in some CSM patients; however, this improvement was less apparent in patients with spinal cord T2-signal hyperintensity. Multidisciplinary studies are needed to further examine the antihypertensive response of surgery on an individual basis.

9:10 - 9:12 am 350 Assessing the Efficacy of the mJOA in Myelopathic Patients: A Cervical QOD Study

Timothy J. Yee, MD; Cheerag D. Upadhyaya, MD; Domagoj Coric, MD; Eric A. Potts, MD, FAANS; Erica F. Bisson, MD, FAANS; Jay D. Turner, MD, PhD, FAANS; John J. Knightly, MD FAANS; Kai-Ming G. Fu, MD, PhD, FAANS; Kevin T. Foley, MD, FAANS; Luis M. Tumialán, MD; Mark E. Shaffrey, MD, FAANS; Mohamad Bydon, MD, FAANS ; Praveen V. Mummaneni, MD, FAANS; Andrew Kai-Hong Chan, MD; Scott A. Meyer, MD, FAANS; Anthony L. Asher, MD, FAANS, FACS; Christopher I. Shaffrey, MD, FAANS; Oren N. Gottfried, MD; Khoi D. Than, MD, FAANS; Michael Y. Wang, MD, FAANS; Avery L. Buchholz, MD, FAANS; Paul Park MD, FAANS

Introduction: The modified Japanese Orthopedic Association (mJOA) score is a validated metric for assessing severity of myelopathy. However, its relationship to functional and quality-of-life outcomes after surgery is incompletely known.

Methods: The cervical module of the prospectively enrolled Quality Outcomes Database (QOD) was queried. Patients over age 18 who underwent single-stage surgery for CSM were included. Revision and operations for infection, trauma, and tumor were excluded. Postoperative outcomes included the modified Japanese Orthopedic Association (mJOA) score, the Neck Disability Index (NDI), and Quality-Adjusted Life Year (QALY) by EQ-5D. Improvement in mJOA was used as the independent variable in univariate and multivariate linear regression.

Results: Across 14 surgical centers, 1,121 patients were identified. Mean age±SD was 60.6±11.8 years, and 52.5% were male. Anterior-only operations were performed in 772 patients (68.9%), and posterior-only operations in 349 patients (31.1%). Mean mJOA±SD scores at baseline, 3 months postoperatively, and 12 months postoperatively were 12.0±2.8 (n=1121), 13.9±2.6 (n=914), and 13.8±2.8 (n=801). Mean NDI±SD scores at baseline, 3 months postoperatively, and 12 months postoperatively, and 20.4±19.4 (n=807). Mean QALY±SD scores at baseline, 3 months postoperatively, and 12 months postoperatively were 0.6±0.2 (n=1029), 0.7±0.2 (n=899), and 0.7±0.2 (n=761). By univariate analysis, improvements in mJOA were associated with improvements in NDI and QALY at 3 and 12 months postoperatively (all p<0.0001). These findings were similar in multivariate analysis.

Conclusion: In this large cohort of patients who underwent surgery for CSM, improvements in mJOA were associated with improvements in NDI and QALY. These findings suggest that changes in mJOA can serve as a proxy for functional and quality-of-life outcomes.

9:12 - 9:14 am **351 Predicting Patient Outcomes After Far Lateral Lumbar Discectomy**

Eric Winter; Donald Detchou; Gregory Glauser; Krista Strouz; Scott D. McClintock; Paul J. Marcotte, MD; Neil Malhotra, MD, FAANS

Introduction: The LACE+ (Length of Stay, Acuity of Admission, Charlson Comorbidity Index (CCI) Score, Emergency Department (ED) visits within the previous 6 months) index has never been tested in a spine surgery population.

Methods: Data were obtained for patients (n=144) who underwent far lateral lumbar discectomy at a single, multi-hospital academic medical center (2013-2020). LACE+ scores were calculated for all patients with complete information (n=100). The influence of confounding variables was assessed and controlled with stepwise regression. Logistic regression was used to test the ability of LACE+ to predict risk of unplanned hospital readmission, ED visits, outpatient office visits, and reoperation after surgery.

Results: Mean age of the population was 61.72 ± 11.55 years, 69 (47.9%) were female, and 126 (87.5%) were non-Hispanic white. Patients underwent either open (n=92) or endoscopic (n=52) surgery. Each point increase in LACE+ score significantly predicted, in the 30-day (30D) and 30-90-day (30-90D) post-discharge window, higher risk of readmission (p=0.005, p=0.009; respectively) and ED visits (p=0.045). Increasing LACE+ also predicted, in the 30D and 90-day (90D) post-discharge window, risk of reoperation (p=0.022, p=0.016; respectively), and repeat neurosurgical intervention (p=0.026, p=0.026; respectively). Increasing LACE+ score also predicted risk of reoperation (p=0.011) within 30 days of initial surgery.

Conclusion: LACE+ may be suitable for characterizing risk of adverse perioperative events for patients undergoing far lateral discectomy.
9:14 - 9:16 am 352 The Effect Of Patient Position On Psoas Morphology And In Lumbar Lordosis

Luiz Pimenta; Rodrigo A. Amaral, MD; Gabriel Pokorny; Murilo Tavares Daher; Raphael Pratali; Carlos Fernando P. S. Herrero

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.

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°) and proximal lordosis (40,4° vs. 36,9°) 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.

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.

9:16 - 9:18 am 353 Validation of a Novel Classification System for Thoracic Disc Herniations and Application to Surgical Approach

Samuel H. Farber, MD; Corey T. Walker, MD; James Zhou, MD; Jakub Godzik; Shashank V. Gandhi, MD; Bernardo De Andrada, MD; Robert Koffie, MD, PhD; Kristina Chapple; Jay D. Turner, MD, PhD, FAANS; Juan S. Uribe, MD, FAANS

Introduction: Thoracic disc herniations (TDHs) are complex entities that can vary substantially by size, location, and degree of calcification. These features likely have a large influence on clinical outcomes, and each may dictate treatment approach. A classification system is needed to more accurately describe and study these complex lesions.

Methods: The classification system includes 5 types of TDHs based on anatomical and clinical characteristics. Type 0 is incidental, and patients are asymptomatic. Type 1 is small (<40% of canal diameter) and paracentral. Type 2 are small and centrally located within the spinal canal. Type 3 are giant (>40% of canal diameter) and paracentral. Type 4 are giant and central within the canal. Each type is further subdivided by a calcification modifier. In types 1-4 patients typically have correlative clinical and radiographic evidence of thoracic spinal cord compression.

To validate this classification system, twenty spine surgeons from across the U.S. who have substantial experience treating TDH were asked to rate ten example cases using this system. Interobserver reliability was determined using Fleiss' kappa coefficient. The surgeons were then surveyed to obtain a consensus regarding their choice of surgical approach for each case- specifically anterolateral (MIS retropleural or open thoracotomy) vs. posterior approaches.

Results: There was a high level of agreement amongst all surgeons surveyed for classifying the cases of TDH with an average of 79% (55%-100%), and an inter-rater reliability of 0.603 (moderate-substantial agreement). 100% of surgeons reported non-operative management of type 0 TDHs. For type 1, 75% of respondents reported they would perform a posterior approach. Respondents reported anterolateral or posterior options were equivalent for type 2 lesions. For type 3 and 4 TDHs a majority of respondents (73% and 70%, respectively) indicated they would perform an anterolateral approach for treatment.

Conclusion: We present validation of a novel classification system to categorize thoracic disc herniations. This system provides standardization for describing these lesions and may help dictate surgical approach.

9:18 - 9:20 am

354 Establishing Fluid Biomarker Gradients based on Severity of Spinal Cord Injury

Nitin Agarwal, MD; Megan Rode; Tavis Taylor, BA; Souvik Roy; Pallavi Muluk; Aparna Krishnamoorthy; Hannah Easow; Gabrielle Stout; Yue-Fang Chang, PhD; David Hamilton; Partha Thirumala;

Introduction: Establishing reliable biomarkers will be useful for prognosis as well as the evaluation of new therapeutic targets to reduce the impact of SCI.

Methods: The test model used forces of 100 and 200 kdyn. Both of these severities have been established for acute spinal cord injury models. SSEPs and MEPs were recorded at both levels of force at various timepoints from before injury to up to 72 hours after SCI. Serum and cerebrospinal fluid (CSF) levels for neurofilament heavy chain (NfH) and neurofilament light chain (NfL) biomarker concentrations were collected at the same time points as well.

Results: After SCI, the amplitude of MEPs and SSEPs decreased, conveying a decrease in the neuropathway's functionality to the hind legs in both injury severities, with the 200 kydn group being a greater decline. Likewise, BBB scores showing locomotion also decreased following the injury. Concentrations of the neurofilament biomarkers greatly increase post-SCI. In the 100 kydn injury group, a statistically significant negative correlation was found between the BBB locomotive score and neurofilament heavy chain (NfH) concentration. Similarly, a statistically significant negative correlation between neuromonitoring amplitudes and the NfH concentration was observed. In the 200 kydn injury group, a negative trend was found between the neurofilament biomarkers and BBB scores as well as the amplitude of evoked potentials.

Conclusion: A negative correlation was observed between biomarkers and functional outcome scores with statistical significance for the lower force 100 kdyn injury. As such, this study demonstrates the potential usefulness of these biomarkers in SCI, especially with regards to impact severity.

9:20 - 9:22 am

355 Single-Position Prone Lateral Interbody Fusion Improves Segmental Lordosis in Single-level Lumbar Spondylolisthesis

Corey T. Walker, MD; Samuel H. Farber, MD; Shashank V. Gandhi, MD; Jakub Godzik; Jay D. Turner, MD, PhD, FAANS; Juan S. Uribe, MD, FAANS

Introduction: Single-position surgery in the prone position is a new option for circumferential transpsoas lateral interbody fusion with pedicle screw fixation. Beyond improving operative efficiency, a putative benefit of this technique is that the positioning allows for maximal improvement in the patient's lordosis. However, there remains no comparative studies that have demonstrated this advantage.

Methods: The first 15 patients treated at our institution by the two senior authors using PL for single-level spondylolisthesis were compared to the last 15 patients treated using DP surgery. Retrospective comparison of the two groups was performed to determine that they were well matched and to examine differences in radiographic measures.

Results: The two groups were similar for age, sex and BMI. There was no difference in the cage length, width or height between the groups, but there was significantly more 10° versus 15° cages inserted in the PL than in the DP group (p<0.01). Radiographically, the groups also had similar baseline spinopelvic parameters, lumbar lordosis, segmental lordosis at the index level, amount of anterolisthesis, and disc height (all p>0.05). At 3 months post-op, the PL group demonstrated a significantly larger improvement in the segmental lordosis (5.1° vs 2.5° increase, p=0.02). However, this was not accompanied by a significant difference in the lumbar lordosis between L1 and S1 (6.3° vs 3.1°, p=0.14). Both groups had similar improvements in pelvic tilt, disc height and the amount of spondylolisthesis reduction (p>0.05). On evaluating the anterior-posterior placement location of the cage, it was noted that the relative distance of the implant from the posterior edge of the vertebral body was greater in the PL group (26% versus 17%, p<0.001). This indicates a tendency for more anterior cage placement in PL, but cage location was not correlated with segmental lordosis change (p=0.35).

Conclusion: This is the first study to demonstrate a significant improvement in segmental lordosis for single-level spondylolisthesis patients treated using the PL technique.

9:22 - 9:24 am

356 Modified-Frailty Index and Outcomes Following Posterior Lumbar Decompression and Fusion for Spondylolisthesis

Aladine A. Elsamadicy, MD; Isaac G. Freedman, BPhil, MPH; Andrew B. Koo, MD; Wyatt David; Benjamin Reeves; John Havlik; Zach Pennington, BS; Luis Kolb, MD; John H. Shin, MD, FAANS; Daniel M. Sciubba, MD

Introduction: Frailty has been associated with inferior surgical outcomes in various fields of spinal surgery. With increasing healthcare costs, hospital length of stay (LOS) and unplanned readmissions have emerged as clinical proxies reflecting overall value of care. However, there is a paucity of data assessing the impact that baseline frailty has on quality of care in patients with spondylolisthesis.

Methods: A retrospective cohort study was performed using the National Surgical Quality Improvement Program (NSQIP) database from 2010 through 2016. All adult (>18 years old) patients who underwent lumbar spinal decompression and fusion for spondylolisthesis were identified using ICD-9-CM diagnosis and procedural coding systems. We calculated a modified frailty index (mFI) for each patient using 5 dichotomous comorbidities. Each comorbidity is assigned 1 point and the points are summed to give a score between 0 and 5. As in previous literature, we considered a score of 0 to be not frail, 1 to be mild frailty, and 2 or greater to be moderate to severe frailty. Patient demographics, comorbidities, complications, LOS, readmission, and reoperation were assessed. A multivariate logistic regression analysis was used to identify independent predictors of extended LOS, complications, and unplanned readmission.

Results: There were a total of 5,296 patients identified, of which 2,030 (38.3%) were mFI=0, 2,319 (43.8%) patients mFI=1, and 947 (17.9%) were mFI >1. The mFI>1 cohort tended to be older (p<0.001) and have a greater BMI (p<0.001). The mFI>1 cohort had a slightly longer hospital stay (3.7 ± 2.3 days vs. mFI=1: 3.5 ± 2.8 days and mFI=0: 3.2 ± 2.1 days, p<0.001). Both surgical AEs and medical AEs were significantly greater in the mFI>1 cohort than the other cohorts, (2.6% vs. mFI=1: 1.8% and mFI=0: 1.2%, p=0.022) and (6.3% vs. mFI=1: 4.8% and mFI=0: 2.6%, p<0.001), respectively. While there was no significant difference in reoperation rates, the mFI>1 cohort had greater unplanned 30-day readmission rates (8;4% vs. mFI=5.6: 4.8% and mFI=0: 3.4%, p<0.001). However, on multivariate regression analysis, mFI>1 was not a significant independent predictor of LOS (p=0.285), complications (p=0.667), or 30-day unplanned readmission (p=0.378).

Conclusion: Our study indicates that frailty may not be a significant independent predictor of LOS, 30-day adverse events, or 30-day unplanned readmission in patients undergoing lumbar spinal decompression and fusion for spondylolisthesis. Frailty should not preclude surgical management of patients with spondylolisthesis, but further investigations of other comorbidities that may impact patient care is warranted to optimize value of care.

9:24 - 9:26 am

357 Fractures of the Axis: A Single-Institutional Experience with 425 Patients

Nathan A. Shlobin; Michael Cloney, MD, MPH; Benjamin Hopkins, MD; Vineeth Thirunavu; Akash Mitra; Nikil Prasad, BS; Hooman Azad; Nader S. Dahdaleh, MD

Introduction: There is significant variability in the management of C2 fractures because of their various morphologies. Accordingly, existing series analyze each fracture type separately, and do not assess the presentation and management of undifferentiated patients.

Methods: We retrospectively analyzed all 425 patients diagnosed with C2 fractures at our institution between 2010 and June of 2019. Data was collected on patient demographics, injury mechanism, presenting signs and symptoms, associated injuries, fracture morphology, management, and neurologic function. Multivariable regression was performed to identify factors associated with the each outcome.

Results: Younger patients (OR=0.969 [0.951, 0.987], p=0.001) and patients presenting after motor vehicle accidents (MVA)(OR=0.287 [0.101, 0.818], p=0.019) were less likely to have neurologic deficits. Falls were associated with lateral mass fractures (OR=4.047 [1.066, 15.365], p=0.040), hangman's fractures were associated with recreational injury (OR=10.049 [1.981, 50.982], p=0.005) and MVA (OR=3.272 [1.580, 6.776], p=0.001), and odontoid fractures were associated with older age (OR=1.029 [1.016, 1.041], p<0.001). Patients were less likely to be managed surgically if they were older (OR=0.966 [0.947, 0.986], p=0.001), or sustained a fall (OR=0.422 [0.201, 0.887], p=0.023) or MVA (OR=0.306 [0.128, 0.733], p=0.008), but were more likely to require surgery with type II odontoid fractures (OR=1.966 [1.153, 3.349], p=0.013). Of the patiens managed non-operatively, older patients were less likely to be treated with halo immobilization (OR=0.932 [0.893, 0.972], p=0.001), while smokers (OR=9.399 [2.053, 43.016], p=0.004) and patients with recreational injuries (OR=156.563 [5.357, 4575.573], p=0.003) were more likely to be treated with halo immobilization. Patients who were managed surgically were more likely to have an improved Nurick score at the time of discharge (OR=3.214 [1.761, 5.867], p=<0.001), and patients with a greater comorbid disease burden were more likely to have worsened Nurick scores at discharge (OR=1.329 [1.018, 1.735], p=0.036)

Conclusion: Specific presentations are associated with specific C2 fracture types, as well as the presence of neurologic deficits. The treatment modality used varied by the pathology, but being treated surgically was predictive of neurologic improvement.

9:26 - 9:28 am 358 Machine Learning Algorithm for Predicting Discharge Disposition following Surgery for Spinal Stenosis

Nida Fatima, MBBS; John H. Shin, MD, FAANS

Introduction: Care transition from the hospital is of utmost importance to improve the health outcomes. Therefore, prognostication of the discharge disposition in patients following surgery for spinal stenosis can improve the efficiency of the hospital management and quality of care. These factors can guide to implement targeted treatment to identify the potential barriers and lay out a groundwork to overcome them.

Methods: The patient cohort was identified from the American College of Surgeons, National Surgical Quality Improvement Program (2011-2016). We performed logistic regression (enter, stepwise and forward) and least absolute shrinkage and selection operator (LASSO) method for selection of variables, which resulted in 16-candidate models. The final model was selected based upon clinical knowledge and numerical results.

Results: Statistical analysis included 37,677 patients with discharge disposition to home following surgery for spinal stenosis in 80.7% (n=30,387) of the patients, while nonroutine discharge was observed in 19.3% (n=7,290) of the patients, which included skilled care (n=685, 9.4%), rehabilitation (n=393, 5.4%), acute care (n=80, 1.1%), and others (n=248, 3.4%). The model with 13-predictive factors which included: gender, American Society of Anesthesiologist's Grade, diabetes mellitus, current smoker, functional health status, chronic obstructive pulmonary disease, congestive heart failure, acute renal failure, bleeding disorders, disseminated cancer, chronic steroid use, preoperative serum albumin, and preoperative platelet counts — performed well on the discrimination, calibration, Brier score and decision analysis to develop a machine learning algorithm. Logistic regression showed higher AUCs than LASSO across these different models. The predictive probability derived from the best model was uploaded on an open access web application which can be found at: https://spine.massgeneral.org/drupal/DischargeDisposition-SpinalStenosis.

Conclusion: Machine learning algorithms provide promising results for prediction of discharge disposition in spine surgery. Hence, these algorithms can provide useful factors for patient-counselling, accurate risk adjustment, and quality metrics.

9:28 - 9:30 am 359 Predictors of Dysphagia after Anterior Surgery for Degenerative Cervical Myelopathy

Harsh Wadhwa; Jigyasa Sharma; Kunal Varshneya ; Karuna Dewan; Martin N. Stienen, MD; Anand Veeravagu, MD, FAANS

Introduction: DCM includes diseases such as cervical spondylotic myelopathy, ossification of the posterior longitudinal ligament, and degenerative disc disease. Though anterior surgical approaches are associated with dysphagia, predictors of dysphagia remain poorly studied.

Methods: Adult patients who underwent anterior spine surgery for DCM from 2007-2016 were identified using the MarketScan database. Exclusion criteria were history of tumor or trauma. Baseline demographics, postoperative complications, reoperations, readmissions, and costs were collected. Multivariable regression models were used to identify independent predictors of dysphagia and determine the independent effects of dysphagia on outcomes and costs.

Results: Of 53,320 patients, 1,449 had postoperative dysphagia (2.7%). The dysphagia cohort was significantly older, had more males, and more comorbidities. On multivariable logistic regression analysis, age >60 years (OR 1.58, 95% CI 1.39–1.79) male sex (OR 1.27, 95% CI 1.13–1.41), anterior instrumentation (OR 0.60, 95% CI 0.50 – 0.72), multistage (OR 1.92 (95% CI 1.61 – 2.30) and multilevel procedures (OR 1.49, 95% CI 1.34 – 1.66) and several medical comorbidities were independently and significantly associated with postoperative dysphagia. Rates of 90-day complications, revision surgery and readmission were higher in the dysphagia cohort, as were hospital payments and length of stay.

Conclusion: Several variables are independent predictors for dysphagia after anterior cervical spine surgery for DCM, of which only few are potentially modifiable or optimizable preoperative. Careful patient and procedural selection, besides a meticulous surgical technique are probably the key elements to lower the rate of postoperative dysphagia.

General Spine Surgery 2/Tumor/Opioids Abstract Breakout Session Saturday, July 31

7:30 - 7:32 am 400 Neighborhood Income as a Predictor of Outcomes and Opioid Use After Spine Surgery in the United States

Eric Montgomery; Umaru Barrie ; Erica Ogwumike; Mark N. Pernik; Zachary D. Johnson, MD; Luke Dosselman; Zachary Christian; Palvasha Deme; Emmanuel Adeyemo; Olatunde Badejo; Nick Stewart; Ruta Uttarkar; Owoicho Adogwa, MD, MPH; Najib El Tecle, MD; Salah G. Aoun, MD; Carlos A. Bagley, MD

Introduction: Socioeconomic status (SES) is a fundamental cause of health disparities but is difficult to capture in clinical research. Here, we present a large series assessing whether SES, measured by neighborhood income, is associated with postoperative outcomes and opioid use after spine surgery.

Methods: This was a single institution retrospective study at an academic medical center which included patients who underwent elective spine surgery between January 2010 and August 2017. Patients were separated into four quartiles based on the ZIP code-level median income, with quartile 1 being the highest income. We analyzed inter-quartile differences in demographic characteristics, operative characteristics, postoperative outcomes, and multiple metrics of opioid use.

Results: Of the 1,299 eligible, 1,138 patients were included in the analysis. There were no interquartile differences in preoperative opioid use or surgical management. Preoperatively, patients in lower quartiles were more likely to have clinical anxiety (OR: 2.05, p=0.002), with trends towards greater rates of tobacco use, affective disorder and depression. Patients in the lowest income quartile exhibited increased odds of 3-month opioid prescription renewal (OR:1.65, p=0.0077) relative to quartile 1 postoperatively. Although there was no difference in the incidence of epidural or intravenous patient-controlled analgesia (PCA) use, quartile 4 had higher total in-hospital postoperative opioid consumption compared to quartile 1 (252.25 MME vs. 131.57 MME, p=0.0087) and through PCA (121.11 MME vs. 87.60 MME; p=0.0037). Length of stay was significantly longer in quartile 4 (3.32 days) compared to quartile 1 (2.17 days, p=0.004), and postop ER visits were higher in quartile 4 compared to quartile 1 (p=0.069).

Conclusion: We find that zip-code based income is associated with greater comorbidities at presentation, increased in-hospital opioid consumption, increased risk of chronic opioid use, and longer length of hospital stay. This suggests that patients from lower income areas may be at higher risk for poor outcomes after spine surgery. It is unclear whether the disparities are intrinsic to patient resource availability or reflective of surgeon bias. Nonetheless, spine surgeons should remain cognizant of their patient's SES due to the health inequities highlighted in this research.

7:32 - 7:34 am

401 Assessment of Efficacy of Teriparatide (PTH 1-34) following Lumbar Fusion Surgery in patients with Osteoporosis

Nida Fatima, MBBS; Elie Massaad; Muhamed Hadzipasic, MD, PhD; Ganesh Shankar; John H. Shin, MD, FAANS

Introduction: Intermittent parathyroid hormone (PTH) treatment improves the bone quality and reduces the risk of osteoporotic vertebral fractures. Pre-clinical data support the efficacy of PTH for lumbar spinal fusion surgeries. However, clinical and radiographic results of PTH for lumbar spinal fusion surgery in patients with osteoporosis have not been studied in detail.

Methods: We conducted a systematic review of the electronic databases using different MeSH terms from 1980 to 2019. Pooled and subgroup analyses were performed using fixed and random effect models based upon the heterogeneity (I2). The results were reported as either mean difference (MD) or odds ratio (OR) with 95% confidence interval (CI).

Results: A total of 667 patients from 11 studies with 327 patients (90.8% females) in the teriparatide group were included. Lumbar spinal fusion rates were significantly higher among patients who received teriparatide compared to non-teriparatide group (OR: 2.25, 95%CI: 1.58-2.20, p<0.00001). Similarly, the screw loosening and subsequent vertebral fractures were 48% (OR: 0.52, 95%CI: 0.28-0.97, p=0.04) and 84% less likely (OR: 0.16, 95%CI: 0.06-0.41, p=0.002) respectively with the use of teriparatide versus non-teriparatide group. The administration of teriparatide significantly reduced the sagittal malalignment (MD: -3.85, 95%CI: -6.49- -1.21, p=0.004), Oswestry Disability Index (MD: -1.25, 95%CI: -2.64-0.13, p=0.08), limb Visual Analogue Score (VAS) (MD: -0.36, 95%CI: -0.64- -0.09, p=0.008) and spinal VAS (MD: -0.24, 95%CI: -0.44- -0.04, p=0.02) compared to non-teriparatide group. However, the post-operative bone mineral density was statistically insignificant between the two groups (MD: 0.04, 95%CI: -0.19-0.29, p=0.74).

Conclusion: This meta-analysis corroborates the effectiveness and safety of teriparatide in the osteoporotic patients planning to receive lumbar fusion surgery.

7:34 - 7:36 am

402 The Role of Intraoperative Hypotension During Spinal Fusion Contributing to Acute Kidney Injury

Rachel Blue, MD; Michael Spadola, MD; Ben Gu; Alexis Gutierrez, BA; Mitchell Weinstein; Dmitriy Petrov, MD

Introduction: Intraoperative hypotension (IOH) is a common side effect of surgery under general anesthesia and has been associated with postoperative complications, such as acute kidney injury (AKI), after major procedures. However, its incidence and implications are poorly understood in spinal fusion procedures.

Methods: This study retrospectively reviewed 910 patients who underwent spinal fusion in our hospital between January 2014 and December 2018. Associations between changes in renal function and various factors, including patient age, gender, preoperative/postoperative creatinine, and preoperative estimated glomerular filtration rate (eGFR), were assessed via linear and logistic regression modeling.

Results: A total of 40 patients (4.4%) demonstrated AKI as defined by a 25% or more increase in creatinine. A total of 838 patients (92%) experienced IOH defined by mean arterial pressure below 65 mmHg, and 621 patients (68%) had over 10 minutes of IOH. On linear regression analysis, decrease in renal function, defined by the ratio of postoperative to preoperative creatinine, was found to be significantly associated with female sex and lower preoperative eGFR. On logistic regression analysis, AKI was found to be associated with increased age [OR 1.07 (95% CI 1.04-1.11)] and preoperative eGFR <60 [OR 2.77 (95% CI 1.92-3.99)]. In both models, occurrence of IOH and total time of IOH were not independently associated with worsening renal function.

Conclusion: AKI in spinal fusion is significantly correlated with lower baseline renal function. However, while IOH is a frequently observed phenomenon in spinal fusion procedures, it does not appear to be significantly associated with kidney injury.

7:36 - 7:38 am

403 Use of Teriparatide Prior to Lumbar Fusion Surgery Lowers the Rate of Complications for Patients with Osteoporosis

Yagiz U. Yolcu, MD; Jad Zreik, BS; Mohammed A. Alvi, MD, MS; Nathan Wanderman; Bayard Carlson; Ahmad Nassr; Jeremy L. Fogelson, MD, FAANS; Benjamin D. Elder, MD, PhD, FAANS; Brett Freedman; Mohamad Bydon, MD, FAANS

Introduction: Poor bone health can create challenges in management which are amplified for patients undergoing spinal fusion. Although previously shown to improve outcomes postoperatively, the impact of preoperative teriparatide use on long-term complications remains unclear.

Methods: Patients with poor bone health undergoing any lumbar fusion surgery at a single institution between 2008 and 2018 were identified and subsequently divided into two groups as teriparatide and non-teriparatide group. Baseline demographics, patient and surgery related factors, and two-year complications were collected through a retrospective chart review. Multivariable logistic regression was performed to evaluate the association between teriparatide usage and development of any related postoperative complication.

Results: A total of 42 and 114 patients were identified for the teriparatide and non-teriparatide groups, respectively. The median age (IQR) for the teriparatide group was 62 years (55.8-68.8), while the non-teriparatide group had a median (IQR) age of 70 years (64-75.8). Overall, there were no statistically significant differences in terms of individual complications between the groups. However, on adjusted regression analysis, teriparatide use was associated with significantly lower odds of related complications for lumbar fusion patients (p = 0.049).

Conclusion: Teriparatide use prior to lumbar fusion procedures resulted in reduced rate of osteoporosisrelated complications within two years postoperatively. Results suggest improved outcomes might be seen in patients with osteopenia and osteoporosis when pre-treating with teriparatide.

7:38 - 7:40 am

404 Racial is an Independent Predictor for Non-Routine Discharges after Spine Surgery for Intradural Spinal Tumors

Aladine A. Elsamadicy, MD; Andrew B. Koo, MD; Wyatt David; Benjamin Reeves; Isaac G. Freedman, BPhil, MPH; Zach Pennington, BS; Jeff Ehresman; Maxwell S.H. Laurans, MD, MBA; Luis Kolb, MD; Daniel M. Sciubba, MD

Introduction: Non-White race has been associated with inferior outcomes in various fields of oncology. Nonetheless, little data exists describing the impact race has on care quality in patients with spinal intradural malignancies.

Methods: A retrospective cohort study was performed using National Inpatient Sample (NIS) database from 2016 through 2017. All adult (> 18 years old) inpatients who underwent surgical intervention for a primary intradural spinal tumor were identified using ICD-10-CM diagnosis and procedural coding systems. Patients were then categorized based on race: African-American and White. Patient demographics, comorbidities, intraoperative variables, complications, LOS, discharge disposition, and total cost of hospitalization were assessed. A backward stepwise multivariable logistic regression analysis was used to identify independent predictors of extended LOS and non-routine discharge disposition.

Results: Of 2,930 patients identified, 310 (10.6%) were African-American (AA) and 2,620 (89.4%) were White (W). African-Americans were 5 years younger on average, were more commonly in the lowest income quartile, and more commonly insured by Medicaid compared to Whites; gender make-up was similar between cohorts. African-Americans more commonly had hypertension, paralysis, and obesity yet the overall number of comorbidities was similar between cohorts. Postoperative complication rates were similar in both groups (W: 7.6% vs. AA: 9.7%, p=0.573). Compared to Whites, African-Americans had a 3.5 day longer LOS (W: 5.4 \pm 4.2 days vs. AA: 8.9 \pm 9.5 days, p=0.004), roughly \$5,000 higher total cost of admission (W: \$22,128 [15,549 – 31,396] vs. AA: \$27,317 [19,754 – 35,248], p=0.010), and a 20% higher rate of non-routine discharge (W: 53.8% vs. AA: 74.2%). On multivariable regression analysis, African-American race was found to be a significant independent predictor of non-routine discharge disposition [OR: 2.57, 95% CI: (1.29, 5.13), p=0.008] but not extended LOS (p=0.520).

Conclusion: Our study indicates that race is an independent predictor of non-routine discharge disposition in patients undergoing surgical intervention for an intradural spinal tumor. Further studies are needed to better understand the underlying reasons for such discrepancies, which may include actionable issues that can be addressed to improve patient care and reduce healthcare costs.

7:40 - 7:42 am

405 Is the Use of rh-BMP associated with Increased Incidence of Cancer?

Nida Fatima, MBBS; John H. Shin, MD, FAANS; Jun Seok Bae; Peter Loughenbury; Rory Murphy, MD; Amit Jain; Zorica Buser; Hans-Joerg Meisel; K. Daniel Riew, MD; AO Spine Knowledge Forum Degenerative Spine

Introduction: Recombinant human bone morphogenetic protein (rhBMP) is frequently used in spinal arthrodesis to stimulate bone fusion. However, there is a potential concern for rhBMP in the promotion of tumor growth due to the presence of BMP receptors on a variety of cancer cells.

Methods: We conducted a systematic review of electronic databases using different MeSH terms from 2000 to 2020. Pooled and subgroup analyses were performed using fixed and random effect models based upon heterogeneity (I2). The results were reported as odds ratio (OR) with 95% confidence interval (CI). Further scatter log plot was conducted to determine the dose-response relationship between rh-BMP and incidence of cancer.

Results: A total of 467,916 patients from 25-studies (10 Randomized Controlled Trials, 14 Retrospective Cohort Studies and 1 Case-Control Study) were included. In our study, 110,808 patients (62.5% females) received rhBMP while the remaining 357,108 patients (58.4% females) were in the control group. There was no statistically significant difference in terms of age (p=0.37), body mass index (p=0.51) and mean follow-up (p=0.28) between the two groups. There did not exist any statistically significant difference in terms of cancer incidence between the treatment and control group (OR: 95% CI: 0.63-4.36, p=0.30). However, the patients receiving rhBMP 2 had significantly higher risk of cancer than those receiving rh BMP 7 (p=0.03) at a mean follow-up of 33.5±20.2 months. Furthermore, lower doses of rhBMP were associated with none-to-minimal incidence of cancer while those receiving higher doses were associated with increased risk of cancer. The steepest point of the dose-response curve corresponded with an EC50 of 8mg/ml rh-BMP.

Conclusion: Our study did not demonstrate any risk of tumorigenesis or metastasis with rhBMP administration compared to the placebo group. However, there was a dose-dependent correlation of rhBMP with cancer. Further prospective studies are needed to validate our results.

7:42 - 7:44 am

406 Automated CT Imaging Biomarkers for Prediction of Outcomes in Spine Surgery for Cancer Metastasis

Elie Massaad; Christopher P. Bridge; Michael Rosenthal; Ali Kiapour, PhD; Muhamed Hadzipasic, MD, PhD; Ganesh Shankar, MD, PhD; Khaterine Andriole; John H. Shin, MD, FAANS

Introduction: Sarcopenia (low muscle mass), poor muscle quality (low muscle radiodensity), and excess adiposity derived from computed tomography (CT) have been related to poor treatment tolerability and increased mortality. This risk is of particular interest in metastatic spine disease for planning a treatment strategy that maximizes the palliative goals in circumstances that warrant careful consideration of the risks and benefits of surgical intervention.

Methods: A deep convolutional network was implemented to automatically extract body composition measures, including muscle area, muscle radiodensity, and adiposity, from routinely performed CT within three months before spine surgery. k-Means clustering was used as a nonhierarchical method to identify k groups of patients that share similar characteristics. We used logistic regression to investigate the relationship between the identified cluster-based measures and clinical outcomes, including 90-day mortality, one-year mortality, complications, and unplanned hospital readmissions.

Results: A total of 300 patients [Median (range) age, 63 (55-85); Female, 42.7% (128 of 300)] were identified from a prospectively maintained spine metastasis database (2008-2019). Cluster analysis suggested the following two subgroups: the high-risk group had a significantly lower BMI (Mean, 23.2 vs. 31.13; P<0.001), lower skeletal muscle index (117.9 vs. 144.6 cm2; P<0.001), less visceral fat (84.2 vs. 231.8, cm2; P<0.001) and less subcutaneous fat (151.5 vs. 280.1 cm2; P<0.001). Patients in the high-risk cluster were more likely to experience a death event within a year after spine surgery (Odds ratio, OR= 1.57; 95%CI, 0.96-2.57) but not within the first 90-days after surgery (OR= 0.99; 95%CI 0.60-1.67). Both clusters had similar rates of complications and readmissions within 30-days after surgery.

Conclusion: Measures of both sarcopenia and adiposity from clinically acquired CT scans in cancer patients hospitalized for spinal metastases provide significant prognostic information to be further investigated to guide treatment decision-making for optimal palliation.

7:44 - 7:46 am 407 Predicting Opioid Use During Hospitalization After Lumbar Fusion: A Contemporary Single Surgeon Series

Victor M. Lu, MD; Gregory D. Brusko, MD; Peter Borowsky; Michael Y. Wang, MD, FAANS

Introduction: The use of opioids during hospitalization after lumbar fusion for pain management is an important area of investigation in spine surgery today. There are few attempts to date made to identify parameters that predict opioid use in the immediate postoperative period.

Methods: A retrospective cohort study of all lumbar surgeries performed by single surgeon for an 18-month period from 2019-2020 was conducted. All opioid medications administered during hospitalization were converted to milligram morphine equivalents (MME). Univariate and multivariate regression analyses were used to assess associations between clinical variables and total opioid use during hospitalization.

Results: Amongst the overall cohort of 136 lumbar fusion patients, the mean age was 66.1 years (range, 26-85) with 63 (46%) males and 73 (54%) females for a mean length of stay 3.3 days (range, 0-26). There were on average 1.7 levels (range, 1-4) treated, with 71 (52%) cases performed by means of a minimally invasive surgery (MIS) approach and 64 (47%) managed by thoracolumbar interfascial plane (TLIP) block. Overall, mean opioid use during hospitalization was 168 MME (range, 0-2733). Multivariate regression analysis found younger age (P<0.01), male patients (P=0.04), MIS approach (P=0.03), and TLIP block (P=0.02) all independently predicted significantly lower opioid use during hospitalization status post lumbar spine surgery.

Conclusion: MIS approach and TLIP block both predict lower overall opioid use for pain management during hospitalization status post lumbar fusion surgery. These surgical adjuncts should be given full consideration when planning lumbar spine surgery in order to minimize postoperative opioid consumption amongst these patients when possible.

7:46 - 7:48 am 408 10-Year Surgical Trends for Patients with Spinal Metastases

Jose Orenday; María José Cavagnaro; Mauricio J. Avila, MD, MHPE; Haroon Kisana; Isabel Martha Strouse; Jacob Howshar; Aaron Dowell; Naushaba Khan; Chung-Yon Lin; Robert Ravinsky; Ali A. Baaj, MD

Introduction: Spinal Metastases are common among oncologic patients, with approximately 20% of cancer patients developing these lesions. With recent technological advancements and better understanding of spinal oncology, there is a trend for less invasive techniques in spinal metastases surgical treatments.

Methods: We performed a comprehensive assessment of peer reviewed papers via PubMed from January 2011-March 2021, regarding surgical treatment for spinal metastases. Special interest was given to cases of neurological/pain improvement, tumor recurrence, re-operation and overall survival.

Results: A total of 859 articles were found within the primary query and 97 were finally selected. There were 29 literature reviews and 68 clinical studies (52 retrospective, 15 prospective and 1 RCT); from which 34(50%) analyzed minimally invasive procedures, 19(28%) open and 11(16%) both. Within the reviewed publications, the consistent surgical practices for surgical decompression are: a) corpectomy (overall-survival 7-20 months, cumulative-1year-survival 30-92%; tumor recurrence 1-27.8%; neurological improvement 43-100%); or b) debulking of the lesion via separation surgery (overall-survival 10-38 months, cumulative-1-year-survival ~76%; tumor recurrence 4.1%-25%; neurological improvement 69-100%). In cases of patients mechanically unstable there is a tendency for using percutaneous screws with/without cement augmentation. For pain management, cement augmentation can also be used through percutaneous vertebral augmentation assisted by PEEK implant (100% pain reduction rate) or vertebroplasty/balloon kyphoplasty (62-100% pain reduction rate). In the last five years newer salvage therapies have been developed as Spinal Laser Interstitial Thermal Therapy (tumor recurrence 18-29%) and radiofrequency-vertebral augmentation (tumor recurrence ~30%).

Conclusion: The last 10 years showed and expansion on the indications and surgical procedures for spine metastases with a tendency towards minimal invasiveness. Most of these novel techniques are being further developed to displace morbid procedures and improve contemporary surgical paradigms.

7:48 - 7:50 am

409 Predictors of Nonelective Surgery for Spinal Metastases: A Nationally-Representative Retrospective Cohort Study

Hammad A. Khan, BS; Nicholas M. Rabah, BS; Vikram Chakravarthy, MD; Raghav Tripathi; Ajit A. Krishnaney, MD, FAANS

Introduction: Spinal metastases may progress to symptomatic epidural spinal cord compression that warrants urgent surgical intervention. While nonelective surgery for spinal metastases has been associated with poorer postoperative outcomes compared to elective surgery, risk factors for receiving nonelective surgery are as yet unknown.

Methods: The National Inpatient Sample (2012-2015) was retrospectively queried for patients who received surgery for spinal metastases. A multivariable logistic regression model was constructed to evaluate the association between patient-level factors and the receipt of nonelective surgery. Additional multivariable logistic regression models evaluated the association between receiving nonelective surgery and perioperative outcomes (discharge disposition, length of stay [LOS], in-hospital complications, and in-hospital mortality). All models adjusted for sociodemographic factors, comorbidity burden, hospital characteristics, and disease-related variables (myelopathy, disease severity, and primary tumor type).

Results: Our sample included 21,950 patients, of which 14,880 underwent nonelective surgery for spinal metastases. After adjusting for baseline covariates, multivariable logistic regression revealed that patients of black (OR=1.38, 95% CI: 1.03-1.84, p=0.032) and other race (OR=1.50, 95% CI: 1.13-1.98, p=0.005) had greater odds of undergoing nonelective surgery than their white counterparts. Patients of lower income (OR=1.40, 95% CI: 1.06-1.84, p=0.019) and public insurance status (OR=1.56, 95% CI: 1.26-1.93, p<0.001) were significantly more likely to receive nonelective surgery than higher income and privately insured patients, respectively. Higher comorbidity burden was also associated with greater odds of nonelective intervention (OR=2.94, 95% CI: 2.07-4.16, p<0.001). With respect to perioperative outcomes, multivariable analysis revealed that patients receiving nonelective surgery were more likely to experience nonroutine discharge (OR=2.50, 95% CI: 2.09-2.98, p<0.001) and extended LOS (OR=2.45, 95% CI: 1.91-3.16, p<0.001) compared to those treated electively.

Conclusion: This study demonstrates substantial disparities in the receipt of nonelective surgery across sociodemographic groups and highlights its association with nonroutine discharge and extended LOS, even after adjusting for baseline covariates. Future studies designed to elucidate reasons for these differences and establish strategies by which to address them are warranted.

7:50 - 7:52 am

410 Non-Elective Admission Status is Associated with Higher Cost of Care and Longer Length of Stay in Spinal Deformity

Emily K. Chapman, BA; Colin Lamb; Jonathan S. Gal, MD; William Shuman; Sean N. Neifert, BS; Jeffrey Gilligan, MD; Ian T. McNeill, MD; John M. Caridi, MD, FAANS

Introduction: Surgery is commonly indicated for spinal deformity – sagittal imbalance and scoliosis. Patients undergoing spinal deformity surgery non-electively – coming from the emergency department or being transferred within or between hospitals – have been associated with higher comorbidity burdens. However, the relative impact of transfer status on the total cost of hospital stay has yet to be quantified.

Methods: All patients who underwent spinal deformity surgery at a single institution between January 2008 and November 2016 were grouped by admission status: elective surgery (EL), emergency (ED) or transfer (from within and outside hospital). Demographics were described and compared by univariate analysis. Cost of care and length of stay (LOS) were compared between admission statuses using multivariate linear regression, controlling for different insurance payers and comparing ED and transfer each to EL. Peri- and postsurgical outcomes such as 30-day readmission were compared using multivariable logistic regression.

Results: There were 526 total spinal deformity surgeries, and ED and transfer patients had higher rates of Elixhauser Comorbidity Index >5 (88.4% and 68.2%, respectively; p<0.001) compared to EL. Insurance status did not differ significantly between admission type cohorts. Unadjusted LOS (p<0.0001) was higher in ED and transfer. Admission status independently affected cost for ED (\$26,158, 95% CI: \$11,794-\$40,522; p<0.0001) and length of stay for ED (18.8, 95% CI: 13.2-24.4; p<0.0001) and for transfer (11.0, 95% CI: 4.8-17.2; p<0.0001). ED and transfer had significantly higher rates of adverse outcomes such as non-home discharge and readmission. ED patients were more likely to have in-hospital complications (OR=0.5, 95% CI:0.5-134; p<0.0001) and non-home discharge (OR=0.1 95% CI:0.1-0.4; p<0.0001). However, likelihood of these adverse outcomes did not significantly differ by patient admission status.

Conclusion: Patients from the ED had significantly higher cost of care and longer LOS compared to elective patients. Transferred patients had significantly longer LOS. These patients also had greater rates of adverse outcomes. Admission status is therefore an important variable for cost prediction models.

7:52 - 7:54 am 411 Robotic Pedicle Screw Placement Accuracy in Spine Surgery Based on Neuromonitoring Thresholds

Charles Kanaly; Danielle Backes; Christine Richardson; Brandon Bucklen, PhD

Introduction: Robotic technology for pedicle screw placement during spinal surgery is common; however, concerns regarding pedicle screw placement accuracy remain. Triggered electromyography (EMG) is a technique used to assess pedicle screw placement, involving electrical stimulation of a pedicle opening or screw to evoke muscle action potential that is recorded by electrodes. While exact threshold remains unclear, studies suggest a stimulation (STIM) threshold of 8mA or less is indicative of a pedicle screw breach.

Methods: Retrospective, IRB-exempt review of patients treated during the first 6 months of use of ExcelsiusGPS[™] robotic system and patients not treated with the robotic system, to analyze screw placement accuracy through triggered EMG thresholds. Parametric tests were used to compare means between groups. Statistical results are defined as significant if p<0.05.

Results: One-hundred thirty-eight patients were included. Ninety-eight patients with mean age of 63±11.2 years were in EMGR group; 40 patients with mean age of 64±12.2 years were in EMGNR group. Days in hospital, operative time, STIM thresholds, and screw sizes were recorded. Days in hospital were significantly lower in the EMGR group (2.4±1.2 vs 2.9±1.9; p=0.05) but had significantly longer operative times (171.7±36.9 vs 141.3±43 minutes; p<0.01). Mean screw diameter and mean screw length were significantly bigger in EMGR group (EMGR 7.1±3.0mm; EMGNR 6.5±0.3mm; p<0.01) and (EMGR 47.6±6.1mm; EMGNR 45.3±4.4mm; p<0.01), respectively. Mean STIM values were significantly higher in EMGR group (EMGR 30±9.9; p<0.01).

Conclusion: STIM scores were higher in EMGR group despite use of larger screws, suggesting use of roboticassisted technology allows for improved pedicle screw placement proximity away from neurovascular structures. Surgeons should consider robotic technology to improve pedicle screw placement while decreasing patient hospital stay.

7:54 - 7:56 am

412 The Effect of Progressive Intraoperative Blood Loss on Viscoelastic Coagulation Parameters in Major Spine Surgery

Colin Lamb; Sean N. Neifert, BS; William Shuman; Daniel Katz; John M. Caridi, MD, FAANS

Introduction: Major spine surgery (>4 levels) is associated with significant intraoperative blood loss. More evidence on the effect of hemodilution on coagulation is needed to develop optimal transfusion protocols for maintaining intraoperative hemostasis.

Methods: Consent was obtained from 27 patients undergoing a multi-level (>4) spinal fusion procedure from 2019-2020. Whole blood samples were drawn from each subject's arterial line prior to incision (baseline) and at 500mL increments of progressive surgical blood loss (i.e. 500mL, 1000mL, 1500mL) as determined by a quantitative blood loss monitoring device. Coagulation kinematics and clot strength were analyzed using rotational thromboelastometry (ROTEM). Descriptive statistics summarized clinical features and a Wilcoxon signed rank test analyzed the differences in clotting time (CT), clot formation time (CFT), maximum clot firmness (MCF), and EXTEM/FIBTEM MCF ratio from baseline to each blood loss interval within each subject.

Results: The time to initial clot formation (CT) did not change significantly from baseline after 500mL, 1000mL, or 1500mL of blood loss (61[15] vs. 61[15], p=0.97; 61 vs. 58[15], p=0.48; 61 vs. 65[26], p=0.58). The time to stable clot formation (CFT) increased progressively with blood loss, reaching significance after 1000mL and 1500mL of blood loss (76[16] vs. 89[18], p=0.014; 76 vs. 96[33], p=0.014). MCF was significantly reduced from baseline after 1500mL of blood loss (66[6] vs. 59[5], p=0.014). FIBTEM/EXTEM MCF ratio was significantly reduced at 500mL, 1000mL, and 1500mL of blood loss compared to baseline (29.4%[9.5%] vs. 26.7%[10.4%], p=0.013; 29.4% vs. 24.6%[6.2%], p=0.0021; 29.4% vs. 21.0%[8.1%], p=0.001).

Conclusion: While initial clot formation in the extrinsic pathway was not affected by continued blood loss, stable clots formed more slowly and the maximum strength reached was lower after 1000mL and 1500mL of blood loss. The contribution of fibrinogen to overall clot strength decreased in respect to the contribution of thrombin-activated platelets (FIBTEM/EXTEM MFC ratio) after 500mL, 1000mL, and 1500mL of blood loss, suggesting that fibrinogen availability within the extrinsic cascade may be disproportionally impacted by blood loss.

7:56 - 7:58 am

413 Diagnostic Yield, Accuracy & Complications of CT-guided Biopsy for Spinal Lesions – A Systematic Review & Meta-Analysis

Giorgos Michalopoulos; Yagiz U. Yolcu, MD; Abdul Karim Ghaith, MD; Mohammed A. Alvi, MD, MS; Carrie Carr; Mohamad Bydon, MD, FAANS

Introduction: CT-guided biopsy is the main diagnostic procedure for histopathological diagnosis of spinal lesions in the clinical setting.

Methods: A comprehensive review of the literature was performed to identify studies reporting details regarding CT-guided biopsies for spinal lesions. Diagnostic yield - the rate of procedures resulting in a specific pathological diagnosis - and diagnostic accuracy - the rate of procedures resulting in the correct diagnosis - were the primary outcomes of interest. Any complications following biopsy procedures were also included.

Results: A total of 1,933 studies conducted between 1975 and 2020 were screened for eligibility. Thirty-nine studies with 3,917 patients undergoing 4,181 procedures were included. Diagnostic yield per procedure was 91% (95% CI: 88%-94%) among 3,598 procedures. Most common reason for non-diagnostic biopsies was inadequacy of sample. No statistically significant difference in diagnostic yield between different locations and between lytic, sclerotic and mixed lesions was found. Diagnostic accuracy per procedure was 86% (95% CI: 88%-94%) among 3,054 procedures. Diagnostic accuracy among 2,426 procedures that yielded a diagnosis was 94% (95% CI: 92% - 96%). Complication rate was 1% (95% CI: 0.4%-1.9%) among 3,357 procedures. Transient pain and minor hematoma were the most common complications encountered.

Conclusion: In our meta-analysis of 39 studies reporting diagnostic performance and complications of CTguided biopsy, we found a diagnostic yield of 91% and a diagnostic accuracy of 86% with a complication rate of 1%. No statistically significant difference in diagnostic yield between different locations and between lytic, sclerotic and mixed lesions was found.

7:58 - 8:00 am

414 Frailty Status but Not Age Predicts Surgical Outcomes in Spinal Tumors: An NSQIP 2015-19 Analysis of 4662 Patients

Syed Faraz Kazim; Christian A. Bowers, MD; Chad D. Cole, MD, FAANS; Rohini Mckee; Meic H. Schmidt, MD, MBA

Introduction: The preoperative risk stratification of patients undergoing spinal tumor resection remains challenging. In recent years, the efforts to look beyond age alone as an outcomes predictor has resulted in the development of measures of physiological reserve (or 'frailty indices'). The most frequently cited index in spine surgery is the modified frailty index [11-point (mFI-11) or 5-point (mFI-5)].

Methods: The National Surgical Quality Improvement Program (NSQIP) database was used to collect data for patients undergoing spinal tumor resection from 2015 to 2019 (n = 4662). Univariate analysis for age and mFI-5 were performed for the following outcomes: 30-day mortality, major complications, unplanned reoperation, unplanned readmission, hospital length of stay (LOS), and discharge to a non-home destination. Multivariable modeling of age and mFI-5, controlling for co-variates, was done to define the discriminative ability of each measure. Effect sizes were summarized by odds ratio (OR) (dichotomous outcomes) or beta coefficients (continuous outcomes) and associated 95% confdence intervals (95% CI).

Results: Univariate analysis demonstrated that mFI-5 but not age was significantly predictive of 30-day mortality, major complication, unplanned readmission, unplanned reoperation, hospital LOS, and discharge to non-home destination. This was confirmed by the multivariable regression analysis (adjusting for sex, BMI, tumor location, tumor type, and operative time). Based on categorical analysis of frailty tiers, increasing frailty was signicantly associated with increased risk of all adverse outcomes, with 'Severely Frail' patients demonstrating an effect size of 16 times larger for 30-day mortality and 3 times larger for major complication and hospital LOS.

Conclusion: Increasing frailty, as measured by mFI-5, and not increasing age, is an independent risk factor for poor postoperative outcomes in patients undergoing surgery for spinal tumors. The mFI-5 may be used for pre-operative risk stratification of spinal tumors patients.

8:00 - 8:02 am

415 Understanding the Natural History of Postoperative Pain and Opioid Use Following Spine Surgery via a SMS Application

Maria Punchak; Anish Agarwal; Disha S. Joshi, BS; Ruiying Xiong; Neil R. Malhotra, MD; Paul J. Marcotte, MD; Ali Ozturk, MD; Dmitriy Petrov, MD; James Schuster; William C. Welch, MD, FAANS, FACS; M. Kit Delgado; Zarina Ali, MD, FAANS

Introduction: There is a gap in understanding how best to appropriately balance opioid stewardship while managing post-operative neurosurgical pain, and minimizing the risks of opioid overprescribing. An SMS based application which immediately collects data on post-operative pain and opioid consumption can inform future prescribing guidelines.

Methods: A prospective, observational study was designed and carried out at a large, urban academic health system in Pennsylvania. Patients >/= 18 years, who underwent surgeries between October 2019 and May 2020 and who were enrolled in a comprehensive enhanced recovery after surgery (ERAS) program, were consented. Data on postoperative pain intensity and patient-reported opioid consumption was collected prospectively using this platform until post-operative month 3. We analyzed the association between the quantity of opioids prescribed and consumed.

Results: 517 patients consented for enrollment into this automated text messaging program. Median pain intensity at discharge from hospital was 4.6 out of a maximum of pain score of 10. All responders' pain scores gradually decreased during the 3 month follow up. During the follow up period, patients were prescribed a median of 40 tablets of 5 mg oxycodone equivalent pills (IQR: 28-40), and responders reported taking a median of 28 tablet equivalents (IQR: 17-40). Responders who were opioid-naïve vs opioid-tolerant took a similar median number of opioid pills post-operatively (28 [IQR: 17-40] vs 27.5 [17.5-40], respectively. There was a statistically significant positive correlation between the quantity of opioids prescribed and used during the 3 month follow up period (Pearson's R=0.85, 95% CI (0.80, 0.89), p<0.001). The correlation was stronger among patients who were discharged to a higher level of care (e.g. acute rehabilitation or skilled nursing facility).

Conclusion: This is one of the first studies to implement a scalable, patient-centered automated SMS system to measure postoperative pain intensity and quantify opioid use after spine and peripheral nerve surgeries. Using real-time, patient-centered pain assessment and opioid consumption data will allow for the development of evidence based opioid prescribing guidelines following spinal and nerve surgery.

8:02 - 8:04 am 416 6-year Follow-up of i-FACTOR® Peptide Enhanced Bone Graft vs Autograft in Single-level ACDF in a FDA IDE Study

Paul M. Arnold, MD, FAANS, FACS; Alexander R. Vaccaro, MD; Rick Sasso, MD; Benoit Goulet, MD; Michael G. Fehlings, MD, PhD, FAANS, FRCS; Robert F. Heary, MD; Michael Janssen; Branko Kopjar, MD, PhD, MS

Introduction: i-FACTOR is a composite bone substitute material consisting of a P-15 synthetic collagen fragment adsorbed onto anorganic bone mineral and suspended in an inert biocompatible hydrogel carrier. Previous analyses of the US FDA IDE study demonstrated the benefits of i-FACTOR compared to local autograft bone in single-level level anterior cervical discectomy and fusion at 12- and 24-months post-operative.

Methods: Of 319 subjects that participated in the IDE study 220 were enrolled into post-approval 6 years follow-up autograft (n = 114) or i-FACTOR (n = 105) in a cortical ring allograft and followed using radiological, clinical, and patient-reported outcomes.

Results: Fusion rates at 72 months were 99.0% in i-FACTOR subjects and 98.2% in autograft subjects, with a difference of 0.8% (95% C.I., (95% CI -2.3%, 4.0%). Mean improvement in NDI in i-FACTOR subjects was 28.56 (95% CI 24.79, 32.33) compared to 29.17 (95% CI 25.46, 32.88) in autograft subjects, with a difference of -0.61 (2.793) (95% CI -6.10, 4.88). Neurologic success rate at 72 months was 95.89% in i-FACTOR subjects and 93.33% in autograft subjects, with a difference of 2.6% (95% CI, -4.70%, 9.81%). Overall success rate was 68% in i-Factor and 62% in autograft subjects. Safety outcomes were similar between the 2 treatment groups. Secondary surgery at any cervical level occurred in 20 (18.9%) i-FACTOR subjects and 23 (20.2%) autograft subjects (p=0.866). Pain and SF-36 outcomes were similar between the groups at all study visits. There were no allergic reactions associated with i-FACTOR.

Conclusion: At 6 years, i-FACTOR in ACDF resulted in similar outcomes compared to local autograft bone. Safety outcomes are acceptable and the clinical and functional outcomes for i-FACTOR in the 12-month and 24-month studies are confirmed.

8:04 - 8:06 am

417 Clinical Accuracy and Initial Experience with Augmented Reality-Assisted Pedicle Screw Placement: The First 205 Screws

Ann Liu, MD; Yike Jin MD; Ethan Cottrill, BS; Majid Khan; Erick M. Westbroek, MD; Jeffrey S. Ehresman, BS; Zach Pennington, BS; Sheng-fu L. Lo, MD; Daniel Sciubba; Camilo A. Molina, MD; Timothy F. Witham, MD, FAANS

Introduction: Augmented reality (AR) is a novel technology which, when applied to spine surgery, offers the potential for efficient, safe, and accurate placement of spinal instrumentation.

Methods: A retrospective review was performed of the first 28 consecutive patients who underwent ARassisted pedicle screw placement in the thoracic, lumbar, and/or sacral spine at our institution. Clinical accuracy for each pedicle screw was graded using the Gertzbein-Robbins Scale by an independent, blinded neuroradiologist.

Results: Twenty-eight consecutive patients underwent thoracic, lumbar, or sacral pedicle screw placement with AR assistance. Median age at the time of surgery was 62.5 (IQR: 14) years and median BMI was 31 (IQR: 8.6) kg/m2. Indications for surgery included degenerative disease (n = 12, 43%), deformity correction (n = 12, 43%), tumor (n = 3, 11%), and trauma (n = 1, 4%). The majority of patients (n = 26, 93%) presented with low back pain, 19 (68%) patients presented with radicular leg pain, and ten (36%) patients had documented lower extremity weakness. A total of 205 screws were consecutively placed with 112 (55%) placed in the lumbar spine, 67 (33%) in the thoracic spine, and 26 (13%) at S1. Screw placement accuracy was 98.5% for thoracic screws, 97.8% for lumbar/S1 screws, and 98.0% overall.

Conclusion: AR depicted through a unique HMD is a novel and clinically accurate technology for the navigated insertion of pedicle screws. We describe the first 205 AR-assisted thoracic, lumbar, and sacral pedicle screws consecutively placed at our institution with an accuracy of 98.0% as determined by Gertzbein-Robbins Grade of A or B.

8:06 - 8:08 am

418 Incidence and Risk Factors of Prolonged Opioid Use Following Lumbar Spine Surgery: A Cohort Study

Anshit Goyal, MBBS; Stephanie Payne; Lindsey Sangaralingham; Molly Jeffery; James Naessens; Halena Gazelka; Elizabeth B. Habermann, PhD; Robert J. Spinner, MD, FAANS, FACS; Mohamad Bydon, MD, FAANS

Introduction: Sustained postoperative opioid use following elective surgery is a matter of growing concern.

Methods: The OptumLabs Data Warehouse (OLDW) was queried for postdischarge opioid prescriptions for patients undergoing elective lumbar decompression (LD) or posterior lumbar fusion (PLF) for degenerative spine disease. Only patients who received an opioid prescription at postoperative discharge and those who had a minimum of 180 days of insurance coverage prior to surgery and 180 days following surgery were included. Opioid-naive patients were defined as those who had no opioid fills in 180 days prior to surgery. The following patterns of long term postoperative use were investigated: additional fills (At least one opioid fill 90-180 days after surgery), persistent fills (Any span of opioid use starting in the 180 days after surgery and lasting at least 90 days) and CONsortium to Study Opioid Risks and Trends (CONSORT) criteria for persistent use (Episodes of Opioid Prescribing lasting longer than 90 days and 120 or more total days' supply or 10 or more prescriptions in 180 days after the index fill). Multivariable (MV) logistic regression was performed to identify predictors of long-term use.

Results: A total of 25,587 patients were included, of whom 52.7% underwent PLF (n=13,486) while and 32.5% (n=8,312) were opioid-naive prior to surgery. The rates of additional fills, persistent fills and CONSORT use were 47%, 30% and 23% respectively following PLF and 35.4%, 19% and 14.2% respectively following LD. The rates among opioid-naive patients were 18.9%, 5.6% and 2.5% respectively following PLF and 13.3%, 2.0% and 0.8% following LD. Using MV logistic regression, the following were identified to be significantly associated with higher risk of long-term opioid use following PLF: discharge opioid prescription =500 MMEs, prescription of a long-acting opioid, female sex, multi-level surgery and comorbidities such as depression and drug abuse (all p<0.05). Elderly (age =65 years) and opioid-naive patients were found to be at lower risk (all p<0.05). Similar results were obtained upon analysis for LD with the following significant additional risk factors were identified: discharge opioid prescription =400 MMEs, prescription of tramadol alone at discharge and inpatient surgery (all p<0.05).

Conclusion: In an analysis of pharamacy claims from a national insurance database, we identified incidence and predictors of long term opioid use following elective lumbar spine surgery.

8:08 - 8:10 am

419 Pre-operative subcutaneous ketamine and associated opioid tapering in patients undergoing spinal fusion surgery

R. Ganko; Le Chi Chiu; Jason Trang; Tillman Boesel; Sushama Deshpande; Mario D'Souza; Thanan Elalingam; Matthew Tait

Introduction: The global burden of opioid dependancy is significant, and pain management of these patients undergoing spinal fusion surgery is difficult. Multimodal approaches have been used. Ketamine, an NMDA receptor antagonist is increasingly being used to reduce post-operative allodynia and hyperalgesia. Increased opioid receptor sensitivity due to opioid sparing, is thought to play a role in improved response to opioids.

Methods: Increasing evidence of the benefit of ketamine in reducing opioid dependance perioperatively, led to a change in practice in our institution. From 2018, opioid dependent patients undergoing anterior or posterior cervical or thoracolumbar instrumented surgery, by one consultant, were consented to 48 hours of subcutaneous ketamine administration and concurrent opioid dose weaning prior to surgery (Group B). We compared 11 of these patients, to 11 consecutive patients undergoing surgery prior to this period, who had not received ketamine preoperatively (Group A). A retrospective analysis was performed.

Results: Group A had a mean reduction in morphine equivalent opioid consumption at discharge of 13.9 (82.20) mg. Morphine equivalent consumption in Group B, was reduced by 32.6 (54.82) mg (18.73, 95%CI: - 43.8, 81.2; p=0.54). There was an average 13% decrease in opioid use preoperatively, in Group B patients. With preoperative co-administration of 48 hours of subcutaneous ketamine, an average of 42% reduction in opioid use was obtained at time of operation. Pain scores on discharge increased by 1.33 (3.64) in patients who were not managed with preoperative ketamine, and reduced by 1.11 (2.67) in those who received ketamine (2.44, 95% CI: -0.7, 5.6; p=0.12).

Conclusion: Preoperative subcutaneous ketamine with concurrent opioid dose reduction in spinal fusion patients, is a novel way to improve postoperative outcomes and reduce the global burden of community opioid dependence. This is the first known study to show effective opioid tapering preoperatively with the co-administration of subcutaneous ketamine in patients undergoing spine fusion surgery.

8:10 - 8:12 am 420 Classifying Patients Operated For Spondylolisthesis: A Machine-Learning Analysis Of Clinical Presentation Phenotypes

Andrew Kai-Hong Chan, MD; Thomas A. Wozny, MD; Erica F. Bisson, MD, FAANS; Brenton H. Pennicooke, MD, MS; Mohamad Bydon, MD, FAANS ; Steven D. Glassman, MD; Kevin T. Foley, MD, FAANS; Christopher I. Shaffrey, MD, FAANS; Eric A. Potts, MD, FAANS; Mark E. Shaffrey, MD, FAANS; Domagoj Coric, MD; John J. Knightly, MD, FAANS; Paul Park, MD, FAANS; Michael Y. Wang, MD, FAANS; Kai-Ming G. Fu, MD, PhD, FAANS; Jonathan Slotkin, MD; Anthony L. Asher, MD, FAANS, FACS; Michael S. Virk, MD, PhD; Panagiotis Kerezoudis, MD; Mohammed A. Alvi, MD, MS; Jian Guan, MD; Regis W. Haid, MD, FAANS; Nitin Agarwal, MD; Vivian Le; Praveen V. Mummaneni, MD, FAANS

Introduction: Comparisons of controlled trials in patients with lumbar spondylolisthesis are difficult due to heterogeneity in the populations studied.

Methods: This is a study of the prospective QOD Spondylolisthesis Module, including patients who underwent single-segment surgery for grade 1 degenerative lumbar spondylolisthesis. Twenty-four-month patient-reported outcomes (PRO) were collected: ODI, NRS back pain (NRS-BP), NRS leg pain (NRS-LP), EQ-5D, and NASS Satisfaction. Variables were introduced into a k-means clustering analysis—an unsupervised machine learning algorithm—to identify clinical presentation phenotypes.

Results: Overall, 608 patients were identified, of which 507 patients (83.4%) had 24-month follow up. Clustering of the 507 patients revealed 2 distinct cohorts. Cluster 1 (high disease burden) was defined by younger patients, higher BMI and ASA grades, and globally worse baseline PROs. Cluster 2 (intermediate disease burden) was defined by older patients, lower BMI and ASA grades, and intermediate baseline PROs. Baseline radiographic parameters were similar (p>0.05). Both clusters improved clinically (p<0.001 all 24-month PROs). Mean 24-month ODI, NRS-BP, NRS-LP, and EQ-5D were markedly worse for the high disease burden cluster (adjusted p<0.001). However, the high disease burden cluster demonstrated greater 24-month improvements for ODI, NRS-BP, and EQ-5D (adjusted-p<0.05) and a higher proportion reaching ODI minimal clinically important difference (adjusted-p=0.001). However, the high disease burden cluster had lower satisfaction (adjusted-p=0.02).

Conclusion: Using an unsupervised machine learning algorithm, we define two distinct groups of patients those with high versus intermediate disease burden—who ultimately present for surgery. The high disease burden cluster—compared to the intermediate disease burden cluster—had worse 24-month satisfaction, disability, back pain, leg pain, and quality of life. However, the high disease burden cluster demonstrated greater 24-month improvements in disability, back pain, and quality of life and had a higher proportion reaching a minimum clinically important improvement in disability. The two clusters are associated with significantly different outcomes and it may be helpful for future investigations to consider these distinctly.

8:12 - 8:14 am 421 Clinical Reliability of Genomic Data Obtained from Spinal Metastatic Tumor Samples

Ori Barzilai, MD; Axel Martin; Anne Reiner; Ilya Laufer; Adam Schmitt; Mark H. Bilsky, MD, FAANS

Introduction: Though routinely used in clinical practice, there are no data exploring the reliability of genomic data obtained from spine metastases (SM) samples, often leading to multiple biopsies.

Methods: Spine tumor samples, obtained from 2013 to 2019, were analyzed using MSK-IMPACT, a nextgeneration-sequencing assay. Samples were matched to primary or metastatic tumors from the corresponding patients. A concordance rate for genomic alterations was calculated for matching pairs within patients for the SM and PT samples and for matching sample pairs of SM and VMs. A subgroup-analyses of known driver mutations specific to the primary histologies was performed.

Results: Eighty-four patients contributed next-generation-sequencing from a SM and at least one other site of disease: 54 from the PT, 39 from another VM, 12 patients from both. For the cohort of matched PT and SM (n = 54) comprised of mixed histologies, we found an average concordance-rate of 96.97% for all genetic events, 97.17% for mutations, 100% for fusions, 89.81% for deletions, and 97.01% for amplifications. The average concordance-rate of driver mutations was 96.99% for prostate, 95.69% for lung and 96.43% for breast cancer. An average concordance of 99.02% was calculated for all genetic events between SM and VM (n=41) and, more specifically, a concordance rate of 98.91% was calculated between SM and liver metastases (n=12).

Conclusion: Large-scale sequencing data performed on spine tumor samples demonstrate high concordance rates for genetic alterations between the PT and SM as well as between SM and VM, particularly for driver-mutations. Spine tumor samples may be reliably used for genomic-based decision-making in cancer care, particularly for prostate, NSCLC and breast cancer.

8:14 - 8:16 am 422 Lumbar Far Lateral Disc Herniation: Single Center Outcomes of Modified Technique

Arsalaan Salehani, MD; Nicholas J. Erickson, MD; Matthew S. Parr, BS; Travis Atchley, MD; James H. Mooney, MD; Sasha Howell; Nicholas M. Laskay, MD; Danielle Koch; Daniel K. Harmon, MD; Mamerhi O. Okor, MD

Introduction: Far lateral lumbar disc herniations account for approximately 10% of all lumbar disc herniations and are increasingly recognized in the era of advanced imaging techniques. These disc herniations typically result in extra-foraminal nerve root compression with the lumbar 4-5 (L4-5) level being most commonly affected. Minimally invasive spine (MIS) techniques are increasingly performed with various degrees of foraminal and facet drilling to decompress the affected nerve root. We present outcomes of a modified technique minimizing the degree of bony drilling required, theorizing less postoperative pain and reduced risk of iatrogenic spinal instability.

Methods: A retrospective chart review was completed of all patients undergoing MIS lumbar far lateral discectomy between 2010-2020. Demographic information including body mass index (BMI) and smoking status were collected. In addition, presenting symptoms, level of disc herniation, pre- and postoperative imaging findings, length of stay (LOS), symptom resolution, disposition, and need for repeat surgery or epidural steroid injection (ESI) were recorded.

Results: A total of 48 consecutive patients underwent MIS lumbar far lateral discectomies from 2010-2020. The mean age was 63 years old with 60.4% males, mean BMI 28.5, and 20.8% smokers. The most common presenting complaint was both low back and radicular pain (79.2%) with 8.3% of patients suffering from motor weakness preoperatively. The most commonly affected level was L4-5 (42%) followed by lumbar 3-4 (30%). No immediate postoperative complications occurred. Mean LOS was 1.3 days with 77.1% patients discharged postoperative day 1. Almost all patients (91.6%) were discharged home. Of the 46 patients in whom follow up was complete, 43 patients (93.5%) had improvement in their symptoms, and 27 (58.7%) ultimately had complete resolution in 2.6 months on average. Six patients (13%) had immediate resolution of symptoms postoperatively.

Conclusion: Using a 2cm incision 1.5cm off midline centered over the disc interspace allows MIS access to the extra-foraminal site of nerve root compression without the need for significant bony drilling. This minimizes postoperative pain and reduces the risk of iatrogenic spinal instability without sacrificing symptom resolution.

8:16 - 8:18 am 423 Safety and Efficacy of Low-Dose rhBMP-2 Use for Anterior Cervical Fusion

Stephen K. Mendenhall, MD; Eric A. Potts, MD, FAANS; Jean-Pierre Mobasser, MD

Introduction: The use of Recombinant Human Bone Morphogenetic Protein-2 (rhBMP-2) in routine anterior cervical fusion (ACF) is controversial. Early reports describe high complication rates. A variety of dosing regimens ranging from 0.6-2.1 mg/level fused have been reported. We hypothesize that the high amounts of rhBMP-2 used in these studies led to the high complication rates observed.

Methods: Patient inclusion criteria were 1) age 18-70; 2) initial stand-alone anterior cervical fusion construct; 3) fusion augmentation with rhBMP-2; and 4) at least 1 year of radiographic follow-up. A successful fusion was defined by either 1) lateral flexion-extension radiographs with <1 mm of movement across fused spinous processes or 2) bone bridging at least half the fusion area originally achieved by surgery on fine-cut CT. Patient demographics, perioperative data, and postoperative complications were recorded.

Results: A total of 198 patients met inclusion criteria and were included for analysis. Sixty-two (31%) were smokers. The median levels fused were 2 (1.25). The mean dose of rhBMP-2 was 0.50 ± 0.09 grams per level. Twenty-two (11%) of patients experienced dysphagia. Eleven (6%) patients experienced cervical swelling. Two (1%) patients returned to the OR for postoperative hematoma. One (0.5%) patient returned to the OR for seroma. Two (1%) patients experienced pseudarthrosis requiring a posterior fusion. Three (2%) patients experienced a new postoperative neurologic deficit that had recovered by last follow-up. Overall, 190 (96%) patients experienced solid arthrodesis over an average of 15-months follow-up. The fusion rate per number of levels fused was as follows: 1 level procedure, 96% (n=75/78); 2 level procedure 96% (n=68/71); 3 level procedure 95% (n=39/41); and 4 level procedure 100% (n=8/8). There was no difference in fusion rates between smokers and non-smokers, p = 0.7073.

Conclusion: The use of low-dose rhBMP-2 safely and effectively augments anterior cervical arthrodesis. Our low-dose protocol appears to significantly reduce complications associated with rhBMP-2 use in ACF compared to the literature. We recommend using low dose rhBMP-2 in smokers, multilevel ACFs, or other patients at high risk of developing pseudarthrosis.

8:18 - 8:20 am

424 Post-MACRA Trends in Lumbar MRI Utilization for Low Back Pain Patients Across 1,373 Reporting Hospitals

Ansh Desai; Tarun Jella; Alexander Acuña; Christina H. Wright, MD; James M. Wright, MD

Introduction: Centers for Medicare & Medicaid Services (CMS) operationalized the treatment of low back pain through the OP-8 score, which is calculated by dividing the number of patients who received MRI-L before receiving alternative treatments (ie physical therapy) by the total number of patients receiving MRI-L in the outpatient setting at a given institution. In other words, a lower OP-8 score signifies more efficient use of MRI-L.

Since the passage of the Medicare Access and CHIP Reauthorization Act of 2015 (MACRA), measurements like OP-8 scores have become increasingly tied to financial bonuses and penalties for hospitals.

Methods: The CMS "hospital compare" database was used to extract information for 1,373 hospitals that reported OP-8 scores. For variations across different years, states, Census regions, and hospital profit statuses, an ANOVA test was conducted. A two-tailed student's T-test was conducted to assess for variation across hospital settings.

Results: After an initial decrease from 2015 to 2016, OP-8 scores plateaued nationally, staying around 40% from 2017-2020 (lower percentage means more efficacious). The average OP-8 score by state varied from 31.7% (lowa) to 47% (Wyoming), and this variation was significant (p < .001). The variation across for-profit, government, and non-profit hospitals was also significant (p < .001), with government hospitals having the highest average at 41.17%. Critical access hospitals had an average of 44.78%, which was significantly higher than that of acute care hospitals (p < .001).

Conclusion: The implantation of MACRA seems to have been unsuccessful in altering practice patterns, given the minimal change in OP-8 scores over the last 4 years. Additionaly, current legislation does not address the institutional factors, such as hospital location and profit-status, that correlate with a lack of adherence to MRI protocols. Future studies should aim to further investigate the factors identified by this work, in an attempt to identify causality.

8:20 - 8:22 am

425 Relationship Between Physician Industry Payments and Cost of ACDF in Medicare Beneficiaries

Matthew Sklar; Christopher Leung; Harsh Wadhwa; Corinna C. Zygourakis, MD

Introduction: Neurosurgery and orthopedic spine surgeons receive substantial amounts of industry support, which is quantified publicly on the Open Payments website. Previous studies have suggested an association between industry payments and physician prescribing patterns for brand-name medications, but work on how industry support affects quality and cost of spine surgery is limited.

Methods: We identified all patients undergoing ACDF (CPT code 22551) from the 20% sample Medicare carrier files from January 1, 2014 through December 31, 2014 (n = 5089). We matched these to the Medicare MedPAR files in order to obtain total hospital charges (in US dollars), which were converted to cost using hospital and year-specific specific cost-to-charge ratios. The physician's full name, city, and state were used to match the operating room surgeon in the Medicare file to the Open Payments database. Industry support was obtained from the Open Payments database for 2014 and categorized by general payments (including royalty or licensing payments, consulting fees, and travel reimbursements), research support, and investments. Linear regression was performed with SAS software (Cary, NC).

Results: Matching across all relevant files resulted in 5,089 ACDF claims. The mean total cost for an ACDF in 2014 for Medicare beneficiaries was \$16,308 (+/- \$6,275). Linear regression found no association between the total hospital cost for ACDF and industry general payments, research support, or investments to the operating surgeon (P = 0.60, P = 0.61, and P = 0.43, respectively).

Conclusion: This study suggests that the amount of industry payments to spine surgeons does not impact the total cost of care for Medicare beneficiaries undergoing ACDF surgery.

8:22 - 8:24 am

426 Molecular Biomarkers & Survival in Breast Cancer Patients with Spine Metastases: A Systematic Review & Meta-analysis

Archis R. Bhandarkar; Mohammed A. Alvi, MD, MS; Shyam Kurian, BS; Waseem Wahood; Larry Prokop; Minetta Liu; Mohamad Bydon, MD, FAANS

Introduction: Reliable estimates of prognosis in patients who have breast cancer that has metastasized to the spine are crucial for patient counseling. A systematic review that investigates the influence of molecular biomarkers on prognosis in this patient population has yet to be performed.

Methods: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to search the literature for studies that reported overall survival (OS) after breast cancer patients presented with spine metastases or had surgery to treat spine metastases. Fixed-effects models were used to generate pooled estimates of hazard ratios. The I2 statistic was used to assess heterogeneity between studies.

Results: Molecular classifications with the greatest highest median OS in our qualitative synthesis included Luminal B status with a median OS of 50.48 months (95%CI: 44.65-56.30 months, n=38 patients, N=3 studies, I2 = 90.8%), PR+ status with a median OS of 32.30 months (95%CI: 25.12-39.48, n=182 patients, N=3 studies, I2 = 45.7%), and HER2+ status with a median OS of 31.31 months (95%CI: 21.29-41.34, n=71 patients, N=3 studies, I2 = 83.2%). Triple negative status had the lowest median OS at 11.70 months (95%CI: 9.99-13.40, n=77 patients, N=3 studies, I2 = 93.1%).

Conclusion: In patients who presents with breast cancer spine metastases, patients with Luminal B, PR+, and HER2+ status had the greatest pooled median OS. Triple negative status patient had the lowest pooled median OS.

8:24 - 8:26 am

427 Single-dose Versus Hypofractionated Focused Radiation in a Newly Developed Radiation-induced VCF Model

Alexander Perdomo-Pantoja, MD; Christina Holmes; Ioan A. Lina, BS; Jason Liauw, MD; Varun Puvanesarajah BS; Brian C. Goh; Chukwuebuka C. Achebe; Ethan Cottrill, BS; Warren Grayson; Kristin Redmond; Soojung C. Hur; Timothy F. Witham, MD, FAANS

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.

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.

Conclusion: Single-dose radiation was detrimental to a greater degree than hypofractionation for the microarchitectural, 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.
8:26 - 8:28 am 428 A Web-Based Calculator for Clinical Outcome Prediction in Sacral Tumor Surgery

James Feghali, MD; Zach Pennington, BS; Bethany Hung; Andrew Hersh; Andrew Schilling; Jeffrey S. Ehresman, BS; Siddhartha Srivastava, BS; Ethan Cottrill, BS; Daniel Lubelski, MD; Sheng-fu L. Lo, MD; Daniel M. Sciubba, MD

Introduction: Sacral tumors are incredibly rare lesions affecting fewer than 1 in every 10,000 persons. Reported perioperative morbidity rates range widely, varying from 30-70%, due to the relatively low volumes seen by most centers. Consequently, individual risk profiling based upon surgeon experience is difficult.

Methods: We reviewed the records of all sacral tumor patients treated at a single comprehensive cancer center. Details were gathered about tumor pathology and morphology, surgery performed, baseline medical comorbidities, preoperative lab data, and patient demographics. Multivariable regressions were conducted to identify independent risk factors of the following outcomes: 1) perioperative complications, 2) hospital length of stay (LOS), 3) non-home discharge, 4) 30-day readmission, and 5) 30-day reoperation. Models were designed using the Akaike Information Criterion, internally validated using 1000 bootstrapped samples, and deployed as web-based calculators.

Results: 132 sacral tumor patients were included (mean age 52.3±14.4 years; 55% female). Independent predictors of perioperative complications included presacral extension (OR=2.4; p=0.044) and surgical invasiveness (OR=1.02 per point; p=0.054). Independent predictors of LOS included American Society of Anesthesiologists class (β =4.9; p=0.031); tumor volume (β =0.03 per cm³; p<0.001), and surgical invasiveness (β =0.3 per point; p<0.001). Tumor volume (OR=1.004; p=0.043), preoperative gait difficulty (OR=4.9; p=0.005), and surgical invasiveness (OR=1.06 per point; p=0.001) predicted non-home discharge. 30-day readmission was predicted by presacral tumor extension (OR=1.3; p=0.04) and 30-day reoperation was predicted by use of an anterior approach (OR=7.3; p=0.007) and surgical invasiveness (OR=1.041; p=0.016). Validation showed the models predictive value ranged from moderate for the LOS model (R²=0.698) to good for the non-home discharge model (C-statistic 0.859). The models were deployed online: https://jhuspine4.shinyapps.io/Sacral Tumor Outcome Calculator/

Conclusion: Based upon the experience of a single comprehensive cancer center, tumor morphology and surgical invasiveness appear to be the strongest predictors of perioperative outcomes in patients treated for sacral tumors. The calculators developed herein are presented as proofs-of-concept for use by spinal oncologists as clinical decision aids when counseling patients with sacral tumors.

8:28 - 8:30 am

429 Association between Vitamin D Deficiency and Surgical Site Infection Following Elective Lumbar Fusions

Ryan F. Planchard, MD; Safwan Alomari; Tej D. Azad, MD; James Feghali, MD; Daniel M. Sciubba, MD; Timothy F. Witham, MD, FAANS; Nicholas Theodore, MD, FAANS, FACS; Ali Bydon, MD, FAANS

Introduction: Vitamin D deficiency has been associated with higher rates of SSI following a variety of surgical procedures. However, this association has been under-investigated for spinal procedures.

Methods: Patients who underwent lumbar fusions between 2011-2014 were reviewed from the HCUP-NIS database. Propensity score matching was utilized to minimize effect of confounding variables between the 2 groups (normal vitamin D vs vitamin D deficiency).

Results: A total of 238,875 cases of lumbar fusions met inclusion criteria for analysis. These included posterior/transforaminal lateral interbody fusions (PLIF/TLIF), Anterior lumbar interbody fusion (ALIF) and lateral lumbar interbody fusion (LLIF). 22,454 (9.4%) patients carried the diagnosis of vitamin D deficiency and were significantly more likely to be non-white (26.5% vs. 19.9%) and obese (21.1% vs. 15.4%) as compared to patients without deficiency. Other patient characteristics, socioeconomic factors, and hospital setting were comparable between two groups. SSI rates were compared between matched cohorts (18,350 patients in each). In patients without vitamin D deficiency, there were 202 (1.1%) cases of SSI recorded, while there were 1266 (6.9%) cases of SSI recorded in patients with vitamin D deficiency (P<0.001). Patients with vitamin D deficiency had higher incidence of thromboembolic events (2.6% vs. 0.3%), length of hospital stay (5.7 vs. 3.4 days) as well as increased hospital charges (87,812\$ vs.79,650),(P <0.05).

Conclusion: Optimizing preoperative vitamin D level could be potentially a cost-effective strategy to reduce the rate of SSI, thromboembolic events and prolonged hospital stay in patients undergoing lumbar fusion. Further cost-effectiveness analyses are encouraged to make definitive claims regarding pre-operative vitamin D screening/supplementation in these patients.

8:30 - 8:32 am

430 Surgical Site Infections Following Spine Surgery: The Effect of Seasonality

William Shuman; Adam Y. Li, BS; Jonathan S. Gal, MD; Sean N. Neifert, BS; Theodore Hannah, BA; Nickolas Dreher; Alex J. Schupper; John M. Caridi, MD, FAANS; Tanvir Choudhri, MD

Introduction: Several risk factors for surgical site infections (SSI) after spine surgery are known. Recent research has investigated seasonality as such a factor, with mixed results.

Methods: The National Surgical Quality Improvement Project (2011-2018) was queried for patients undergoing posterior cervical fusion, cervical laminoplasty, posterior lumbar fusion, lumbar laminectomy, and spinal deformity surgery. Patients older than 89, non-elective surgeries, and procedures for tumors, fractures, infections, were excluded. Patients were divided into warm (April-September) and cold (October-March) seasons by admission date. Demographics were compared using univariate analysis. Endpoints of SSI and reoperations for wound debridement or drainage were compared using univariate analysis and multivariable logistic regression. Stratified analyses were performed by surgery type and whether infections occurred before or after discharge.

Results: In the overall population (N=208,291), SSI was more likely in the warm season (OR=1.15, 95%CI=1.08-1.23, p<0.0001), as well as for posterior cervical fusions (OR=1.40, 95%CI=1.08-1.80, p=0.011), posterior lumbar fusions (OR=1.15, 95%CI=1.04-1.28, p=0.006), and lumbar laminectomies (OR=1.13, 95%CI=1.03-1.25, p=0.014). Post-discharge infections were also more likely in the warm season overall (OR=1.15, 95%CI=1.07-1.23, p<0.0001), and for cervical (OR=1.32, 95%CI=1.01-1.73, p=0.041) or lumbar (OR=1.14, 95%CI=1.03-1.27, p=0.014) fusions, and laminectomies (OR=1.15, 95%CI=1.04-1.27, p=0.007). Inhospital infections were more likely during the warm season only for cervical fusions (OR=2.54, 95%CI=1.06-6.10, p=0.037). Reoperations for infection were more likely during the warm season for lumbar fusions (OR=1.29, 95%CI=1.08-1.54, p=0.005).

Conclusion: Posterior cervical and lumbar fusion and lumbar laminectomy surgeries during the warm season had significantly higher odds of SSI, especially post-discharge. Reoperation rates for wound management were also significantly elevated during the warm season for lumbar fusions. No seasonality effect was found in cervical laminoplasty or deformity surgery. Identifying causes of seasonal effects merits further investigation and may influence surgeon scheduling and expectations.

8:32 - 8:34 am 431 Validation of Machine Learning-based Frailty Indices to Predict Adverse Events after Surgery for Spinal Metastases

Elie Massaad; Natalie Williams; Ali Kiapour, PhD; Muhamed Hadzipasic, MD, PhD; Ganesh Shankar, MD, PhD; John H. Shin, MD, FAANS

Introduction: Frailty is recognized as an important consideration in patients with cancer undergoing therapies, including spine surgery. The definition of frailty in the context of spinal metastases is unclear and few have studied such markers and their association with postoperative outcomes and survival. The Metastatic Spinal Tumor Frailty Index (MSTFI) was developed using national databases as a tool to predict outcomes in this specific patient population and has not been tested with external data.

Methods: Electronic health record data from 479 adult patients admitted to a tertiary academic hospital from 2010 to 2019 for metastatic spinal tumor surgery formed a validation cohort for the MSTFI to predict major complications, in-hospital mortality, and length of stay (LOS). The 9 parameters of the MSTFI were modeled in three machine learning algorithms (Lasso regularization logistic regression, random forest, gradient-boosted decision tree) to assess clinical outcomes prediction and determine variable importance. The models' prediction performance was measured by computing C-statistics, calibration, confusion matrix metrics (positive predictive value, sensitivity, and specificity), and subjected to internal bootstrap validation

Results: Of 479 patients, (median age 64 years; interquartile range, 55-71 years; 58.6% male), 28.4% had complications after spine surgery. The in-hospital mortality rate was 1.9% and mean LOS was 7.8 days. The MSTFI demonstrated poor discrimination for predicting complications [C statistic; 0.56 (95% CI, 0.50-0.62)] and in-hospital mortality [C statistic; 0.69 (95% CI, 0.54-0.85)] in the validation cohort. For postoperative complications, machine learning approaches showed a greater advantage over the logistic regression model used to develop the MSTFI {[C statistic, 0.62 (95% CI, 0.56-0.68)] for random forest vs. [0.56 (95% CI, 0.50-0.62)] for logistic regression}. Random forest had the highest positive predictive value (0.53; 95% CI, 0.43-0.64), and highest negative predictive value (0.77; 95% CI, 0.72-0.81) with chronic lung disease, coagulopathy, anemia, and malnutrition identified as the most important predictors of postoperative complications.

Conclusion: This study highlights the challenges of defining and quantifying frailty in the metastatic spine tumor population. Further study is required to improve the determination of surgical frailty in this specific cohort.

8:34 - 8:36 am

432 A Web-based Calculator for Wound Complications After Metastatic Spine Tumor Surgery

Andrew Hersh; James Feghali, MD; Bethany Hung; Zach Pennington, BS; Andrew Schilling; Albert Antar; Jaimin Patel; Jeffrey S. Ehresman, BS; Daniel Lubelski, MD; C. Rory Goodwin, MD, PhD; Daniel M. Sciubba, MD

Introduction: Surgery for spinal metastases is associated with a significant risk of both wound infection and wound dehiscence, with previous series describing rates between 4.5% and 20%. These complications likely worsen short-term quality of life, increase healthcare utilization, and oftentimes require reoperation. Understanding the drivers of these complications may thereby facilitate better outcomes in spine metastasis patients.

Methods: Patients treated at a single comprehensive cancer center between April 2013-2020 were retrospectively identified. Demographic information, primary pathology, clinical characteristics, pre-operative laboratory values, and operative details were collected. Factors with p<0.15 on univariate regression were entered into a stepwise multivariable logistic regression to generate predictive models that were internally validated using 1000 bootstrapped samples.

Results: 330 patients were included in the study, of which 29 (7.6%) experienced surgical site infections. Independent predictors of increased odds of a wound-related complication included a higher Charlson Comorbidity Index (CCI) (OR=1.41 per point; p<0.001), Karnofsky Performance Status (KPS) score = 70 (OR=2.14; p=0.04), lower pre-operative platelet count (OR=0.49 per 105/ μ L; p=0.001), undergoing revision versus index surgery (OR=3.10; p=0.02), and increased incision length (OR=1.21 per level; p=0.02). Independent predictors of increased odds of wound infection included a higher CCI (OR=1.60 per point; p<0.001), lower pre-operative platelet count (OR=0.35 per 105/ μ L; p<0.001), undergoing revision versus index surgery (OR=4.63; p=0.01), and increased incision length (OR=1.25 per level; p=0.03). Finally, independent predictors of undergoing reoperation for a wound complication included higher CCI (OR=1.39 per point; p=0.003), prior radiation therapy (OR=2.52; p=0.04), lower pre-operative platelet count (OR=0.57 per 105/ μ L; p=0.02), and undergoing revision versus index surgery (OR=3.34; p=0.03), The optimism-corrected areas under the curve (AUCs) were 0.75, 0.81, and 0.72 for the wound complication, infection, and reoperation models, respectively. The models were deployed as web-based calculators (https://jhuspine4.shinyapps.io/MetsWoundComplications/).

Conclusion: We identified low pre-operative platelet count, increased baseline medical comorbidities, longer incision length, and undergoing revision versus index surgery as predictors of increased risk of wound infection and wound complications following surgery for spine metastases. Future research can assess whether interventions to increase platelet count will decrease post-operative complications and reoperation rates. The calculators can be used by spine oncologists when counseling patients about surgery for spinal metastases.

8:36 - 8:38 am 433 A Biomechanical Investigation of Lumbar Interbody Fusion Techniques

Jamie Baisden, MD, FAANS; Sagar Umale, PhD; Hoon Choi, MD, PhD, FAANS; Narayan Yoganandan

Introduction: The anterior, posterior ,transforaminal and circumferential lumbar interbody fusions (ALIF,PLIF, TLIF, CLIF/360) are used to treat spondylolisthesis, trauma, and degenerative spinal pathologies.

Methods: A validated T12-sacrum lumbar spine finite element model FEM) was used to simulate surgical fusion at the L4-L5 segment using ALIF, PLIF with one and two cages, TLIF with unilateral and bilateral fixation, and CLIF/360. The models were simulated under pure-moment and combined (moment and compression) loadings to investigate the effect of different lumbar interbody fusion techniques on range of motion, forces transferred through the vertebral bodies, disc pressures, and endplate stresses.

Results: The range of motion of the spine was most decreased for fusions with bilateral posterior instrumentations (TLIF, PLIF, and CLIF/360). The increase in forces transmitted through the vertebrae and increase in disc pressures were directly proportional to the range of motion. The discs superior to fusion were under higher pressure, which was attributed to adjacent segment degeneration in the superior discs. The increase in endplate stresses was directly proportional to the cross-sectional area and was greater in caudal endplates at the fusion level, which was attributed to cage subsidence.

Conclusion: The response of the models was in line with overall clinical observations from the patients and can be further used for future studies, which aim to investigate the effect of geometrical and material variations in the spine. The model results will assist surgeons in making informed decisions when selecting fusion procedures based on biomechanical effects.

8:38 - 8:40 am

434 Transforaminal versus lateral lumbar interbody fusion: Analysis of the Michigan Spine Surgery Improvement Collaborative

Michael J. Strong, MD, PhD; Timothy J. Yee, MD; Siri Sahib Singh Khalsa, MD; Yamaan S. Saadeh, MD; Osama Kashlan, MD; Jacob R. Joseph, MD; Nicholas J. Szerlip, MD, FAANS; Paul Park, MD, FAANS; Mark E. Oppenlander, MD

Introduction: Interbody fusion techniques including lateral lumbar (LLIF) or transforaminal lumbar (TLIF) are commonly employed to treat a multitude of spinal pathologies including degenerative spondylosis and spondylolisthesis. While the concept of direct decompression using TLIF or indirect decompression using LLIF is controversial and still debated, the question of which approach to use for single level treatment remains unanswered.

Methods: Retrospective analysis of prospectively collected clinical and operative characteristics within the Michigan Spine Surgery Improvement Collaborative (MSSIC) database was performed for all patients (> 18 years) who underwent interbody fusion (LLIF or TLIF) combined with posterior instrumentation for degenerative spondylosis at the University of Michigan, from 2015 to 2019. Operative characteristics, complications, and patient reported quality scores were assessed.

Results: One hundred sixty-eight patients were identified with 50 patients in the LLIF group and 118 patients in the TLIF group. The average surgical time was significantly less in the LLIF compared to the TLIF group (194.1 min vs 222.9 min). Similarly, average blood loss was less in the LLIF group (59.3 mL vs 296.9 mL). A total of 9 intraoperative complications occurred in the TLIF group compared to zero in the LLIF group. Furthermore, 4 patients required re-operation in the TLIF group. Despite having no intraoperative complications in the LLIF group, approach-related complications in the form of thigh numbness and weakness was significantly higher compared to TLIF. Lastly, the majority of patient-reported outcome measures were not statistically significant between LLIF and TLIF, except for the VAS back pain score, which demonstrated an improved score at 90 days and 2 year follow up for TLIF compared to LLIF.

Conclusion: The use of both LLIF and TLIF are both highly effective in improving patients' symptoms and function. Although the TLIF group had a higher rate of intraoperative and perioperative complications, back pain scores seem to improve more in this group. There is decreased operative time and blood loss for the LLIF group; however, approach-related complications were higher.

8:40 - 8:42 am 435 Results of a Multi-center Randomized Clinical Trial Comparing Surgical Strategy for Cervical Myelopathy

Zoher Ghogawala, MD, FAANS; Melissa Dunbar; Janis Breeze; Adam S. Kanter, MD, FAANS; Praveen V. Mummaneni, MD, FAANS; Erica F. Bisson, MD, FAANS; Frederick G. Barker, MD, FACS; James S. Harrop, MD, FAANS; Subu N. Magge, MD, FAANS; Robert F. Heary, MD; Michael G. Fehlings, MD, PhD, FAANS, FRCS; Todd Albert, MD; Paul M. Arnold, MD, FAANS, FACS; K. Daniel Riew, MD; Michael P. Steinmetz, MD, FAANS; Marjorie C. Wang, MD, MPH; Robert G. Whitmore, MD; John Heller; Edward C. Benzel, MD, FAANS

Introduction: Cervial spondylotic myelopathy is the most common cause of spinal cord dysfunction worldwide. The optimal surgical approach is not known.

Methods: A randomized clinical trial of patients aged 45 to 80 years with multi-level cervical spondylotic myelopathy enrolled 163 patients at 15 large North American Hopsitals from 2014-2018. Two-year follow-up was obtained by April 15, 2020. Patients were randomized to ventral surgery (n=63) or dorsal surgery (n=100). Ventral surgery involved anterior cervical discectomy and instrumented fusion. Dorsal surgery involved either laminectomy and instrumented fusion or laminoplasty. Choice of dorsal surgery (laminoplasty vs. fusion) was at surgeon's discretion. Primary outcome was the change in SF-36 PCS score at 1 and 2 years. Secondary outcomes included change in 1-year mJOA score, complications, work status, health resource utilization (diagnostic imageing, opioid utilization, physical therapy), and change in neck disability index or EQ-5D scores.

Results: Among 163 patients who were randomized (mean age 62 years, 49% female), 155 (95%) completed 1-year follow-up (80% at 2 years). All patients had surgery, but 5 did not received their allocated assignment (ventral , n=1; dosral, n=4). One-year SF-36 PCS mean improvement was not significantly different between ventral surgery (5.9 points) and dorsal surgery (6.2 points) (P=0.86). Ventral surgery had more complications than dorsal surgery (48% vs 24%, P=0.002). A pre-specified secondary nonrandomized analysis showed that laminolasty was associated with greater improvement in SF-36 PCS score compared with dorsal fusion at 1 year (9.4 vs 4.6 points; P=0.02) and at 2 years (10.1 vs 4.3 points; P=0.01). Laminoplasty was associated with a nonsignificant difference vs ventral fusion at 1 year 9.6 vs 5.7; P=0.06) and was associated with a significant imporvement vs ventral fusion at 2 years 10.1 vs 5.0; P=0.02). Laminoplasty was also associated with fewer complications (P=0.002), less diagnostic imaging (p=0.02), less opioid usage (P=0.02) and less ongoing physical therapy (P=0.03).

Conclusion: Among patients treated for cervical myelopathy, both ventral and dorsal surgery provide comparable and significant improvements. A secondary nonrandomized analysis found that laminoplasty was associated with superior patient-reported physical functioning, fewer complications, and less outpatient health resource utilization for 1 year after surgery compared to ventral or dorsal fusion options.

8:42 - 8:44 am

436 Thoracolumbar Interfascial Plane Block Reduces Postoperative Opioid Consumption Compared to Traditional Field Block

Gregory D. Brusko, MD; Victor M. Lu, MD; Peter Borowsky; Michael Y. Wang, MD, FAANS

Introduction: Local infiltrative anesthetics are commonly administered intraoperatively to provide a local field block for several days after surgery. How these blocks exactly impact the immediate postoperative pain management following lumbar spine surgery is unclear.

Methods: A retrospective review of a single surgeon, single institution series of adult thoracolumbar fusion patients was conducted between July 2019 and November 2020. Patients were divided into the TLIP or Traditional group depending on which infiltration technique was used. All opioid amounts were converted into morphine milligram equivalents (MMEs) for standardization. Analyses were conducted using chi-square exact test and Wilcoxon rank-sum test for categorical and continuous data, respectively.

Results: A total of 136 patients were included. Sixty-four (47%) and 72 (53%) managed by TLIP and traditional approaches respectively. Overall mean age was 66.1 years (range, 26-85) with 63 (46%) males and 73 (54%) females, with no significant difference between groups. TLIP patients on average required less hydromorphone than Traditional patients on POD1 (25.1 vs 58.1mg, P=0.03) and overall (99.2 vs 184mg, P=0.04), less diazepam overall (4.1 vs 10.4mg, P=0.01) and less overall opioid medication on POD1 (65.9 vs 95.6 MME, P=0.04) and overall (221 vs 325 MME, P=0.03). There was no statistical difference in Percocet use, or any opioid medications on POD0. TLIP patients experienced shorter length of stay compared to the Traditional group although this difference did not achieve significance (3.0 vs 3.6, P=0.28). Complication rates were comparable between groups.

Conclusion: In our single surgeon series of thoracolumbar fusion patients, those managed by TLIP required less hydromorphone and diazepam, as well as total narcotics during their hospital stay. This could a consequence of less severe pain and muscle spasms postoperatively. Therefore, TLIP blocks appear to be an effective adjunct to multimodal analgesic regimen to reduce postoperative narcotics consumption following thoracolumbar fusion with minimal clinical risk.

8:44 - 8:46 am

437 Exploring the Relationship Between Smoking Cessation Therapy and Lumbar Fusion Outcomes: A Matched Analysis

Owoicho Adogwa, MD, MPH; Syed I. Khalid; Sai Chilakapati; Palvasha Deme; Rachyl Shanker; Ravi S. Nunna, MD; Samantha Maasarani; Brittany Hunter; Nicholas Duff; Jennifer Smith; James Caruso, MD; Tabinda Ali; Ravinderjit Singh; Cody M. Eldridge

Introduction: While there are several reports on the impact of smoking tobacco on spinal fusion outcomes, there is minimal literature on the influence of modern cessation therapies on such outcomes.

Methods: MARINER30, an all-payer claims database, was utilized to identify patients undergoing single-level lumbar fusions between 2010 and 2019. The primary outcomes were the rates of any complication, symptomatic pseudarthrosis, need for revision surgery, and all-cause readmission within 30 and 90-days.

Results: The exact matched population analyzed in this study contained 31,935 patients undergoing singlelevel lumbar fusion with 10,645 (33.33%) each in the following groups: (1) patients on smoking cessation therapy; (2) active smokers; and (3) those without any smoking history. Patients undergoing smoking cessation therapy have reduced odds of developing any complication following surgery (OR 0.86, CI 95% 0.80-0.93) when compared to actively smoking patients. Nonsmokers and patients on cessation therapy had a significantly lower rate of any complication (17.01% vs. 19.21% vs. 9.53%, (smoking cessation vs. active smokers vs. nonsmokers)) and revision surgery (1.95% vs 2.33% vs 1.59%) compared to the smoking group.

Conclusion: When compared to active smoking, preoperative smoking cessation therapy within 90 days of surgery decreases the likelihood of all-cause postoperative complications. However, there were no between group differences in the rates of pseudarthrosis, revision surgery, or readmission within 90 days.

8:46 - 8:48 am 438 Race and Survival Rate of Spinal Astrocytoma Patients: A 20-year Observational Study Using the SEER Database

Kyle McGrath; Chris Karas, MD, ABNS

Introduction: Spinal astrocytomas are primary tumors found in the intramedullary compartment of the spinal cord. They are a subclassification of gliomas, the most common type of central nervous system tumor. Astrocytomas are commonly seen in young adult populations and can exhibit benign or malignant behavior. We reviewed racial discrepancies in the observed survival of spinal astrocytomas over a 20-year period.

Methods: We gathered survival data for spinal cord astrocytoma patients from the National Cancer Institute's Surveillance Epidemiology and End Results (SEER) Database. The data consisted of 12, 24, 36, 48, and 60-month survival rates of patients of all ages and genders with respect to race for the decades of 1990-1999 and 2000-2009.

Results: The SEER Database collected 268 total patients between 1990 and 2009. Short and long-term survival rates were compared across both decades (1990-1999 rates vs. 2000-2009 rates). All patients: Short-term (12-month) survival (+2% [83%; 85%]); long term (60-month) survival (+14% [60%; 74%]). White population: Short-term survival (+4% [81%; 85%]); long-term survival (+12% [61%; 73%]) survival. Black population: Short-term survival (-11% [90%; 79%]); long-term survival (+15% [64%; 79%]). All other races (American Indian, Alaska Native, Asian, and Pacific Islander) collectively: Short-term survival (+9% [82%; 91%]); long-term survival (+28% [45%; 73%]).

Conclusion: All groups individually witnessed an increase in short and long-term survival with the exception of African Americans. The African American population witnessed a significant decrease in short-term survival, being the only group in which survival did not improve over the 20-year period. It may be expected that during the study period, improved access to care and understanding of this disease would lead to an increase in survival rates for all populations, however a significant decrease in short-term survival in the African American population may suggest otherwise. This study has successfully demonstrated SEER's utility as a public epidemiological database, and we hope this data influences further study of how this disease affects underserved populations.

8:48 - 8:50 am

439 Robotic Prone Trans Psoas (RPTP): Harnessing Robotic Assistance for Prone, Circumferential Access to the Lumbar Spine

David R. Santiago-Dieppa, MD; Arvin R. Wali, MD; Lauren Stone, MD; Martin H. Pham, MD; William R. Taylor, MD; Andrew D. Nguyen, MD, PhD

Introduction: Effective decompression, arthrodesis, and correction of deformity frequently requires exposure of both the anterior and posterior spinal column (APSC). Recently our group described the Prone Trans Psoas (PTP) approach, a novel technique that facilitates simultaneous access to the APSC utilizing a single position. Concurrently, robotic spine techniques are rapidly emerging as an important tool in minimally invasive spine surgery, and the current report describes our early experience combining these techniques.

Methods: The operative technique for accessing the lateral lumbar interbody space from a prone transpsoas approach and simultaneously placing robotic pedicle screws is described within this manuscript. The rationale for combining these techniques and illustrative cases is reviewed.

Results: The RPTP approach has been performed in 11 patients to access interbody levels ranging from L1-L5. We found that performing the procedure in the prone position enabled efficient completion of an anterior column arthrodesis, direct posterior decompression, multi-segment pedicle fixation, and restoration of alignment, in a single prone position. We found that the prone position seamlessly facilitated robotic assistance. There were no intraoperative or postoperative complications.

Conclusion: The authors early experience with the RPTP technique suggest that it is safe and effective approach that allows for single-position surgery maximizing both anterior and posterior column access and corrective techniques. Further long-term follow-up studies of this technique are under investigation.

8:50 - 8:52 am

440 Factors Associated with Adjacent Level Progression Following Surgery-Radiosurgery for Metastatic Spinal Cord Compression

Vikram Chakravarthy, MD; Hammad A. Khan, BS; Shaarada R. Srivatsa, BA; Todd Emch; Ajit A. Krishnaney, MD, FAANS

Introduction: Separation surgery followed by spine stereotactic radiosurgery has been shown to achieve favorable rates of local tumor control and patient-reported outcomes in patients with metastatic epidural spinal cord compression (MESCC). However, factors associated with adjacent level progression (ALP) in this population are unknown. The present study aimed to identify factors associated with ALP and examine its association with overall survival (OS) in patients receiving surgery-radiosurgery for MESCC.

Methods: Patients who underwent separation surgery followed by radiosurgery for MESCC at a tertiary referral center were retrospectively reviewed. Radiologic measurements were collected from preoperative, postoperative, and post-radiosurgery MRIs. Statistical analysis was conducted using the Kaplan-Meier product-limit method and cox proportional hazards test. Subgroup analysis was conducted for patients who experienced tumor progression into the adjacent epidural space (ALP-E).

Results: Our cohort included 39 patients with a median OS of 14.7 months (2.07-96.3). ALP was observed in 16 patients (41.0%) at a mean of 6.1 \pm 5.4 months post-radiosurgery, of whom 4 patients (10.3%) experienced ALP-E. Patients with ALP had shorter OS (13.0 vs. 17.1 months, p=0.047) compared to those without ALP. Factors associated with an increased likelihood of ALP included the amount of bone marrow infiltrated by tumor at the index level, amount of residual epidural disease following separation surgery, and prior receipt of radiotherapy at the index level (p<0.05). Subgroup analysis revealed that primary tumor type, amount of preoperative epidural disease, time elapsed between surgery and radiosurgery, and prior receipt of radiotherapy at the index level were significantly associated with ALP-E (p<0.05).

Conclusion: To the authors' knowledge, this study is the first to identify possible risk factors for ALP and suggest that it may be associated with shorter OS in patients receiving surgery-radiosurgery for MESCC. Future studies with higher power should be conducted to further characterize factors associated with ALP in this population.

8:52 - 8:54 am 441 Is it Better to Stop at C2 or C3/4 in Elective Posterior Cervical Decompression and Fusion?

Steven G. Roth, MS, MD; Inamullah Khan, MD; Silky Chotai, MD; Byron Stephens; Amir Abtahi; Clinton J. Devin, MD; Scott L. Zuckerman, MD

Introduction: When performing posterior cervical laminectomy and fusion (PCLF), spine surgeons must select the upper instrumented vertebrae (UIV), frequently choosing to stop at C2 or the subaxial cervical spine (C3/C4). Differences in long-term complication rates and patient-reported outcomes (PROs) for these techniques remain unknown.

Methods: A single-institution, prospective, longitudinal registry was queried for patients undergoing elective PCLF for degenerative conditions from 12/2010-06/2018. Patients with a UIV of C1 or above and C5 and below, and those with non-degenerative etiologies were excluded. Included patients were divided into those with a UIV of C2 or C3/C4. Cohorts were 2:1 propensity matched for the variable of fusion extension to the thoracic spine. Demographic, operative, complication, and 1-year PRO data were collected. Student's t-tests and chi-squared tests were performed.

Results: A total of 117 patients were successfully propensity matched (44 C2 vs. 88 C3/C4). Demographics were similar between groups, notably including fusion extension to the thoracic spine (p=0.588). As expected, the C2 group featured more levels fused (5.63 ± 1.89 vs. 4.50 ± 0.91 , p=0.001) and longer operative times (225 ± 63 vs. 181 ± 45 , p<0.001). No differences in estimated blood loss (EBL) (365 ± 307 vs 422 ± 465 , p=0.494) or length of stay (LOS) (4.38 ± 4.10 vs. 3.85 ± 3.04 , p=0.424) were detected. Twenty-one total adverse events were recorded. Identical surgical complication rates (7.7%, p=1.000) were seen including pseudoarthrosis and implant failure (5.1%, p=1.000). Both groups achieved significant improvement in PROs at 1-year including EQ-5D, numeric rating scale-neck/arm pain, and neck disability index. A subanalysis of the C2 cohort by screw type (pedicle, pars, laminar) revealed no significant differences in operative data, complications, or PROs.

Conclusion: In a cohort of patients undergoing PCLF, those with a UIV of C2 had only longer operative times compared to those with an UIV of C3/C4, with no differences in EBL, LOS, complication rates, or 1-year PROs. Screw type at C2 did not impact outcomes. These results suggest, with the exception of increased operative times, extension to C2 has no appreciable difference on surgical outcomes.

8:54 - 8:56 am

442 Radiographic and Clinical Outcomes Related to Interbody Cage Morphology in Transforaminal Lumbar Interbody Fusions

Nathaniel Toop, MD; Dominic Maggio, MD, MBA; James Oosten; Kyle Deistler; Ty Gilkey; Francis Farhadi, MD , PhD; Andrew J. Grossbach, MD, FAANS; Stephanus Viljoen, MD

Introduction: Transforaminal lumbar interbody fusion with posterior instrumentation (TLIF) is an effective treatment for degenerative lumbar spondylolisthesis. While various interbody cage designs are in common use, associations between cage morphology and outcomes have not been thoroughly investigated.

Methods: We retrospectively reviewed consecutive one- and two- level TLIFs at a single tertiary care center between August 2012 and November 2019 with minimum one year follow-up. Two cohorts were compared based on interbody cage morphology: steerable "banana" versus straight "bullet" shaped cages. Patient reported outcome measures (PROMs), radiographs, and complications were analyzed.

Results: 114 patients with 149 interbody cages were identified; 29 patients with 32 straight cages and 85 patients with 117 banana-shaped cages. PROMS significantly improved with both cage types, but comparatively greater for SF-36 Pain with banana-shaped cages $(15.1 \pm 32.5 \text{ versus } 39.0 \pm 29.0, p=0.02)$. Segmental lordosis increased with banana-shaped, while segmental lordosis decreased with straight cages $(3.5 \pm 5.4 \text{ vs} - 2.3 \pm 5.0, p<0.001)$. Conversely, adjacent-level segmental lordosis decreased in the former, while it increased in the latter group (-0.37 $\pm 3.5 \text{ vs} 0.49 \pm 3.8, p=0.04$). This reciprocal relationship results in global sagittal parameters that did not change following surgery with either cage morphology. Comparison of reoperation rates for adjacent segment disease (ASD) within two years of index surgery identified no significant difference (10.3% for the straight versus 3.5% of banana-shaped cage group, p=0.35).

Conclusion: Steerable banana-shaped cages increase index level segmental lordosis, but are accompanied by a reciprocal decrease in segmental lordosis at the adjacent lumbar levels. The converse relationship occurs for straight cages, ultimately resulting in no difference in global sagittal parameters following surgery in either group. Taken together with the noted difference in SF-36 Pain outcomes, further long-term follow up appears warranted to clarify the potential clinical relevance of our cage morphology-related findings.

8:56 - 8:58 am 443 Differences in Discharge Disposition on Patient Reported Outcomes and 30-Day Readmission/Reoperation Rates

Christine Park, BA; Chad Cook, PT, PhD, MBA; Oren N. Gottfried, MD

Introduction: Previous studies have shown that there is an association between discharge disposition and patient outcomes. Specifically, patients discharged to rehabilitation-based/skilled care facilities had longer hospital length of stays and higher rehospitalization rates compared to those discharged to non-rehabilitation discharge destinations.

Methods: This retrospective study used the Quality Outcomes Database (QOD) Spine Registry of patients who underwent lumbar surgery in 2016. The two cohorts of patients discharged to home and to healthcare facilities were derived by propensity score matching with a probability threshold of > 0.1 and controlled for age, gender, education, employment, and baseline disability and pain scores. Discharge to home included Healthcare facilities included skilled nursing facilities and inpatient rehabilitation and extended care facilities. Outcomes measured at 12-month follow-up included Oswestry Disability Index (ODI) for disability, Visual Analog Scale (VAS) back pain (BP) and leg pain (LP), EuroQol Visual-Analogue Scale (EQ-VAS) for quality of life, and 30-day readmission and reoperation rates.

Results: A total of 4,777 matched patients were included in the study with 3,865 patients discharged to home and 912 discharged to healthcare facilities. At 12-month follow-up, those who were discharged to healthcare facilities had worse ODI, VAS-BP, VAS-LP, and EQ-VAS (all p<0.01) compared to those who were discharged home. Furthermore, patients who were discharged to healthcare facilities had higher rates of reoperation (chi-square 61.45, df=2, p<0.01) and readmission (chi-square 25.60, df=1, p<0.01) rates within 30 days.

Conclusion: Even with propensity score matching, patients who were discharged to healthcare facilities reported poorer patient-reported outcomes and had higher 30-day reoperation/readmission rates compared to those discharged home.

8:58 - 9:00 am 444 Impact of Race & Socio-Economic Status in Clinical & Patient Reported Outcomes after Surgery for Cervical Myelopathy

Anthony L. Asher, MD, FAANS, FACS; Clinton J. Devin, MD; Yagiz U. Yolcu, MD; Mohammed A. Alvi, MD, MS; Giorgos Michalopoulos; Andrew Kai-Hong Chan, MD; Brenton H. Pennicooke, MD MS; Erica F. Bisson, MD, FAANS; Steven D. Glassman, MD; Kevin T. Foley, MD, FAANS; Christopher I. Shaffrey, MD, FAANS; Eric A. Potts, MD, FAANS; Avery L. Buchholz, MD, FAANS ; Mark E. Shaffrey, MD, FAANS; Domagoj Coric, MD; John J. Knightly, MD, FAANS; Paul Park, MD, FAANS; Michael Y. Wang, MD, FAANS; Kai-Ming G. Fu, MD, PhD, FAANS; Jonathan Slotkin, MD; Michael S. Virk, MD, PhD; Jian Guan, MD; Regis W. Haid, MD, FAANS; Praveen V. Mummaneni, MD, FAANS; Mohamad Bydon, MD, FAANS

Introduction: Race and socio-economic status (SES) have been shown to impact not only access to care, but also outcomes of patients undergoing treatment for various pathologies.

Methods: For the current study, we queried the Quality Outcomes Database (QOD) cervical module for patients undergoing surgery for cervical myelopathy between 2016 and 2018 at 14 of the highest enrolling sites. The primary predictors of interest for our study were race, ethnicity and socioeconomic status (SES) index. Our primary outcomes of interest included achieving 30% improvement in Neck Disability Index (NDI) score, achieving minimal clinically important difference (MCID) in EQ5D assessment and patient satisfaction at 2-year follow-up (assessed using the NASS satisfaction questionnaire).

Results: A total of 1,151 patients were included, of which 74.97% (n=863) were non-Hispanic Caucasians, 15.3% (n=176) were African Americans, 3.2% (n=37) were Hispanic Caucasians while 65.8% (n=75) were included in other race group. Per SES grouping, 51.5% (n=593) were found to be from high SES quartiles (1 or 2), while 49.5% (n=558) were from low SES quartiles (3 or 4). On univariate analysis, among those belonging to low SES, African Americans and Caucasian Hispanic had significantly longer length of stay (p=0.041), African American patients had higher non-routine discharge (p=0.04), significantly lower patient satisfaction at 3 (p=0.01) and 12 months (p=0.014), and lower quality of life index at 3 (p=0.01) and 12 months (p<0.001). On multivariable logistic regression, African American patients, compared to non-Hispanic Caucasians, were less likely to return to work (OR: 0.37, 95% CI: 0.16-0.84, p=0.017). Moreover, we also found the interaction between race and SES for African American from low SES to be significant for quality of life at 1 year (B=-0.082, p=0.036).

Conclusion: Our results suggest that for patients undergoing surgery for cervical myelopathy, race and SES may be important determinants of clinical and patient reported outcomes.

9:00 - 9:02 am 445 Dysphonia Following Stand-alone ACDF: Incidence, Severity and Resolution

Akhil Chandra; Avani Vaishnav; Hikari Urakawa; Jung K. Mok, BS; Derek Colaizzo; Marcel Dupont; Evan Sheha; Catherine H. Gang; Sheeraz Qureshi

Introduction: Studies regarding the incidence of postoperative complications after Anterior Cervical Discectomy and Fusion (ACDF) with stand-alone or zero-profile implant are limited, particularly with regard to post-operative dysphonia.

Methods: We performed a retrospective review of prospectively collected data on patients who had undergone stand-alone ACDF performed by a single surgeon between 2017-2020. Patients completed the Dysphagia, Odynophagia and Voice (DOV) Questionnaire pre-operatively and at each post-operative timepoint (2 weeks, 6 weeks, 12 weeks, 6 months, 1 year and 2 years) as standard of care. The "Voice" component of the DOV Questionnaire was used for this study. Patients were asked to select one of four scaled answer choices (0-3). Scores of 1, 2, 3, and 4 were graded as mild, moderate, severe, and very severe, respectively. A multivariable logistic regression model was fit to calculate the adjusted odds ratio of factors associated with the incidence of post-operative dysphonia after stand-alone ACDF.

Results: Forty-eight patients (mean age:58.46+/-9.74 years, mean BMI:27.38+/-4.76 kg/m²; 31(64.6%) males and 17(35.4%) females) were included.

There were 17(35.4%) single-level, 24(50.0%) two-level and 7(14.6%) three-level surgeries.

3(6.3%) patients reported dysphonia pre-operatively and had complete symptom resolution by 12 weeks. Eleven(22.9%) patients reported dysphonia at 2 weeks post-operatively. Of these, 7 patients had resolution during the available follow-up, with 5 patients reporting resolution by 6 weeks, and 2 patients reporting resolution by 1 year. In addition, 2(4.2%) patients reported new-onset mild dysphonia at 6 weeks, of whom 1 had symptom resolution by 6 months, and the second patient had follow-up data available till 6 months at which point they reported persistent dysphonia.

Revision procedures(OR6.573,p=0.040) and longer operative times(OR1.039,p=0.038) were significantly associated with dysphonia at 2 or 6 weeks even after controlling for age, gender and number of levels.

Conclusion: Approximately a quarter of all patients reported dysphonia within 6 weeks of stand-alone ACDF. These findings support the wider use of patient-reported outcome measures which also assess dysphonia, and not dysphagia alone.

9:02 - 9:04 am 446 Surgeon Specialty Effect on Early Outcomes of Elective Anterior/Lateral Lumbar Interbody Fusions

Safwan Alomari; Jose L. Porras, MD; Sheng-Fu L. Lo, MD, FAANS ; Daniel M. Sciubba, MD; Nicholas Theodore, MD, FAANS, FACS; Timothy F. Witham, MD, FAANS; Ali Bydon, MD, FAANS

Introduction: Comparative effectiveness research has a vital role in recent health reform and policies. Specialty training is one of these provider-side variables, and surgeons who were trained in different specialties may have different outcomes upon performing the same procedure. Anterior/lateral lumbar interbody fusion is one of the common spinal procedures that are being performed by both neurosurgeons and orthopedic surgeons for patients with degenerative diseases.

Methods: This is a retrospective, 1:1 propensity score-matched cohort study. 9,070 patients who underwent ALIF/LLIF were reviewed from ACS-NSQIP database. Propensity score matching was utilized to account for preoperative characteristic differences between the cohorts. Subgroup analysis was used to stratify the cases into single- and multi-level procedures.

Results: Patients operated on by neurosurgeons were more likely to be older, of male gender, of white race, smokers, functionally dependent, and to have higher BMI, an ASA class 3 or more, COPD, baseline dyspnea, diabetes mellitus, and hypertension. After controlling for baseline characteristics in both groups (single/multi-level ALIF/LLIF), patients operated on by neurosurgeons had longer operation time (188 vs 172 minutes/ 239 vs 221 minutes), shorter total hospital stay (71 vs 90 hours/ 89 vs 96 hours), and lower rates of return to the operating room (2.1% vs 4.1%/2.4% vs 4.2%), non-home discharge (8.7% vs 11.1%/10.1% vs 14.9%), discharge after postoperative day 3 (22.0% vs 30.0%/38.0% vs 43.9%), and perioperative blood transfusion (2.1% vs 5.1%/% 5.0 vs 9.9%), (p <0.05). In multi-level ALIF/LLIF, patients operated on by neurosurgeons had lower readmission rates (3.9% vs 6.9%), (p <0.05). Other outcome measures and mortality rates were similar among the 2 cohorts in both groups.

Conclusion: Our analysis found significant differences in early perioperative outcomes of patients undergoing elective ALIF/LLIF for degenerative spine diseases by neurosurgeons and orthopedic surgeons. These differences have significant clinical and cost implications for patients, physicians, program directors, payors and health systems.

9:04 - 9:06 am 447 A Self-Controlled Study of Fusion and Subsidence in TLIF with PEEK-Ti Versus 3D-Ti Cages

Ali Chahlavi, MD; Sonic Oun; Marcela Pacheco-Zhang; Sara Tish Mikoczi; Frank Vizesi

Introduction: Implants employing new surface technologies, such as PEEK-Titanium (PEEK-Ti) and 3D-Titanium (3D-Ti) cages, have entered the spinal market to overcome reports of sub-optimal osseointegration and bony fusion with PEEK. Although these new surface technologies may overcome PEEK's limitations, compelling clinical evidence has yet been demonstrated.

Methods: Forty-eight patients were retrospectively evaluated. The PEEK-Ti and 3D-Ti cages used were equivalent across all patients and graft material equivalent within each patient. Independent radiographic analysis of CT and/or X-ray imaging was performed for each spinal level and visit throughout a 12-month follow-up period. Fusion was defined as evidence of bridging trabecular bone within and/or outside the cage and subsidence was incursion into one/both vertebral bodies >20% cage height. Outcomes were analyzed with Fisher's exact test, significance being p<0.05.

Results: Thirty-six 2-level and 12 three-level TLIFs (2-levels: PEEK-Ti = 4, 3D-Ti = 8) were performed in 48 patients (age: 61.9, 47.9% F, BMI: 30.6). CT availability at 6 and 12-months was 86.7% and 95.2%, respectively, for 108 spinal levels. There were no reported perioperative complications. A statistically significant difference in subsidence (4.3% PEEK-Ti, 25.0% 3D-Ti, p=0.007) and comparable fusion at 6-months (93.6% PEEK-Ti, 91.7% 3D-Ti, p=1.000) were demonstrated. Analyses at 12-months exhibited a significantly lower rate of subsidence with PEEK-Ti than 3D-Ti (9.1% PEEK-Ti, 36.0% 3D-Ti, p=0.041) with no significant difference in fusion rates (100.0% PEEK-Ti, 88.0% 3D-Ti, p=0.238).

Conclusion: A statistically lower subsidence rate was associated with a PEEK-Ti cage, as compared to 3D-Ti, 6 and 12 months after TLIF. Results may not be generalized across technologies due to differences in cage designs; additional research studies are warranted.

9:06 - 9:08 am

448 Insurance Status as a Mediator of Clinical Presentation and Neurologic Outcomes for Patients with Metastatic Disease

Tara E. Dalton; Meghan Price; Jessica Goodwin; Rafael De la Garza Ramos, MD; Cesar Baeta; Edwin McCray; Reza Yassari, MD, FAANS; Isaac O. Karikari, MD, FAANS; Muhammad M. Abd-El-Barr, MD, PhD; Andrea Goodwin; C. Rory Goodwin, MD, PhD

Introduction: It is well established that insurance status is a mediator of disease management, treatment course, and clinical outcomes in patients diagnosed with cancer. Specifically, due to disparities in access to healthcare and early screening protocols, under-insured patients may experience complications of late stage cancer presentation and metastatic spine disease (MSD) more frequently.

Methods: The United States National Inpatient Sample database (2012-2014) was queried to identify patients with diagnoses of secondary metastases to the spine. Patients were categorized by insurance status (Medicare, Medicaid, private or unknown). Clinical presentation, type of intervention, mortality rates, and inhospital complications were compared amongst patients by insurance coverage.

Results: A total of 51,800 patients were identified. Patients with Medicaid coverage presented with significantly higher rates of visceral metastases (p<0.001) in addition to neurological complications including metastatic spinal cord compression (MSCC) (p < 0.001) and paralysis (0.008), while those with Medicare had higher rates of vertebral pathologic fracture (p < 0.001) but the lowest rate of concomitant visceral metastases (p<0.001). Medicaid patients had significantly higher rates of smoking (p<0.001) and higher rates of lung cancer when compared to patients with private insurance (p<0.001). In-hospital mortality rates were significantly higher for patients with Medicaid (OR 1.34; 95% CI 1.01-1.79; p= 0.042) and private insurance (OR 1.34; 95% CI 1.07-1.66; p=0.010). Patients with Medicaid had higher rates of prolonged length of stay (OR 1.34; 95% CI, 1.13-1.59; p = 0.001) while both Medicare and Medicaid patients were more likely to have non-routine discharges (p < 0.001).

Conclusion: Patients with late stage metastatic disease differed significantly in clinical presentation and outcomes by insurance status. Given the higher rates of late stage cancer complications in patients with Medicaid, our results suggest disparities in access to healthcare based on insurance coverage and emphasize the importance of efforts to increase healthcare coverage and mitigate the negative effects of un and under-insurance.

9:08 - 9:10 am 449 Impact of Cage Type (PEEK vs. Titanium) on Subsidence and Patient Outcomes after TLIF: N2QOD Single-institution Study

Robert Kim, MD; Forrest Hamrick; Andrew T. Dailey, MD; Erica F. Bisson, MD, FAANS; Jessica A. Colon, MD, FAANS; Marcus D. Mazur, MD

Introduction: Polyetheretherketone (PEEK) and titanium cages are commonly used for arthrodesis in transforminal lumbar interbody fusion (TLIF). Although it is generally believed that titanium demonstrates superior osseointegration but higher subsidence rate compared to PEEK cages, there is paucity of data that evaluates risk-stratified subsidence rate between the two cage types.

Methods: National Neurosurgery Quality Outcomes Database (N2QOD) was utilized to identify all adult patients who underwent one level TLIF between 2014-2019. Patients with history of prior lumbar fusion, long-segment fusion, revision, anterior/lateral approaches, and follow up <12 months were excluded. Chart review was performed to identify cage subsidence, fusion status, and average hounsfield unit (HU) of the superior and inferior endplates at index level. Univariate analysis was performed to assess cage subsidence, clinical, and patient-reported outcomes. Risk stratification was performed based on subsidence grades. Multivariate analysis was performed to identify potential risk factors for subsidence.

Results: A total of 130 TLIF levels utilized 78 PEEK and 52 titanium cages. Demographics, clinical characteristics, and average HU did not differ between the cage types. PEEK and titanium groups demonstrated similar fusion rates, 92.3% and 93.6%, respectively. Subsidence rate was similar between the groups (43.6% PEEK, 48.1% titanium). Titanium group had greater proportion of patients with higher subsidence (grade 1-3) compared to PEEK group (60% vs. 38.2%). Post-operative outcomes, as well as long-term patient reported outcomes were similar between the groups. When stratified by subsidence grades, direct correlation was observed between the increasing subsidence rate and increasing age and increasing non-union. No direct correlation was observed between the increasing subsidence grades and BMI, female sex, average HU, or mean ODI/VAS. Multivariate analysis suggested titanium cage, increasing age, BMI, female sex, and decreasing HU to increase the odds of high grade subsidence, but without statistical significance.

Conclusion: Titanium cages result in higher grade subsidence compared to PEEK cages without significantly enhancing the fusion rate. Cage subsidence is likely a multi-factorial process which warrants further high powered, risk-adjusted studies. With comparable clinical and patient-reported outcomes, cost should be factored in when selecting the appropriate cage type.

9:10 - 9:12 am

450 Impact of Lidocaine/Bupivacaine Use on Opioid Consumption Following Spinal Surgery:A Systematic Review and Meta-Analysis

Shyam Kurian, BS; Sung Huang Laurent Tsai; Yagiz U. Yolcu, MD; Shao-Wen Hung; Giorgos Michalopoulos; Mohammed A. Alvi, MD, MS; Tsai-Sheng Fu; Mohamad Bydon, MD, FAANS

Introduction: Pain management following spine surgery remains a challenge. The significant use of opioids may lead to opioid-related adverse events. These complications can increase perioperative morbidity and rapidly expend health care resources by developing chronic pain. Although intraoperative pain control for surgery has been studied in the literature, a thorough assessment of the effect in spine surgery is rarely reported.

Methods: An electronic literature search was conducted for studies on the use of lidocaine and bupivacaine in spine surgery for all years available. Only articles in English language were included. Postoperative opioid consumption, VAS score, nausea/vomiting, and length of hospital stay comprised the outcomes of interest. Pooled descriptive statistics with Risk Ratios (RR), Mean Differences (MD) and 95 % confidence interval were used to synthesize the outcomes for each medication.

Results: A total of 10 studies (n = 579) were included in the analysis. Comparison of the opioid consumption revealed a significant mean difference between lidocaine and bupivacaine (MD: -12.25, and MD: -0.4, respectively, p = 0.01), favoring lidocaine. With regard to postoperative VAS, the pooled effect of both groups decreased postoperative pain (MD: -0.61 (95 % CI: -1.14, -0.08)), with a more significant effect in the lidocaine group (MD: -0.84, (95 % CI: -1.21, -0.48)). There was no significant effect in length of stay, and postoperative nausea/vomiting.

Conclusion: The results of the present meta-analysis indicate that lidocaine and bupivacaine use may decrease postoperative pain and opioid consumption. Lidocaine had a stronger effect on the reduction of opioid consumption compared to bupivacaine.

9:12 - 9:14 am

451 Metastatic Epidural Spinal Cord Compression Neurological and Survival Scoring System: SpINS Score.

Nida Fatima, MBBS; John H. Shin, MD, FAANS

Introduction: Decompressive Surgery (DS) for the Metastatic Epidural Spinal Cord Compression (MESCC) is an expeditious treatment to relieve the cord compression.

Methods: Retrospective review of MESCC was performed for 199 patients (63% males) with a median age of 67 years (range, 33-84 years). Excluded were patients with spinal metastasis without cord compression, treatment with either radiotherapy or radiosurgery alone, patients with prior surgery for bone metastasis, and those with incomplete medical records.

Results: Overall, thirty-five patients (29.4%) improved to modified Frankel Grade E postoperatively, whereas 2 patients (1.7%) deteriorated to Grade A. Multivariate testing found that tumor characteristics of MRI that includes: ill-defined margins of abnormal signals (hazards ratio [HR]: 0.89, 95% confidence interval [CI]: 0.12-0.97, p=0.01), pedicle involvement (HR: 0.72, 95%CI: 0.54-0.91, p=0.02), vertebral fracture (HR: 0.59, 95%CI: 0.34-0.87, p=0.05), and paravertebral soft tissue involvement (HR: 0.81, 95%CI: 0.49-0.97, p=0.05) were negative risk factors for clinical improvement. The overall median survival after surgical intervention was 345 days (95%CI: 91.7-658.2 days). Multivariate testing found that tumor characteristics of MRI that includes: illdefined margin of abnormal signals (HR: 2.51, 95%CI: 1.30-4.84, p=0.006), and low-intermediate signal of spinal cord on T2W1 at the level of epidural compression (HR: 1.57, 95%CI: 1.23-1.99, p=0.04). Thirty-two patients (26.8%) developed complications postoperatively including wound infection and dehiscence in 12 patients (10.1%), deep venous thrombosis (DVT)/pulmonary embolism (PE) in 15 patients (12.6%), and instrumentation failure in 5 patients (4.2%). Multivariate testing found that tumor characteristics on MRI that includes: ill-defined margin of abnormal signals (HR: 1.79, 95%CI: 1.60-5.19, p=0.02), pedicle involvement (HR: 1.13, 95%CI: 1.06-2.61, p=0.04), involvement of posterior element (HR: 1.78, 95%CI: 1.23-2.59, p=0.03), and vertebral fracture (HR: 2.68, 95%CI: 1.01-7.92, p=0.01) were significantly associated with surgical-related complications.

Conclusion: Patients with well-defined margins of abnormal signals of the tumor, no involvement of pedicle, no involvement of posterior element, no involvement of paravertebral soft tissue, no vertebral body fracture, and bright high signal of abnormal intensity at the site of lesion (T2W1) had the best outcomes after DS.

9:14 - 9:16 am 452 Long-Term Upright Radiographic Outcomes after Intradural Tumor Resection via Laminectomy and Laminoplasty

Clinton D. Morgan, MD; Evan Richman; Jay D. Turner, MD, PhD, FAANS

Introduction: The resection of intradural spinal lesions typically requires laminectomy or laminoplasty, each carrying risk for iatrogenic index or adjacent level accelerated degeneration. Upfront fixation and fusion is often performed in the junctional or mobile spine to mitigate this risk. Radiographic outcomes of patients undergoing intradural tumor surgery have been reported in some studies. These studies are mostly limited by short follow-up and by dependence upon supine surveillance MRI and CT scans to assess spinal curvature, spinopelvic parameters, and instability. Nevertheless, long-term upright radiographs may provide the most sensitive assessment of these important parameters.

Methods: Patients undergoing laminectomy or laminoplasty with or without fusion for intradural lesion resection were identified from 2001-2019. In those patients without post-operative upright x-rays performed at least 1 year after surgery, letters were sent to patients requesting follow-up upright radiographs.

Demographics, pathology, operative details, global and segmental sagittal and coronal parameters were measured with the patient in the upright position on post-operative radiographs performed at least 1 year after surgery.

Results: The 64 patients (48% male, 52% female) identified had median and mean radiographic follow-up of 5.8 years and 6.4 years, respectively. The most common pathologies were schwannoma (25%), meningioma (23%), and ependymoma (16%). Cervical pathology was treated in 25/64 (39.0%); instability, focal deformity, or spondylolisthesis were identified in 6/8 patients undergoing laminoplasty alone and 2/4 undergoing laminectomy alone. In the 39/64 (61%) of patients in the thoracolumbar cohort, while de novo index or adjacent sagittal plane pathology was seen, multiple patients with long-term follow-up in both decompression types developed less expected segmental coronal pathology.

Conclusion: To our knowledge, this cohort has the longest mean follow-up using upright radiographs in patients undergoing resection of intradural spinal lesions. Laminoplasty did not appear to be specifically protective against segmental coronal or sagittal plane iatrogenic deformity. Furthermore, long-term upright radiographs revealed deformities which would not likely be detected using supine MRI or CT alone.

9:16 - 9:18 am 453 Finite Element Analysis and Spinal Metastatic Disease

Jamie Baisden, MD, FAANS; Sagar Umale, PhD; Vaibhav Porwal; Prashant Khandelwal; Hoon Choi; Narayan Yoganandan

Introduction: Spinal Metastasis is common among cancer patients. It may result in pathologic fractures with instability and neurologic compromise. The treatment of vertebroplasty or kyphoplasty with PMMA injected into the vertebral body may prevent pathologic fracture and neurologic injury.

Methods: A validated T12-S FEM was used and the L3 vertebral body was subjected to 6 clinical scenarios: healthy, osteoporotic, 40% metastatic burden, 80% metastatic burden, 4cc PMMA with 40% mets, and 4cc PMMA with 80%mets. All were subjected to pure compression (1kN) and combined compression (1kN) and bending moment (1Nm) in flexion and extension. The loading was applied at T12 and the sacrum secured. This loading represents carrying / lifting 10kg from the ground or bending to tie shoes. 18 cases were simulated and range of motion, vertebral body forces and discal pressures analyzed.

Results: Heathy and osteoporotic spines showed similar ROM however metastasis at L3 decreased the stiffness, and increased ROM under all loading conditions. The 80% metasasis case had higher ROM but less VB force hence a higher potential for fracture and instability. PMMA increased the stiffness in the 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 model allowed the L3 VB forces to reach within 15% of the healthy model. At 80% mets, the L3 VB forces were unchanged and clinically insignificant with the injection of 4cc PMMA

Conclusion: Increased metastatic burden increases instability of the spine. Pure compression loading resulted in higher VB forces and DP. Thus, the activities which result in pure compression (carrying/lifting) are more severe than activities which involve flexion or extension. PMMA may be effective in vertebrae with 40% mets and patients may be able to perform ADL's safely, however at 80% mets the PMMA was ineffective and performing ADL's puts the patient at risk of pathologic fracture with instability.

9:18 - 9:20 am 454 Factors Associated with Recurrence of Low-Grade Spinal Ependymomas: A Systematic Review and Meta-analysis

Waseem Wahood; Yagiz U. Yolcu, MD; Panagiotis Kerezoudis, MD; Giorgos Michalopoulos; Mohamad Bydon, MD, FAANS

Introduction: Spinal ependymomas are the most common primary spinal tumor in adults, accounting for 5% of all CNS tumors. According to the World Health Organization (WHO), there are three histopathological grades: Grade I (myxopapillary and subependymoma), Grade II (classical ependymomas), and Grade III (anaplastic). Literature on treatment modalities for low-grade ependymomas and their association with recurrence is scarce; some studies may combine histopathological grade when evaluating risk and prognostic factors.

Methods: PRISMA guidelines were used to conduct a systematic review and meta-analysis to compare sex (female vs male) and types of treatment modalities [gross total resection (GTR) vs GTR with adjuvant radiotherapy (RT), GTR vs subtotal resection (STR) with adjuvant RT, STR vs STR with adjuvant radiotherapy] with regards to recurrence. A subgroup analysis for myxopapillary ependymomas was also conducted.

Results: A total of 18 studies (577 patients) were included in this meta-analysis. Females had a similar odds of recurrence compared to males (OR: 1.05; 95% CI: 0.43-2.55; p=0.92). GTR alone had a similar odds of recurrence compared to GTR+RT (OR: 3.08; 95% CI: 0.41-22.93; p=0.27). STR+RT had a similar odds of recurrence compared to STR alone (OR: 0.88; 95% CI: 0.32-2.41; p=0.80). GTR alone had a lower odds of recurrence compared to STR+RT (OR: 0.18; 95% CI: 0.06-0.57; p<0.001). Subgroup analysis indicated that GTR alone had a similar odds of recurrence compared to STR+RT (OR: 0.18; 95% CI: 0.06-0.57; p<0.001). Subgroup analysis indicated that GTR alone had a similar odds of recurrence compared to STR+RT (OR: 0.18; 95% CI: 0.06-0.57; p<0.001). Subgroup analysis indicated that GTR alone had a similar odds of recurrence compared to STR+RT for myxopapillary ependymomas (OR: 0.49; 95% CI: 0.16-1.49; p=0.21).

Conclusion: This meta-analysis demonstrated that treatment modalities had similar odds of recurrence, except that GTR alone showed lower odds of recurrence compared to STR+RT. However, this comparison was nulled when only myxopapillary ependymomas were analyzed.

9:20 - 9:22 am

455 Postoperative Urinary Retention after Elective Spine Surgery: Systematic Review and Metaanalysis

Brij S. Karmur, MD; Jonathan Cunningham; Peter Lewkonia; Steven Casha; Michael M.H. Yang, MD

Introduction: Postoperative urinary retention (POUR) is a well-described adverse event after spine surgery, which can lead to discomfort, anxiety, and prolonged hospital stay for patients.

Methods: MOOSE standards were followed. MEDLINE, EMBASE, CINAHL, and PsychInfo databases were searched from inception until September 2020. Studies in any language were included if they reported on POUR after elective spine surgery in adults (=18 years) and reported a measure of association between POUR and at least one risk factor. Articles were screened, and data extracted by 2 independent reviewers. Measures of association for each risk factor were pooled using random effects models.

Results: Twenty-nine studies representing 30,657 patients were included in this review. The overall incidence of POUR was 8.36%. Significant preoperative risk factors of POUR included older age (mean difference [MD] 6.19 years [95%CI 2.70-9.68]), male sex (OR 1.32 [95%CI 1.11-1.57]), history of benign prostate hyperplasia (OR 2.47 [95%CI 1.89-3.22]), history of diabetes (OR 1.44 [95%CI 1.14-1.81]), body mass index > 30kg/m2 (OR 1.14 [95%CI 1.04-1.25]), and history of urinary retention (OR 15.46 [95%CI 4.84-49.36]). Significant perioperative risk factors included duration of surgery (MD 28.97 minutes 95%CI [7.02-50.92]), fusion (OR 1.67 [95%CI 1.24-2.25]), use of rhBMP-2 (OR 1.36 [95%CI 1.07-1.73]), and volume of fluids administered intraoperatively (MD 67.22mL [95%CI 29.4-105.03]). Early postoperative ambulation on the day of surgery was associated with lower incidence of POUR (OR 0.54 [95%CI 0.49-0.59]). History of ischemic heart disease, chronic kidney disease, depression, location of surgery, surgical approach, general anesthesia, and minimally invasive surgery were not associated with POUR. Study quality was generally low given the high number of retrospective studies.

Conclusion: POUR is common after elective spine surgery. Eleven significant risk factors of POUR were identified. These should be recognized as potentially important factors to consider in postoperative discharge planning and in the development of strategies to improve POUR outcomes.

9:22 - 9:24 am

456 Patient-Reported Outcomes After Treatment of Tumor-Related Spinal Instability Using Fenestrated Pedicle Screws

Elie Massaad; Ali Kiapour, PhD; Muhamed Hadzipasic, MD, PhD; Ganesh Shankar, MD, PhD; John H. Shin, MD, FAANS

Introduction: Achieving rigid spinal fixation can be challenging in patients with cancer-related instability as factors such as osteopenia, radiation, and immunosuppression adversely affect bone quality. Augmenting pedicle screws with cement is a strategy to overcome construct failure.

Methods: A retrospective review was performed for patients who underwent surgery for cancer-related spine instability from 2016-2019 at a tertiary academic hospital. Patient demographics, surgical details, radiographic characteristics, patterns of cement extravasation, complications, and prospectively collected Patient-Reported Outcomes Measurement Information System (PROMIS®) Pain Interference and Pain Intensity scores were analyzed using descriptive statistics. Logistic regression was performed to determine factors associated with cement extravasation.

Results: Sixty-nine patients underwent open posterior surgery with a total of 502 screws augmented, a mean of 7.8 screws per construct. The median follow-up period for those who survived past 90 days was 25.3 months (interquartile range [IQR], 10.8-34.6). Thirteen patients either died within 90 days or were lost to follow-up (18.8%). Postoperative CT was obtained to assess the instrumentation and patterns of cement extravasation. There was no screw loosening, pullout, or failure. The rate of cement extravasation was 28.9% (145/502), most commonly through the segmental veins (77/145; 53.1%). Screws breaching the lateral border of the pedicle but with the fenestrations within the vertebral body had a higher risk of leak through the segmental veins compared to screws without any breach (Odds Ratio OR = 8.77; 95% CI, 2.84-29.79; p<0.001). Cement extravasation was asymptomatic except for one patient who developed symptomatic thoracic radiculopathy requiring decompression. There was one case of asymptomatic pulmonary cement embolism. Patients experienced significant pain improvement at 3-months with decreases in Pain Interference (mean change 15.8; 95% CI, 14.5-17.1; P <.001) and Pain Intensity (28.5; 95% CI, 26.7-30.4; P < .001).

Conclusion: Cement augmentation through fenestrated pedicle screws is a safe and effective technical option for spine stabilization in the cancer population. The risk of clinically significant adverse events from cement extravasation is very low.

9:24 - 9:26 am

457 Racial Disparities in Perioperative Morbidity following Spine Oncological Surgery

Rafael De la Garza Ramos, MD; Jong Hyun Choi; Ishan Naidu; Joshua Benton; Yaroslav J. Gelfand, MD; Murray Echt, MD; David J. Altschul, MD; Vijay Yanamadala, MD, MBA; Reza Yassari, MD, FAANS

Introduction: Race is a known risk factor for disparities in outcome of major cancer surgery. However, there is limited data on the impact of race on outcomes after spine oncology surgery.

Methods: Adults with cancer who underwent spine tumor surgery were identified in the American College of Surgeons National Surgical Quality Improvement Program datasets from 2012 to 2016. Clavien-Dindo Grade I-II (minor complications) and Clavien-Dindo Grade III-V (major complications including 30-day mortality) complications were compared between non-Hispanic Whites (NHW) and Black patients. A multivariable analysis was conducted to identify independent predictors of outcome.

Results: Of 1,226 identified patients, 85.9% were NHW (n=1,053) and 14.1% were Black (n=173). The overall rate of Grade I-II complications was 17.4%; 15.1% for NHW patients and 23.1% for Black patients (p=0.008). On multivariable analysis, Black patients had significantly higher odds of having a complication compared to NHW patients (OR 1.87; 95% CI, 1.16 - 3.01; p=0.010). On the other hand, the overall rate of Grade III-V complications was 13.3%; 12.5% for NHW patients and 16.2% for Black patients (p=0.187). On multivariable analysis, Black race was not associated with higher odds of developing a major complication (OR 1.26; 95% CI, 0.71 - 2.23; p=0.430). Median length of stay was 8 days (IQR 5 – 13) for NHW patients and 10 days (IQR 6 – 15) for Black patients (p=0.011).

Conclusion: In this study, Black patients who underwent metastatic spinal tumor surgery were at a significantly increased risk of perioperative morbidity compared to NHW patients independent of baseline and operative characteristics. Major complications did not differ between groups. Race should be further studied in the context of metastatic spine disease to improve our understanding of these cancer health disparities.

9:26 - 9:28 am

458 Preoperative Treatment of Osteoporosis and Health Care Utilization in Patients Undergoing Thoraco-Lumbar Spine Fusions

Mayur Sharma, MD, MPH; Kevin John, BS; Nicholas Dietz, MD; Nikhil Jain; Wang Dengzhi; Beatrice Ugiliweneza, MSPH; Doniel Drazin, MD, MA; Maxwell Boakye, MD, FAANS

Introduction: Osteoporosis (OP) has a significant impact on health care utilization and revision surgeries in patients undergoing thoraco-lumbar fusions.

Methods: We used ICD9/10 and CPT codes to extract data from MarketScan (2000-2018). Patients were divided into two groups based on preoperative treatment of OP within one year prior to the index spinal fusion: medication (m-OP) cohort and non-medication (nm-OP) cohort. The OP medications included in this study were bisphosphonates (alendronate, etidronate, ibandronate, pamidronate, risedronate, and zoledronic acid), teriparatide, calcitonin, denosumab and raloxifene. We used multivariable generalized linear regression models to analyze outcomes of interest (re-operation rates, re-admission, complications, healthcare utilization) at 1-,12-, 24- and 60-months.

Results: We identified 3606 patients with OP who underwent thoraco-lumbar fusions and 60 months followup. Of these, 65% (n=2330) of patients did not receive OP medications (nm-OP). At index hospitalization, there were no difference in LOS (median nm-OP: 3 days vs. m-OP:4 days), discharge to home (nm-OP 80% vs. m-OP 75%) and complications (nm-OP 13% vs. m-OP 12%). Reoperation rates were not different among the cohorts at 12- (nm-OP 5.7 % vs. m-OP 4.2%), 24- (nm-OP 9.4% vs. m-OP 7.8) and 60 months (nm-OP 16.9% vs. m-OP 14.8%) following the index procedure. Patients in m-OP cohort incurred higher overall median payments at 12 months (\$17,866 vs. \$ 16,010), 24-months (\$38,634 vs. \$34,454) and 60-months (\$94,797 vs. \$91,072) compared to nm-OP cohort.

Conclusion: Preoperative treatment of OP had no impact on complications, LOS, discharge disposition following TL fusions. Similarly, no impact of preoperative treatment was noted in terms of reoperation rates at 12-, 24- and 60 months following the index spine fusion. Patients who received preoperative treatment for OP incurred higher health care utilization at 12-, 24- and 60 months following surgery.

9:28 - 9:30 am 459 Exploring the Effects of Rod Instrumentation Order on Strain in Posterior Thoracolumbar Fixation Constructs

Kyle McGrath; Callan Gillespie, MS; Jeremy Loss; Robb Colbrunn, MS; Swetha J. Sundar, MD; Michael P. Steinmetz, MD, FAANS

Introduction: High rod and pedicle screw strain in posterior fusion constructs has been associated with increased risk of hardware failure and pseudoarthrosis. Literature has documented the effects of posterior construct length on rod strain and construct stress. However, there is debate on whether sequence of rod and screw placement has a measurable effect on rod strain. Rod bending is imperfect, and initial rod placement may increase strain on the subsequent rod. If rod strain during placement exceeds the rod's yield strain, construct failure may ensue.

Methods: Five human cadaveric spines (T9 – sacrum) were instrumented with pedicle screws from T12-S1 and mounted to a six degree-of-freedom robot. Rods were bent to the contour of the spine, installed, and final tightened to T12 initially. Rods were then final tightened to S1 in two different sequences: Left rod tightening, followed by right rod tightening, and vice versa. Using strain gauges between T12 and L1, strains were calculated as the delta between the strain encountered with initial pedicle screw (T12) final tightening and the 2nd (S1) final tightening for each sequence. This was done in three separate conditions of increasing lordotic correction.

Results: Difference in strain between each tightening sequence for all conditions was calculated, and no significant difference in strain was found for the left rod (p=0.185), right rod (p=0.429), or total (p=0.116) for any condition. Final rod strain was measured and compared to the yield strain of the titanium rods being tested, and never exceeded rod yield strain within any correction group.

Conclusion: While differences in rod strain were identified between all conditions, these differences were not statistically significant. Furthermore, no trends in strain were identified between sequences or within any correction group, suggesting that sequence of rod installation may not correlate strongly to clinical outcome. Our results imply that rod installation order is not associated with construct failure based on increased rod strain during placement. Further research is needed to better understand the clinical and biomechanical effects of rod installation sequence.

General Spine Surgery 3/Peripheral Nerve/Basic Science Abstract Breakout Session Saturday, July 31

7:30 - 7:32 am 500 Does Added Compression Alter Intervertebral Disc Surface Strain During Multi-directional Loading?

Brian Kelly; Anna Sawa; Piyanat Wangsawatwong; Luke O'Neill; Bernardo Andrada, MD; Jake Godzik, MD MSc; Jay D. Turner, MD, PhD, FAANS

Introduction: Knowledge of the stress strain behaviors of the intervertebral disc (IVD) is significant towards understanding IVD mechanics and mechanisms of disc disease. Gold standard in-vitro tests often apply pure bending loads only, whereas the in-vivo spine is also subjected to compression. The load dependent nature of intervertebral disc strain has not been well characterized, particularly in the setting of in-vitro flexibility testing.

Methods: 3D digital imagining correlation (DIC) (Vic-3D) was used to quantify laterally viewed (left side) maximum (ϵ 1, tensile) and minimum (ϵ 2, compressive) principle strains on the L3-L4 IVD of 7 healthy human (L3-S) spine segments (3F/4M mean (\pm SD) age 44 \pm 14 years). Non-destructive tests to 7.5 Nm bending were performed in flexion, extension, right lateral bending, and right/left axial rotation, followed by same loads in combination with constant compression (400 N). Mean strains from rest to peak loads in four similarly sized quarter regions (Q1 anterior to Q4 posterior) on the surface of the L3-4 IVD were statistically compared with and without compression (p<0.05).

Results: During extension mean ε 1 strains significantly increased in the posterior (Q4) disc region (8,706µe versus 12,880µe, p=0.002) with compression. In contrast mean ε 1 strains in the posterior half of the IVD were significantly reduced with added compression in right lateral bending (Q3: 87,158µe versus 64,466µe, p=0.043, Q4:101,539µe versus 54,599µe, p=0.013) and left axial rotation (Q3: 29,406µe versus 13,937µe, p=0.016, Q4: 27,437µe versus 12,548µe, p=0.021). Mean ε 2 strains were significantly reduced in the anterior half of the IVD with added compression in left lateral bending (Q1: -49,862µe versus -29,286µe, p=0.006 Q2:-78,872µe versus -60,220µe, p=0.006) and right axial rotation (Q1: -36,508µe versus -12,030µe, p=0.004 Q2:-30,840µe versus -9,275µe, p=0.004). Similarly compression significantly reduced mean ε 2 strain in the posterior-mid disc region in right lateral bending (Q3:-28,785µe versus -13,738µe, p=0.034) and in the anterior-mid disc region (Q2:-35,994µe versus -13,278µe, p=0.013) in left axial rotation. In the sagittal plane the presence of compression reduced mean anterior ε 2 strains in flexion only (Q1:-53,259µe versus -39,989µe, p=0.039).

Conclusion: DIC analysis of L3-L4 IVD principle surface strains under in-vitro loading demonstrated significant and substantial differences in both ε 1 and ε 2 principle strain magnitudes in the presence of a compression load versus pure moment loading only. In the majority of instances added compression mitigated IVD bending strains. Loading conditions should be carefully considered when studying and interpreting IVD stress and strain.

7:32 - 7:34 am

501 Ramifications of Post-Operative Dysphagia on Healthcare Resource Utilization following Elective ACDF for CSM

Aladine A. Elsamadicy, MD; Andrew B. Koo, MD; Wyatt David; Isaac G. Freedman, BPhil, MPH; Benjamin Reeves; Jeff Ehresman; Zach Pennington, BS; Maxwell S.H. Laurans, MD, MBA; Luis Kolb, MD; Daniel M. Sciubba, MD

Introduction: Postoperative dysphagia is one of the most common complications following anterior cervical discectomy and fusion (ACDF). However, there is a paucity of data on factors predisposing patients to dysphagia and the burden this complication has on healthcare resource utilization.

Methods: A retrospective cohort study was performed using the Nationwide Inpatient Sample (NIS) database from 2016 and 2017. All adult (>=18 years old) patients undergoing primary, anterior cervical discectomy and interbody fusion for CSM were identified using the ICD-10 CM diagnosis and procedural coding system. Patients were then categorized by whether they had a recorded post-operative dysphagia or no dysphagia. Weighted patient demographics, comorbidities, perioperative complications, LOS, discharge disposition, and total cost of admission were assessed. A multivariate stepwise logistic regression was used to determine both the odds ratio for risk-adjusted post-operative dysphagia as well as extended LOS.

Results: A total of 17,385 patients were identified, of which 1,400 (8.1%) experienced post-operative dysphagia. The Dysphagia cohort tended to be older and have a greater prevalence of comorbidities than the No-Dysphagia cohort. The Dysphagia cohort had a higher rate of fusion of two levels or more (No-Dysphagia: 75.4% vs. Dysphagia: 81.1%, p=0.039). Compared to the No-Dysphagia cohort, the Dysphagia cohort had a greater proportion of patients experiencing a complication (p=0.004), including no complication (No-Dysphagia: 96.8% vs. Dysphagia: 92.9%), 1 complication (No-Dysphagia: 2.9% vs. Dysphagia: 6.8%), and >1 complication (No-Dysphagia: 0.3% vs. Dysphagia: 0.4%). The Dysphagia cohort experienced significantly longer hospital stays (No-Dysphagia: 1.9 \pm 2.1 days vs. Dysphagia: 4.2 \pm 4.3 days, p<0.001), higher total cost of admission (No-Dysphagia: \$19,441 \pm 10,495 vs. Dysphagia: \$25,529 \pm 18,641 , p<0.001), and increased rates of nonroutine discharge (No-Dysphagia: 16.5% vs. Dysphagia: 34.3%, p<0.001). On multivariate analysis, increased age, large Hospital size, cardiac arrhythmias, hypothyroidism, fluid and electrolyte disorders, fusion of two levels or more, and presence of postoperative complication were found to be significant independent predictors of post-operative dysphagia. Postoperative dysphagia was found to be a significant independent risk factor for extended LOS on multivariate analysis, with an odds-ratio (OR) of 5.37 [95% CI: (4.09, 7.05), p<0.001].

Conclusion: Our study identified several independent patient- and hospital-level risk factors for post-operative dysphagia. Patients experiencing post-operative dysphagia were found to have significantly longer hospital LOS, higher total cost of admission, and increased non-routine discharge when compared to the patients who did not. Furthermore, post-operative dysphagia was found to be an independent predictor of extended LOS. These findings further advocate for the need for interventions that may reduce the incidence of post-operative dysphagia to better patient quality of care and reduce the associated healthcare expenditures.

7:34 - 7:36 am

502 Seasonal Effects on Postoperative Complications Following Spinal Surgery

Phil Henson; William Shuman; Adam Y Li, BS; Muhammad Ali; Alex J. Schupper; Jonathan S. Gal, MD; Jeremy Steinberger, MD; Tanvir Choudhri, MD

Introduction: Postoperative complications have been reported in up to 20% of spinal surgeries. Seasonal changes have been previously associated with postoperative complications such as the presence of higher infection rates in the summer, but complications outside the surgical site have been studied much less extensively.

Methods: Data were obtained from the American College of Surgeons National Surgical Quality Improvement Program database from 2011-2018. Current Procedural Terminology codes were used to identify several common spinal surgery procedures. In addition to demographics, the database was queried for deep vein thrombosis (DVT), pulmonary embolism (PE), pneumonia, sepsis, septic shock, Clostridium difficile infection, stroke, cardiac arrest, myocardial infarction, urinary tract infection (UTI), and readmission. Warm season was defined as April – September while cold season was defined as October – March. Statistical analysis included computing overall complication rates and comparison between seasons using univariate analysis and multivariable logistic regression.

Results: 208,291 individuals underwent spinal surgery from 2011-2018. There was a statistically significant increase in UTI (OR 1.16, 95% CI: 1.07 - 1.26, p = 0.0002) and readmission (OR 1.06, 95% CI 1.02 - 1.11, p = 0.007) in the warm season compared to the cold season. All other postoperative complication rates did not change significantly between seasons. A secondary analysis investigating if the influx of new healthcare workers in July impacted surgical complications revealed increases to DVT (OR 1.24, 95% CI 1.03 - 1.48, p = 0.020) and thromboembolic events (TE; OR 1.17, 95% CI 1.01 - 1.35, p = 0.032) in July – September compared to the preceding three months. All other postoperative complication rates did not change significantly in the July – September quarter.

Conclusion: The results showed a higher odds of UTI and readmission among spine surgery patients in the warm season and a higher odds of DVT and TE from July – September. In both cases, the effect of seasonality is statistically significant, but the absolute difference is small and may not suggest policy changes.

7:36 - 7:38 am 503 Using QOD to Identify Indicators of Postoperative Dissatisfaction in Surgical Treatment of Spondylolisthesis

Geoffrey R. O'Malley, Jr.; Ricky Greff; Sudheesha Perera; Dimple Gandhi ; Scott A. Meyer, MD, FAANS; John J. Knightly, MD, FAANS

Introduction: When patients respond to the North American Spine Satisfaction Patient Satisfaction Index (PSI) with options 3, "I did not improve as much as I had hoped, and I would not undergo the same procedure again for the same results" or 4 "I am the same or worse before treatment" they are considered clinical failures. The unsatisfied patient population was analyzed to identify trends in hopes of increasing future patient satisfaction.

Methods: The authors queried the Quality Outcomes Database (QOD) of a single practice for spondylolisthesis patients who underwent decompressions. Patients were selected as unsatisfied if they responded with 3s or 4s to the PSI portion of the survey at 12 or 24-months post operatively. Comorbidities and baseline, 12-month and 24-month patient-reported outcomes (PROs) were compiled for ODI, NRSLP, NRSBP, and Patient Satisfaction Index (PSI).

Results: From QOD 20 patients were identified as satisfied, while 17 patients were identified as unsatisfied. No difference in age was observed between patient's satisfaction cohorts, but satisfied patients were predominantly female (70% v. 47%; α =0.15). Satisfied patients had higher incidences of anxiety (25% v. 6%; α =0.10), while unsatisfied patients had higher BMIs (29.6 v. 26.6; α =0.05) and incidence of diabetes (35% v. 10%; α =0.10). Baseline PROs of both cohorts were similar. Following surgery unsatisfied patients had a higher rate of return to the OR for revision (24% v. 5%; α =0.10). Satisfied patients tended to report better improvement to back and leg pain 12-months post operatively, but after 24-months they had similar improvements to unsatisfied patients. Satisfied patients saw superior postoperative improvement in ODI at 12-months (-26.1 v. -11.2; α =0.01) and 24-months (-23.0 v. -13.2; α =0.10).

Conclusion: The unsatisfied patient cohort is predominantly more male and has higher rates of diabetes and CAD, while satisfied patients have higher incidences of anxiety and depression. The difficulty in predicting the satisfaction of patients pre-operatively is illustrated in the lack of differences in baseline pain and disability indexes. These patients present similarly, undergo the same procedure for the same condition, but see different improvements in disability post operatively leading to a higher re-operative rate and less satisfaction. Further research is needed to establish diabetes and CAD as indicators of postoperative dissatisfaction.
7:38 - 7:40 am 504 Cervical Spine Steroid Injections for Delay of Surgery for Cervical Spondylotic Myelopathy

Mustfa Manzur; Andre Samuel; Avani Vaishnav; Sravisht Iyer; Steven Mcanany, MD; Todd Albert; Catherine H. Gang; Sheeraz Qureshi

Introduction: Cervical spine steroid injections are increasingly being used for diagnosis and treatment of degenerative pathology.

Methods: All patients with a new diagnosis of cervical spondylotic myelopathy, without previous cervical spine surgery or steroid injection treatment, were identified in a large insurance database. Administration of steroid injections and surgical treatment timing was determined based on Current Procedural Terminology (CPT) codes. Multivariate logistic regression was used to determine the association of steroid injection administration with surgical treatment at various time points after initial diagnosis. Significance at P<0.01.

Results: A total of 686 surgically managed CSM patients were retrospectively identified in the PearlDiver database. A total of 244 patients underwent pre-surgical spinal steroid injection therapy to manage CSM symptoms. Of these, 185 patients (75.8%) underwent epidural steroid injections, 35 (14.3%) underwent zygapophyseal injections, and 24 (9.8%) underwent transforaminal steroid injections. Median time from initial CSM diagnosis to surgery was 75.5 days (μ =351.6 days; S=544.9 days). In multivariate analysis, both transforaminal injections (OR=0.40, P=0.20) and zygapophyseal injections (OR=0.33, P=0.02) were insignificantly associated with decreased odds of surgery within 1 month of diagnosis, while epidural injections were not associated with decreased odds of surgery (OR=1.17, P=0.35). Interestingly, epidural and transforaminal injections were both associated with increased odds of surgery after six months post-diagnosis (P<0.01). Only zygapophyseal injections had consistently reduced odds of surgery (without significance).

Conclusion: The practice of steroid injection, regardless of approach (epidural, transforaminal, or zygapophyseal), does not prevent treatment of CSM via a surgical modality over the long term. While symptomatic relief may lead to short-term benefits from steroid injection, specifically with transforaminal and zygapophyseal injections, it appears that this short-term benefit only delays definitive surgical treatment. Assessment of diagnostic and treatment decision-making workflow may enable identification of other aspects of CSM management that lead to delays in diagnosis and definitive treatment as well as additional cost burden.

7:40 - 7:42 am

505 Nerve Transfers after Cervical Spine Surgery: Multi-Institutional Case series and review of the literature

Daniel Lubelski, MD; Zach Pennington, BS; Srujan Kopparapu; Daniel M. Sciubba, MD; Allen T. Bishop, MD; Alexander Y. Shin, MD; Robert J. Spinner, MD, FAANS, FACS; Allan J. Belzberg, MD, FAANS

Introduction: Up to 10% of cervical spine surgeries are complicated by postoperative weakness. Though many patients recover with non-operative management, some require surgery for restoration of function.

Methods: A retrospective review of patients from two academic medical centers who underwent nerve transfer for C5-6 root injury following cervical spine surgery was performed

Results: Of the ten treated patients, nine experienced recovery at last follow-up, demonstrating improvements in strength and motion in the affected muscles. Successful nerve transfers occurred between 3 and 8 months after the index spinal surgery and included spinal accessory nerve to suprascapular nerve, triceps branch to anterior division of the axillary nerve, and/or ulnar or median fascicles to motor branches of the musculocutaneous nerve. The unsuccessful patient underwent nerve transfer surgery approximately 11 months following the index operation and failed to obtain functional recovery.

Conclusion: Patients who experience C5-6 weakness following cervical spine surgery should be evaluated and considered for nerve transfer surgery if they have continued severe functional deficits at 6-months post-operatively. Earlier referral for nerve transfer is associated with improved functional outcomes in this cohort.

7:42 - 7:44 am 506 Titanium Plasma Spray Enhances Ability of PEEK to Promote Gene Expression Related to Bone Formation

Sheeraz Qureshi; Roland Beard; Margaret Van Horn; Brandon Bucklen, PhD

Introduction: Polyether-ether-ketone (PEEK) is a commonly used material in orthopedic implant applications for its radiolucency and mechanical properties that more closely resemble bone than metallic materials. However, several studies have shown that bone does not directly bond to PEEK. Titanium plasma spray (TPS) can be applied as a coating to PEEK; this coating has been hypothesized to improve the ability of PEEK to bond to bone while maintaining radiolucency. The roughness and material properties of TPS coating may promote an osteogenic cellular environment.

Methods: Murine bone marrow mesenchymal stem cells were cultured on discs made of TS, PEEK, and PT along with tissue culture polystyrene (TCPS) at a density of ~56 x103 cells/cm2. Cell count was measured over 14 days using a cell viability assay. Gene expression was analyzed over 14 days using two-step RT-qPCR for the following markers of bone formation: Alkaline Phosphatase (ALP), Vascular Endothelial Growth Factor (VEGF), Osteocalcin (OCN), and RUNX2.

Results: The cell count on the PT substrate was significantly (p<0.05) greater than both TS and PEEK at day 1 (D1) (70±1.6 x103, 30±9 x103, and 57±1.6 x103 respectively) and TS at day 7 (D7). By D7, PT, PEEK, and TS cultures resulted in the growth of (124±12, 122±22, and 47±45) x103 cells, respectively. At day 14 (D14), cell count on the PT, PEEK, and TS substrates were (114±8, 134±7, and 103±83) x103 cells, respectively. Cells seeded on PT also expressed enhanced osteogenic gene expression (ALP, OCN, VEGF, RUNX2) than TS and PEEK over 14 days.

Conclusion: Titanium plasma sprayed PEEK exhibited higher osteogenic gene expression and cell viability than both smooth titanium and PEEK over 14 days. Future research in an interbody animal model is required to assess the osseointegration potential of titanium plasma sprayed PEEK.

7:44 - 7:46 am

507 Radiographic and Clinical Outcomes with the Single Position Prone Lateral Transpsoas Approach

Samuel H. Farber, MD; Komal Naeem, MD; Malika Bhargava, BE, ME, MD, MBA; Randall W. Porter, MD, FAANS

Introduction: Lateral transposas lumbar interbody fusion (LLIF) is a workhorse minimally invasive approach for lumbar arthrodesis which is often combined with posterior pedicle screw fixation. Recently, there has been increasing interest in performing single position surgery allowing access to the anterolateral and posterior spine without the need for patient repositioning. The feasibility of performing the transposas approach in the prone position was recently reported.

Methods: A retrospective review of a single surgeon consecutive case series was performed. All adult patients (>18 years) who underwent single position prone LLIF for any indication between October 2019 to November 2020 were included. Operative details including operative levels, cage use, surgical duration, estimated blood loss (EBL), and complications were recorded. Intra-operative and post-operative radiographs were reviewed to assess for subsidence. Clinical outcomes are also reported.

Results: A total of 96.6% (28/29) of patients underwent successful treatment with the prone lateral approach over the study interval. The average age was 67.9 (9.3) years and 75% (n=21) were females. Overall, 39 levels were treated- single level fusion in 64.3% (n=18), two level fusion in 32.1% (n=9), and three level fusion in 3.6% (n=1) of patients. The most commonly treated level was L3-4 (n=15), followed by L2-3 (n=12) and L4-5 (n=11). L1-2 was fused in one patient. Overall mean operative time was 287 (101) minutes. The average retractor time was 29.2 (13.5) minutes per level. Estimated blood loss (EBL) was 298.5 (365) ml. Average fluoroscopy duration was 215.5 (99.6) seconds and intra-operative radiation dose was 170.1 (94.8) mGy. Intra-operative subsidence was noted in one case (3.6% of cases, 2.6% of levels). The average hospital length of stay (LOS) was 4.8 (3.7) days. Intra-operative lateral access complications occurred in 10.7% of patients (cage repositioning, n =1; inadvertent rupture of the anterior longitudinal ligament, n=2). Subsidence occurred in 5 of these patients (22.7%) and at 6/33 levels (18.2%). There were significant improvements in ODI, SF-36, and VAS-back and leg scores post-operatively.

Conclusion: This single surgeon consecutive case series demonstrates this novel technique is well-tolerated with acceptable clinical and radiographic outcomes.

7:46 - 7:48 am

508 Congenitally-fused Cervical Spine Associated with Adjacent Level Degeneration in the Absence of Cervical Spine Surgery

Gabriel Friedman; Ben L. Grannan, MD; Robert Koffie, MD, PhD; Aniket N. Zinzuwadia; Ziv Williams, MD; Jean-Valery Coumans

Introduction: Cervical fusion surgery is associated with adjacent level degeneration, but surgical and technical factors are difficult to dissociate from the mechanical effects of the fusion itself.

Methods: We identified 95 patients with incidental single-level cervical congenital fusion on CT imaging using a multi-layered high-throughput free-text search of all radiology reports available from a quaternary academic medical system. We compared these patients to an age-matched control cohort of 80 patients without congenital fusion. We quantified adjacent level degeneration through direct measurements of intervertebral disc parameters as well as the validated Kellgren & Lawrence classification scale for cervical disc degeneration. Ordinal logistic regression and 2-way ANOVA testing were performed to correlate extent of degeneration and the congenitally-fused segment.

Results: Average patient ages in the congenital fusion and control cohorts were 51.0 and 51.7 years, respectively (p = 0.84). 955 motion segments were analyzed. The number of patients with C2-3, C3-4, C4-5, C5-6, and C6-7 congenitally-fused segments were 47, 11, 11, 17, and 9, respectively. We found that patients with congenital fusion at C4-C5 and C5-C6 had a significantly greater extent of degeneration at adjacent levels compared to the degree of degeneration at the same levels in control patients ($p = 4.3 \times 10-7$ and p < 0.001, respectively) as well in as patients with congenital fusion at other cervical levels ($p = 4.7 \times 10-8$), even while controlling for expected degeneration. Patients with C4-C5 and C5-C6 congenital fusion also displayed significantly smaller cervical mid-point disc heights compared to these groups ($p < 4.3 \times 10-8$).

Conclusion: Taken together, our data suggest that congenitally-fused cervical spinal segments at C4-C5 and C5-C6 are associated with adjacent level degeneration independent of fixation instrumentation. Interestingly, this pattern is not seen in patients congenitally-fused at C2-C3, C3-C4, or C6-C7. This study design removes technical factors that might contribute to adjacent level degeneration. These findings may inform surgical strategy given that not all cervical spine levels are equally susceptible to adjacent level degeneration.

7:48 - 7:50 am 509 Does Screw Length Impact 1-Year Fixation in 3-Level Anterior Cervical Discectomy and Fusion?

Alysha Jamieson, Noah M. Nichols, BS; Vivian P. Le, MPH; Burooj Mahmood, BA; Rafael Guizar III, BA; Joshua Rivera, BA; Dean Chou, MD; Praveen V Mummaneni, MD; Lee A. Tan, MD

Introduction: Several studies have suggested that enhanced rigid fixation supports arthrodesis following anterior cervical discectomy and fusion (ACDF). Using 2-level ACDF cases, authors recently demonstrated that a ratio of screw length to vertebral body (VB) anterior-posterior length not exceeding 75% is significantly associated with interspinous motion (ISM) = 1mm. ISM < 1mm on lateral films has been offered as a radiographic marker of fusion and is comparable to CT-based modalities.

Methods: We reviewed all C3-6, C4-7, and C5-T1 ACDF cases performed by the three spine surgeons from November 2005 to December 2019. All cases utilized anterior plates with locking screw mechanisms and two screws in each vertebral body. Patients with use of bone morphogenetic protein were excluded. Screw length relative to the instrumented VB was accessed via techniques previously described in Lee et al. to yield a VB ratio. ISM values were gathered using previously published methods at 6 weeks, 6 months, and 1 year. ISM was assessed only at the respective articulating vertebral bodies relevant to the construct. Data analysis was performed using RStudio.

Results: 68 patients with a total of 268 VB ratios were included in this study. No significant correlation was found between VB ratio and fixation at any level of construct, nor any period post-operatively. A larger VB ratio had a greater effect on fixation in the early post-operative period, but little effect at the one-year mark. Additionally, when using the 75% VB ratio threshold suggested by Lee et al., there was no significant difference in fixation between the two cohorts.

Conclusion: The data suggests there is no significant correlation between VB ratios, ranging from 58.09% to 99.64%, and fixation in 3-level ACDF when examined in a level-specific manner. It is likely that for 3-level ACDF, compared to 2-level ACDF, there is a greater biomechanical force that overshadows the possible effect of a few millimeter increase in screw length.

7:50 - 7:52 am 510 Natural History of Extracranial Schwannomas: A Single Institutional Series

Daniel Lubelski, MD; Zach Pennington, BS; Arinze Ochuba; Tej D. Azad, MD; Jaishri Blakeley, MD; Allan J. Belzberg, MD, FAANS

Introduction: Given the benign nature of extracranial schwannomas and the low rate of conversion to malignancy, management is often dictated by a patient's clinical presentation and the tumor's growth. For patients who are managed expectantly, there remains the question of what is the expected natural history of the lesion. This can help drive decisions of earlier (and potentially safer) resection versus the possibility of stability in size and continued observation.

Methods: A retrospective review was performed to identify patients with non-syndromic extracranial schwannomas at a single tertiary care institution diagnosed between 2002 and 2019. Patient data and tumor characteristics were recorded. Location was divided as brachial plexus, peripheral nerve, and spine. Tumor volume was calculated from magnetic resonance imaging at each followup timepoint.

Results: 227 patients were identified (mean age 51, 42% male); 82 had peripheral schwannomas, 36 with brachial plexus schwannomas, and 109 with spinal schwannomas. At the time of diagnosis, peripheral lesions were significantly larger than spinal (59cm³ vs 13cm³) and brachial plexus lesions (15cm³). Mean follow-up was 27.8 months. Analysis of growth rates revealed distinct patterns within each location. For peripheral nerve lesions, 34 tumors demonstrating fast growth (β =0.176% per day) and the remaining 48 showed slow growth or relative stability (β =0.021% per day; p<0.01). Patients with fast-growing peripheral lesions were far more likely to be female (OR=2.9). Spinal schwannomas showed three distinct growth patterns with 30 showing fast growth (β =0.229% per day), 16 with moderate growth (β =0.071% per day), and 63 with slow growth (β =0.022% per day; p=0.03). The brachial plexus lesions did not demonstrate distinct growth patterns, and had moderate growth (β =0.065% per day).

Conclusion: Variations exist in the growth patterns of extracranial nonsyndromic schwannomas that differ based on location and patient demographics. Many of these patterns can be ascertained within 1-2 followup images within the first year. The volumetric growth rates presented herein may have implications for patient counseling, therapeutic decision-making, and future molecular investigations.

7:52 - 7:54 am 511 ACDF with a Porous PEEK Cage vs. Fibular Allograft: Clinical/Radiographic Outcomes at 1-Year Postoperatively

Lacin Koro; Josha Woodward, MD; Dominick Richards; Zakariak Siyaji; John Paul G. Kolcun, MD; David Fessler; Richard G. Fessler, MD, PhD, FAANS

Introduction: Anterior cervical discectomy and fusion (ACDF) is the most common surgical treatment for cervical degenerative disc disease (cDDD). First generation non-porous polyetheretheerketone (PEEK) cages gained widespread popularity due to favorable biomechanical properties and imaging characteristics despite reduced rates of osseointegration. Herein, we evaluate the radiographic and clinical outcomes, as well as safety, of a novel porous PEEK vs. fibular allograph (FA) interbody.

Methods: A single center retrospective review of 66 consecutive adult patients who underwent ACDF with a porous PEEK vs. FA interbody was performed. Preoperative and 1-year postoperative neutral and flexion/extension radiographs were analyzed for alignment, balance, and interbody dimensions. Clinical parameters including pain and disability metrics were assessed by serial confidential surveys. Outcomes between groups were recorded and compared statistically.

Results: 66 patients (mean age = 60.5, 56.1% male), who underwent 1-level (24.2 %), 2-level (51.6%) or 3-level ACDF (24.2%) were equally divide between a porous PEEK vs. FA interbody cohort. At baseline, no significant differences in demographics, radiographic or clinical parameters were observed between cohorts. At 1-year post surgery the porous PEEK cohort showed statistically significant improvement in C2-7 SVA, anterior, middle and posterior disc height (anterior 7.03 \pm 1.10 to 6.13 \pm 1.14 (p<0.001), middle 6.61 \pm 1.0 to 5.9 \pm 0.97 (p<0.001), posterior 5.8 \pm 0.91 to 5.33 \pm 0.94 (p = 0.004), respectively. Statistically improved but non-significant gains in C2-7 lordosis (p=0.98 to p=0.70) were achieved. At 1-year post surgery, PEEK vs. FA fusion rates were 94% and 91% with comparable reduction of spondylolisthesis (p>0.05). Improved yet non-significant gains in VAS neck, arm, leg and back scores as well as NDI score was observed (p>0.05). No instances of hardware malfunction, cage subsidence or migration requiring reoperation were observed.

Conclusion: We report promising and improved trends in radiographic and clinical parameters favoring porous PEEK vs. a FA interbody. These results suggest a porous PEEK interbody is a safe and reliable alternative, however additional investigation is necessary to better understand nuance differences and long-term outcomes.

7:54 - 7:56 am 512 Posterior Cervical Decompression and Fusion Terminating at C7

Susanna Kwok; Anant Naik; Chengmin Zhang, PhD; Qiang Zhou; Paul M. Arnold, MD, FAANS, FACS

Introduction: As the population of adults aged 65 and older continues to grow, so does the prevalence of agerelated spine degeneration. Posterior spinal fusion and fixation remains an effective treatment for this condition; therefore, it is imperative to innovate and evaluate surgical techniques that maximize therapeutic effects and minimize negative outcomes. Due to its unique biomechanics and anatomy, surgery on the cervicothoracic junction (CTJ) remains a challenge. Serving as the transition between the flexible lordosis of the cervical spine to the rigid kyphosis of the thoracic spine, the CTJ is a site of increased stress during rest and motion. Posterior cervical fusion and fixation has traditionally extended into the thoracic region with the goal of enhancing stability; however, this practice has not been heavily supported by direct evidence.

Methods: In a single-center, retrospective cohort analysis, the post-surgical outcomes for patients who have undergone posterior cervical fusion terminating at C7 was evaluated. C2-C7 sagittal vertical axis, C2-C7 Cobb angle, C7-T1 Cobb angle, C2 slope, C7 slope were measured pre-operatively, post-operatively, and at one-year. This data was collected along with post-surgical complications and post-operative cervical MRI.

Results: Of the 174 patients reviewed, 83 patients met the inclusion criteria of having posterior cervical decompression that stopped at C7, and 49 of these patients had at least one-year follow up. Radiologic analysis showed no statistical differences in axes, angles, or slopes at the three timepoints. Post-operative cervical MRI scans did not show spondylolisthesis. Additionally, post-surgical complications were minimal (cerebrospinal fluid leak was reported for 1 patient, pseudarthrosis for 3 patients, and loosening of C3 screws for 2 patients).

Conclusion: This study showed posterior cervical decompression and fusion ending at C7 to be an effective surgical option with minimal complications and spondylolisthesis after one-year follow up. Our results did not show reduced stability in the cervicothoracic junction as a result of C7 termination.

7:56 - 7:58 am 513 A Rough 3D-Printed Surface Enhances Stem Cell Proliferation and Osteoblast Differentiation

Sheeraz Qureshi; Margaret Van Horn; Roland Beard; Brandon Bucklen, PhD

Introduction: The advancement of manufacturing techniques, such as 3D-printing, has facilitated the design of complex and previously unattainable implant surface topographies. Research has shown surface properties, especially roughness, of an implant directly influence cellular response at the cell-material interface. Alkaline phosphatase (ALP), an early cellular marker of osteoblast differentiation, has been studied extensively to understand osteogenic cellular responses to a substrate. The identification of implant surfaces that promote a osteogenic environment may help identify those that improve healing.

Methods: BM-MSCs were cultured on the following substrates: PEEK, sTAV, and r3DP (n=6 per group). Cellular proliferation was measured using a colorimetric, viability assay to estimate the cell count on each substrate at days 1, 3 and 7. ALP activity was measured from cell lysate using a standard ALP assay on day 7.

Results: Cell count on day 7 for r3DP was significantly greater than PEEK (p<0.05) and not significantly different from TAV (p>0.05). ALP activity was significantly greater in the r3DP group (8.8 ± 1.1 nmol/µg) compared to both PEEK (5.7 ± 1.4 nmol/µg) and TAV (4.4 ± 0.9 nmol/µg) (p<0.05). There was no significant difference in ALP between TAV and PEEK (p>0.05).

Conclusion: Cells on a roughen 3D-printed TAV substrate exhibited significantly higher proliferation compared to PEEK and significantly higher ALP activity than both TAV and PEEK. Therefore, the r3DP substrate facilitated a cellular environment more favorable for osteoblast differention than TAV and PEEK substrates. Future research in an animal model is necessary to evaluate the downstream effects of an interbody implant with a roughened 3D-printed TAV surface on the healing process.

7:58 - 8:00 am

514 Machine Learning Approach to Differentiation of Peripheral Neurofibromas and Schwannomas: A Multi-Center Study

Michael Zhang, MD; Elizabeth Tong; Samuel Wong; Forrest Hamrick; Maryam Mohammadzadeh; Vaishnavi Rao; Courtney Pendleton, MD; Brandon Smith; Nicholas F. Hug; Sandip Biswal; Jayne Seekins; Sandy Napel; Robert J. Spinner, MD, FAANS, FACS; Jessica A. Colon, MD, FAANS; Kristen Yeom; Thomas J. Wilson, MD

Introduction: Preoperative diagnosis of benign peripheral nerve sheath tumors (BPNSTs) can provide guidance for patient counseling and surgical planning.

Methods: We assembled a cohort of neurofibromas and schwannomas from 3 independent institutions and extracted high-dimensional radiomic features from gadolinium-enhanced, T1-weighted MRI using the PyRadiomics package. 900 Imaging Biomarker Standardization Initiative imaging features were extracted from segmented tumor volumes. Clinical data including age, sex, neurogenetic syndrome, spontaneous pain, and motor deficit were recorded. Feature reduction was performed by LASSO regression and cross-validation. Retained features were inputted to six training models, including support vector machine, logistic regression, k-nearest neighbor, random forest, eXtreme Gradient Boosting, and neural net. Finally, four board neuroradiologists and peripheral nerve surgeons reviewed the MRIs and clinical information to measure and compare human performance.

Results: 59 neurofibromas and 107 schwannomas were included. The primary models included both clinical and imaging data. The highest area under the curve (AUC) for the receiver operating characteristic (ROC) curve was achieved by the Logistic Regression and K Nearest Neighbor classifiers (0.923). The most accurate classifiers were the Support Vector Machine and Logistic Regression classifiers (0.929). NF1 status consistently had the strongest contribution across classifiers. Spherical Disproportion (inversely proportional to true sphericity) was consistently the most influential imaging feature and predictive of neurofibroma. Comparatively, human experts achieved an AUC of 0.766 and an accuracy of 0.765. Human evaluators did not significantly exceed the no information rate (NIR), whereas the Support Vector Machine, Logistic Regression, and Random Forest classifiers exceeded the NIR. Using the method of DeLong, the AUC for the Logistic Regression and K Nearest Neighbor classifiers was significantly greater than the human evaluators (p = 0.041).

Conclusion: The radiomics-based classifiers developed here proved to be more accurate and had a higher AUC on the ROC curve than expert human evaluators. This demonstrates that radiomics using routine MRI sequences and clinical features can aid in the evaluation of neurofibromas and schwannomas.

8:00 - 8:02 am 515 Risk Factors for Allograft Subsidence following ACDF

Zachariah Pinter; Anthony L. Mikula, MD; Matthew Shirley; Ashley Xiong; Brett Freedman; Bradford L. Currier, MD; Benjamin D. Elder, MD, PhD, FAANS; Mohamad Bydon, MD, FAANS; David Kaye; Chris Kepler; Scott Wagner; Ahmad Nassr; Arjun Sebastian, MD

Introduction: Previous studies have suggested, that graft subsidence in ACDF is associated with higher rates of pseudarthrosis.

Methods: We performed a retrospective review of a prospective cohort of patients undergoing 1 to 3 level ACDF with an allograft interbody at a single institution between the years of 2011-2017. Graft subsidence was assessed on CT scan performed at least 6 months postoperatively. We classified subsidence as none if <2mm, mild if 2-3mm, moderate if 3-4mm, and severe if >4mm. Student's t-test and ANOVA were used to compare all means between groups.

Results: We identified 98 patients (152 levels) for inclusion. On sagittal CT for the entire cohort, the mean superior endplate subsidence was 1.62mm+/-0.90 and the mean inferior endplate subsidence was 1.62mm+/-0.91. The number of levels that underwent <2mm, >2mm, and >4mm of subsidence was 73 (48.0%), 79 (51.9%), and 18 (11.8%), respectively. Of the 18 levels with severe subsidence, 14 occurred in multi-level constructs, 2 of which occurred in both levels of a two-level ACDF in one patient. Of the remaining 12 levels of severe subsidence, 11 (92%) occurred at the caudal level and to a significantly higher degree at the inferior end plate (p<0.001). On univariate analysis of levels with severe subsidence, a decreased distance from the screw tip to the inferior endplate was associated with increased subsidence (p<0.05). Both mild and severe subsidence were significantly influenced by intraoperative loss of vertebral body height (p<0.005). 16 patients (94.1%) with severe subsidence experienced pseudarthrosis compared to only 11 patients (13.6%) with <4mm subsidence (p<0.001). However, reoperation rate was not significantly different between the severe subsidence and non-severe subsidence groups (11.8% vs 17.3%, p=0.44).

Conclusion: Based upon our study, some allograft subsidence in ACDF is expected, but too inferior screw placement at the caudal vertebral level and excessive endplate resection should be avoided to prevent severe subsidence.

8:02 - 8:04 am

516 Differences in Human, Pig, and Rat Spinal Cord Stem Cells in Response to Inflammatory and Regenerative Factors In Vitro

Ahmad Galuta; Abdul Mounnem Yassin Kassab; Diana C. Ghinda, MD, PhD; Ryan Sandarage; Jason Kwan; Suzan Chen; Angela Auriat; Eve C. Tsai, MD, PhD, FRCS(C), CIP

Introduction: In animal models of spinal cord injury, inflammation activates neural stem and progenitor cells (NSPCs) which differentiate into glial scar astrocytes. To direct NSPC fate and promote regeneration instead, NSPCs can be targeted using growth factors. However, the mechanisms regulating human spinal cord NSPC pathophysiology and regeneration are not known.

Methods: To mimic post-injury inflammation, primary-derived NSPCs from adult humans (n=8), pigs (n=5), and rats (n=6) were treated with pro-inflammatory factors interleukin-6 (IL-6), tumor necrosis factor- α (TNF α), or transforming growth factor- β (TGF β). To direct regeneration, NSPCs were treated with retinoic acid (RA), platelet derived growth factor (PDGF α), or bone morphogenic protein-(BMP4) to induce neurons, oligodendrocytes or astrocytes, respectively. Cultures were treated for 7 or 14 days and characterized by immunocytochemistry (GFAP, β -iii tubulin, O4, and BrdU)

Results: IL-6, TNF α and TGF β induced astrogenesis of rat NSPCs (3.9±0.7, 5.0±0.9, and 4.0±0.6 fold, respectively) and reduced neurogenesis (0.14±0.90, 0.07±0.04, 0.07±0.05 fold, respectively) after 7 days. Pig NSPCs increased astrogenesis (1.38±0.04, 1.26±0.05, and 1.45±0.04 fold, respectively) after 14 days. Human NSPCs had reduced astrogenesis (0.14±0.07, 0.6±0.2, and 0.12±0.07 fold, respectively) over 14 days, but generated more neurons with IL-6 and TGF β treatments (1.23±0.05 and 1.34±0.04 fold, respectively). RA increased neurogenesis of human and rat NSPCs, PDGF α increased oligodendrocyte differentiation of rat NSPCs, and BMP4 increased astrogenesis of human and rat NSPCs at low (40ng/mL) and high (100ng/mL) concentrations, respectively.

Conclusion: For the first time, we have compared spinal cord NSPCs from humans, pigs, and rats and determined differences in their response to pathophysiological and regenerative factors. Improved understanding of these differences be important for the successful translation of regenerative therapies to humans.

8:04 - 8:06 am 517 A Retrospective Study of Patient Complaints in the Post-operative Period Following Spinal Surgery

Andrew Ronald; Vineeth Saada; Nicholas M. Rabah, BS; Michael P. Steinmetz, MD, FAANS

Introduction: Patient complaints are associated with a number of surgical and medical outcomes. Despite efforts being made to study patient complaints across medicine and surgery, few studies have analyzed the complaints of patients undergoing spinal surgery. We present a retrospective analysis that to our knowledge is the first study to investigate the complaints of spinal surgery patients in the postoperative period.

Methods: Institutional records were reviewed over a 5 year period (2013-2018) to identify patients (complaintgroup) who underwent spine surgery and submitted a complaint to the institution's ombudsmen within 1 year of their surgery. Patient complaints were reviewed and grouped into 1 of 5 previously validated categories (Communication, Care & Treatment, Humaneness, Access, Environment). A control group, comprised of patients who underwent spine surgery but without an ombudsmen complaint, was matched to the first by admission diagnosis and procedure codes through propensity score matching. Patient demographic and clinical data was obtained by medical record review and compared between the two groups.

Results: There were 61 total complaints identified from 59 different patients. Patient complaints most commonly fell into the categories of "Care & Treatment" (46%) and "Communication" (34%). Patients who submitted complaints were more likely to identify as non-white (24% vs 6%, p = 0.0024), have private health insurance (56% vs 38%, p = 0.0408), have psychiatric comorbidities (46% vs 20%, p = 0.0016), and worse preoperative neurologic function (median ALS gait score = 2 vs 1, p = 0.0411). Additionally, patients who submitted complaints were more likely to experience postoperative complications both prior to discharge (25% vs 10%, p = 0.0361) and post-discharge (58% vs 23%, p < 0.0001).

Conclusion: The majority of patient complaints following spine surgery were related either directly to the care received or poor communication regarding care. Furthermore, a number of static, patient level characteristics were associated with an increased likelihood of a complaint being filed. Further study is needed to investigate ways to optimize the care of these patients.

8:06 - 8:08 am 518 Surgical Autonomy Program (SAP) for Evaluation of Resident Performance in Spine Surgery

Kelly R. Murphy, MD; Alexander Suarez; Andrew B. Cutler, MD; Elayna Kirsch; Lefko Charalambous, BS; Nandan P. Lad, MD, PhD; Katherine McDaniel, PhD; Michael M. Haglund, MD, PhD, MACM

Introduction: Resident education in spine surgery depends on proficiency in fundamental cases as set by the Accreditation Council of Graduate Medical Education (ACGME). The Surgical Autonomy Program (SAP) has been implemented to track resident surgical performance on individual index cases with the goal of improving skill progression and promoting attending-to-resident feedback.

Methods: Each index spine operation was deconstructed into four Zones of Proximal Development (ZPDs) based on Social Learning Theory. Data was collected through submission of evaluations by both the resident and attending at the completion of the case. Documentation included the case performed, perceived degree of difficulty, ZPD of current focus, and corresponding level of autonomy for each ZPD. Attendings were also able to provide free-text direct feedback to residents.

Results: We describe the results from 746 spine cases completed by Duke University neurosurgery residents. For the higher volume cases, we determined the average number of cases that a resident needed to successfully progress through each ZPD. We also assessed an aggregated learning curve for each index case. The median time spent in completing the evaluation was 17 seconds for residents and 40.7 seconds for attendings. Residents indicated they received "significant feedback" during the case in 85% of cases, while attendings utilized the ZPD model in their teaching for 89.7% of cases. In 58.1% of cases, attendings wrote specific free-text performance feedback. Residents and attendings showed concordance of performance level autonomy approximately half of the time (57.1% ZPD1, 50.8% ZPD2, 53.1% ZPD3, and 48.5% ZPD4).

Conclusion: We have demonstrated the utility of a rapid surgical educational tool in quantifying resident skill acquisition in spine surgery with high incidence of feedback exchange. These results and the SAP model will not only impact individual surgeon development, but they will also assist with curriculum development and inform case-volume minimums for residents.

8:08 - 8:10 am 519 Midpoint of C7 lateral mass serves as an accurate reference point for placement of T1 pedicle screws

Michael Panagos; Charles A. Sansur, MD, MHSc; Kevin Kim; Ashish Sharma; Timothy Chryssikos, MD, PhD; Kenneth M. Crandall, MD

Introduction: T1 pedicle screw insertion can often be challenging during spine surgery. While fluoroscopy is the standard imaging technique used to confirm the placement of pedicle screws in spine surgery, it is often difficult to image T1 pedicle anatomy due to the patient's shoulders compromising the lateral image. Sometimes the AP image is also compromised by the operating room table compenents. As such, the freehand technique is often utilized for T1. The senior author has had great success in identifing the entry point for T1 pedicle screws using midpoint of the C7 lateral mass. For this reason, we performed a review of twenty 3D reconstructed CT scans of the c-spine to demonstrate the relationship of the midpoint of the C7 lateral mass with the T1 pedicle.

Methods: We used TerareconsTM iNtuition 3D reconstruction software to create 3D recons of the C7 and T1 vertebrae. We subtracted the T1 transverse process, lamina, and superior articular process to expose the cancellous bone of the T1 pedicle. We were then able to visualize the surface of the C7 lateral mass its relationship to the T1 pedicle. We examined the midpoints of the C7 lateral mass and T1 pedicles and detrmined how far apart they were from each other. A total of 40 C7 lateral masses and T1 pedicles were evaluated.

Results: On avergae, the midpoint of the C7 lateral mass was found to be within 0.5mm of the midpoint of the T1 pedicle screw in 40 C7 lateral masses and T1 pedicles.

Conclusion:

The midpoint of the C7 lateral mass serves as an excellent predictor of the midpoint of the T1 pedicle. Knowledge of this relationship between the C7 lateral mass and the T1 pedicle can be useful during freehand placement of T1 pedicle screws.

8:10 - 8:12 am

520 3 and 12-month Change in Patient Reported Outcomes & MCID by Myelopathy Severity Following Cervical Decompression

Connor Berlin; Alexandria Marino; Juan S. Uribe, MD, FAANS; Luis M. Tumialán, MD; Jay D. Turner, MD, PhD, FAANS; Praveen V. Mummaneni, MD, FAANS; Michael Y. Wang, MD, FAANS; Erica F. Bisson, MD, FAANS; Andrew Kai-Hong Chan, MD; Oren N. Gottfried, MD; Khoi D. Than, MD, FAANS; Kai-Ming G. Fu, MD, PhD, FAANS; Paul Park, MD, FAANS; Mohammed A. Alvi, MD, MS; Cheerag D. Upadhyaya, MD; Jack Knightly, MD, FAANS; Domagoj Coric, MD; Eric A. Potts, MD, FAANS; Kevin T. Foley, MD, FAANS; Mohamad Bydon, MD, FAANS; Scott A. Meyer, MD, FAANS; Anthony L. Asher, MD, FAANS, FACS; Mark E. Shaffrey, MD, FAANS; Avery L. Buchholz, MD, FAANS

Introduction: While surgical decompression is an important treatment modality for cervical stenotic myelopathy (CSM), it remains unclear how severity of preoperative myelopathy affects potential benefit from surgical intervention, and when maximal patient benefit can be expected postoperatively.

Methods: A total of 1151 patients with CSM were prospectively enrolled from the Quality Outcomes Database at 14 U.S. hospitals. Baseline demographics and pre- and postoperative PROs at 3- and 12-months were measured. These included the modified Japanese Orthopedic Association (mJOA) score, Neck Disability Index (NDI), Quality Adjusted Life Years (QALYs), and EuroQol-Visual Analog Scale (Eq-VAS). Patients were stratified by myelopathy criteria established by the AOSpine study group: mild (mJOA = 15-17), moderate (mJOA = 12-14), or severe (mJOA < 12). North American Spine Society (NASS) satisfaction scale was used to define responders and non-responders when determining MCID. Univariate analysis was used to identify demographic variables that significantly varied between myelopathy groups. Then, multivariate linear regression and linear mixed regression was used to model the effect of severity and time on PROs, respectively.

Results: For NDI, Eq-VAS, and QALY, patients in all myelopathy groups achieved statistically significant, maximal improvement at 3-months, without further improvement at 12-months. An exception was the mild myelopathy group NDI, which continued significant improvement at 12 months. For mJOA, moderate and severe myelopathy groups demonstrated maximal improvement at 3 months, without further improvement at 12-months. The mild myelopathy group did not demonstrate significant change in mJOA. Calculated MCID values for mJOA, NDI, Eq-VAS, and QALY were 1.55, 11, 7, and 0.122, respectively.

Conclusion: Patients with moderate and severe cervical myelopathy experience maximal improvement in their pain, disability, and quality of life following surgical decompression at 3-months postoperatively. Patients with mild myelopathy improve in all PROs at 3-months except mJOA. There were incremental improvements in mild myelopathy at 12-months. The data presented here will aid surgeon decision making tools for patient selection, preoperative counseling, and expected postoperative time courses.

8:12 - 8:14 am

521 Diagnosis Related Group as a Predictor of Length of Stay, Disposition in Patients Undergoing ACDF

Ansh Desai; Jeff Butke; Uma V. Mahajan, BS; Collin Labak, MD; Eric Herring, MD; Berje H. Shammassian, MD; Rohit Mauria, MD; Manish K. Kasliwal, MD, MCh, FAANS

Introduction: Anterior Cervical Discectomy + Fusion (ACDF) for disc herniation can be used to treat a heterogeneous group of pathologies caused by disc herniation. The first of which is cervical radiculopathy in the case of nerve root impingement. The second is to treat myelopathy due to spinal cord compression. Patients who are myelopathic require a higher degree of rehabilitation and we believe these patients will remain in the hospital and in inpatient rehabilitation post-discharge for a longer period.

Methods: The study includes 133 patients who were treated at a single institution over the past 10 years (2010-2020). The study involved retrieval and analysis of information from the patient's medical record throughout hospital stay, including the variables below:

- Surgical procedure performed (1-level vs multilevel ACDF; corpectomy)
- Postoperative complications
- Principal diagnosis
- Presence of myelopathy
- Surgical history
- Comorbidity status
- Length of stay
- Evidence of cord signal change/myelomalacia on preoperative MRI
- Evidence of central canal/neuroforaminal stenosis on preoperative MRI/CT
- Evidence of spondylolisthesis on preoperative flexion/extension XR

MANOVA (multivariate analysis of variance) tests were performed to test differences in length of stay and postdischarge disposition by diagnosis.

Results: Patients undergoing ACDF who had myelopathy as a component of their disease process had longer lengths of stay and had a higher incidence of being discharged to acute inpatient rehabilitation postoperatively.

Furthermore, patients undergoing ACDF who have myelopathy as a component of their disease process had significantly higher Charlson Comorbidity Index scores.

Conclusion: A one-size-fits-all reimbursement for ACDF is not consistent with the two distinct disease courses for which patients undergo an ACDF. Therefore, holistic modifications must be made to the payment structure associated with this procedure, in order to minimize the financial and psychological burden put on the patients.

8:14 - 8:16 am 522 3-D Patient-specific Monitored Guidewire Placement-guides: A Safe(r) Technique

Raul B. Santos, MD; Carlos M. Ribeiro, CMR; Antonio M. Baptista, MD

Introduction: Fixation of the subaxial cervical spine is usually performed with lateral mass screws. Cervical pedicle screws are viewed as a salvage option due to their higher risk of neurovascular injury. 3-D printed patient-specific screw placement-guides have shown promise in decreasing implant mispositioning, but data on their use in the subaxial cervical spine is scarce.

Methods: A 53-year-old male presented with weight loss and bilateral lower-limb weakness. CT scan showed a tumor involving the apex of the right lung, pleura and rib cage with invasion of T1, T2 and T3. The T2 vertebral body had collapsed causing a kyphotic deformity and sagittal and coronal plane translation. The patient had undergone a laminectomy of the affected levels and thus suffered from a complete cervico-thoracic dissociation and high risk of further neurologic injury.

After multidisciplinary discussion, given the extended size of the lesion and subclavian artery involvement, a decision for palliative surgery was made.

In a case of cervico-thoracic dissociation, lateral mass screws did not provide the needed biomechanical strength.

A posterior fixation was performed using pedicle screws from C4 to T6. After planning of each pedicle trajectory using AutoCad®, patient-specific guidewire placement-guides printed in polyactic acid were used. The guidewires were coupled to an electrical conductivity sensor to ensure an intra-osseous trajectory and increase procedure safety. Correct positioning of all 14 guidewires was confirmed with intra-operative imaging and pedicle-screws were placed.

Results: Postoperative imaging showed no cortical breaches. No neurovascular injuries occurred.

Conclusion: The use of 3-D patient-specific guidewire placement-guides in the subaxial cervical and thoracic spine is safe. Guidewire monitoring during placement is a valuable tool to prevent neurovascular injury.

8:16 - 8:18 am

523 Demographic Risk Factors and Use of Annular Closure to Avoid Disability with Reoperations Following Lumbar Discectomy

R. Todd Allen; Michael J. Musacchio, MD, FAANS; Claudius Thomé; Adisa Kursumovic; Peter D. Klassen

Introduction: A previous report from a randomized clinical study of a bone-anchored annular closure device (ACD) reported significant morbidity and socioeconomic burden associated with reoperations following a lumbar discectomy within two-years.

Methods: Primary discectomy patients with large annular defects were randomized intra-operatively for treatment with discectomy-alone (Control, n=278) or discectomy with ACD (n=272). Disability at 3-years was quantified using four measures: VAS leg or back pain>=40, ODI>=40, and a status of not working. Univariate and multivariate logistic regressions were used to evaluate predictive factors for each of the disability measures.

Results: Significantly more Control patients underwent index-level reoperation than ACD patients (18.3% vs. 11.8%, p=0.03), resulting in significantly more hospitalization days for the reoperated group (7.7 vs. 0.1 days, p<0.0001). All measures of disability were significantly correlated with whether or not the subject had experienced a reoperation (p<0.003, HR 2.4–4.9). In the multivariate logistic regression models, reoperation status was found to be the most impactful predictor of disability. Females were predictive of high leg (p<0.001, HR=2.9) and back pain (p=0.012, HR=2.1). High BMI was predictive of high back pain (p=0.012, HR=1.4), and age was predictive of not working (p<0.001, HR=1.8). The multivariate logistic models estimated that females who have been reoperated and have BMIs>=29 have a 63% probability of suffering from high back pain. Subjects age>=51 who have been reoperated have a 55% risk to not be working.

Conclusion: Reoperation, female gender, older age, and higher BMI were all found to be risk factors for increased disability and its associated socioeconomic burden. Reoperation was the most predictive statistically significant factor. ACD was shown to significantly reduce reoperation at three-years and therefore should reduce the morbidity and socioeconomic impact of these risk factors.

8:18 - 8:20 am 524 Lymphoceles Following Anterior Lumbar Interbody Fusion: A Review of 1322 Patients

Justin K. Scheer, MD; Alexander F. Haddad, BS; Andrew Kai-Hong Chan, MD; Charles Eichler; Bobby Tay, MD; Shane Burch; Dean Chou, MD, FAANS; Christopher P. Ames, MD; Praveen V. Mummaneni, MD, FAANS

Introduction: Anterior lumbar interbody fusion (ALIF) is an effective surgical modality for a variety of lumbar degenerative pathologies. However, a rare and less reported complication is postoperative lymphocele.

Methods: A retrospective review of the electronic medical record was completed identifying all patients (=18 years) at a single institution that underwent at a minimum a single level ALIF from 2012 through 2019. Of those, any post-operative imaging was evaluated for mention of a lymphocele in the radiologist report. Clinical data was collected and reported for patients with a lymphocele on imaging.

Results: 1322 patients were included: 20 (1.5%) were found to have a postoperative lymphocele. The mean age was 67 ± 10.9 years with 50% male to female ratio. Patients with a lymphocele were significantly older than those without a lymphocele (66.9 years vs. 58.9 years, p=0.006). In addition, patients with a lymphocele had a higher number of mean levels fused (2.5 vs. 1.8, p<0.001) and were more likely to have an ALIF at L2-L4 (95.0% vs. 66.4%, p=0.007). On subsequent multivariate analysis, age (OR:1.07, CI:1.01-1.12, p=0.013), BMI (OR:1.10, CI:1.01-1.18, p=0.021), and number of levels fused (OR:1.82, CI:1.05-3.14, p=0.032) were independent prognosticators of postoperative lymphocele development. Symptomatic lymphoceles were successfully treated achieving radiographic resolution with either IR drainage and/or sclerosis therapy. The mean length of stay was 9.1±5.2 days. Ten patients (50%) were discharged to a rehabilitation center postoperatively, 8 (40%) to home, 1 (5%) to a skilled nursing facility, and the remaining patient (5%) to a long-term acute care facility.

Conclusion: Following ALIF, 1.5% of patients were diagnosed with a radiographically identified postoperative lymphocele. Risk factors for lymphocele development included increased age, BMI and number of levels fused. Most patients with a lymphocele presented within 1 month postoperatively; clinical presentations included abdominal pain, abdominal distension and/or wound complications. Of note, 25% of the identified lymphoceles were discovered incidentally. Symptomatic lymphoceles were successfully treated with either IR drainage and/or sclerosis therapy.

8:20 - 8:22 am

525 Variations in the Microorganisms, Biomarkers, and Management of Wound Infections After Posterior Spinal Fusion

Michael Cloney, MD, MPH; Benjamin Hopkins, MD; Nathan A. Shlobin; Max Kelsten, BS; Nader S. Dahdaleh, MD

Introduction: Wound infections are common complications after posterior spinal fusion (PSF), and can require prolonged antibiotics, washouts, and hardware removal. Existing literature is often lacking with respect to the microbial data, biomarkers, and infection timing.

Methods: We retrospectively analyzed all 3965 PSF patients at our institution between 2000 and 2015. We collected patient and procedural data, and data on antimicrobials use and biomarkers for infection. Multivariable logistic regression was performed to identify factors independently associated with each outcome.

Results: Wound infection was associated with preoperative anemia (OR=1.708 [1.092, 2.671], p=0.019), a history of peripheral vascular disease (OR 1.786 [1.050, 3.040], p=0.033), the use of immunosuppressive medications (OR=1.729 [1.045, 2.862], p=0.033), having a staged procedure (OR=3.499 [2.134, 5.737], p<0.001), and the number of levels fused (OR=1.073 [1.014, 1.136], p=0.014). Male sex was an independent risk factor for gram positive infection (OR=2.664 [1.099, 6.458], p=0.030), having a staged procedure was an independent risk factor for gram negative infection (OR=3.528 [1.368, 9.102], p=0.009), and age was negatively associated with polymicrobial infections (OR 0.885 [0.808, 0.971], p=0.010). Among patients who developed infections, gram negative infections were associated with using ancef irrigation (OR=5.075 [1.780, 14.470], p=0.002). Patients with a history of smoking were more likely to require reoperation with the first 30 days postop (OR=3.169 [1.205, 8.338], p=0.019). Patients who underwent MIS procedures were less likely to require wound washouts (OR=0.289 [0.084, 0.989], p=0.048). Patients who had undergone staged procedures were more likely to require hardware removal (OR=4.811 [1.263, 18.328], p=0.021). Patients with a higher peak WBC count (OR=1.124 [1.021, 1.238], p=0.017) or greater comorbid disease burden (OR=1.237 [1.001, 1.527], p=0.049) were more likely to be selected for a longer antibiotic course. Gram negative infections showed a trend toward delayed presentation (HR=0.7037, p=0.0784).

Conclusion: Specific patient and procedural characteristics predict wound infection after PSF, and distinct predictors exist for gram positive, gram negative, and polymicrobial infections, as well as their subsequent management.

8:22 - 8:24 am

526 Age as a Risk Factor for Complications Following ACDF: Michigan Spine Surgery Improvement Collaborative (MSSIC)

Chad F. Claus, DO; Michael H. Lawless, DO; Doris Tong; Robert W McCabe, DO; Connor Hanson; Lucas Garmo; Chenxi Li; Paul Park, MD, FAANS; Muwaffak Abdulhak, MD, FRCS; Teck-Mun Soo, MD, FAANS

Introduction: Elderly patients (=70 years) undergoing Anterior Cervical Discectomy and Fusion (ACDF) are considered a higher risk for complications. However, conclusive evidence is lacking. The Michigan Spine Surgery Improvement Collaborative (MSSIC) is a quality improvement collaborative with 30 hospitals across Michigan.

Methods: The study included all patients who had 1-4 level ACDF (9/2015-8/2019) for 90-day complications. Major and minor complications were defined using a validated classification. Multiple imputations were used to generate complete covariate datasets. A generalized estimating equation model was used to identify associations with complications using the whole cohort and elderly (=70 years) subgroup analyses. Bonferroni correction was used.

Results: 8,697 patients (11.2% >70-y-o and 88.8% <70-y-o) with 1,711 complications were analyzed. Comparing elderly vs. non-elderly, elderly had a significantly higher rate of any complications (31.5% vs. 24.0%, p<.001) and major complications (14.1% vs. 6.9%, p<.001). On multivariable analysis, age was not independently associated with any complication. POD#0 ambulation (OR 0.74, 0.66-0.83 95% CI) and preop independent ambulation (OR 0.63, 0.54-0.72 95% CI) were independently associated with significantly decreased odds of any complication. In the elderly, POD#0 ambulation was protective for any complications (OR 0.59, 0.43-0.81 95% CI) and independent preoperative ambulation was protective for any complication (OR 0.54, 0.39-0.74 95% CI) and especially major complications (OR 0.37, 0.24-0.55 95% CI).

Conclusion: Age was not an independent risk factor for complications for patients undergoing ACDF. In the elderly, independent preoperative ambulation was especially protective for major complications, and POD#0 ambulation was protective for any complications.

8:24 - 8:26 am

527 Longitudinal Analysis of Peripheral Nerve Surgery Training: Comparing Neurosurgery to Plastic and Orthopedic Surgery

Paulomi Gohel, BS; Mike White; Daryl Fields; Nitin Agarwal, MD; Nima Alan, MD

Introduction: Residents in multiple surgical specialties are trained to do peripheral nerve surgery, but the extent of exposure to this field varies among specialties.

Methods: We queried ACGME for neurologic, plastic, and orthopedic surgery residents case logs. We compared the mean number of peripheral nerve surgeries between specialties using paired t-test. Linear regression was calculated to determine trends within and across the specialties over the study period.

Results: Neurosurgery residents (24.76 ± 3.41) performed significantly less peripheral nerve procedures than their counterparts in orthopedic surgery (54.56 ± 6.85) and plastic surgery (71.96 ± 12.20), p < 0.001. Residents in neurological surgery reported over 1.5 fold as many cases as their ACGME required minimum, in contrast to plastic surgery (2.5 fold) and orthopedic surgery (5 fold). Plastics residents (3.46 cases/year) demonstrated the greatest longitudinal increase in peripheral nerve surgeries over the course of the study, followed by neurosurgery residents (0.81 cases/year). Peripheral nerve surgery accounted for a mean of 5.81% of total neurosurgery resident cases, 4.20% of total plastic surgery resident cases, and 2.98% of total orthopedic surgery resident cases (p<0.001).

Conclusion: Neurosurgery residents exceeded the required minimum number of peripheral nerve surgery and were increasingly more exposed to these surgeries over the study period. However, compared to their counterparts in orthopedic and plastic surgery, neurosurgery residents did significantly fewer peripheral nerve surgeries. Exposure for neurosurgery residents remain essentially unchanged over the study period while continuously growing for plastic surgery residents. The deficiency in exposure for neurosurgical residents must be addressed to harness interest and proficiency in peripheral nerve surgery.

8:26 - 8:28 am

528 Older Spondylolisthesis Patients Undergoing Decompressions See Less Satisfaction Post Surgery

Geoffrey R. O'Malley, Jr.; Ricky Greff; Sudheesha Perera; Dimple Gandhi; Scott A. Meyer, MD, FAANS; John J. Knightly, MD, FAANS

Introduction: Prior research compared the surgical treatment of spondylolisthesis by decompression between a surgical practice and a paper cohort. The practice tended to operate on an older patient and produced equal results, but its patients were less satisfied. The authors performed an analysis of the older patients in the practice to better understand their lack of satisfaction.

Methods: The authors queried the Quality Outcomes Database (QOD) of a single practice for spondylolisthesis patients who underwent surgical interventions. Patients were separated by age with the older group consisting of patients over the age of 73 (n=20). Comorbidities and baseline, 12-month and 24-month patient-reported outcomes (PROs) were compiled for ODI, NRSLP, NRSBP, and Patient Satisfaction Index (PSI).

Results: Relative to the younger patients at the practice, the oldest patients have equivalent distribution of comorbidities and baseline ODI and EQ-5D scores. Older patients report significantly lower baseline NRSBP (α =0.05) and tend to have lower baseline NRSLP. After 24-months the oldest group sees lower improvement in ODI, NRSBP, NRSLP and EQ-5D (α =0.05). Notably, the NRSBP of the oldest group is on average worse 24 months after surgery than before (-0.8, α =0.05). Between 12 and 24-months the younger patient cohort sees little to no change in PROs, while the older group sees a significant reduction. At 12 and 24-months the older cohort reports lower satisfaction.

Conclusion: Analysis suggests that older patients see less improvement in PROs, which likely causes their reduced satisfaction. However, it must be considered if surgery was an appropriate intervention as their baseline backpain was lower than the younger population at baseline and their backpain typically worsened after surgery. Further research should be performed to determine how similarly aged spondylolisthesis patients performed in PROs after undergoing fusions or without undergoing surgery over the same time frame.

8:28 - 8:30 am 529 Identifying Treatment Patterns in Patients with Bertolotti Syndrome: An Elusive Cause of Chronic Low Back Pain

Kyle McGrath; Nicholas M. Rabah, BS; Michael P. Steinmetz, MD, FAANS

Introduction: Bertolotti Syndrome is diagnosis given to patients with pain arising from a lumbosacral transitional vertebra (LSTV). A specific LSTV type involves a "pseudoarticulation" between the L5 transverse process and sacrum, resulting in a semi-mobile joint with cartilaginous surfaces. Treatment of Bertolotti Syndrome can involve injections and ultimately surgical resection of the pseudoarticulation, meaning a missed diagnosis can result in differences in treatment options available to these patients.

Methods: This study was a retrospective analysis of patients with diagnosed and undiagnosed Bertolotti Syndrome. Identification of an LSTV was confirmed through provider notes and imaging. Variables collected included demographics, injection history and outcomes, and surgical history for those who underwent pseudoarticulation resection.

Results: Our cohort included 67 patients with Bertolotti Syndrome, 22 of which were undiagnosed. Diagnosed patients underwent fewer injections than those with an undiagnosed LSTV (p = 0.031). Pseudoarticulation injections, offered only to those with a diagnosis, were more likely to provide immediate symptomatic improvement compared to all other injection types (p = 0.002). Pseudoarthrectomy was offered to patients who reported temporary relief after a pseudoarticulation injection, which was more likely to result in symptomatic relief at most recent follow up than continued injections among non-surgical patients (p < 0.001).

Conclusion: Accurate diagnosis of Bertolotti Syndrome may dramatically alter a patient's clinical course as they can only be offered treatment directed towards the LSTV once it is identified. Undiagnosed patients are subject to a higher quantity of injections directed at anatomic locations less likely to provide relief than pseudoarticulation injections. Furthermore, undiagnosed patients never undergo pseudoarthrectomy, which can result in significant symptomatic relief compared to continued injections alone. This study suggests that Bertolotti Syndrome may be a commonly missed diagnosis of chronic low back pain, resulting in a significant number of patients who may never receive adequate treatment.

8:30:00 AM - 8:32:00 AM 530 Clinical Outcome of Surgical Site Infection After Spinal Fusion

Jennifer Mao, MBA; Brian A. Karamian, MD; Mahir A. Qureshi; David Reiter; Jenna Mandel; Jeremy Heinle; Paul Minetos; Stephen DiMaria; Olivia Silveri; Alan Hilibrand; Chris Kepler; Jack Jallo, MD, PhD, FACS; Srinivas K. Prasad, MD, FAANS; Joshua E. Heller, MD, FAANS; Ashwini D. Sharan, MD, FAANS; Gregory Schroeder; James S. Harrop, MD, FAANS; Alex Vaccaro

Introduction: Surgical Site infection (SSI) is among the most common preventable health-care-associated infections. As healthcare systems move towards a value-based approach, there is a need to understand the clinical outcomes associated with SSI.

Methods: A retrospective 3:1 propensity matched case-control study was conducted for patients who underwent thoracolumbar fusion from March 2014 to January 2020 at a single academic institution. Inclusion criteria was adult patients who had complete preoperative and a minimum of 1-year postoperative outcomes data. SSI was defined by the Centers for Disease Control and Prevention. The patient's charts were reviewed for demographic, perioperative, readmission, and microbiological data. Functional disability and pain intensity were assessed through the Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) -Back and -Leg. Physical component (PCS) and Mental Component (MCS) of the SF-12 assessed physical function and mental health, respectively.

Results: 172 patients (129 Control, 43 SSI) were included in final analysis. While the infections group had a greater proportion of patients with previous spine surgery (p<0.001), there was no difference in preoperative diagnosis, vertebral levels fused, procedure type, estimated blood loss, or length of stay between groups. There was a greater proportion of readmissions in the SSI group (Control:0.78% v SSI:9.30%, p = 0.014). All patients improved significantly in ODI (Control:p<0.001, SSI:p=0.006), VAS-Leg (Control:p<0.001, SSI:p<0.001), VAS-Back (Control:p<0.001, SSI:p=0.002), PCS-12 (Control:p=0.005, SSI:p=0.01), and MCS-12 (Control:p=0.48, SSI:p=0.01) scores postoperatively. While the SSI group had worse postoperative ODI (Control: 27.8 v. SSI: 37.0 p=0.023) and VAS Leg (Control: 3.13 v. SSI: 2.15 p=0.001), there was no difference between Δ ODI or Δ VAS Leg. There was no difference between groups in the change in back pain, physical function, or mental health. No difference in patient reported outcomes were detected on multivariate regression after accounting for previous surgery and readmission status.

Conclusion: Development of SSI does not influence long term functional disability, physical health status, or mental health status. Patients with SSI after thoracolumbar fusion can expect to have similar outcomes to patients without SSI.

8:32 - 8:34 am

531 Preoperative Cross-sectional Area of Psoas Muscle Impacts Postoperative Functional Outcomes of Posterior Lumbar Surgery

Hikari Urakawa; Kosuke Sato; Avani Vaishnav; Sohrab Virk; Yoshihiro Katsuura; Evan Sheha; Takashi Kaito; Catherine H. Gang; Sheeraz Qureshi

Introduction: The decrease of psoas cross-sectional area has been reported to be a predictor of increased risk of mortality and complications in spine surgery. However, it is unclear which level should be selected to measure it on MRI and whether the psoas size impacts postoperative functional outcomes.

Methods: Patients who underwent posterior lumbar surgery for degenerative diseases with more than 6 months follow-up were included in this study. The cross-sectional area of psoas muscle was measured at each intervertebral level on T2-weighted axial images of preoperative MRI by 2 observers. Normalized total psoas area (NTPA) (mm2/m2) was calculated as total psoas area normalized to patient height.

Intraclass Correlation Coefficient (ICC) was calculated to evaluate inter-rater reliability of NTPA at each level. Patient reported outcome measures (PROMs) including ODI, VAS (back, leg), SF-12 (PCS, MCS) and PROMIS were collected at pre-op, 2 weeks, 6 weeks, 3 months and 6 months.

Results: A total of 215 patients were included in this study. ICC was the highest at L3/4.

Patients were divided into 2 groups at the point of the sex-specific lowest quartile of NTPA at L3/4 threshold. There were no significant differences in preoperative PROMs except for SF-12 MCS, however, they were significantly worse in the low NTPA group at 6 months.

In terms of SF-12 MCS, preoperative score was significantly better in the low NTPA group, however, no significant differences were found at all postoperative points. Multivariate logistic regression demonstrated that low NTPA was an independent predictor of failure to reach MCID in ODI and VAS leg.

Conclusion: Decreased psoas cross-sectional area on preoperative MRI had a negative correlation with shortterm functional outcomes after posterior lumbar surgery. Low NTPA, a sarcopenia-related parameter, was an independent predictor of failure to reach MCID in ODI and VAS leg. NTPA is a highly reliable and readily assessable measure of muscle health, especially at L3/4.

8:34 - 8:36 am

532 C5 Nerve Sheath Tumors are Significantly Associated with New Postoperative Weakness

Anthony L. Mikula, MD; Brandon Smith; Nikita Lakomkin, MD; Matthew Doan; Megan M. Jack, MD, PhD; Mohamad Bydon, MD, FAANS; Robert J. Spinner, MD, FAANS, FACS

Introduction: When nerve sheath tumors involve nerves contributing to the brachial plexus, resection carries an inherent risk of new postoperative deficit. Most muscle groups in the upper extremities are supplied by at least two spinal nerves, but shoulder muscles are a notable exception. The deltoid, supraspinatus, and infraspinatus muscles are innervated solely by the C5 spinal nerve, putting their function at potentially higher risk than other brachial plexus supplied muscles if the innervating spinal nerve is damaged.

Methods: A retrospective chart review identified patients with pathologically confirmed schwannomas or neurofibromas from the C5-T1 nerves. Patients with plexiform nerve sheath tumors, tumors involving more than one nerve, and malignant peripheral nerve sheath tumors were excluded. Collected variables included basic demographics, tumor dimensions, its location relative to the dura, involved nerve level, surgical approach, extent of resection, presenting symptoms, postoperative neurologic deficits, and recurrence rate.

Results: Forty-six patients (23 men, 23 women) were identified for inclusion in the study with an average age of 47 ± 17 years, BMI of 28 ± 5 , and follow up of 32 ± 45 months. Thirty-nine (85%) patients had schwannomas versus seven (15%) had neurofibromas. Tumors involved the C5 (12), C6 (11), C7 (14), C8 (6), and T1 (3) nerves. Multivariable logistic regression analysis with an AUC of 0.85 demonstrated C5 tumor level as an independent predictor of new postoperative weakness with an odds ratio of 7.4 (p-value = 0.028). Of those patients with new postoperative weakness, 75% improved and 50% had complete resolution of their motor deficits.

Conclusion: Patients with C5 nerve sheath tumor resections are at higher odds of new postoperative weakness. This may be due to the predominant single innervation of shoulder muscle targets in contrast to other upper extremity muscles which receive input from two or more spinal nerves. These findings are important for clinical decision making and pre-operative patient counseling.

8:36 - 8:38 am 533 Awareness of Complex Regional Pain Syndrome Among Medical Professionals

Tariq Al-Saadi, MD; Yahya Al-Kindi; Mundher Abudraz; Abdullah Al Balushi

Introduction: Complex regional pain syndrome (CRPS) is a chronic inflammatory and neurological condition with a complex broad spectrum of symptoms and requires input from various clinical specialists such as orthopedic surgeons, anesthetists, rheumatologists, and rehabilitation physicians (1,2).

Methods: The study was conducted using a cross-sectional survey. A postal questionnaire was sent online to different medical professionals. The questionnaire included two sections. The first section was about personal demographic whereas the second section was about the CRPS symptoms, diagnosis criteria, and management

Results: The study resulted in a total number of 97 participants that filled the questionnaire completely with the highest number working at tertiary health centers (59.8%) followed by primary health centers (30.9%) and secondary health centers students (9.3%). Seventeen percent of the participants were aware of the diagnostic criteria of this condition, while only 15.4% have applied these criteria before. Awareness of risk factors and complications were 22.7% and 23.7%; respectively. The mean of the cumulative score out of 11 awareness among our participants was 2.48 (range; 0-10). 37 (38.1%) of the participant scores 0/11 while none of the participants were able to score 11/11. Our study identified an association between years of experience and the level of awareness with a P value of .007.

Conclusion: The awareness of CRPS among medical professionals was not sufficient to meet the recommendation of CRPS criteria and guidelines. Physicians from different specialties need to increase their knowledge and awareness about this conditions

8:38 - 8:40 am

534 Relationship Between Restraint System Use & Brachial Plexus Injuries in Motor Vehicle Accidents: A Case-Control Study

Anshit Goyal, MBBS; Sung Huang Laurent Tsai; Megan C. Kaszuba, MD; Courtney Pendleton, MD; Kristen Scheitler, MD; Elizabeth B. Habermann, PhD; Mohamad Bydon, MD, FAANS; Robert J. Spinner, MD, FAANS, FACS

Introduction: High-speed motor vehicle accidents (MVAs) are an important cause of brachial plexus injury (BPI). Some case reports have demonstrated shoulder seat belt use resulting in traction injuries to the brachial plexus.

Methods: The authors queried the National Trauma Databank (NTDB) between 2016 and 2017 for patients with a hospital admission following anMVA. Cases with BPI were identified using International Classification of Disease, Tenth Edition (ICD-10-CM) diagnosis codes. Case-control matching by age and sex was performed to identify two non-BPI controls for every case of BPI. Multivariable (MV) conditional logistic regression adjusting for body mass index (BMI), alcohol use and drug use was then performed to determine the adjusted association between safety equipment use (seat belt use and airbag deployment) and BPI.

Results: A total of 526,007 cases of MVAs were identified, of which 704 (0.13%) sustained a BPI. The incidence of BPI in patients without any protective device, with airbag deployment alone, with seat belt use alone and with combined airbag deployment and seat belt use were the following: 0.16%, 0.08%, 0.08% and 0.07%. Following 1:2 case-control matching by age and sex and multivariable conditional logistic regression, seat belt use (OR 0.55 (0.42-0.71), p<0.001) and airbag deployment (OR 0.52 (0.33-0.82), p=0.004) were found to be associated with decreased odds for BPI, with the least odds observed with combined seat belt use and airbag deployment (OR 0.49 (0.33-0.74), p=0.001).

Conclusion: Despite anecdotal evidence suggesting increased likelihood of BPI with shoulder seat belt use, case-control analysis from a national trauma registry demonstrated that both seat belt use and airbag deployment are associated with lower odds of sustaining BPIs in MVAs, with the highest protective effect observed with combined use. Future studies adjusting for rider location (passenger vs. driver) and other potential confounders such as make, type and speed of vehicle may help further characterize this association.

8:40 - 8:42 am

535 CT Hounsfield Units as a Predictor of Reoperation and Graft Subsidence Following Lateral Lumbar Interbody Fusion

Daipayan Guha, MD, PhD; Harry Mushlin, MD; Nallammai Muthiah; Lena Vodovotz; Nitin Agarwal; D. Kojo Hamilton, MD, FAANS; David O. Okonkwo, MD, PhD, FAANS; Adam S. Kanter, MD, FAANS

Introduction: Graft subsidence following lateral lumbar interbody fusion (LLIF) is a known complication, and has been associated with poor overall bone mineral density (BMD). Previous research has demonstrated the utility of CT Hounsfield Units (HU) as a surrogate for BMD. Standalone and multi-level LLIF are increasingly being applied for degenerative conditions and minimally-invasive deformity surgery.

Methods: A prospectively-maintained single-institution database was retrospectively reviewed for LLIF patients from 2017-2020, either single or multi-level, standalone or with posterior fixation. Data on demographics, graft parameters, BMD on DEXA, preoperative mean segmental CT HU, and postoperative subsidence and reoperation, were collected. Three-foot standing radiographs were used to measure preoperative global sagittal alignment and disc height, and subsidence at last follow-up. Subsidence was classified using a grading system corresponding to disc height loss: Grade 0:0-24%; I:25-49%; II:50-74%; III:75-100%.

Results: 89 LLIF patients met study criteria, with mean follow-up 19.9 ± 13.9 months. Among 54 patients undergoing single-level LLIF, mean segmental HU was 152.0 ± 8.7 in 38 patients with Grade 0 subsidence, 136.7 ± 10.4 in 9 with Grade I, 133.9 ± 23.1 in 3 with Grade II, and 119.9 ± 30.9 in 4 with Grade III (p=0.032). Among 35 patients undergoing multi-level LLIF, with 96 instrumented levels, 83 had Grade 0 subsidence, 11 Grade I, 1 Grade II and 1 Grade III, with no differences in HU. In multivariate logistic regression, increased CT HU was independently associated with a decreased risk of reoperation in both single-level and multi-level LLIF (OR:0.983, 95%CI:0.976-0.993, p=0.046; and OR:0.971, 95%CI: 0.947-0.995, p=0.017, respectively). BMD on DEXA was not associated with graft subsidence nor reoperation. Using a receiver-operating-characteristic curve to establish separation between patients requiring reoperation vs. not, the most appropriate threshold HU for single-level LLIF was 131.4 (sensitivity-0.62, specificity-0.65), and for multi-level 131.0 (sensitivity-0.67, specificity-0.63).

Conclusion: Lower CT HU are independently associated with an increased risk of reoperation and graft subsidence following single and multi-level LLIF. Preoperative CT HU may provide a more robust gauge of local bone quality and likelihood of graft subsidence requiring reoperation following LLIF, than overall BMD.

8:42 - 8:44 am 536 Reliability of Neuromonitoring in the Detection of Postoperative C5 Palsy after Posterior Cervical Surgery

Clinton D. Morgan, MD; Robert Koffie, MD, PhD; Juan S. Uribe, MD, FAANS

Introduction: Post-operative C5 palsy is a widely reported and feared neurologic complication of both anterior and posterior cervical decompression and fusion. Intraoperative neuromonitoring (IONM) is utilized as a tool in the operating room to, in theory, warn the surgeon of impending or active danger to the neuraxis. This study evaluated the use, technical protocol, and reliability of intraoperative neuromonitoring (IONM) in the detection of C5 palsy in a large consecutive series of patients with posterior cervical decompression with or without fusion at a single high-volume institution.

Methods: A database was created that included all patients who underwent posterior cervical decompression with or without fusion between . Patient demographics, perioperative details, IONM protocol and intraoperative data, and immediate postoperative course were collected. Postoperative neurologic deficits were identified by analysis of the electronic medical record in the first 24 hours after surgery.

Results: A total of 755 cases of posterior cervical decompression with or without fusion were identified. IONM metrics were assessed in the 677 (89.7%) cases that involved decompression or fusion at C4-C6. The most common neurologic deficit was new C5 palsy (11 of 21 new deficits, 52.3%). Most (497 of 677, 73.4%) cases involving C4-C6 were monitored using somatosensory evoked potentials (SSEPs); in this large group, SSEP monitoring gave no indication of impending deficit in 9 of 11 cases. In the 180 of 677 (26.6%) cases where SSEP and motor evoked potentials (MEPs) were used for IONM, MEPs failed to detect postoperative C5 palsy. In cases where SSEP and MEP monitoring were combined (80 of 180, 44.4%), there was no alert associated with the single case of postoperative C5 palsy.

Conclusion: Postoperative C5 palsy was the most common neurologic deficit after posterior cervical laminectomy and fusion at C4, C5, and C6 in this large series. Although IONM was used for every case at this institution, SSEP and MEP monitoring were poor at detecting this debilitating deficit.

8:44 - 8:46 am 537 Does Posterior Ligamentous Complex Disruption Following Lumbar Fixation Affect the Upper Adjacent Level?

Brian Kelly; Piyanat Wangsawatwong; Anna Sawa; Bernardo De Andrada, MD; Luke O'Neill; Juan S. Uribe, MD, FAANS; Jay D. Turner, MD, PhD, FAANS

Introduction: The lumbar level above the fusion segment is the most common level for the development of adjacent level instability. The posterior ligamentous complex (PLC), (e.g. interspinous ligament, and supraspinous ligament) a posterior tension band that stabilizes the spine, is usually removed for laminectomy during lumbar fusion and decompression surgery. The removal of the posterior complex may jeopardize upper adjacent level stability.

Methods: 7 human cadaveric L3-S1 specimens were instrumented with L4-5 PSR. Specimens were tested multi-directionally under pure moment loading (7.5Nm) following: 1) L4-5 PSR, 2) L4-5 PSR + bilateral L4 laminotomy while preserving PLC and 3) L4-5 PSR + L4 conventional laminectomy. DIC was performed with cameras positioned laterally (left side) to capture the change in disc principal tensile (Pmax) and compressive (Pmin) strains at the upper adjacent level (L3-4) under peak load. Optical motion tracking was simultaneously performed on the right side. The disc region was divided into four similar sized quarters and included upper and lower endplates. Analysis of variance of upper adjacent level (L3-4) range of motion (ROM) and disc strain between the groups was performed. Statistical significant was set at p=0.05

Results: ROM of the upper adjacent (L3-4) level was significantly greater with L4-5 PSR + laminectomy (6.26 degree) versus L4-5 PSR + bilateral laminotomy (5.94 degree, p=0.006), and L4-5 PSR (5.20 degree, p<0.001) respectively, during flexion. During extension, left lateral bending, and axial rotation, upper adjacent level ROM was significantly greater with L4-5 + laminectomy and L4-5 PSR + bilateral laminotomy versus L4-5 PSR (p=0.046) but there were no significant differences between L4-5 PSR + laminectomy and L4-5PSR + bilateral laminotomy (p=0.087). The intervertebral disc Pmax strains of the upper adjacent level were significantly greater with L4-5 PSR + laminectomy than L4-5 PSR during flexion (25,225 VS 18,007uE, p=0.031), extension (22,803 VS 19,356uE, p=0.020), left lateral bending (32,778 VS 24,100uE, p=0.027), right lateral bending (88,761 VS 62,869uE, p=0.024), and right axial rotation (24,747 VS 19,289uE, p=0.025)

Conclusion: The posterior ligamentous complex disruption during lumbar fusion surgery was associated with significant increases in upper adjacent level instability and principle (Pmax) intervertebral disc stress/strain

8:46 - 8:48 am

538 CSRS-CSDI: A PROM Quantifying the Effect of Post-Arthrodesis Cervical Stiffness on Patient Quality of Life

Andrew S. Jack, MD; Erik Hayman, MD; Clifford A. Pierre, MD; Christopher D. Witiw, MD; Rod J. Oskouian, MD; Jens Chapman, MD; Robert A. Hart

Introduction: Although a common treatment strategy for cervical spondylotic myelopathy/radiculopathy, arthrodesis also results in increased neck stiffness as a collateral outcome. No current patient reported outcome measure (PROM) exists quantifying the impact of postoperative cervical stiffness on patient quality of life.

Methods: The Cervical Spine Research Society-Cervical Stiffness Disability Index (CSRS-CSDI) was created through a modified Delphi process. The resultant 10-item questionnaire yields a score out of 100 with higher scores indicating increased functional difficulty related to neck stiffness.

A cross-sectional study was completed for CSRS-CSDI validation. Healthy controls and postoperative spondylotic patients completed the questionnaire. Retest reliability (intraclass correlation coefficient (ICC)), internal consistency (Cronbach alpha (CA)), responsiveness (levels fused vs CSRS-CSDI scores), and discriminatory validation (CSRS-CSDI vs Neck Disability Index scores) were completed.

Results: Initially, 24 questions were refined into a questionnaire of 10-items through expert consensus. A total of 57 spondylotic and 24 healthy control patients then completed the questionnaire. Spondylotic patients had undergone a variety of procedures: 11 (19%) Motion Preserving decompressions (6 laminoplasties and 5 disc arthroplasties), 9 (16%) Subaxial 1-2 level fusions, 7 (12%) Subaxial 3-5 level fusions, 5 (9%) C1-Subaxial Cervical spine fusions, 20 (35%) C2-Upper Thoracic spine fusions, 5 (9%) Occiput-Subaxial/Thoracic spine fusions. No statistical between group difference was found with respect to age at the time of surgery, age at the time of questionnaire completion, nor time between surgery and survey completion.

The questionnaire demonstrated high internal consistency (CA = 0.92) and excellent test-retest reliability (ICC = 0.95, P < 0.001). Average CSRS-CSDI score was 25.7 for spondylotic and 8.5 for healthy patients. Good responsiveness validity with a significant between fusion cohort difference was found (P < 0.001, rs = 0.63). Patient CSRS-CSDI scores also correlated well with NDI scores recorded (P < 0.001, r = 0.70).

Conclusion: This is the first study to create a PROM addressing the impact of cervical stiffness following surgical arthrodesis. The CSRS-CSDI was found to be a reliable and valid measure of postoperative stiffness on patient quality of life. This may prove useful in counseling patients regarding their expected outcomes with further investigation demonstrating its value in a prospective fashion currently underway.

8:48 - 8:50 am

539 Differences in Clinical and Operative Characteristics, and PROs Between Patients with Myelopathy and Myelo-Radiculopathy

Erica F. Bisson, MD, FAANS; Mohamad Bydon, MD, FAANS; John J. Knightly, MD FAANS; Mohammed A. Alvi, MD, MS; Yagiz U. Yolcu, MD; Abdul K. Ghaith, MD; Andrew Kai-Hong Chan, MD; Jian Guan, MD; Kevin T. Foley, MD, FAANS; Jonathan Slotkin, MD; Eric A. Potts, MD, FAANS; Mark E. Shaffrey, MD, FAANS; Christopher I. Shaffrey, MD, FAANS; Kai-Ming G. Fu, MD, PhD, FAANS; Michael Y. Wang, MD, FAANS; Paul Park, MD, FAANS; Cheerag D. Upadhyaya, MD; Anthony L. Asher, MD, FAANS, FACS; Luis M. Tumialán, MD; Praveen V. Mummaneni, MD, FAANS

Introduction: Degenerative cervical myelopathy (DCM) is an umbrella terms used for referring to weakness and disability caused by compression of the cervical spinal canal. However, some patients with DCM may also present with radicular or dermatomal pain (myeloradiculopathy).

Methods: We queried the American Spine Registry (ASR) (formerly the QOD) for patients undergoing surgery for cervical myelopathy between 2016-2018. Demographic, socioeconomic, clinical and operative characteristics as well as baseline patient reported outcomes (PROs) were compared between the two groups.

Results: A total of 1,123 patients were identified, of which 67.5% (n=759) had myelopathy and 32.5% (n=364) had myelo-radiculpathy. Patients presenting with myelo-radiculopathy were more likely to be younger (<65: 71.2% vs 55.2%, p<0.001), employed (57.4% vs 41.4%, p<0.001), have foraminal-stenosis (53.8% vs 36.1%, p<0.001), have listhesis (33.6% vs 19.4%, p<0.001) and more likely to have ndependent ambulation at presentation (86.5% vs 79.5%, p=0.006). Patients with myeloradiculopathy were more likely to have higher ASA scores (1/2: 58.4% vs 46.6%, p=0.001) and were more likely to undergo an anterior surgery (76.6% vs 65.6%, p<0.001). We found no differences in total neck-disability-index (NDI) score between the two groups; however, patients with myeloradiculopathy were more likely to report higher (worse) scores for pain intensity (p<0.001), reading (p<0.001), headache (p=0.024), concentration (p<0.001), driving (p=0.018), and sleeping (p=0.001). For quality of life, myelo-radiculopathic patients were more likely to report lower (worse) scores for mobility (p-0.001) using the Euro-QOL 5-D score. Finally, for modified Japanese Orthopedic Association (mJOA), myelo-radiculopathic patients were more likely to report better scores for walking-ability (p<0.001), numbness in legs (p<0.001), and urination (p=0.006).

Conclusion: Patients myeloradiculopathy may have different presenting symptoms compared to patients with myelopathy. These results may help setting post-operative expectation for patients undergoing cervical surgery.
8:50 - 8:52 am 540 Biomimetic Laser-etched Titanium Promotes Gene Expression of Early Bone Markers

Sheeraz Qureshi; Roland Beard; Margaret Van Horn; Brandon Bucklen, PhD

Introduction: Surface properties are a key factor in how bone interacts with an implant material. Accordingly, surface modification of materials can increase the prevalence of fast and stable fixation at the bone-implant interface. Subtractive laser etching is a technique that can be used to create intentionally designed surface pores that mimic features found in that of native bone, specifically osteoclast resorption pits. Surfaces with microscale surface roughness and biomimetic features may promote an osteogenic cellular response.

Methods: Discs of TS, PEEK, and TL along with tissue culture polystyrene (TCPS) were used to culture murine bone marrow mesenchymal stem cells at a density of ~56 x103 cells/cm2. Cell count was measured using a cell viability assay at day 1 and 7 for all materials. Gene expression was analyzed at day 1 and 7 using two-step RT-qPCR for the following markers of bone formation: Alkaline Phosphatase (ALP), Vascular Endothelial Growth Factor (VEGF), and RUNX2.

Results: TL exhibited higher cell count than TS and PEEK over 7 days, though significantly less than the TCPS at all time points. By D7, TCPS, TL, PEEK, and TS cultures resulted in the proliferation of (383±16, 162±7, 122±22, 47±45) x103 cells, respectively. The TL cell count was significantly (p<0.05) higher than both PEEK and TS at D7 (162±7 x103, 122±22 x103, and 47±45 x103 respectively). Cells seeded on TL also exhibited enhanced bone-relevant gene expression compared to TS and PEEK over the 7 day experiment.

Conclusion: This study suggests that biomimetic patterning of titanium enhances the cellular response compared to titanium. Biomimetic, laser-etched titanium exhibited significantly higher cell counts and early bone markers than both smooth titanium and PEEK over 7 days. Further research using an animal model is required to assess the osseointegration potential of laser-etched titanium interbody spacers in vivo.

8:52 - 8:54 am

541 Degenerated Intervertebral Disc Reconstruction Using Hydrogel Scaffold Nucleus Pulposus Stem Cell Impregnated Matrix

Mick J. Perez-Cruet, MD, FAANS; Rasul Chaudhry, PhD; Christina McKee; Lee Ong Chieng

Introduction: Degenerative disc disease (DDD) is one of the major causes of chronic debilitating low back pain. DDD is characterized by changes in cell populations that result in loss of extracellular matrix (ECM) water holding capacity of the nucleus pulposus. DDD can lead to translation of physiologic loads from the anterior 2/3 to the posterior 1/3 of the spinal column resulting in stress placed on the facets and ligamentum flavum resulting in hypertrophy and canal stenosis. Novel stem cell regenerative therapies could restore the anterior column load via nucleus pulposus regeneration.

Methods: A hydrogel scaffold was created composed of self-assembling polyethylene glycol (PEG) functionalized with acrylate and thiol end groups. The scaffold was impregnated with nucleus pulposus (NP) cells differentiated from human umbilical cord mesenchymal stem cells (MSCs). Impregnated NP-scaffolds were then implanted into an ex vivo rabbit model of DDD and the viability and function of NP cells analyzed.

Results: The NP-scaffolds limited leakage and retained the cells in the NP region of the degenerated disc. Both the NP-scaffold and disc environment promoted differentiation of the MSCs into cells types capable of producing the ECM including sulfated glycoaminoglycans at levels higher than MSCs injected into the intervertebral disc. NP-scaffold cells also expressed chrondrogenic markers like SOX9, COL2 and ACAN at higher levels as well as NP markers FOXF1, K19, and Vimentin determined by real-time polymerase chain reaction (PCR) and immunostaining.

Conclusion: This study demonstrated that a hydrogen scaffold impregnated with NP cells was much more effective at disc regeneration than NP cells alone and can lead to novel therapies for treating DDD.

8:54 - 8:56 am 542 Fatty Infiltration in Cervical Flexors and Extensors in Degenerative Cervical Myelopathy

Monica Paliwal, PhD; Kenneth Weber; Andrew Smith; James Elliott; Fauziyya Muhammad; Nader S. Dahdaleh, MD; Jerzy Bodurka; Zachary Smith

Introduction: Patients with degenerative cervical myelopathy (DCM) show spinal cord compression and sensorimotor dysfunction such as hyperreflexia, loss of proprioception and strength, gait, and balance disturbances. However, the degree of compression does not directly associate with severity of clinical disability. In addition to spinal cord damage (demyelination of white matter and gray matter loss), pathological infiltration of fat in cervical muscles may exacerbate clinical disability in DCM. Quantification of muscle fat infiltration (MFI) is often impeded by laborious manual segmentation of cervical muscles and hence application of machine learning to automate segmentation are essential.

Methods: Eighteen patients with DCM (8F/10M, age= 59±14 years, BMI=26.0±4.1 kg/m²) and 25 healthy controls (12F/13M, age= 53±12 years, BMI=25.2±3.7 kg/m²) underwent 3D Dixon fat-water MRI imaging (Siemens Prisma) of the cervical spine. A dense V-net CNN segmented cervical muscles such as multifidus and semispinalis cervicis (MFSS) and longus colli/capitis (LC). MFI = fat signal/(fat signal + water signal) × 100. Clinical scores- modified Japanese Orthopedic Association (mJOA) and Nurick were collected. Mean differences in MFI between patients and controls were assessed (ANCOVA- controlling for age, sex and BMI). We assess association between MFI and clinical disability (Spearman's ρ , *p*≤0.05, SPSS).

Results: Patients with DCM had significantly higher MFI in deep cervical flexors (LC: 18.74 ±6.7 vs 13.66 ± 4.91, p= 0.021) and extensors (MFSS: 20.63 ±5.43 vs 17.04 ± 5.24, p= 0.043). Increased clinical disability was associated with increased MFI in LC (mJOA: ρ = -0.399, p=0.008 and Nurick: ρ = 0.436, p=0.003) and MFSS (mJOA: ρ = -0.332, p=0.036 and Nurick: ρ = 0.341, p=0.031).

Conclusion: Increased fatty infiltration in cervical flexors and extensors associate with sensorimotor deficits and clinical disability. Higher MFI may diminish muscle contractibility and affect postural biomechanics, proprioception, and fine motor control. MFI assessments may inform management, interventions, and clinical care in patients with DCM. Implementation of CNNs may enhance clinical feasibility of quantitative MRI.

8:56 - 8:58 am

543 In Vitro Assessment of Adjustable Lordotic Expandable Lateral Interbody Spacers on Endplate Loading, Lordosis Correction

Ripul R. Panchal, DO; Dhara Amin; May Allall; Jonathan Harris; Brandon Bucklen, PhD

Introduction: Anterior column realignment is a minimally invasive technique that aims to restore sagittal balance. Resection of the ALL enables use of expandable lateral lumbar interbody fusion (LLIF) spacers with larger implant heights and lordosis to increase lordosis correction and minimize endplate mismatch.

Methods: Seven L4–L5 cadaveric segments were used. A 55 lb axial load was applied to L4 to simulate intraoperative loads. Segments were instrumented with bilateral pedicle screws and a sequence of expandable spacers with anterior fixation at varied heights and implant lordosis (10 constructs), including (A) 0°, 6°, and 20° lordosis with intact ALL; B) 20° and 30° lordosis following ALL resection. Segmental lordosis and endplate force-maps were collected. An equivalent loading ratio (ELR=anterior load/total load*100%) was calculated.

Results: Mean intact L4–L5 lordosis was 11.5°±3.0°. Average contact area between the spacer and endplate was 71.2%±11.2%. Following ALL resection, 20° and 30° spacers with largest expansion (17.4 and 20.4mm, respectively) significantly increased lordosis to 22.5°±4.9° and 25.6°±5.6°, respectively (p<0.001). Prior to ALL resection, the 0°, 6°, and 20° LLIF produced ELRs of 54.1%, 60.8%, and 70.5%, respectively, indicating increased anterior loads. Following ALL resection, the 20° spacer with expansion (11.5mm) resulted in 52% ELR, indicating equivalent loading. Consistent anterior loading was observed for the remaining spacer height and lordosis combinations after ALL resection.

Conclusion: This study suggests that expandable spacers may help to balance anterior-posterior endplate loading while maximizing lordosis correction. Following ALL release, larger implant heights and lordosis did not increase anterior endplate loading; therefore, spacers may be selected for maximum lordosis.

8:58 - 9:00 am

544 Cervical Paraspinal Muscle Fatty Degeneration does not relate to Muscle Cross Sectional Area

Zachariah Pinter; Scott Wagner; Ashley Xiong; Bradford L. Currier, MD; Brett Freedman; Chris Kepler; Benjamin D. Elder, MD, PhD, FAANS; Mohamad Bydon, MD, FAANS; Ahmad Nassr; Arjun Sebastian, MD

Introduction: Previous studies have suggested a relationship between paraspinal sarcopenia and postoperative outcomes following cervical spine surgery.

Methods: We performed a retrospective review of a prospectively collected database of patients who underwent 1-3 level ACDF for degenerative conditions of the cervical spine from 2011-2017 at a single institution. Measurements of paraspinal muscle CSA were made using a standardized protocol at C2-3, (to measure obliquus capitus inferior) and at the C5-6 disc space (to measure longus colli, multifidus, and sternocleidomastoid). Goutalier classification of the right sided paraspinal muscle complex was performed by two independent reviewers blinded to the clinical outcomes. We then compared patients categorized according to the Goutalier qualitative grading system to their paraspinal CSA measurements. We utilized Student's t-test and ANOVA to compare all means between groups.

Results: We identified 98 patients for inclusion. Overall, 54.5% were 1 level, 30.3% were 2 level, and 15.1% were three level fusions. Utilizing the Fuchs modification of the Goutalier classification, groups were categorized into Normal (grade 0-1), Moderate (Grade 2) and Severe (Grade 3-4) degeneration. Overall we classified 41 patients as Normal, 47 as Moderate, and 10 as Severe. No significant difference in average paraspinal CSA for obliquus capitus inferior (p= 0.51), multifidus (p =0.11), or sternocleidomastoid (p = 0.85) was found between classification groups. Slightly higher longus colli CSA (p = .03) was found for the moderate and severe groups (73.6 mm2 and 66.3 mm2) in comparison to the normal group (62.8 mm2).

Conclusion: In this cohort of patients, nearly 60% had qualitative evidence of cervical paraspinal sarcopenia with 10.2% having severe muscle degeneration. While significant variation in paraspinal muscle CSA was observed, there did not seem to be a significant relationship between paraspinal CSA and paraspinal muscle deterioration. Given the established association between sarcopenia and perioperative outcomes, we recommend that qualitative measurements be used preferentially over quantitative measures to assess for cervical sarcopenia.

9:00 - 9:02 am

545 Comparison of Reoperation Rate Following TLIF Using 3D-printed Porous Titanium Interbody Cages or PEEK Cages

Isaac Lapite; Nicole Keller; Robert Winkelman, MD; Ryan McNassor; Todd Emch; Ajit A. Krishnaney, MD, FAANS; Jason Savage, MD; Michael P. Steinmetz, MD, FAANS

Introduction: Lumbar interbody fusions are now the most common method of fusion, with rates of lumbar fusion continuing to increase. Recent additive manufacturing has led to the creation of 3D printed titanium interbody cages with hollow geometry, thought to improve osteointegration.

Methods: Retrospective analysis of two cohorts who underwent TLIF with 3D printed titanium cage or PEEK cage at a single institution with a radiographic analysis of a subset of patients. Primary outcome evaluated reoperation defined as an additional surgery within 2 years to address failure to fuse or adjacent segment disease. Propensity matching was performed for baseline demographics, history of prior spine surgery, number of interbody cages and, number of vertebrae fused.

Results: There were no significant differences between the PEEK and 3D printed titanium alloy cohorts. The one year reoperation rate in PEEK was 4% and 3D printed titanium alloy was 12% (P value = 0.0372), and the rate increased to 10.8% and 22.5% at two years respectively (P value = 0.0503). Radiographic imaging review showed 58% of bony fusion at 6 months with a 3D printed titanium alloy, compared to 43% of bony fusion in the PEEK comparison group (P = 0.452). Subsidence was observed in 38.46% of 3D Printed Titanium Alloy compared to 19.35% of PEEK cages (P = 0.138). Mean migration of PEEK cages was 2.903 \pm 4.519mm and 3D Printed Titanium Alloy was 1.462 \pm 1.555mm (P = 0.123).

Conclusion: Reoperation rate is a clinically important outcome that should be considered when evaluating new technology for TLIF surgery. This study found a significantly higher reoperation rate in the 3D Printed Titanium alloy cohort at 1 year, but no significant difference at 2 years. There was a trend towards higher bony fusion and subsidence in the 3D printed titanium alloy on radiograph analysis.

9:02 - 9:04 am

546 Magnetization Transfer Imaging and Atlas Based Mapping of the Spinal Cord in Degenerative Cervical Myelopathy

Monica Paliwal, PhD; Kenneth Weber, PhD; Fauziyya Muhammad; Grace Haynes; Benjamin Hopkins, MD; Nader S. Dahdaleh, MD; Todd B. Parrish, PhD; Jerzy Bodurka; Yasin Dhaher, PhD; Zachary A. Smith, MD, FAANS

Introduction: Degenerative cervical myelopathy (DCM) is the leading cause of spinal cord dysfunction in the elderly. Patients present with increased reflexes, loss of proprioception and strength, gait and balance disorders. However, spinal cord compression only weakly associates with symptoms. There is significant heterogeneity in clinical presentation and recovery after surgery. DCM's pathophysiology is multifactorial; postmortem histological studies show demyelination of the spinal cord contributes to disability. Advanced MRI techniques such as magnetization transfer (MT) imaging enable quantification of demyelination in vivo. Improvements in spinal cord atlas based post-processing permit analysis of regional spinal cord injury.

Methods: Thirteen patients with DCM (8M/5F, 59.7±11.3 years) and 15 healthy controls (6M/9F, 52.3±12.6 years) underwent MT imaging using a 3T MRI (Siemens Prisma). MTR was calculated for anterior, posterior, and lateral cord using Spinal Cord Toolbox (V4.2, PAM50 template). Clinical scales- modified Japanese Orthopedic Association (mJOA), Nurick, and neck disability index (NDI) were collected. Independent sample t-tests and Spearman's correlation were used to assess differences in MTR between groups and its association with clinical scores (SPSS, $p \le 0.05$).

Results: Patients with DCM had significantly lower MTR in anterior (32.4 ± 9.2 vs 39.1 ± 3.9 , p=0.02) and lateral cord (33.0 ± 4.4 vs 37.5 ± 4.4 , p=0.016) than controls but not in posterior cord (36.4 ± 6.1 vs 35.9 ± 5.4 , p=0.816) region. Anterior cord MTR was associated with Nurick (p= -0.491, p=0.011) and NDI (p= -0.458, p=0.019) scores. Lateral cord MTR was associated with Nurick (p= -0.416, p=0.043), mJOA (p= 0.392, p=0.058) and NDI (p= -0.400, p=0.053).

Conclusion: In patients, lower MTR in anterior and lateral cord is associated with poor clinical function, hyperreflexia, arm/neck pain and discomfort. This suggests that injury to the anterior and lateral cord white matter is a driver of clinical disability in DCM. Regional MTR analysis could help to explain variance in sensorimotor dysfunction in patients with comparable spinal cord compression. Quantitative MRI (MTR) is emerging as a potential biomarker that may assist diagnosis, guide interventions, and enhance healthcare in patients with DCM.

9:04 - 9:06 am 547 Should SSEP and MEP Monitoring be Routinely used in Posterior Cervical Operations?

Robert Koffie, MD, PhD, MBA; Clinton D. Morgan, MD; Courtney Hemphill; Juan S. Uribe, MD, FAANS

Introduction: Posterior decompression with or without instrumented fusion (PCF) are some of the most common procedures performed by spine surgeon. PCF can be the preferred approach for treating patients with cervical spinal traumatic fractures, degenerative spondylosis, deformity tumors, infection and vascular malformations. Intra-operative monitoring is helpful during cases where direct or indirect manipulation of the cord is expected. However, whether neuro-monitoring is necessary in routine PCF surgery for degenerative cervical spine conditions remains unknown.

Methods: We retrospectively reviewed cases in which PCF was performed for a variety of cervical spine conditions at our institute over a 5-year period. SSEP monitoring was performed in all patients with MEP monitoring performed in only a subset of patients. Patients who had neurologic deficits post-operatively were then identified and detailed analysis perform to ascertain whether SSEP or MEP monitoring accurately predicted onset of post-operative deficits. The sensitivity, specificity and predictive value of each monitoring paradigm was then determined.

Results: We retrospectively evaluated clinical outcomes and intraoperative monitoring data in 757 patient and identified 498 patients who underwent posterior cervical operations for degenerative conditions of the cervical spine, excluding indications such as tumor, trauma, deformity, vascular lesions, and infection. Forty percent were female, 60% were male with ages ranging from 22 to 93 years-old (mean 67 years-old). SSEP was monitor for all 498 patients during surgery (121 patients [24.3%] had both MEP and SSEP monitoring). Twenty-one patients (4.2%) had neurological deficits after surgery in this cohort. SSEP monitoring had a higher specificity and sensitivity than MEP monitoring for detecting neurologic compromise intra-operatively in PCF cases (91% vs 79% and 60% vs 20% respectively). The positive (PPV) and negative predictive values (NPV) of SSEP monitoring in picking up intraoperative changes that translated to post-operative neurologic deficit were 30% and 97% respectively where as PPV and NPV of MEP monitoring were 6% and 96% respectively.

Conclusion: Taken together, this data suggests that intra-operative SSEP and MEP monitoring during PCF is not reliable at predicting post-operative neurologic deficits. With their relatively high NPV, however, MEP and more so SSEP are useful to provide a peace of mind intraoperatively when no abnormalities are detected. Thus, use of SSEP and MEP monitoring in PCF should only be limited to cases where the risk of post-operative neurologic deficit is high.

9:06 - 9:08 am 548 Frailty is a Better Predictor of Negative Outcomes After Posterior Spinal Fusion Than Age

Michael Cloney, MD, MPH; Benjamin Hopkins, MD; Nathan A. Shlobin; Nader S. Dahdaleh, MD

Introduction: Frailty is the physiologic vulnerability to adverse events, and has increasingly been found to be associated with a variety of health outcomes in elderly patients, including wound healing. While frailty has been demonstrated to predict outcomes elsewhere in the neurosurgical population, it remains under-investigated in the spine surgery context.

Methods: We retrospectively assessed all patients age 65 and older presenting to our institution for posterior spinal fusion between 2009 and 2016, and gathered relevant clinical, demographic, and procedural data. Frailty was measured using the Canadian Study on Health and Aging Modified Frailty Index (mFI). Stepwise, multivariable regression was performed ot examine the outcomes of interest

Results: Among patients 65 and older, there is no correlation between age and mFI (R squared 0.0163, p<0.001). mFI score independently predicted readmission (OR 1.118 [1.004, 1.246], p=0.042) and postop wound infection (OR 1.205 [1.040, 1.395], p = 0.013), showered a trend toward significance in predicting reoperation within 30 days (OR 1.112 [0.997, 1.241], p=0.057). The number of levels fused independently predicted reoperation within 30 days (OR 1.105 [1.037, 1.177], p=0.002), and showed a trend toward an association with 30-day readmission (OR 1.058 [0.989, 1.131], p=0.099) and postop wound infection (OR 1.089 [0.999, 1.186], p=0.051). BMI showed a trend toward an association with postop wound infection (OR 1.042 [0.993, 1.093], p = 0.095), and smoking history independently predicted gram positive infection (OR 8.030 [1.022, 63.102], p=0.048). Within this subpopulation, age did not independently predict any of the outcomes assessed.

Conclusion: Among elderly patients undergoing posterior spinal fusion, frailty, as measured by the mFI, is associated with 30-day readmission and wound infection, and may also be associated with the need for reoperation. Frailty does not correlate with age in this population, and age itself does not predict such outcomes. Frailty may be superior to age as a metric for risk-stratification in this patient population.

9:08 - 9:10 am 549 3D-Printed Porous Biomimetic Titanium Promotes Osteogenic Gene Expression in Murine Mesenchymal Stem Cells

Sheeraz Qureshi; Roland Beard; Margaret Van Horn; Brandon Bucklen, PhD

Introduction: Titanium is a commonly used implant material in orthopedics due to its biocompatibility with bone. Nonetheless, bone resorption caused by stress shielding is a concern. Advancements in 3D-printing allow for the design of implants with unique, porous architecture that mimics the structure of trabecular bone. Surfaces with microscale surface roughness and biomimetic features may promote an osteogenic cellular environment.

Methods: Discs of TS, PEEK, and T3 along with tissue culture polystyrene (TCPS) were used to culture murine bone marrow mesenchymal stem cells at a density of ~56 x103 cells/cm2. Cell count was measured using a cell viability assay over 14 days. Gene expression was analyzed over 21 days using two-step RT-qPCR for the following markers of bone formation: Alkaline Phosphatase (ALP), Vascular Endothelial Growth Factor (VEGF), Osteocalcin (OCN), and RUNX2.

Results: T3 exhibited higher cell count than other discs over 14 days, though significantly less than TCPS at all time points. Cell count on T3 discs was significantly higher than TS at D1 (58±3 x103 and 30±9 x103 respectively), TS and PEEK at D7 (167±8 x103, 47±45 x103, and 122±22 x103 respectively), and PEEK at D14 (207±10 x103 and 134±7 x103 respectively) (p<0.05). Cells on T3 also exhibited higher gene expression of several bone markers over the 21 Day experiment.

Conclusion: This study suggests that 3D-printed, porous, titanium implants provide a more osteogenic environment than smooth titanium and PEEK, since cells cultured on 3D-printed titanium exhibited higher cell counts and enhanced bone marker production compared to both smooth titanium and PEEK over 21 days. Further research is required to assess the osseointegration potential of 3D-printed porous, titanium interbody spacers in vivo.

9:10 - 9:12 am

550 Correlations between disc dimensions and principal surface strains across the L4-5 intact IVD during in vitro loading

Anna Sawa; Piyanat Wangsawatwong; Bernardo De Andrada, MD; Jakub Godzik; Jay D. Turner, MD, PhD, FAANS; Brian Kelly

Introduction: Understanding the biomechanical behavior of the intact intervertebral disc (IVD) is of great importance when studying disc disease. Experimental data describing the relationship between disc dimensions and sub-regional principal strains of the intact lumbar intervertebral disc during multi-directional loading is lacking.

Methods:

The mean height and depth of the L4-5 IVD of 14 seemingly healthy human spine segments [6F/8M, mean(±SD) age: 45±13years; BMD: 0.916±0.120 g/cm2] were determined using lateral view x-rays and ImageJ. The IVDs were part of L3-S1 spine segments that were tested using non-destructive loading (7.5 Nm) in flexion (FL), extension (EX), right/left lateral bending (RLB/LLB), right/left axial rotation (RAR/LAR), followed by compression (Comp, 400 N). Mean principal strains (Pmax and Pmin) in four similarly sized quarters of the L4-5 IVD were assessed using 3D digital image correlation (DIC, Vic-3D) with cameras positioned directly lateral on the specimen's left side. Relationships between sagittal view disc measurements (disc height, disc size [sagittal plane disc surface area] and anterior-posterior disc height ratio [wedge shape]) and mean principal strains (Pmax angle] per laterally viewed disc quarter [Q1(ant)-Q4(post)] were studied using Pearson Correlation analysis (SigmaPlot v14 with p<0.05).

Results:

Taller discs correlated significantly with decreased Pmax during LAR (Q2 and Q3: R=-0.55, p<0.05), and RAR (Q1 and Q2: R=-0.54, p<0.05); increased Pmin during RAR (Q1, Q2 and Q3: R=0.53, p<0.05); decreased Pmin during LLB (Q3 and Q4: R=-0.54, p<0.05); decreased gamma (direction of Pmax relative to horizontal) during FL (Q3: R=-0.54, p<0.05), EX (Q1 and Q4: R=0.42, p<0.04), and LLB (Q2: R=-0.57, p<0.04).

Larger sagittal plane surface area correlated significantly with decreased Pmax during FL (Q3: R=-0.54, p<0.05) and RAR (Q1 and Q2: R=-0.55, p<0.04); decreased Pmax during compression (Q4: R=-0.58, p<0.03), and decreased Pmin (increased magnitude Pmin) during LAR (Q2 and Q3: R=0.54, p<0.05). There were no correlations between disc size and direction of principal strain (gamma) (p>0.05).

More wedge-shaped discs correlated significantly with decreased Pmax during LAR (Q2 and Q3: R=-0.55, p<0.05), and increased Pmin (decreased magnitude Pmin) during RAR (Q1 and Q2: R=0.57, p=0.03).

Conclusion: Significant relationships were found between disc dimensions and mean principal strains in sagittally viewed sub-regions of the L4-5 intervertebral disc, during different directions of loading. These relationships will aid in understanding intact disc biomechanical behavior during loading and will help improve the quality of finite element models of lumbar spine segments.

9:12 - 9:14 am

551 Assessing the Performance of SANE Score in Predicting Long-Term Outcomes after Surgery for Low Grade Spondylolisthesis

Scott C. Wagner; Mohammed A. Alvi, MD, MS; Abdul K. Ghaith, MD; Arjun Sebastian, MD; Andrew Kai-Hong Chan, MD; Praveen V. Mummaneni, MD, FAANS; Erica F. Bisson, MD, FAANS; Mohamad Bydon, MD, FAANS

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.

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: A total of 6,138 patients had available PROM data at 3 months, and 4,817 patients had data out to 12 months post-surgery. At 3 months of follow up, a total of 2,712 (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) had a NASS satisfaction score of 1 or 2 at 3 months. At 12 months follow up, a total of 2,191 (45.6%) achieved MCID change in EQ5D, a total of 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) had a NASS satisfaction score of 1 or 2 at 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.

Conclusion: This study is the first to assess the one-question SANE score after spine surgery. Our results demonstrate that the single-question SANE score can be utilized to obtain clinically important information about patient outcomes after one or two-level lumbar fusion. Furthermore, the SANE performs similarly to more burdensome legacy PROMs, and may offer the quickest and easiest method by which spinal surgeons can assess patient outcomes after lumbar fusion surgery.

9:14 - 9:16 am

552 The Psychological Burden of Disease Among Patients Undergoing Cervical Spine Surgery

Peter G. Passias, MD; Sara Naessig; Waleed Ahmad; Katherine Pierce; Nicholas Kummer; Lara Passfall; Oscar Krol; Brooke O'Connell; Constance Maglaras; Bassel G. Diebo, MD

Introduction: Psychological distress is associated with poor outcomes in patients with chronic neck pain. Maladaptive thoughts and behaviors contribute to chronicity and disability.

Methods: Patients age >18 with cervical degenerative disease were included. Those with history of major depression were excluded. Demographics and patient reported outcome measures (NDI, EQ5D, PCS, FABQ) were assessed via descriptive analyses. Mental health scores (PCS, FABQ) were compared to a lumbar spine population and stratified by severity (severe = PCS>30; FABQ>34). Correlations assessed mental health components and severity of disability described by NDI (Not Disabled=0-4, Mild=5-14, Moderate=15-24, Severe=25-34, Complete=34+). Logistic regressions assessed the relationship between NDI and psychological burden by PCS and FABQ.

Results: Of 47 patients (53.6 years, BMI 29.4 kg/m2), 32% were diagnosed with radiculopathy, 26% myelopathy, 15% herniated disc, 16% spondylosis, 10% stenosis, and 6% degenerative disc disease. All were scheduled to undergo spinal fusions with decompression and had failed at least 3 months of conservative treatment. Average levels fused was 2.27 ± 1.4 . At baseline, average measures of mental health were PCS: 27.4 and FABQ: 40. The population had average EQ5D of 9.3 and NDI of 25.6. 57.1% of patients had severe FABQ, 40.8% severe PCS, and 26.5% severe NDI. Compared to lumbar patients, the cohort had greater psychosomatic pathology by FABQ (40 vs 17.55) and PCS (27.4 vs 19.25). Increasing neck disability was correlated with greater PCS measured disability (Mild r=-0.4, Moderate r=-0.32, Complete r=0.58; p<0.05). Complete disability had significant relationship with severe PCS independent of levels fused and diagnosis (11.7[90.5-1.5]; p=0.019). This trend was similarly identified for FABQ (Mild r= -0.39, Moderate r= -0.2, Complete r=0.4; all p<0.05). Severely disabled patients were not significantly associated with these mental health scores at baseline. Age was also not a significant predictor for baseline severe mental health scores.

Conclusion: Cervical spine patients, compared to lumbar spine patients, have greater baseline rates of mental health pathology despite stratification by disability and severity. The mental health of patients undergoing cervical surgery should warrant pre-operative treatment.

9:16 - 9:18 am

553 Biomimetic 3D-printed Titanium Interbody Spacers Demonstrate Osseointegration in an Ovine Lumbar Interbody Fusion Model

Frank LaMarca; Roland Beard; Margaret Van Horn; Wenhai Wang, PhD; Bryan W. Cunningham; Ken Mullinix; May Allall; Brandon Bucklen, PhD

Introduction: Through advancements in 3D-printing, titanium-alloy (TAV) interbody spacers can now be designed with unique, porous architectures that mimic trabecular bone. Spacers with a microscale surface roughness and biomimetic porosity may promote formation of new bone and improve implant osseointegration compared to traditional materials.

Methods: Eighteen mature female sheep underwent two-level (L2–L3 and L4–L5) lateral interbody fusion using either a 3DP, PEEK or a TAV spacer (n=6 levels for each spacer per time point). Animals were sacrificed at 6 and 12 weeks post operatively. Microcomputed tomography (microCT) and histomorphometric analyses were performed on each surgical level to quantify bone volume (BV) through the spacers and the total surface bone apposition ratio (BAR), respectively.

Results: At 6 weeks, the 3DP-treated group demonstrated significantly higher BV than PEEK and TAV groups (177.3±44.1 mm3, 116.9±43.0 mm3, and 108.7±15.2 mm3, respectively) (p<0.05). At 12 weeks, there was no significant difference in BV between the groups (p>0.05). BV significantly increased for all groups from the 6 to 12 week time point (p<0.05). At both 6 and 12 weeks, the 3DP-treated group (23.6±10.9% and 36.5%±10.9%, respectively) had significantly greater BAR than PEEK (8.6±2.1% and 14.0±5.0%, respectively) and TAV-treated groups (6.0±5.7% and 4.1%±3.3%, respectively) (p<0.05).

Conclusion: This study demonstrated that 3DP porous, biomimetic spacers facilitated greater bone growth through spacers at 6 weeks and greater bone apposition onto the surface of the spacers at both 6 and 12 weeks postoperative compared to solid PEEK and TAV interbodies. The 3DP spacers led to bone formation in an ovine model, as evidenced by bony ongrowth and equivalent bone volume compared to PEEK and TAV at 12 weeks postoperative. These interbody spacers must still be evaluated in a clinical setting.

9:18 - 9:20 am

554 The Role of Plasma Derived Purified Exosome Product (PEP) for Improved Locomotor Recovery in Spinal Cord Injured Rats

Chiduziem Onyedimma; F.M. Moinuddin, PhD; Yagiz U. Yolcu, MD; Mohamad Bydon, MD, FAANS

Introduction: Preclinical studies indicate that mesenchymal stem cell-derived secretomes exert immunomodulatory and neuroprotective effects in various spinal cord injury models. Exosomes as one of the secretomes, have been shown to successfully aid wound healing for the skin and following myocardial infarction. However, the effects of human plasma-derived purified exosomal products (PEP) on spinal cord injury (SCI) have not been explored to this date.

Methods: Twenty-four female rats were randomly divided into five groups. These included 2 control groups for the I.V or I.T injected PEP groups and a sham group. Groups were subject to a T9 laminectomy, followed by a moderate contusion SCI. After 24 hours, lactated ringer solution or PEP was injected through I.V or IT routes. Rats were assessed weekly for a total period of 10 weeks by an open field Basso, Beattie, and Bresnahan (BBB) motor score and a postmortem quantification of external scaring, neuronal regeneration, cavity volume, and glial scarring was carried out at the end of the follow-up period.

Results: Animals treated with I.V PEP or IT PEP had significant improvement within the first-week post-injury (1.05±1.2 vs. 2.16±3.15) and (1.08±3.5 vs. 4.5±0.083) respectively, with sustained improvement in BBB score at 10 weeks (11±1.16 vs. 13.8±1.90),(11.3±1.4 vs. 14±1.16).

Conclusion: Our preliminary results suggest that I.V or IT PEP injection without immunosuppression might provide beneficial effects initially following traumatic SCI.

9:20 - 9:22 am 555 Use of Incisional Negative Pressure Wound Therapy in Complex Spinal Surgery

Daniel Myers, MD; Rocco M. Dabecco, DO; Chen Xu, MD; Rebecca Schorr; Alexander Kwong-Tak Yu, MD;

Introduction: Negative pressure wound therapy (NPWT) is a common tool for assistance with wound healing in a number of different clinical settings and has enhanced wound care over the past two decades. Incisional NPWT in a novel wound care strategy that has been shown to improve wound healing in multiple surgical areas; however, there is a paucity of evidence regarding the efficacy and use of incisional NPWT in the setting of spinal surgery and its potential benefits towards enhancing wound healing in complex spine wounds.

Methods: This was performed as a retrospective descriptive study. 12 months of consecutive cases deemed complex spine cases were selected. Demographic, preoperative, operative, and postoperative clinical data were recorded.

IRB Approved.

Results: 105 consecutive cases were included. Of these cases 76 patients were treated with iNPWT with 29 patients treated with standard postoperative wound care. In the iNPWT group, there was a significantly higher percentage of non-degenerative pathology including traumatic (11.8% vs 6.9%), Infectious (14.4% vs 6.9%) and neoplastic (14.4% vs 13.7%) with degenerative being a higher percentage of cases in the standard therapy group (72% vs 59%). iNPWT patients tended to have longer instrumentation constructs mean 6.89 levels, vs 4.07 levels. Other significant risk factors were more common in the iNPWT group including immunocompromised state, presence of diabetes mellitus, cancer, smoking, steroid use, and radiation.

Incidence of wound revisions were 10% lower (23.7% vs 34.5%) in the iNPWT group, as were SSI rates (14.4% vs 24.1%).

Average BMI was relatively similar in both groups (31.2 vs 30.9).

There were no complications related to use of iNPWT in our series.

Conclusion: Based on these data, iNPWT is a safe and effective adjunct to wound healing via primary intention in complex open spine surgery. Despite a population of patients with a higher incidence of risk factors for SSI and wound complications, the iNPWT group showed a significantly lower incidence of postoperative SSI and wound revisions.

9:22 - 9:24 am

556 Association Between Social Determinants of Health and Postoperative Outcomes in Single-Level Lumbar Fusions

Owoicho Adogwa, MD, MPH; Syed I. Khalid; Sai Chilakapati; Palvasha Deme; Samantha Maasarani; Ravi S. Nunna, MD; Rachyl Shanker; James Caruso, MD; Alecia Cherney; Jennifer Smith; Anne-Isabelle Reme

Introduction: Decreasing postoperative complication rates is of great interest to surgeons and healthcare systems. Postoperative complications are associated with poor convalescence, inferior patient reported outcomes measures, and increased healthcare resource utilization. Better understanding of the association between Social Determinants of Health (SDH) on postoperative outcomes maybe helpful to decrease postoperative complication rates.

Methods: MARINER 2020, an all-payer claims database, was utilized to identify patients undergoing singlelevel lumbar fusions between 2010 and 2018. The primary outcomes were the rates of any postoperative complication, symptomatic pseudarthrosis, need for revision surgery, or 30-day and 90-day all-cause readmission. Exact 1-to-1 matching based on patient age, gender, history of diabetes mellitus, hypertension, ischemic heart disease, chronic kidney disease, obesity (body mass index greater than 35 kg/m2), smoking, and rheumatoid arthritis was used to create two identical groups, stratified by the presence of at least one SDH disparity. Sensitivity analysis using adjusted multivariate logistic regression models was also performed.

Results: The exact matched population analyzed in this study contained 16,560 patients [8,280 (50.0%) patients undergoing single-level lumbar fusion with an SDH disparity; 8,280 (50.0%) patients undergoing single-level lumbar fusion without a disparity]. Both patient groups were balanced at baseline. The rate of symptomatic pseudarthrosis (1.0% vs 0.6%, p<0.05) and any postoperative complication (16.3% vs 10.4%, p<0.05) in the matched analysis was higher in the disparity group. The presence of a disparity was associated with 70% increased odds of developing any complication (OR 1.7, 95% CI 1.53-1.84) or symptomatic pseudarthrosis (OR 1.7, 95% CI 1.17-2.37). Unadjusted and adjusted sensitivity analyses yielded similar results as the primary analysis.

Conclusion: Social Determinants of Health affect outcomes in spine surgery patients and are associated with an increased increase risk of developing postoperative complications following lumbar spine fusion.

9:24 - 9:26 am 557 A Novel Fusion Classification System for the Advent of Bioactive Interbody Implants

Robert Eastlack, MD; Hani Malone; Martin Collier; Hazem Elsebaie; Gregory M. Mundis ; Bahar Shahidi; Behrooz A. Akbarnia, MD

Introduction: Historically, intervertebral fusion required bone bridging exclusively, but new bioactive interbody devices, which allow for appositional integration of bone at the endplate-implant interface, demands an evolution in our radiographic assessment of such fusion processes. Specifically, acknowledgement that endplate bone adhesion to the surface of these implant confers stability, and potentially an effective 'fusion', warrants strong consideration within a new classification scheme.

Methods: A novel grading system for intervertebral fusion was developed by the authors and included fusion consolidation through and/or around the intervertebral device, as well as the apposition of bone to the surface of the implants. The prosed system is as follows, Grade 1: intervertebral bone connection through and/or around the implant + endplate bone connection to cranial and caudal implant surfaces, Grade 2: bone connection through/around implant, without connection to cranial or caudal implant surfaces, Grade 3: cranial and caudal implant-endplate connection without intervertebral bone connection, Grade 4: no intervertebral continuous bone connection and lack of bone attachment to cranial or caudal implant surface. Ten cases with 1yr CT scans were used for a survey of surgeon respondents. Surveys were administered twice, >2wks apart, with cases in different order. Intraclass Correlation Coefficient (ICC) was used to calculate inter and intra-rater reliability.

Results: 51 spine surgeons participated, with 37 of them completing surveys on two separate occasions. For the entire cohort, ICC interrater reliability (95% CI) mean was 0.618 (0.435-0.834; p<0.001), while the intrarater reliability mean was 0.778 (SD=0.211). Four respondents had outlier intra-rater reliability scores (avg=0.259). When removing those 4 respondents (10.8%), and analyzing the more consistent (90%) of the cohort, the ICC for inter- and intra-rater reliability were 0.628 (0.445-0.841; p=<0.001) and 0.831 (SD=0.125), respectively.

Conclusion: Our novel interbody fusion classification system demonstrated substantial/good interrater and intra-rater reliability. Future assessment of interbody fusions should consider use of this new system in order to address the important contribution of appositional ongrowth/ingrowth, along with traditional bone healing through and around devices. We are currently applying the system in a large clinical study to further validate its reliability.

9:26 - 9:28 am

558 Radiographic Outcomes of Anterior-alone Reconstruction with Expandable Cages After Corpectomy for Cervical Spondylosis

Robert North; Michael J. Strong, MD, PhD; Brandon W. Smith, MD, MSCR; Yamaan S. Saadeh, MD; Jacob R. Joseph, MD; Osama Kashlan, MD; Nicholas J. Szerlip, MD, FAANS; Mark E. Oppenlander, MD; Paul Park, MD, FAANS

Introduction: Modular expandable cages are an attractive reconstruction option for cervical corpectomy. However, dedicated studies examining radiographic outcomes using these devices in the cervical spine are very limited. The few existing studies include heterogeneity in both treated pathologies and use of anterior and posterior instrumentation.

Methods: A retrospective review was performed of all patients who underwent anterior cervical corpectomy for cervical spondylosis at a single center from 2014-2020 using a titanium expandable cage for reconstruction and with greater than 1 year of follow up. C2-C7 lordosis, segmental lordosis, C2-C7 SVA, and T1 slope were measured on upright lateral radiographs pre-operatively, immediately post-operatively, 1-year follow up, and last available follow up. Cage subsidence was measured on lateral radiographs immediately post-opertively, at 1 year follow up, and last available follow up. Evidence of fusion by Brantigan-Steffee criteria using lateral radiographs was examined at 1 year and last available follow up.

Results: 37 patients were included with average follow up of 24 months. All cases involved a single level corpectomy with expandable cage reconstruction and anterior plating. C2-C7 lordosis was significantly increased immediately post-op but not at 1 year and last follow up. Segmental lordosis was significantly increased comparing pre-op to post-op, at 1 year, and at last follow up. C2-C7 SVA and T1 slope was not significantly different comparing pre-op to post-op, at 1 year, and at last follow up. Total cage subsidence averaged 0.4 mm immediately post-op, 1.5 mm at 1 year, and 2.8 mm at last follow up. Fusion was achieved in 23/28 (70%) of cases at 1 year and 12/15 (80%) for patients with > 1 year follow up. No patient required revision at the index level, 4 patients required surgery for symptomatic adjacent segment degeneration.

Conclusion:

Single-level cervical corpectomy for cervical spondylosis with anterior-alone reconstruction using an expandable cage and anterior plating provides immediate, significant increase in C2-C7 lordosis and segmental lordosis, no significant change to C2-C7 SVA or T1 slope, modest rates of subsidence, and up to 80% rate of fusion.

9:28 - 9:30 am 559 Rheumatoid Arthritis in Spine Surgery: A Systematic Review and Meta-Analysis

Benjamin Streufert; Chiduziem Onyedimma; Abdul K. Ghaith, MD; Yagiz U. Yolcu, MD; Ahmad Nassr; Benjamin D. Elder, MD, PhD, FAANS; Arjun Sebastian, MD; Bradford L. Currier, MD; Mohamad Bydon, MD, FAANS

Introduction: Rheumatoid arthritis (RA) commonly affects the spine. While the initial treatment is medical, patients often require surgical management of spinal pathology due to neural element compression, instability, or deformity. The systemic inflammatory nature of this autoimmune disease as well as the subsequent medical treatments have been implicated in increasing complication rates in orthopaedic and other surgery. Newer disease modifying antirheumatic drugs (DMARDs) are increasingly prescribed for RA due to their efficacy in lowering overall morbidity, however, less is known regarding their impact in the perioperative period. While the perioperative management of antirheumatic medication has some concensus described in other areas of elective orthopaedic surgery, specific guidance surrounding spine surgery is lacking.

Methods: A search of available published literature on patients with RA and spine surgery was performed according to Preferred Reporting for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Studies were included if they provided a direct comparison of outcomes between the patients undergoing spine surgery with or without RA diagnosis. Single arm studies on RA patients with no comparative group were excluded. Data was extracted from included studies on patient demographics, perioperative medical management, operative details, and postoperative outcomes and complications. When specific details regarding management of antirheumatic medication was unavailable, recommendations were extracted from included studies on operative time, estimated blood loss, overall complications, infection, and implant-related complications. Categorical outcomes were presented using risk ratios with 95% confidence intervals while continuous outcomes were presented using mean differences (MDs). Pooled estimates and effect sizes were represented by forest plots.

Results: Included in analysis were 9 studies with 703 patients with RA undergoing spine surgery and 2569 patients without RA. Specific information regarding perioperative management of antirheumatic medications was not available; practices were varied among studies and are qualitatively described. In RA patients compared to non-RA patients undergoing spine surgery, the relative risk of infection was 2.29 times higher (p=0.036; 95% CI [1.08; 4.84]), overall complications 1.61 times higher (p<0.001; 95% CI [1.28; 2.03]), and implant-specific complications 3.93 times higher (p=0.009; 95% CI [1.41; 10.97]). Operative time and estimated blood loss were not significantly different between groups.

Conclusion: Treatment of spinal pathology in patients with RA carries an increased risk of infection, implantrelated complications, and overall complications when compared to patients without RA. Complications after spine surgery in RA patients may stem from altered anatomy in the operative field and increased medical complexity of the RA patient. The reason for this increased risk of infection is likely multifactorial as well, with the systemic autoimmune effects and anti-rheumatic medical treatments contributing to an altered immunologic environment. Spine-specific guidelines for perioperative management of anti-rheumatic medication are not well delineated and deserve further exploration. This review helps identify risk profiles in RA specific to spine surgery and may guide future studies seeking to medically optimize RA patients perioperatively.

Spinal Deformity Abstract Breakout Session Saturday, July 31

7:30 - 7:32 am 600 Which Coronal Measurements & How Much Coronal Malalignment Most Accurately Predict 2-year PROs After ASD Surgery?

Scott L. Zuckerman, MD; Christopher Lai; Daniel Shen; Meghan Cerpa; Mena G. Kerolus, MD; Ian A. Buchanan, MD; Alex Ha; Eric Leung; Nathan Lee; Lawrence Lenke

Introduction: Adult spinal deformity (ASD) surgery has underemphasized the importance of coronal malalignment (CM). Little is known about how much CM will impact outcomes.

Methods: A single institution ASD registry of patients having \geq 6 level fusions was queried. CM was defined as CVA>3cm. Coronal variables included: 1) CVA (cm); 2) max Cobb angle, 3) lumbosacral fractional curve assessment (L4/L5 tilt), 3) PO (angle between iliac crest and horizontal plane), & 4) LLD (difference in femur head to tibial plafond). Threshold analysis differentiated patients with ODI<40 and SRS-pain+function>6 at 2-years postop. Univariate & multivariate regression was performed.

Results: 174 patients had 2-year follow-up with a mean age of 50.9 ± 17.6 and mean instrumented levels of 13.4±4.0. Mean preop CVA was 2.9±2.8cm, & 64 (37%) had preop CM. At 2-yrs postop, all measurements and PROs significantly improved (p<0.05), with 24 (14%) patients having postop CM (p<0.001). Multivariate linear regression controlling for SVA showed that final CVA at 2-years postop was independently associated with 2-year ODI (β =3.20, 95%CI 0.62,5.78, p=0.016), in addition to SRS-total (β =-3.35, 95%CI -5.88,-0.83,p=0.010) and SRS-function (β =-0.15, 95%CI -0.28,-0.03,p=0.018). Change in CVA had no correlation with ODI/SRS-22r. No meaningful associations were seen between ODI/SRS-22r and max Cobb angle, L4/5 tilt, PO, or LLD. 2-year CVA threshold that optimally distinguished patients with ODI<40 was 1.8cm (AUC=0.667) & SRS-pain+function>6 was 2.1cm (AUC=0.722).

Conclusion: CVA was the superior coronal measurement and was independently associated with 2-year postop PROs in patients with and without preop CM, while controlling for SVA. 2-year CVA threshold most predictive of optimal PROs was approximately <2cm from midline.

7:32 - 7:34 am

601 Establishing a Threshold of Impairment to Define Coronal Malalignment in Adult Spinal Deformity Patients

Scott L. Zuckerman, MD; Christopher Lai; Daniel Shen; Meghan Cerpa; Mena G. Kerolus, MD; Ian A. Buchanan, MD; Alex Ha; Zeeshan Sardar; Ronald A. Lehman, MD; Lawrence Lenke

Introduction: No radiographic alignment threshold defines preop coronal malalignment (CM) in adult spinal deformity (ASD) patients based on disability.

Methods: A single-institution registry was searched for all pts undergoing ASD surgery with ≥6 level fusions. Coronal vertical axis (CVA) & sagittal vertical axis (SVA) were collected. PROs were preop ODI/SRS-22r scores. First, CVA & SVA thresholds were derived to accurately differentiate pts with ODI>40 & SRS-pain+function scores<6. Second, pts were separated and compared based on 4 groups: 1) Neutral Alignment (NA); 2) Coronal Malalignment only (CM); 3) Sagittal Malalignment only (SM); 4) Combined Coronal & Sagittal Malalignment (CCSM). Chi-square, Kruskal-Wallis, & linear regression were performed.

Results: 368 patients underwent ASD surgery with a mean CVA of 3.1 ± 4.1 cm. Part 1: Thresholds to distinguish patients with ODI>40 and SRS-pain/fx<6 were: 1) CVA=3.96cm (ODI) and 3.17cm (SRS); 2) SVA=4.97cm (ODI) and 7.52cm (SRS). To stay conservative, the lower numbers were chosen to define each threshold: CVA=3cm; SVA=5cm. Part 2: Alignment breakdown was: NA 179 (48.6%), CM 66 (17.9%), SM 65 (17.7%), & CCSM 58 (15.8%). Based on preop ODI scores, both SM (p=0.006) & CCSM (p<0.001) patients were significantly worse than NA pts. CCSM pts were significantly worse than SM alone (p=0.010). Based on preop total SRS-22r scores, only CCSM (p=0.003) pts were significantly worse than the NA group. CVA significantly correlated with 4/7 (57%) PROs (ODI/SRS-total/function/image), while SVA correlated with 5/7 (71%) PROs (ODI/SRS-total/function/image/pain). A linear relationship was seen between increasing CVA & worsening ODI (β =0.92, p=0.001). A significant yet slightly stronger relationship was seen between increasing SVA & worsening ODI (β =1.28, p<0.001).

Conclusion: Alignment thresholds that accurately distinguished ASD pts with severe pain and disability preoperatively were 3cm for CVA and 5cm for SVA. Preop CM was significantly associated with worse ODI, SRS-22r total/function/image scores. CCSM lead to more disability than SM alone.

7:34 - 7:36 am 602 What is the Lowest Achievable Rate of Complications Following Corrective Surgery for Adult Spinal Deformity?

Lara Passfall; Nicholas Kummer; Oscar Krol; Sara Naessig; Bhaveen Kapadia; Shaleen Vira; Renaud Lafage; Virginie Lafage, PhD; Peter G. Passias, MD

Introduction: It has not yet been quantified to what extent preoperative patient-related factors can influence complication rates in adult spinal deformity patients.

Methods: Included: operative ASD patients with preop(BL) data. Complication groups were defined as follows: 1) any complication, 2) major, 3) medical[cardiac event, ileus,etc.], 4) surgical[site infection, wound dehiscence, etc.], 5) mechanical [implant failure, rod fracture, etc.], 6) radiographic[PJK, pseudoarthrosis], and 7) reoperation. Univariate analysis identified patient factors associated with increased odds of complication: severe deformity by SRS-Schwab SVA, being Elderly [≥70 years; Caterino, am J Emerg Med], frailty [Miller 40item index], high CCI[≥1 SD above mean], obesity[BMI >30kg/m2], osteoporosis, diabetes, and hypertension. Up to 2Y comp rates were assessed by count of risk factors present, and then stratified by SVA deformity. To assess the incremental benefit of having fewer risk factors, the absolute risk reduction (ARR) was calculated in reference to complication rates in patients with no risk factors and baseline SVA 0 by SRS-Schwab criteria.

Results: 360 ASD pts included(59yrs, 27.2kg/m2, CCI: 1.70±1.73, levels fused 11.1±3.9). By 2Y, 66.4% of pts(n=239) developed \geq 1 comp. 20% had major comp, 22% med, 22% surg, 56% rads, and 20% mech. 19% required reop. Overall, 75.0% of pts(n=270) had \geq 1 risk factor: 30.1% ++SVA, 52.4% frail, 23.1% Elderly, 16.1% had osteoporosis, 24.2% obesity, 5.6% diabetes, and 36.7% had HTN. Comp rates and ARR are reported in. With increasing risk factor count, there is a trend toward higher comp rate across all categories. For pts without risk factors and SVA 0, comp rates were: any 52.6%, major 6.6%, med 14.5%, surg 15.8%, mech 18.4%, rads 50.0%, reop 14.5%. The highest observed ARR in comparison to these "lowest achievable" rates was 85.8%.

Conclusion: In operative ASD patients, deformity severity and specific baseline patient-related factors are associated with variable complication risk. These differing rates of expected complication profiles based on presentation are inherent to projecting appropriate risk expectations. Notably, even in the most ideal operative candidate with respect to patient-related risk profile, the risks of surgical correction are not eliminated.

7:36 - 7:38 am

603 Evaluation Quality of Life Following Adult Spinal Deformity Surgery in Three Domains: Physical, Mental, and Functional

Jianning Shao, BA; Arbaz Momin; Jonathan J. Rasouli, MD; Amy S. Nowacki, PhD; Jacob Enders, BSE; Precious Oyem; Emily Abramczyk; Carlos Munoz; Edward C. Benzel, MD, FAANS; Michael P. Steinmetz, MD, FAANS

Introduction: In patients with severe sagittal deformity, adult spinal deformity (ASD) surgery can restore spino-pelvic harmony and significantly improve quality of life. While previous studies have reported on this topic, many focuses on a single domain such as physical or mental health.

Methods: Retrospective cohort review was performed on all patients at our institution who underwent surgical correction for adult spinal deformity over the past 20 years. Patient demographics, history of prior spine operations, frailty measures including the modified frailty index-11 (mFI-11), comorbidity burden (Charlson Comorbidity Index/CCI), Clinical Frailty Scale (CFS), and preoperative Karnofsky Performance Scale (KPS) scores, along with surgical parameters were collected. We collected QOL data representing three domains: functional, mental, and physical health, utilizing the following indices/questionnaires: KPS, modified Oswestry Disability index (ODI), patient health quessionnaire-9 (PHQ9), and Patient-Reported Outcomes Measurement Information System (PROMIS) Global physical health. Regression analyses were performed to determine factors associated with each domain of postoperative QOL.

Results: 600 patients were included in the final analyses: 198 (35.6%) males and 358 (64.4%) females, with an average age of 59.8 ± 16.7 years. Multivariable analyses indicate history of prior spine surgery is correlated with higher PHQ9 scores at 3 months (b= 1.72, p=0.008) and 12 months (b=1.87, p=0.02), in addition to lower PROMIS scores at 12 months (b= -3.56, p=0.001). Additionally, higher number of surgical levels was correlated with lower PROMIS scores at 3 (b= -0.34, p=0.02) and 12 months (b= -0.34, p=0.03). Higher preoperative CFS scores were correlated with increased PHQ9 at 3 months (b=0.91, p=0.01) and 12 months (b=1.02, p=0.02). Lastly, higher preoperative KPS scores were correlated with higher postoperative KPS scores at both 3 months (b=7.28, p<0.0001) and 12 months (b=6.4, p<00001).

Conclusion: Patients with a history of prior spine surgery have higher levels of depression and lower levels of physical function following ASD surgery. Higher number of surgical levels is correlated with decreased physical functionality following surgery. Similarly, a higher degree of preoperative frailty is correlated with increased depression and decreased functional status postoperatively.

7:38 - 7:40 am

604 Do Adult Spinal Deformity Patients Undergoing Surgery Continue to Improve After 1-year Postoperative?

Scott L. Zuckerman, MD; Christopher Lai; Daniel Shen; Meghan Cerpa; Mena G. Kerolus, MD; Ian A. Buchanan, MD; Alex Ha; Lawrence Lenke

Introduction: It remains unknown how much time is required to maximize outcome scores following adult spinal deformity (ASD) surgery.

Methods: A database of ASD patients undergoing ≥6 level fusions was searched. Demographics and radiographic variables were collected. PROs were ODI/SRS-22r scores at: preop, 1-year and 2-years. The 3 outcome measures of clinical improvement during the 1-2y time interval were: 1) group medians, 2) percent minimum clinically important difference (MCID), and 3) percent with minimal symptom scale (MSS) (ODI<20 or SRS-pain+function>8). Non-parametric wilcoxon rank-sum tests, chi-squared tests and logistic regression were performed.

Results: A total of 88 patients undergoing ASD surgery with 2-year follow-up were included. Mean age was 53.2 and mean instrumented levels was 13.1. Preop alignment was: Neutral (N) 47.7%, Coronal Malaligned (CM) 18.2%, Sagittal Malaligned (SM 15.9%), and Combined Coronal/Sagittal Malaligned (CCSM) 18.2%. From preop to 1-year, and preop to 2-years, all ODI/SRS-22r significantly improved (p<0.001). In all patients, the only significant improvement in PROs between 1 and 2 yr postop were those reaching ODI MCID (69% 1-year vs. 84% 2-years, p<0.001). Upon subgroup analysis, certain populations experienced significant improvement in the 1-2y interval. Those \geq 55yo had an improved median ODI (18 vs. 8, p=0.047) and an improved percent achieving ODI MCID (73% vs. 84%, p=0.048). Those with CCSM experienced significant improvement in SRS-appearance score (75% vs. 100%, p=0.050), along with those with severe preop SM>7.5cm (73% vs. 100%, p=0.032). No significant improvement occurred during 1-2year interval in patients undergoing three-column osteotomies or those with a complication/reoperation (p>0.05).

Conclusion: Most ASD patients experience the majority of PRO improvement by 1-year postop. However, a subset of patients that may continue to improve after 1-year are patients with age>55, combined preoperative coronal/sagittal malalignment, and severe preoperative sagittal malalignment ≥7.5cm.

7:40 - 7:42 am 605 PEEK vs Titanium implants in single level lateral lumbar interbody fusion: does it matter for outcomes?

Robert Koffie, MD, PhD, MBA; Ifije Ohiorhenuan, MD; Courtney Hemphill; Juan S. Uribe, MD, FAANS

Introduction: Lateral lumbar interbody fusion (LLIF) is becoming an increasingly common procedure for treating patients with lumbar spondylolisthesis, adjacent level degeneration and lumbar spondylosis with instability. LLIF requires use of interbody implants with or without supplementation with posterior pedicle screw fixation. PEEK and titanium implants have become the most common implants to use in these procedures.

Methods: We performed a retrospective review of a prospectively collected data set of patients who underwent single-level LLIF procedures for degenerative spinal conditions at our institution from 2016 to 2019. The rate of radiographic subsidence and clinical outcomes as measure by ODI, SF36, and VAS leg were collected at 1.5, 3, 6, and 12 months after surgery. Statistics was performed using analysis of variance (ANOVA) with p<0.05 considered significant.

Results: One hundred and four patients met criteria and were included in the study: 56 were male and 48 were female. The age range was 39 to 87 years with no significant different noted between groups. Titanium interbody implants were used in 51 of these patients, whereas PEEK implants were used in 53 of these patients. Of the patients who had titanium implants 27 (53%) also has posterior percutaneous pedicle screw fixation whereas of those who received PEEK implants 31 (58%) also had posterior pedicle screw fixation at the time of surgery. The rate of radiographic subsidence was highest among the standalone PEEK implant group with 7.5% (compared to 3.9% in titanium alone), which was decreased to 3.8% with the use of posterior pedicle screw supplementation (compared to 0 % in the titanium group). Clinical outcomes significantly improved in all groups at 3 months and this was sustained at one year post-operatively regardless of presence of radiographic subsidence.

Conclusion: While the rate of radiographic interbody subsidence is higher in patients with PEEK implants compared to titanium implants, there is no statistical difference in long term clinical outcomes among the two groups. Further, augmenting PEEK or titanium interbodies with posterior pedicle screw fixation was effective at decreasing radiographic subsidence but was not associated with any further increase in long-term clinical outcome at 1 year. Taken together, these findings suggest that in single level LLIF for degenerative lumbar conditions, PEEK is as effective as titanium for achieving a favorable long-term clinical outcome.

7:42 - 7:44 am

606 Biomechanics of Spinal Deformity Correction Constructs: Implications for Proximal Junction Kyphosis Risk Assessment

Robert Koffie, MD, PhD, MBA; Bernardo De Andrada, MD; Jennifer Lehrman, BSE, MS; Jakub Godzik; Anna Sawa; Shashank V. Gandhi, MD; Brian Kelly; Juan S. Uribe, MD, FAANS; Jay D. Turner, MD, PhD, FAANS

Introduction: Proximal junctional kyphosis (PJK) at the adjacent level of fusion constructs is a common complication after complex spinal deformity correction in adults. Although multiple approaches have been proposed to prevent postoperative PJK, the biomechanical basis for PJK is not completely understood.

Methods: Standard nondestructive flexibility tests (7.5 Nm) were performed on 21 cadaveric specimens: 14 had PSO and 7 had ACR as the prime approach for correction. ROM at the adjacent free level was analyzed using repeated-measures analysis of variance and 2-tailed paired Student t-test (P<0.05 was considered significant).

Results: ACR constructs have a lower ROM on flexion at the proximal adjacent free level compared with constructs with PSO (1.02 vs 1.32, normalized to intact specimen, P<0.01). Use of lateral lumbar interbody fusion (LLIF) adjacent to PSO and 4 rods were more effective at limiting ROM at the free level when compared with using transforaminal interbody fusion (TLIF) and 2 rods in correction constructs with PSO (1.10 vs 1.32, normalized to intact specimen, P<0.05). Use of 2 screws to anchor ACR interbody further decreases ROM at the proximal adjacent free level on flexion, but when the ACR 2-screw construct with 4 rods was compared with the 2-rod construct with the same ACR condition, there was no significant difference. There was also no statistical difference in ROM at the proximal adjacent free level on extension in all constructs evaluated.

Conclusion: ACR constructs have less ROM at the adjacent level compared to PSO constructs. Among constructs with ACR, anchoring the ACR interbody with 2 screws is most effective at limiting motion at the proximal adjacent free level. In cases where PSOs are used, LLIF adjacent to the PSO level is superior to TLIF at limiting motion at the adjacent free level; adding 4 rods instead of 2 rods also limited motion at the adjacent free level in the PSO group but not in the ACR group. These findings have an implication for the pathogenesis and prevention of PJK.

7:44 - 7:46 am

607 Posterior Polyethylene Tethers Reduce Occurrence of Proximal Junctional Kyphosis after Multilevel Spinal Instrumentation

Emily Rabinovich; Harrison Snyder; Jesse McClure; Thomas Buell, MD; Justin S. Smith, MD, PhD, FAANS; Christopher I. Shaffrey, MD, FAANS; Avery Buchholz

Introduction: Proximal junctional kyphosis (PJK) is a common postoperative complication after adult spinal deformity (ASD) surgery, and if severe, may manifest associated symptoms including neurological decline, worsening spinal deformity, and spinal instability which warrant reoperation. Rates of PJK may be as high as 69.4% after ASD surgery, and various PJK-prophylactic techniques have been proposed. Junctional tethers may prevent occurrence of PJK by attenuating transitional stress at the proximal junction.

Methods: Single-center retrospective analysis of adult patients (age = 18 years) who underwent ASD surgery with index operations performed between November 2010 and June 2016 and achieved minimum two-year follow-up. Patients with ASD were subdivided into three treatment cohorts based on institutional protocol: no tether (NT), polyethylene tether-only (TO), and tether with crosslink (TC). PJK was defined as a proximal junctional angle (PJA) >10° and 10° greater than the corresponding preoperative measurement. Patient demographics, operative details, standard radiographic scoliosis measurements (including PJA and assessment of PJK), and complications were analyzed.

Results: Of 184 patients, 146 (79.3%) achieved minimum two-year follow-up (mean = 45 months; mean age = 67 years; 67.8% women). PJK rates reported for the NT, TO, and TC cohorts were 60.7% (37/61), 35.7% (15/42), and 23.3% (10/43), respectively. PJK rate among tethered (TO + TC; 29.4% [25/85]) patients was significantly lower than that non-tethered (60.7% [37/61]) (P = 0.0001).

Conclusion: Junctional tethers significantly reduced the incidence of PJK and revisions for PJK among ASD patients treated with long-segment posterior instrumented fusions who achieved minimum 2-year follow-up.

7:46 - 7:48 am

608 Clinical Utility of Intraoperative Spinal Curvature Assessment with Multi-slot Extended View Imaging on the O-arm System

Amanda Sacino, MD; Sutipat Pairojboriboon; Xiaoxuan Zhang; Ali Uneri; Michael Ketcha; Yixuan Huang; Pengwei Wu; Craig Jones; Patrick Helm; Jeffrey Siewerdsen; Sheng-Fu L. Lo, MD, FAANS

Introduction: Spinal deformity is a complex clinical entity. The global spinal alignment (GSA) parameters were developed to assess proper spinal alignment. Unfortunately, it can be difficult for spine surgeons to reliably evaluate changes to the GSA parameters in the operating room once patients are in the prone position using standard C-arm fluoroscopy due to the inability to achieve long-film radiographs.

Methods: The radiographic parameters were verified in EV images on a cadaveric torso. The thoracic and lumbar spine regions were scanned using multi-slot EV imaging on the O-arm, and the images were stitched together based on imaging gantry motor positions in order to acquire the long-film imaging view. Our EV images represent normal, kyphotic, and lordotic spinal alignment in the intraoperative prone positions. Long-film images of the pre-instrumentation and post-instrumentation thoracolumbar spine with 18 pedicle screws from T6 to L5 (4 unilateral, 7 bilateral) were also achieved. The GSA parameters and pedicle screw positions were evaluated.

Results: The normal alignment of the EV images represents lumbar lordosis (38.91°), T5-T12 angle (29.87°), and sacral slope (28.08°). The coronal views show T5-T12 angle (4.3°), T10-L2 angle (5.1°), and L1/2 disc - L4/5 disc apex (8.23°). The post-instrumentation images demonstrate a medial pedicle breach on the right at T9 as well as a vertebral endplate violation on the left at T12. The kyphotic and lordotic spinal sagittal alignment of EV images were also measured using the GSA parameters.

Conclusion: The multi-slot extended view imaging on the O-arm with long-film images is clinically useful to assess intraoperative thoracic level identification, proper placement of hardware, and GSA metrics. In particular, we can evaluate spinal deformity intraoperatively using GSA alignment parameters after performing spinal osteotomies and/or rod instrumentation compression or distraction for correction.

7:48 - 7:50 am

609 Biomechanical Effects of Proximally Extending Long Segment Constructs with PEEK Rods: A Cadaveric Study

Bernardo De Andrada, MD; Piyanat Wangsawatwong; Jennifer Lehrman; Anna Sawa; Jakub Godzik; Samuel H. Farber, MD; Brian Kelly; Juan S. Uribe, MD, FAANS

Introduction: Proximal Junctional Kyphosis (PJK) remains an unresolved problem and is a potential cause of mechanical failure, i.e. top screw loosening and pullout, and is an important contributing factor to high rates of revision surgery. The high mechanical stress zone created by the sudden transition from a rigid to a flexible region is one factor involved on the physiopathology of PJK.

Methods: Eight cadaveric specimens T2-pelvis with rib cage intact were selected. Pure moment tests (7.5 Nm) in flexion (F), extension (E), lateral bending (LB) and axial rotation (AR) followed by compression (C)(200N) were performed. Conditions:1) Intact; 2)T10 to S2-alar-iliac pedicle screws and rods (PSR); 3)Extending proximally to T6 with PEEK rods (PEEK). Strain gages were used on the rod at T10-T11 as well as on T9 anterior bone surface. T10 screw bending moments were recorded. Data were analyzed using RM-ANOVA or ANOVA (p<0.05).

Results: Compared to intact, PSR increased ROM at T9-T10 for all load directions except F but without significance (p>0.107). After extending the construct with PEEK rods, T9-T10 ROM decreased in F (p=0.022) and E (p=0.002). Compared to intact, PEEK decreased T9-T10 ROM in F (p=0.022) and E (p=0.002). PSR decreased T10-T11 ROM in F (p=0.017) and right LB (p=0.039) compared to intact. PEEK showed a decrease in T10-T11 ROM in F (p=0.004), E (p=0.041) and right LB (p=0.022) compared to intact. Reduction in T9 bone strain occured during right LB (p=0.019). Addig PEEK to PSR, caused reversed direction of bending on T10-T11 rod strain with during all directions of loading. Compared to PSR, the addition of the PEEK rods caused a slight increase in T10 screw bending moment during F, E, LB and C but with no significance (p>0.07), however reduced during left AR (p=0.026) right AR (p=0.527).

Conclusion: Extending a long-segment construct using PEEK rods redistributed the strain on the upper instrumented and adjacent levels, as well as caused a decrease in adjacent level hypermobility. Further studies are necessary.

7:50 - 7:52 am

610 Surgical Realignment of Adult Degenerative Scoliosis Improves Short Term Gait

Ram Haddas; Cezar Sandu; Addison Wood; Varun Sambhariya; Isador H. Lieberman, MD

Introduction: Adult degenerative scoliosis (ADS) has been shown to have a substantial impact on functional abilities including the ability to walk. Gait analysis can assist in objectively determining the effect of surgery.

Methods: We conducted a non-randomized, prospective study with 50 symptomatic ADS patients and 30 agematched healthy volunteers. Gait evaluations were performed prior to surgery (Pre), 3 months postoperatively (Post3), and compared to healthy controls.

Results: Symptomatic ADS patients presented with significant differences including slower gait (p<0.001), longer stride (p=0.023) and step time (right, p=0.049; left, p=0.018), and shorter stride (p=0.003) and step length (right, p=0.006; left, p=0.007) in comparison to controls. They also had decreased sagittal knee (right, p=0.023; left, p=0.001) RoM when compared to controls.

Operative intervention led to improved walking speed (p=0.003), shorter stride (p=<0.001) and step time (right, p=.024; left, p=0.005), shorter single-support (p=0.047), longer stride (0.016) and step length (right, p=.018; left, p=0.006). Furthermore, postoperative patients had improved sagittal plane knee flexion (right, p=.032; left, p=0.007), hip flexion (right, p=.025; left, p=0.042), and pelvic flexion (p=0.003), suggesting decreased compensatory requirements. As expected for surgical realignment of ADS, the primary Cobb angle show significant reduction (p<0.001), along with improvements in sagittal vertical axis (p=0.030), coronal vertical axis (p=0.041), sagittal pelvic tilt (p=0.036), and PI-LL mismatch (p=0.002). Moreover, patient reported outcomes significantly improved (p<0.015).

Surgery improved functional gait and compensatory joint mechanics of patients with ADS, but post-operative gait profiles did not completely match those of healthy controls.

Conclusion: This study demonstrated that patients with ADS showed improvements in gait speed and spatiotemporal parameters 3 months post-operatively when compared to a healthy control group. Additionally, static radiographic sagittal alignment parameters were also significantly improved with corresponding reductions in compensatory lower extremity joint angles in the post-operative group at 3 months. The results of this study indicate that spinal realignment surgery can result in early improvements in the functional gait of patients afflicted by adult degenerative scoliosis.

7:52 - 7:54 am

611 The Influence of Frailty on PJF – Is Optimal Realignment Superseded by Physiologic Age?

Oscar Krol; Lara Passfall; Nicholas Kummer; Waleed Ahmad; Sara Naessig; Bassel G. Diebo, MD; Shaleen Vira; Virginie Lafage, PhD; Peter G. Passias, MD

Introduction: Patients receiving surgery for adult spinal deformity (ASD) are often frail and may be at risk of adverse events following these intensive procedures, including proximal junctional failure (PJF). The role of physiologic age in prognosticating this outcome is not well defined

Methods: Operative ASD patients (scoliosis >20, SVA>5cm, PT>25, or TK>60) with available baseline (BL) and 2-year (2Y) radiographic and HRQL data were included. The Miller Frailty Index (FI) was used to stratify patients into 2 categories: Not Frail (FI <3) and Frail (>3). Proximal Junctional Failure (PJF) was defined using the Lafage criteria. Conditional inference tree analysis (CIT) was used to establish thresholds for the association between frailty and the risk of PJF.

Results: 245 ASD patients met inclusion criteria (57yrs±15.0, 82%F, BMI: 26.3 kg/m2 ±6.0, ASD-FI: 2.9±1.6, CCI: 1.55 ±1.7). Surgical patients had a mean levels fused of 11.4±4, LOS of 7.7 days±4.4, EBL of 1686 mL, operative time of 374 min, with 70% undergoing an osteotomy. In terms of surgical approach, 76% were posterior-only, and 23.6% had a combined approach. 138 (55%) of patients were characterized as Not Frail, 107 (43%) as Frail. Overall rate for PJK was 49%, and 12% for PJF. The presence of PJF in the NF group was lower than in the F group, (7% vs. 18%; p<0.05). Controlling for age, BL deformity, and surgical invasiveness, a higher BL Frailty index was correlated with increased odds of developing PJF (OR: 1.4, 95% CI: 1.01-1.9) and the risk of developing PJF for F vs NF patients was 3x higher (OR: 3 95% CI: 1.3-7). Controlling for BL deformity and invasiveness, patients matched in SVA still developed PJF with a high frailty index (OR: 1.7, 95% CI: 1.02-2.8, p=.014). CIT found patients with a frailty index greater than 3.4 had a 2.5x higher likelihood of developing PJF (OR: 2.5, 95% CI: 1.14-5.5, p=.026) and, in a cohort of patients matched in SVA, a frailty index higher than 4.9 led to a 5x higher likelihood of developing PJF (OR: 5, CI: 1.2-20, both p<0.05)

Conclusion: Frailty is a significant independent predictor of PJF development, and while optimal alignment may mitigate this effect, frailty still remains a risk factor.

7:54 - 7:56 am 612 Compensatory Mechanisms in Adult Degenerative Thoracolumbar Spinal Deformity

Nicholas Dietz; Basil Gruter; Edin Nevzati; Mazda Farshad, MD, MPH; Samuel K. Cho, MD; Peter Hollis, MD, FAANS; Alexander Spiessberger

Introduction: Loss of lumbar lordosis (LL) in degenerative deformity can activate compensatory mechanisms of the spine to maintain a neutral C7 sagittal vertical axis (C7SVA), namely: increase in pelvic tilt (PT) and/or decrease in thoracic kyphosis (TK).

Methods: A cohort of 43 adult patients with adult degenerative thoracolumbar deformity were included in this retrospective study and radiographic measurements were obtained before and after corrective surgery: C7SVA, TK, T10L2 kyphosis, LL, pelvic tilt (PT) and PI. Pearson correlations were calculated between PI-LL and T10L2 kyphosis, PT, TK, C7SVA before surgery for the whole cohort as well as for subgroups stratified by pelvic incidence, grouped into low and high PI group.

Results: Preoperative PI-LL mismatch significantly correlated with an increase in PT and decrease in TK in the whole cohort r=+0.66 (95%CI 0.44-0.8) and r=-0.67 (95%CI -0.81- -0.47) respectively at a relative rate of 0.37 (SD 0.07) and -0.57 (SD 0.09) respectively. In patients with low PI only TK showed a significant correlation with PI-LL, r=-0.56 (95%CI -0.8 to -0.16), at a rate of -0.57 (SD 0.19). The high PI subgroup showed significant correlation with PT, TK and C7SVA, r=0.62 (95%CI 0.26-0.82), r=-0.8 (95% CI -0.9- -0.58), r=0.71 (95%CI 0.41-0.87) at rates of; 0.48 (SD 0.11), 0.-72 (SD 0.12) and 0.62 (SD 1.27). Perioperative change of LL showed significant correlations with TK in the whole cohort, r=+0.63 (95%CI 0.31-0.82) at a rate of +0.80 (SD 0.20), with PT and TK (trend towards significance) in the low PI group, r=-0.48 (95%CI -0.77-0.02) and r=+0.49 (95%CI -0.06-0.8) at a rate of -0.44 (SD 0.20) and +0.72 (SD 0.38). In the high PI group significant correlations were found for TK and C7SVA (trend towards significance), r=0.76 (95%CI 0.31-0.93), r=-0.54 (95%CI -0.86-0.09) at rates of 0.81 (SD 0.22) and -2.3 (SD 1.2). The ratio of PT:TK change preoperatively was 0.46 (SD 0.28) in the low PI group and 1.47 (SD 2.16) in the high PI group.

Conclusion: Decrease of TK was a significantly more consistent compensatory mechanism in patients with low and high PI when compared to an increase in PT. PI-LL mismatch induced more pronounced changes in TK than in PT in all groups. Postoperatively the reversal of compensatory changes were more consistent for TK than for PT. Lastly patients with high PI relied more on PT increase to compensate for PI-LL mismatch than patients with low PI.

7:56 - 7:58 am

613 Changes in Coronal Alignment in Obeid Type 1 and Type 2 Adult Scoliosis after Lateral Interbody Fusion

Gregory A. Kuzmik, MD; Sigurd Berven, MD; Alexa Semonche, MD; Alvin Chan; Justin Lee; Shane Burch; Vedat Deviren; Praveen V. Mummaneni, MD, FAANS; Dean Chou

Introduction: Lateral interbody discectomy and fusion can be a powerful technique to correct coronal deformity and malalignment. However, in certain cases, correcting a scoliotic deformity through a lateral approach may worsen coronal malalignment.

Methods: A retrospective analysis of patients with adult scoliosis who underwent lateral lumbar interbody fusion (LLIF, both pre-psoas and transpsoas) by 5 surgeons from 2013 to 2018 was performed. Patients were included if they underwent at least one level of LLIF and had preoperative and postoperative anteroposterior 36-inch radiographs. Patients were excluded if they received a posterior osteotomy or had tumor, trauma, or infection. Patients were stratified into two groups based on Obeid type. Coronal vertical axis (CVA) and scoliosis Cobb measurements were measured preoperatively and postoperatively. Patients with anterior-only LLIF surgeries were separately analyzed.

Results: Of 413 patients who underwent LLIF, 114 patients met inclusion criteria. Amongst all patients, coronal imbalance improved from a mean of 20.6mm preoperatively to 10.6mm postoperatively. In the Obeid type 1 group, the mean reduction in CVA was 15.4mm, while in the Obeid type 2 group the mean reduction was 1.3mm (p = 0.02). In the Obeid type 1 group, scoliosis Cobb angle improved by a mean of 12.1°, while in the Obeid type 2 group the Cobb angle improved by a mean of 8.3° (p = 0.04). For the 56 patients with anterior-only surgeries, the mean reduction in CVA was 7.2mm in the Obeid type 1 group, while in the Obeid type 2 group the CVA worsened by 5.5mm; however this trend was not statistically significant (p = 0.15).

Conclusion: Obeid type 1 adult scoliosis patients have better correction of their CVA when undergoing a LLIF compared to those with an Obeid type 2 scoliosis. In patients who had a lateral only procedure, there was a trend towards improvement of the coronal alignment in Obeid type 1 patients and worsening in Obeid type 2 patients, although this trend was not statistically significant.

7:58 - 8:00 am

614 Assessing Coronal Alignment from Odontoid to Sacrum: A Normative Volunteer Study of the Odontoid-CSVL Distance

Scott L. Zuckerman, MD; Zeeshan Sardar; Meghan Cerpa; Jean-Charles Le Huec; Stephane Bourret; Kazuhiro Hasegawa; Hee-Kit Wong; Gabriel Liu; Hwee Weng Dennis Hey; Michael Kelly; Hend Riahi; Lawrence Lenke

Introduction: Coronal alignment in adult spinal deformity (ASD) surgery is underappreciated and currently does not take into account upper cervical alignment.

Methods: Adult volunteers without current neck/back pain or spine disorders were enrolled from 5 countries. All volunteers had standing full-body stereoradiographs. Demographics and Oswestry Disability Index (ODI) scores were collected. The OD-CSVL was the difference (mm) between the odontoid plumb line (line from odontoid tip vertically down) and the CSVL (vertical line up from the center of the sacrum). Radiographic measurements included common coronal/sagittal distances (mm) and angles (°). Chi-square, t-tests, Kruskal-Wallis, linear regression, and Pearson's correlation were used.

Results: Normative OD-CSVL values for 488 adult volunteers by age decade, gender, BMI, and country are reported. Mean OD-CSVL was 8.6±6.8mm (range 0.0-34.1), and 33 (6.8%) volunteers were near-perfectly aligned, with an OD-CSVL <1mm. A linear relationship between OD-CSVL and age (β =0.12, p<0.001) and BMI (β =0.21, p=0.003) existed. OD-CSVL varied significantly by ethnicity (p=0.004). Caucasians had the highest OD-CSVL (9.8mm), while Japanese had the lowest (7.1mm). OD-CSVL correlated most strongly with the global coronal distances of C7-CSVL (r=0.76), OD-knee (r=0.64), and auditory meatus-knee (r=0.61), in addition to regional TL Cobb angle (r=0.42) (all p<0.001). As expected, OD-CSVL had negligible correlation with sagittal measurements. Increased OD-CSVL was significantly associated with increased ODI in the highest quartile (β =0.25, p=0.005).

Conclusion: In asymptomatic adult volunteers, increased OD-CSVL was significantly associated with increased age and BMI and ethnicity, and strongly correlated with other coronal radiographic measurements. A higher OD-CSVL was significantly associated with increased ODI at the highest quartile of coronal malalignment.

8:00 - 8:02 am 615 Housfield Units vs DEXA T-score as a Predictor for Post-operative PJK

Dominic Maggio; Nathaniel Toop, MD; Andrew James Grossbach, MD, FAANS; Stephanus Viljoen, MD; Francis Farhadi, MD, PhD

Introduction: During pre-operative evaluation, spine surgeons utilize pre-operative hip DEXA scores as the standard of care method to estimate bone quality. These scores are utilized to start potential surgical patients on bone augmenting agents such as Teriparatide (Forteo), as well as to estimate a given patient's surgical risk. Hip DEXA scores are an indirect measurement of overall bone quality of the spine. Spine DEXA scores are notoriously unreliable and dramatically influenced by numerous factors including subtle compression fractures. Direct evaluation of vertebral body (VB) bone density is possible via measurement of the vertebral body Hounsfield units (HUs) on the patient's pre-operative CT. It is possible that this quick and easy measurement can predict post-operative proximal junctional kyphosis better than the current standard of care.

Methods: 108 patients were analyzed from a single institution who underwent a long-segment thoraco-lumbar fusion. Demographic characteristics, radiologic measurements, complication profile, and clinical outcomes via patient reported outcome measures were recorded both pre- and post-operatively (when applicable). Linear regression was performed to determine the correlation in the change in either HUs or DEXA t-scores with changes in post-operative cobb angles. A Youden J-statistic was calculated based on an ROC analysis of the UIV/UIV+1 Hounsfield unit data to give a single HU threshold to segregate patients into either a high or low HU group. The patients were divided into four groups: low/high HU, and low/high DEXA t-score. Patient groups were then compared with respect to the mentioned clinical and radiographic outcome measures.

Results: Linear regression analysis demonstrated a significant association between a decrease in HU at both the UIV and UIV+1 with an increase in proximal junctional cobb angle on both the one year and two year post-operative standing long segment radiographs (UIV vs 1-year, r=0.269, p=0.017), (UIV+1 vs 1 year, r=0.319, p=0.004)), (UIV vs 2-year, r=0.376, p=0.008), (UIV+1 vs 2 year, r=0.302, p=0.035). No significant correlation was seen with DEXA t-scores and cobb angles. Youden statistic revealed a HU threshold value of 126.8. Significant differences were seen between the pre-operative and one year post-operative cobb angles between the high and low HU group (p<0.0001), as well as comparing the 2 year post-operative cobb angles (p=0.0002). A trend, but no significant difference was seen in the mentioned cobb angles between the high and low hip DEXA at either the 1 year (p=0.1791) or 2 year (p=0.3919) time point. No significant differences were seen in rates of hardware failure or between pre/post-operative PROMs.

Conclusion: We demonstrate that assessment of bone quality via pre-operative measurement of the UIV+1 VB HU can predict post-operative changes in proximal junctional cobb angle. Specifically, HUs < 126.8 are significantly associated with elevated proximal junctional cobb angles. This finding was not seen by utilizing DEXA t-scores, regardless of forteo use. As the rate of complications were low, more patients will likely be needed to accurately demonstrate whether HU are associated with increased rates of complications. Similarly, measures of PROMS (especially back pain) will likely need a larger patient cohort to demonstrate whether an effect, if any, exists.
8:02 - 8:04 am

616 The Impact of Osteoporosis on Adult Deformity Surgery Outcomes in Medicare Patients

Kunal Varshneya; Rayyan Jokhai; Parastou Fatemi, MD; Zachary A. Medress, MD; Martin N. Stienen, MD; Allen L. Ho, MD; John K. Ratliff, MD, FAANS, FACS; Anand Veeravagu, MD, FAANS

Introduction: Patients with osteoporosis and advanced age experience higher than average rates of adult spinal deformity. However, poor bone density could undermine the durability of a deformity correction. Little data exists regarding the postoperative morbidity and construct longevity of Medicare patients undergoing adult spinal deformity surgery.

Methods: We queried the MarketScan Medicare Supplemental database to identify patients who underwent ASD surgery from 2007 to 2016. Patients were then stratified based on osteoporosis status at the time of the index surgery. Patients under the age of 65 years and those with any prior history of trauma or tumor were excluded from this study.

Results: A total 2,564 patients met the inclusion criteria of this study, of which n = 971 (61.0%) were diagnosed with osteoporosis. Patients with OS had a higher 90-day postoperative complication rate than non-OS patients (54.6% vs 49.2%, p < 0.0076). This was primarily driven by higher incidence of posthemorrhagic anemia (37.6% vs 33.1%, p < 0.0201). Rates of revision surgery were similar at 90-days (non-OS 15.0%, OS 16.8%), but by 1 year, OS patients had a significantly higher reoperation rate (24.1% vs 19.8%, p < 0.0096). In multivariate regression analysis, OS increased odds for revision surgery at 6 months (OR 1.3), 1 year (OR 1.4) and 2 years (OR 1.5) following surgery (all p < 0.05). OS was also an independent predictor of readmission at all time points (90 days, OR 1.3, p < 0.05). In a subgroup analysis of osteoporosis patients only, the use of BMP led to lower rates of revision surgery in the short-term.

Conclusion: In this study, Medicare patients with OS had elevated rates of complications, reoperations, and outpatient costs after undergoing primary ASD surgery. Further research should explore ways to improve ASD outcomes in elderly patients with compromised bone structure.

8:04 - 8:06 am 617 Tension Parameters of Junctional Tethers in Proximal Junction Kyphosis

Mary O'Hehir; Tim O'Connor, MD; Brandon Mariotti; Munish C. Gupta, MD; Sigurd Berven, MD; John Pollina, MD, FAANS; David W. Polly, MD; Jeffrey P. Mullin, MD, MBA

Introduction: Proximal junctional failure (PJF) following surgical correction for adult spinal deformity (ASD) significantly impacts patients' quality of life and increases the economic burden of treating underlying spinal deformity. Tethering devices have been shown to decrease the occurrence of proximal junctional kyphosis (PJK) following multilevel posterior spinal fusion to correct adult spinal deformity. However, there are currently no studies evaluating the optimal tension parameters to use when applying tethers to reduce PJK. As a result, it is unknown how much force is required to adequately tighten the tether system to prevent PJK while minimizing the risk of spinous process fractures or creating PJK above the tether system.

Methods: Specimens were instrumented from T2 to S1 bilaterally leaving the facet joints and posterior ligamentous complex intact. Levels for testing included T3-T4, T9-T10, and L1-L2. T7-T8 was used as a control level. Based on the literature and our feasibility study, we used tensions of 150N and 75N, quantified as 2/3 max and 1/3 max using a maximum of 250N. Each spine was alternatingly assigned a tension for each level, excluding the control level. The tether was secured in a figure eight pattern to mimic clinical use through UIV+1 and UIV+2. Cadavers were secured to the biomechanical model, and cyclically flexed at a net 150N. Testing was carried out until either PJK (angle change of 10 degrees), hardware failure, tissue failure, or maximum number of cycles was reached.

Results: Use of a junctional tether provided a protective effect in all experimental levels. The control group showed similar failure rates indicating that these results were primarily due to the tether and not differences in specimens. In the lumbar spine and lower thoracic spine, tether tensions of 75N and 150N were equally protective. In the upper thoracic spine, 150N was the most protective tension.

Conclusion: This is the first study to show that optimal tension parameters in tethers can be quantified and depend on the spinal level of interest.

8:06 - 8:08 am

618 Multi-Level Stabilization Screws Preventing Kyphosis in Adult Spinal Deformity Surgery: A Comparative Cohort Study

Ascher Kaufmann; Chad F. Claus, DO; Doris Tong; Robert W. McCabe, DO; Connor Hanson; Clifford M. Houseman, DO; Daniel A. Carr, DO; Teck-Mun Soo, MD, FAANS

Introduction: Proximal junctional kyphosis (PJK) and failure (PJF) occur in up to 40% of adults who undergo open thoracolumbar fusion for adult spinal deformity (ASD). Proximal stabilization techniques have been proposed to prevent PJK/PJF without conclusive results.

Methods: With MLSS, the most cephalad screw was inserted into the pedicle from the inferolateral aspect along a superomedial trajectory, reaching the superior cortex at the anterior aspect of the pedicle. This trajectory continued transdiscally through the superior vertebral level.

We performed an observational longitudinal cohort study comparing MLSS with standard stabilization instrumentation. We retrospectively reviewed the charts of consecutive ASD patients who underwent open thoracolumbar fusion, defined as >3 levels cranially above T6 and caudally below T12, between 2009-2017, and were followed for >2 years postoperatively. PJF was defined using International Spine Study Group (ISSG) criteria and PJK as Cobb angle increase >10°. The upper-instrumented-vertebra (UIV) was defined as the most cephalad vertebral body with bilateral MLSS. Confounders, MLSS-specific complications and radiographic outcomes were collected.

We evaluated comparability between groups using univariate analyses. We adjusted for covariates by using multivariable regressions modeling PJF and PJK separately with a p-value <.008 considered significant after Bonferroni correction. Sensitivity analysis was utilized for patients lost to follow-up.

Results: Seventy-six patients (50 MLSS vs 26 controls) were included. MLSS patients were significantly older (64.5±8.9 vs. 54.8±19.9 years, p=.024) and had significantly more operative levels (11.8±2.6 vs. 10.7 ± 1.9, p=0.036).

MLSS patients had a significantly lower PJF incidence (10.0% vs. 30.8%, p=.023) and kyphosis (1.3°±5.3° vs. 5.2°±6.3°, p=.014). MLSS was independently associated with decreased kyphosis compared to controls (B: - 4.5, 95%CI:-7.72 – -1.29, p=.007). MLSS-specific complications were not significantly different between groups.

Conclusion: MLSS was independently associated with significantly reduced incidence of PJF and acute PJF. MLSS was independently associated with a significantly decreased degree of post-operative kyphosis. We demonstrated that MLSS was not associated with increased perioperative and postoperative complications.

8:08 - 8:10 am 619 Biomechanical Investigation of an L5 Pedicle Subtraction Osteotomy for Sagittal Malalignment: An in-vitro Study

Burhan Janjua; Gerald Hayward; Jonathan Harris; May Allall; Brandon Bucklen, PhD

Introduction: Adult spinal deformity may result from progression of prior (childhood/adolescence) spinal kyphoscoliosis or an iatrogenic degenerative spinal disease. Sagittal malalignment has been established with poor health-related quality of life. Planned osteotomies may help achieve optimal sagittal correction. The objective of this study is to investigate the effect of an L5 pedicle subtraction osteotomy (PSO) on sagittal correction, as well as range of motion, following L2–S2 fixation.

Methods: Six cadaveric specimens (L1–pelvis) were tested in flexion-extension (FE), lateral bending (LB), and axial rotation (AR) to ±12.5 Nm. Constructs included intact and PSO with fixation from L2–S2 with S2-alar iliac fixation (L2–S2+PSO) with lordosis measurements recorded for each construct. Lordotic angles, measured from the inferior endplate of L4 and superior endplate of S1, were recorded for intact and post-L5-PSO specimens to determine the impact of sagittal correction.

Results: Mean lordotic angles [±SEM] in the intact and L2–S2+PSO specimens were 30.12° [±7.56°] and 46.81° [±7.75°], respectively, with L2–S2+PSO having significantly higher lordotic angles (p<0.05). L2-S2+PSO significantly reduced motion compared to intact across all bending planes (15.4%, 15.3%, and 50.9% in FE, LB, and AR, respectively).

Conclusion: In this cadaveric study, significant correction was achieved with an L5 PSO, similar to other biomechanical studies investigating mid-lumbar PSOs. However, the most caudal lumbar level (L5) osteotomy provided the greatest contribution to overall spinopelvic sagittal alignment. Supplemental pelvic fixation plays an additive role in construct stability.

8:10 - 8:12 am 620 Comparison of Sagittal Vertical Axis Correction after L4 versus L3 Pedicle Subtraction Osteotomies

Joshua Rivera; Praveen V. Mummaneni, MD, FAANS; Jeremy Guinn; Hao-Hua Wu; Minghao Wang; Ping Guo Duan, MD, PhD; Zhuo Xi, MD, PhD; Justin Lee; Burooj Mahmood; Parishkrita Srivastava; Rafael Guizar III; Xiao Tan; Jeremy Huang; Vivian Le; Shane Burch; Sigurd Berven, MD; Dean Chou, MD, FAANS

Introduction: Historically, the pedicle subtraction osteotomy (PSO) has been done at L3, but are increasingly performed at L4 because of possible increased sagittal vertical axis (SVA) correction and lordosis position.

Methods: Patients with L3 or L4 PSO by 4 surgeons from 2005-2019 were retrospectively studied. Inclusion criteria were single-level L3 or L4 PSO, minimum 1-year follow-up, and comparison 36" films. Demographic variables, operative factors, and radiographic measurements were collected. Univariate analysis using was used to determine any baseline differences. Multivariate regression was performed to identify possible confounding variables.

Results: One-hundred three patients (63 female) met inclusion criteria. The mean age was 65.6 years, and mean follow-up was 3.05 years (1.01-8.09). PSO at L3 was performed in 75 patients and at L4 in 28 patients. Univariate analysis demonstrated significant differences in pre-operative pelvic incidence (PI) (p = 0.03) and pre-operative pelvic incidence and lumbar lordosis mismatch (PI-LL) (p=0.01).

There were no baseline differences in sex (p = 0.85), body mass index (p = 0.62), age (p = 0.43), estimated blood loss (p = 0.99), surgical time (p = 0.75), levels of fusion (p = 0.56), non-PSO osteotomies (p = 0.32), or number and types of interbody fusion (p = 0.91, 0.26). Pre-operative SVA, central sacral vertical line (CSVL), pelvic incidence (PI), lumbar lordosis (LL), and PI-LL were not different between groups (all p values >0.05).

Multivariate regression showed no differences with respect to changes from pre-op to post-op L3 versus L4 SVA (-47.89 mm, -69.06 mm, p = 0.07), CSVL (-2.09 mm, -6.10 mm, p = 0.26), SS (6.81°, 7.50°, p = 0.73), PT (3.02°, -3.04°, p = 0.13), LL (23.81°, 25.36°, p = 0.61), PI-LL (-20.91°, -27.87°, p = 0.18), and osteotomy angular correction (22.04°, 24.18°, p = 0.19).

Conclusion: Despite theoretical advantages of performing an L4 versus L3 PSO, we did not observe an increased correction of SVA increased advantages of spinopelvic parameter correction with L4 versus L3 PSO.

8:12 - 8:14 am

621 Symptomatic Proximal Junction Failure Following Deformity Surgery in Patients Undergoing Active Smoking Cessation

Jared M. Robichaux, MD; Kevin D. Morrow, MD; Adam Podet, MD; John C. Steck, MD

Introduction: Symptomatic proximal junction failure (SPJF) secondary to proximal junctional kyphosis (PJK) and adjacent segment disease (ASD) is a significant morbidity following spinal deformity surgery. Smoking has been shown to be detrimental in achieving spinal fusion. Treatment of smokers with spinal deformity surgery remains controversial.

Methods: We performed a retrospective review of adult deformity cases at our institution from 2014-2020. SPJF was defined as PJK or ASD requiring reoperation. ASC patients were defined as smokers who agreed to quit smoking and passed nicotine testing prior to surgery. Patient characteristics included gender, age, osteoporosis/osteopenia status, diabetes status, and smoking status. Perioperative parameters evaluated included blood loss, intra-operative complications, intubation >24 hours, post-operative cardiopulmonary complications, wound infections, and discharge disposition. Rates of SPJF and time to reoperation were compared between the ASC and NS groups.

Results: Ninety-six consecutive adult deformity surgeries were reviewed. Twenty-two patients were defined as ASC and 74 were defined as NS. There was no differences in patient demographics or comorbidities between groups. There was no difference between the ASC and NS groups in OR time ($442 \pm 131 \text{ vs } 515\pm130 \text{ min}$, p=0.065), blood loss ($1158\pm693 \text{ vs } 1236\pm744 \text{ mL}$, p=0.71), intra-operative complications (9.52% vs 10.67%, p=0.65), intubation > 24 hours (4.76% vs 5.33%, p=0.918), post-operative cardiopulmonary complications (19.05% vs 10.67%, p=0.31), or wound infections (5% vs 10.67%, p=0.44). Discharge disposition did not differ between groups, X2 (2, N=95) = 0.793, p=0.673. SPJF was significantly higher in the ASC group compared to the NS group (28.57% vs 10.67%, p=0.04). For the ASC group, 50% (3/6) SPJF occurred within 6 months of surgery compared to 25% (2/8) in the NS group.

Conclusion: Our study adds to the growing body of data indicating poorer outcomes for smokers undergoing deformity surgery. In addition, we showed an increased proclivity for early failures in the ASC group. This data is useful in counseling smokers in consideration of deformity surgery. Further investigation into causation and mitigation of the effects of smoking on SPJF are necessary.

8:14 - 8:16 am

622 Intraoperative use of O-Arm in deformity surgery, outcome on screw accuracy and radiation exposure.

Davide M. Croci, MD; Sarah E. Nguyen; Seth Streitmatter; Brandon Sherrod, MD; Ilyas Eli, MD; Michael T. Bounajem, MD; Jeremy Hardy; Kyril Cole; Austin Gamblin; Marcus D. Mazur, MD; Andrew T. Dailey, MD

Introduction: Intraoperative 3-dimensional fluoroscopy (O-arm/Stealth) navigation has been described to improve accuracy and safety in pedicle screw placement. However, the efficiency on screw accuracy and the radiation exposure in long thoracolumbar deformity surgery remains unclear.

Methods: All patients aged >18 years who underwent long thoracolumbar spine fusion (defined as more than 4 level fused) using O-Arm January 2016 to December 2018 were retrospectively reviewed. Primary outcome was pedicle screw accuracy according to the Heary grade and radiation exposure. Secondary outcomes were: revision surgery because of screw misplacement, peri and postoperative complications, length of surgery, and revision surgery within 3 years. Misplaced screws were defined as Heary Grade III or higher.

Results: A total of 1477 screws were placed in 91 patients, on average 16.41 ± 5.77 screws per patient. Etiology of deformity was degenerative in 86.8% of patients, traumatic in 7.7%, tumor in 3.3%, and infection in 2.2%. 1208 pedicle screws (81.8%) were available for Heary grade evaluation on postoperative CT-scan. 99.1% of the evaluated pedicle screws were Heary grade I or II, 0.8% Heary Grade III, 0.1% Heary Grade IV and 0% Grade V. Patients had, on average 3.6 (± 1.5) O-arm spins Fluoroscopy attributed effective dose was minimal and less than 2 mSv (0.46 ± 0.44) for all the patients assessed. For the cone-beam portion of the effective dose estimates, the average effective dose was 29.54 ± 14.29 mSv and effective dose per spin 8.25 ± 2.65 mSv. Cumulative effective dose per patient for fluoroscopy and CBCT combined was 30.00 ± 14.59 mSv. Revision surgery rate for screw misplacement was 0%. No postoperative neurological worsening or vascular injuries were recorded.

Conclusion: Despite effective doses similar to neuroendovascular procedures, reported in the literature, the use of O-arm in deformity surgery resulted in high screw accuracy, no need for surgical revision due to screw mispositioning, reduced additional imaging and no radiation exposure for the surgical team.

8:16 - 8:18 am

623 How Much Pelvic Obliquity Exists in a Normative Population? A Multi-ethnic Study of Asymptomatic Adult Volunteers

Scott L. Zuckerman, MD; Zeeshan Sardar; Meghan Cerpa; Jean-Charles Le Huec; Stephane Bourret; Kazuhiro Hasegawa; Hee-Kit Wong; Gabriel Liu; Hwee Weng Dennis Hey; Hend Riahi; Michael Kelly; Lawrence Lenke

Introduction: When assessing coronal alignment in patients with adult spinal deformity (ASD), an appreciation of pelvic obliquity (PO) is important in preventing postoperative coronal malalignment.

Methods: Asymptomatic, adult volunteers were enrolled from 5 countries (France, Japan, Singapore, Tunisia, and U.S.), forming the multi-ethnic alignment normative study (MEANS). Volunteers had no neck/back pain or spinal disorders and underwent standing full-body stereoradiographs. Demographics and Oswestry Disability Index (ODI) scores were collected. PO was defined as the distance between the highest points of each acetabulum (mm), with presence of PO defined at ≥10mm difference. Kruskal-Wallis tests, Pearson's correlation, and linear regression were performed.

Results: Normative PO values in 488 volunteers showed that the overall incidence of PO≥10mm was 4.5%, and the incidence of PO increased by approximately 1.2% each decade (β =0.012, 95%CI 0.00-0.02, p=0.043). Though no significant difference in PO between gender or ethnicity was seen, PO significantly differed across BMI categories (p=0.031), without a linear relationship. The largest mean PO values were in the BMI<18 category (5.5mm) and BMI 32-35 category (5.3mm). Except for one negligible correlation with knee flexion (r=0.115, p=0.030), no significant correlation existed with any other radiographic measurements. Higher PO was significantly associated with an increased ODI, but only in the upper 3rd quartile of PO measurements (β =1.64, 95%CI 0.12-3.16, p=0.035).

Conclusion: Pelvic obliquity ≥10mm occurred in 4.5% of asymptomatic adult volunteers and increased with age. PO poorly correlated with other radiographic parameters, emphasizing the importance of intentionally assessing PO on all patients undergoing reconstructive spinal surgery, given the importance of PO in potentially creating coronal malalignment postoperatively.

8:18 - 8:20 am

624 A Comparison Between Same-Day Vs Staged Anterior/Posterior Spinal Fusions For Adult Spine Deformity Correction.

Ahmed Albayar, MD; Kobina Mensah-Brown; Mitchell Johnson; Michael Spadola, MD; Comron Saifi, MD; William C. Welch, MD, FAANS, FACS; Ali Ozturk, MD

Introduction: The utilization of complex spinal fusion procedures for adult spine deformity (ASD) is increasing in the United States and worldwide. Patients undergoing surgery for ASD often undergo combined anterior posterior fusion (APF) procedures to maximize correction and achieve solid fusion. In this study, we aimed to compare patients who underwent staged (STA) vs. same day (SD) APF for ASD correction.

Methods: This is a retrospective review of patients who underwent APFs in a single institution from September 2013 – December 2018. Inclusion criteria: ASD diagnosis, Age =40 years, and PSFs involving =7 thoracolumbar levels. Demographic data, Body Mass Index (BMI), preoperative diagnoses, surgical details, complications, as well as 30 and 90-day readmission status were recorded. Pearson's Chi-squared test and independent-sample t-test were employed to analyze the difference between both groups.

Results: A total of 67 (STA= 34, SD=33) patients were included in the study. More females were found in the SD group (28 (84.8%) vs 21 (61.8%), p=0.033). There were no significant differences between the two groups in age, race, BMI, smoking status, substance abuse, diabetes, COPD, cardiovascular comorbidities, anemia, coagulation disorders, malnutrition, history of deep venous thrombosis (DVT) or pulmonary embolism (PE), postmenopausal osteoporosis and preoperative ASA score. The STA group showed a significantly higher number of levels fused both anteriorly (p=0.006) and posteriorly (p<0.001). There were no differences between the two groups in blood loss, rates of intraoperative complications, wound dehiscence, hematoma, superficial and deep wound infections, DVT, PE, postoperative self-reported pain, 30 and 90-day readmission rates and disposition. The SD group showed a significantly higher requirement of blood transfusions during hospital admission (p=0.047) and shorter length of stay (LOS) (p<0.001).

Conclusion: Surgeons tended to stage APFs when longer anterior and posterior fusions were planned. Consistent with the literature, STA was associated with greater LOS while, interestingly, SD was associated with greater blood transfusions during hospitalization. However, there were no differences in postoperative complications or readmission rates between both groups.

8:20 - 8:22 am

625 Understanding Proximal Junctional Kyphosis: New Way of Evaluating Adjacent Segment Strain and Vulnerability to Failure

Jakub Godzik; Jennifer Lehrman, BSE, MS; Bernardo De Andrada, MD; Piyanat Wangsawatwong; Anna Sawa; Brian Kelly; Jay D. Turner, MD, PhD, FAANS

Introduction: Proximal junctional kyphosis (PJK) and failure (PJF) are common and devastating complications of long segment fusions. Presumably, PJF occurs due to excessive or altered strain distribution at the proximal level above a fusion construct; however, this has not been previously studied or proven experimentally.

Methods: Nondestructive flexibility tests (4.0 Nm) were performed on 7 specimens (T2-T12) to compare range of motion (ROM), posterior rod strain (RS), as well as intervertebral disc (IVD), endplate, and bone surface strains at the proximal junction during flexion, extension, axial rotation (AR) following pedicle screw fixation (PSR) from T4 to T12. Specimens were coated with a high contrast speckle pattern for optical tracking of movements using digital image correlation (DIC) with conversion to principle strain measured at the proximal junction disc and vertebral body bone surfaces. Data were analyzed using a two-way ANOVA followed by post hoc comparisons.

Results: PSR resulted in significantly greater mobility at the proximal free level (T3-4) in flexion compared to intact (p=0.005), but not extension (p=0.3). PSR resulted in significantly lower ROM in flexion and extension across the instrumented T5-T12 levels (p<0.001) compared to intact. In flexion, PSR resulted in decreased strain at the posterior T3 inferior endplate compared to intact (p=0.038). In extension, PSR resulted in decreased strain at the anterior aspect of the disc (p=0.014), but increased strain at the posterior aspect of the disc (p=0.026) compared to intact. In AR, PSR resulted in elevated strain at the T3 inferior endplate (p=0.028). Average T4 surface bone strain was lower with PSR compared to intact in flexion (p=0.039) and extension (p=0.028), and lower in the inferior anterior vertebral body in left AR (p=0.045).

Conclusion: This represents the first cadaveric biomechanical study of bone and soft tissue strain following long segment spinal instrumentation. Our results suggest that instrumentation alters the normal anterior-posterior and cranial-caudal strain profile across the proximal disc and vertebral body—the most common failure points in PJK. This study provides a foundation for understanding the biomechanics underlying PJK, and will allow for the development of more targeted prevention strategies.

8:22 - 8:24 am

626 Utilization Trends, Cost, and Payments for Adult Spinal Deformity Surgery Using the MarketScan and Medicare Databases

Harsh Wadhwa; Christopher P. Ames, MD; Corinna C. Zygourakis, MD

Introduction: Previous studies have characterized utilization rates and cost of adult spinal deformity surgery, but the differences between these factors in commercially insured and Medicare populations are not well studied.

Methods: We identified all adult patients who underwent fusion for spinal deformity, 2007-2015, in 20% Medicare inpatient file (n=21,614) and MarketScan commercial insurance database (n=38,789). Patient age, sex, race, insurance type, geographical region, Charlson Comorbidity Index (CCI) and length of stay were gathered. Primary outcomes included surgical utilization rates, total cost (calculated via Medicare charges and hospital-specific charge-to-cost ratios), and total Medicare and commercial payments for adult spinal deformity.

Results: Rates of fusion increased from 9.0 and 8.4 per 10,000 in 2007 to 20.7 and 18.2 per 10,000 in 2015 in both commercial and Medicare populations, respectively. Medicare median total charges increased from \$88,106 to \$144,367 (compound annual growth rate CAGR: 5.6%) and median total cost increased from \$31,846 to \$39,852 (CAGR: 2.5%). Commercial median total payments increased from \$58,164 in 2007 to \$64,634 in 2015 (CAGR: 1.2%), while Medicare median total payments decreased from \$31,415 in 2007 to \$25,959 in 2015 (CAGR: -2.1%). The Northeast and Western regions were associated with higher payments than the Midwest and South in both commercial and Medicare populations. States with the highest commercial payments were Wyoming (\$137,256), Alaska (\$107,299), and Montana (\$93,718); lowest were Alabama (\$35,379), Michigan (\$41,893), and Arkansas (\$43,173). States with highest Medicare payments were Vermont (\$45,757), Alaska (\$41,560), and Delaware (\$38,607); lowest were Pennsylvania (\$19,991), Louisiana (\$21,397), and Ohio (\$21,698).

Conclusion: Rate of fusion for adult spinal deformity more than doubled from 2007 to 2015 among commercial and Medicare beneficiaries. Despite increasing costs, median Medicare payments have decreased. On the other hand, median commercial payments have increased, though charges and costs are not available. The northeastern and western US are associated with higher payments, but there is substantial state-level variation in this pattern.

8:24 - 8:26 am

627 Postop Coronal Malalignment After Adult Spinal Deformity Surgery: Incidence, Risk Factors, and Impact on 2-year Outcomes

Scott L. Zuckerman, MD; Christopher Lai; Daniel Shen; Meghan Cerpa; Ian A. Buchanan, MD; Mena G. Kerolus, MD; Alex Ha; Eric Leung; Nathan Lee; Zeeshan Sardar; Ronald A. Lehman, MD; Lawrence Lenke

Introduction: Little is known regarding the incidence and risk factors for postop coronal malalignment (CM) after adult spinal deformity (ASD) surgery.

Methods: A single-institution database was queried for ASD pts undergoing =6 level fusions from 2015-19. Postop CM was defined as C7 coronal vertical axis (CVA) >3cm. latrogenic CM was defined as postop CVA>3cm in pts without preop CM. Demographic, radiographic, and surgical variables were collected. 2-year outcomes included: complications, readmissions, reoperations, & ODI/SRS-22r. Logistic regression was performed.

Results: 243 ASD patients had preop and immediate postop measurements; 174 patients (72%) had 2-year follow-up. Mean age was 50.9±17.6 & mean instrumented levels was 13.5±3.9. Mean preop CVA was 2.9±2.7cm, and 90 (37%) had preop CM. Postop CM was seen in 43 (18%) patients, 13 (5%) of which were iatrogenic. Significant risk factors for postop CM were: EBL (OR 1.00,p=0.026), operative time (OR 1.16;p=0.045), preop CVA (OR 1.21;p=0.001), preop SVA (OR 1.05;p=0.046), pelvic obliquity (angle between horizontal and iliac crests) (OR 1.21;p=0.008), lumbosacral fractional (LSF) curve concavity to the same side as the CVA (OR 2.31;p=0.043), and max cobb angle concavity opposite the CVA (OR 2.10;p=0.033). The single significant risk factor for iatrogenic postoperative CM was a LSF curve concavity to the same side as the CVA (OR 11.39;p=0.020). Patients with postop CM were more likely to sustain a postop complication (31.0% vs. 14.3%,p=0.009), yet no differences were seen in readmissions (p=0.743) or reoperations (p=1.000). No significant differences were seen in 2-year PROs according to postop CM.

Conclusion: Postop CM occurred in 18% of ASD patients and was most associated with preop CVA, pelvic obliquity, LSF curve to the same side as the CVA, and max cobb angle to the opposite side of the CVA. Though postop CM was significantly associated with increased complications, surprisingly, readmission, reoperation, and 2-year PROs were similar in those with and without CM.

8:26 - 8:28 am

628 Preop Coronal Malalignment Often Leads to More Extensive Surgery Than Sagittal Malalignment in Adult Spinal Deformity

Scott L. Zuckerman, MD; Christopher Lai; Meghan Cerpa; Ian A. Buchanan, MD; Mena G. Kerolus, MD; Alex Ha; Nathan Lee; Eric Leung; Lawrence Lenke

Introduction: Though the invasiveness of adult spinal deformity (ASD) surgery is well understood, it remains unknown how coronal and/or sagittal malalignment contribute to surgical invasiveness and complications.

Methods: A single-center ASD database was searched for all patients undergoing surgery of \geq 6 level fusions. Patients were categorized into 4 global alignment groups: 1) Neutral alignment (N): CVA \leq 3cm & SVA \leq 5cm 2) Coronal malalignment only (CM): CVA \geq 3cm 3) Sagittal malalignment only (SM): SVA \geq 5cm and 4) Coronal and sagittal malalignment (CCSM): both CVA \geq 3cm & SVA \geq 5cm. One-way ANOVA, Kruska-wallis, chi-square, and multivariate linear regression were performed.

Results: A total of 243 patients were evaluated. Preop alignment was: N 115(47.3%), CM 48 (19.8%), SM 38(15.6%), and CCSM 42 (17.3%). Total instrumented levels differed across all groups (p<0.001) and was highest in the CM (14.5 \pm 3.7) & CCSM groups (14 \pm 4.0). More 3-column osteotomies (3CO) were performed in the SM (21.1%) and CCSM (28.9%) groups than CM (10.4%) (p=0.003). EBL was significantly different across all groups (p<0.001) and highest in the CM (1451 \pm 777cc) and CCSM groups (1875 \pm 1049cc) groups than the SM group (1225 \pm 803cc). Operative time was significantly different (p<0.001), highest in the CM (8.6h) and CCSM (9.0h) than the SM group (7.9h). Multivariate linear regression showed that preop CVA was an independent predictor of total instrumented levels (β =0.34,p=0.001), EBL (β =83.8, p<0.001), and operative time (β =14.96, p<0.001), whereas preop SVA only significantly predicted EBL (β =21.7, p=0.009), and was weaker than CVA. Over 2-years of f/u, both SM & CCSM patients had higher readmission (p=0.003) & reoperation rates (p<0.001) than CM patients (p=0.001).

Conclusion: Preop CM was a better predictor of surgical invasiveness than SM even though 3COs were more commonly performed in SM patients. Combined coronal and sagittal malalignment led to more invasive operations and complications.

8:28 - 8:30 am

629 Management of the Lumbosacral Junction in Long Deformity Spine Surgery in Adults: A Systematic Review

María José Cavagnaro; Jose Orenday; Haroon Kisana; Mauricio J. Avila, MD, MHPE; Naushaba Khan; Aaron Dowell; Chung-Yon Lin; Jacob Howshar; Isabel M. Strouse; Robert Ravinsky; Ali A. Baaj, MD

Introduction: There is no consensus regarding the best surgical management of the lumbosacral junction (LSJ) in long constructs for adult spinal deformity (ASD). The use of interbody fusion (IBF) has been advocated to increase fusion rates, and additional pelvic fixation (PF) is common. The actual benefit of either or both techniques has not been vigorously analyzed

Methods: A systematic review from PUBMED and Cochrane databases was performed to identify all the relevant studies in English, that have been published from 1982 to the present, addressing the management of lumbosacral junction in long constructs (defined as = 5 levels) in ASD. The search terms used were: "Lumbosacral Junction", "Long constructs", "Long Fusion To The Sacrum", "Sacropelvic Fixation", "Interbody Fusion" or "Iliac Screw". We excluded the technical notes, comprehensive and cadaveric studies, pediatric population, case reports, pathologies different from ASD and constructs less than 5 levels.

Results: 12 studies were included and divided in 3 groups: Group 1 compared using PF or not (n=5); Group 2 PF with IBF or not (n=6); and Group 3 was 1 study comparing ALIF vs TLIF when PF+IBF was performed. 1216 patients data points were analyzed. In Group 1, 4 studies showed a rate of pseudoartrosis 20% superior when non-PF was performed. Statistically significant lower rates of pseudoartrosis and rod breakage were found on 2 of them. Even though Group 3 and most of the studies of Group 2 have been shown to have high rates of fusion (3 >85%,1>70%), a significant difference (p<0,05) with respect to non IBF groups of patients has not been identified in this systematic review. Therein, both approaches seem to be valid. Alignment was achieved in all the cases.

Conclusion: In the setting of long constructs to the sacrum, many spine surgeons have suggested that lumbosacral IBF is necessary in order to prevent non-union and rod fractures. Interestingly, this contention is not supported by the literature. The use of pelvic fixation, however, with or without IBF, appears to be strongly supported

8:30 - 8:32 am

630 Patient and Spine Surgeon Perceptions on Shared Decision Making in Undergoing Surgery for Adult Spinal Deformity

Owoicho Adogwa, MD, MPH; Palvasha Deme; Anjali Perera; Sai Chilakapati; Ravinderjit Singh; Cody M. Eldridge; James Caruso, MD; Shaleen Vira; Salah G. Aoun, MD; Una Makris; Sonja Stutzman, PhD; Carlos A. Bagley, MD

Introduction: Surgery for correction of adult spinal deformity is often beneficial, however, in over 20% of older adults (age>65 years), outcomes from surgery are less desirable. Deciding between treatment strategies presents a considerable decision-making challenge for older adults.

Methods: Using purposive sampling we identified older adult patients who underwent deformity correction surgery and were both satisfied and not satisfied with outcomes based on their responses to the Ottawa decision regret questionnaire. We conducted semi-structured, in-depth interviews with six older adult patients, and five fellowship trained spine surgeons. Two investigators independently coded the transcripts using constant comparative method, and an integrative, team-based approach to identify themes.

Results: Three patient themes emerged: (1) patients mentally committed to surgery prior to the initial encounter with their surgeon and felt that surgery was their only choice;(2) patients felt that the current decision support tools were not effective in preparing them for surgery; and (3) patients felt that pain management was the most difficult part of recovery from surgery. Three surgeon themes emerged: (1) spine surgeons did not consider patients' chronological age as a major contraindication to undergoing surgery, however, preoperative functional limitations were strongly considered; (2) while spine surgeons intuitively understood the concept of shared decision making, they varied substantially in their interpretations; (3) spine surgeons felt that patient expectations from surgery were often established prior to their initial surgery visit, frequently required recalibration, and there is a goal mismatch where patients prioritize complete pain relief while surgeons prioritize concrete functional improvement.

Conclusion: Older adult patients' felt they were "running out of time" and surgery as the "only choice"; whereas spine surgeons expressed the need for recalibrating patient expectations and balancing the risks and benefits when considering surgery. The variability in the discussions surrounding deformity correction surgery highlights the need for improved understanding of both sides of shared decision making.

8:32 - 8:34 am 631 Back to OR:Predicting Return to the Operating Room following Surgery for Adult Spinal Deformity

Nida Fatima, MBBS; John H. Shin, MD, FAANS

Introduction: Financial penalties have been expanded beyond medical conditions to include surgical procedures. In an effort to reduce take-back rates, we present a novel machine learning algorithm designed to identify cases most at risk for eventually requiring a return to the operating room (OR) following surgery for adult spinal deformity (ASD)

Methods: The patient cohort was identified from the American College of Surgeons, National Surgical Quality Improvement Program (2014-2016). We performed logistic regression (enter, stepwise and forward) and least absolute shrinkage and selection operator (LASSO) method for selection of variables, which resulted in 21-candidate models. The final model was selected based upon clinical knowledge and numerical results

Results: Statistical analysis included 2,625 patients with return to OR in 4.0% (n=105) of the patients. The model with 7-predictive factors which included: age, body mass index, American Society of Anesthesiologists Grade, arthrodesis, osteotomy, preoperative serum albumin and preoperative white blood cell count—performed well on the discrimination, calibration, Brier score and decision analysis to develop a machine learning algorithm. Logistic regression showed higher Area Under the Curve than LASSO across these different models. The predictive probability derived from the best model was uploaded on an open access web application which can be found at: https://spine.massgeneral.org/drupal/ReturntoOR-SpinalDeformity

Conclusion: Machine learning algorithms provide promising results for prediction of return to OR following surgery for ASD. Hence, these algorithms can provide useful factors for patient-counselling, accurate risk adjustment, and quality metrics

8:34 - 8:36 am 632 Trends in 2 Year Outcomes of a Prospective Consecutively Enrolled Single-Center Adult Cervical Deformity Series

Lara Passfall; Nicholas Kummer; Oscar Krol; Bassel G. Diebo, MD; Shaleen Vira; Peter G. Passias, MD

Introduction: Adult cervical deformity (CD) is a debilitating disorder of the spine characterized by radiographic malalignment of the cervical vertebral segments in the sagittal and/or coronal planes. CD significantly compromises patient's health-related quality of life. While advances in spinal realignment have shown promising short-term clinical results, the durability of CD-corrective surgery remains a clinical challenge.

Methods: Operative CD patients >18yrs with up to 2-year(2Y) HRQL/radiographic data were included. Cervical deformity was defined as meeting at least one of the following radiographic parameters: C2-C7 lordosis < -15°, TS-CL >35°, segmental cervical kyphosis >15° across any 3 vertebra between C2-T1, C2-C7 SVA >4cm, McGregor's slope >20°, or CBVA > 25°. Univariate analyses assessed demographics, surgical descriptors, radiographic parameters, HRQL scores, and complication rates from baseline(BL) to 2Y postop.

Results: 141 surgical CD patients included (59.6yrs, 54%F, levels fused 6.1±4.9). By approach, 68% posterior-only and 16% combined. 68 pts(48.2%) underwent osteotomy, of which 58 had facet osteotomy or Ponte, 13 had partial or complete corpectomy, 4 opening wedge, and 8 closing wedge or VCR. By 2Y postop, 13 pts improved in Ames cSVA modifier, 19 in TS-CL, 8 in Horiz gaze, 1 in SVA, and 6 in mJOA. Overall, 36 pts(25.5%) improved in ≥1 Ames modifier. By 2Y, 26 pts met MCID for EQ5D, 34 for NDI, and 21 for mJOA. Patients who improved in the Ames mJOA modifier were also more likely to meet MCID for NDI and EQ5D by 2Y(both p<0.01). By 2Y, 22 pts(15.6%) required reoperation. Overall, 70 pts(49.6%) experienced a complication. 2 pts developed dysphagia, 11 had neurologic complication, 6 cardiopulmonary, 13, had operative complication like wound dehiscence or hematoma, and 6 developed a surgical site infection. There were 2 mortalities. 34 pts(24.1%) had radiographic complication. There were 28 cases of DJK (Δ DJKA>10° between LIV and LIV-2), of which 9 were DJF (DJK requiring reoperation).

Conclusion: Correction of cervical deformity results in notable clinical and radiographic improvement. Most patients achieve favorable outcomes, though complications most notably distal junctional kyphosis or failure still occur and need to be minimized.

8:36 - 8:38 am

633 Race on Outcomes and Healthcare Costs Following Spinal Fusion for Adolescent Idiopathic Scoliosis

Aladine A. Elsamadicy, MD; Andrew B. Koo, MD; Wyatt David; Isaac G. Freedman, BPhil, MPH; Adam Kundishora, MD; Christopher Sungwoon Hong, MD; Margot Sarkozy; Daniel M. Sciubba, MD; Kristopher T. Kahle, MD, PhD; Michael DiLuna

Introduction: Racial disparities in spine surgery have been shown to impact surgical management and postoperative complications. However, for adolescent patients with idiopathic scoliosis (AIS) treated by posterior spinal fusion (PSF), the influence of race on postoperative outcomes remains unclear.

Methods: The Kids' Inpatient Database year 2012 was queried. Adolescent patients (age 10-17 years old) with AIS undergoing elective, PSF (³4 levels) were selected using the International Classification of Diseases, Ninth Revision, Clinical Modification coding system. Patients were divided into 2 cohorts: Black and White race. Patient demographics, comorbidities, complications, length of hospital stay (LOS), discharge disposition and total cost were recorded. The primary outcome was the rate of intraoperative and postoperative complications and resource utilization after elective PSF intervention.

Results: Patient demographics significantly differed between the two cohorts. While age was similar (p=0.134), the Black cohort had a smaller proportion of female patients (White: 79.0% vs. Black: 72.1%, p=0.001) and almost 3-times greater proportion of patients in the 0-25th income quartile compared to White cohort (White: 16.1% vs. Black: 43.3%, p<0.001). The majority of patients for both cohorts were treated in the South at large, urban teaching hospitals. Baseline comorbidities were similar between the cohorts. While most intraoperative variables were similar between the cohorts, the use of blood transfusions was significantly greater in the Black cohort compared to the White cohort (White: 16.7% vs. Black: 25.0%, p<0.001). The rate of complications encountered during admission was similar between the two cohorts (White: 21.9% vs. Black: 23.6%, p=0.406). LOS (p=0.511), discharge disposition (p0.465), and total cost of admission (p=0.624) were similar between both cohorts.

Conclusion: Our study suggests that Black race may not have a significant impact on surgical outcomes after elective posterior spine surgery for adolescent idiopathic scoliosis. Further studies are necessary to corroborate our findings.

8:38 - 8:40 am

634 The Clinical Impact of Failing to Achieve Ideal Proportional Realignment in Adult Spinal Deformity Patients

Peter G. Passias, MD; Lara Passfall; Oscar Krol; Nicholas Kummer; Waleed Ahmad; Sara Naessig; Bhaveen Kapadia; Bassel G. Diebo, MD; Virginie Lafage, PhD

Introduction: There is paucity in the literature addressing the impact of not achieving optimal GAP score in ASD correction on clinical outcomes in the setting of global and regional correction.

Methods: Included: operative ASD patients with fusion to S1/pelvis and pre-(BL) and 2-year(2Y) postop radiographic/HRQL data. Pts with PJK at or before 6 weeks(6W) were excluded. Pts were assessed for matching 6W age-adjusted PT, PI-LL, and SVA alignment goals. Pts with ≥1 age-adjusted match at 6W postop[Match] were stratified by 6W GAP proportionality (ideal: P; moderate: MD; severe: SD) and assessed for differences in complications occurring by 2Y. Binary logistic regression assessed the influence of not achieving ideal GAP proportionality on postop outcomes for pts with and without Match.

Results: 123 operative ASD pts included(61yrs, 81%F, 26.9kg/m2, CCI 1.74, levels fused 11.9±4.0). By BL SRS-Schwab modifiers: 42.3% ++PI-LL, 29.3% ++SVA, 25.2% ++PT. At 6W: 10.8% ++PI-LL, 5.0% ++SVA, and 10.0% ++PT. By GAP proportionality: 39.8% SD at BL, and 12.5% SD at 6W. Of the 123 ASD pts, 51.2%(n=63) had ≥1 age-adjusted match at 6W[Match]. The rate of being SD did not differ by Match status(p=0.945). SD pts without Match had higher rates of reop, implant failure, and PJF by 2Y postop(all p<0.05). Regressions controlling for age at BL, levels fused, and CCI, revealed that 6W SD pts without Match had higher rates of reoperation, implant failure, PJK, or PJF(all p>0.05). SD pts with Match did not have higher rates of reoperation, implant failure, PJK, or PJF(all p>0.05). Regressions controlling for age, levels fused, and CCI, revealed that 6W SD pts with Match did not have higher rates of reoperation, implant failure, PJK, or PJF(all p>0.05). Regressions controlling for age, levels fused, and CCI, revealed that 6W SD pts with Match did not have higher rates of reoperation, implant failure, PJK, or PJF(all p>0.05). Regressions controlling for age, levels fused, and CCI, revealed that 6W SD pts with Match did not have higher rates of reoperation, implant failure, PJK, or PJF(all p>0.05). Regressions controlling for age, levels fused, and CCI, revealed that 6W SD pts with Match did not have higher rates of reoperation, implant failure, PJK, or PJF(all p>0.05).

Conclusion: In ASD patients who meet age-adjusted realignment goals, GAP proportionality does not significantly alter complication rates. However, GAP proportionality remains an important consideration in patients with less than optimal age-adjusted alignment, in which cases of severe global disproportion are associated with higher rates of reoperation, implant failure, rod fracture, and PJK.

8:40 - 8:42 am

635 Influence of Race on Early Outcomes of Elective Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis

Safwan Alomari; Ryan F. Planchard, MD; Tej D. Azad, MD; Sheng-Fu L. Lo, MD, FAANS; Ali Bydon, MD, FAANS

Introduction: Existing literature demonstrates well-identified racial disparities in spine surgery outcomes. However, such studies on posterior spinal fusions (PSF) for adolescent idiopathic scoliosis (AIS) are limited.

Methods: This is a retrospective cohort study. All pediatric patients with AIS who underwent PSF between 2012-2018 were reviewed from the (ACS-NSQIP) pediatric database. Propensity score matching was used to determine whether race (i.e. black vs. white) had an influence on 30-day perioperative complications.

Results: 4051 PSF for AIS cases met inclusion criteria and were reviewed. 3221 (79.5%) patients were white and 830 (20.5%) were black. Patients in the black cohort were more likely to have higher BMI (23.8 vs 21.1), be of female gender (78.2% vs 74.5%), have an ASA class 3 or more (13.7% vs 11.1%), have asthma (8.3% vs 4.9%), have cardiac risk factors (5.1% vs 2.6%), use steroids (3.8% vs 1.1%). In the black cohort, 8% of the cases had up to 6 vertebral segments fused, 64.4% had 7-12 vertebral segments fused and 27.6% had 13 or more vertebral segments fused. In the white cohort, 15.9% of the cases had up 6 vertebral segments fused and 26.9% had 13 or more vertebral segments fused. After controlling for differences in baseline factors, except for the higher incidence of venous thromboembolism in the black cohort (2.8% vs 0.1%), (p <0.001), there were no significant differences in morbidity and mortality between the black and white cohorts.

Conclusion: Patients in the black cohort had a higher pre-operative comorbid burden compared to patients in the white cohort. In contrast to previous reports, our analysis found that black race is not an independent risk factor for higher perioperative morbidity or mortality in patients undergoing PSF for AIS, except for the higher incidence of venous thromboembolism. This finding has implications for patient counseling in explaining that previously reported worse perioperative morbidity and mortality outcomes for black patients may be attributable to differences in baseline health status. Moreover, it identifies pre-operative comorbidity burden as potential target for risk reduction prior to surgical intervention in this patient population.

8:42 - 8:44 am

636 Peak Force of the Posterior Ligamentous Complex in Patients with Adult Spinal Deformity Requiring Revision Surgery

Bahar Shahidi; Brad Anderson; Tina Iannacone; Courtney Moltzen; Robert Eastlack, MD; Gregory M. Mundis

Introduction: Proximal Junctional Kyphosis (PJK) is observed in up to 40% of those undergoing fusion surgery for adult spinal deformity (ASD). The transition between the upper instrumented vertebra (UIV) and the levels above suffers increased biomechanical stress, possibly due to in part to biomechanical impairment of the posterior ligamentous complex (PLC). Despite common use of surgical techniques reinforcing ligamentous integrity. It is unknown whether ligamentous biomechanics are impaired in this population, and potentially contributing to PJK risk.

Methods: Intraoperative biopsies of the PLC were harvested from 23 consented individuals with ASD undergoing primary (N=14) or revision (N=9) multilevel spinal fusions (>4 levels). Biopsies were taken 2 levels below the upper instrumented level (primary) or at the failed junctional segment (revision). Peak force (strength) and elastic modulus (stiffness) were compared between primary and revision groups, and relationships between biomechanical parameters and patient characteristics evaluated.

Results: Participants in the revision group were older (73.3(3.6) years) than the primary group (54.7(19.2)years), p=0.02, but did not differ in number of fused vertebrae (12.0(4.3); primary and (11.3(3.4); revision), p=0.71). Peak force was significantly lower in the revision group (143.1(72.5) N) compared to the primary group (238.5(109.8) N), p=0.03. There were no differences in ligament stiffness between the primary (5.9(2.0) MPa) and revision groups (5.3(3.1) MPa), p=0.92). Peak force was associated with age (r=-0.56, p=0.003), ligament area (r=0.50, p=0.015), vitamin D levels (r=-0.63, p=0.015), and pre-operative PI-LL (r=-0.53, p=0.014). Ligament stiffness was associated with post-operative PJK (r=0.60, p=0.013).

Conclusion: Peak force of the PLC in individuals undergoing revision surgery was <60% of those undergoing primary surgery, suggesting an important role of ligament in stabilization of the proximal junctional interface in patients with ASD, particularly in older individuals. Augmentation techniques that better preserve and/or reinforce ligamentous integrity at proximal junctional areas of ASD correction may be more critical in these patients.

8:44 - 8:46 am 637 The Effect of Undercorrection on Distal Junctional Kyphosis in ACD Patients

Oscar Krol; Peter G. Passias, MD; Lara Passfall; Nicholas Kummer; Shaleen Vira; Bassel G. Diebo, MD

Introduction: Distal junctional kyphosis (DJK) development after cervical deformity (CD) corrective surgery is a growing concern for surgeons and patients. Although proper realignment is known to help mitigate the development of DJK, there has yet to be a study that critically analyzes under correction in certain parameters and the effects on development of DJK.

Methods: Inclusion criteria: operative CD patients (Cervical kyphosis>10°, with cSVA>4cm or CBVA>25°) and >18yrs with up to 2Y radiographic and HRQL follow-up. Significant differences in surgical, radiographic, and clinical factors and outcomes were determined. Under correction was defined by a deformity in TS-CL or cSVA Ames Modifier. Moderate Ames Cervical Lordosis deformity(CL) was TS-CL >15 and High >20, High cSVA deformity was >8cm.

Results: 195 CD patients met inclusion criteria (58.3yrs, 46% Female, 28.3 kg/m2). Overall, 40 (21%) of these patients developed DJK. At BL patients presented with the following radiographic profile: PT (18.3), PILL (-.65), SVA C7-S1 (-6.54), cSVA C2-C7 (9.7), and TS-CL (24). Patients under corrected in TS-CL developed DJK at a greater rate (28% vs 15%, p=.02), and patients under corrected in cSVA developed more DJK (65% vs 16%) and underwent more reoperations (42% vs 17%, both p<0.05). Controlling for BL deformity, frailty, and age, patients who maintained a high cSVA deformity had a 3.2x higher likelihood of developing DJK (3.2[1.6-6.8], p=.002). Patients with a post-operative moderate CL deformity had a 1.8x higher likelihood of DJK (1.8[.9-3.8], p=.105), and with a high CL deformity, a 2.8x higher likelihood (2.8[1.1-7.2], p=.03). Controlling for the same factors, patients who remained under corrected in both cSVA and TS-CL had a 6x times higher likelihood of developing DJK (6[1.9-17], p=.002). Using CIT to find a threshold cutoff, the risk of DJF was considerably increased for patients with a TS-CL greater than 13.5, (2.4[1.14-5], p=.026), and a cSVA deformity greater than 6cm (3.2[1.5-6.6], p=.026). Patients who were adequately corrected in cSVA and under corrected in TS-CL demonstrated no significant increased vulnerability to DJK, (p>0.05).

Conclusion: The TS-CL and cSVA components of Ames criteria show a strong correlation with development of distal junctional kyphosis (DJK). Thresholds for DJK development suggests even patients who fall into a mild deformity as per the Ames criteria are still at an increased risk, and more strict alignment goals may further prevent mechanical failure. cSVA was found to be the dominant radiographic parameter impacting DJK development.

8:46 - 8:48 am

638 Use of Osteotomy Techniques in Cervical Deformity Procedures: Are Approaches and Practices Changing Over the Years?

Peter G. Passias, MD; Oscar Krol; Nicholas Kummer; Lara Passfall; Shaleen Vira; Bassel G. Diebo, MD

Introduction: Cervical deformity(CD) corrective procedures are ever-evolving, along with the field of spine surgery. The goal of this study was to examine whether surgical advancements over the years have improved or changed outcomes, and the overall way in which we approach CD surgery.

Methods: CD patients(=18 yrs) with complete BL and 2Y HRQL and radiographic data were included. Descriptive analysis included demographics, radiographic, and surgical details. Patients were stratified into 2 groups based on DOS: early (Group I-2012-2014) and later (Group II-2015-2019). Osteotomies were grouped using grading by Ames et al. into low grade (LGO): Grade 1 & 2, and high grade (HGO): Grade 6 & 7. UVA and MVA analyzed differences in osteotomy usage and radiographic, surgical and clinical parameters. Significant CD was characterized by extension XR TS-CL >17°. Rigid deformity was defined by a change of <10° difference between flexion and extension XR.

Results: 123 CD patients met inclusion criteria(61yrs, 63%F, 29.0kg/m2, CCI: 1±1.4). Radiographically at baseline, patients presented with: PT: 19.6± 11°; PI: 55±13°; PI-LL: .9±17.4°; SVA:-3±68mm, TS-CL: 39 ±21°; cSVA: 45±26. Surgical details were 7.7± 4 levels fused with a mean EBL of 1031mL. By surgical approach, 46% had a posterior approach, 20% anterior, and 37% combined. Group I had 49 patients, and Group II had 74. Group II had a higher CCI (1.1 vs .8, p=.2) while there were no significant differences in number of levels fused, reoperations, DJK development, or HRQL metrics between groups (p>0.05). Overall, 53% of patients had an osteotomy. Patients in Group II had a lower usage of HGO (9% vs 23%, p<0.05). In patients with significant CD, Group II received less HGO(3% vs 33%, p<0.05). In posterior approaches, controlling for age, BL deformity, and CCI, Group II underwent less HGO .32[.08-1.2] p=.1. Controlling for age, CCI, and BL deformity, Group II had lower usage of HGO in rigid deformity (.197[.04-.97], p<0.05).

Conclusion: Overtime, patients undergoing cervical deformity surgery received less high-grade osteotomies, even with high grade deformities. Despite operating on a cohort with a greater degree of comorbidity, there was no deterioration in clinical and radiographic outcomes. These findings reflect a better understanding of surgical management and the utility of invasive osteotomies in adult cervical deformity.

8:48 - 8:50 am

639 Comparison of Complications, Outcomes, and Cost in Frail vs Non-Frail ASD Surgery Patients

Oscar Krol; Peter G. Passias, MD; Nicholas Kummer; Lara Passfall; Waleed Ahmad; Shaleen Vira; Jordan Lebovic

Introduction: Frailty is a dynamic measure of physiological age that is a strong predictor of a patient's surgical risk. The purpose of this study is to investigate the impact of frailty on the perioperative outcomes and costs associated with operating on frail ASD patients.

Methods: Operative ASD patients (scoliosis >20, SVA>5cm, PT>25, or TK>60) with available baseline (BL) and 2-year (2Y) radiographic and HRQL data were included. The ISSG frailty index was used to stratify patients into 2 categories: Not Frail(NF) (<3), and Frail(F) (>3). Univariate and multivariate analysis assessed differences in radiographic, surgical, and clinical factors. IHS-adjusted ODI and SRS (Passias et al.) compared recovery periods between F/NF patients. Cost utility using published methods convert ODI to SF-6D obtained Quality Adjusted Life Years (QALY). QALYs utilized a 3% discount rate for residual decline to life expectancy (78.7 years). Direct costs calculated using the PearlDiver database incorporating complications, LOS, and associated healthcare costs.

Results: 245 ASD patients met inclusion criteria (57yrs±15.0, 82%F, BMI: 26.3 kg/m2 ±6.0, ASD-FI: 2.9±1.6, CCI: 1.55 ±1.7). Surgical patients had a mean levels fused of 11.4±4, LOS of 7.7 days±4.4, EBL of 1686 mL, operative time of 374 min, with 70% undergoing an osteotomy. In terms of surgical approach, 76% were posterior-only, and 23.6% had a combined approach. Frailty breakdown was: 138 (55%) NF, and 107 (45%) F patients. F patients had higher mean PT (25 vs 20), PILL (21 vs 10), TK T4-T12 (-33 vs -36), SVA C7-S1 (80 vs 35), and a higher BL ODI (52 vs 27, all p <0.05). F patients had a higher level of invasiveness (99 vs 88), greater EBL (2058 vs 1560) and a longer LOS (8.6 vs 7, all p<0.05), as well as, more overall complications (86% vs 78%, p=.094), more major complications (41% vs 24%, p=.003), and more reoperations (24% vs 18%, p=.314). Improvement in ODI was greater for frail patients (-19 vs -12), however, at 2Y ODI remained significantly higher (32 vs 15, both p<0.05). F patients had a higher IHS-adjusted ODI (32 vs 15, p<0.05). In a cost analysis, 2Y cost of F patients was higher (\$90,967 vs \$81,479), however, due to a greater gain in QALY, cost per QALY at life expectancy was comparable to NF patients (\$71,600 vs \$75,191).

Conclusion: Frail patients experienced a longer LOS, and higher EBL, possibly due to the increased invasiveness used to treat a more severe deformity with a worse preoperative physiological state. Although frail patients experienced more complications, the higher overall improvement in ODI contributed to a comparable cost utility despite a higher initial cost.

8:50 - 8:52 am 640 Transforaminal thoracic interbody fusion (TTIF) for treatment of thoracic proximal junctional kyphosis

Bryan Ladd, MD; Christophe T. Martin, MD; Jonathan N. Sembrano, MD; David W. Polly, MD; Kristen E. Jones, MD, FAANS

Introduction: TTIF has not previously been reported to surgically treat proximal junctional failure (PJF).

Methods: We performed a single-center retrospective review of patients undergoing TTIF for thoracic PJF. All patients underwent Schwab grade 2 osteotomies at the level of PJF with pedicle sparing transforaminal interbody cage placement and extension of prior surgical level with pedicle screws. Outcome measures were degree of change between pre- to post-treatment of proximal junctional kyphosis (PJK) (measured from original UIV to UIV+2) for all patients. Oswestry Disability Index (ODI) was included for all patients with at least 1-year follow-up. Surgical complicationsI were recorded.

Results: From 2014 to 2020, we performed 61 cases of TTIF, of which 24 cases were performed for PJK. 18 patients had complete one year radiographic and clinical follow-up. 7 presented with symptomatic myelopathy from thoracic spinal cord compression at the level of PJF. Average kyphosis correction was $15.5^{\circ} \pm 10.7^{\circ}$ [0°-40°]. Mean percentage of presenting kyphosis correction was $50.3\% \pm 28.0\%$ [0%-90.9%]. 1 patient, with severe preoperative myelopathy, experienced neuromonitoring changes during compression across the osteotomy sites for kyphosis correction, therefore correction was aborted. There was postoperative neurologic deterioration, which had resolved at follow up. No other patient had postoperative neurologic worsening. 1 interbody cage migrated anteriorly and was asymptomatic. 1 patient had a postoperative cerebrovascular stroke. 1 patient had a symptomatic postoperative pulmonary embolism. All patients maintained kyphosis correction and demonstrated arthrodesis. Mean ODI reduction at 1-year follow-up was $13.5\% \pm 23.7\%$ [-18% - 54.7%], which did not meet statistical significance (p=0.051). 5 patients had a clinically significant reduction in ODI at 1-year follow-up.

Conclusion: TTIF is a promising technique for surgical treatment of PJF with safe, effective, and durable correction of PJK.

8:52 - 8:54 am 641 Impact of Preoperative Cross-sectional Area of Psoas Muscle on Outcomes of Adult Spinal Deformity Surgery

Hikari Urakawa; Kosuke Sato; Jonathan Elysee, BA; Renaud Lafage; Avani Vaishnav; Yucheng Yao; Han Jo Kim, MD; Frank Schwab; Virginie Lafage, PhD; Sheeraz Qureshi

Introduction: Proximal junctional kyphosis (PJK)/proximal junctional failure (PJF), which is caused by soft tissue or bony failure, is a critical challenge in ASD surgery. The cross-sectional area of psoas muscle has been used as a parameter of sarcopenia and reported to have a negative impact on functional outcomes of lumbar surgery for degenerative diseases. However, it is unclear whether it also impacts outcomes of adult spinal deformity (ASD) surgery.

Methods: ASD patients who were over 18 years old and underwent posterior fusion surgery with > 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) at pre-op and 6 months and prevalence of PJK/PJF at 6 months.

Results: A total of 65 patients were included in this study.

Patients were divided into 2 groups [lower NTPA group (LG) and Higher 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.

In radiographic parameters, C2-C7 SVA was significantly higher and SS was significantly lower in the LG at pre-op and 6 months.

Prevalence of PJK was significantly higher in the LG, compared to the HG, while there were no patients with PJF in both groups.

Conclusion: The decrease of 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.

8:54 - 8:56 am

642 Biomechanics of a Laterally Placed SI Joint Device Supplemental to S2AI Fixation in Adult Spinal Deformity Construct

Bernardo De Andrada, MD; Piyanat Wangsawatwong; Jennifer Lehrman; Anna Sawa; Derek Lindsey, MS; Scott Yerby; Jakub Godzik; Juan S. Uribe, MD, FAANS; Brian Kelly

Introduction: S2 alar-iliac (S2AI) screw fixation effectively enhances stability in long-segment constructs. Although S2AI fixation provides a single transarticular sacroiliac joint fixation (SIJF) point, the additional fixation points may provide greater stability and attenuate screw and rod strain.

Methods: Eight L1-pelvis human cadaveric specimens underwent pure moment (7.5 Nm) and compression (400 N) tests in 4 conditions: (1) intact (pure moment loading only), (2) L2-S1 pedicle screw and rod with L5-S1 interbody fusion, (3) added S2AI screws, and (4) bilateral laterally placed SIJF added. Range of motion (ROM), rod strain, and screw-bending moment (S1 and S2AI) were analyzed.

Results: Compared to S1 fixation, S2AI fixation significantly reduced L5-S1 ROM in right lateral bending by 50% (0.11°, p=0.049) and in compression by 39% (0.22°, p=0.003). Compared with fixation ending at S1, extending fixation with S2AI significantly decreased sacroiliac joint ROM by 52% (0.28°, p=0.02) in flexion, by 65% (0.48°, p=0.04) in extension, by 59% (0.76°, p=0.02) in combined flexion/extension, and by 36% (0.09°, p=0.02) in left axial rotation. The addition of S2AI screws reduced S1 screw-bending moment in all directions by a mean of 42%, albeit significantly only in flexion (43%, 0.106 Nm, p=0.046). With S2AI fixation, posterior L5-S1 primary rod strain increased by 124% (159 μ e, p=0.002) in flexion, by 149% (285 μ e, p=0.02) in left axial rotation, and by 99% (254 μ e, p=0.04) in right axial rotation. Compared with S2AI fixation, the addition of SIJF reduced L5-S1 strain during right axial rotation by 6% (28 μ e, p=0.04) and increased L5-S1 strain in extension by 6% (28 μ e; p=0.02).

Conclusion: Long-segment constructs ending with S2AI screws created a more stable construct than S1 fixation, reducing lumbosacral and sacroiliac joint motion. S2AI fixation also decreased S1 screw-bending moment compared with fixation ending at S1. These benefits, however, were paired with increased rod strain at the lumbosacral junction. The addition of SIJF decreased L5-S1 rod strain in axial rotation but increased it in extension compared with constructs ending in S2AI.

8:56 - 8:58 am

643 Achievement of Robust Optimal Alignment and Functional Status in Adult Spinal Deformity Surgery: 3-Year Outcome Analysis

Lara Passfall; Nicholas Kummer; Oscar Krol; Sara Naessig; Waleed Ahmad; Katherine Pierce; Bhaveen Kapadia; Shaleen Vira; Bassel G. Diebo, MD; Peter G. Passias, MD

Introduction: Surgical correction of adult spinal deformity (ASD) has been associated with superior alignment and functional outcomes. Isolated predictors of optimal radiographic and functional outcomes have been published for various postoperative time points. However, the factors that contribute to the sustainability of such optimal outcomes remain unclear.

Methods: Included: operative ASD patients with pre-(BL) and 3-year(3Y) postop radiographic/HRQL data. At 1Y and 3Y postop, a favorable outcome was defined as meeting =3 of 4 criteria: 1) no PJF or mechanical failure with reop, 2) best clinical outcome(BCO) for SRS[=4.5] or ODI[<15] per Smith et al., 3) improving in =1 SRS-Schwab modifier, and 4) not worsening in any SRS-Schwab modifier. A robust outcome was defined as having favorable outcome at both 1Y and 3Y. Predictors of robust outcome were identified using multivariate regression, with machine learning conditional inference tree (CIT) for continuous variables.

Results: 157 ASD patients included (57yrs, 82%F, 26.2kg/m2, CCI: 1.71, levels fused: 11.3±3.9). By BL SRS-Schwab modifiers: 29.3% ++PI-LL, 25.5% ++SVA, 21.0% ++PT. At 3Y postop: 9.9% ++PI-LL, 0.0% ++SVA, 15.9% ++PT. At 1Y, 62 pts(39.5%) met the BCO definition for ODI and 33 (21.0%) for SRS. At 3Y, 58 pts(36.9%) had BCO for ODI and 29 (18.5%) for SRS. 95 pts(60.5%) were identified as having a favorable outcome at 1Y postop. At 3Y, 85 pts(54.1%) had favorable outcome. 78 pts(49.7% of the full cohort) qualified as having a robust outcome. Multivariate regression controlling for age, CCI, and PI-LL, identified predictors of a robust outcome: surgical invasiveness >65, being fused to S1/pelvis, BL to 6W PI-LL diff >13.9°, having ideal PI-LL by SRS-Schwab at 6W, being GAP proportional at 6W; all p<0.05.

Conclusion: In our study, almost 50% of ASD patients had a robust outcome, with favorable radiographic alignment and functional status maintained up to 3 years postoperatively. Robustness was more likely in patients whose reconstruction was fused to the pelvis and addressed the lumbopelvic mismatch with adequate surgical invasiveness to achieve full alignment correction.

8:58 - 9:00 am 644 The Effects of Global Alignment and Proportionality Scores on Post-Operative Outcomes Following ASD Correction

Oscar Krol; Lara Passfall; Nicholas Kummer; Shaleen Vira; Peter G. Passias, MD

Introduction: Restoring sagittal alignment in adult spinal deformity (ASD) surgery is a common goal to improve patient clinical outcomes and minimize long term complications. Recent enthusiasm has suggested that achievement global alignment and proportionality alignment may influence mechanical failures and as such may potentially influence ultimate outcomes.

Methods: Operative ASD patients (scoliosis >20°, SVA>5cm, PT>25°, or TK>60°,) with a fusion at L1 or higher with available baseline (BL) and 2-year (2Y) radiographic and HRQL data were included. Multivariate analysis (MVA) was used to find an association between the Global Alignment and Proportionality (GAP) score higher risk individual categories: Moderately Disproportioned (MD)- (GAP >2 and <7) and Severely Disproportioned (SD) -(GAP >7). Severe sagittal deformity was defined by a ++ in SRS-Schwab for SVA, or PILL. Mechanical complications excluded PJK.

Results: 227 ASD patients met the inclusion criteria (59.9yrs±14.0, 79%F, BMI: 27.7 kg/m2 ±6.0, ASD-FI: 3.3±1.6, CCI: 1.8 ±1.7). Surgically, patients had mean levels fused of 11.1±4.4, length of stay (LOS) of 7.9 days±4.4, estimated blood loss (EBL) of 1577 mL, operative time of 377 min, with 63% undergoing an osteotomy. In the full cohort, controlling for age, and CCI, MVA showed no association of GAP MD or SD patients with PJF, or mechanical complications, (p>0.05) but MD patients showed a positive correlation with development of PJK [OR: 2, 95% CI: 1-3.7, p<0.05]. In a cohort of patients with severe sagittal deformity, GAP MD (4.2[1.3-13.4]) and GAP SD (3.3[1.06-10]) criteria was predictive of PJK by 2 years, and in a cohort of patients 65 and older, GAP MD (5[1.4-18], p=.014) and GAP SD (3.6[1-12], p=.04) were also predictive of 2Y PJK development. There was no association with PJF or mechanical complications. In a cohort of patients with a history of prior fusion, or in patients less than 65 years of age, there was no correlation of GAP MD/GAP SD with PJK, PJF, or mechanical complications. The continuous 6W GAP score, as well as the GAP categories, did now show significant correlations with patient reported outcomes at 2 years

Conclusion: Since the introduction of the Global Alignment and Proportionality (GAP), literature has been inconclusive on the utility of the GAP score in clinical practice. Our study shows that the GAP score had strong predictive potential for proximal junctional kyphosis (PJK), specifically, in patients with severe baseline sagittal malalignment and/or those 65 and older, and, may have less utility in younger patients, or those with a previous fusion.

9:00 - 9:02 am

645 Experience with Novel Posterior Tether Applicator to Prevent Proximal Junctional Kyphosis after Long-segment Fusion

Ethan Srinivasan; Vikram Mehta, MD; Thomas Buell, MD; Eric W. Sankey, MD; Timothy Y. Wang, MD; Alexandria M. Ayala, BS; Camille Pierre; Christopher I. Shaffrey, MD, FAANS; Muhammad M. Abd-El-Barr, MD, PhD; C. Rory Goodwin, MD, PhD; Isaac O. Karikari, MD, FAANS

Introduction: Incidence of proximal junction kyphosis (PJK) following long-segment fusion is between 20 and 40%, with re-operation rates as high as 55%. Interspinous tension bands bridging the upper instrumented vertebra to the adjacent noninstrumented vertebrae aim to decrease the strain at this junction.

Methods: This is a single-center, retrospective study of all patients who underwent spinal instrumentation at =6 motion segments with use of a 2-level "weave" posterior tethering configuration secured to crosslinks with vertical tensioning towers.

Pre-operative, post-operative, and final standing long-cassette films at a minimum follow-up of 6 months were evaluated for proximal junctional kyphosis, defined as a proximal junctional angle (PJA) >10° with >10° change from the pre-operative measurement.

Results: Fifty-nine patients met inclusion criteria, with median follow-up of 10.2 months (IQR 7.6-13.2) and age of 69 (61-74). Thirteen patients (22%) developed PJK. Patients with PJK did not significantly differ than those without PJK across BMI (26.6 vs 29.8, p = 0.38), pre-operative American Society of Anesthesiologists (ASA) score (3 to 3, p = 0.82), current smoking status (0% to 7%, p >0.99), pre-operative T-score (-0.8 to -1.5, p = 0.09), history of previous spinal fusion (69% to 57%, p = 0.41), prior history of PJK (23% to 22% p > 0.99), median number of instrumented levels (11 to 10, p = 0.49), median duration of follow-up (10.2 to 10.1 months, p = 0.91), or rate of re-operation (15% to 13%, p = 0.83). Radiographically, the only significant differences between the PJK and non-PJK groups were the initial post-operative change in PJA (6° to 0°, p = 0.003), final follow-up PJA (26° to 10°, p < 0.001), and final follow-up change in PJA (20° to 2°, p < 0.001).

Conclusion: Usage of posterior tension banding may lower the rate of PJK relative to previous literature reported incidence of non-banded patients. The initial change in PJA may signify an increased risk, and can be used to aid in identification of patients who would benefit from closer follow-up.

9:02 - 9:04 am

646 Identifying T1SIope and C2SIope Thresholds for Optimal Functional and Clinical Outcomes in Cervical Deformity Correction

Lara Passfall; Nicholas Kummer; Oscar Krol; Bhaveen Kapadia; Renaud Lafage; Bassel G. Diebo MD; Virginie Lafage, PhD; Peter G. Passias, MD

Introduction: Surgical correction of cervical deformity (CD) has been associated with superior alignment and functional outcomes. It has not yet been determined whether baseline and postoperative T1 slope and C2 slope correlate with health-related quality of life (HRQL) metrics and radiographic complication.

Methods: Included: Operative CD patients with UIV above C7 and with pre-(BL) and up to 2-year(2Y) postop radiographic/HRQL data. Cervical deformity was defined as meeting at least one of the following radiographic parameters: C2-C7 lordosis < -15°, TS-CL >35°, C2-C7 SVA >4cm, McGregor's slope >20°, or CBVA >25°. Logistic regression and conditional inference tree(CIT) were used to determine baseline radiographic thresholds for improving in =2 HRQL metrics [NDI, mJOA, EQ5D, NRS Neck, NRS Back] from BL to 2Y, and 2Y radiographic thresholds for developing DJK or DJF by 2Y postop.

Results: 119 operative CD patients met inclusion criteria(62yrs, 63%F, levels fused 7.5±3.7). By approach, 19.3% anterior-only, 44.5% posterior-only, 36.1% combined. Mean BL radiographic parameters: PT 19.6°, PI-LL 1.4°, SVA 1.9mm, T2-T12 kyphosis -46.8°, C2-C7 lordosis -9.0°, T1S 29.0°, TS-CL 38.2°, C2S 37.7°, cSVA 44.0mm, and C2-T3 -18.0°. Mean BL HRQLs: NRS back 5.0, NRS neck 6.7, NDI 47.9, mJOA 13.5, and EQ5D 0.74. Spearman correlation and linear regression identified no association between baseline T1S or C2S and HRQL metrics, or between 2Y postop T1S and HRQLs(all p>0.05). Correlation and linear regression found significant associations of higher C2S with higher NDI(p=0.042), lower mJOA (p=0.011), and lower EQ5D(p=0.009), all indicating higher degree of disability at 2Y postop. Logistic regression with CIT identified thresholds for improving in 2 or more HRQL metrics by 2Y postop: baseline T1S <32.8°(OR:2.47) and C2S<46.7°(OR:2.40); both p<0.05. Regression and CIT also identified postoperative radiographic thresholds for developing DJK or DJF by 2Y: T1S >45.3°(OR: 16.0) and C2S >32.5°(OR: 6.07); both p<0.05.

Conclusion: Baseline deformity severity in terms of T1 slope and C2 slope can be predictive of postoperative functional outcomes in cervical deformity patients, while postoperative deformity in T1S and C2S can be predictive of DJK and DJF occurrence.

9:04 - 9:06 am 647 Should our Corrective Re-Alignments be Tailored to Different Frailty States?

Peter G. Passias, MD; Oscar Krol; Lara Passfall; Nicholas Kummer; Shaleen Vira; Bassel G. Diebo, MD

Introduction: Adult spinal deformity is associated with severe pain and disability. Recent literature has shown that surgical intervention can significantly improve patient's quality of life and lessen disease burden. As many patients requiring spine surgery are elder and often frail, restoration of alignment targets may differ. There is paucity in literature on how different frailty states affect realignment goals.

Methods: Operative ASD patients(scoliosis=20°, SVA=5cm, PT=25°, or TK =60°) with available BL and 2Y radiographic and HRQL data were included. ASD Frailty Index was used to stratify patients into Not Frail (NF) and Frail (F) categories. Linear regression analysis established normative radiographic thresholds, utilizing previously published age specific US-Normative ODI values (Lafage et al.) and the Frailty Index, based on a cohort of patients with an Ideal Clinical Outcome (no major complications, no PJK, and a SRS-Satisfaction of >4). Patients were considered "matched" if 2-year postop alignment was within 1 standard deviation(+1SD Overcorrected-1SD Undercorrected).

Results: 245 patients included (57±15yrs, 82% female, 26±5.14kg/m2, ASD-FI: 2.9±1.6, CCI: 1.8±1.7). Patients had a mean levels fused of 11.1±4.4, LOS of 7.7 days±4.4, EBL of 1577 mL, operative time of 377 min, with 63% undergoing an osteotomy. In terms of surgical approach, 69.9% posterior-only, and 29.3% had a combined approach. Primary analyses demonstrated correlation between BL frailty index, PT, PILL, SVA, and ODI, (p<0.05). Linear regression analysis developed age and frailty adjusted alignment threshold. Thresholds for correction were found to increase with age, as previously determined by Lafage et al, as well as, increase with a higher Frailty Index. Frail patients, corresponding to the same age, were found on average to have a higher alignment threshold than Not Frail patients in SVA, PI-LL, and PT. Controlling for age, CCI, and BL deformity, F patients experienced less overall PJK when undercorrected in PILL in the Lafage Schwab age adjusted parameters (.28[.09-.85], p=.024). Patients that achieved a match in the newly developed age and frailty adjusted parameters in PI-LL had lower rates of PJF (5% vs 15%, p=.014 with improved HRQLs, and those matched in SVA patients had a shorter LOS.

Conclusion: Age-Adjusted alignment by Lafage et al. was the first study to recognize that older age warrants a lower degree of correction, and, the original SRS-Schwab criteria was modified accordingly. Alignment targets accounting for both frailty and age were developed with larger thresholds for increasing frailty. In this study, we found patients who were matched in these age and frailty adjusted thresholds had lower rates of PJF and significantly improved HRQL outcomes.

9:06 - 9:08 am

648 Factors Predicting Complications in Surgically Treated Patients with Cervical Deformity

Asad M. Lak, MD; Noah Nawabi; John Kilgallon; Elie Massaad; Hasan A. Zaidi, MD, FAANS; John H. Shin, MD, FAANS

Introduction: Cervical deformity is a debilitating condition with a challenging surgical correction.

Methods: A retrospective, multicenter study including patients with cervical deformity i.e. C2-C7 lordosis > 10° , C2-C7 SVA > 4.0 cm or chin-brow vertical angle > 25° who underwent surgical treatment and had a follow-up of at least > 1 year were included.

Results: A total of 63 patients were included in the study. The mean age was 61.4 years and 63.5% were females. Pre-operatively, neck pain (85.7%) was the most common symptom followed by weakness (55.5%), sensory deficit (52.4%) and imbalance (38.0%). The mean cervical lordosis was 16.4°, C2-C7 SVA was 3.8 cm and T1-slope was 20.7°. Most patients underwent posterior only approach (71.4%) and 28.5% also had osteotomies. The mean number of levels operated were 6.5, the mean estimated blood loss was 737.0 mL and the mean length of stay was 5.3 days.

Post-operatively, 23.8% patients had ongoing neck pain, 17.5% weakness, 12.7% sensory deficits and 9.5% imbalance. The incidence of overall complications was 38.0% and early (i.e. 30-day) complications was 28.5%. The mean follow-up was 3.2 years.

Multivariate logistic regression identified age and post-operative imbalance as risk factors for the occurrence of any complication (OR 1.07 and 21.7 respectively; p < 0.05) and early complications (OR 1.15 and 12.6 respectively, p < 0.05).

Conclusion: Increasing age and post-operative imbalance were found to be associated with an increased risk of complications. The knowledge of these factors may help in surgical decision making and improve clinical outcomes.

9:08 - 9:10 am

649 Failure to Achieve Pelvic Balance Following Hip Replacement Surgery May Be a Risk Factor for Degenerative Scoliosis

Asad M. Lak, MD; Francesca Siddi; Fidelia Ida; Hasan A. Zaidi, MD, FAANS; Timothy R. Smith, MD, PhD, MPH; Yi Lu, MD, PhD, FAANS

Introduction: In the global alignment of the body, the pelvis and spine are strictly and mutually connected.

Methods: A retrospective, multi-institutional case-control study was conducted. Patients who underwent THA followed by spine surgery primarily because of scoliosis (scoliosis group) were compared to patients who only underwent THA (no scoliosis group). Any patient in either group who had spine surgery prior to THA was excluded. Propensity score matching was utilized to match the two groups on age, gender and etiology for THA.

Results: A total of 78 patients (39 in each group) were included in the study. The median age was 63 years in the scoliosis group and 64 years in no scoliosis group. The most common etiologies for THA were osteoarthritis, fracture and avascular necrosis. The median pelvic obliquity as measured by the O'Brien method was 2.8° (0.2-6.5) in the scoliosis group and 0.85° (0 – 4.5) in no scoliosis group. This difference in pelvic obliquity between the two groups was statistically significant (p<0.01). The median time interval between THA and spine surgery was 7 years. The median follow-up in the scoliosis group was 11 years and 7.5 years in no scoliosis group.

In the scoliosis group, the median lumbar Cobb angle was 19° and presenting symptoms were; back and LE pain (83%), back pain with LE paresthesia (11.4%) and back pain with LE weakness (5.7%). Patients primarily underwent decompression with (54%) or without instrumented fusion (8%) or decompression alone (37.8%).

Conclusion: Altered pelvic parameters following hip surgery may be a contributing factor in the development of thoracolumbar scoliosis. Future biomechanical studies are needed to look more closely at the relationship of pelvic parameters to spine.

9:10 - 9:12 am

650 Operative Levels and Patient Frailty Inform Hospital Course Following Adult Spinal Deformity Surgery

Jianning Shao, BA; Arbaz Momin; Jonathan J. Rasouli, MD; Amy S. Nowacki, PhD; Jacob Enders, BSE; Precious Oyem; Emily Abramczyk; Carlos Munoz; Edward C. Benzel, MD, FAANS; Michael P. Steinmetz, MD, FAANS

Introduction: Adult spinal deformity (ASD) surgery has been well documented at correcting sagittal imbalance and restoring spino-pelvic harmony. However, these operations are associated with high complication rates of up to 49% and protracted hospital course.

Methods: All patients who underwent ASD surgery at our institution over the past two decades were retrospectively reviewed. Data on patient demographics, history of prior spine surgery, frailty parameters including Clinical Frailty Scale (CFS) and modified frailty index-11 (mFI-11), comorbidity burden as measured by the Charlson Comorbidity Index (CCI), functional status measured by the Karnofsky Performance Scale (KPS), surgical parameters, LOS, discharge disposition, and readmission with 30 days were collected. Multivariable logistic regression was performed to identify factors associated with discharge to facility and readmission with 30 days. Multivariable linear regression was performed to identify factors associated with LOS. All patients who were not discharged home were designated as discharged to facility.

Results: A total of 600 patients were included in the final analysis: 198 (35.6%) males and 358 (64.4%) females, with an average age of 59.8 \pm 16.7 years. 414 (69%) patients had prior spine surgery. Multivariable regression analysis indicated CFS (b=0.93, p=0.0002) and higher number of operative levels (b=0.41, p<0.0001) were significantly correlated with increased LOS. Multivariable logistic regression showed that increasing age (OR=1.24, p=0.008), higher BMI (OR=1.03, p=0.03), higher CFS (OR=1.41, p=0.003), lower preoperative KPS (OR=0.78, p=0.01), and higher number of operative levels (OR=1.13, p<0.0001) were correlated with discharge to facility. Elderly age (OR=0.83, p=0.048), higher comorbidity burden/CCI (OR=1.22, p=0.01) and higher number of operative levels (OR=1.1, p=0.03) were correlated with readmission within 30 days.

Conclusion: Higher number of operative levels and higher degrees of patient frailty are correlated with protracted hospital stay, discharge to disposition, and readmission with 30 days following ASD surgery.

9:12 - 9:14 am

651 Bone Morphogenetic Protein Use in Adult Thoracolumbar Deformity Surgery: Impact on Reoperation Rate and Cancer Risk

Kunal Varshneya; Martin N. Stienen, MD; Zachary A. Medress, MD; Atman Desai; John K. Ratliff, MD, FAANS, FACS; Anand Veeravagu, MD, FAANS

Introduction: Bone morphogenetic protein (BMP) has been shown to stimulate bone growth and improve fusion rates in spine surgery. However, there is controversy regarding the impact of BMP on postoperative outcomes, reoperation rates, and risk of developing cancer in patients undergoing surgery for thoracolumbar deformity correction.

Methods: We queried the MarketScan database in order to identify patients who underwent ASD surgery from 2007-2016. Patients were then stratified into whether or not BMP was used in the index operation. Propensity score matching (PSM) was then utilized to mitigate intergroup differences between BMP and non-BMP patients. Patients under the age of 18 years and those with any prior history of cancer were excluded from this study. Baseline demographics and comorbidities, postoperative complication rates, short and long-term reoperation rates, and 5-year cancer risk were determined.

Results: A total of 33,610 patients met the inclusion criteria of this study, of which n = 1759 (5.2%) received BMP during their index deformity operation. Patients in the BMP cohort experienced a higher rate of postoperative complications within 90-days of surgery than control patients (29.0% vs 25.1%, p < 0.05). Patients receiving BMP during the index operation had lower rates of any revision surgery than control patients at 90 days (8.2% vs 11.6%, p < 0.05), 6 months (10.2% vs 13.2%, p < 0.05), 1 year (12.1% vs 15.2%, p < 0.05) and 2 years (13.9% vs 18.0%, p < 0.05). Overall risk of developing cancer was similar between the two cohorts (control: 22.7%, BMP 22.4%).

Conclusion: The use of BMP during ASD led to slightly higher immediate postoperative complications, reduced reoperations, and did not increase the risk of developing a malignancy. Further prospective studies should be undertaken to determine the impact of high and low dose BMP on outcomes for adult spinal deformity.
9:14 - 9:16 am

652 Are we Improving at 3-Column Osteotomy in Terms of Achieving Optimal Realignment and Minimizing Complications in ASD?

Peter G. Passias, MD; Oscar Krol; Lara Passfall; Virginie Lafage, PhD; Renaud Lafage; Justin S. Smith, MD, PhD, FAANS; Breton G. Line, BSME; Alan H. Daniels, MD; Shaleen Vira; Bassel G. Diebo, MD; Jeffrey L. Gum, MD; Khaled Kebaish, MD; Khoi D. Than, MD, FAANS; Han Jo Kim; Richard A. Hostin, MD; Munish C. Gupta, MD; Robert Eastlack, MD; Neel Anand, MD; Christopher P. Ames, MD; Robert A. Hart; Douglas C. Burton, MD; Frank Schwab; Christopher I. Shaffrey, MD, FAANS; Eric Klineberg; Shay Bess, MD

Introduction: Three-column osteotomies (3CO), in the form of pedicle subtraction or vertebral column resection, have become common in adult spinal deformity (ASD) in cases of severe deformity or iatrogenic sagittal malalignment. Although a powerful surgical intervention, 3COs can increase the risks associated with correction. The purpose of this study is to investigate whether more appropriate usage of 3CO is occurring over time.

Methods: Operative ASD patients (scoliosis >20°, SVA>5cm, PT>25°, or TK>60°) with available baseline (BL) and 2-year (2Y) radiographic and HRQL data were included. Patients were stratified into 2 groups by DOS: Group I (2008-2013) and Group II (2013-2018). Patients who underwent a 3CO in Group I and Group II were then isolated for outcomes analysis. Severe sagittal deformity was defined by a SVA >9.5cm and "match" was defined by meeting ideal age-adjusted alignment. Best clinical outcome (BCO) was defined as ODI <15 and SRS >4.5 as per Smith et al. Univariate, bivariate (BVA) and multivariate analysis (MVA) was used to assess differences in surgical, radiographic, and clinical parameters.

Results: 762 ASD patients met inclusion criteria (59.9yrs±14.0, 79%F, BMI: 27.7 kg/m2 ±6.0, ASD-FI: 3.3±1.6, CCI: 1.8 ±1.7). Controlling for baseline SVA, mismatch, revision status, age, and CCI, Group II was less likely to have a 3CO (OR: .6, 95% CI: [.4-.97]) compared with Group I (21% vs 31%, both p<0.05). Controlling for age, CCI, and BL deformity, patients who achieved a match in SVA or PI-LL in Group II showed a lower rate of 3CO (OR: .510, 95% CI: [.27-.98], p<0.05). In an isolated cohort of patients with severe sagittal deformity, controlling for age and CCI showed a lower likelihood of Group II receiving a 3CO (OR: 0.5, 95% CI: [.3-.94], p<0.05). The following analysis is based solely on patients who had a 3CO from each Group (79 patients in Group I and 59 patients in Group II). MVA controlling for age, deformity, CCI, and invasiveness showed Group II had a higher usage of hooks, tethers, and cement prophylaxis (OR: 2, 95% 95% CI: [.86-4.7], p=.11), a higher usage of supplemental rods (OR: 21.8, 95% CI: [7.8- 61], p=.001), and had a lower likelihood of PJF (OR: 0.23, 95% CI: [.07-.76]), PJK by 3Y (OR: 0.23, 95% CI: [.1-.55]), rod breakage (OR: 0.30, 95% CI: [.1-.9]), and overall hardware complications (OR: 0.28, 95% CI: [.1-.8], all p<0.05). Group II had a lower 2Y ODI and higher SF-36 Mental/Physical/Social/Emotional, SRS Activity/Mental/Pain and SRS-Total, p<0.05. Controlling for BL ODI, Group II was more likely to reach BCO ODI (OR: 2.8, 95% CI: [1.2-6.4] and SRS (OR: 4.6, CI: [1.3-16], both p<0.05).

Conclusion: Over a seven-year period, the rates of 3CO usage have declined, including in cases of severe deformity, with an increase in the usage of PJK prophylaxis. A better understanding of the utility of 3CO, along with a greater implementation of preventative measures, has led to a decrease in complications, PJF, PJK, and a significant improvement in patient reported outcome measures.

9:16 - 9:18 am

653 Delineation of Alignment Goals in Cervical Deformity Correction Associated with Optimal Clinical and Functional Outcomes

Lara Passfall; Oscar Krol; Nicholas Kummer; Waleed Ahmad; Sara Naessig; Katherine Pierce ; Renaud Lafage; Virginie Lafage, PhD; Peter G. Passias, MD

Introduction: Surgical correction of cervical deformity (CD) has been associated with superior alignment and functional outcomes. It remains unclear which baseline and postoperative radiographic parameters correlate with improved health-related quality of life (HRQL) metrics and minimized complication rates.

Methods: Included: surgical CD patients with UIV above C7 and with pre-(BL) and up to 2-year(2Y) postop radiographic/HRQL data. Cervical deformity (CD) was defined =1 of the following radiographic parameters: C2-C7 lordosis < -15°, TS-CL>35°, cSVA >4cm, MGS >20°, CBVA >25°. An optimal outcome by 2Y postop was defined as 1) no DJF, and 2) meeting Virk et al. good clinical outcome [=2 of the following: NDI<20 or meeting MCID, mild myelopathy (mJOA=14), NRS-Neck=5 or improved by =2 points from BL]. Regression analysis and conditional inference tree (CIT) identified BL and 3-month (3M) postop radiographic thresholds predictive of an optimal outcome.

Results: 119 CD patients met inclusion criteria (61.2 ± 10.5 yrs, 63%F, BMI 29.0 ±7.5 kg/m2, CCI: 1.00 ±1.31) and underwent surgery (levels fused 7.5 ±3.7 , EBL 990mL, op time 547min). By approach, 19.3% anterior-only, 44.5% posterior-only, and 36.1% combined. Mean BL radiographic parameters: sacral slope 34.3°, PT 19.6°, PI-LL 1.4°, SVA 1.9mm, T2-T12 kyphosis -46.8°, T1S 29.0°, C2-C7 lordosis -9.0°, TS-CL 38.2°, C2S 37.7°, cSVA 44.0mm, C2-T3 -18.0°, and C2-T3 SVA 75.2mm. Mean BL HRQLs were as follows: NRS back 5.0, NRS neck 6.7, NDI 47.9, mJOA 13.5, and EQ5D 0.74. By 2Y postop, there were 12 cases of DJF. 50 patients (42%) met the good clinical outcome criteria. Overall, 48 patients (40.3%) had an optimal outcome. Regression analysis with CIT identified the following baseline radiographic thresholds predictive of an optimal outcome: C2-T3 >9.7° (OR: 15.9, p=0.010) and C2S <34.0° (OR: 3.9, p=0.001). The following 3M postoperative radiographic thresholds were predictive of an optimal outcome: TS-CL <36.8° (OR: 15.1), C2-C7 lordosis >9.3° (OR: 4.2), cSVA <36.8mm (OR: 5.3), C2-T3 >16.8° (OR: 17.3), and C2S <29.4° (OR: 9.9); all p<0.05.

Conclusion: This study identified new baseline radiographic thresholds as well as postoperative realignment goals predictive of favorable functional and clinical outcomes in cervical deformity patients.

9:18 - 9:20 am

654 Role of Pelvic Obliquity & Leg Length Discrepancy in Adult Spinal Deformity Patients with Coronal Malalignment

Scott L. Zuckerman, MD; Christopher Lai; Daniel Shen; Meghan Cerpa; Mena G. Kerolus, MD; Ian A. Buchanan, MD; Alex Ha; Eric Leung; Nathan Lee; Lawrence Lenke

Introduction: Achieving optimal coronal alignment can be a formidable challenge in ASD surgery, and how PO and LLD relate to CM remains poorly studied.

Methods: Pts undergoing ASD surgery (=6 level fusions) were reviewed from a single-institution. Variables were: 1) Pelvic obliquity (PO): angle between horizontal plane and a line touching bilateral iliac crests; 2) Leg-length discrepancy (LLD): distance from femoral head to the tibial plafond. Coronal vertical axis (CVA) and sagittal vertical axis (SVA) were collected, both from C7. Coronal malalignment (CM)=CVA>3cm. Oswestry Disability Index (ODI) was collected at preop and 2-years.

Results: Of 237 pts undergoing ASD surgery, 90 (37.0%) had preop CM. Pts. with preop CM had a higher PO (2.8±3.2 vs. 2.0±1.7, p=0.013), higher % of patients with PO>3° (35.6% vs. 23.5%, p=0.044), and higher % of patients with LLD>1cm (21.1% vs. 9.8%, p=0.014) (Table 1). While preop PO was significantly correlated with CVA (r=0.26, p<0.001) and max cobb angle (r=0.30, p<0.001), preop LLD was only correlated with CVA (r=0.14, p=0.035). 12.2% of CM patients had both clinically significant PO and LLD. Postoperatively, preop PO was significantly associated with both postop CM (OR=1.22, 95%CI,p=0.008) and postop CVA (β =0.11,p<0.001). A higher preop PO was independently associated with postop complications after multivariate logistic regression (OR=1.24,p=0.010); however, 2-year ODI scores were not. Preop LLD had no significant relationship to postop CM, CVA, ODI, or complications.

Conclusion: Clinically significant PO=3° or LLD=1cm was seen in 44.1% of pts with preop CM, but also 23.5% of pts with normal coronal alignment. Preop PO was significantly associated with preop CVA and max cobb angle, while preop LLD was only associated with preop CVA. The direction of PO and LLD showed no consistent pattern with CVA. Preop PO was independently associated with complications but not 2-year ODI scores.

9:20 - 9:22

655 Improvements in Outcomes and Cost after Adult Spinal Deformity (ASD) Corrective Surgery between 2008 and 2019

Peter G. Passias, MD; Nicholas Kummer; Virginie Lafage, PhD; Renaud Lafage; Justin S. Smith, MD, PhD, FAANS; Breton G. Line, BSME; Bassel G. Diebo, MD; Jeffrey L. Gum, MD; Alan H. Daniels, MD; Eric Klineberg; Munish C. Gupta, MD; Khaled Kebaish, MD; Amit Jain; Dean Chou, MD, FAANS; Leah Carreon; Michael Kelly; Robert A. Hart; Douglas C. Burton, MD; Christopher I. Shaffrey, MD, FAANS; Christopher P. Ames, MD; Frank Schwab; Richard A. Hostin, MD; Shay Bess, MD

Introduction: As surgical methods and technology advance, so should improvements in patient outcomes and cost effectiveness.

Methods: ASD patients with baseline (BL) and up to 2-year (2Y) Health-Related Quality of Life (HRQL) data between the years of 2008-2019 were included. Incomplete yearly data from 2008 and 2019 were combined with 2009 and 2018, respectively. ANCOVA established estimated marginal means for outcome measures (complication rates, reoperations, HRQLs, total cost, utility gained, Quality Adjusted Life Years [QALYs]) by initial surgery year adjusting for covariates: age, gender, decompression or osteotomy, surgical approach, invasiveness, and BL deformity (Pelvic Tilt, Pelvic Incidence, Lumbar Lordosis). Trend-line slope showed yearly changes. Cost was calculated using PearlDiver and assessed for Complications/Major Complications and Comorbidities according to CMS.gov. The costs represented national averages of Medicare pay-scales for services within a 30-day window including length of stay and death differentiated by complication/comorbidity, revision, and surgical approach. Internal cost data was based on individual patient DRG codes, limiting revisions to those within 2Y of the initial surgery.

Results: There were 1236 patients (2009: 117 patients, 2010: 97, 2011: 75, 2012: 45, 2013: 106, 2014: 127, 2015: 115, 2016: 204, 2017: 202, 2018: 148) included with no significant differences in baseline ODI by year. Overall, there was a decrease in complication rates, with a strong decrease in minor and overall complications. Difference from BL to 2Y follow-up improved yearly in SF-36 PCS and ODI measures. National average and internal DRG cost data showed a downward trend in average 2Y cost, with enhanced cost effectiveness via cost per QALY.

Conclusion: Between 2008 and 2019, rates of complications have decreased concurrently with improvements in patient reported outcomes, resulting in improved cost effectiveness according to national Medicare average and individual patient cost data.

9:22 - 9:24 am

656 Anterior Lumbar Interbody Fusion Stability in Lengthening Posterior Instrumentation Constructs: A Biomechanical Study

Kyle McGrath; Eric Schmidt, MD; Jeremy Loss; Michael P. Steinmetz, MD, FAANS

Introduction: Excessive stress and motion at the L5-S1 level can lead to degenerative changes, especially in patients with posterior instrumentation suprajacent to L5. Attention has turned to utilization of L5-S1 Anterior Lumbar Interbody Fusion (ALIF) to stabilize the lumbosacral junction, although questions remain regarding the effectiveness of standalone ALIF in the setting of prior posterior instrumented fusions.

Methods: Seven human cadaveric spines (T9-sacrum) were instrumented with pedicle screws from T10 to L5 and mounted to a six degree-of-freedom robot. Posterior fusion constructs lengths (T10-L5, T12-L5, L2-L5, L4-L5) were instrumented to each specimen, and torque-fusion level relationships were determined for each construct in flexion-extension (FE), axial rotation (AR), and lateral bending (LB). An L5-S1 ALIF was then instrumented and L5-S1 motion was measured as increasing pure moments (2 to 12 Nm) were applied. Motion reduction was calculated by comparing L5-S1 motion across the ALIF and Non-ALIF states.

Results: The average motion at L5-S1 in AR, FE, and LB was assessed for each fusion construct with and without ALIF. Motion reductions at each fusion level and the ratio between ALIF L5-S1 motion and native state motion are shown. ALIF placement significantly reduced L5-S1 motion in all conditions (p < 0.05) except for LB in the L2-L5 fusion condition (p = 0.156). L5-S1 motion in the ALIF states increased and eventually exceeded the native Non-ALIF state motion as fusion level increased.

Conclusion: ALIF instrumentation resulted in a significant reduction in motion in all conditions except one. Applying a cut-off of 70% reduction in motion as a potential positive indicator of fusion would indicate that posterior fusion constructs up to T12-L5 could be appropriately stabilized by a stand-alone L5/S1 ALIF. Our findings can be used to better guide clinicians seeking to treat L5/S1 pathology in patients with prior posterior thoracolumbar constructs.

9:24 - 9:26 am

657 Can We Reliably Predict Autocorrection of Concurrent Cervical Malalignment Following Thoracolumbar Deformity Surgery?

Peter G. Passias, MD; Lara Passfall; Oscar Krol; Nicholas Kummer; Bassel G. Diebo, MD; Virginie Lafage, PhD

Introduction: Cervical malalignment is often concurrent with adult thoracolumbar spinal deformity (ASD). It is currently unknown whether specific patient or operative factors are associated with autocorrection of cervical spine malalignment after surgical correction of thoracolumbar deformity.

Methods: Included: operative ASD patients >18yrs with baseline(BL) and 2-year(2Y) radiographic/HRQL data. Pts with UIV above T1 during index surgery or revision, or with PJK by 2Y were excluded. Cervical deformity(CD) was defined radiographically: C2-C7 kyphosis<-15°, TS-CL>35°, cSVA>4cm, CBVA>25°, MGS>20°. If pts met CD criteria at BL but not at 6 weeks(6W) or 2Y, they were considered autocorrected[AC]. Univariate analyses assessed BL factors associated with AC. Machine learning conditional inference tree (CIT) determined BL radiographic thresholds predictive of 6W AC. Thresholds were assessed using stepwise multivariate regression and ROC curve.

Results: 120 ASD patients included(53yrs, 82%F, 25.9kg/m2, levels fused: 11.0±4.1). Mean BL radiographic parameters: SS 32.4°, PT 21.1°, PI-LL 10.5°, SVA 49.6mm, TS-CL 19.8°, cSVA 28.4mm, CBVA 7.2°, C2-T3 7.9°, and C2-C7 lordosis 7.7°. 54.2% of pts(n=65) had preop CD. By 6W postop, 19 pts(29.2%) with preop CD no longer met radiographic CD criteria[AC]. 23.1%(n=15) of preop CD patients were AC by 2Y. Among patients without BL CD(n=55), 38.2%(n=21) developed CD by 2Y. CIT identified radiographic cut-offs for 6W AC: T2-T12 kyphosis =44.4°, T1S =35.2°, C2-C7 lordosis =19.4°, and C2-T3 =-8.9°. Binary logistic regressions confirmed that all thresholds were associated with higher odds of 6W AC (all p<0.05). Multivariate regression and ROC analysis including these thresholds as well as age, CCI, BMI, osteoporosis, and age-adjusted SVA, resulted in a predictive model for 6W AC with AUC of 94.4%.

Conclusion: Autocorrection of cervical deformity following thoracolumbar ASD correction occurred in almost 30% of patients by 6 weeks postop. AC occurs in patients without baseline cervical hyperlordosis, with modest T1 slope, and with less pronounced thoracic kyphosis. In ASD patients with similar characteristics to those in this study, reconstruction should perhaps not routinely be extended into the cervical spine.

9:26 - 9:28 am

658 Normalization of Pelvic Tilt Following Adult Spinal Deformity Correction: Analysis of Prevalence, Timing, and Predictors

Peter G. Passias, MD; Lara Passfall; Oscar Krol; Nicholas Kummer; Waleed Ahmad; Renaud Lafage; Virginie Lafage, PhD

Introduction: Increasing pelvic tilt (PT) is a primary compensatory mechanism in adult spinal deformity (ASD). By SRS-Schwab criteria, PT >20° is considered pathologic. Some ASD patients improve their PT following ASD correction, while others do not. The driving forces behind this lack of PT-response are not well defined.

Methods: Included: operative ASD patients fused to S1/pelvis with preop(BL), 6-week(6W), 1-year(1Y), and 2year(2Y) postop radiographic data. PT normalization was assessed at 6W and 2Y. Univariate analyses compared normalized(PTNorm) and non-normalized(NON) pts in terms of surgical and radiographic descriptors, postop alignment, and clinical outcomes. Multivariate regression and ROC curve assessed preop factors predicting 6W PTNorm. Conditional inference tree(CIT) determined thresholds for continuous variables identified as independent predictors of PTNorm.

Results: 176 operative ASD patients included(63yrs, 80%F, 26.9kg/m2, CCI: 1.88, levels fused 12.1±3.9). Mean PT was as follows: BL: 25.7°, 6W: 19.0°, 1Y: 21.2°, and 2Y: 22.3°.Patients classified as having normal PT by SRS-Schwab criteria(PT<20°): BL: 27.8%(n=49), 6W: 52.3%, 1Y: 47.2%, 2Y: 40.9%. Of the 127 pts with non-normal PT at BL, 50 (39.4%) normalized by 6W postop. Few pts normalized after the 6W mark: 7 by 1Y and another 2 by 2Y postop for a total of 37 2Y PTNorm pts. 16 pts with non-normal PT at BL normalized by 6W, but reverted at 2Y. 6W PTNorm pts and 2Y PTNorm pts had lower rates of implant failure and rod fracture than NON pts(all p<0.05). Binary logistic regression with CIT identified predictors of 6W PTNorm: combined approach, UIV at or above T8, levels fused >10, invasiveness score >109, baseline cSVA<41.5°, 6W PTNorm including these factors yielded an AUC of 85.2%.

Conclusion: PT normalization following ASD correction occurred in almost 40% of patients by 6 weeks postop. Normalization is more likely to occur in patients where reconstruction addresses lumbopelvic mismatch, extends above the apex of the thoracic kyphosis, and has adequate surgical invasiveness to achieve full alignment correction.

9:28 - 9:30 am 659 Evaluation of Sagittal Spino-pelvic Balance in Spinal Cord Stimulator Patients

Royce Woodroffe, MD; Eli Perez; Brian Park, MD; Scott Seaman, MD; Matthew A. Howard, MD; Saul Wilson, MD

Introduction: Spinal cord stimulation (SCS) has become a popular non-opioid pain intervention for patients with persistent back and leg pain after prior decompressive spine surgery with or without fusion. However, the treatment failure rate for SCS remains unacceptably high and many of these patients have poor sagittal spinopelvic balance, which has been found to correlate with increased pain and decreased quality of life.

Methods: Comparative retrospective analysis was performed between two cohorts of patients who had undergone SCS placement, those who had either subsequent removal of their SCS system (representing a treatment failure cohort) and those that underwent generator replacement (representing a successful treatment cohort). The electronic medical record was used to collect demographic and surgical characteristics which included radiographic measurements of lumbar lordosis (LL), Pelvic Incidence (PI), Pelvic Tilt (PT), and sacral slope. Also included were data on pain medication usage including opioid and non-opioid therapies.

Results: 81 patients met inclusion criteria, 31 had complete removal and 50 had generator replacements. Univariate analysis demonstrated more diabetics (p = 0.029) and less opioid users (p = 0.032) in the generator replacement than the explanation cohort. Measurement of sagittal balance parameters demonstrated that many of the patients had poor alignment, with 34 patients outside normal range for LL (10 vs 24 in removal and replacement cohorts respectively), 30 patients for PI [12 (38.7%) vs 18 (36.0%)], 46 patients for PT [18 (58.1%)vs 28 (56.0%)], 38 for SS [18 (58.1) vs 20 (40.0%)], and 39 for PI-LL mismatch [14 (45.2%) vs 25(50.0%)]. There were no significant differences in sagittal alignment parameters between the two cohorts.

Conclusion: This retrospective cohort analysis of SCS patients that either had their systems explanted or generators replaced did not demonstrate any relationship between poor sagittal alignment and failure of SCS therapy. Further studies of larger databases should be performed to determine how many patients ultimately go on to have additional structural spinal surgery after failure of SCS and whether or not those patients go on to have positive outcomes.

Scientific Session 5: Setting the Path: A View to the Future Saturday, July 31

9:41 - 9:46 am J.A.N.E. AWARD PRESENTATION 700 The Central Cord Score: A Novel Classification and Scoring System for Acute Traumatic Central Cord Syndrome

Wyatt L. Ramey, MD; Angelica Alvarez Reyes; R. John Hurlbert, MD, PhD, FRCSC, FACS; Jens Chapman, MD; Travis M. Dumont, MD

Introduction: Acute traumatic central cord syndrome (ATCCS) remains the most common form of SCI in the United States. Its treatment remains controversial and is likely from ATCCS having an inherently unique natural history, thus requiring a separate classification system relative to conventional SCI. We have devised a novel Central Cord Score (CCscore) that both guides treatment and tracks improvement over time with symptoms specific to ATCCS.

Methods: We retrospectively reviewed the medical records of patients diagnosed and treated with ATCCS at one institution. The CCscore was devised based on classic signs, symptoms, and imaging findings most important in assessing severity of ATCCS. Numeric values are assigned according to: 1) distal upper extremity motor strength, 2) upper extremity sensation 3) ambulatory status, 4) presence of T2 MRI cord signal, and 5) urinary retention. A total CCscore of 0-5 represents Mild injury, a score of 6-10 represents moderate injury, and 11-15 represents severe ATCCS.

Results: Fifty-one patients with follow-up were identified with ATCCS; there were 17 cases of mild injury, 23 moderate, and 11 severe. Patients treated surgically had statistically significantly greater improvement in upper extremity motor scores and total CCscore up to, but not beyond, 3 months. In terms of timing of surgery, patients treated <24hrs had significantly improved upper extremity motor scores and overall CCscores at last follow-up >3 months.

Conclusion: The CCscore provides a severity scale specific to ATCCS, which could guide necessity and timing of decompressive surgery. We retrospectively applied the CCscore to our patient population and demonstrate its usefulness in tracking outcome measures specific to the constellation of ATCCS. Based on data herein, the CCscore has the ability to objectively categorize severity of ATCCS and track outcome, which will be a major step forward in the quest to determine the ultimate efficacy and timing of surgery for ATCCS.

9:53 - 9:58 am MAYFIELD CLINICAL SCIENCE AWARD PRESENTATION 701 Enhanced Recovery After Surgery (ERAS) Protocol for Open Transforaminal Lumbar Interbody Fusion

Ken M. Porche, MD; Ronny Samra; Meghan M. Brennan, MD, MS; Sasha Vaziri, MD; Daniel J. Hoh, MD, FAANS; Basma Mohamed

Introduction: The enhanced recovery after surgery (ERAS®) protocol is a multidisciplinary, multimodal approach which has been shown to facilitate recovery of physiological function, and reduce postoperative pain, complication rates, and length-of-stay (LOS). Design and implementation in the recent spine surgery literature have primarily focused on patients undergoing minimally invasive lumbar surgery.

Methods: Patients that underwent 1-2 level open TLIF for degenerative disease by a single surgeon were included in this retrospective chart review, and compared to a Pre-ERAS control cohort propensity-matched for age, body mass index, sex, and smoking status. Patient demographics, surgical characteristics, LOS, first day to ambulate, first day to bowel movement, first day to void, daily average and maximum pain scores, opioid use, discharge disposition, 30-day readmission rate, and re-operations were collected and compared. Multivariate models were further developed for pain scores, opioid consumption, LOS, and physiological function.

Results: 114 patients were included with 57 in Pre-ERAS and 57 in the ERAS cohorts. 14 two-level surgeries were in each group. Patient characteristics were similar between groups. LOS decreased from 4.6 ± 1.7 days to 3.6 ± 1.6 days with ERAS (p<.0001). First day of ambulation, bowel movement, and bladder voiding improved by 0.8 (p<.0001), 0.7 (p=0.008), and 0.8 (p<.0001) days, respectively, in the ERAS cohort. Total daily IV MME (36 ± 38 vs 8 ± 9 , p<.0001) was significantly lower in the ERAS cohort. Average daily pain scores and overall opioid consumption were similar between groups once correcting for home opioid use.

Conclusion: Consistent with other surgical procedures and other spinal procedures, Implementation of an ERAS protocol was associated with reduced length of stay, decreased operative time, decrease in IV opioid consumption, and improved physiological outcomes for open 1-2 level TLIFs. No change was seen for average pain scores, overall opioid consumption, complications, 30-day readmission, reoperation rate, or EBL.