number of levels included in the fixation, reintervention with a change of implant choice, use of iliac screws, use of growing rods and VEPTR. Documented protective factors against implant failure were higher age and higher density of implants, both presenting with significantly lower rates of implant failure. **Conclusion:** Our study showed an overall rate of implant failure of 11.5% in pediatric deformity correction surgery, being the implant pull out the most common type of failure. Protective factors against implant failure were higher patient age and implant density in the fixation. Risk factors for implant failure were neuromuscular or syndromic scoliosis, longer fixations, iliac fixation, reintervention with implant change and the use of growing rods or VEPTR.

1173
A263: Is isolated Pulmonary Function Test (PFT), sufficient to asses the pulmonary status in scoliosis deformity correction cases?

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Introduction: Scoliosis is a three-dimensional deformative abnormality of the spine. There is substantial interest in the relationship between spinal deformity and pulmonary function due to potentially high rates of morbidity and mortality. The deformed structures compress the lung parenchyma causing a decrease in lung volume and its compliance. These changes along with the increased effort to breathe may result in alveolar hypoventilation, hypercapnia, and hypoxemia leading to cor-pulmonale and right-sided heart failure. Since poor pulmonary function may lead to a higher incidence of postoperative pulmonary complications, preoperative pulmonary function tests (PFT) have commonly been used to predict postoperative complications concerning the severity of scoliosis. The objective of this study was to assess whether PFT was sufficient to evaluate the improvement in pulmonary function pre and post-deformity correction. **Materials and methods:** This was a retrospective analysis among patients with thoracic or thoracic lumbar scoliosis who were admitted to our institution for deformity correction between June 2014 to June 2019. The patients enrolled in the study were aged between 10-17 years, had a preoperative diagnosis of predominant thorasic scoliosis with a pre-operative PFT available for analysis. All the included patients were followed up radiographically along with the pulmonary function tests to measure total lung capacity (TLC), forced vital capacity(FVC), and forced expiratory volume in one second (FEV1) along with a functional assessment of the lung capacity. Each test was repeated three times and the single best effort was recorded. We focussed on percent predicted values of FVC and FEV1 to asses restrictive lung disease. **Results:** 17 patients were included in the study, with a mean age of 13.7 (10-17 years) at deformity correction. 8 patients had congenital scoliosis and 9 had adolescent idiopathic scoliosis. The mean preoperative FVC was 1.552 and percent predicted FVC was 63%. After posterior instrumentation corrective surgery, the mean FVC was 1.803 and percent predicted FVC was 66.5%. At 2years follow-up, PFT did not show any improvement for the correction of curves involving 5 levels or more. Patients with severe scoliosis with preoperative severe restriction showed a significant improvement of percent predicted FVC from 37% to 59% ($P < .05$). However, functional improvement was noted in the rest with significant improvement in right heart pressure with no significant improvement in PFT. **Conclusion:** Despite demonstrating a significant improvement in their functional status corresponding improvement in their pulmonary function was not noticed which raises the question that whether these cases had a lung compromise, to begin with, or whether pulmonary compensation was established before the surgery. Since PFT was the only measure utilized to assess the status of the lung, we probably could not essentially establish the extent of the lung compromise pre-operatively. We recommend additional measures to asses on going right heart compensation with echocardiography and pulmonary artery pressure to objectively establish the pre-operative pulmonary status beforehand.

809
A264: Comparison of Flexibility Assessments in Adolescent Idiopathic Scoliosis (FLEXIS)

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Introduction: There is no consensus as to which type of dynamic radiograph is optimal in predicting the true flexibility of a curve in adolescent idiopathic scoliosis (AIS) or the final behavior of the curve post-surgical correction. This study aims to investigate the flexibility equivalence of different bending methods. **Material and Methods:** Patients diagnosed with AIS who had reached the threshold for surgical correction were prospectively recruited in two centres. Data regarding demographics, concomitant treatment and curve characteristics were obtained. Radiographs of standing whole spine, supine side-bending, awake traction, supine traction under general anaesthesia (STUGA) and

fulcrum bending were performed preoperatively. The following formulae were calculated to determine which type(s) of flexibility films were most accurate in predicting the final behavior of the curve post-surgical correction: Flexibility index (%) = [(Pre-operative Cobb angle - Bending Cobb angle)/Pre-operative Cobb] x 100% Correction rate (%) = [(Pre-operative Cobb angle-Post-operative Cobb angle)/Pre-operative Cobb angle] x 100% Correction index (%) = (Correction rate/Flexibility) x 100%. **Results:** 132 patients (19 male and 113 female) with a mean age at the time of surgery of 14 ± 1.74 years were recruited from Turkey and Hong Kong. Patients were analysed according to curve patterns. 90 patients had thoracic major curves. The correction indices were 508.9 ± 159.2%, 183.0 ± 193.5%, 135.5 ± 97.4%, 153.1 ± 21.1% and 139.6 ± 22.9% for supine, supine side bending, fulcrum bending, awake traction and STUGA respectively. For lumbar major curves (n = 42), the correction indices were 342.4 ± 209.6%, 138.4 ± 72.3%, 121.5 ± 39.6%, 131.6% and 136.5 ± 67.6% respectively. **Conclusion:** The correction index takes into account the inherent curve flexibility, and an index close to 100% suggests that the instrumentation has taken up all the flexibility revealed by the dynamic radiograph. This study showed that for thoracic curves, the fulcrum bending radiograph most accurately predicted post-operative curve correction, whereas for lumbar curves, all dynamic radiographs apart from supine films showed similar predictability for curve correction. Fulcrum bending radiographs can help preoperative planning for AIS surgeries including the need for intraoperative releases and fusion level determination, particularly for thoracic curves.

975
A265: Changes in shoulder balance and prediction of final shoulder imbalance during growing-rod treatment for early-onset scoliosis: a case series

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Introduction: Achieving and maintaining shoulder balance after the entire growing-rod (GR) treatment is essential for early-onset scoliosis (EOS) patients. However, few studies have reported the outcomes of shoulder balance after the entire GR surgery in EOS patients, and the risk factors for shoulder imbalance after final fusion in EOS patients have been understudied. This study investigated changes in shoulder balance of early-onset scoliosis (EOS) patients during the GR treatment, analysed risk factors for final shoulder imbalance, and evaluated the satisfaction of patients' parents with shoulder balance after the treatment. **Material and Methods:** In total, 24 consecutive 'growing-rod graduates' were studied. Demographic data, surgical-related factors, and radiographic parameters were analysed to identify risk factors for final shoulder imbalance, and shoulder balance changes from GR implantation to last follow-up after fusion were analysed. The satisfaction of parents was evaluated by an adapted questionnaire. **Results:** Early postfusion shoulder imbalance (odds ratio (OR): 19.500; 95% confidence interval (CI)=1.777-213.949; P = .015) was identified as an independent risk factor for final shoulder imbalance at the last follow-up. Radiographic shoulder height (RSH) was significantly improved after GR implantation (P = .036), and further improved during the postfusion period (P = .021). Through the whole treatment, from GR implantation to the last follow-up after fusion, the value of RSH showed significant improvement (P = .011). Similar trends were also found in other parameters, including clavicle angle (CA), coracoid height difference (CHD), and T1 tilt (T1T). The postimplantation shoulder balance and imbalance patients had no significant difference in final RSH (P > .05), while the shoulder balance significantly improved in patients with prefusion shoulder imbalance after fusion (P = .045). All parents (100%) were satisfied with the final shoulder condition and entire treatment. **Conclusion:** GR surgery improved shoulder balance. Shoulder balance status after GR implantation did not determine the final status, but final fusion could further adjust the shoulder balance of patients with prefusion shoulder imbalance. For patients with early shoulder imbalance after final fusion, there was a high probability of shoulder imbalance at the final follow-up. Postfusion spontaneous adjustment after final fusion significantly improved shoulder balance.

1587
A266: Should Selective Thoracic Fusion be Reserved for Non-Structural Compensatory Lumbar Curves? Radiographic and Clinical Results from Propensity Matched Patients at Minimum 5-Year Follow-Up

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Hypothesis: Selective thoracic fusion results in worse radiographic outcomes compared to non-selective fusion for Lenke 1-4C curves, but similar patient reported outcomes for Lenke 1-2C curves. **Study Design:** Retrospective analysis of multicenter, prospectively collected data. **Introduction:** For adolescent idiopathic scoliosis

(AIS) Lenke Type 1-4C curves, controversy exists whether selective thoracic fusion (STF) is sufficient or non-selective fusion (NSF) should be used to treat the associated lumbar curves. **Methods:** A prospective, multicenter database was queried for Lenke 1-4C curves (min 5-yr follow up). Patients were dichotomized to STF (fusion L1 or above) vs NSF (fusion below L1). We analyzed two subgroups: 1) non-structural lumbar curves (1-2C), and 2) structural lumbar curves (3-4C). After propensity score matching within each subgroup for age and preop thoracic and lumbar Cobb angles, we conducted within and between group comparisons of radiographic data and SRS-22 scores. **Results:** Of 124 patients with 1-2C curves, 74 matched (37 STF, 37 NSF). At 5 years postop, both STF and NSF led to improvement in main thoracic (MT) and compensatory lumbar (CL) Cobb angles as well as coronal balance (C7-CSVL), but NSF values were better than STF ($P < .05$). While SRS total and self-image scores improved for each procedure ($P < .05$), there were no significant differences in STF and NSF patient reported outcomes (PROs). Of 95 patients with 3-4C curves, 36 matched (18 STF, 18 NSF). At 5 years postop, both STF and NSF led to improvement in MT and CL cobb angles, but again NSF values were better than STF ($P < .05$). NSF reported better total SRS ($P < .02$) and self-image ($P = .05$) scores when compared to STF. **Conclusions:** In propensity score matched patients treated for Lenke Type 1-2C curves, STF results in slightly less radiographic correction but similar patient reported outcomes as NSF at 5 years. In contrast, matched patients treated for Lenke Type 3-4C curves with NSF have both better radiographic and patient reported outcomes when compared to STF. **Summary:** In this multicenter study with minimum 5-year follow-up, we performed propensity score matching to compare patients treated with selective thoracic fusion and non-selective fusion for Lenke 1-2C curves vs 3-4C curves. We found that selective thoracic fusion resulted in slightly less radiographic improvement compared to non-selective fusion for all curves. While STF led to similar patient-reported outcome scores as NSF for Lenke 1-2C curves, NSF led to better scores for Lenke 3-4C curves.

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A267: Fusing to the Pelvis in the Correction of Scoliosis Associated with Rett Syndrome

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Introduction: Rett syndrome is a rare disorder characterised by severe, C shaped scoliosis in up to 80% of cases. In the past, posterior spinal fusion has been the mainstay of treatment, most often including the pelvis. However, fusing to the pelvis has been shown to influence function of the spinopelvic relationship, which has been hypothesised to reduce the ability to ambulate in these patients. In this study, we sought to show the results of the surgical treatment of scoliosis in patients with Rett syndrome and analyse the impact of fusing to the pelvis on ambulation. **Materials and Methods:** A retrospective case series methodology was used to analyse the radiographic, clinical and functional outcomes of consecutive patients treated for Rett syndrome associated scoliosis treated surgically between the ages of 10 and 8 years in a single tertiary referral paediatric spinal unit. Cases were identified through departmental and neurophysiological records, and patients were excluded if the diagnosis of Rett syndrome was not confirmed. **Results:** Seven eligible cases were identified. The mean coronal Cobb angle was 90.9°, mean sagittal Cobb 72.0° and pelvic obliquity 24.5°. The mean post-operative improvement in coronal Cobb was 53.2° and pelvic obliquity was not significantly improved. These did not change during a mean follow up of 2.7 years. None showed any post-operative complications and of the 4 patients fused to the pelvis, only 1 was able to ambulate preoperatively, and this ability was lost postoperatively. **Conclusions:** Our data suggests that with modern technology, severe curves can be safely treated, and that fusion to the pelvis is not necessary to prevent curve progression, which may be important in preserving patient mobility post operatively.

1618
A268: Anterior vs Posterior Approach for the Treatment of Lenke 5c Curves in Patients with Idiopathic Scoliosis; Results from the Swedish Spine Registry

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Introduction: Adolescents with severe idiopathic scoliosis may be treated with anterior or posterior fusion surgery, although there is no consensus as to which is associated with the best outcome. Moreover, studies with longer term follow-up are limited. Material and Methods: We used data from the Swedish spine registry and identified 59 patients with idiopathic scoliosis treated with fusion for Lenke 5C type curves; 27 patients underwent anterior surgery and 32 underwent posterior surgery. All patients had pre- and postoperative radiographic data and postoperative clinical data at a minimum of 2 year after surgery. Patient reported outcomes measures included the SRS-22r, EQ-5D-3L, EQ-VAS and

VAS for back pain. Radiographic assessment included measurement of the Cobb angle of the major curve, curve flexibility, rate of curve correction, any difference in sagittal parameters, number of fused vertebrae and length of fusion. Results: The mean age at surgery was 16 years in both groups. The mean follow-up time was 3.8 years. There were no significant differences in the SRS-22r score and EQ-5D-3L index at follow-up (all $P \geq .1$). Postoperatively, both the anterior and posterior fusion group demonstrated a significant correction of the major curve ($P \leq .001$) with no significant difference of the correction rate between the groups ($P = .4$). The posterior fusion group had shorter operative time ($P < .001$) and higher perioperative blood loss ($P = .004$) while the anterior group had lower number of fused vertebrae ($P < 0.001$). Conclusion: The type of surgical approach for Lenke 5C curves is not associated with any measurable differences in health-related quality of life, despite the lower number of fused vertebrae after anterior surgery.

1185
A269: Effect of Tranexamic Acid Dosing on the Percent of Total Blood Lost During Adolescent Idiopathic Scoliosis Surgery

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Introduction: Posterior spinal fusion (PSF) for adolescent idiopathic scoliosis is associated (AIS) with significant intraoperative blood loss. Tranexamic acid (TXA) is an antifibrinolytic agent that is known to reduce the percent of total blood volume lost during posterior spinal fusion, however the optimal dosing regimen has not been defined. **Material and Methods:** Fifty-three AIS patients underwent PSF in 2011-2019; 18 received no-TXA, 18 received low dose TXA (10 mg/kg loading 1 mg/kg/hr infusion), and 17 received high dose TXA (30 mg/kg loading, 10 mg/kg/hr infusion). We retrieved relevant demographic, hematologic, intraoperative, and outcomes information from medical records. The primary outcome was percent total blood volume lost (%TBVL) per level fused, calculated from estimates of intraoperative blood loss, estimated total blood volume per patient (via Nadler's equations), and number of levels fused. Unadjusted outcomes were compared using standard statistical tests. **Results:** The %TBVL per level fused was significantly lower in the high dose TXA vs no-TXA group (0.9% vs 1.8%; $P = .003$) and in the low dose TXA vs no-TXA group (1.1% vs 1.8%; $P = .03$). There was no significant difference in % TBVL per level fused between the high dose TXA and low dose TXA groups (1.1 vs 0.9; $P = .75$). No patients had documented seizures, DVTs, or PEs. **Conclusion:** Both high and low dose TXA significantly reduced the percentage of total blood volume lost per level fused when compared to no-TXA in AIS patients who underwent PSF using a standardized blood loss measure. No significant difference in percentage of total blood volume lost per level fused was found when comparing high dose TXA to low dose TXA. There were no documented complications of seizure, DVT, or PE in any of the patients in the study.

1917
A270: VCR-Based and Non-VCR-Based Surgical Maneuvers in Deformity Correction for Achieving Spinal Balance in Severe Rigid Scoliosis Patients: Weighing the Odds

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Introduction: Severe rigid scoliosis defined as Cobb of ≥80° in spine patients can result in significant neurological deficits, cardiopulmonary complications as well as psychological and social stigmatization based cosmetic appearance. When the deformity is severe and rigid in patients, aggressive surgical approaches are sometimes considered to achieve desired corrective outcomes. Vertebral column resection (VCR-based) has the potential of about ≥60 degree of correction while other surgical osteotomy techniques (non-VCR-based) may range from 15-45° of correction while attempting to establish spinal balance in these patients. We evaluated the corrective rates of spinal balance and radiographic parameters between VCR-based and non-VCR-based surgery in severe rigid scoliosis patients. **Materials and Methods:** A comprehensive literature review was performed from January 2000-December 2019. The selection criteria for included studies included: *average major curve Cobb angle of ≥80°*, *case series of ≥10 patients*,

reported coronal and sagittal parameters with information on both *coronal* (*CB*) and *sagittal balance* (*SB*) *at preoperative and final follow-up, with a 2-year minimum follow-up period*. Primary outcomes compared between the two surgical technique groups included: baseline averages of demographics, etiological diagnoses, estimated blood loss (EBL), mean surgery duration, average fusion length (FL), major curve (MC) Cobb angle, MC apical vertebral translation (AVT), MC flexibility, thoracic kyphosis (TK), lumbar lordosis (LL), CB and SB. Secondary outcomes included: final follow-up (FFU) averages of MC Cobb angle, MC correction rate, MC AVT, MC AVT correction rate, TK, LL, CB, CB correction rate, SB and SB correction rate. **Results:** A total 303 patients from 11 retrospective studies and 1 prospective study were observed. Of 303 severe rigid scoliosis patients observed, 41.25% (n = 125) and 58.75% (n = 178) were VCR-based and non-VCR-based, respectively. The averages of age: 17.80 years and 21.63 years, female incidence: 58.10% and 68.20%, idiopathic etiology: 65.24% and 63.50%, congenital etiology: 23.96% and 19.5%, estimated blood loss: 2943.33 ml and 1125.22 ml, mean operation time: 510.27 mins and 649.78 mins were observed for VCR-based and non-VCR-based patients, respectively. The baseline average MC Cobb angles of 101.65^{o} and 109.20^{o} were corrected at rates of 64.70% and 60.80% at FFU for VCR-based and non-VCR-based patients, respectively. The average correction rates of MC AVTs were 66.18% and 70.70% in VCR-based and non-VCR-based groups, respectively. The baseline outcomes for CB: 1.52 cm and 1.42 cm and SB: 1.74 cm and 1.73 cm for respective VCR-based and non-VCR-based patients were corrected at respective rates of 38.83% and 28.90% for CB and 32.20% and 43.93% for SB. Postoperative cardiopulmonary complications, were higher in the Non-VCR-based patient group at a rate of 18.63% compared to an incidence rate of 5.10% in the VCR-based group. Other medical and implant-related complications between the two surgical groups were comparable. **Conclusion:** Findings from this study indicate that both VCR-based and non-VCR-based surgical spinal fusion technique maneuvers for the correction of severe rigid curves of ≥80 degrees are equally effective and can achieve correction rates of ≥60% at 2-year following corrective surgery. VCR-based surgery achieved higher CB correction rates while non-VCR-based surgery achieved higher SB correction rates.

OP31: Surgical Complications 2

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A271: Spinal Surgery Complications. An unsolved problem. Is the world health organization safety surgical Checklist an Useful Tool to Reduce Them?

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Introduction: To face the problem of surgical complications, which is generally relevant in surgical fields, an intraoperative checklist (Safety Surgical Checklist, SSC) was elaborated and released by the World Health Organization in 2008, and its use has been described in 2009 [1]. In our Institution, the WHO SSC was introduced in 2011. In spinal surgery, many preventive measures were investigated to reduce complications, but there is no report on the effectiveness of the WHO checklist in reducing complications. The aim of this study was to compare the incidence of complications between the two periods, from January to December 2010 (without checklist) and from January 2011 to December 2012 (with checklist), in order to assess the checklist effectiveness. **Material and Methods:** A retrospective and single center study was carried out on patients who underwent spinal surgery during the three-year period from January 2010 to December 2012. Patients were classified according to the spine pathology and the different presentation of the complication. According to the pathology treated, there were oncological, degenerative, traumatic and infectious groups. Complications were divided into seven categories:(1). post- surgical hematoma. (2). surgical site infection. (3) cerebrospinal fluid (CSF) leakage or fistula. (4). mechanical complications (misplaced instrumentation and/or failure). (5). neurological complications. (6). systemic complications. (7). surgery related death. The complications' classification and the patients' inclusion into the categories were performed by independent investigators, i.e. non-MD clinical researchers (1 research nurse and 1 clinical research assistant) not directly involved in the care of the patients. The WHO Safety Surgical was introduced for the first time in our center in 2011. We registered the complications arising in patients treated from 2010 to 2012 during a 3 years follow up period for each patient, assessing the possible differences before and after the checklist's introduction. **Results:** The sample size was 917 patients, the mean age was 52.88 years. The majority of procedures were performed for oncological diseases (54.4%) and degenerative diseases (39.8%). 159 complications in total were detected (17.3%). The overall incidence of complications for trauma, infectious pathology, oncology, and degenerative disease was 22.2%, 19.2%, 18.4%, and 15.3%, respectively. No correlation was observed between the type of pathology and the complication incidence. We observed a reduction of the overall incidence of complications following the introduction of the SSC: in 2010 without checklist, the incidence of complications was 24.2%, while in 2011 and 2012, following the checklist introduction, the incidence of

complications was 16.7% and 11.7%, respectively (mean 14.2%). **Conclusion:** Despite the limitations of the study, in particular the impossibility to carry out a randomized study,SSC seems to be an effective tool to reduce complications in spinal surgery. We propose to extend the use of checklist system also to the pre-operative and post-operative phases in order to further reduce the incidence of complications.

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939
A272: Outcomes in Spinal Surgery During theCOVID-19 Pandemic

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Introduction: The COVID-19 pandemic has had a hugely detrimental impact on hospital services worldwide. There has also been increasing evidence about the higher patient mortality and morbidity associated with contracting SARS-CoV-2 in the perioperative period. This is supported by a study carried out in China, which revealed that patients in the incubation phase of COVID-19 had a higher rate of ITU admission and mortality following elective surgery. A multicentre international cohort study recently published in the Lancet looked at the outcomes of 1128 patients with perioperative COVID-19 infection. The results showed that 51.2% patients developed pulmonary complications and the 30 day mortality was 23.8%, highest in male patients aged 70 or over. These increased risks to patients during COVID-19 have been recognised by the British Association of Spinal Surgeons (BASS) who produced a COVID-19 information leaflet for patients to sign. We analysed the risk/benefit ratio of surgery for individual patients, and we have continued our emergency and urgent spinal operating services. This study describes the measures and pathways taken in our university hospital to protect patients and staff, and our outcome measures during COVID-19. **Material and Methods:** This is a prospective single-centre study of all patients who underwent spinal surgery in a four month period during the pandemic. All spinal surgical patients' data were collected to identify demographics, comorbidities, ASA grade, surgical indication and procedure, time to surgery, length of stay, need for ITU admission, COVID-19 swab result, complications and outcomes including mortality. Hospital theatre systems, intra-operative notes, patient pathways, both national and local, for elective and emergency patients [blue, green or yellow] were also reviewed. We compared the outcomes of patients under each pathway with our historic database over preceding years. **Results:** 72 patients underwent spinal surgery during this four month period; this was significantly lower than the 167 patients in the equivalent period in 2019 due to bed restrictions to accommodate COVID-19 patients. Emergency operating took up a higher proportion of the workload - with 37.5% spinal operations being emergency surgery, and 62.5% operations classified as urgent. None of the patients required ITU admission. There were 11 complications; 4 dural tears treated intra-operatively with no sequelae, 4 superficial wound infections, 1 post-operative chest infection (normal chest x-ray), 1 patient with mild dysphagia (following ACDF) and 1 ongoing urinary dysfunction (following cauda equina compression). None of the patients contracted COVID-19. There were three mortalities post-discharge in the community; none were related to surgery or to COVID-19. **Conclusion:** There was no variation in clinical outcomes in patients operated on before and during COVID-19 in our hospital. This is likely to be in part due to the procedures brought in on our wards and in our theatre complex as a response to the virus, as well as the new 'blue' pathway designed for urgent elective patients. These results should encourage other departments worldwide to adapt their surgical pathways to protect their patients and to restart their spinal elective service when their hospitals have the capacity to do so.

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A273: Adverse Events Occurring up to 5-Years After Complex Adult Deformity Surgery: A Scoli-RISK-1 Analysis

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Summary: Following complex ASD surgery at 5-years postoperative, 77.9% of patients experienced an adverse event (AE). Of patients with an AE, 20.2% had a severe complication, while 59% of patients that experienced an AE required surgical treatment. 75.9% of neurologic deficits were transient and improved over time. Common etiologies for neurologic AEs were nerve root retraction, compression, direct injury, and distraction. Most common spine complication in years 2-5 was implant failure, followed by sensory and motor deficit. **Hypothesis:** Prospectively evaluate neurologic and non-neurologic adverse events (AEs) occurring up to 5-yrs postop following surgical correction of complex ASD. **Study Design:** Prospective/multicenter/international/observational, Scoli-Risk-1. **Introduction:** Surgical treatment for complex adult spinal deformity (ASD) is associated with a variety of postop complications. Rates of perioperative complications following complex ASD surgery are well established, while reports of long-term postop complications remain unclear. **Methods:** 272 ASD pts undergoing surgery from 15 centers were enrolled. Inclusion criteria: Cobb>80, corrective osteotomy for congenital or revision deformity, and/or 3-column osteotomy (76% of all patients). At each follow-up visit any neurologic or non-neurologic AE was documented & categorized. **Results:** Of the 272 patients, follow-up rates were: 271 (99.6%) discharge, 260 (95.6%) 6-weeks, 255 (93.8%) 6-months, 217 (79.8%) 2-year, and 77 (28.3%) at 5-years. By 5-years postop, 212/272 patients (77.9%) experienced an AE. Of those that experienced an AE, 20% had a severe AE, 24% mild, and 33% moderate. A total 190/272 (69.9%) experienced a non-neurologic AE & 101 (37%) experienced a neurologic AE. Of all patients with complications, conservative management or no action was taken in 87 patients (41%), whereas 125 (59%) of the patients that experienced AEs required some form of surgical treatment (either revision spine or other surgery). 3 deaths occurred, none of which were directly related to surgery: ileus 3.2 months postop, cardiac arrest 9.8 months postop, and suicide 1.2 years postop. Specifically in the 2-to 5-year period, a total of 58 complications occurred that were related or possibly related to surgery, including: 27 (47%) implant failure, 6 (10%) sensory deficits, 3 (5%) loss of correction, 3 (5%) cord/motor deficits, and 2 (3%) deep infections. **Conclusion:** At 5-years postop following complex ASD surgery with prospective assessment, 77.9% of patients experienced an AE, with 20% having a severe complication and 59% requiring surgical treatment either spine or non-spine. 75.9% of neurologic deficits were transient and improved over time. The most common spine complication in the 2- to 5-year period was implant failure, followed by motor and sensory deficits.

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A274: The influence of hospital type, insurance type, and patient income on 30-day complication and readmission rates following lumbar fusion

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Introduction: Several studies have shown that factors such as insurance type and patient income are associated with different readmission rates following certain orthopaedic procedures. However, no studies have investigated how 30-day complication and readmission rates vary by hospital type, insurance type, and patient median income following lumbar spine fusion. **Material and Methods:** A retrospective cohort study was conducted using the National Readmissions Database (NRD) from 2010-2016 using ICD-9 and ICD-10 codes, which identified 596,568 patients with primary lumbar fusion. Statistical analysis was conducted in R. Kruskal-Wallis tests with Dunn's pairwise comparisons were performed to analyze differences in 30-day readmission and complication rates in patients who underwent lumbar spine fusion. Complications analyzed included infection, wound injury, hematoma, neurological injury, thromboembolic event, and hardware failure. **Results:** The hospital types analyzed were metropolitan non-teaching (212,131 patients), metropolitan teaching (364,752 patients), and rural (19,685 patients). 30-day readmission was significantly higher in rural and metropolitan teaching hospitals compared to metropolitan non-teaching hospitals ($P < .01$). Patients treated at rural hospitals were also more likely readmitted at 30 days than those treated at metropolitan teaching hospitals ($P < .001$). Compared to those treated at metropolitan non-teaching hospitals, patients from metropolitan teaching hospitals had significantly higher rates of infection ($P < .0001$), wound injury ($P < .0001$), hematoma ($P = .018$), and hardware failure ($P < .002$). The insurance types analyzed included Medicare (213,534 patients), Medicaid (78,520 patients), private insurance (196,648 patients), and out-of-pocket (45,025 patients). Privately insured patients were significantly less likely to be readmitted at 30 days than those paying with Medicare or Medicaid ($P < .01$). Infection, hematoma, and hardware device failure rates were significantly higher in out-of-pocket payers compared to all other groups ($P < .0001$). Infection, wound injury, and hematoma rates were significantly lower in Medicare payers compared to all other groups ($P < .0001$). Patient income was separated into quartiles, with 112,083, 145,755, 156,276, and 147,289 patients placed in quartiles 1 to 4, respectively. No difference in readmission rates were found between any of the income groups, although patients in quartile 4 were significantly more likely to develop hematomas

compared to those in quartiles 1 and 2, and were more likely to experience a thromboembolic event compared to all other groups. **Conclusion:** Patients undergoing lumbar spine fusion at metropolitan non-teaching hospitals and paying with private insurance had significantly lower 30-day readmission rates than their counterparts. Complications within 30 days following lumbar spine fusion were significantly higher in patients treated at metropolitan teaching hospitals and in patients paying out-of-pocket. However, aside from a few exceptions, patient income was generally not associated with differential complication rates.

1915
A275: Endplate Volumetric Bone Mineral Density is a Predictor for Cage Subsidence Following Lateral Lumbar Interbody Fusion: A Risk Factor Analysis

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Introduction: Lateral lumbar interbody fusion (LLIF) is a common procedure used for various spinal conditions. One of the common complications of this procedure is subsidence, which is the sinking of the interbody device into adjacent vertebrae. Previous work has shown that a decreased BMD as measured by DXA is a risk factor for subsidence, but emerging data suggests a lower endplate volumetric BMD (EP-vBMD) as measured by Quantitative Computed Tomography is a risk factor for subsidence following standalone LLIF. However, it remains unclear if this is the case for LLIF with posterior screws. Additionally, there is interest in the role that patient factors, such as BMI and diabetes status, plays on bone quality. The purpose of this study is to investigate risk factors for subsidence following LLIF. **Materials and Methods:** We reviewed the data of consecutive patients undergoing LLIF from 2014-2019 at a single academic institution who radiological imaging between 5 and 14 months after surgery. We excluded levels with previous instrumentation, previous fractures, and poor imaging quality. Cage subsidence was measured using the grading system devised by Marchi et al.[1] We collected preoperative body mass index (BMI) along with diabetes status. We measured both EP-vBMD and the trabecular volumetric BMD measurement of the vertebral body (VB-vBMD). EP-vBMD was the average of the upper and lower endplate vBMDs measured in cortical and trabecular bone with a 5mm region of interest beneath the cage contacting surfaces. Univariable analysis and multivariable logistic regression analyses with a generalized mixed model were conducted. Multivariable analysis included BMI, diabetes status, EP-vBMD, VB-vBMD, and all trending ($P < .20$) factors in univariable analyses as explanatory variables. Ad hoc analysis, including receiver operative characteristic curve analysis, identified the cut-off values in significant continuous variables for subsidence. The statistical significance level was set at $P < .05$. **Results:** 567 levels in 347 patients were included in the final analysis. Mean age (±SD) was 61.7 ± 11.1 yrs. 50.3% of the patients were male. 134 (38.7%) patients were overweight, 114 (32.9%) were obese, and 45 (13%) were diabetic. Subsidence with a grade of at least 1 was observed in 160 levels (28.2%). After adjusting for age, American Society of Anesthesiologists Physical Status, Charlson comorbidity index, LLIF level, and VB-vBMD, standalone status ($P = .001$) and EP-vBMD ($P = .032$) were associated with subsidence. ROC curve analysis demonstrated a cutoff of 211 kg/m^2 for EP-vBMD. Ad hoc analysis demonstrated patients with no risk factors had subsidence at 18.3% of levels, 31.1% of levels with one risk factor, and 44.9% of levels with both risk factors ($P < .0001$). **Conclusion:** A decreased local EP-vBMD and the absence of posterior screws are risk factors for subsidence following LLIF. When performing LLIF, the preoperative EP-vBMD measurement should be considered, and in patients with a low EP-vBMD, the addition of pedicle screws could be included to limit the risk of subsidence.

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1873
A276: Severe short-term complications after cerebrospinal fluid leakage following lumbar spine surgery. A retrospective single-centre study

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Introduction: Cerebrospinal fluid (CSF) leak as a result of an incidental durotomy is a relatively common complication associated with spine surgery. It may lead to more serious conditions such as meningitis or intracranial hypotension. This study aims to assess the severe complication rate followingCSF leakage. **Material and Methods:** The authors conducted a retrospective study on patients who underwent lumbar spine surgery and were readmitted due to postoperative CFS leak in one of the Neurosurgery Departments in

Poland. The clinical data of spine surgeries from January 2015-September 2020 was collected from the local hospital database. Factors included into the analysis were: age, Body Mass Index (BMI), nicotinism, comorbidities, lenght of hospitalization, initial spine surgery, dural tear recognition during revision surgery, usage of external lumbar drainage. Patients treated for emergency spine cases were excluded from this study. **Results:** Out of 3080 patients after spine surgery 73 cases were included. The male-to-female ratio was 50:50. The mean age was 55 years (range 24-86 years) among women and 58.8 years (range 31-80 years) among men. The overal incidence of CSF leakage was 2.37% of which 12% had other severe complications. Meningitidis was the most common one (n = 7, 9.5%). No correlation was found between meningitidis and nicotinism, BMI or previous spine surgery. There was 1 (1.36%) case of pneumocephalus and 1 case of an acute subdural heamatoma (1.36%) induced by intracranial hypotension. Surgical management of CSF leaks correlated with shorter hospital stay ($P < .05$). **Conclusion:** Unintended durotomy is a common complication in spine surgery. As presented in this study, griveous complications may occur due to postoperative CSF leakage. The surgeon and patient need to be aware of these potentially fatal conditions in order to reduce them.

1793
A277: Comparison of Implant-Related Complications Between the Magnetically Controlled Growing Rod and The Spring Distraction System for the Treatment of Early Onset Scoliosis

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Introduction: Traditional Growing Rod surgery for Early Onset Scoliosis (EOS) is associated with high complication rates, which are attributed to the need for frequent re-operations. Although this need can be mitigated by using the Magnetically Controlled Growing Rod (MCGR), recent literature shows that complications are still frequent, possibly owing to MCGRs mechanical complexity. We developed the Spring Distraction System (SDS), which continuously distracts the growing, scoliotic spine through a compressed titanium spring that is positioned around a standard growing rod. Although it offers a theoretical favorable biomechanical stress profile, its effect on complications has not yet been studied. Therefore, the current study aims to compare the complication rate and complication profile of the MCGR and the SDS. **Material and Methods:** We performed a retrospective cohort study to compare consecutive EOS patients between 2013 and 2018 who underwent primary implantation with either a hybrid MCGR construct or the SDS implant. Patient- and disease-related variables were collected and 2 observers independently scored and graded complications in all included patients. Complication rate was reported as complications/patient/year and a Kaplan-Meier survival analysis with the Log-Rank method was performed to compare the time to complications between the groups. **Results:** We included 32 EOS patients, 14 MCGR and 18 SDS patients. Mean age at surgery was 7.9 ± 1.6 and 8.4 ± 1.9 years for MCGR and SDS respectively. Mean follow-up was 4.1 ± 1.6 (MCGR) and 3.0 ± 0.4 (SDS) years. The MCGR group showed 18 complications (1.3/patient), which corresponded to 0.31 complications/patient/year. Ten patients (71%) had at least 1 complication. There were 4 anchor failures, 2 rod fractures and 8 actuator malfunctions in which the MCGR failed to lengthen any further (after a mean of 3.4 years) and had to be replaced to allow for further spinal lengthening. In addition, there were 3 cases of proximal junctional kyphosis and 1 case of post-operative neurological injury. The SDS group showed 17 complications (0.9/patient), corresponding to 0.31 complications/patient/year. Eleven patients (61%) had at least 1 complication. There were 3 anchor failures, 3 rod fractures, 1 case of rod slippage, 3 side-to-side connector complications and 2 wound complications (1 wound dehiscence and 1 deep surgical site infection). There were no cases where the SDS implant failed to lengthen during the study period. However, there were 5 cases of implant kyphosis resulting in implant prominence. Across all patients, median complication survival (i.e. the point where half of the patients suffered a complication) was 2.8 years. The Kaplan-Meier analysis showed no significant difference ($P = .408$) in median complication survival between the MCGR (3.0 years) and SDS (2.5 years) group. **Conclusion:** Although complication rate normalized for follow-up was similar between MCGR and SDS patients (0.31 complications/patient/year), complication profile was different between groups. In the MCGR group, failure to lengthen occurred in >50% of patients, while the SDS group showed no patients in whom spring lengthening stalled during growth. However, SDS patients had a higher rate of implant kyphosis. The median complication survival for all patients was 2.8 years, with no differences between the groups.

388
A278: Complication Rates Following Posterior Lumbar Fusion in Osteoporotic Patients Taking Bisphosphonates

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Introduction: Osteoporosis has been shown to have negative effects on outcomes of spine surgery and is associated with increased post-operative complication rates. Bisphosphonates are one of the most commonly prescribed drug classes for osteoporosis, and the current body of literature has mixed results with regards to the effect of bisphosphonates on spinal fusion and post-operative complications. The present study aims to elucidate the effects of bisphosphonates on complications following posterior lumbar fusion (PLF) with a large database study. **Material and Methods:** The PearlDiver patient record database was queried to identify adult patients (over 18 years of age) who had undergone posterior lumbar fusion (PLF) using Current Procedural Terminology (CPT) codes. Those patient cohorts were divided based on a diagnosis of osteoporosis prior to surgery and bisphosphonate usage. This yielded three groups: $Osteo^{+}Bisph^{+}$, $Osteo^{+}Bisph^{-}$, and $Osteo^{-}Bisph^{-}$. The surgery groups were matched according to age, sex, and Charlson Comorbidity Index (CCI). Incidence of post-operative complications were analyzed and statistical analysis was conducted using Pearson chi-square analysis. **Results:** Patients with osteoporosis (both groups $Osteo^{+}Bisph^{+}$ and $Osteo^{+}Bisph^{-}$) had higher rates of revision surgery than patients without osteoporosis at 6 months and 1 year but these results were not statistically significant. Patients with osteoporosis (both groups $Osteo^{+}Bisph^{+}$ and $Osteo^{+}Bisph^{-}$) also had higher rates of instrumentation complications and post-operative vertebral fractures with $Osteo^{+}Bisph^{-}$ having the highest rate of both complications. These results were also not statistically significant. There was no statistically significant difference in pseudarthrosis between the three groups. $Osteo^{-}Bisph^{-}$ had significantly higher rates of post-operative leg pain than $Osteo^{+}Bisph^{-}$ ($P = .0036$) and significantly higher rates of post-operative back pain than both groups $Osteo^{+}Bisph^{+}$ and $Osteo^{+}Bisph^{-}$ ($P = 0.00349$) (Table 1). **Conclusion:** Patients with osteoporosis had higher rates of post-operative revision, instrumentation failure and post-operative fracture than patients without osteoporosis, however these results were not statistically significant. There was also no significant difference in the aforementioned complications between osteoporotic patients taking bisphosphonates and those who did not. Patients without osteoporosis had higher rates of post-operative back pain and leg pain than patients with osteoporosis regardless of bisphosphonate usage.

1312
A279: Safety and efficacy of magnetically controlled growing rods in an early onset scoliosis population

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Introduction: There has been controversy surrounding the safety and efficacy of magnetically controlled growing rods (MCGR) for the treatment of patients with early onset scoliosis (EOS). The primary aim of our study was to evaluate the efficacy of MCGR in correcting and controlling spinal deformity progression. The secondary aim was to evaluate the number of patients that needed additional unplanned surgery in the follow-up period. **Material and Methods:** All 88 patients who had MCGR inserted from 2014 onwards in our institution were included in this study. This cohort comprised of 41 Females and 47 Males and were sub classified according to the C-EOS classification system. This revealed 19 Congenital, 23 Idiopathic, 16 Syndromic and 30 Neuromuscular origin patients. The following outcomes were measured: Pre- and post-operative Scoliosis Major Cobb (MCA) and Major Kyphosis (MKA) angles, space available for lung ratios (SALR), T1- T12 heights, rod length changes, additional unplanned surgeries, and implant failures. Results: (Our data is represented as means with SD in brackets) The mean age at surgery was 8.14 years (±2.81) and mean follow up after surgery was 35 months (± 15). The pre- and immediate postoperative MCA's were 76 (±21)° and 36 (±19)°, respectively. The latest MCA was 44° (±21). Pre- and immediate postoperative MKA's were 43 (26) degrees and 28 (±16)°, respectively. The latest MKA was 32 degrees (± 17).The preoperative and latest SALR's were 86% (±13) and 95% (±9) respectively, an increase of 9%.The pre- and immediate postoperative T1-T12 heights were 168mm (±30) and 193 mm (±30) respectively. The latest T1-T12 height was 209 mm (±33), an increase of 16mm (8.3%) from the immediate postoperative measurement. The increase in rod lengths were 17 mm (±10) and 18 mm (±10) for right and left side rods, respectively. Macroscopic evaluation of implants and radiographic evaluation revealed bilateral actuator pin failure in 2 patients (2.27%) and there was no evidence of end cap failure. 24 patients (27%) had additional unplanned surgery due to infection, inadequate deformity control and rod or anchor point failure. **Conclusion:** Our findings suggest that MCGR can achieve success in controlling significant deformity in the EOS population over the short to medium term. As with other treatment options, additional unplanned surgery may be needed and this must be communicated to the affected individuals and their guardians. Further research continues to define long term outcomes for the EOS population.

OP32: Clinical Biomechanics 2

1036
A280: Spine Stability After Treatment of Degenerated Intervertebral Discs with Percutaneous Cement Discoplasty

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Introduction: Low back pain can be caused by nerve compression due to stenosis of the foramen associated with intervertebral disc degeneration. Invasive surgical solutions are not suitable for old patients with comorbidities. A minimally invasive approach, percutaneous cement discoplasty, has been recently developed for the polymorbid patients [1]. The mechanical impact on the spine stabilization and surrounding tissues have not been investigated yet. This *in vitro* study aimed at: (1) testing the stabilization of human spine segments after discoplasty by monitoring the disc height and the range of motion (ROM), (2) preventing complications by assessing the strains on the specimen surface, (3) relating the surgery quality to the biomechanical stability of the spine segments. **Material and Methods:** 27 fresh-frozen human cadaveric lumbar FSUs were obtained from 15 donors (35-86 y.o., 63-132 kg) after ethical approval. The soft tissues were removed, leaving the ligaments intact. The specimens were potted with the intervertebral disc horizontal and prepared with a water-based white-on-blue speckle pattern in order to measure surface strains with Digital Image Correlation (DIC) [2]. The specimens were mechanically tested in flexion and extension under 50% body weight axial load combined to an offset. The ROM, the stiffness, and the disc height were measured. Disc surface images were recorded and analysed by a 3D-DIC system using optimized parameters. Cement distribution within the disc and surface contact with the endplates were analysed from CT scan segmentations. The specimens were tested under two conditions: (1) Simulated degeneration: the intervertebral disc manually emptied through an incision in the annulus. (2) Discoplasty: after acrylic cement injection (Mendec Spine, Tecres, Italy). **Results:** Discoplasty increased the disc height by 34% in flexion and 35% in extension compared to the degenerated conditions, thus increasing the width of the foramens. On the contrary, discoplasty only impacted the ROM in flexion with a 27% reduction with respect to nucleotomy condition. Discoplasty was associated with a 37% increase of stiffness in flexion and a reduced neutral zone. The highest strains were exhibited in the disc after nucleotomy. Cement injection resulted in a restrained gradient over the disc, with a localization of compressive strains along the endplates. **Conclusion:** Similarly to clinical observations, discoplasty recovered the disc height, thus rehabilitating the neuroforamen area. The large volumes of cement improved spine stability in flexion resulting in stiffer segments. Disc tissue underwent reduced deformations which concentrated on the endplates.

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Acknowledgements

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Ethical approval

The entire study was approved by the bioethical committee of University of Bologna, protocol 76497 of 1st June 2018. The specimens were obtained through ethically-approved International donation programs.

1702
A281: Analysis of the Largest Database of Anthropometric Measurements of the Occipito-Atlantoaxial Joints

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Introduction: The complex geometrical and biomechanical dynamics of the occipito-atlantoaxial joints remain unparalleled in the human body. The atlantal (C1) joint plays a central role in the craniocervical junction, which is comprised of the occipito-atlantal joint (C0-C1) and the atlantoaxial joint (C1-C2). Due to complexities related to its anatomy, there is no consensus on the precise biomechanics of the occipito-atlantoaxial spine. For further clarification, many anatomists have endorsed developing a quantitative database measuring key anatomical landmarks of the cervical spine to provide a better understanding of its geometry and kinematics. This report presents an analysis of the largest database describing the atlas' radiographic measurements and their relationship to surrounding structures. **Material and Methods:** KKT Orthopedic Spine Centers provide wave treatments to manage chronic back and neck pain. As part of their treatment process, three x-ray images (lateral, frontal, and top skull) of the patient's cervical spine are obtained in a uniform manner and stored in a centralized database. The data is then analyzed by a proprietary software, Spinalytics®, which calculates distances and angles between key landmarks on the cervical spine x-rays. This study included all patients visiting any of the KKT Orthopedic Spine Centers with x-rays analyzed by Spinalytics® between November 2006 and June 2019. Data regarding the occipito-atlantal angle, atlas angle, antlanto-cervical angle, and atlas rotation were extracted from the database and included in this study. The occipito-atlantal angle describes the angle between the skull line and the true

vertical through the atlas midpoint. The atlas angle is the acute angle formed between the mastoid line and the true horizontal line through the atlas midpoint. The atlanto-cervical angle is between the spinal line and true vertical through the atlas midpoint. The atlas rotation is the angle between the vertical line and the lateral mass line on the side of the atlas' acute angle on the top skull X-ray. **Results:** This study included 49,937 patients in 25 centers in 14 countries. The average patient age was 45 (SD: 16) years old, with 49% male. The mean deviation of the occipito-atlantal angle is 2.37° to the right, the mean atlas angle is 1.86° to the right, and the mean atlanto-cervical angle deviation is 2.20° to the left. The average atlas rotation angle is tilted 87.86° anteriorly. Linear regression models suggest that the atlas influences the angles between the skull and cervical spine, bi-directionally. However, deviations in the skull do not impact the cervical spine and vice versa. **Conclusion:** This study's results show a clockwise rotation of the axis with a higher degree of rotation in the occipito-atlantal angle than the atlanto-cervical angle. The atlas angle appears to influence deviations in occipito-atlantal and atlanto-cervical angles; therefore, deviations' primary foci appear to be the atlas. Further studies amongst healthy volunteers and correlation with clinical data are required to clarify the clinical significance of these anthropometric measurements.

1625
A282: A Simple Biomechanical Study, Reveals that a Reversal in Direction of Compression, Could Greatly Improve Restoration of Lordosis in Lumbar Fusion

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Introduction: Lumbar lordosis is usually lost in the degenerative process, and when lumbar fusion is required, restoration of the correct shape of the spine is one of the modern metrics of a successful operation. However, operations regularly fail to achieve adequate lordosis and one of the reasons why, is one that is rarely discussed, namely that achieving lordosis can be difficult. We sought to investigate this. Study of the anatomy, normal vertebral motion, and current techniques, led to the hypothesis that simply changing direction of compression during surgical fusion, would gain more lordosis. **Method:** Using a biomechanically validated Sawbones ™ model we inserted standard polyaxial pedicle screws (Nuvasive™, 'Reline') from S1-L4 in a surgically correct, well aligned position. A standard lordotic rod was placed in the screws without requiring rod reduction, and the caps attached but left unlocked. Markers were attached to L4 and S1 spinous processes to allow photographic analysis of lordosis. Two techniques of compression were compared. A-Standard, whereby caudal screws were locked first and compression proceeded sequentially in a cranial direction prior to locking. B-Alternate, whereby cranial screws were locked first and compression proceeded caudally. A standard parallel compressor was used. Both methods were repeated to confirm consistent reproducibility, and after increasing levels of surgical invasiveness; intact, add interbody cage, add inferior facet resection, add Ponte resection. Standardised photographs were analysed to measure change of lordosis with each technique. The methodology was also tested for accuracy against a previously validated digital multicamera system similar to image guidance systems. Compression was done by the same surgeon to the same 'white knuckle' force. **Results:** There was an increase in the lordosis gained using method B of 300% for an intact model, 195% after a cage insertion, 60% after adding inferior facet resection and 33% for a full Ponte osteotomy. Statistical analysis of the results demonstrated a significant difference ($P = .002$) between the two methods for all levels of model integrity. **Conclusion:** In this biomechanical model, locking the top screws first was a consistently superior method of compression to gain lordosis. If confirmed clinically, without changing instrumentation, surgeons should consider reversing direction of compression to a "Top down" technique. No previous literature regarding this matter was found. Our pre-experiment hypothesis was that intact and possibly inferior facet resection would favour technique B. This was based on the following observations; the initial locking of one tulip also fixes the position of the rod and so the moving tulip has to follow this rod, the alignment of the normal facet joints forms about a 90 degree angle with moving superior screw, while the moving inferior screw forms about a 45° angle. The moving superior screw could thus be expected to block earlier i.e. produce less lordosis than a moving inferior screw. What was unexpected was that "Top Down" was superior after Ponte resection, (i.e. total facet resection) indicating additional unknown factor(s) were dictating the results.

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A283: Biomechanics of the Active Apex Correction Technique of Early Onset Scoliosis: A Parametric Finite Element Study Simulating 6-Month Growth

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Summary: The active apex correction (APC) technique demonstrates the possibility of effective remodulation of the wedging at the apex using a modified SHILLA approach. This may in turn nullify the complications inherent with SHILLA by avoiding apical fusion. The current finite element (FE) study explores the parametric effect of compression during APC with a 6-month follow up. Results show the magnitude of the initial compressive force dictates the degree of correction, while maintaining the correction. **Hypothesis:** Clinical outcome of implant constructs with different materials could impact surgical planning for surgeons using the APC technique. **Study Design:** Finite element study simulating APC with a 6-month follow-up period. **Introduction:** Newer, modified techniques like the active apex correction (APC), aim to nullify the complications inherent with SHILLA by avoiding apical fusion. This study evaluates the effect of the correction achieved by the APC technique (or APC). Additionally, we explored the effect of the compression force applied during the surgery. **Methods:** A FE model simulating coronal (T5-T11 cobb angle: 44° & T11-L1 secondary curve) of 36° and sagittal deformity (T4-T12 kyphosis: 36° & L1-S1 lordosis: 46°) was compressed. 3 models with the APC construct were simulated with compression varying from 1 mm-5 mm displacement (6-30N) applied between screws proximal and distal to the apex(T8). The model simulated the effect of gravity and muscle forces and 6-month epiphyseal spinal growth (Figure 1). The clinical output parameters were measured and compared for these models at various time points. **Results:** Compared to the base model with no instruments, the instrumented models achieved a reduction in the coronal and sagittal angles, apical vertebral translation and wedging at the end of the 6-month growth period, across the different compressive force cases (Table 1). **Conclusion:** The output parameters showed consistent maintenance of the correction achieved by the APC, with the magnitude of the initial compressive force dictating the degree of correction. **Take Home Message:** The results show that tethering through a posterior approach, which is the gold standard for spine surgeons tackling EOS, we can perform this active apex correction technique to get excellent results.

Figure 1. Schematic showing the modified SHILLA approach with active apex correction used in this study

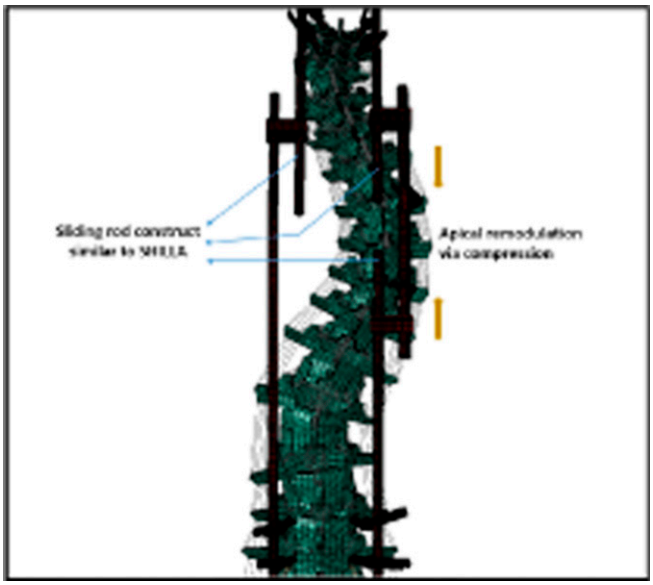

Table 1. Output parameters from the finite element model simulating the Active Apex Correction technique with different compressive force cases

Parameters	Base model	30N compression (5mm)		18N compression (3mm)		6N compression (1mm)	
		Compression	6 month growth	Compression	6 month growth	Compression	6 month growth
Height (T1-S1)	332.2 mm	335.6 mm	338.9 mm	334.3 mm	337.1 mm	332.9 mm	335.8 mm
Sag Height (T1-S1)	326.4 mm	329.9 mm	333.1 mm	328.6 mm	331.3 mm	327.2 mm	329.9 mm
Cobb (T5-T11)	43.9°	40.9°	41.3°	42.3°	42.8°	43.4°	43.8°
Secondary curve(T11-L1)	36.1°	35.4°	35.9°	35.7°	36.3°	36.0°	36.5°
AVT (mm)	31.9 mm	28.8 mm	29.1 mm	30.2 mm	30.3 mm	31.4 mm	31.5 mm
Kyphosis (T4-T12)	36.0°	31.3°	31.1°	33.1°	33.1°	35.0°	35.0°
Lordosis (T12-S1)	46.5°	44.9°	45.2°	45.5°	45.7°	46.2°	46.4°
Apical Vertebral height(T8): Concave side	11.61 mm	11.71 mm	12.09 mm	11.66 mm	11.99 mm	11.62 mm	11.89 mm
Apical Vertebral height(T8): Convex side	15.26 mm	15.12 mm	15.47 mm	15.19 mm	15.41 mm	15.24 mm	15.53 mm
Wedge ratio: Convex height/ Concave height	1.31	1.29	1.28	1.3	1.29	1.31	1.31

640
A284: Update on the Biomechanics of the Transverse Atlantal Ligament in the Elderly

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Introduction: The transverse ligament is the strongest ligament of the craniocervical junction and therefore, plays a critical role in atlanto-axial stability. However, several clinical studies have questioned this ligament's strength in the elderly. The goal of this biomechanical study was to reevaluate the force required for the transverse ligament to

fail in a more physiological biomechanical model in elderly specimens. **Material and Methods:** Twelve C1-2 specimens were harvested from fresh-frozen Caucasian cadavers with a mean age at death of 81 years (range 68-89 years). Only the transverse ligament was preserved, and the bony C1-2 complex was left intact. The dens was pulled away from the anterior arch of C1 using a strength test machine that applies controlled increasing force. After testing, the axis was split in half to check for hidden pathologies and osteoporosis. The differences in the failure force between sex and age groups (group 1: < 80, group 2: > 80 years) were compared. **Results:** The mean force required for the transverse ligament to fail was 236.2 ± 66 N (range 132-326 N). All but two specimens had significant osteoporotic loss of trabecular bone. No significant differences between sex and age groups were found. **Conclusion:** The transverse ligament's failure in elderly specimens occurred at an average force of 236 N, which was lower than that reported in the previous literature. The ligament's failure force in younger patients differs and may be similar to the findings published to date.

974
A285: Influence of Pelvic Incidence on the Segmental Lordotic Parameters in Normal Adults

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Introduction: We performed this study to understand the spectrum of sagittal spino-pelvic parameters, segmental lumbar parameters and the location of lumbar apex in asymptomatic adult population and analyse their correlations with each other. **Materials and Methods:** Hundered asymptomatic adult volunteers (Mean age of 29.1 (±7.9) years; 69 males, 31 females) who satisfied the selection criteria were enrolled for the cross sectional study. Standing antero-posterior and lateral whole spine and pelvis X-rays were performed and the radiographic parameters were analyzed. We introduced a "segmentation line" bisecting the apical vertebra/disc to divide the ULL (upper arc of lumbar lordosis) &LLL (Lower arc of lumbar lordosis). **Results:** The mean PI (Pelvic incidence) was 48.02, ULL was 29.12, LLL was 16.02, TLL (Total lumbar lordosis) was 45.14, LTA (Lumbar tilt angle) was4.73 and LLA (Location of lumbar apex) was 4.11. As the PI increases, the location of the lumbar apex moved higher. The PI had a significant positive correlation with the LLL($r = .582$, $P < .001$) and TLL($r = .579$, $P < .001$) but not with the ULL($r = .196$, $P = .05$). The LLA is strongly correlated positively with the ULL($r = .349$, $P < .001$), negatively with the LLL($r = -0.63$, $P < .001$) and not correlated with the TLL($r = -0.177$, $P = .078$). **Conclusions:** The PI influences the location of the lumbar apex, the lower arc of lordosis and the total lordosis but not the upper arc of the lordosis. The location of lumbar apex does not influence the total amount of lumbar lordosis but the segmental lordosis is strongly influenced by its location.

863
A286: Novel Biomechanical Model for Proximal Junctional Kyphosis

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Introduction: A biomechanical model was created to evaluate repetitive fatigability testing on long thoracolumbar constructs. **Material and Methods:** An explanted spine was instrumented from T3-Sacrum and secured to a rigid frame constructed from aluminum t-slot extrusion. A 20 cm rod was attached to bilateral pedicle screws placed on the level immediately rostral to the upper instrumented vertebrae of interest (UIV+1), and spectra cord was secured to the rod. The explanted spine was oriented in a lateral position to avoid unintended moment applied by the remaining rostral spine. The rostral aspect of the spine was then suspended from above to allow largely unrestricted movement in the medial plane. The cord was deflected by a pulley 90 degrees to run vertical to the floor and secured to a water-filled container that could be filled or emptied to adjust the load applied. A pneumatic actuator raised and lowered the loading weight to cyclically flex the spine, while a counterweight provided a constant extension force of 5 N. Circular markers were placed on separate metal rods secured to the pedicles of the UIV and UIV+1 to allow measurements of change in angle. A python script using the Hough Circle Transformation tracked the circular markers via a Logitech webcam and used the marker positions to calculate change in angle between UIV and UIV+1. To evaluate the reliability of the tracking script, a series of measurements were taken without moving the markers and the standard deviation of these measurements were assessed. An electrical solenoid valve allows programmable control of repeated loading cycles. **Results:**

This biomechanical model was able to successfully apply repetitive forces with a variety of moment arms and shear forces that can be increased independently from one another. Moment can be increased independent of shear force by increasing the rod length attached to the UIV + 1; adjusting the water level in the loading weight will modulate moment and shear in tandem. The Python angle measurement script was able to successfully interact with a commonly available Logitech webcam to act as an optical tracker, and successfully record the relative angles of the UIV and UIV + 1 endplates. Evaluation of 46 measurements of the same marker position showed a standard deviation of 0.16 degrees suggesting that this method is adequate for measuring angle changes less than half a degree. **Conclusion:** This is the first description of a novel biomechanical model that can successfully test long thoracolumbar constructs with repetitive flexion and accurately measure the relative change of angles of individual endplates. This model can be used to provide information regarding optimal tension parameters in junctional tethers, as well as fatigability testing for a variety of spine applications.

899
A287: Association of Facet Tropism at the Last Mobile Segment with Sacralisation of the L5 Vertebrae

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Introduction: An association between asymmetry of the lumbar facet joints and disc pathology has been studied previously. Researchers have shown a relationship between facet tropism and disc herniation. The present study aims at finding an association between facet tropism at the last mobile segment with sacralisation of L5 vertebrae. There have been many literatures on facet joint degeneration at the L5 vertebrae as well as sacralisation of L5 vertebrae but limited knowledge on its association with the mobile segment or transition segment of a sacralised L5 and facet joint asymmetry. **Materials and Methods:** The sampling was done by dividing the total study group into two on the basis of the MRI findings. Group A included patients with sacralisation of the lumbar vertebrae (L5) and Group B included the patients with normal lumbosacral vertebral morphology, all who had low back pain. The sample study included 230 patients and divided into 115 patients in each group. Analysis is done by using Chi square test, Odds Ratio, Kappa ratio and Student's t test. A statistical analysis is conducted using IBM, SPSS 17.0 and $P < .05$ is considered as significant. **Results:** Among the 230 patients selected for the study 53% of the patients were males and 47% were females. Among the females in the study 65.4% of them had sacralised vertebrae and 36.5% males had sacralised vertebrae. 27% of the total patients suffered from both low back pain and sciatica. 70% of the total patients suffered from disc degeneration. All patients in the age group 30-40 years who presented with low backpain were found to have facet tropism. 90.9 % of the total study group who had facet tropism in the sacralised vertebrae were in the age group less than 40years. In the group B, the patients who had sacralised vertebrae 83 % of them had developed disc degeneration, but facet tropism was found to be 79% of the total study group. The association of facet tropism with sacralisation using chi square test of independence was found to be highly significant at X^2 (1, N = 230) = 53.010 $P < .001$. The association of facet tropism with disc degeneration and age was also found to be significant. **Conclusion:** This study showed significant association of facet tropism at last mobile segment with sacralisation of L5 vertebrae. The statistical analysis shows that facet tropism is eight times more likely to be seen in sacralised vertebra when compared with non sacralised vertebra. The age group less than 40 years who had low back pain showed higher incidence of facet tropism and disc degeneration. Similar to literature, our study also found significant association between facet tropism and transitional vertebra with disc degeneration. Using regression coefficient the study also found to have statistical significance for transitional vertebra to predict disc degeneration. Patients with sacralised vertebrae showed early disc degenerative disease when compared with patients who did not have sacralisation of L5 vertebrae.

1726
A288: Implant Surface Functionalization Technologies and the Need af a Transparent Quality Evaluation System

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Introduction: For bone implants, osseointegration resulting in a good and fast bone-implant contact is of primary importance to secure a proper implant function and to avoid implant loosening or inflammation resulting in necessary revision surgeries causing pain to the patients and immense costs. Especially Polyetheretherketone (PEEK) is a promising implant material due to the close mechanical properties to bone but it is completely bio-inert hindering osseointegration and making surface functionalization necessary. Many different surface functionalization technologies have been reported both of physical and chemical nature. The same is true for the other prominent implant materials titanium and ceramics although they already have a naturally better osseointegration than PEEK but are much harder and stiffer than bone and brittle in case of ceramics. Surface functionalization, which can be subdivided into surface coating and material modification

needs to be judged from a quality and safety viewpoint. **Material and Method:** However, a literature research resulted in the fact, that no quality standard yet exists for implant surface functionalization. This makes it difficult to impossible to compare the safety and performance of different surface functionalized bone implants clearly showing the need to establish a transparent quality evaluation system for bone implants. **Results:** In this perspective article, we give the state of the art and then develop a quality evaluation system, which is based on 6 main categories as important benchmarks for the quality of a surface functionalized bone implant material. A simple catalogue of questions can be answered and from the resulting scores, the Safety Performance Evidence Level (SPEL) representing the safety and quality of a given implant can be calculated in %. This simple SPEL system allows an easy and transparent judgement and comparison of bone implants, which will hopefully assure the easy identification of safe and well performing high-quality bone implants in the future. **Keywords:** bone implant, polyetheretherketone (PEEK), surface functionalization, quality evaluation, safety and performance evaluation level (SPEL)

OP33: Robotics, Navigation and VR

1310
A289: Learning Curve in Pedicle Screw Insertion Using an Intraoperative Computertomography (ICT) Guided Navigation

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Introduction: iCT navigation guided screw placement has an extraordinary low misplacement rates. There is a lack of evidence concerning the learning curve in this technique. Aim of this single center retrospective study is to show the effect of learning curve in the first year of use. **Methods:** A retrospective analysis of all patients undergoing pedicle screw instrumentation within the first year (October 2015 and December 2016) of introducing iCT navigated spinal instrumentation was done. In each surgery, an intraoperative CT scan for referencing the navigation was performed and subsequently one or more CT scans for intraoperative control of screw placement accuracy where performed. The cases were divided into three equal intervals for analysis. **Results:** Sixty five patients were identified. There were 55.4% female and 44.6 male patients. Median age of 68 years. According to the Gertzbein and Robbins classification grades, there was proper placement (A + B grade) in 85,5%, 88.8% and 87%in the first, second and third time interval, respectively. The intraoperative revision rate was 10.5%, 6.5% and 5.8% in the in the first, second and third interval, respectively. None of the patients required secondary surgery caused by screw misplacement or had any neurovascular damage. **Conclusion:** The learning curve for iCT was evident after 3 months**.** There was no difference in accuracy or revision rates between the second and third interval.

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A290: The trends in robot-related complications, operative efficacy, radiation exposure, and clinical outcomes after robot-assisted spine surgery: a multicenter study of 722 patients and 5,005 screws from 2015 to 2019

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Introduction: With the arrival of robot-assisted spine surgery nearly twenty years ago, there has been a growing amount of literature that suggests robots are safe and can achieve comparable outcomes to conventional techniques. However, much of this literature is limited by small sample sizes and single-surgeon or single center series. Furthermore, it is unclear what the impact of robotic technology has made on operative and clinical outcomes over time. This is the first and largest multicenter study to examine the trends in outcomes and complications after robot-assisted spine surgery over a five-year period. **Material and Methods:** We included adult (≥18 years old) patients who underwent robot-assisted (Mazor Renaissance, X, and Stealth) spine surgery from 2015-2019. Several perioperative factors were compared across the years of surgery. Outcomes of interest included operative efficiency (robot time per screw), radiation exposure (fluoroscopy time per screw), robot complications (e.g. screw exchange, robot abandonment), and clinical outcomes (e.g., length of stay, 90-day reoperations). The minimum

follow-up was 90 days after the index surgery. Chi-square/fisher exact test and t-test/ANOVA were used for categorical and continuous variables, respectively. The Cochran-armitage test was used to examine statistically significant trends. **Results:** A total of 722 adult patients were included in this study (117 Renaissance, 477 X, 128 Stealth). The mean (standard deviation) Charlson comorbidity index was 1.5 (1.5) and 54.4% of patients were female. The most common diagnoses included high grade spondylolisthesis (40.6%), degenerative disc disease (18.4%), and degenerative scoliosis (17.6%), and the mean number of instrumented levels was 3.8 (3.4). Most patient and operative factors (e.g. gender, smoking status, total instrumented levels, and pelvic fixation,) were similar across the years. From 2015 to 2019, the mean robot time per screw decreased from 7.2 minutes to 5.5 minutes ($P = .004$, $R^2 = .65$) and the mean fluoroscopy time per screw decreased from 15.2 seconds-9.4 seconds ($P = .002$, $R^2 = .83$). Similarly, the rates of both intraoperative screw exchange for misplaced screw ($P = .0115$, $R^2 = .13$) and robot abandonment ($P = .011$, $R^2 = .22$) improved significantly over time. The incidence of other intraoperative surgical complications (e.g., dural tear, loss of motor/sensory function, blood transfusion) remained consistently low, but similar between years. The length of stay decreased by nearly 1 day from 2015-2019 ($P = .007$, $R^2 = .78$), even though the mean Charlson comorbidity index worsened with time ($P = .036$). The 90-day reoperation rate did not change significantly over the last five years. **Conclusion:** Current trends demonstrate that robot screw accuracy, reliability, operative efficiency, and radiation exposure have improved significantly over the last five years. This is likely the result of increased surgeon experience with robots and the recent advances in robotic technology. The 90-day surgical complication rates remain consistently low and the mean length of stay has reduced significantly with time. These findings further validate continued usage of robot-assisted spine surgery and the potential path toward improved value-based care.

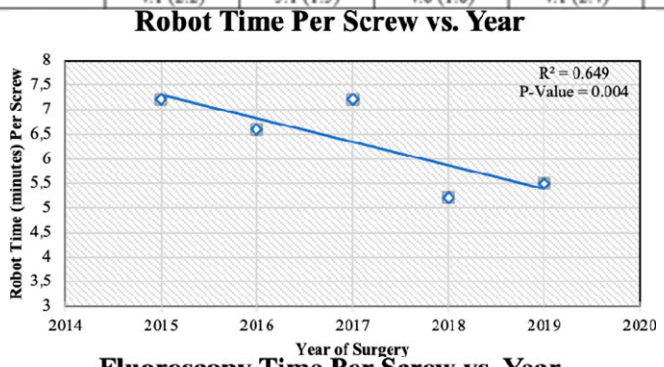
Table 1. Trends in Patient Factors, Indications, and Operative Factors for Robot-Assisted Spine Surgery (2015-2019)

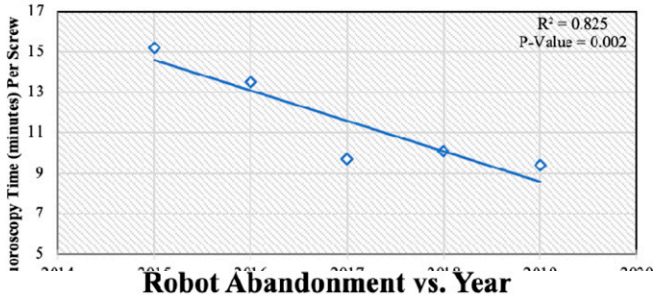
	All		2015		2016		2017		2018		2019		
	N	%	N	%	N	%	N	%	N	%	N	%	
Total # of Patients	722	100%	40	6%	58	8.0%	165	22.9%	198	27.4%	261	36.1%	**P-Value**
Female	393	54.4%	17	42.5%	33	56.9%	92	55.8%	117	59.1%	134	51.3%	0.259
Obese (BMI>30Kg/m2)	299	41.4%	18	45.0%	18	31.0%	66	40.0%	79	39.9%	118	45.2%	0.198
CCI, Mean (standard deviation, SD)	1.5 (1.5)		0.95 (1.2)		1.3 (1.3)		1.6 (1.5)		1.5 (1.3)		1.7 (1.6)		**0.036**
Prior/Current Smoker	153	21.2%	3	7.5%	6	10.3%	47	28.5%	45	22.7%	52	19.9%	0.288
Preoperative Diagnosis													
High Grade Spondylolisthesis	293	40.6%	25	62.5%	27	46.6%	71	43.0%	86	43.4%	84	32.2%	**<0.001**
Degenerative Disc Disease	133	18.4%	5	12.5%	10	17.2%	31	18.8%	23	11.6%	64	24.5%	0.051
Degenerative Scoliosis	127	17.6%	7	17.5%	10	17.2%	23	13.9%	44	22.2%	43	16.5%	0.762
Spinal Stenosis	116	16.1%	3	7.5%	5	8.6%	24	14.5%	29	14.6%	55	21.1%	**0.003**
Pseudarthrosis, Implant Failure	40	5.5%	0	0.0%	3	5.2%	11	6.7%	12	6.1%	14	5.4%	0.509
Other	14	1.9%	0	0.0%	3	5.2%	5	3.0%	4	2.0%	2	0.8%	0.148
Operative													
Open (vs. Percutaneous)	309	42.8%	5	12.5%	23	39.7%	67	40.6%	101	51.0%	113	43.3%	**0.004**
Prior Spine Surgery	76	10.5%	6	15.0%	12	20.7%	19	11.5%	16	8.1%	23	8.8%	**0.020**
Total Instrumented Levels Per Patient, Mean (SD)	3.8 (3.4)		3.5 (2.5)		3.9 (2.8)		3.4 (3.0)		4.0 (4.0)		4.0 (3.4)		0.407
Pelvic Fixation	142	19.7%	1	2.5%	18	31.0%	34	20.6%	42	21.2%	47	18.0%	0.902
Interbody Fusion	190	26.3%	0	0.0%	10	17.2%	57	34.5%	68	34.3%	55	21.1%	0.284
TLIF	122	16.9%	0	0.0%	7	12.1%	32	19.4%	35	17.7%	48	18.4%	**0.030**
ALIF	10	1.4%	0	0.0%	0	0.0%	5	3.0%	3	1.5%	2	0.8%	0.773
OLIF	43	6.0%	0	0.0%	3	5.2%	12	7.3%	24	12.1%	4	1.5%	0.386
XLIF	19	2.6%	0	0.0%	0	0.0%	9	5.5%	9	4.5%	1	0.4%	0.392
Planned Robot Screws Per Patient, Mean (SD)	7.4 (6.3)		7.2 (5.5)		6.8 (4.4)		6.8 (5.6)		7.3 (7.1)		8.0 (6.4)		0.353
Executed Robot Screws Per Patient, Mean (SD)	6.0 (6.0)		5.7 (5.0)		6.0 (4.9)		6.2 (5.2)		6.9 (6.5)		7.9 (6.4)		**0.017**
Robot System													
Renaissance	117	16.2%	40	100.0%	58	100.0%	19	11.5%	0	0.0%	0	0.0%	**<0.001**
X	477	66.1%	0	0.0%	0	0.0%	146	88.5%	197	99.5%	134	51.3%	**<0.001**
Stealth	128	17.7%	0	0.0%	0	0.0%	0	0.0%	1	0.5%	127	48.7%	**<0.001**

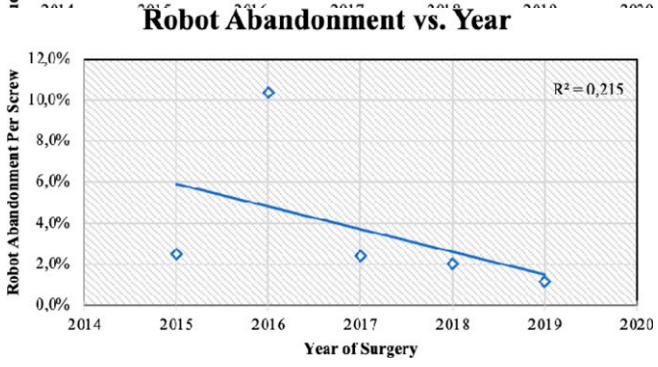
Table 2. Trends in Operative Efficacy and Radiation Exposure							
Mean (SD)	All	2015	2016	2017	2018	2019	P-Value
Operative Time (minutes)	205 (131)	165 (102)	175 (154)	181 (129)	223 (127)	242 (125)	**<0.001**
Robot Time (minutes)	41.2 (33.3)	39.5 (36.1)	33.2 (24.4)	35.9 (28.6)	47.9 (36.2)	53.5 (39.5)	**0.002**
Robot Time Per Screw (minutes/screw)	6.5 (3.8)	7.2 (4.8)	6.6 (4.6)	7.2 (3.9)	5.2 (2.3)	5.5 (2.4)	**0.004**
Total Fluoroscopy Time (seconds)	49.0 (36.5)	63.7 (32.0)	50.3 (29.5)	43.3 (34.8)	47.8 (36.2)	50.4 (39.5)	**0.034**
Fluoroscopy Time per Screw (seconds/screw)	10.4 (10.0)	15.2 (7.9)	13.5 (10.5)	9.7 (9.2)	10.1 (11.0)	9.4 (9.7)	**0.002**

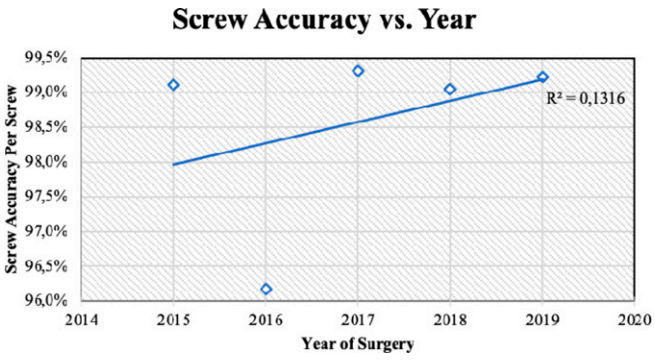
Table 3. Trends in Robot Complications and Other Surgical Complications													
	All		2015		2016		2017		2018		2019		
	N	%	N	%	N	%	N	%	N	%	N	%	
Total # of Executed Robot Screws	5,005	100.0%	226	4.5%	340	6.8%	1,018	20.3%	1,367	27.3%	2,054	41.0%	**P-Value**
Exchange of Malpositioned Robot Screw	51	1.0%	2	0.9%	13	3.8%	7	0.7%	13	1.0%	16	0.8%	**0.015**
Robot Abandonment	18	2.5%	1	2.5%	6	10.3%	4	2.4%	4	2.0%	3	1.1%	**0.011**
Due To Registration Error	12	1.7%	1	2.5%	6	10.3%	1	0.6%	1	0.5%	3	1.1%	**0.008**
Due to Unreachable Anatomy	4	0.6%	0	0.0%	0	0.0%	1	0.6%	3	1.5%	0	0.0%	0.924
Other Surgical Complications													
Dural Tear	29	4.0%	1	2.5%	1	1.7%	5	3.0%	10	5.1%	12	4.6%	0.217
Loss of Motor/Sensory Function	5	0.7%	0	0.0%	0	0.0%	0	0.0%	2	1.0%	3	1.1%	0.128
Return to Operating Room During Same Index Admission	4	0.6%	0	0.0%	0	0.0%	0	0.0%	4	2.0%	0	0.0%	0.740
Perioperative Blood Transfusion	67	9.3%	0	0.0%	7	12.1%	21	12.7%	22	11.1%	17	6.5%	0.583
Estimated Blood Loss (mL), Mean (SD)	255 (407)		89 (110)		247 (380)		239 (362)		272 (427)		281 (450)		0.082

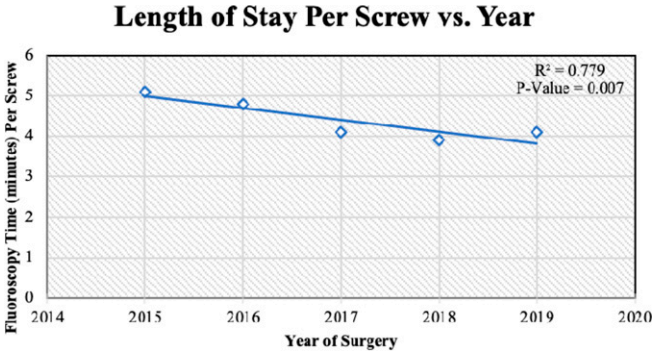
Table 4. Trends in Length of Hospital Stay and 90 Day Reoperations													
	All		2015		2016		2017		2018		2019		
	N	%	N	%	N	%	N	%	N	%	N	%	P-Value
Any Reoperation within 90Days After Index Surgery	20	2.8%	1	2.5%	2	3.4%	7	4.2%	1	0.5%	9	3.4%	0.828
Wound Complication	9	1.2%	1	2.5%	0	0.0%	4	2.4%	1	0.5%	3	1.1%	0.519
Neurologic Deficit	1	0.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	0.4%	0.308
Implant Failure	2	0.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	0.8%	0.149
Screw Malposition	1	0.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	0.4%	0.308
Dura Fistula	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	
Length of Hospital Stay, Mean (SD)	4.1 (2.2)		5.1 (1.3)		4.8 (1.8)		4.1 (2.4)		3.9 (2.5)		4.1 (2.0)		**0.007**











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A291: The iliac kickstand screw: a novel pelvic screw for correction of coronal spinal imbalance

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Summary: The "iliac kickstand screw" is a novel pelvic screw that facilitates correction of coronal spinal imbalances. It has a uniquely lateral starting point which creates a longer lever arm for distraction. It was placed in 24 consecutive patients using the free hand technique with no neurovascular or visceral complications. The mean starting point is 6cm lateral to midline on the iliac crest. The screw trajectory is approximately 10 degrees of lateral angulation and 60 degrees cephalocaudal angulation. **Hypothesis:** The iliac kickstand screw can be placed safely and reliably. **Study Design:** Retrospective radiographic study. **Introduction:** The goal of spinal deformity surgery is to restore spinal alignment in both sagittal and coronal planes. While there has been significant emphasis placed on sagittal plane correction, coronal imbalance can also be debilitating. However, correction of large coronal deformities is challenging. We recently described the "kickstand rod" technique for correction of coronal imbalance. This technique utilizes powerful "construct-to-construct" distraction between a fixed multi-screw thoracic construct and the ilium, facilitated by a novel "iliac kickstand screw". The technique for freehand placement of the "iliac kickstand screw", as well as screw trajectories and parameters, have not been previously described. **Methods:** Consecutive adult patients who underwent spinal deformity surgery and coronal imbalance correction using the "kickstand rod" by the senior surgeon were identified. All screws were placed using the free hand technique. The starting point for the screw is near the most cephalad surface of the iliac crest, approximately 6cm lateral to midline. Screw accuracy was assessed using intraoperative O-arm imaging and screw trajectories and breaches were analyzed using 3D visualization software. **Results:** Twenty four consecutive screws were analyzed. The mean patient age was 50.1 years. 20 were female. 12 were left sided screws and 12 were right sided screws. The mean starting point was 59.5 mm lateral to midline. The mean horizontal angle was 10.8°, and the mean caudal angle was 57.9 . The mean screw size was 7.88 mm (range 7.5-8.5mm) and screw length was 74.2mm (range 70-90mm) 6 of 24 screws had cortical breaches, 5 of which perforated medially and 1 of which perforated inferiorly. There were zero clinically notable neurovascular or visceral complications. **Conclusion:** The "iliac kickstand screw" is a novel pelvic screw that facilitates correction of coronal spinal imbalances. It was placed in 24 consecutive patients using the free hand technique with no neurovascular complications. **Take Home Message:** We describe a novel "iliac kickstand screw" which facilitates correction of coronal imbalance.

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A292: The "Unfair Advantage" of Mixed-Reality Simulation for Percutaneous Pedicle Screw Placement Makes it as Effective as Cadaver Training: a Prospective Randomized Study with Novice Volunteers

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Introduction: Becoming proficient in percutaneous pedicle screw placement requires training several skills such as correct c-arm adjustment, determining an ideal entry point and advancing the trocar using the projection images. The recommended gold standard training model is the cadaver. Its disadvantages are availability, cost and radiation dose. A hybrid simulator co-developed at the LMU Munich uses a clever combination of 3D printed specimens with virtual imaging and guidance to train these skills. This study will investigate the hypothesis that a mixed-reality simulator can be used to train the skill of percutaneous pedicle screw placement as effectively as with the cadaver and real

C-arm imaging. **Material and Methods:** The mixed-reality simulator consists of a torso with an exchangeable spinal segment (lumbar and thoracic models were used). All instruments are electromagnetically tracked and the software can generate x-rays in all projections as well as CT and 3D rendering images in real-time. The study design is a randomized prospective study with a simulator group and a control group training on cadavers. The study is divided into a training day followed by a test day. Initially, theoretical training was given in a common seminar format. While the control group was then intensively trained in teams of two on the cadaver itself by an experienced surgeon for > 1 hour per individual trainee, the simulator group initially received only peer-teaching by a trained student on the simulator. On the test day, the simulator group participants were individually trained by the expert for 30 minutes before the test. All participants then implanted 2 percutaneous pedicle screws on the cadaver without further assistance. After each session, a CT was performed and the screw positions were evaluated. Time, number of images and radiation dose were recorded. **Results:** 12 medical students were equally randomized to both groups. All participants completed the training and test day. The main outcome parameter quality of pedicle screw placement was evaluated on CT according to Gertzbein-Robbins (GR). The simulator group achieved GR grade A or B (under 2 mm pedicle breach) in 93% of cases, the control group only in 58%. The stat. significance was slightly missed with $P = .059$. With regard to time, there was a tendency towards superiority of the simulator group that further showed a significantly reduced radiation personal dose over both days. **Conclusion:** The simulator group showed no inferiority but a clear tendency towards superior performance. Especially compared to day 1 of the control group, a strong effect of the simulator on skills is measurable. This is probably due to the "unfair advantage" of the constant availability (training immediately before the "real intervention" is possible), the repeatability as well as the visualization (to train projection thinking) and realistic haptics of the simulator. At least for the learning of percutaneous pediculation, the simulator shows excellent transfer learning and is at least an equivalent substitute for cadaver training.

1214
A293: Procedural Metrics for Minimally Invasive Lumbar Stenosis Decompression Using a Lumbar Astenosis Simulation Model to Improve the Skills and Accelerate the Learning Curve in Orthopedic and Neurosurgical Trainees

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Introduction: Surgical training as a resident or fellow as well as during specialization on master level depends on theoretical knowledge as well as the manual ability to perform a specific task skillfully, reliable and safely. Many experienced surgeons who expertly perform a specific procedure are able to identify and agree on the essential "steps" to be completed and " errors" to be avoided, whereas they rarely think about the procedures they perform with the level of detail needed to identify those key features. Previous studies demonstrated that repetition of surgical tasks and using real surgical instruments while training on a simulator can help trainees to improve their surgical skills, performance and level of comfort during surgery. This might even be enhanced by a step-by-step guide performance metrics for a minimal invasive unilateral laminotomy for bilateral decompression (ULBD) of lumbar spinal stenosis with and without spondylolisthesis were defined in an earlier study. **Material and Methods:** In a prospective two-armed comparative study simultaneously performed at 2 centers, one in the US (Neurosurgery) and one in Germany (Orthopedic surgery) 6 trainees from each center performed three identical decompression procedures on a spinal simulator using the metrics for ULBD**.** The learning curve was evaluated regarding technical skills, timing and occurrence of errors and sentinel errors using the metrics sheet as well as instructor and personal surveys and a gap analysis. Furthermore, video recordings of all procedures were rated by 3 individual experts using a global rating scale and a video specific checklist. **Results:** Within all residents the quantity of errors and sentinel errors were significantly reduced from procedure 1 to procedure 3 with a concomitant reduction of surgical time and skipped steps. Not only did the participants report progress in subjective perception with the personal survey, but the improvement of the surgical skills with better surgical outcome, higher economy of motion and instrument use was accredited by all evaluation tools (instructor survey, gap analysis, video analysis) and within all levels of experience. **Conclusion:** Procedural metrics for ULBD in combination with a surgical simulator can be successfully used in surgical training to improve the surgical skills of surgeons of all levels.

1907
A294: Evolution of image guidance in minimally invasive transforaminal lumbar interbody fusion (MI-TLIF): comparing the learning curves of fluoroscopy, navigation and robotics

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Introduction: Intra-operative image-guidance has undergone tremendous advancements in recent years, evolving from two-dimensional modalities such as 2D fluoroscopy or serial radiography to 3-dimensional computer assisted navigation, and more recently robotics. Despite these advances, concern regarding the learning curve of new technologies remains a deterrent to greater adoption. Thus, the purpose of this study was to evaluate the learning curve of fluoroscopy, intra-operative navigation (ION) and robotic navigation for minimally invasive TLIF (MI-TLIF). **Material and Methods:** A retrospective review of prospectively collected data on consecutive patients who underwent single-level MI-TLIF by a single surgeon using fluoroscopy, intra-operative navigation or a robot was performed. Outcomes of interest were operative time, estimated blood loss, intra-operative complications, radiation exposure, length of stay (LoS) and reoperations. Chronologic case number for each modality was plotted against each outcome of interest. The derivative of a nonlinear association or dissociation curve fit to the dataset was solved for the point at which the slope of the curve equaled the linear slope. At this point, average rate of change equals the instantaneous rate of change on the nonlinear curve. Therefore, rate of change after this case will be less than the average rate of change, suggesting a plateau in learning had occurred. **Results:** Of the 225 patients included, 109 underwent MIS-TLIF using fluoroscopy, 77 using ION and 39 using robotic navigation. There was no learning curve for estimated blood loss, length of stay or operative complications in any cohort. Fluoroscopy. Median operative time was 112 minutes, fluoroscopy time 144seconds and radiation dose was 62.7 mGy. There were no intra-operative complications; 11(10.0%) patients required reoperation (2 epidural hematoma, 2 failed hardware, 2 pseudarthrosis, 2 recurrent stenosis, 3 ASD).Operative time: Proficiency: 38 cases (Before vs after proficiency = 137 vs 104minutess, $P < .0001$). Fluoroscopy time: Proficiency: 51 cases (Before vs after proficiency = 168 vs 126 seconds, $P < .0001$). Radiation dose: Proficiency: 51 cases (Before vs after proficiency = 72.05 vs 53.95 mGy, $P = .008$). Reoperations: Proficiency: 43 cases. (Before vs after proficiency = 18 vs 5%; $P = .023$). Intra-operative 3D Navigation. Median operative time was 88minutes, fluoroscopy time 25seconds and radiation dose 47 mGy. There were no intra-operative complications; 5(6.5%) patients required a repeat spin intra-operatively and 7(9.1%) underwent a reoperation (1 each - SSI, screw repositioning, cage displacement, superficial hematoma, ASD, recurrent stenosis, pseudoarthrosis with painful hardware). Operative time: Proficiency: 31 cases (Before vs after proficiency = 95 vs 80 minutes, $P < .0001$) Fluoroscopy time, radiation dose, repeat spin and reoperations: No learning curve. Robotic Navigation. Median operative time was 103 minutes, fluoroscopy time 18seconds and radiation dose 38.1 mGy. There were no intra-operative complications; the first patient required intra-operative manual repositioning of one screw (2.6%), and 1 (2.6%) required a revision surgery for residual stenosis. Operative time, fluoroscopy time and radiation dose: No learning curve. Intra-operative screw repositioning and reoperations: Could not be assessed due to low incidence. **Conclusion:** Our results suggest that newer intra-operative image-guidance modalities have the potential to reduce or even eliminate the learning curve for minimally invasive procedures and may thus allow for greater adoption of these techniques.

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A295: Does Robot-Assisted Spine Surgery Achieve Better Patient - Reported Outcomes than Freehand Techniques?

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Introduction: It is well-known that robot-assisted spine surgery can achieve similar pedicle screw accuracy as conventional freehand techniques. However, the literature comparing the patient-reported outcomes remains relatively sparse. **Material and Methods:** We included adult (≥18 years old) patients who underwent robot-assisted spine surgery from 2016 to 2018. The minimum follow-up was 2-years after the index surgery. Patients with missing values were excluded. A propensity-score matching algorithm accounted for several perioperative factors (gender, Charlson comorbidity index, preoperative diagnoses, instrumented levels, interbody fusion, and pelvic fixation) to control for the potential selection bias between freehand and robot-assisted surgery. Patient reported outcomes were measured using the Oswestry Disability Index (ODI). The minimum clinically important difference (MCID) rates between groups were assessed at each follow-up period (6-weeks, 6-months, 1-year, and 2-years). Chi-square/fisher exact test and t-test/ANOVA were used for categorical and continuous

variables, respectively. **Results:** After propensity score matching, a total of 70 patients remained. The mean (standard deviation) Charlson comorbidity index was 1.4 (1.0) and 57% of patients were female. The most common diagnoses included degenerative disc disease (37.1%), degenerative scoliosis (27.1%), and high grade spondylolisthesis (19%), and the mean number of instrumented levels was 4.6 (4.4). Rates for intraoperative complications, postoperative complications, and any reoperation within 2 years after surgery were low and similar between groups. The baseline ODI scores were similar between freehand (39.1) and robot-assisted surgery (40.5, *P*-value = .736). By two years, substantial improvements in both groups (mean ODI - freehand: 4.6, robot-assisted: 1.5; and MCID% - freehand:77.1%, robot-assisted: 82.9%) were achieved, but not significantly different. Similarly, no differences were observed for the other follow-up periods. When comparing individual component scores, the robot-assisted group scored higher in "Lifting," "Sitting," and "Standing;" however, the magnitudes of these differences were less than 1 point. **Conclusion:** In this single-surgeon series, robot-assisted spine surgery can achieve excellent and similar patient-reported outcomes to conventional freehand techniques. Future studies should include large, prospective randomized controlled trials as well as the inclusion of other patient reported outcome measures.

Table 1. Perioperative Factors Between the Freehand and Robot-Assisted Spine Surgery After Matching

	All		Freehand		Robot		
	N	%	N	%	N	%	
Patient	70	100%	35	50.0%	35	50.0%	**P-value**
Female	40	57.1%	19	54.3%	21	60.0%	0.629
Charlson Comorbidity Index, mean (sd)	1.4 (1.0)		1.2 (1.2)		1.5 (0.9)		0.213
Race							
Caucasian	59	84.3%	31	88.6%	28	80.0%	0.369
African American	8	11.4%	2	5.7%	6	17.1%	
Asian American	1	1.4%	1	2.9%	0	0.0%	
Other	2	2.9%	1	2.9%	1	2.9%	
American Society of Anesthesiologists, mean (sd)	2.2 (0.5)		2.2 (0.5)		2.2 (0.5)		0.636
Body Mass Index, mean (sd)	27.9 (5.3)		27.5 (5.5)		28.4 (5.2)		0.509
Prior/Current Smoker	45	64.3%	20	57.1%	25	71.4%	0.212
Osteoporosis/Osteopenia	18	25.7%	9	25.7%	9	25.7%	1
Hypothyroidism	12	17.1%	7	20.0%	5	14.3%	0.526
Anxiety	15	21.4%	7	20.0%	8	22.9%	0.771
Depression	8	11.4%	4	11.4%	4	11.4%	1
Diagnosis							
Degenerative Scoliosis	19	27.1%	8	22.9%	11	31.4%	0.148
Degenerative Disc Disease	26	37.1%	12	34.3%	14	40.0%	
High Grade Spondylolisthesis	13	18.6%	5	14.3%	8	22.9%	
Pseudarthrosis	11	15.7%	9	25.7%	2	5.7%	
Other	1	1.4%	1	2.9%	0	0.0%	
Operative							
Interbody Fusion	60	85.7%	28	80.0%	32	91.4%	0.172
ALIF	1	1.4%	0	0.0%	1	2.9%	0.092
TLIF	4	5.7%	0	0.0%	4	11.4%	
OLIF	55	78.6%	28	80.0%	27	77.1%	
Instrumented Levels Per Patient, mean (sd)	4.6 (4.4)		4.7 (4.8)		4.5 (4.0)		0.850
Pelvic Fixation	28	40.0%	11	31.4%	17	48.6%	0.143

Table 2. Bivariate Comparison of Freehand versus Robot-Assisted Spine Surgery for Inpatient Complications							
	ALL		Freehand		Robot		
	N	%	N	%	N	%	
Total Number of Patients	70	100%	35	50.0%	35	50.0%	**P-value**
Operative Time (minutes), Mean (sd)	304 (147)		291 (146)		317 (152)		0.484
Intraoperative Complication							
Dural Tear Requiring Repair	10	14.3%	2	5.7%	8	22.9%	0.084
Motor/Sensory Deficit	2	2.9%	1	2.9%	1	2.9%	1
Estimated Blood Loss (mL), Mean (sd)	544 (471)		496 (376)		591 (558)		0.410
Robot Abandonment					4	11.4%	
Postoperative Complication/Outcomes							
Perioperative Blood Transfusion	17	24.3%	9	25.7%	8	22.9%	0.781
Return to Operating Room During Same Inpatient Stay	0	0.0%	0	0.0%	0	0.0%	
Motor/Sensory Deficit	0	0.0%	0	0.0%	0	0.0%	
Length of Stay, mean (sd)	5.2 (6.0)		5.7 (7.9)		4.7 (3.5)		0.534
Postdischarge Complications							
Any Reoperation within 2 Years After Index Admission	3	4.3%	2	5.7%	1	2.9%	0.555
Wound Complication	2	2.9%	1	2.9%	1	2.9%	1
Implant Failure	1	1.4%	1	2.9%	0	0.0%	0.314

Table 3. A Comparison of the Overall ODI (mean [sd]) Score by Follow-up for Freehand versus Robot-assisted Spine Surgery				
	All	Freehand	Robot	P-Value
Baseline	39.8 (16.8)	39.1 (16.5)	40.5 (17.5)	0.736
6 Weeks	23.9 (19.4)	27.9 (23.0)	20.9 (16.3)	0.180
6 Months	9.2 (14.3)	11.0 (14.2)	7.8 (14.7)	0.384
1 Year	5.5 (9.3)	7.3 (9.9)	3.8 (8.6)	0.125
2 Years	3.1 (7.5)	4.6 (1.2)	1.5 (0.2)	0.088

Table 4. The % of Patients who Achieved the Minimum Clinically Important Difference Threshold at Each Follow Up (Reference is Baseline)							
	ALL		Freehand		Robot		
	N	%	N	%	N	%	P-value
6 Weeks	20	28.6%	7	20.0%	13	37.1%	0.112
6 Months	40	57.1%	18	51.4%	22	62.9%	0.334
1 Year	52	74.3%	24	68.6%	28	80.0%	0.274
2 Years	56	80.0%	27	77.1%	29	82.9%	0.550

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A296: Clinical Outcomes and Complications of Computer Navigated Minimal Invasive Postero-Lateral Sacro-Iliac Joint Fusion Using a Threaded Bolt System

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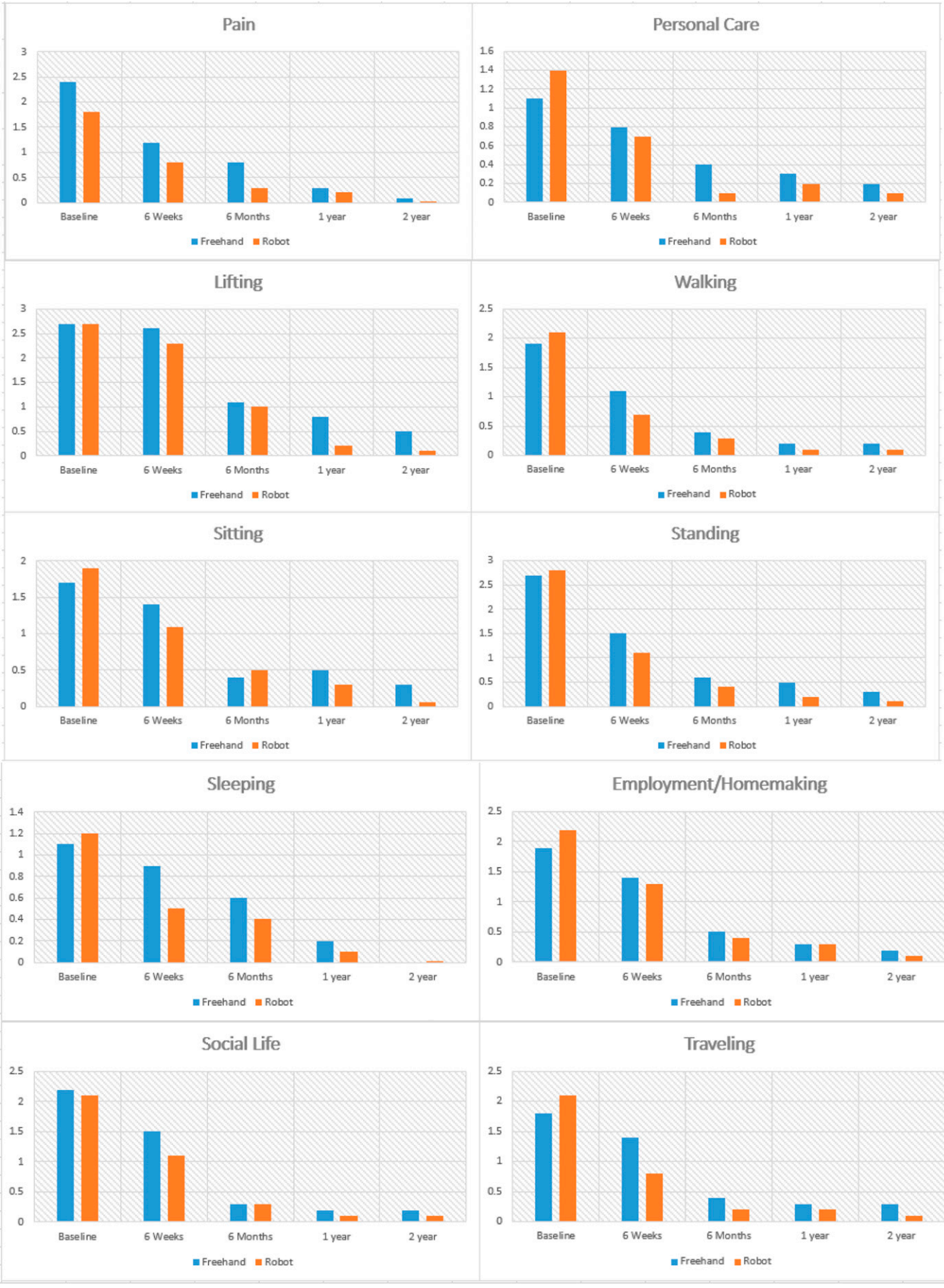
Introduction and Purpose: We report the clinical and radiological outcomes or a retrospective case series (novel postero-medial approach) to perform a minimal invasive SIJ fusion using a threaded bolt system performed under computer navigation. **Materials and Methods:** Between September 2017 and August 2020, we identified 27 consecutive patients undergoing SIJ fusion. The diagnosis of SIJ pain was made following a detailed clinical history, examination, CT and MRI scans, followed by positive diagnostic injections. Patient related outcome measures (PROMS) were collected preoperatively, 3 months, and 6 months postoperatively. PROMS included Oswestry Disability Index (ODI), SF-36, EQ5-D, Visual Analog Scale (VAS) for both back (BP) and leg pain (LP). We collected estimated blood loss (EBL), duration of surgery (DOS) and length of hospital stay (LOS). Technique: In a prone position, a 2 cm skin incision is made 2 cm lateral and superior to the postero-superior iliac crest. Then 2 implants were threaded across the SIJ via a postero-medial 'tubular' approach under 3D computer navigation, aimed parallel to the S1 endplate or pointed toward the sacral promontory, and crossing just proximal to the SIJ sulcus into the subchondral bone. Appropriate length threaded hollow bolts that was packed with local bone autograft and allograft (human DBM) before final insertion through the pilot hole. **Results:** There were 77% female and 23% male with mean age 53 (24-85) years,


Pain
3
2.5
2
1.5
1
0.5
0
Baseline
6 Weeks
6 Months
1 year
2 year
Freehand
Robot
Personal Care
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Baseline
6 Weeks
6 Months
1 year
2 year
Freehand
Robot
Lifting
3
2.5
2
1.5
1
0.5
0
Baseline
6 Weeks
6 Months
1 year
2 year
Freehand
Robot
Walking
2.5
2
1.5
1
0.5
0
Baseline
6 Weeks
6 Months
1 year
2 year
Freehand
Robot
Sitting
2
1.5
1
0.5
0
Baseline
6 Weeks
6 Months
1 year
2 year
Freehand
Robot
Standing
3
2.5
2
1.5
1
0.5
0
Baseline
6 Weeks
6 Months
1 year
2 year
Freehand
Robot
Sleeping
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Baseline
6 Weeks
6 Months
1 year
2 year
Freehand
Robot
Employment/Homemaking
2.5
2
1.5
1
0.5
0
Baseline
6 Weeks
6 Months
1 year
2 year
Freehand
Robot
Social Life
2.5
2
1.5
1
0.5
0
Baseline
6 Weeks
6 Months
1 year
2 year
Freehand
Robot
Traveling
2.5
2
1.5
1
0.5
0
Baseline
6 Weeks
6 Months
1 year
2 year
Freehand
Robot

average LOS 2.1 days (range 1-3), mean EBL <20 ml, and DOS 60 minutess (range 40-120). For ODI, statistically significant mean improvements from pre-operative at 3 and 6 months follow-up were 11.9 ± 9.1 ($P < .001$) and 18.2 ± 13.7 ($P < .001$) respectively. For VAS BP, similar significant mean improvements of 2.6 ± 2.1 ($P < .0001$) and 3.5 ± 2.2 ($P < 001$), and for VAS LP of 2.8 ± 2.8 ($P < .0001$) and 3.3 ± 2.5 ($P < .0001$). The PCS and MCS domains of SF-36 and EQ-5D will be presented at the congress. 14 patients had history of previous lumbar spine surgery.Based on a previous study 1 the percentage of patients that met the MCID at 6 months for ODI, VAS BP and VAS LP were 66%, 85% and 77% respectively. No serious adverse events occurred, and no one required a return to the operating theatre for revision surgery. **Conclusions:** Surgery using this threaded Titanium hollow bolt system performed via a novel postero-medial approach under 3D computer navigation allows for a truly safe minimal invasive surgery to fuse the SIJ. The technique results in minimal blood loss, rapid patient mobilization and early discharge home within 48 hours. Early 6 months results show statistically significant improvements in all aspect of PROMS and MCID. Further follow-up at 1 and 2 years will continue to confirm the durability of this technique.

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A297: First Experiences With a Reinforced Lumbopelvic Fixation Technique with 6 Months Follow-Up

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Introduction: Lumbopelvic fixation is a common procedure in primary and revision spinal surgery but leads to high biomechanical stress on adjacent segments and the SIJ, resulting in implant failure such as breakage and loosening and pain. This frequently results in further surgery. For patients showing clinical and radiological signs of SIJ affection/arthrosis who fail conservative therapy, lumbopelvic fusion may be considered. The Bedrock™ technique has been described as a new option for reinforced lumbopelvic fixation, fusing the SIJ with additional triangular titanium implants, thereby reducing biomechanical loads off the S2AI screws. We share our first experiences with this new technique with a mean follow-up of 6.6 (SD = 6.6) months. **Materials and Methods:** Six patients suffering from persisting low back pain (LBP) with indication for reinforced lumbopelvic fixation and SIJ fusion were treated with this new technique. All surgeries were carried out by a single surgeon at our orthopedic university hospital. Data was gathered retrospectively. **Results:** Since January 2019, six patients (3f, 3m) were treated with reinforced lumbopelvic fixation and SIJ fusion with a mean follow up of 6.6 months (SD = 6.6). Walking distance was reduced to an average < 100 m. Standard treatment involved S2AI screws and triangular titanium implants (SIBone, iFuse 3D™) Five patients had prior lumbar or lumbosacral fusion but persistent LBP and significant SIJ arthrosis. Three patients had screw loosening and/or low grade infection of the screws. One patient suffered from multisegmental osteochondrosis/SIJ arthrosis. Mean age was 72.5 years (SD = 10.2), mean length of stay in hospital was 15.7 days (SD = 9.4). Average number of fused lumbar/thoracic segments 3.8 (SD = 2.1). Sagittal balance improved from (PI-LL) pre-OP 32.2° (SD = 22°) to post-OP 20.6° (SD = 11.5°). Average implant length was 65 mm bilaterally. There were no intraoperative or implant associated adverse events (AE) or serious adverse events (SAE). Postoperative imaging demonstrated good implant positioning and function. At time of article submission, all patients regained walking ability for distances > 1000 m and were satisfied with the result. All patients reported significant reduction of SIJ pain. One revision case had prior suspicion of infection that was treated conservatively via i.v. and oral antibiotics. One dural tear occurred at the lumbar level. One patient had a L5 screw misplacement requiring revision surgery six months later. **Conclusion:** We report our results of six patients with a new reinforced lumbopelvic fixation and fusion by S2AI screws augmented by one parallelly placed triangular titanium implant fusing the SIJ bilaterally with a mean follow-up of 6.6 months. Intra- and postoperatively we experienced no implant associated adverse event. Patients regained significant walking ability and significant reduction of SIJ pain. Radiologically no signs of implant loosening or failure were detected at the end of follow-up. Our first results seem to demonstrate a safe and efficacious surgical technique for reinforced lumbopelvic fixation with fusion of SIJ with significant improvement of the health care related quality of life. Further studies need to be conducted in order to obtain additional evidence.

OP34: Trauma-Cervical

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A298: Long Term Proms (Patient Reported Outcome Measures) for the Non-Operative Management of Odontoid Peg Fractures in the Elderly

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Objectives: Controversy persists on the best management of C2-peg fractures in the elderly. The aim of this study was to investigate the effect of conservative treatment with a neck brace using patient-reported outcome measures. **Design:** This was a questionnaire-led, prospective cohort study. **Subjects:** Elderly patients with a type II C2-peg fracture who were managed in a brace for three months between June 2015 and March 2019 were divided into three age groups: 65-75, 75-85 and >85. **Methods**: Participants were invited to complete COMI and NDI questionnaires. Results were collated, stored on a database and analysed using descriptive statistics. Means are reported with standard deviation, and medians with interquartile range. **Results:** 110 patients completed the NDI and 107 patients completed the COMI. The mean age for the COMI and NDI was 78.3 (±8.0) and 78.2 (±8.1) years. The median examination interval was 6.4 (5.3) and 6.3 (4.0) months for the COMI and NDI respectively. Whilst 29% of the whole cohort reported no problems, 50% reported some neck pain but only 15% describing this pain as severe. 34% reported no pain. 77% experienced nil, slight or infrequent headaches. 62% had sleepless nights only lasting 0-2 hours. Mean neck pain was rated 3.5 (±2.9)/10, with mean arm/shoulder pain rated 2.4 (±2.9) /10. Pain decreased as examination interval increased in groups 65-75 and 75-85, but not in those aged >85 where pain slightly increased. Overall 75% described their quality of life (QoL) as very good, good or moderate. These results were maintained across all age groups, with 50% aged >85 experiencing no pain and 69% rating their QoL as very good, good or moderate. **Conclusion:** Neck brace management of C2-peg fractures for three months avoids the risks of surgery and has a clear benefit with a good patient-reported QoL and minimal effect on the functional aspects of patients' lives.

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A299: Variation in Global Treatment Practices of Subaxial Cervical Facet Fractures

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Introduction: The management, including the workup and treatment, of unilateral subaxial facet fractures remains controversial. Given this uncertainty, it is important to understand the effects of regional bias on the treatment of facet fractures and elucidate what surgeon characteristics influence treatment preferences. The goal of this study, therefore, is to determine the variation in the global treatment practices for unilateral facet fractures, and to determine how surgeon experience, practice setting, and subspecialty affect the work-up and treatment of subaxial cervical spine facet fractures. **Methods:** A 22-question survey was sent to 272 members of the AO Spine Cervical Classification Validation Group. These spine surgeons represent six world regions: North America, Latin and South America, Europe, Africa, Asia, and the Middle East. Clinical vignettes consisted of fracture types F1-F3 with various associated neurologic injuries (N0-N2) classified using the AO Spine Subaxial Cervical Classification System. Questions surveyed surgeon preferences with regards to diagnostic workup and management. **Results:** A total of 161 responses were received. The AO Spine Subaxial Classification system remains the most widely used classification system among surgeons globally, preferred by 71.9% of all surgeons, with no statistically significant differences between world regions, surgeon experience, practice setting, or surgical subspecialty. Academic surgeons use the facet portion of the AO Spine classification system less frequently (61.6%) compared to hospital employed and private practice surgeons (81.1% and 81.8%, respectively) ($P = .029$). The overall consensus was for the operative treatment of any facet fracture with radicular symptoms and for any fractures categorized as F2N2 and above (ie F3N0, F3N1, F3N2). For F3N0 fractures, significantly less surgeons from Africa/Asia/Middle East (49%) and Europe (59.2%) chose operative treatment than from North/Latin/South America (74.1%) ($P = .025$). For F3N1 fractures, significantly less surgeons from Africa/Asia/Middle East (52%) and Europe (63.3%) recommended operative treatment than from North/Latin/South America (84.5%) ($P = .001$). For fractures treated non-operatively, the preferred method by the majority of surgeons was immobilization in a hard collar. No consensus could be made regarding anterior versus posterior surgical approach for operative management. Greater than 95% of surgeons included CT in their work-up of facet fractures, regardless of type. No statistically significant differences were seen in the need for MRI to decide treatment. **Conclusion:** This is the first study to evaluate global variation in the management of subaxial facet fractures. This study demonstrates considerable agreement between surgeon preferences with regards to facet fracture management despite differences in geographic region, surgeon experience, practice setting, or subspecialty with few exceptions.

522
A300: Posterior Atlantoaxial Fusion: Technique and Retrospective Case Series

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Introduction: The most common indications for posterior atlantoaxial fusion are trauma and degeneration, which can encompass a spectrum of pathologies including atlantoaxial arthrosis and atlantoaxial instability. This study is a description of technique with accompanying operative video and retrospective case series of patients undergoing posterior atlantoaxial fusion. **Material and Methods:** All patients who underwent atlantoaxial posterior fusion by one surgeon at an academic medical center between 2010 and 2018 were included. Primary outcome measures included number of levels instrumented, estimated blood loss (EBL), complications, reoperations, length of stay, destination upon discharge, and rate of postoperative fusion which was assessed by computed tomography (CT) at the 12 month postoperative visit. Patient reported outcomes, prospectively collected and retrospectively analyzed, including Short Form Survey (SF-12), Modified Japanese Orthopedic Association Scale (mJOA), Neck Disability Index (NDI), and Visual Analogue Scale (VAS) were also assessed. **Results:** The key aspects of the employed operative technique include: positioning of the patient under live fluoroscopic x-ray to ensure adequate visualization of C1 and C2, coagulation and division of the C2 nerve roots proximal to the ganglion, placement of bilateral machined cortical allografts into the C1-2 facet joint space, placement of bi-cortical guide holes into each C1 lateral mass using a 0.63mm K-wire and drill prior to placement of C1 lateral mass screws, passage of a suture beneath the lamina of C1 tied to an Atlas cable that is then looped around the spinous process of C2 and used to tightly secure a rib graft in place. Forty-seven patients (mean age 65.4 ± 15.8 years) were included in analysis following C1-2 fusion with mean follow-up 13.8 ± 11.4 months. The most common surgical indications were C1-2 instability, C1-2 arthrosis, and type II odontoid fracture. The mean total number of instrumented levels was 2.6 ± 1.2. Mean estimated blood loss was 351.1 ± 390.4cc. The minor complication rate was 12.8%, with the most common complication being postoperative hyponatremia, and major complication rate was 2.1%, a single postoperative mortality related to multisystem organ failure. The reoperation rate was 8.5% and the average time to reoperation was 436.3 ± 576.5 days. Average length of stay was 7.6 ± 9.1 days. Seventy-four percent of patients were discharged to home. The postoperative fusion rate was 81%. Postoperatively, SF-12 mental health and physical health scores increased from 40.8 ± 11.3 and 33.8 ± 9.9 to 48.1 ± 10.3 and 36.0 ± 11.1, respectively. The increase in the SF-12 mental health was statistically significant(P = .002). NDI decreased from 43.4 ± 16.4 to 38.5 ± 24.3. VAS-neck scores significantly decreased from 6.4 ± 2.5 to 4.2 ± 2.8 (P = .002). There were no significant changes in mJOA or VAS-arm scores. **Conclusion:** The above technique for C1-2 fusion has shown to be safe with a major complication rate of 2.1% and reoperation rate of 8.5% and effective with a high rate of postoperative fusion (81%) likely related to the fastidious operative technique. During the course of the study patients showed significant improvements in SF-12 mental health and VAS-neck scores. Although there was a decrease in NDI postoperatively, the difference was not statistically significant.

1172
A301: Risk Factors Associated with 90-Day Readmission Following Odontoid Fractures - A Nationwide Readmissions Database Study

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Introduction: Hospital readmissions represent a large financial burden upon our healthcare system. Management of odontoid fractures, which are the most common isolated spine fracture in the elderly, continues to be debated. We used the Nationwide Readmission Database (NRD) to identify readmission rates and factors related to readmission after surgical and non-surgical management of odontoid fractures. **Methods:** A retrospective study was performed using the 2016 Healthcare Utilization Project (HCUP) NRD. Demographic information and factors associated with readmission were collected. Readmission rates, complications, length of hospital stay were collected. Patients treated operatively, non-operatively, and patients who were readmitted or not readmitted were compared. Statistical analysis was performed using open source software SciPy (Python v1.3.0) for all analyses. **Results:** We identified 2,921 patients who presented with Type II dens fractures from January 1st 2016 to September 30th 2016, 555 of which underwent surgical intervention. The readmission rate in patients who underwent surgery was 16.4% (91/555) and 29.4% (696/2366) in the non-operative group. Hospital costs for readmitted and non-readmitted patients were $353,704 and $174,922, and $197,099 and $80,715 for non-operatively managed patients, respectively. Medicaid and Medicare patients had the highest readmission rate in both groups. Charlson and Elixhauser comorbidity indices were significantly higher in patients who were readmitted (P < .0001). **Conclusion:** We report an overall 90-day readmission rate of 16.4% and 29.4%, in operative and non-operative management of type II odontoid fractures, respectively. In the face of a rising incidence of this fracture in the elderly population, an understanding of the comorbidities and age-related demographics associated with 90-day readmissions following both surgical and non-surgical treatment are critical.

1263
A302: Diagnostic Imaging in Subaxial Discoligamentous Injury - Is CT Sufficient?

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Introduction: Traumatic injuries of the cervical spine can be accompanied by significant neurological deficits and an impaired prognosis. Choosing the best therapy and prevention of secondary injuries relies on an adequate and reliable diagnostic. Discoligamentous injuries are often concomitant to cervical fractures or can appear as solitary lesions and still are diagnostic challenging. The aim of our study was to assess the sensitivity and specifity of CT and MR imaging for diagnosis of discoligamentous injuries. **Methods:** In this retrospective study, only patients after subaxial cervical spine injuries with abnormal findings on initial CT or MR imaging were included. Vertebral body burst fractures and luxation injuries were excluded. Clinical data was extracted from in-house medical charts. **Results:** In this retrospective study, a total of 34 patients, treated between 2010 and 2018 at our department, were included. 31 cases were examined with initial CT and followed MRI scan, 3 cases had only an MRI scan. Neurological status was unaffected within 13 patients, 8 showed injuries of cervical nerve roots, incomplete tetraplegia was observed in 10 patients, complete paraplegia/tetraplegia in 2. Primary CT was suspicious for discoligamentous injuries in 24 cases, MRI scan was followed in all these patients. Within 3 of these, no lesion was detected within MRI and flex/ext. x-ray films. In 7 cases, CT finding was primary negative, but MRI was performed due to neurological deficits, radicular pain or severe neck pain. In all of these cases, MRI revealed a discoligamentous injury. A total of only one MRI was confirmed false negative with gross instability in flex/ext. x-ray films and complete disc rupture shown during surgery. 3 CT scan were rated false positive and another 6 as false negative. 29 cases were treated surgically, one with external bracing and 4 patients with conservative therapy. **Conclusions:** Beside an accurate diagnostic quality of CT for bony injuries of the cervical spine after trauma, for the detection of discoligamentous injuries MRI is still superior. Despite the higher sensitivity of MRI, some cases will still need a further clinical evaluation or dynamic motion studies via flexion-extension X-ray films. A clinical neurological symptomatic, also pain too, should be indication for MRI.

1259
A303: Traumatic Cervical Spine Injuries in Rugby Players: A South American Trinational Case Series

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Introduction: Traumatic cervical spine injuries may carry catastrophic consequences to patients and their families. Although infrequent, their incidence after rugby-related trauma has increased in recent years, as reported mainly in literature from the UK, France and New Zealand. Until the year 2000, most of these lesions were produced by traumatic mechanisms to the cervical spine occurring during a scrum, leading to modifications in scrumming regulations, which helped to reduce the injury risk in forwards. Recent literature has reported a higher incidence of injuries among backs and during tackling. There is still no consensus regarding return to rugby practice after a traumatic cervical spine injury. We describe a case series of rugby players from three Latin American countries with traumatic cervical spine injuries due to game-related trauma, focusing on injury mechanism, treatment modality and return to play. **Material and Methods:** Retrospective, descriptive case series. We collected cases of rugby-related traumatic cervical spine injuries using the authors' network of spine surgeons in Argentina, Chile and Uruguay. We used an electronic spreadsheet format to collect several variables (demographics, player position, injury mechanism and type, diagnostic study, treatment and return to sport, particularly return to rugby). The information was filled in by the collaborating spine surgeons and all the collected data was pooled into one file for statistical analysis. **Results:** We collected a total of 38 male patients (63.2% from Argentina, 21% from Chile and 15.8% from Uruguay), injured between 1993 and 2019. Mean age 22 years (range 15-35 years) and 57.9% were backs. Regarding the mechanism, 52.6% of the patients were injured during tackles (even distribution of tacklers and tackled players), 28.9% in scrums and 18.4% during other formations. All the patients presented single-level injuries, with fracture-dislocations as the most frequent type of lesion (57.9%), followed by fractures (26.3%) and traumatic cervical disc herniations (15.8%). The most affected levels were C5-C6 and C6-C7 (23.7% each). Under one third of the patients (31.6%) was able to continue playing after the injury and 55.3% presented some type of neurological impairment, ranging from complete tetraplegia (7.9%) to transient radicular symptoms. Thirty-one patients (81.6%) required surgical treatment, mainly in the form of an anterior cervical discectomy and fusion (45.2%), while 25.8% required a combined anterior/posterior approach. Regarding return to sports, 73.7% was able to resume some type of sport, while 78.6% of them (22/28 patients) returned to rugby, with a median of 314 days after the accident (range 55-609 days). **Conclusion:** Traumatic cervical spine injuries

must be ruled-out in rugby players presenting neck pain and/or neurological symptoms after a game-related trauma. In line with recent literature, in our case series the incidence was higher among backs and during tackling and their treatment usually required surgery. Although over 50% was able to return to rugby, there is still no consensus regarding this topic.

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A304: Regional and Experiential Differences in Surgeon Preferences for the Treatment of Cervical Facet Injuries

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Introduction: The management of cervical facet dislocation injuries remains controversial. There is persistent debate among surgeons regarding imaging modalities, the appropriateness of nonoperative management, as well as surgical approach. The main purpose of this investigation was to identify whether a surgeon's geographic location or years in practice influences their preferred management of traumatic cervical facet dislocation injuries. **Methods:** A 25-question survey was sent to 272 AO Spine members located in six different geographic regions (Africa, Asia, Europe, Latin/South America, the Middle East and North America) with various years of practice experience. The survey included clinical case scenarios of cervical facet dislocation injuries and asked responders to select preferences among various diagnostic and management options. **Results:** A total of 189 complete responses were received. Over 50% of responding surgeons in each region elected to initiate management of cervical facet dislocation injuries with an MRI, with 6 case exceptions. Overall, surgeons that chose operative management were more likely to intervene with an anterior cervical discectomy and fusion (ACDF) for either bilateral (43.3%) or unilateral (46.0%) jumped facets status post-reduction. There was considerable agreement between American and European responders regarding management of these injuries, with only 3 cases exhibiting a significant difference. Additionally, results also exhibited considerable management agreement between those with ≤ 10 and > 10 years of practice experience, with only 2 case exceptions noted. **Conclusion:** More than half of responders, regardless of geographical location or practice experience, identified MRI as a screening imaging modality when managing cervical facet dislocation injuries, regardless of the status of the spinal cord and prior to any additional intervention. Additionally, a majority of surgeons would elect an anterior approach for the surgical management of these injuries. The study found overall agreement in management preferences of cervical facet dislocation injuries around the globe.

1420

A305: Unstable Jefferson Burst Fractures: Intraoperative Stability Testing After Posterior Atlas Ring Osteosynthesis (C1-Ro) Regardless of Dickman Type Transverse Atlantal Ligament (Tal) Lesion Allows Determination of The Extent of the Surgical Procedure

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Introduction: Atlas ring osteosynthesis (C1-RO) is a motion preserving operative option in unstable Jefferson burst fractures (JBF). Dickman type II transverse atlantal ligament (TAL) lesion is a commonly accepted indication for C1-RO. There is one biomechanical and one clinical report that Dickman type I TAL lesions may also be treated with C1-RO. In 2017, we introduced an intraoperative stability test to assess craniocervical and C1-C2 stability in posterior C1-RO. The objective of this work is to present mid-to longterm results of posterior C1-RO vs C1-C2 stabilization in unstable JBF based on the results of the intaoperative stability test after C1-RO -regardless of Dickman type TAL lesion. **Material and Methods:** The clinical findings (pain and clinical ability to rotate the head) and radiological results (CT-scan and flexion-extension-views postoperatively and at last observation) of 5 consecutive cases (47-75 years age, mean age 61) with unstable JBF (two

Dickman type I, three Dickman type II lesions) from 2017-2019 with posterior C1-RO or C1-C2 osteosynthesis with therapy decision after reduction, C1-RO and intraoperative stability test, were retrospectively analyzed. **Results:** Surgical procedures were completed as C1-RO in 4 patients, as sufficient stability could be assessed intraoperatively. One C1-RO (a JBF with a Dickman Type II lesion) was converted intraoperatively to a C1-C2 osteosynthesis with a cross connector because of assessment of significant instability C1-C2 in the intraoperative stability test by means of tilting C1 over C2. In all cases of C1-RO, bony stabilization of the atlas ring could be demonstrated during the follow-up period (3.5-21 months postoperatively). No morbidity was observed. The anterior atlanto dental interval (AADI) in the flexion-extension x-ray views did not increase during follow-up period (mean 12 months postoperatively) and all patients were free of significant pain. Therefore, no case with C1-RO had to undergo further surgical stabilization procedure. **Conclusion:** The intraoperative stability test in treatment of unstable JBF by means of posterior C1-RO with reposition enables the determination of the extent of the surgical procedure. Dickman type I TAL lesions may also be treated with C1-RO, if found stable in the test after lifting up C0 and restoring longitudinal stabilizers, as the assessed intraoperative stability remains. Furthermore, we suggest that any attempted posterior C1-RO in unstable JBF should undergo intraoperative stability testing after initial C1-RO to assess individual resulting stability. Hence we think that the ability to test stability intraoperatively is an advantage of the posterior over the anterior C1-RO.

1807
A306: Isolated C1 Fixation for Traumatic Jeffersons Fractures Using a Novel Surgical Technique

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Introduction: Isolated C1 fractures are commonly managed non-operatively. Patients report severe neck pain and often treatment involves prolonged use of a hard collar for immobilisation. The traditional operative approach for unstable C1 fractures involved a C1-2 fixation causing significant reduction in patient's rotational movement of the neck. Here the authors describe their novel technique of C1 fixation and report the clinical outcomes in our cohort of patients. **Material and Methods:** Retrospective review of prospectively collected electronic database. All patients with a diagnosis of C1 fracture who underwent spinal surgery between January 2017 and July 2020 at Royal London Hospital (RLH) were included. Patient demographics, radiological fracture characteristics, surgical procedure details and clinical outcomes were extracted by case note review. Study methods were compliant with the STROBE checklist. **Results:** 11 consecutive patients with traumatic C1 fractures underwent surgery using our novel technique at RLH during the study period. Male:Female = 9:2. Mean age = 59.1 years (range 23-84 years). Patient reported neck pain improved significantly following surgery ($P = .0008$ 95% CI = 1.74-4.26; paired t-test). One patient returned to theatre for re-positioning of metalwork. All patients maintained their neurological function post-operatively. Mean length of inpatient hospital stay = 8.25 days (range 1-30 days). Rotational movement was generally well preserved. **Conclusion:** We report a novel technique of C1 fixation that allows early removal of a collar and effective fracture reduction thereby facilitating fusion. We report good clinical outcomes with patients maintaining functional rotational movement and improvements in pain scores following surgery. Our series suggests that in carefully selected cases isolated C1 fixation may be used to treat traumatic C1 fractures effectively.

OP35: Arthroplasty-Cervical

1032
A307: Preoperative Ossification and Range of Motion were Risk Factors for High-Grade Ossification

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Introduction: Heterotopic ossification (HO) was one of the main postoperative complications following TDR, however, the etiology of HO remains unclear. As we all know, mild HO such as McAfee I or II was considered not clinically relevant, but severe HO which grades III or IV was of great clinical significance. Although it was widely accepted that HO will progress as times goes by, direct studies about risk factors for high-grade HO are still limited. Additionally, the impact of HO on clinical outcomes remains controversial. The present study included the largest sample size among any known HO studies and the objective of this study was to explore the risk factors for HO and high-grade HO, as well as their effect on clinical outcomes. **Material and Methods:** Overall, 286 patients with TDR or hybrid surgery were involved in the present study. The sex, age, clinical symptoms, surgical procedures, involved levels, follow-up period, preoperative ossifications, and preoperative operative range of motion of replacement level were collected as the potential risk factors for HO. The JOA, NDI, VAS scores and range of motion of replacement levels and the cervical spine were collected to evaluate the impact of HO on clinical outcomes. Preoperative ossifications including (1) ossification of anterior/posterior longitudinal ligament; (2) bubble osteophytes; (3) ROM-limiting osteophytes; (4) ligamentum nuchae ossification. **Results:** There were 125 patients with single-level TDR, 21 patients with double-level TDR, 72 patients with double-

level hybrid surgery and 68 patients with three-level hybrid surgery involved in this study. HO was found in 186 (65.03%) patients while high-grade HO was observed in 26 (9.09%) patients. The preoperative ossification signs ($P < .001$, OR: 2.991, 95%CI: 1.759-5.085) and ROM of replacement levels ($P = .017$, OR: .934, 95%CI: .884-.988) were shown to be significant factors of HO occurrence in logistic regression. No significant differences were found in JOA($P = 0.123$), NDI($P = 0.925$) and VAS($P = .074$) scores between patients with and without HO. Although more ROM was found in patients without HO, no statistical differences were found between them at the final follow-up. And the logistic regression showed that the preoperative ossification signs ($P = .022$, OR: 3.282, 95%CI: 1.183-9.108) and ROM of replacement levels ($P = .005$, OR: .830, 95%CI: .729-.944) were risk factors for high-grade HO. The ROM of replacement levels in high-grade HO group were significantly lower than those without high-grade HO (3.96° vs 10.06°, $P < .001$), as well as the ROM of C2-7 (44.44° vs 52.43°, $P = .004$). **Conclusion:** Preoperative ossification signs and preoperative ROM of replacement levels were considered as the risk factors of HO and high-grade HO. No differences were observed on clinical outcomes and postoperative ROM between patients with and without HO. However, the ROM of replacement levels and the cervical spine were significantly limited in patients with high-grade HO. The results of this study might provide more evidence that HO is likely a reflection of the patients' own characteristics rather than an unnatural phenomenon and unpredictable postoperative complication.

1001
A308: Comparison of Two Anterior Hybrid Techniques for Three-Level Cervical Degenerative Disc Disease

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Introduction: In recent years, novel hybrid surgery that incorporate anterior cervical discectomy and fusion, and total disc replacement has clinically been widely in use. Based on the number of the implanted disc, three-level hybrid surgery is categorized into two groups including, single fusion combined double replacement (1F2R) and single replacement combined double fusion (1R2F). Previous studies have primarily focused on fusion versus hybrid or replacement versus hybrid. However, limited studies have directly compared the clinical characteristics of different hybrid techniques. Herein, we aimed to compare the clinical and radiological outcomes between the two groups and assess the characteristics and benefits of both operations. **Material and Methods:** Sixty-four consecutive patients who underwent three-level hybrid surgery by single fusion combined with double replacement or single replacement combined with double fusion were retrospectively evaluated. The clinical outcomes such as VAS, JOA score, and JOA recovery rate was collected. And radiological evaluation including range of motion and cervical lordosis were analyzed. Heterotopic ossification was assessed according to the McAfee classification and dysphagia was quantified using Bazaz scoring system. The reoperation rate and other complications were all collected. **Results:** In total, 32 patients were involved in 1F2R group and 32 patients in 1R2F group, and all the patients had a satisfactory clinical outcome. The JOA recovery rate of 1F2R and 1R2F group was 76.47% and 76.09%, respectively. And no significant differences were observed on VAS scores between two groups at the last follow-up. The C2-7 cervical lordosis was similar between two groups at the last follow-up, however, there was a statistical difference in the 1R2F group when compared to the preoperative level (pre 6.48° vs last 10.12°, $P = .003$). The range of motion decreased in both two groups, but 1F2R group showed a better range of motion at the final follow-up (38.25° vs 29.17°, $P = .001$). Heterotopic ossification was observed in 10 segments (15.63%) in 1F2R group and 17 levels (53.13%) in 1R2F group, but severe heterotopic ossification was only observed in 2 and 1 patients in 1F2R and 1R2F group, respectively. Additionally, one patient underwent the re-operation for the fourth level in 1F2R group and no spinal cord injury, wound infection or hoarseness were observed. **Conclusion:** This study indicated that the two kinds of hybrid surgery incorporating fusion and non-fusion are safe and effective in the treatment of three-level CDDD. The 1R2F operation was better in correcting the cervical lordosis irrespective of higher incidence of HO. On the other hand, 1F2R operation was superior in maintaining cervical ROM. However, the biomechanical characteristics for different HS were complex. Therefore, further randomized controlled studies on HS groups are indispensable.

287
A309: The Impact of Physical Therapy After Cervical Spine Surgery for Degenerative Spine Disorders: A Systematic Review

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Introduction: Cervical spondylosis is a chronic degenerative disorder affecting both the discs and joints of the cervical spine which can result in a combination of neck pain, cervical radiculopathy, and/or cervical myelopathy. Once symptoms become recalcitrant to conservative management or there is progressive deterioration of neurological status, surgical intervention may be indicated. There is paucity of evidence

concerning post-operative management of these patients, specifically the use of physical therapy (PT). Physical function deficits can be present up to 14 years after cervical surgery. It is important to determine if the literature indicates a need for post-operative PT, that may improve patient outcomes and decrease healthcare costs. The aim of this systematic review was to identify the impact of PT after cervical spine surgeries regarding complications, patient-reported outcomes (PROs), physical function and cost-effectiveness. **Material and Methods:** The following bibliographic databases were searched electronically from the date of inception until July 2019: PubMed, Embase, Cochrane Central Register of Controlled Trials (CENTRAL), Physiotherapy Evidence Database (PEDro), and the Web of Science. Four reviewers independently reviewed the titles, abstracts and full texts of identified records based on the eligibility criteria. Inclusion criteria: peer-reviewed, English language, at least ten adult patients (diagnosed with degenerative spine disorders) who had undergone cervical spine surgery with post-operative PT. Exclusion criteria: poorly defined surgical/PT protocols, outcome measures, trauma, cancer or infection. The Revised Cochrane risk-of-bias tool for randomized trials (RoB 2) assessed risk of bias. Meta-analysis was not performed due to study heterogeneity and limited data for comparisons. The findings were described narratively and the GRADE approach was used to define the certainty of evidence. **Results:** 10,743 studies were screened on the title and/or abstract level. Twenty studies were selected for full-text review and six studies met the inclusion criteria, including two randomized controlled trials (RCTs) None of the RCTs or longitudinal studies had a lone surgical comparator group. Both RCTs were at moderate risk of bias overall. Methodological concerns included potential for bias in the outcome measurement and lack of blinded assessment for PROs. RCTs included 63 and 201 patients with cervical radiculopathy. Surgeries included 1-3 level anterior cervical discectomy and fusion or posterior foraminotomy with or without laminectomy. Post-operative PT consisted of exercise, cognitive behavioral therapy and optional vestibular rehabilitation. PROs: studies demonstrated reduction in Neck Disability Index, Visual Analog Scale for pain and improvement in the Global Assessment, EuroQol-5D, and Modified Odom Scale. Physical function: studies demonstrated improvement in cervical active range of motion, manual dexterity, hand strength, and neck muscle endurance. Between-group comparisons were generally insignificant. No studies reported complications, adverse events or cost-effectiveness relating to PT with or without surgery. **Conclusion:** PT after cervical surgery for spondylosis appears to be tolerated without notable adverse effects and may lead to improvements in pain, disability, and physical function. However, due to limited availability of studies, heterogeneity in study design and lack of lone surgical control groups in current literature, it is difficult to determine the true effect of the addition post-operative PT to cervical surgery.

1358
A310: Assessment of the Self-Reported Dysphagia in Patients Undergoing One-Level Versus Two-Level Cervical Disc Replacement with the Prestige-LP Prosthesis

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Introduction: Incidences of dysphagia in cervical disc replacement (CDR) are lower than those reported in anterior cervical discectomy and fusion (ACDF). Surgical CDR is has a clinical importance due to its complicated outcomes. It has been documented that surgery may lead to high dysphagia rates in ACDF. There is paucity of documented information on the differences in post-operative dysphagia of CDR between one-level and two-level CDR. This paucity, therefore, necessitated this retrospective study on post-operative dysphagia after one- and two-level CDR. **Material and Methods:** The prevalence and severity of post-operative dysphagia between one-level and two-level CDR was evaluated by the Bazaz grading system during the follow-up time. Regression analyses were done to identify confounding factors associated with post-operative dysphagia after CDR. **Results:** One hundred and fourteen patients in one-level CDR group and forty eight patients in two-level CDR group were recruited. The overall dysphagia occurrences in the one- and two-level CDR groups were 17.54% and 35.41% at week one, 12.28% and 25% after one month, 9.65% and 18.75% after three months, 6.14% and 14.58% after six months, 4.39% and 6.25% after one year, and 3.51% and 4.17% at the final follow-up, respectively. The identified risk factors for dysphagia after CDR were advanced age, C4/5 surgery, two-level surgery, dC2-C7 angle $\geq$ -5° and $\geq$ 6 mm changes in the prevertebral soft tissue swelling (dPSTS). **Conclusion:** It was revealed that patients who experienced two-level CDR may have weak swallowing functions in the early post-operative term. However, after mid-to-long-term follow-ups, these patients exhibited better improvements in post -operative swallowing compared to those who had undergone one-level CDR.

1968
A311: Management of Cervical Spondylotic Myelopathy with Total Cervical Disc

Replacement: Analysis of Patients with Clinical and Radiological Signs of Cervical Myelopathy

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Introduction: Over the past decade, total cervical disc replacement (cTDR) has been established as a viable treatment option for cervical degenerative disc disease. Especially patients with radiculopathy due to certain disc pathologies have been treated successfully with excellent clinical long-term results in the past. The aim of this study was to question the clinical and radiographic efficacy of Pro Disc Vivo cervical disc arthroplasty in patients with clinically and radiographically documented myelopathy due to degenerative changes at the index level. **Material and Methods:** 18 consecutive patients (10 males, 8 females) with documented clinical and radiological signs of myelopathy, as part of an ongoing prospective non-randomized single center study, were included in this investigation. All of the patients underwent the same procedure through an anterior cervical approach and a ProDisc Vivo cervical disc prosthesis was inserted within strict inclusion criterias (e.g. no instability, no kyphotic deformity, residual motion of the index segment, no distinct bony osteophytes, no osteoporosis). MRIs were taken routinely to confirm the diagnosis of spinal stenosis with myelopathy. Conventional x-rays of the cervical spine were taken in ap and lateral as well as in flexion/extention to determine the global lordosis as well as the range of motion (ROM). Patients without radiographic (MRI) evidence of myelopathy were excluded. Enrolled patients were calculated Nurick grade together with VAS, NDI and JOA scores preoperatively and also during the follow-up appointments. **Results:** The study population had a mean age of 52.4 years and a follow up period of 20.3 months in average(range 3-48 months). Cervical disc arthroplasty was performed in 15 patients for one, in 2 patients for two and one patient for three levels. The mean range ROM of the index level stayed consistent with 9.4° preoperatively and 9.6° ($P = .637$) at the last follow up, the global lordosis in neutral position changed from 5.8° to 14.2° significantly ($P = .002$). The JOA score improved from 11.3 (Grade I: 9 patients, Grade II: 9 patients) to 16.62 (all patients: Grade I) ($P < .001$/$P = .003$) as well as the NDI 36.71 (73.43%) to 10.3 ($P < .001$) and the VAS score from 5.71/6.07 (arm/neck) to 1.3/2.0 ($P < .001$/$P < .001$). The mean Nurick grade was 1.33 preoperatively and dropped down in all cases to Nurick grade of 0 ($P < .001$). At the latest follow-up visit all patients were highly satisfied by means of social functioning and pain. They were all able to return to work, daily activities and recreational sports. **Conclusion:** This study proved that Pro Disc Vivo cervical disc arthroplasty was a viable treatment option with excellent outcomes even in management of cervical myelopathy with regard to pain scores (VAS) and neck disability index by improving the neurologic deficit, arm pain and local neck symptoms together with scores of functional outcome (JOA and NDI scores). Considering the Nurick grades our clinical results revealed that, anterior decompression and implantation of cTDR could improve the severity of myelopathy within strict inclusion criterias as well. This study also concluded that cTDR was improving the pre-operative ROM and lordosis with great statistical significance.

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1119
A312: Effect of Changes in Postoperative Intervertebral Space Height on Clinical and Radiological Outcomes After Cervical Disc Replacement

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Introduction: Narrowing of intervertebral space height (ISH) is an important pathological change in degenerative spinal disease, and ideal intraoperative distraction and postoperative intervertebral space maintenance is one of the most expectant goals pursued by spinal surgeons. It has been reported that the distraction of intervertebral space height has a close association with axial symptoms, adjacent segment degeneration, and neurologic recovery after cervical surgery. However, compared with cervical intervertebral space distraction, which has received considerable attention in previous studies, limited studies analyse the relationship between the maintenance of ISH and clinical and radiological outcomes after CDR. **Material and Methods:** In this study, the height variation and general trend of postoperative ISH in all patients were analysed. The patients were divided into three groups based on the change of postoperative intervertebral space height (ISH); group A (ISH < 2 mm), group B (ISH 2-4 mm), and group C

(ISH >4mm) and the clinical and radiographic results compared among the three groups. A total of 120 consecutive patients with symptomatic cervical disc disease were included in this study. **Results:** The results showed that the mean ISH increased significantly from 0.729 mm before surgery to 1.143 mm at one week, then gradually decreased to 1.032 mm at three months, 0.980 mm at six months, 0.760 mm at one year, and 0.750 mm at the final follow-up. The average postoperative Neck Disability Index (NDI) was 19.73 ± 0.81, 13.74 ± 4.94, 17.19 ± 4.22 in the three groups at one year after surgery and the average range of motion (ROM) was 5.44 ± 3.85° in group A, 9.34 ± 4.38° in group B and 6.51 ± 4.38° in group C. The mean diameter of the intervertebral foramen (IVF) was 6.54 ± 1.86 mm in group A, 9.63 ± 2.38 mm in group B and 9.31 ± .68 mm in group C. Degeneration at the superiorly adjacent disc level was observed in 13.51% patients in group A, 9.37% in group B and 21.05% in group C. Degeneration at the inferiorly adjacent level was radiographically identified in 21.62% in group A, 14.06% in group B, and 26.32% in group C. **Conclusion:** This study revealed that cervical disc replacement cannot maintain the intervertebral disc height obtained immediately after surgery. There is no obvious correlation between the change in intervertebral space height and clinical efficacy in the early postoperative stage. However, the intervertebral disc height may affect the NDI index one year after surgery. If the postoperative intervertebral space height change can be maintained at 2-4 mm in a year, satisfactory ROM, intervertebral foramen diameter, and relatively low ASD may be obtained after cervical disc replacement.t

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A313: Effect of disc height and degree of distraction on heterotopic ossification after cervical disc replacement

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Introduction: Heterotopic ossification (HO) is a potential and severe complication of cervical disc replacement (CDR). However, the underlying mechanism of CDR and its association with preoperative disc height loss (DHL) and postoperative degree of distraction (PDD) remain unclear. We hypothesized that DHL and PDD could predict HO after CDR. **Material and Methods:** Data were obtained from 127 patients who underwent single-level CDR with a minimum follow up of two years. DHL and PDD were obtained from lateral radiographs and HO was evaluated at the last follow up appointment. Receiver operating characteristic (ROC) curves were calculated to verify the diagnostic value of DHL and PDD in predicting HO. **Results:** Both DHL and PDD were significantly larger in the HO group than the non-HO group ($P < .05$). DHL ≥ 24.97% increased the risk of HO by 5 times ($P = .003$, 95% CI: 1.62-15.49), and PDD ≥ 36.67% increased the risk of HO by 3.87 times ($P < .001$, 95% CI: 1.81-8.27). A combined DHL and PDD (combined parameter) cut-off of 60.36 had a sensitivity of 87.18%, specificity of 67.35%, and area under the curve of 0.77 for predicting HO. **Conclusion:** DHL and PDD are associated with the development of HO after CDR. The cut-off value of DHL may narrow criteria for CDR with the aim of reducing HO formation. The combined parameter may help surgeons to select the most suitable implant height to reduce the prevalence of HO.

1356
A314: Outcomes Following Cervical Disc Replacement vs Anterior Cervical Discectomy and Fusion in Patients with Predominantly Neck Pain Complaints

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Introduction: Although cervical disc replacement (CDR) continues to increase in popularity for the treatment of cervical radiculopathy, the presence of preoperative neck pain is often cited by surgeons as a reason for choosing anterior cervical discectomy and fusion (ACDF) instead.[1] The origin of neck pain is often multifactorial and there is some literature that suggests comparable results between CDR and ACDF in patients who have both neck pain and upper extremity radiculopathy.[2-5] The purpose of our study was to compare outcomes between CDR and ACDF in patients who presented with predominantly neck pain complaints. **Methods:** A retrospective review of prospectively collected data was performed on patients undergoing one or two-level CDR or ACDF by three surgeons at a single academic institution. Patients who had presented with predominant complaints of neck pain (pNP; VAS-neck>VAS-arm) were initially identified and subsequently stratified into two cohorts by procedure: CDR (n = 41) and ACDF (n = 83). Outcome data was collected at preoperative visits and at each of the following postoperative visits: 2 weeks, 6 weeks, 12 weeks, 6 months, 1 year, and 2 years. The following MCID-threshold values were used, based on previous studies in the literature: NDI: -15.0, VAS-Neck: -2.5, VAS-Arm: -2.5, SF-12: PCS +8.1, SF-12 MCS: +4.6. Differences in PROMs were analyzed with Wilcoxon-Signed-Ranks-Tests within each cohort and Mann-Whitney-U-Tests to compare PROMs between groups. Rates of MCID achievement were analyzed for each PROM with Fischer's-Exact-Tests. **Results:** 124 total patients presenting with pNP were included (mean age: 49.93 ± 11.73 years, mean BMI: 26.65 ± 4.05 kg/m^2). In those with

minimum six-month follow-up, both the CDR (median follow-up: 336.5 days) and ACDF (median follow-up: 336.5 days) cohorts demonstrated significant improvements in NDI ($P < .001$), VAS-neck ($P < .001$), and SF-12 PCS ($P < .001$). While both cohorts demonstrated improvements postoperatively in these three PROMs, the degree of improvement was not significantly different between the two cohorts in any PROM (all $P \geq .185$). In addition, the CDR cohort demonstrated significant improvement in SF-MCS ($P = .022$). There were no significant differences in any of the final PROMs (all $P \geq .320$) between CDR and ACDF patients with a minimum six-month follow-up. When comparing cumulative percentages of patients achieving MCID at each post-operative time point, no significant differences were observed between the two cohorts at any time point (all $P \geq 0.236$) with 90.2% (n = 37) of CDR patients and 84.1% (n = 69) of ACDF patients achieving MCID in ≥1 PROM by the 2-year follow-up. **Discussion and Conclusion:** Historically, surgeons have favored ACDF in patients presenting with a primary complaint of neck pain in the setting of cervical radiculopathy. While the presence of neck pain and significant radiographic facet arthritis should continue to be a contraindication to CDR, our findings suggest that disc replacement may be a viable surgical option in an appropriately indicated subset of patients who present with a predominant.

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A315: Cervical Sagittal Alignment After Prestige Lp Cervical Disc Replacement: Radiological Results and Clinical Impacts

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Introduction: Cervical disc replacement (CDR) has been widely used to treat one- and two-level cervical degenerative disc disease. Studies have shown the effectiveness of CDR in preserving range of motion (ROM) and delaying adjacent segment degeneration (ASD). Cervical sagittal alignment is an important factor affecting favorable clinical outcomes in cervical spine surgery. This study aimed to explore whether cervical sagittal alignment can be maintained after CDR and to identify the impact of cervical sagittal alignment on outcomes after CDR. **Material and Methods:** This was a single-center, retrospective study. 132 patients who underwent one-level CDR were included. Cervical sagittal alignments, including cervical lordosis (CL), segmental alignment (SA), sagittal vertical axis (SVA), T1 slope (T1s), and T1s minus CL (T1s-CL), were measured. The effects of cervical sagittal alignment on the CDR outcomes were analyzed. Patients were divided into the heterotopic ossification (HO) group and ASD group to determine the potential impacts of cervical sagittal parameters. **Results:** The cervical sagittal alignment parameters, except for the SVA, were significantly improved after CDR and showed decreasing trends at the last follow-up. Significantly higher CL and T1s were found in patients with better ROM after CDR. SVA ≥ 20 mm increased the risk of anterior HO (odds ratio = 2.945, $P = .007$). Significantly kyphotic SA and lower T1s values were found in the ASD patients than in the non-ASD patients ($P < .05$). Patients with ASD at the inferior level showed significantly worse CL ($P < .05$). **Conclusion:** CDR had limited function of improving cervical sagittal alignment. Poor cervical sagittal alignment after CDR was associated with HO, ASD, and less ROM.

OP36: Spinal Tumor Surgery 2

597
A316: Analysis of unplanned hospital readmissions up to two-years after metastatic spine tumour surgery

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Introduction: Unplanned hospital readmissions (UHR) after discharge following metastatic spine tumour surgery(MSTS) adversely affect quality of life of these patients. Majority of studies on UHR focus on assessment of readmissions within 30 days following index-discharge. The aim of this study was to investigate rates, causes, and risk factors of UHR within 30 days, 90 days, 1 year and 2 years after MSTS to augment multi-disciplinary treatment planning and improve patient education. **Materials and Methods:** We retrospectively reviewed 272-patients (age ≥18 years) who underwent MSTS between 2005-2016 with a follow-up for minimum two-years or until their demise, whichever was earlier. Institutional review board approval was obtained prior to commencement of study. Hospital records were utilised to obtain demographics, oncological and procedural details, and postoperative outcomes. All UHR within 2years were reviewed. UHR were defined as unscheduled hospitalisations after index-discharge and did not include planned follow-up/readmissions for radiotherapy/chemotherapy. Primary outcomes were rates and causes of UHR. Four-time frames were considered with regards to UHR: (1 < 30 days, (2) 30-90 days, (3) 90days-1year, and (4) 1-2years. UHR rate was calculated as number of patients being readmitted divided by total number of surviving patients within each timeframe. Risk factors for UHR were evaluated using multivariate logistic regression analysis.

Results: A total of 204-patients were included in the final analysis. The mean age was 60+12 years; 49% were females. An Eastern Cooperative Oncology Group Performance Status (ECOG-PS) score of 0-2 was noted in 88% of patients. Median Charlson Comorbidity Index (CCI) and Tokuhashi scores were 7 and 8, respectively. Most common primary tumour type was lung (24.5%), followed by breast (19.1%). Majority underwent open surgery (72.1%). Overall, perioperative complication rate was 46%. A total of 425-UHR occurred across all four studied timeframes in 151-patients. Thirty-day, 90-day, 1year, and 2year UHR-rates after MSTS were 17.2%, 31.1%, 46.2%, and 52.7%, respectively. Majority of patients had their first UHR between 30-90days (32.5%). The highest number of readmission-events occurred after one year from discharge (n =153/425). Lung cancer primaries had the highest UHR-events (24.7%) whilst renal/thyroid displayed the least (6.6%). Disease-related causes (16.2%) were the most common reason for readmissions across all timeframes, followed by respiratory (13.7%) and progression of metastatic spine disease (12.7%). Urological conditions accounted for majority of readmissions within 30days (25%); disease-related causes (27.9%), symptomatic spinal metastases (16.7%), and respiratory conditions (19.6%) represented the most common causes at 30-90 days, 90 days-1year, and 1-2 years, respectively. An ECOG >1 (P = 0.057), CCI >7 (P = .01), and primary lung tumour (P = .02) significantly increased UHR-risk on multivariate analysis. **Conclusion:** Our study findings offer useful insights into UHR during the overlooked timeframe of beyond 90days. Overall, 74% of patients had at least one UHR within 2years of MSTS and majority were secondary to disease-related causes. Majority of first UHR occurred between 30-90 days after surgery. Local disease progression and overall disease progression accounted for the highest UHR-events at 90 days-1 year and 1-2 year timeframes, respectively. This information allows clinicians to anticipate causes of UHR within specific timeframes, thereby enabling better surveillance and prevention of MSTS-related morbidity.

736
A317: Symptomatic Ventriculus Terminalis in a 64-Year-Old Female: A Case Report

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Introduction: Ventriculus terminalis (VT) or the "fifth" ventricle is an embryological remnant consisting of an ependyma-lined cavity located in the conus medullaris. VT is extremely rare in adults and asymptomatic in the vast majority of cases; but may occasionally become symptomatic if cystic dilation occurs. Surgical treatment is still matter of debate. Material and Methods: We report a case of 64-year-old female. **Results:** We report the case of a 64-year-old female, who was referred to our department with a 6 months history of sphincter dysfunction made of urinary incontinence and chronic constipation. On physical examination, muscle strength was normal in both lower limbs, deep tendon reflexes were weak with bilateral Babinski sign. Magnetic resonance imaging (MRI) of the spine showed a cystic lesion at D10-D12. (length: 4 cm; volume 4.5 cm^3) similar to CSF in both T1 and T2-weighted images with no contrast enhancement which then was reported as VT. This lesion was associated to a 3 mm large hydromyelia extending from D2 to D8. Decision was to address the VT with posterior approach, D9-D12 laminectomy, myelotomy and cyst fenestration. Post-operative course was uneventful and the patient was discharged three days following surgery. Six-months control MRI showed significant cyst size reduction and a marked improvement in sphincter dysfunction was noted starting 9 months after surgery. Conclusion: Microsurgical fenestration is a safe and effective treatment strategy for symptomatic VT and can be associated with a good clinical outcome even in elderly patient.

1367
A318: Clinical Outcomes in 91 Patients Treated with Hybrid Spinal Surgery for Metastatic Renal Cell Carcinoma

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Introduction: The management of renal cell carcinoma (RCC) spinal metastases is controversial in regards to extent of resection and adjuvant radiation dosing. We present outcomes of patients with RCC spinal metastases treated by hybrid spinal surgery which consists of an initial posterior transpedicular approach for circumferential decompression of the neural elements plus instrumented stabilization, followed by adjuvant radiation therapy. **Methods:** A retrospective study of a prospectively collected cohort of patients undergoing hybrid surgery for pathology-proven spinal metastases from renal cell carcinoma between 2003 and 2017 was performed. Radiation therapy was either single fraction, hypofractionated with high dose per fraction, or hypofractionated with low-dose per fraction. Patient demographic, clinical, and surgical data were collected. The degree of systemic disease was at time of surgery was divided into solitary metastasis,

oligometastatic disease (2-5 metastatic lesions regardless of organ system involved), or widespread metastatic disease (greater than 5 metastatic lesions regardless of organ system involved). Complications were divided into major and minor complications, with major complications requiring invasive measures or those resulting in permanent disability or death. **Results**: A total of 91 patients were included (84% male). Median age was 62.2 years old. 89% involved the thoracolumbar spine. 56% of patients had widespread disease, 33% had oligometastatic disease, and 11% had a solitary metastasis. Median operative time and blood loss were 162 minutes and 1000 mL, respectively. 25 patients received SRS in a single fraction. 56% of patients had hypofractionated PORT with high-dose per fraction (3 fractions with 800-900 cGy per fraction). 15 patients had hypofractionated with low-dose per fraction (5 fractions with 600-900 cGy per fraction). 16 patients had complications related to treatment, of which 11 were major. The median length of stay was 5 days and 87% of patients were discharged home. There was an overall 92% PFS rate. The median time to POD requiring treatment was 422 days. At 12-month follow-up, 44% of patients had died, with 44% demonstrating ECOG scores ranging from 0-2. The mean overall survival for the cohort was 686 days. For patients still alive, median time to last follow-up was 1163 days. For patients that died during the study, mean survival was 543 days. When stratifying patients by degree of systemic disease, there was an expected increased risk of death (1.09x) and progression (1.21x) with widespread disease. Patients with a solitary metastasis received a higher median dose of PORT (2850 cGy). Patients with oligometastatic disease were 11% less likely to die and 9% less likely to progress than patients with a solitary metastasis. There was increasing risk of POD with hypofractionated regimens (1.5x for high-dose, and 5x with low-dose). **Conclusion:** Patients treated with hybrid spinal surgery for metastatic RCC demonstrate a PFS rate of 92%, mean OS of 686 days, and 12% risk of major complications. The median time to POD requiring treatment was 422 days. There was a 1.5-5x increased risk for POD with for hypofractionated regimens. Patients with widespread disease at the time of surgery had a 1.1-1.2x increased risk for POD and death.

723
A319: Neurological Outcome and Respiratory Insufficiency in Intramedullary Tumors of the Cervical Spine

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Objective: Intramedullary tumors of the upper cervical spine are challenging entities with a high risk of postoperative neurological deterioration. As the levels above C4 are responsible for volitional ventilatory control, patients are at risk of permanent respiratory dysfunction with the need of long-term ventilation. **Methods:** We retrospectively reviewed all patients treated for intramedullary lesions including the upper cervical spinal cord above the C4 level in our neurosurgical department from January 2008-December 2019. Patient's demographics, pre- and postoperative clinical status as well as operative technique and complications were extracted and analyzed. **Results:** In total, 34 patients underwent a surgical treatment for intramedullary lesions including or above the C4 level from 2008 to 2019. Median age was 44 years, and 56% of the patients were male. The most common entity was ependymoma (n: 22, all WHO II), 7 patients were treated for intramedullary glioma (WHO I-IV) and 5 patients for a hemangioblastoma. In total, 22 patients presented with neurological deficits preoperatively (65%). Respiratory dysfunction was observed in only one patient requiring tracheotomy (2.9%). Postoperative neurological worsening was observed in 56% (motor function deterioration in 35% of the cases, sensory deficits in 50%), but the majority of patients recovered, and was independent at follow-up (median McCormick grade 2, 76.7% of the cases with McCormick grade 1 or 2). **Conclusions:** Intramedullary tumors of the upper cervical spine remain challenging neurosurgical entities. Despite its high-risk location, respiratory insufficiency seems to remain a rather are complication, while transient postoperative neurological deterioration is observed in more than half of the cases.

1750
A320: Apolipoprotein E4 (rs429358) Variant Genotype: A Risk Gene Associated with Higher Serum Lipid Profile and Spine-Related Neck or Back Pain

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Introduction: The apolipoprotein E (ApoE) gene that is implicated in regulating serum metabolic and lipid species is also reportedly associated with vertebral column and neurological degeneration. Increasing ApoE genetic polymorphic studies indicate that the wild-type (WT) genotypes of apolipoproteins Eε2 and Eε4 specifically hold metabolic *health* and *risk* gene properties, respectively. Nevertheless, as to whether their variant (VT) genotypes carry the same functional properties in the transportation and regulation of serum lipids in spine patient outcomes remain elusive. To this end, we evaluated the relationship(s) between WTs and VTs of ApoEε2 and ApoEε4 genotypes on serum lipid profile as well as the associated clinical outcomes in spine patients perioperatively. **Materials and Methods:** Following approval by the institutional review board (IRB) of Beijing Tiantan Hospital-Affiliated Capital Medical University, a prospective clinical study of 336 adult (≥18 years) intradural spinal cord tumor (ID-SCT) patients who underwent surgical treatment without any prior primary therapy were assessed. Patients within each ApoE2 and ApoE4 categories were then dichotomized into homozygosity-wild type (**WT**) and heterozygosity-variant type (**VT**). We compared patient outcomes of ApoEε2-(rs7412) [WT (***C/C***)] *versus* ApoEε4-(rs429358) [WT (***T/T***)] and ApoEε2-(rs7412) [VT (***C/T***)] *versus* ApoEε4-(rs429358) [VT (***C/T***)]. The impact of WT and VT genotypes on serum metabolic and lipid profiles associated with perioperative clinical outcomes were evaluated. Key primary outcomes comprised of demographics, daily dietary outcomes, and serum metabolic panel. Secondary outcomes compared neurological and PROs between the genotypes at baseline and at 2-year postoperative for patient self-reported outcomes that included: visual analogue scale (VAS), Neck Disability and Oswestry Disability Indices (NDI or ODI), Chinese national daily foods frequency questionnaire (FFQ). Functional measures included: McCormick's classification and the RAND-36 [Short-Form 36 (SF-36)] health-related quality of life (HRQoL) assessment. Laboratory measures included: Serum glucose, lipids, and protein profiles. Univariate and multivariate analyses were carried out by student t-test, Pearson's Chi-squared test, Mann-Whitney U test and general linear model (GLM), respectively, with age, gender, body mass index (BMI), and multivitamin intake considered as covariates. Statistical significance was set at ($P < .05$). **Results:** Of the 336 ID-SCT patients, approximately 85.4% vs 81.2% were ApoEε2-(rs7412)-WT vs ApoEε4-(rs429358)-WT and 14.6% vs 18.8% were ApoEε2-(rs7412)-VT vs ApoEε4-(rs429358)-VT carriers, respectively. At baseline, the ApoEε4-(rs429358)-VT carriers showed significantly higher average serum total cholesterol (TC), low-density lipoprotein (LDL-c), LDL-c/HDL-c ratio, cholesterol ratio (CR), and apolipoprotein B (Apo-B) than ApoEε2-(rs7412)-VT carriers. The ApoEε4-(rs429358)-VT carriers also demonstrated 390% increase in Neck or Back Pain incidence and 390% increased Neck or Back Pain intensity compared to the ApoEε2-(rs7412)-VT carriers at baseline ($P < .05$). **Conclusion:** Findings from this study indicate that the WTs of both ApoEε2 and ApoEε4 genotypes were potentially comparable at regulating serum lipid species. ApoEε4-(rs429358)-VT genotype was a risk gene and associated with potential lipid-induced systemic inflammation and significantly increased neck or back pain incidence and intensity preoperatively. Further studies are encouraged to assess how the ApoEε4-(rs429358)-VT genotype impacts preoperative prescriptions of pain medications including opioids and to extrapolate the potential impact(s) of this gene is affecting opioid dependency and crisis following surgical treatment in spine patients.

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A321: Responder-analysis of pain relief after surgery for the treatment of spinal metastatic tumors

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Introduction: The current analysis focused on the patient pain experience after surgery for the treatment of spinal metastatic tumors. Responder analysis was carried out to capture patient-level pain experience and to study the variability of pain improvement. **Materials and Methods:** The patient population included 174 patients who underwent surgery for the treatment of metastatic spine tumors. Brief Pain Inventory (BPI) and MD Anderson Symptom Inventory-Spine Tumor (MDASI-SP) instruments were used to measure patient reported outcomes. Logistic regression modeling was used to associate preoperative characteristics with "treatment success" defined as rating the BPI worst pain item 0-4. Linear regression modeling was used to associate preoperative

characteristics with minimal clinically important improvement (MCI) in physical functioning defined by distribution as a one-point decrease in the BPI Interference Construct score from preoperative (baseline) to 6 months postop. **Results:** Patient-level analysis of pain response revealed that 60% of patients experienced at least a minimally important decrease in pain. At least one-third of the patients experienced a substantial reduction in pain and twelve percent experienced complete resolution of pain. At least half of the patients experienced a decrease in pain sufficient to result in minimal clinically important improvement in physical functioning, evidenced by a 1-point decrease in the BPI Pain Interference construct. Cutpoint analysis revealed that 48-49% were classified as responders based on the change from more severe to less severe pain categories in the Worst Pain BPI and Average Pain BPI items and BPI Pain Severity Construct. Increasing scores on all of the preoperative pain intensity BPI items, the MDASI Core Symptom Severity, the MDASI Spine Tumor Specific Construct and the presence of preoperative neurologic deficits were associated with lower probability of pain treatment success. Postoperative complications were also associated with decreased probability of pain treatment success. On the other hand, increasing severity in all BPI pain items and MDASI constructs was associated with increased probability of a minimal clinically important improvement in physical function. **Conclusions:** The current analysis confirms that a significant proportion of patients experience significant and clinically important pain relief after surgery for the treatment of spinal metastatic tumors. Patients with milder preoperative symptoms are more likely to reach a "low pain" or pain treatment success outcome after surgery, suggesting that earlier intervention may lead to improved postoperative outcomes. However, patients with higher preoperative symptom severity also benefit from surgery through the attainment of adequate pain relief to achieve an improvement in physical function.

1296
A322: Clinical Outcomes of Symptomatic Spinal Metastases Treated with Hybrid Therapy (Separation Surgery Followed by Radiosurgery) for Colorectal Adenocarcinoma

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Introduction: Twenty-seven percent of patients with colorectal cancer (CRC) develop bone metastasis. There is a paucity of evidence regarding the outcomes of patients who undergo surgery for spinal metastasis from colorectal origin. Treatment of symptomatic spinal metastases is palliative and achieved through surgery, radiotherapy, or a combination of both. Over the past decade, Hybrid therapy (i.e., separation surgery followed by radiosurgery) has become a widely accepted treatment paradigm for metastatic spine disease regardless of histologic subtype. Understanding histology specific outcomes facilitates informed decision making in a rapidly evolving field of multimodality therapies including targetable mutations. This study evaluates outcomes of CRC patients who underwent hybrid therapy for spinal metastases. **Material and Methods:** A retrospective chart review of all patients at a single institution who underwent surgery for spinal metastasis followed by SRS with a confirmed diagnosis of CRC was performed. Fifty CRC patients were identified. Data collected for this study included patient demographics, tumor histology, type and extent of spinal intervention, radiation data including treatment dose and field, molecular diagnostic pathology (EGFR exon 19, Her2, KRAS, tp53, and APC exon 16) and outcomes were measured and evaluated included survival, local control, complications including re-operations, repeat irradiation, and/or postoperative kyphoplasty at previously treated level. **Results:** Fifty CRC patients were identified with 32 male, 18 female patients with a mean age of 55.06 (25-83). Fifty-five of these patients were treated with open decompression and stabilization, and 2 were treated with minimally invasive surgery. Average survival from the time of surgery was 288 days (31-1422). Ten patients (20%) had local progression of disease with an average time to progression of 365 days (30-840). Twelve patients (24%) required a reoperation; 6 for local tumor recurrence, 1 for tumor progression at an adjacent level, 3 for wound complication and 1 for progressive spinal instability. Tumor mutations (exon 19, her2, KRAS, TP53, APC exon 16) had no impact on local control. Twenty-one patients (42%) had progression of disease to other spinal levels. Of note, those who survived over 1 year from the day of surgery (DOS), the odds of local progression of disease needing reoperation, RT, and/or kyphoplasty was markedly increased (OR 28.5. 95% CI: 4.2487-191.1784) and statistically significant ($P = .0006$). **Conclusion:** Hybrid therapy provides a safe and effective therapy for treatment of symptomatic spine metastases for CRC patients. Local control rates of 80%, lower than previously reported for other histologies, suggest a more challenging disease to treat in the context of spinal cord compression. These outcomes were not significantly affected by the genomic landscape of the primary cancer. Patients surviving beyond one year after surgery had higher odds of requiring further interventions for local progression.

1297
A323: Outcomes of Surgery Followed by Radiosurgery for Treatment of Spinal Metastases from Non-Small Cell Lung Cancer: Do Targetable Mutations Matter?

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Introduction: Spine metastases occur in 30-40% of all patients with cancer. Because of their relative resistance to radiation, non small cell lung (NSCLC) metastases causing epidural spinal cord compression are challenging to treat. Over the past decade, Hybrid therapy (i.e. separation surgery followed by radiosurgery) has become a widely accepted treatment paradigm for metastatic spine disease regardless of histologic subtype. Understanding histology-specific outcomes is key to informed decision-making in a rapidly evolving field of multimodality therapies including targetable mutations. The advent of new biologics and small molecules that target specific mutations has extended overall survival for multiple cancers and is a rapidly changing landscape. This study evaluates patients who underwent hybrid therapy for NSCLC spinal metastases to determine if targetable mutations affect outcomes. **Material and Methods:** A retrospective chart review of patients who underwent surgery followed by stereotactic body radiation therapy (SBRT) for symptomatic spinal metastases from NSCLC at a single, tertiary, cancer center was performed. One hundred and five NSCLC patients were included in this analysis. Data evaluated included patient demographics, surgical details, radiation data including dose and fractionation, adjuvant chemotherapy, molecular diagnostic pathology, targeted therapies (immunotherapy, targeted small molecule therapy, and chemotherapy), and outcomes including overall survival (OS), progression free survival (PFS), local tumor control, reoperations, repeat irradiation, and/or postoperative kyphoplasty at previously treated level. **Results:** One hundred and five NSCLC patients were identified with 56 male, and 49 female patients with a mean age of 65 (32-85.4). This cohort had an average SINS score of 9.5 (5-15), and a construct length of 5.9 (3-12) with an average of 2.6 levels decompressed (1-6). Ninety-four of these underwent open decompression and stabilization, while 11 were treated with minimally invasive surgery. Average survival from the time of surgery was 414.7 days (30-2572). Local control was obtained in 89.5% of patients. 11 patients had local progression of disease; the average time to progression was 366 days (26-2305). Sixteen patients returned to the OR: 4 for tumor recurrence at the index level, 4 for progression at adjacent levels, 2 wound complications, 5 for pathological fracture or hardware failure, and 1 for hematoma evacuation. Twenty-nine of the 105 patients received PD-1 immunotherapy (28%), 35 out of 105 received VEGF immunotherapy (33%), 81 out of 105 received anti-neoplastic agents (77%), and 40 out of 105 received small molecule therapy in the form of kinase inhibitors (38%). Exon 19 mutation significantly increased the odds of local progression (OR 4.8,4 95% CI: 1.08-21.74, $P = .04$). Average pack years for this cohort was 22.1 (0-102); current smoker status at time of surgery and SBRT significantly increased the risk of PFS and OS. **Conclusion:** Hybrid therapy is a safe and effective method for treatment of symptomatic spine metastases from NSCLC origin providing durable local control with low complication profiles. Our data demonstrate that EGFR exon 19 mutations increase the odds of local progression of disease. These data provide initial insight to the possible role of mutational analyses for prognostication and informed decision making in the management of spinal metastases.

1295
A324: Spinal Cord Compression and Spinal Instability in Multiple Myeloma - A Shifting Paradigm Towards Non-Operative Management

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Introduction: Patients with metastatic spinal cord compression (MSCC) or unstable spinal lesions warrant early surgical consultation. In multiple myeloma, chemotherapy and radiotherapy have the potential to decompress the spinal canal effectively in the presence of epidural lesions. Mechanical stability conferred by bracing may potentiate intraosseous and extraosseous bone formation, thus increase spinal stability. With this in mind, this study aims to review the role of non-operative management in myeloma patients with a high degree of spinal instability, in a Specialist Tertiary Centre. **Material and Methods:** Retrospective analysis of a prospectively collected database of 83 patients with unstable myelomatous lesions of the spine, defined by a Spinal Instability Neoplastic Score (SINS) of 13-18. Data collected include patient demographics, systemic treatment, neurological status, radiological presence of cord compression, most unstable vertebral level and presence of intraosseous and extraosseous bone formation. Post-treatment scores were calculated based on follow-up imaging which was carried out at 2 weeks for cord compression and 12 weeks for spinal instability. A paired t-test was used to identify any significant difference between pre- and post-treatment SINS and linear regression was used to assess the association between variables and the change in SINS. **Results:** A significant reduction in SINS was observed from a pre-treatment average score of 14 to a score of 9, following treatment for myeloma ($P < .001$). A higher initial score and a younger age were associated with a larger overall reduction in SINS ($P < .001$ and $P = .02$ respectively). Not one particular variable (bisphosphates, chemotherapy,

radiotherapy and steroids) had a significant association in SINS reduction. 25 (30%) patients had spinal cord compression, all of which showed radiological resolution of cord compression at 2 weeks. No patients developed neurological deterioration during treatment and all patients had an improvement in their pain scores. 64 (77%) patients had evidence of intraosseous and/or extraosseous bone formation on their follow-up scan. **Conclusion:** Non-operative management in the form of bracing and systemic therapy is a safe and effective treatment for spinal instability and spinal cord compression in myeloma. The decision to adopt a non-operative approach in this cohort of patients should be made in a tertiary centre with expertise in multiple myeloma and in a multidisciplinary setting.

OP37: Surgical Complications 3

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A325: Human lumbar Discs are not Sterile! - Defining the Normal Intervertebral Disc Microbiome

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Introduction: Traditionally, Central Nervous System, spinal cord, eye, fetus and Intervertebral Disc were considered to be to be sterile and immune privileged. With the advent of 16SrRNA sequencing, it has been proved that each of the above have a microbiome which plays an essential role in maintaining homeostasis. With increasing reports of subclinical infection as an etiology of disc degeneration and Modic changes, it remains unknown, whether lumbar discs are truly sterile. The primary aim of the study was to investigate the presence of Disc microbiome and its microbial composition. **Materials and Methods:** In order to obtain true normal controls, intervertebral discs were collected from MRI normal brain-dead voluntary organ donors with no history of back pain. The study was performed after the approval of IRB. The discs were dissected in surgical sterile conditions and were snap frozen immediately to -160 C and the processed samples were subjected to total DNA extraction using QIAamp® DNA Mini Kit and enrichment using NEBNext® Microbiome DNA Enrichment Kit (Cat # E612S/L; New England BioLabs, Ipswich, MA). The purified DNA was amplified using v1-V9 specific primers and the sequencing was performed using Illumina MiSeq platform. Raw data was analysed using Bioinformatic tools such as Greengenes database and kraken2. Proteomic analysis was also performed to confirm bacterial presence. **Results:** All the eight normal disc samples had bacteria. 42.75% OTUs were classified at the Kingdom level, 44% at Phylum level, 22.62% at Genus level and 5.5% at Species level. A total of 355 bacterial species were identified in normal discs which were distributed under five major phyla- *Proteobacteria, Parcubacteria, Firmicutes, Cyanobacteria* and *Actinobacteria.* 21 abundant genera *including Pseudomonas, Acinetobacter, Anoxybacillus, Sphingomonas, Bordetella, and Brevundimonas* were identified. At species level, the five most abundant bacteria identified were *Anoxybacillus kestanbolensis, Acinetobacter lwoffii, Sphingomonas yabuuchiae, Stenotrophomonas acidaminiphila* and *Pseudomonas veronii*. The much-discussed *Propionibacterium acnes* ranked ninth in abundance in the normal discs. Bacterial presence was confirmed through proteomics data by identification of bacteria specific proteins and vital enzymes. **Conclusion:** This is the first metagenome study in world literature to document the entire microbiome of MRI normal disc. The results of this study prove that lumbar discs are not sterile structures as traditionally thought. This brings out the question of what spectrum of organisms could invoke subclinical infection and disc degeneration. In addition, the presence of Propionibacterium acnes in normal disc samples raises a doubt in its etiopatholgical role in disc degeneration. It would be interesting to analyze the microbiome of degenerated discs to analyze whether a differential microbial composition is associated with disc degeneration.

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A326: Highly Concentrated Bupivacaine Does not Lead to Increased Local Toxicity Following Skeletal Surgery: a Proof of Concept

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Introduction: Skeletal surgeries are generally perceived as exceptionally painful. Currently, postoperative pain is treated in a multimodal fashion with a prominent role for opioids. The recent societal debate regarding opioids and their frequent adverse effects have sparked the development of non-opioid alternatives. A number of non-opioid analgesics aim to provide a local, sustained release of the aminoamide anesthetic bupivacaine. To obtain extended pain relief, incorporation of a high bupivacaine dose is necessary. The local toxicity induced by high concentrations of

bupivacaine is unknown. This study describes local toxicity thirty days following infusion of ascending concentrations of bupivacaine in a rat model of spinal and femoral surgery. **Material and Methods:** Wistar rats (n = 16) underwent either spinal or femoral implantation of a screw using established approaches. A custom-made cannula for bupivacaine infusion was attached under the screw-head close to the periosteum. Next, either the clinically used concentration of 0.5%, or higher concentrations of 2.5% or 5% bupivacaine was administered, leading to cumulative doses of .67, 3.3 and 6.7 mg/kg bupivacaine, respectively. Half of the rats received the complete dose as bolus infusion. immediately to simulate a dose-dumping scenario. The other half received the dose over 72 hours of pump-controlled infusion, resulting in 12 different treatments. Body weight, leukocyte and creatinine kinase (CK) levels were monitored during the postoperative period. Thirty days after surgery, rats were killed and the implantation site was collected. Hematoxylin-eosin slides were assessed by a blinded pathologist for signs of inflammation, fibrosis, bone reaction, periosteal reaction, osteoclast activity, necrosis and muscle damage. A cumulative histology toxicity score was calculated. Data were analyzed using a multivariate regression analysis. **Results:** All but two rats recovered uneventfully. Weight, leukocyte counts and CK-levels normalized in all rats during the postoperative period. Bupivacaine concentration, implantation location and speed of administration did not affect postoperative weight gain, leukocyte counts and CK-levels. No difference in histology toxicity score between bupivacaine concentrations was observed, non between administration speeds. Histology toxicity score was significantly higher for spinal implantation compared to femoral implantation, probably corresponding to the more invasive dissection during the procedure. **Conclusion:** This animal study found no concentration-dependent local toxicity of bupivacaine for skeletal surgery. The toxic effects of even the highest bupivacaine concentration used appear minor/negligible in light of the surgical intervention sustained. The current results might facilitate orthopedic application of sustained-release formulations, containing high concentrations of bupivacaine.

1102
A327: The influence of frailty on the outcomes of spine surgery; a systematic review

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Introduction: With an aging population, there is an increasing number of elderly patients undergoing spine surgery. Recent literature in other surgical specialties suggest frailty to be an important predictor of outcomes. The aim of this review was to examine the association between frailty and outcomes after spine surgery. **Material and Methods:** A systematic review was performed registered with PROSPERO (ID:129928). Search strategies 1946 to 2020 with subject headings and keywords for "frailty", "elderly" and "spine surgeries" and conditions of interest were defined for three databases (Ovid Medline and Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid Embase Classic + Embase and Ovid Cochrane Central Register of Controlled Trials). Filters for human studies were used, and were not limited by date or language. The search results were filtered by abstract, and relevant articles were then graded by 3 authors independently. Articles were grouped by index applied, and where possible classified into disease-specific partitions. The primary outcome measure reported was adverse events. Secondary outcomes included other measures of morbidity, mortality, and patient outcomes. Sample size, mean age, age limitation, data source, study design, primary pathology, surgical procedure performed, follow-up period, assessment of frailty used, surgical outcomes, and impact of frailty on outcomes were extracted from eligible studies. Quality and bias was assessed using the PRISMA 27-point item checklist and the QUADAS-2 tool. **Results:** Initial search returned 4727 results, which were narrowed to 189 after screening by abstract. 30 full text articles were graded and included in the final analysis (total of 127 813 patients). The measure most frequently cited was the 11-point Modified Frailty Index (n = 18), calculated from inpatient diagnostic codes. The most common pathology was degenerative disease followed by adult spinal deformity (ASD), metastatic disease and trauma/spinal cord injury. Pooled quantitative analysis was possible for only 2 articles (ASD). Frailty was universally associated with increased perioperative complications, mortality, length of stay and non-home discharge destination. Only ASD showed correlation with long-term patient-reported outcomes. Morphometric analysis has suggested that measures of sarcopenia may have better acuity for predicting complications compared to frailty. **Conclusion:** There is strong evidence that frailty is associated with increased risk of morbidity and mortality in patients who received spine surgery. However, it remains inconclusive whether frailty impacts patient outcomes and quality of life after surgery.

1181
A328: Pedicle Screw Stacking: A Technical Note on Instrumentation of Lumbar Spine with a Broken Pedicle Screw

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Introduction: With a substantial increase in the number of pedicle screw breakage in failed spine surgeries, it becomes imperative to instrument the involved level to attain maximum stability to enhance fusion following revision surgeries. We present a novel, feasible bailout procedure called Pedicle Screw Stacking (PSS) to instrument lumbar pedicles with a broken screw inside them. **Materials and Methods:** Five patients with nine broken pedicle screws at the screw-shaft junction were preoperatively assessed to determine the position of the broken screw within the pedicle. Based on location, they were classified into Type I, Type II, and Type III when they occupied superior, middle, and inferior zones in the pedicle respectively. Stack screws were inserted inferiorly in Type I, superiorly in Type III, and by a tricortical method in Type II. **Results:** One inferior stack screw at L5 (Type I), five superior stack screws at S1 (Type III), and three tricortical pedicle screws at L5 (Type II) were placed in five patients during revision surgeries. All patients had improvement in functional scores without post-operative neurological deficit or implant failure or screw related complications at a follow-up of not less than two years. **Conclusion:** PSS is a safe method to instrument the index level, without removal of the broken screw while revising a failed lumbar spine surgery. This technique potentially avoids the instrumentation of additional segments and improves the stability of the revision construct. However, meticulous pre-operative assessment of anatomy is needed to assess the feasibility of the technique based on pedicle anatomy on a case-to-case basis.

1137
A329: Tranexamic Acid in Elective Spine Surgery: A Randomised Controlled Trial Analysing the Efficacy of Intravenous, Local Infiltration and Topical Administration of Tranexamic Acid

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Introduction: Intravenous tranexamic acid (ivTXA) has almost become a standard for bleeding management in spine surgery. However, the systemic complications associated with it may be rare but not uncommon. To negate these effects, topical application of tranexamic acid (tTXA) has been used recently with good amount of success. Although local infiltration of tranexamic acid (loTXA) has been used in trauma related haemorrhages, till date there is no literature available examining its efficacy in spine surgery. The purpose of the study is to evaluate the safety and efficacy of tranexamic acid administered through various routes in instrumented spine surgeries. **Material and Methods:** 104 people undergoing instrumented spine surgery were randomly assigned to 4 groups. Groups included (1) ivTXA-intravenous administration of TXA one hour prior to surgery. (2) loTXA-local infiltration of TXA bilaterally into the paraspinal musculature prior to incision. (3) tTXA-Topical application of TXA just before wound closure. (4) Control group. Outcome measures include intraoperative blood loss, post-operative blood loss, need for blood transfusion, length of hospital stay, blood parameters. **Results:** All the three groups with different modes of TXA administration were found to be effective in reducing blood loss compared to control group. Intra-operative blood loss was significantly reduced in ivTXA(223.6 ± 40.1 ml, P-< .0001) and loTXA (256.07 ± 119 ml, P-0.0039) groups when compared to controls(344 ± 88.5 ml).Whereas, the post-operative blood loss was least in tTXA followed by ivTXA, loTXA and controls. There was 67% reduction in need for blood transfusion in tTXA group, 55.5% reduction in ivTXA group, and 33% reduction in loTXA group when compared to control group. **Conclusion:** In instrumented spine surgery, ivTXA and loTXA were found to be equally effective in reducing the intra-operative blood loss. Whereas, the tTXA has better post-operative blood conserving effects. This is the first study to detail about safety and efficacy on local infiltration of TXA in spine surgery, which is an effective and safe method for reducing intra-operative blood loss.

1125
A330: Risk Factors for Post-Operative Venous Thromboembolic Events in Patients Undergoing Thoracic Spine Surgery

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Introduction: Venous thromboembolic events (VTEs), including pulmonary embolism and deep vein thrombosis, are preventable postsurgical complications that are associated with high morbidity and mortality in addition to increased hospital costs and prolonged hospital stays. There is a need for preoperative criteria to identify risk factors for postoperative thromboembolism in patients undergoing thoracic spine orthopedic procedures. This study aimed to elucidate the relative rates and temporal trends of VTEs after various thoracic spine procedures, and the comorbidities and demographics that were independent predictors of VTE. **Material and Methods:** This is a retrospective study utilizing the PearlDiver insurance database to identify patients who underwent primary single- or multilevel thoracic spine surgery from 2010-2018. Procedures evaluated included fusion, laminectomy/decompression, corpectomy, osteotomy, and kyphoplasty/vertebroplasty. Patients undergoing these procedures were identified using

Current Procedural Terminology (CPT) codes. International Classification of Diseases (ICD), Ninth and Tenth Revision diagnosis codes were used to determine the incidence of postoperative VTEs and identify patient comorbidities. Complication codes for VTEs were queried at postoperative day (POD) 0, 1, 7, 30, and 90. Summary statistics, including VTE incidence rates and odds ratios (ORs), were calculated for patient risk factors and demographics. **Results:** A total of 41,689 patients who underwent thoracic spine surgery from 2010-2018 were identified (52.0% female). Within the entire patient population, the incidence of VTE was 1.40% within a 90-day follow-up period, with an incidence of thromboembolism of 0.21%, 0.46%, and 1.06% by POD 1, 7, and 30, respectively. Patients aged 70-74 represented the most common age group to undergo thoracic spine surgery (17.7%) and experienced the greatest incidence of VTE of any age group (1.79%). Males had an increased incidence of VTE compared to females (1.43% vs 1.38%). Fusion was the most common procedure performed (59.4%) and was associated with the greatest incidence of VTE (1.52%). Osteotomy and laminectomy were associated with VTE incidence rates of 1.40% and 1.34%, respectively. Among individuals with one or more of the queried risk factors, the incidence of VTE was 1.79%, compared with an incidence of 1.20% in individuals without these factors. Risk factors associated with the highest incidence of postoperative VTE were extremity paralysis (7.25%), central venous lines (3.84%), heart failure (3.36%), arrhythmia (3.34%), and hypertension (1.88%). The lowest incidence of VTE was seen in patients with a history of tobacco use (1.25%). **Conclusion:** Our preliminary data suggests there are identifiable risk factors associated with increased risk of postoperative VTE in patients undergoing thoracic spine surgery. The highest incidence of VTE was observed following fusion. Patients aged 70-74 experienced the highest rate of VTE, and males had a higher incidence of VTE than females. Individuals with one or more queried risk factors had a higher incidence of VTE than those without any factors. These findings regarding the incidence and timing of VTEs have the potential to guide clinician assessment of patient risk and screening practices prior to thoracic spine surgery.

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A331: Post-Operative Complications Following Sacroiliac Joint Fusion to Treat Sacrum Pain, Sacroiliitis, Sacral Instability, or Spondylosis

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Introduction: The sacroiliac joint has been implicated as a source of chronic low back pain. Many have turned to sacroiliac joint fusion after failure of conservative care to relieve symptoms. However, identifying patients who will respond positively from the sacroiliac joint fusion is still unclear. This study examines the postoperative outcomes of sacroiliac joint fusion based on the primary diagnoses of sacrum pain, sacroiliitis, sacral instability, or spondylosis. **Material and Methods:** Using the 2016 National Readmission Database, we conducted a retrospective cohort analysis of 1,272 patients who received a sacroiliac joint fusion for diagnosed sacrum pain (n = 288), sacroiliitis (n = 536), sacral instability (n = 135), or spondylosis (n = 155) using ICD-10 coding. We then collected all of the individuals that had a non-elective readmission, separated them by their primary diagnosis, and analyzed for postoperative complications including infection, urinary tract infection, pain, osteomyelitis, thromboembolisms, sepsis, pneumonia, pseudoarthrosis, novel lumbar pathology, nervous system complications, and need for revision surgery. Statistical analysis was conducted in R. Tukey multiple comparisons of means was used to compare complications by diagnosis. **Results:** Sacroiliitis had the highest rate of non-elective readmissions (17.1%), followed by those diagnosed with sacrum pain (14.2%), spondylosis (11.6%), and sacral instability (9.6%), but these rates were not significant between any groups on pairwise comparison. However, those with a primary diagnosis of sacroiliitis had a significantly higher average number of readmissions (1.80 ± 1.16 readmissions) than those with a primary diagnosis of sacrum pain (1.24 ± 0.58 readmissions, $P = .013$), but no differences existed between other groups. After comparing the different categories of postoperative complications, significant differences in postoperative infection rates were noted between patients with a primary diagnosis of sacroiliitis and those with a primary diagnosis of sacrum pain ($P = .008$). **Conclusion:** Patients diagnosed with sacroiliitis had the highest rate of non-elective postoperative readmissions following sacroiliac joint fusion, and patients diagnosed with sacral instability had the lowest rates of non-elective postoperative readmission. The reasons for readmission were not significantly different across each group, except for infection rates of those with a primary diagnosis of sacroiliitis being significantly higher than those diagnosed with sacrum pain.

1861
A332: Short Term Complications Related to the Lumbar Interbody Fusion Approach

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Introduction: Lumbar interbody fusion is a therapeutic option that has demonstrated its efficacy in the treatment of various degenerative discal pathologies. However, this technique requires a learning curve and, in some cases, a longer operating time, which may expose the patient to complications that differ depending on the technique chosen. The main objective of our work was to study the rate and type of short term complications related to the lumbar interbody fusion approach. **Material and Methods:** We conducted a retrospective study of 42 lumbar interbody fusions operated in our department. We used the Eurospine "Spine Tango" form for the fellow, the collection of clinical and epidemiological data. All patients underwent standard pre-operative radiological explorations with magnetic resonance imaging (MRI). Complications were divided into non-specific such as non-fusion, recurrence of clinical symptoms and surgical site infection; specific complications related to the approach such as meralgia for the anterolateral approach. Risk factors for complications were analyzed using SPSS version 20. **Results:** The average age of our patients was 53 years with a female predominance (sex ratio of 3.6). The main pathologies were degenerative disc disease (38%), degenerative spondylolisthesis (29%) and lumbar spinal stenosis (26%).23 patients were operated by posterior approach (12 PLIF and 11 TLIF) and 19 patients were operated by anterior or anterolateral approach (4 ALIF and 15 OLIF). The operating time was between 2 and 3 hours in 60% of cases. Blood loss was estimated between 100 and 500ml in 66% of cases. An intraoperative transfusion was performed for 2 patients. The overall complication rate was 28,6%. For the posterior approach, we found one case of dural tear which was sutured, one case of spondylodiscitis which was treated with debridement washing and antibiotics with no post-operative clinical impact and 4 cases of clinical recurrence of sciatica. For patients who had an anterior approach, 5 presented a post-operative meralgia and 1 patient with hypoesthesia around the approach. There were no cases of non-fusion or instability. No patient presented a thromboembolic complication. **Conclusion:** The advantages of lumbar interbody fusion compared to the classical posterolateral fusion technique are well known. However, the complication rate of this technique remains high and must be considered during decision making regarding the approach choice.

1727
A333: Comparing Clinical Outcomes from Pedicle Screw Insertions with Robotic Guidance vs Freehand vs Computer Navigated Techniques: A Systematic Review

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Introduction: The placement of pedicle screws is now common practice in spinal surgery. The freehand method (FH) is a well-established technique of screw insertion where anatomical landmarks and surface topography of the posterior spine are used in order to safely instrument the spine with pedicle screws. Due to the proximity of the pedicle to the neural elements as well as the arrangement of vascular structures adjacent to the spine, inaccurately placed screws can result in significant neurological and vascular complications. Accurate screw placement using the FH method is therefore reliant on the skill and experience of the surgeon. In recent years, significant effort has been placed into the development of surgical tools such as image guided spinal navigation (NV) and more recently robotic assisted guidance (RG) in order to improve the accuracy of screw placement. Whilst the literature thus far has shown that RG improves the accuracy of pedicle screw placement, it remains unclear whether this translates into improved clinical outcomes for patients. We aimed to provide a systematic review of the available literature, comparing clinical outcomes from pedicle screws placed via RG versus NV versus the conventional FH approach. **Material and Methods:** The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed. A literature review was conducted in the Medline, Embase, SCOPUS and Cochrane databases from the year 2000 onwards using predetermined search terms. All peer reviewed English language human studies were included. Both prospective and retrospective studies were eligible for analysis. The primary outcome was the rate of post-operative revision surgeries due to misplaced screws. Secondary outcomes were intra-operative screw revision rates, radiation exposure, length of hospital stay, operation duration, blood loss, changes in leg and back pain, changes in disability and complication rates. **Results:** Among 19 studies, intraoperative revision rates, post-operative revision rates, blood loss and radiation exposure were improved by RG compared to the FH approach. Complication rates, neurologic injury rates, length of hospital stay, length of operations, changes in disability and changes in pain were equivalent between RG and the FH approach. There is lack of available literature comparing RG to NV techniques. **Conclusion:** Based on the available literature, RG has the potential to minimize the incidence of clinically important adverse events compared to the FH technique. Given the evidence, RG may reduce intra-operative screw revision and the need for post-operative revision. Additionally, RG is associated with reduced blood loss compared to FH,

likely due to its minimally invasive nature. Radiation exposure is also reduced with RG compared to FH, yet it should be noted that in cases of osteolytic spinal disease, the benefit in this domain may be limited. Overall, although it is clear that RG does provide benefit across multiple domains compared to the FH approach, it remains questionable whether the size of these benefits is clinically significant. Future research should evaluate whether the improved patient outcomes can justify the costs associated with RG systems.

OP38: Cervical Trauma

1522
A334: Comparing Outcomes of Subaxial and Alantoaxial Trauma in Elderly Patients

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Introduction: In contrast to younger patients, the elderly are more likely to sustain severe cervical spine trauma from relatively low energy mechanisms of injury. The presence of pre-existing spine pathology such as osteoporosis, cervical stenosis, ankylosis, spondylosis, and degenerative changes can predispose elderly patients to fractures and neurologic injury. To date, there has been little research comparing outcomes and mortality rates of patients with upper cervical (occiput-C2) versus subaxial (C3-C7) cervical spine injuries. Given this paucity of data on this subject, we sought to compare mortality rates and outcomes between using our prospective trauma database. **Materials and Methods:** All elderly trauma patients (65+) with cervical spine injuries who presented to a single, high-volume, level I trauma center between 2010-2019 were identified via an institutional trauma database. Retrospective chart review was performed to assess treatment rendered, complication, and outcome measures and then stored in a deidentified database. Imaging characteristics of patients including psoas index (a marker for sarcopenia) and L3 Hounsfield Unit (an indicator of osteoporosis) were calculated using standard technique and recorded. Patients were sorted into upper cervical (occipital condyle, C1, and C2 vertebral fractures and ligamentous injuries) and subaxial (C3-7) cohorts and by treatment (operative vs non-operative management). Surgical and medical morbidity variables recorded include surgical site infection, pneumonia, STEMI, DVT/PE and stroke. Pearson's Chi-squared tests were used to compare rates of mortality and complications between groups. **Results:** A total of 922 patients were identified, with 545 upper cervical (59%), and 377 subaxial (41%) trauma patients. Patients with upper cervical spine trauma were significantly older ($P < .001$), more sarcopenic ($P = .002$), osteoporotic ($P = .002$), and had higher rates of dementia ($P = .003$). There was no significant difference in cardiac or pulmonary comorbidities between the two groups ($P = .7$). Patients with subaxial injuries had a higher injury burden, with significantly higher Injury Severity Scale (ISS) scores ($P = .008$), non-contiguous spine injuries ($P = .016$), closed head injury ($P = .04$), and pelvic fractures ($P = .04$). Comparing operative cohorts, there was a higher proportion of medical and surgical complications in the upper cervical group ($P = .006$), and specifically higher incidence of pneumonia ($P = .009$). There was also found to be higher overall mortality in all upper cervical injuries both operative and nonoperatively managed as compared to the subaxial cohort ($P = .015$). There was no significant difference in in-hospital mortality between the two groups ($P = .25$). **Conclusion:** Although patients with subaxial injuries were found to be more severely traumatized with higher energy mechanisms and more severe associated injuries, our data demonstrates that patients with upper cervical trauma are at higher risk for medical and surgical complication and mortality, regardless of need for operative intervention. This is likely secondary to poor reserve given their older age, advanced sarcopenia, and increased morbidity associated with both operative management and nonoperative immobilization. In conclusion, we have demonstrated in the largest study to date that patients with upper cervical injuries, although less severely traumatized, should be critically evaluated given their increased risk for morbidity and mortality, especially during discussions with the patient and family about expected outcomes and functional status.

1552
A335: Complications of Anticoagulation Therapy for Thromboembolic Event Prophylaxis in Patients with Cervical Spine Fractures

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Introduction: The role and timing of anticoagulation (AC) therapy for thromboembolic event (TEE) prophylaxis in patients with cervical fractures is an ongoing debate in the literature with poor evidence dictating guidelines specific to these injuries. The risk of TEE must be weighed against the risk of bleeding complications from the therapy itself. Patients with cervical fractures may be at greater risk of bleeding complications. Therefore, the purpose of this study was to evaluate comorbidity burden, rate of thromboembolic events, rate of anemia and transfusion events, and utilization rates of

various forms of pharmacologic prophylaxis following cervical spine fracture. **Material and Methods:** A retrospective review of the Humana insurance database from 2007 to 2016 was performed to identify patients with cervical spine fractures. Patients were subdivided by AC therapy prescribed within 6 months of cervical spine fracture. Each cohort was longitudinally tracked for incidence of thromboembolic events, anemia, or transfusion at 2 weeks, 4 weeks, 12 weeks, and 6 months following cervical fracture. Demographics analysis and Charleston Comorbidity Index (CCI) was recorded. Sub-analysis by comorbidity was performed between cohorts. Chi-squared test was used to determine significance and compound annual growth rate was used to analyze utilization. **Results:** Five thousand eight hundered and seventy one patients were identified as having AC therapy with aspirin/anti-platelet, heparin/LMWH, warfarin or factor Xa inhibitors within 6 months of cervical spine fracture. Patients on aspirin/anti-platelet therapy were the least likely cohort to have any TE (2.1%, $P < .5$), particularly DVT (1.3%) and PE (0.6%). There was no difference found between cohorts in regards to incidence of stroke, proportion of transfusion, and anemia. **Conclusion:** Aspirin and anti-platelet anticoagulation therapy after cervical fracture had the least number of thromboembolic events when used within 6 months compared to other common forms of anticoagulation. Further research is needed to better understand the relationship between timing of specific anticoagulation therapy with the risks of the specific patient (cervical fracture pattern, medical comorbidities, etc.) and these significant complications to create a more individualized protocol.

1964
A336: Results in Dorsal Percutaneous C1/C2-Screw-Osteosynthesis in Instable Odontoid Fracture Type Anderson 2 and Combined Facture C1/C2 in the Elderly

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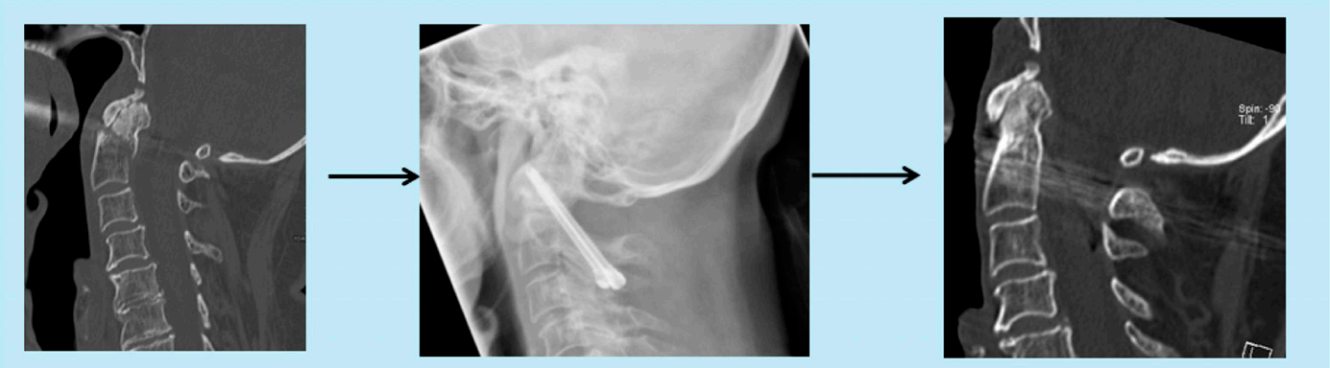
Question: For the surgical treatment of unstable odontoid fractures or combined fracture of C1/C2 ("unhappy triad") in old age several surgical procedures are possible:(1) direct anterior screw fixation of the odontoid, (2) dorsally by C1/C2-screw-osteosynthesis, open with iliac crest bone graft and cerclage (n.Gallie) or, (3) dorsally by C1/C2-screw-osteosynthesis percutaneously with two C1/C2-screws. The anterior direct screw osteosynthesis in osteoporotic bone metabolism is not successful, the dorsal C1/C2-screwing in open technique with iliac crest bone graft and cerclage is very stressful for the elderly. The percutaneus C1/C2-screw-osteosynthesis can lead to healing of the odontoid fracture; after completion of the fracture healing the screw fixation can be removed. **Methodology:** In a prospective study 32 patients with unstable odontoid fracture and an age over 60 years were stabilized with percutaneous posterior dorsal screw fixation C1/C2. The surgery was performed with 3D image converter for documentation of the reposition preoperatively and postoperatively to control the screw position. Intraoperative the percutaneous approach was documented with the exact image converter in two planes, ap and strictly laterally. Postoperative clinical controls were performed and CT inspection to document the stability and he healing of the fracture of the odontoid within a year. **Results:** In the period from January 2007 to December 2012 was carried out in 32 patients with unstable odontoid fractures with percutaneous screw fixation C1/C2 posterior stabilization. 17 women, 15 men with a mean age of 81.8 years / - 7.5 (median 84, min 57, max 91) were stabilized. The mean OR-time was 50.0 min / - 24.3 (median 44.5, Min 16, Max 123). In the mean follow-up of 117 days / - 244 (median 29.5), all patients had a stable course. In 12/32 patients the healing of the fracture could be demonstrated by CT, in 3/32 the metal was removed. **Conclusions:** The C1/C2 dorsal percutaneous screw fixation of unstable odontoid fractures is a safe and promising, the patient little burdensome procedure. With the help of 3D-imaging operating profit can be improved. Especially the older patients benefit from this supply strategy with high healing rate of the fractures. The metal removal can be effected by fracture healing of the odontoid, and thus the C1/C2-joint can be given free again.



1764
A337: Timing of Surgery and Pre-Operative Physiological Parameters as Clinical Outcomes in Traumatic Subaxial Cervical Spine Fractures and Dislocations

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Introduction: The burden of disability and rehabilitation with Spinal Cord Injury is immense and increasing with the advent and easier availability of high-speed vehicles in developing countries. Primary insult to spinal cord caused by compression due to dislocation or burst is irreversible. This injury further leads to progressive and continuous compression leading to hypoperfusion of the injured segment increasing the oedema and cord contusion. Pre-clinical studies have suggested direct co-relation between the period of compression of the cord and the extent of the structural irreversible damage to the cord. This finding has led spine surgeons to offer early surgical intervention to mitigate the damage and promote neurological recovery in such patients. An early surgical decompression targets to attenuate a secondary hit mechanism cascade including ischemia which ultimately leads to permanent loss of function for spinal cord. Despite the world-wide use of early decompression in patients with sub axial cervical fracture dislocation as a standard, it's role in improving neurology and decreasing mortality/morbidity remains controversial. There is a lacunae in the data of the surgical and functional outcomes of sub axial cervical spine fractures and dislocations in terms of patient's pre-operative physiological profile and surgical timing. Also there has been a considerable difference in the studies performed in the developing world and the developed world with respect to the surgical and functional outcomes, disability and mortality. This may be due to constraints of resources, sporadic health infrastructure, disregard for aggressive rehabilitation of the patients with permanent disabilities, lack of research funding and prioritization of other communicable and curable diseases with respect to the spinal cord injuries in developing countries. In this study, we have aimed to evaluate the risk factors associated with sub axial cervical spine fractures and dislocations in terms of patient's pre-operative physiological parameters and surgical timings. **Material and Methods:** Twenty six patients with sub axial cervical spine fractures and dislocations were enrolled. Demographic data of patients, appropriate radiological investigation and physiological parameters like respiratory rate, blood pressure, heart rate, PaO2 and ASIA impairment scale were documented. They were divided pre-operatively into 2 groups. Group U with patients having abnormal physiological parameters and Group S including patients having physiological parameters within normal range. They were further sub divided into early and late groups according to the timing of surgery as U_{early}, $U_{late,}$ S_{early} and S_{late}. All the patients were called for follow up at 1, 6 and 12 months. **Results:** Patients in Group S had neurological improvement by one ASIA grade and a good outcome irrespective of the timing of surgery. Patients in Group U having unstable physiological parameters and undergoing early surgical intervention had poor outcomes. **Conclusion:** This study concludes that early surgical intervention in physiological unstable patients had strong association as a risk factor in the final outcome of the patients in terms of mortality and morbidity. Also, no positive association of improvement in physiological stable patients with respect to timing of surgery could be established.

1676
A338: YouTube as a Source of Patient Information on Cervical Spine Fractures: A Content-Quality and Optimization Analysis

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Introduction: Due largely to its convenience, the internet allows patients to search the web for health information. For this reason, it is critical to check the quality and adequacy of information published online. In this paper, we evaluated the information available on YouTube concerning cervical spine fractures. **Material and Methods:** The first 35 videos for each of the following search terms were considered for analysis: cervical spine fracture, cervical spine injury, broken cervical spine, broken neck, neck trauma and c spine trauma. All the videos were searched on October 4, 2020. The search was conducted under the default "relevance" sorting in "incognito mode" without being logged to any personal browser account. Videos were assessed by two independent evaluators using the DISCERN scoring system, the Journal of the American Medical Association (JAMA) score and the Global Quality Score (GQS). "VidIQ Vision for YouTube" plugin was used to investigate the quantitative information the analysed videos. The discrepancy between individual videos and the 2 evaluators (a 6th year medical Student and a 4th year neurosurgery resident) was statistically evaluated and compared. Non-English videos, videos greater than 60 minutes and videos containing irrelevant information (e.g., music videos and pranks) were excluded. **Results:** Out of the 210 videos considered, only 65 (31%) met the inclusion criteria. The DISCERN score ranged from 18 to 53 while the mean between the raters was 32 points which indicates an overall poor quality of videos on cervical spine fractures. Qualitative analysis showed that the vast majority of videos had clear information (n = 59, 90.77%). Most of the videos included anatomy (n = 44, 67.69%), mechanisms of injury (n = 43, 66.15%) and symptoms of cervical trauma (n = 34, 52.31%). 66.15% (n = 43) of videos had a doctor speaking.

Most videos were uploaded by physicians (27.69%). The absolute agreement for the intraclass correlation coefficient was .97 for DISCERN, .86 for JAMA and 0.74 for GQS. Videos explaining cervical spine anatomy, treatment options, treatment procedures and risks had a statistically significant higher DISCERN, GQS and JAMA score. Videos containing: clear information, radiographs, diagrams and a doctor speaker had a higher DISCERN, GQS and JAMA score. Patient speakers correlated with lower video scores. No correlation was found between the length of video, words per minute or the number of likes, animation and the JAMA/GQS/DISCERN scores. Videos uploaded by patients had a statistically significant lower scores in all three scales. **Conclusion:** The quality of cervical spine fracture videos on YouTube is poor. Considering the extent to which patients rely on YouTube as a source of information, the educational quality of videos on this topic can be much improved. We have highlighted specific topics that are commonly omitted so that future content creators may use it as a guide to make more robust educational videos.

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A339: Epidemiological and Surgical Aspects of Post-Traumatic Syringomyelia in A Rehabilitation Hospital

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Introduction: Patients who are victims of traumatic spinal cord injury (SCI) may develop late neurological signs and symptoms directly related to the initial trauma, or even worsening of the pre-established neurological symptoms. In these cases, differential diagnoses should be investigated including syringomyelia. Post-traumatic syringomyelia (PTS) is the development of a spinal cord cyst caused by changes in the CSF flow. The incidence of symptomatic PTS is observed in 4-40% of cases of SCI, but the literature is heterogeneous and scarce. The objective of this study is to analyze the cases of PTS in terms of prevalence, prognostic factors and results of surgical therapy. **Material and Methods:** A retrospective study was carried out using electronic records from the hospital database of patients with PTS. Clinical and radiological data were extracted from January 2000-December 2018. Prevalence, patient demographic data, information about the traumatic event, clinical and radiological factors, and the impact of different surgical techniques adopted for the treatment of PTS were analyzed. **Results:** A total of 920 patients diagnosed with SCI were recorded and 85 patients met the inclusion criteria for diagnosis of PTS. Traffic accidents were the most common cause (N = 58; 68.2%), the thoracic segment was the most affected (N = 56; 65.9%) and upper limb paresis was the most common clinical alteration that motivated surgery (N = 27; 45%). Surgical treatment was indicated in 48 patients distributed among the following types of surgery: syringo-pleural shunt (N = 29; 60.4%), adhesiolysis (N = 17; 35.4%) and syringo-subarachnoid shunt (N = 2). The prevalence of PTS in the hospital was 9%, being more frequent in ASIA A patients. The majority of patients with PTS (63 patients; 74.1%) were operated in the first SCI approach. Specific surgical treatment for syringomyelia significantly reduced the cyst, both in the number of levels ($P = .05$) and by reducing a large part of the cyst ($P = .001$). The reoperation rate after using the adhesiolysis technique was 47%, while the cyst derivation technique showed a rate of 38%. **Conclusion:** The follow-up and monitoring of patients with spinal trauma are important for the diagnosis of syringomyelia, especially the late neurological symptoms. Surgery has a positive impact on the radiological reduction of the syringomyelia cyst.

1601
A340: Standard Set of Network Outcomes for Traumatic Spinal Cord Injury: A Consensus-Based Approach Using the Delphi Method

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Introduction: In the acute care for patients with traumatic spinal cord injury (t-SCI), the primary focus is to prevent and reduce secondary damage. The focus during the rehabilitation phase is to regain the best level of participation. At the moment, large practice variation in treatment exists in level one-trauma centers and in rehabilitation centers. To understand and reduce practice variation, standardization of treatment outcomes is warranted. With systematic and continuous outcome monitoring during both the clinical and rehabilitation phase, it is possible to assess the value of provided care. The data can be used to describe care patterns, including suitability of care and inequalities in care provision. Purpose: to define a standardized (network) outcome set for t-SCI, including patient-relevant outcomes, adequate

measurement instruments, as well as case-mix and risk factors. **Material and Methods:** Based on peer-reviewed literature and (inter-)national databases as the EMSCI (European Multicenter Study about Spinal Cord Injury) and the Dutch SCI database (Nederlandse Dwarslaesie Database; NDD), a preliminary set of outcomes, casemix and risk factors, and adequate measurement instruments was composed. A multidisciplinary panel participated, consisting of 19 health-care professionals (orthopaedic and neurosurgeons, rehabilitation physicians, physiotherapists, occupational therapists, psychologists, nurses) with experience (average 14 years) in t-SCI management. A modified Delphi method was performed to reach formal consensus and consisted of two web-based surveys and one face-to-face meeting (threshold for consensus: 70%). **Results:** In the first two Delphi rounds, 18/19 invited panelists (94.7%) responded and 10 panelists participated in the final meeting. The prefinal set was confirmed by all panelists. The standard set encompasses the three-tiered outcome hierarchy and consists of patient-reported and clinician-reported outcome domains, covering the surgical and rehabilitation phase. It includes survival (survival rate, trauma severity), degree of health or recovery (functional status; neurological status [ASIA], walking ability [e.g. SCIM-III, 10MWT, WISCI], quality of life [EQ5D5L, AOSpine PROST]), time to recovery and to return to normal activities (time of injury, admission, surgery, rehabilitation and discharge), disutility of care or treatment process (operative mortality, re-operations, adverse events), sustainability of health and nature of recurrences (participation, caregiver burden), and long-term consequences of therapy (pneumonia, decubitus, surgical interventions). The panelists reached consensus on a measurement schedule (acute [<72 hours], sub-acute and chronic [1, 3, 6 and 12 months] phase) and on the proposed casemix and risk factors, including demographics (e.g. age, gender), clinical status (e.g. physical status, co-morbidities), and treatment process ((non-) surgical treatment and rehabilitation program). **Conclusion:** A standard set for network outcomes is developed and can be implemented in hospitals and rehabilitation centers involved in the treatment of t-SCI. The set facilitates pooling of data and can be used to compare casemix and risk-adjusted outcomes across regions, studies, and registries in order to improve the quality in clinical practice in t-SCI. Using the standard set, prognostic prediction of outcomes of treatment is feasible, so each patient receives the right care at the right time in the right place. In future, this supports patient-specific decision-making, and ultimately improved outcomes and value of care for patients with t-SCI.

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A341: Pedicle Screw in Lower Cervical Spine

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Background: Pedicle screw fixation of lower cervical spine is a new technique that provides an alternative to posterior lateral mass plating. Although biomechanical studies suggest the use of pedicle screws to reconstruct the cervical spine, placing screw in small cervical pedicle poses a technical challenge. Penetreation of screw in pedicle is a primary complication associated with screw insertion in the lower cervical spine. **Aim and Objective:** To manage the cervical spine injuries by pedicle screw presented to department of Orthopaedics, BPKIHS, Dharan. **Materials and methods:** This is retrospective interventional study done at the department of Orthopaedics,B.P.Koirala Institute of Health Sciences, Dharan, Nepal over a period of 7 years from March 2012-April 2019. A total of 55 patients with cervical spine injuries were treated by pedicle screw. The patient's age ranged from 20 to 60 years and the mean follow-up was 12 weeks. **Results:** The study comprised of 55 patients with cervical spine injuries were treated by pedicle screw The age incidence in this series ranged from 20 years-60 years. 40 patients were males and 20 was female. All had fractures or fracture dislocation at different levels of lower cervical spine.The mechanism of injury included falls from height (80%), motor vehicle accidents (18%) and sports related injury (2%). **Discussion:** Pedicle screw insertion into th*e pedi*cles in the lower cervical spine is technique that requires a solid knowledge of 3-dimensional anatomy of cervical spine and experience of pedicle screw fixation in thoracolumbar spine. The biomechanical advantages of pedicle screw fixation in cervical spine is obvious, but data are limited. However, safety and role of pedicle screw fixation in reconstruction in the lower cervical spine have not been defined. **Conclusion:** It is indicated in patients with osteoporotic bone or when rigid internal fixation can not be achieved by conventional techniques. **Keywords:** Cervical pedicle screw, lower cervical spine, lateral mass

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A342: Modern Guerilla Warfare and Penetrating Missile Injuries of the Cervical Spine: Characteristics of Penetrating Missile Injuries to the Cervical Spine in a Large War Time Cohort of Modern Guerrilla Warfare

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Introduction: Missile injuries are very serious injuries particularly in the cervical region. They are classified into high and low missile injuries when it involves the cervical spine. In modern guerrilla warfare, one must be aware of ballistic pathology with bullets as well as from explosives. In particular, improvised explosive devices commonly known as IED's play a new and important pathophysiology whether they are suicided

vests or roadside bombs. They usually produce severe or lethal injuries and serious neurovascular deficit is frequent. We present the details of 40 patients with local experience on how to handle serious penetrating cervical missile injuries. **Methods:** All cases were collected from the record of Basrah University Hospital, Iraq. Healthy military gentlemen with ages ranging between 20-35 years were included. **Results:** 11 patients had bullet injuries and 29patients had fragments of shell injuries. The sites of injuries were 9: C2-C3, 12: C5-C6,12: C4-C5 and 7: C7-T1. Bullet entrance was anterior in 23 patients, posterior in 7 patients and lateral in 10 patients. The cervical vertebrae were injured in 37 patients at body or lamina level while in 3 patients it was only neural tissue injuries. Missiles were retained in 13 patients. All injuries showed some degree of neurological deficit with quadriplegia in 26 patients. 9 patients presented with very serious injuries. No relation was found between the size of the missile and the extent of damage. Outcome of treatment in all patients was poor. **Conclusion:** Gunshot wounds only account for approximately one third of penetrating missile injuries in patients who survive and are well enough to receive medical treatment. 62% of patients' cohort were from explosive devices, consistent with data from 2010, where 58% of fatalities were from IED's occurring in foreign soldiers in Afghanistan. We discuss the importance of general supportive measures, generous wound excision, removal of the retained missiles and heavy cover of antibiotics.

OP39: Minimally Invasive Spine Surgery

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A343: Minimally Invasive vs Open Surgery for Lumbar Spinal Stenosis in Patients with Diabetes - A CSORN Study

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Introduction: Patients with diabetes experience worse outcomes following spine surgery. It is important to optimize the outcomes of patients with diabetes as they are at greater risk of complications and comorbidities. Studies comparing MIS vs OPEN spine surgery for patients with diabetes are lacking. This study compares the outcomes of patients with diabetes undergoing MIS vs OPEN surgery for lumbar spinal stenosis (LSS). **Material and Methods:** This is a multi-center retrospective cohort study. Baseline, surgical, 6-12 week and 12 month follow-up data were obtained for patients with diabetes diagnosed with LSS from the Canadian Spine Outcomes and Research Network (CSORN) registry. Exclusion criteria were American Society of Anesthesiologists (ASA) scores >3 or >3 levels operated on. Primary outcomes of interest were blood loss, length of hospital stay, adverse events, modified Oswestry Disability Index (ODI) and the Numerical Rating Scales (NRS) for leg and back pain. Two separate analyses were run to compare the effects of MIS vs OPEN surgery for two treatment cohorts: (1) patients undergoing decompression without fusion (N = 116; MIS n = 58; Open n = 58), (2) patients undergoing decompression with fusion (N = 108; MIS n = 54; Open n = 54). A 2 (MIS vs OPEN) x 3 (baseline; 6-12 weeks; 12 months) mixed measures analysis of co-variance (ANCOVA) with ASA scores as a covariate were run for each cohort. Categorical variables were analyzed with 2x2 chi-square tests and continuous variables were analyzed with t-tests. Significance was set at $P < .05$ and mean differences were compared against published values for minimal clinical important difference (MCID). **Results:** All patients had significant improvements on ODI and pain scores from baseline to 6-12 weeks and 12 months which met MCID, regardless of surgical technique. There was no significant difference between MIS and OPEN surgery on long-term outcomes in the decompression without fusion cohort. The MIS group who underwent decompression with fusion had significantly lower ODI (mean difference 14.25; $P < .001$) and back pain (mean difference 1.64; $P = .002$) compared to OPEN surgery at 12 months post-operation, the difference exceeded the MCID. The MIS groups in both cohorts had significantly less blood loss (without fusion mean difference 99.77 ml, $P = .002$; with fusion mean difference 244.23 ml, $P < .001$) and significantly shorter length of stay in hospital (without fusion mean difference 1.15 days, $P = .008$; with fusion mean difference 1.23 days, $P = .026$). There were no statistical differences in adverse events for either cohort (without fusion $P = .485$; with fusion $P = .079$). **Conclusion:** Patients with diabetes benefit long-term from decompression with and without fusion for LSS regardless of surgical technique. MIS surgery for LSS is associated with significantly less blood loss and shorter length of hospital stay. MIS decompression with fusion for LSS provides patients with diabetes with less disability (ODI) and back pain one year post-operation compared to OPEN procedures. To optimize outcomes, MIS approaches should be promoted for patients with diabetes undergoing decompression with fusion for LSS.

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A344: Patient Reported Outcomes of Patients that Fail to Reach Minimum Clinically Important Differences: Comparison of MIS to Open TLIF

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Introduction: Treatment of degenerative lumbar diseases has been shown to be clinically effective with open or minimally invasive transforaminal lumbar interbody fusion (TLIF), with equivalent clinical outcomes between the two modalities. Despite this, a substantial proportion of patients will not meet minimal clinically important differences (MCID) on patient reported outcomes (PROs). Previous studies have not compared subsets of patients that fail to reach MCIDs after open (O-TLIF) or minimally invasive (MIS-TLIF) TLIF in order to identify clinical variables associated with poor outcome. **Material and Methods:** Patients undergoing O-TLIF or MIS-TLIF for lumbar degenerative disorders enrolled in the Canadian Spine Outcomes and Research Network prospective registry. The outcomes of patients not meeting MCID on the Owestry Disability Index (ODI of 15) at 2 years post-operatively were analyzed at 24 months post-operatively on the ODI, SF-12 Physical (PCS) and Mental (MCS) scales, numeric rating scale (NRS) leg and back pain, and Euroqol-5D (EQ5D). **Results:** 41.4% (181 of 437) and 42.1% (53 of 126) of patients in the O-TLIF and MIS-TLIF, respectively, did not reach a MCID of 15 on the ODI at 2 years. Patients undergoing MIS-TLIF were younger (55.0 ± 14.9 vs 59.7 ± 13.0, P = .041) but otherwise had similar demographic characteristics. Operative time was similar between the groups (P = 0.16), however blood loss was significantly greater in the O-TLIF cohort (635.0 ± 625.5 ml vs 179.3 ± 159.44 ml, P < .001). There were no significant differences between any baseline PROs. The 2-year post-operative NRS-leg scores were significantly lower in each group than the baseline scores (O-TLIF: 7.12 ± 2.06 vs 2-year, 4.84 ± 3.09; MIS-TLIF: baseline, 6.45 ± 2.73 vs 2-year, 4.38 ± 3.17, < .001), however, the proportion of patients meeting MCID on the NRS-leg at 2 years was significantly higher in the O-TLIF group (75.63% vs 56.52%, P = .015). On the NRS back pain scale, 2-year post-operative scores were significantly lower than baseline in both groups (P < .001) but the proportion of patients reaching MCID was not different (48.62% and 47.06%, P = .99). The 2-year scores and rates of reaching the MCID on the EQ5D, PCS, and MCS were not different. Multivariable regression analysis for the MIS-TLIF cohort demonstrated higher baseline back pain scores were independently associated with worse ODI (P = .0096). In the O-TLIF cohort, higher baseline back pain scores, symptom duration > 6 months, and increasing blood loss (in millilitres) were associated with worse ODI scores (P < .0001, P = .036, P = .039). Single level fusion operations were independently associated with improved ODI scores (P = .001). **Conclusion:** Similar rates of patients fail to reach MCID at 2-years on the ODI after open or MIS TLIF (~40%). Of these patients, MIS-TLIF operations were associated with significantly fewer patients achieving MCID on NRS leg pain scores at 2 years. Higher baseline back pain, longer symptom duration, and increasing blood loss were independently associated with worse ODI scores after open TLIF while higher baseline back pain was an independent predictor of worse ODI scores after MIS TLIF. These data provide novel insights into patient counseling as well as surgical selection when deciding which patients will derive the most benefit from MIS or open operations.

1586
A345: Open vs Minimally Invasive Transforaminal Lumbar Interbody Fusion: A Matched Cohort Analysis with Five-Year Follow-Up

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Introduction: Transforaminal lumbar interbody fusion (TLIF) is a widely performed procedure that has evolved as a treatment option for addressing conditions such as spinal stenosis, disc herniation and spondylolisthesis of the lumbar spine. With the advent of new minimally invasive techniques, minimally invasive TLIF (MI-TLIF) has gained popularity as a surgical option and offers potential advantages of reduced tissue trauma, blood loss, medication use and cost. Despite numerous reports on short-term outcomes comparing the open versus the minimally invasive technique, a paucity of literature exists comparing outcomes with long-term follow-up of matched cohorts. Therefore, the purpose of this study was to determine the overall revision rates, rates of fusion, and functional clinical outcomes of open versus MI-TLIF with five-year follow-up. **Material and Methods:** A retrospective review was performed to identify all patients between 2012-2015 with at least 5-year follow-up who underwent single-level open or minimally invasive TLIF. Each cohort was matched for age, sex, BMI and levels operated. Revision rates, time to revision, graft subsidence and fusion rates in each group were compared. Graft subsidence was defined as cage migration into one vertebral endplate >3 mm on plain radiographic measurement. Bony fusion was defined as the absence of a radiolucent gap between the cages and endplates and the presence of trabeculation and bony bridging between cages and adjacent endplates. Functional outcomes were assessed with ODI, VAS-l and VAS-b measurements at follow-up visits. Standard binomial and categorical comparative analyses were performed. **Results:** A total of 90 patients were included in

this study, 45 in the open TLIF cohort and 45 in the MI-TLIF cohort. Mean follow-up of the open and MI-TLIF cohorts were 90.3 and 97.9 months, respectively. The overall revision rates were 13.3% for the open TLIF group and 15.6% for the MI-TLIF group ($P = .764$). Mean time to revision was 1,281.3 and 718.1 days for the open and MI-TLIF groups, respectively ($P = .015$). The most common reason for revision surgery was pseudarthrosis (57.1%) in the MI-TLIF cohort and hardware failure with accompanying adjacent segment degeneration (33.3%) in the open TLIF cohort. At the 5-year mark postoperatively, 11.1% of patients in the open TLIF group and 8.9% of patients in the MI-TLIF group had radiographic signs of subsidence ($P = .725$). Successful spinal fusion at 5 years was 89.1% and 91.1% in the open and MI-TLIF cohorts, respectively. There were 18 females and 27 males in each cohort matched for age, sex, BMI and levels operated (1: L3-4, 28: L4-5, 16: L5-S1). Average blood loss was 235.6 ± 40.1 and 83.2 ± 28.1 ml in the open and MI-TLIF groups, respectively ($P = < .001$). Both groups experienced significant improvements in their functional outcome scores (ODI, VAS-leg, VAS-back) compared to their pre-operative values. **Conclusion:** MI-TLIF is a safe and effective alternative to the open transforaminal approach in the treatment of single-level lumbar spinal disease, demonstrating long-lasting benefit. After five-year follow-up, MI-TLIF demonstrated similar improvements in functional outcome scores without increased rates of revision or subsidence. Larger, prospective studies are required to corroborate these findings.

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A346: Minimally Invasive Scoliosis Surgery with Trans-Kambin Posterior Oblique Lateral Lumbar Interbody Fusion: Single Surgeon Feasibility Study

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Introduction: Degenerative deformities of the spine have traditionally been treated with extensive open surgeries. However, these open procedures are associated with a high degree of surgical morbidity. In this study, we explore whether clinical improvement in patients with spinal deformities can be achieved using a new minimally invasive surgery (MIS) called oblique lateral lumbar interbody fusion (OLLIF). OLLIF is a MIS single surgeon procedure in which the disc is approached through Kambin's triangle. OLLIF can achieve correction of spinal deformities through careful cage placement. **Material and Methods:** This study is a retrospective review of 37 OLLIF surgeries in 36 patients with symptomatic degenerative spinal deformity. Collected perioperative data included surgery time, blood loss, and hospital stay. Follow-up was conducted at least 150 days post surgery. We recorded complications and patient reported outcomes such as Oswestry Disability Index (ODI) and pain scale. Imaging was conducted pre- and post-surgery. Fusion rates and changes in Cobb angle were also measured. **Results:** A total of 37 surgeries that treated 100 vertebral levels were performed. For two and three level procedures, respectively, the mean blood loss was 83 and 178 ml, the average surgery time was 74 and 158 minutes and the average hospital stay was 2.6 and 3.3 days. The patients ambulated within 24 hours in all but two cases. The patients reported pain improvements on the ten-point pain scale from 8.3 to 3.7 ($P < .001$) and on the ODI from 53% to 32%. Cobb angles decreased from 16° to 9.3° ($P < .001$), amounting to 2.5° of correction per level of surgery. Detailed imaging was reviewed by independent radiologists for 24 cases and 100% interbody fusion was achieved along with 71% right posterolateral and 74% left posterolateral fusion. There were three cases of mild nerve irritation/neuropraxia and no infections. **Conclusion:** OLLIF is a safe and effective MIS technique to correct adult degenerative scoliosis. Unlike alternative procedures, OLLIF is technically less complex than comparable procedures and can safely be used from the thoracolumbar junction to S1.

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A347: Minimally invasive versus open transforaminal lumbar interbody fusion in obese patients: a propensity score matched study on perioperative, functional and subjective outcomes

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Introduction: The perioperative benefits of minimally invasive surgery in obese patients have been described. However, there is a paucity of literature on the patient-reported outcomes (PROs), satisfaction and return to work following minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) and Open TLIF in this subgroup of patients. This study aimed to compare the clinical outcomes of obese patients undergoing MIS and Open TLIF. **Materials and Methods:** Patients who were obese (BMI ≥30.0 kg/m2) and underwent a primary, one- to two-level TLIF were retrospectively reviewed and stratified into two cohorts: Open TLIF and MIS TLIF. The cohorts were matched in a 1:1 ratio for age, sex, body mass index, comorbidity burden, number of levels fused and preoperative PROs using propensity scoring. Operative time, length of stay and perioperative outcomes were recorded. Differences in PROs, including Oswestry Disability Index (ODI), 36-Item Short-Form Physical Component Score (SF-36 PCS), Mental Component Score (SF-36 MCS), Visual Analogue Scale (VAS) back pain, and VAS leg pain, at each postoperative time point were compared between the cohorts using independent sample t-tests. Achievement of minimal clinically important difference (MCID), patient satisfaction assessed using the North American Spine Society questionnaire, and return to work were compared using Chi-

square analysis. Revision procedures were recorded at mean follow-up of 10 ± 3.3 years. **Results:** In total, 236 obese patients were included: 118 Open TLIF and 118 MIS TLIF. The two cohorts were closely matched in terms of demographics, perioperative variables and preoperative PROs. Length of stay was longer in the Open TLIF cohort (7.0 ± 5.2 vs 4.4 ± 2.5 days, $P < .001$) and there was a trend towards a higher complication rate (14.4% vs 8.5%, $P = .075$). However, there was no difference in operative time, transfusions or readmissions. Patients who underwent Open TLIF reported worse ODI ($P = .043$) and VAS leg pain at 2 years, although the latter did not reach statistical significance ($P = .095$). Achievement of MCID for each PRO, patient satisfaction and return to work were comparable between the cohorts. A total of 8 Open TLIFs and 6 MIS TLIFs were revised ($P = .582$). **Conclusion:** Obese patients who underwent MIS TLIF had less perioperative complications, shorter length of stay and improved functional disability compared to a matched group who underwent Open TLIF. However, a similar proportion achieved a clinical meaningful improvement. Patient satisfaction and return to work were also comparable at 2 years.

579
A348: Percutaneous Kyphoplasty Vs Percutaneous Vertebroplasty for Neurologically Intact Osteoporotic Kümmell's Disease: A Systemtic Review and Meta-Analysis

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Introduction: Kümmell's disease (KD) is a relatively rare entity secondary to vertebral compression fracture (VCF), characterized by delayed vertebral collapse and kyphosis. Percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP) are widely-used minimally invasive techniques for the treatment of neurologically intact osteoporotic KD, but which one is preferable choice remains controversial. Therefore, a systematic review and meta-analysis should be performed to shed light on the facts regarding the efficacy and safety of both procedures for neurologically intact KD, providing evidence-based medical support for clinical decision-making. **Material and Methods:** The PubMed, Embase, Web of Science, Cochrane library, Wanfang, CNKI were searched from inception to September 1, 2020, for all randomized controlled trials or cohort studies that compared PVP and PKP in treating KD patients without neurological deficits. All eligible studies were selected based on predesigned screening criteria. Two investigators independently conducted the quality assessment and extracted the data. Fixed-effect and random-effect models were used for pooled analysis according to the heterogeneity. All statistical analysis was performed by Stata software 14.0. **Results:** Eight eligible studies with a total of 438 KD patients (195 undergoing PKP and 243 undergoing PVP) were included in the final analysis. Patients were followed up for at least one year. Pooled results showed no difference between PKP and PVP in clinical outcomes (short-term and long-term visual analogue scale and Oswestry disability index) and perioperative complications (overall complications, bone cement leakage and new vertebral fracture). Regarding radiographic outcomes, PVP was associated with better improvement in short-term and long-term Cobb's angle compared to PKP [SMD = -.37, 95% CI (-.64, -.10), $P = .007$; SMD = -0.34, 95%CI (-.61, -.07), $P < .012$]. Even though the restoration of vertebral height in PKP group was slightly better than PVP group in the short run [SMD = 0.43, 95%CI (0.14, 0.71), $P = .003$], there were no significant differences between two groups at the final follow-up ($P = 0.186$). In addition, PKP required more consumption, including bone cement injection volume [SMD = .50, 95%CI (.27, .73), $P < .001$], operating time [SMD = 1.80, 95%CI (.67, 2.93), $P < .001$], fluoroscopy times [SMD = 1.02, 95% CI (1.62, 1.43), $P < .001$], intraoperative blood loss [SMD = 0.96, 95%CI (.41, 1.91), $P < .001$] and operation cost [SMD = 31.12, 95%CI (1.48, 60.77), $P < .040$]. **Conclusion:** This study demonstrated that PVP was as similar as PKP in clinical outcomes and perioperative complications, which indicated both procedures are effective and safe for treating neurologically intact osteoporotic KD. In addition, PVP could provide better correction of spinal kyphosis and less consumption. Based on the current evidence, we recommended PVP as the superior technique. The future directions of KD treatment relies on the results of randomized controlled trials with higher quality and larger sample sizes.

1700
A349: Prospective Comparative Study of Functional Outcome in Open vs Minimally Invasive Tubular Discectomy for Lumbar Disc Herniation

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Aim: Aim of the study was to compare the functional outcome of open vs minimally invasive tubular discectomy for lumbar disc herniation. **Material and Methods:** All patients undergoing discectomy for lumbar disc herniation were prospectively followed for one year. VAS (Visual analogue score), ODI (Oswestry Disability Index) were used to analyse the functional outcome at post-operative period day one, two

weeks, One month, three months, Six months and one year. Data was divided into open and minimally invasive group (MIS) and analysed. **Result:** 218 patients were included in the final analysis. 82 were from MIS group and 136 underwent open discectomy. While pre-operative mean VAS scores were comparable for both the groups, follow up VAS scores were significantly better for MIS group at post-operative day one(P = .001), two weeks(P = .001), One month(P = .001), three months(P = .003) and six months (P = .023). Similarly ODI scores were also significantly better for MIS group at post-operative day one(P = .004), two weeks(P = .001) and one months(P = .003). No significant difference was found between one year VAS scores and ODI scores between the two groups (P > .05). Incidence of dural tear was significantly less (6%) in minimally invasive group compared to open surgery (13.9%) (P = .001). **Conclusion:** Functional outcome of minimally invasive tubular discectomy for lumbar disc herniating are comparable with open discectomy with significantly improved VAS scores up to 6 months and significantly better ODI scores up to one month and with significant less chances of dural tear.

1265
A350: Stable Low Grade Spondylolisthesis Does not Compromise Clinical Outcomes of Minimally Invasive Tubular Decompression in Patients with Spinal Stenosis

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Background: Surgical decompression has been shown to be superior to conservative management in lumbar spinal stenosis (LSS) patients. The purpose of the present study is to compare the clinical outcome and complication rates following minimally invasive (MIS) tubular decompression without arthrodesis in patients suffering from LSS with or without concomitant stable low grade degenerative spondylolisthesis. **Methods:** Ninety six consecutive patients who underwent elective MIS lumbar decompression with a mean follow-up of 27.5 months were included in the study. The data was collected prospectively to our data base. The spondylolisthesis (S) group comprised 53 patients who suffered from LSS with stable degenerative spondylolisthesis, and the control (N) group included 43 patients suffering from LSS without spondylolisthesis. Outcome measures included complications, and revision surgery rates. Pre- and post-operative visual analog scale (VAS) for both back and leg pain was analyzed, and theOswestryDisability Index (ODI) was used to evaluate functional outcome. **Results:** The two groups were comparable in most demographic and preoperative variables. VAS for back and leg pain improved significantly following surgery in both groups. Both groups showed significant improvement in their ODI scores, one and two years postoperatively. The average length of hospital stay was significantly higher in patients with spondylolisthesis (P-value< .01). There was no significant difference between the groups in terms of post-operative complications and revision surgeries. **Conclusions:** Our results indicate that MIS tubular decompression may be an effective and safe procedure for patients suffering from LSS, with or without degenerative stable spondylolisthesis.

769
A351: Lumbar Interbody Fusion in Adult Isthmic Spondylolisthesis: Does Minimally Invasive Surgery Benefit Patients Compared with Open Surgery?

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Introduction: Isthmic spondylolisthesis is common in younger patients and can be treated with Open or Minimally Invasive transforaminal interbody lumbar fusion (MIS TLIF). While technical and approach-related considerations have received much attention for this pathology, few studies have directly compared the clinical effectiveness between Open and MIS TLIF. This study aimed to compare the patient-reported outcomes (PROs), satisfaction and return to work in patients following Open and MIS TLIF for isthmic spondylolisthesis at minimum 2-year follow-up. **Materials and Methods:** Patients who underwent a primary single-level TLIF for low-grade isthmic spondylolisthesis were retrospectively reviewed and stratified into two cohorts: Open TLIF and MIS TLIF. The cohorts were matched in a 1:1 ratio for age, sex, body mass index, comorbidity burden and preoperative PROs using propensity scoring. Operative time and length of stay were recorded. Differences in PROs, including Oswestry Disability Index (ODI), 36-Item Short-Form Physical Component Score (SF-36 PCS), Mental Component Score (SF-36 MCS), Visual Analogue Scale (VAS) back pain, and VAS leg pain, at each postoperative time point were compared between the cohorts using independent-sample t-tests. Achievement of minimal clinically important difference (MCID), patient satisfaction assessed using the North American Spine Society questionnaire, and return to work were compared using Chi-square analysis. **Results:** In total, 136 patients were included: 68 Open TLIF and 68 MIS TLIF. The two cohorts were closely matched in terms of demographics, perioperative variables and preoperative PROs. Operative time was similar, but the MIS TLIF cohort had a shorter length of stay (3.3 ± 1.2 vs 5.4 ± 3.0 days, P < .001). There was no difference in PROs between the cohorts at all time points. The Open TLIF cohort had a higher rate of MCID achievement for SF-36 PCS at

24 months (83.8% vs 64.7%, $P = .018$), but both cohorts demonstrated similar achievement of MCID for ODI, VAS back pain, VAS leg pain. Patient satisfaction and return to work were also comparable. The Open TLIF cohort took 82.8 ± 66.7 days to return to work while the MIS TLIF cohort took 89.2 ± 76.8 days ($P = .695$). **Conclusion:** Patients with low grade isthmic spondylolisthesis who underwent MIS TLIF had a shorter length of stay. However, both MIS and Open techniques produced similar improvements in pain, disability and quality of life. Patient satisfaction and return to work was also comparable at 2 years.

OP40: Deformity-Thoracolumbar (Adolescent) 3

1778
A352: The Analysis of Progression of Disc Degeneration in the Unfused Segments in Post-Operative Adolescent Idiopathic Scoliosis - A 10 Year Follow-Up MRI-Based Study

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Introduction: The impact of long-segment fusions on the distal mobile vertebral segments is of major concern. There is currently a paucity of literature on the progression of disc degeneration in the distal un-fused segments in patients with strategic pedicle screw instrumentation. The current retrospective study was thus planned to analyse the progression of the Pfirrmann's grade in the distal un-fused lumbar segments in postoperative Adolescent Idiopathic Scoliosis (AIS). **Methods:** A total of 58 patients who underwent surgery for AIS with minimum 6.5-year follow-up (5-15) were included. Coronal Cobb's angle (CCA), apical translation, lower instrumented vertebra tilt (LIV tilt), lower instrumented vertebra-sacral angle (LIV-Sacral angle), sagittal spinal parameters [Thoracic kyphosis (TK) and lumbar lordosis (LL)]; and pelvic parameters were measured. Disc health was assessed in Magnetic Resonance Imaging (MRI) by Pfirrmann's grading, Total endplate score (TEPS) and facet degeneration were measured by Fujiwara's grading. Functional evaluation was performed using SRS 22 score. **Results:** A total of 58 patients were included in the study. The mean follow-up was 10 years. Based on MRI scan, 43 were included in Pfirrmann's grade static (PGS) group and 15 in Pfirrmann's grade progressed (PGP) group. Of the15 patients in PGP group, LIV was L4 in 8, L3 in 3, L1 in 3 and L2 in 1. Fifteen patients in our cohort had a progression of Pfirrmann's grade. Among these patients, 11 (73.3%) progressed from grade 1 to grade 2; but in 4 patients (26.6%), Pfirrmann's grade progressed to more than 3. The progression of degeneration did not significantly correlate with the preoperative and postoperative TEPS score, coronal or sagittal parameters. **Conclusion:** The analysis of progression of the Pfirrmann's grade in distal un-fused segments did not show any significant correlation with the pre-operative and post-operative coronal or sagittal parameters and the number of unfused segments.

1250
A353: Studies on the Influence of Growth Friendly Implants Used in Eos Treatment on Titanium Ion Release into the Tissue

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Introduction: The long-term cumulative effects of the presence of implants after surgical treatment of Early-Onset Scoliosis (EOS) may be harmful.The aim of the study is to evaluate the influence of different growth-friendly systems used for surgery in EOS on the level of titanium ions (Ti) in samples tissues taken intraoperatively. **Material and Methods:** The study group included 77 patients (mean 13,5 yo) who were surgically treated with implants made of Ti-6Al-4V titanium alloy. The stabilization covered on average 11 segments. Mean observation time was 3,25 ± 1,14 years. Patients were divided into 5 groups: traditional growing rods (TGR), guided growth system, VEPTR, revision group (patients who had a fracture of the implant) and a control. The concentration of Ti was examined on Inductively Coupled Plasma Optical Emission Spectrometry. **Results:** There was a higher content of Ti in clean tissue and in the blood in boys vs girls (0.0068 mg/g vs 0.0035 mg/g and 4, 1962 μg/L vs 3.6465 μg/L respectively). Ti in contaminated tissue was the highest in the GGS group than VEPTR, revision group and TGR (3.855 mg/g, 1.456 mg/g, 1.022 mg/g and 0.52 mg/g respectively). Ti in the blood increases was the highest in the GGS group than VEPTR, revision group and TGR (14.12 ± 0.12 μg/L, 8.875 ± 3.65 μg/L, 4.435 μg/L and 3.454 μg/L respectively). There was no correlation with the number of implanted anchors and the observation time. **Conclusion:**(1). Movement between implants affects the number of Ti released. (2). The duration of implants in the child's body doesn't affect the content of Ti, putting this aspect of treatment among arguments for not delaying the start of surgical treatment of patients with EOS. (3). Mechanical failure to the implant has no significant effect on increasing the content of Ti.

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A354: What a Stranded Whale with Scoliosis can Teach us About Human Idiopathic Scoliosis

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Introduction: Scoliosis is a deformation of the spine that may have several known causes, but only humans can develop scoliosis without any obvious underlying cause. This is called 'idiopathic' scoliosis and is the most common type. Recent observations showed that human scoliosis, regardless of its cause, has a uniform three-dimensional anatomy. We hypothesize that scoliosis is a universal compensatory mechanism of the spine, independent of cause and/or species. **Material and Methods:** We had the opportunity to study the rare occurrence of scoliosis in a whale that stranded in July 2019 in the Netherlands. A multidisciplinary team of biologists, pathologists, veterinarians, taxidermists, radiologists and orthopedic surgeons conducted necropsy and CT-imaging analysis. In areas of the spine that did not show underlying anatomical changes, we analyzed the compensatory curves in 3D and compared the morphology with the non-scoliotic spine of 10 control whales. **Results:** The stranded animal was a common minke whale (Balaenoptera acutorostrata) and was a 403 cm long, 530 kg female juvenile, with an estimated age between 0.5-4 years. The most likely cause of death was considered to be acute recent blunt trauma. Visual inspection showed epiphysiolysis at the left-side of the lower endplate of vertebra L3, a burst upper endplate at the right-side of vertebra L4, fractured spinous processes of vertebrae L1 to L6, severely wedged vertebrae T11 and T12 and detachment of the transverse processes at multiple levels. Two traumatically deformed vertebrae had led to an acute post-traumatic scoliosis, which had initiated the development of compensatory curves in regions of the spine without anatomical abnormalities. The 3D analysis of the compensatory curves showed a rotation of the vertebral bodies in the transverse plane into the convexity of the curve. The mean anterior-posterior length discrepancy (AP%) of the total compensatory curvature was +9.4% in the whale, indicating a lordosis. This is significantly different from the kyphosis in the same part of the spine in the non-scoliotic control group, with a total AP% of -2.1 ± 0.4% ($P < .001$). On the contrary, the bony morphology of the vertebral bodies was similar to the controls; the vertebral body AP% of the whale was -2.5%, which was comparable to the kyphotic shape of the vertebral bodies in controls with -1.8 ± 0.8% ($P = .429$). Almost all anterior lengthening was present in the intervertebral discs, as the disc AP% in the compensatory curvature of the whale was +99.5%, which meant a lordotic shape of the intervertebral discs with an anterior length almost twice the posterior length. This is in sharp contrast to the kyphosis in the discs of controls with -4.6 ± 5.0% ($P < .001$). **Conclusion:** Three-dimensional analysis of these compensatory curves showed strong resemblance with different types of human scoliosis. This indicates that any decompensation of spinal equilibrium can lead to a uniform response, regardless of underlying cause or species. The unique biomechanics of the upright human spine, with significantly decreased rotational stability, explains why only in humans this universal mechanism of scoliosis can occur in an 'idiopathic' way.

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A355: Management of Progressive Neuromuscular Scoliosis and Respiratory Distress in a Child with Nemaline Rod Myopathy

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Introduction: Nemaline Rod Myopathy (NRM) is the commonest among non-dystrophic congenital myopathies. Clinical presentation is highly variable due to variable mutations in large number of genes. Variable clinical presentations ranging from normal lifespan with mild symptoms to neonatal death have been reported. Children with NRM have generalized muscle weakness with predilection to neck, face, axial and proximal extremity muscles. Respiratory muscle weakness is the most prominent feature and affects the overall prognosis and survival. Even ambulant and mildly affected patient may develop unsuspected hypoxia especially during night and hence requires assisted mechanical ventilation. **Materials and Methods:** Eleven-year-old wheelchair bound girl presented with progressive breathing difficulty, deformity of back, and worsening sitting balance of 2 years duration. Following an uneventful normal delivery to a non-consanguineously married couple, the parents had noticed the child to grow normally except for delayed motor milestones. The child from the age of 3-years started developing repeated respiratory difficulties and was started on nocturnal

BiPAP ventilator support. In view of generalized motor weakness and respiratory difficulty, the muscle biopsy done revealed NRM. The child had multiple episodes of respiratory worsening and admission to ICU. The child presented to Spine Care for the management of progressive spinal deformity affecting the sitting balance on wheel chair. **Results:** We corrected the rigid right Thoracolumbar Scoliosis T3-L1 (Cobb angle 87°) successfully using multi-modal intra-operative neuromonitoring with multiple Ponte osteotomies and instrumented fusion T2-ilium. Following surgery she was able to sit independently, able to breathe better and requiring less BiPAP support. At 2-years follow up, her breathing reserve improved significantly and not even requiring nocturnal ventilator support. **Conclusion:** To the best of our knowledge this is *the first rep*orted case of a severe rigid scoliosis in a child with NRM managed surgically successfully. Surgical management of these patients requires multidisciplinary approach for successful outcome in view of respiratory failure. Deformity correction will improve the respiratory reserve of child and may even obviate the need of nocturnal mechanical ventilation support.

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A356: Leaving Out Often Difficult to Place Proximal Thoracic Concave Apical Screw(S) in Adolescent Idiopathic Scoliosis: Are these Screws Necessary?

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Summary: Proximal thoracic (PT) concave apical screw placement in AIS patients are challenging due to pedicle morphology, wound depth, concavity trajectory and spinal cord location directly adjacent to the medial pedicle wall. We evaluated 40 patients with Lenke Type 1-2 AIS curves, 63% of which had PT concave apical screw(s) purposely left out. The most common levels left out were T5 (30%) and T6 (53%). No difference in correction of PT (P = 0.44) and main thoracic(MT) (P = .93) curves between groups was seen. **Hypothesis:** Proximal thoracic (PT) concave apical screw(s) in AIS patients are often difficult to place, carries high neurologic risk, and adds operative time with little to no benefit seen in deformity correction. Thus these screws can be left out of AIS constructs involving the PT region. **Study Design:** Retrospective, single-institution. **Introduction:** In AIS patients, the concave PT pedicles are often small (Type C or D) and rotated, making placement challenging. The spinal cord is also draped along the concave pedicle-vertebral body junction thus rendering even a slight medial trajectory/breach a potential neurologic complication. Additionally, concave PT curve correction occurs with distraction distributed away from the apex, making the apical screw unnecessary. We sought to evaluate whether leaving these concave apical PT screw(s) out affected overall curve correction**. Methods:** AIS patients with Lenke Type 1-2 curves with UIV of T4 or cephalad were identified. Mean age was 15.3 yrs, 27 (68%) had Type 1 curves, and 13 (33%) had Type 2. The UIV was T1 in 1 (3%), T2 in 11 (28%), T3 in 14 (35%), and T4 in 14 (35%) pts. The levels where PT apical screws were left out were analyzed using Cobb angles for PT and main thoracic (MT) curves (pre- and postop standing radiographs). **Results:** Of 40 AIS patients, 25 (63%) had PT concave apical screw(s) left out: 59% of Type 1, and 69% of Type 2 curves. Screws were left out at the following levels: T4-15%, T5-30%, T6-53%, T7-3%. Preoperative PT and MT Cobb angles of both groups were similar preoperatively. Postoperative PT correction was similar between both groups: screws left out 10° (2-26) vs all screws 9° (3-23), P = .44. Postoperative MT correction was also similar between both groups: screws left out 10° (1-31) vs all screws 10° (1-18), P = .93). **Conclusion:** Leaving out the proximal thoracic concave apical pedicle screw(s) in Lenke Type 1-2 AIS showed no difference in correction compared to all levels instrumented. Leaving out screws theoretically minimizes risk of neurologic complications and decreased OR time to place these challenging screws without sacrificing coronal correction. **Take Home Message:** Leaving out the PT concave apical pedicle screw(s) in Type 1/2 AIS patients has no effect on coronal correction while avoiding unnecessary risks of these challenging and neurologically risky screws.

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A357: The Use of 3 Rods in Correcting Severe Scoliosis

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Introduction: The three rod technique, utilising a short apical concavity rod is an option to achieve controlled correction in severe scoliosis. We describe this technique, the complications encountered, and the long term outcomes. **Materials and Method:** All paediatric patients who underwent corrective surgery for scoliosis ≥ 100° using 3 parallel rods were included. Radiographs were assessed to evaluate the correction and clinical records examined for

any loss of correction, complications, revision procedures or neuromonitoring events. **Results:** 27 patients met the inclusion criteria. All underwent posterior instrumented fusion, 5 underwent a circumferential fusion to prevent crankshaft phenomenon and 3 underwent preoperative halogravity traction. The main thoracic curve (MT) measured 112° (100- 145°), the proximal thoracic (PT) 48° (20- 75°) and thoracolumbar (TL) 22° (2- 97°). 4 patients with an MT not significantly different to the remainder of the group (P = 0.73) underwent anterior fusion. Eleven patients showed loss of motor evoked potentials, all of which returned to within 25% of baseline. All patients had normal postoperative neurology. One patient underwent removal of hardware for late infection. The cohort showed a 47% (95% CI 42-53%) correction of their MT. PT was corrected by 15° (95% CI 10- 19) and TL 23° (95% CI 16-31°). There was no significant loss of correction at 2 years. **Conclusion:** Our series suggests that three rod constructs lead to a 50% correction of severe curves, that three column osteotomies may not be necessary, and that the technique is safe and effective for the correction of severe scoliosis.

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A358: Development of Thoracic Kyphosis After High Implant Density Posterior Correction and Fusion for Adolescent Idiopathic Scoliosis

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Introduction: Posterior correction and fusion provides good results in the coronal plane. But pedicle screw based instrumentations tend to flatten the spine. Previous studies on thoracic kyphosis (TK) restoration have produced mixed findings on the ability of posterior instrumentations to achieve that goal. With derotation the anterior column is lengthened which sacrifices kyphosis. Although there is a paucity of evidence to prove that this affects long-term outcome and quality of life, it is logical to assume that TK restoration may optimize global sagittal alignment and slow down lumbar and cervical disc degeneration. **Material and Methods:** Radiographs of 100 consecutive patients that underwent posterior correction and fusion for adolescent idiopathic scoliosis (AIS) at a single center were analyzed. 5.5 mm titanium or cobalt chromium rods were used. Thoracic Kyphosis (TK) was measured preoperatively and two years postoperatively for the whole group, and separately for hypo-, normo- and hyperkyphotic patients (according to the Lenke classification). A one-sided one-sample t-test was performed to compare pre- and postoperative values. **Results:** For all patients mean TK significantly decreased by 3.8° ± 3.4 (P = .005). For hyperkyphotic patients (n = 9) mean TK significantly decreased by 18.9° ± 3.8 (P = .006). For normokyphotic patients (n = 75) mean TK significantly decreased by 3.9° ± 3.2 (P = .001). For hypokyphotic patients (n = 16) mean TK significantly increased by 4.9° ± 2.4 (P = .005). **Conclusion:** The results are ambivalent which is consistent with the literature. Except for the hyperkyphotic group the differences are within or close to the range of a measurement error. The main conflict of implant stiffness versus lengthening the anterior column with derotation remains unsolved. Additionally, it is difficult to define an optimal TK for any given patient. TK restoration remains a challenge. Even with translation maneuvers and the use of cobalt chromium rods, creation of kyphosis is difficult. However, in patients that are already hypokyphotic it is possible to achieve good coronal correction without sacrificing additional kyphosis.

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A359: How Close are We to "Complication Free" Adolescent Idiopathic Scoliosis Fusion Surgery?

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Summary: This study examines recent rates of complication and readmission following posterior spinal fusion for adolescent idiopathic scoliosis (AIS). We observed no readmissions, reoperations, or major medical or surgical complications in this series of 76 consecutive cases. **Hypothesis:** We hypothesized that posterior spinal fusion for treatment of AIS currently has lower complication and readmission rates than previously reported. **Study Design:** Consecutive single surgeon series. **Introduction:** Historically, rates of complication associated with posterior spinal fusion for AIS have been reported to range between 5 to 10%, with 30-day unplanned readmission rates around 3%. With the development of improved intraoperative techniques and perioperative care protocols, one would expect these rates to have improved in recent years. Yet, little is known about current rates of complication and readmission. **Methods:** We collected surgical and postoperative data on 76 consecutive cases of posterior spinal fusion for AIS using pedicle screw constructs in patients aged 11-18 years who underwent surgery between 2015 and 2019. All surgeries were performed in a tertiary children's hospital (43%) or in a tertiary spine-focused hospital (57%) by a single surgeon with greater than 25 years experience in deformity surgery. **Results:** Mean age was 15.8 ± 1.8 yrs and time since surgery was 2.1 ± 1.2 yrs. An average of 11 ± 2 levels were instrumented/fused per case and the distribution of Lenke classification types was: 1 = 39%, 2 = 26%, 3 = 12%, 4 = 1%, 5 = 12%, 6 = 9%. The mean surgical time was 4.3 ± 0.8 hour,

estimated blood loss was 565 ± 291 cc, and length of stay was 3.6 ± 0.8 days. The rates of readmission and/or reoperation were 0%, with up to 4 year follow up for the earliest patients. There were no major medical or surgical perioperative complications. There were two minor complications (3%) including 1 durotomy and 1 transient postoperative ileus. Seventeen patients (22%) received blood transfusions. In 4 cases (5%), there were concerning neuromonitoring changes that resolved following corrective maneuvers and there were no postoperative neurologic deficits. **Conclusion:** In this consecutive series of AIS spinal fusion patients over a 4 year period, we observed no readmissions, reoperations, or major medical or surgical complications. This current state of the art information will be important for patient counseling and comparison as newer techniques, such as non-fusion options, become available. **Take Home Message:** Surgeons can potentially achieve extremely low complication rates when treating AIS with posterior spinal fusion. This must be considered as alternatives to this gold-standard treatment are investigated in the future.

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A360: Radiographic Outcomes of 3-D Alif Stand-Alone Cages Implementation for Ads Patients (Retrospective Study)

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Introduction: Is well known that the usage of minimal invasive surgery (MIS) techniques for adult degenerative scoliosis (ADS) require correct placement of interbody cages.For the purpose of improving segmental and total lordosis were invented interbody cages with certain lordotic angles which contribute not only to appropriate correction degree but although to indirect decompression by increasing of intervertebral heights. Implementation of 3D printing in nowadays practice has allowed more individualize preoperative planning and implant preparation for achieving definite goals of spinal surgery. In case of ADS, asymmetric lordotic titanium cages could help not only in sagittal but in frontal balance correction that can improve radiographic outcomes. The goal of this study is to evaluate changes of radiographic parameters at patients with ADS whom performed anterior correction with asymmetric titanium lordotic cages. **Material and Methods:**This is a single center retrospective study of 50 patients (19 men, 31 women) who underwent oblique and anterior interbody fusion using titanium custom asymmetric lordotic cages for ADS correction. Were formed 2 groups according to SRS-Schwab classification (2012): first group 25 patients with PI-LL mismatch moderate and second group 25 patients with PI-LL mismatch severe.Period of observation from april 2018 to august 2020. Standing full spine and conventional radiographs at pre-op and 1-6-12-mounth follow-up were performed. Observed radiographic parameters: SVA, LL, PT, central line and Cobb angle for frontal deformation. Intragroup results were compared using t Student test. And intergroup results were evaluated with U Mann-Whitney test. **Results:**21patients underwent 3-level MIS ALIF, OLIF, and 29 underwent 2-level. The mean age was 58 years, with prevalence of 64% women. In both groups, frontal deformation correction was achieved. Was found statistical difference between pre-op and post-op radiographic parameters in first ($P = .019, P < .05$) and the second ($P = .042, P < .05$) group. Comparing results entre groups we found that mean post-op values of SVA, PT, LL were significantly higher in the first group (mean $SVA_1 = 25 \pm 8$ mm, mean $SVA_2 = 87 \pm 19$ mm, $P = .018$; mean $PT_1 = 14 \pm 3^0$, mean $PT_2 = 28 \pm 4^0$, $P = .032$; mean $LL_1 = 47 \pm 2^0$mean $LL_2 = 31 \pm 1^0$, $P = .024$). In addition, 74% of patients of the second group subsequently required posterior transpedicular fixation and Smith-Peterson Osteotomy (SPO) performing for achieve full sagittal correction. Wherein in the first group only 18% patients were held second stage surgery. **Conclusion:**Titanium custom asymmetric lordotic cagesprovided significant increase in sagittal balance correction among patients with moderate deformity (first group), instead of the second group where the majority of patients with severe deformations for reasons of non-achieved significant improvement of correction required additional surgery.

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