Preliminary Comparison of Objective Functional Balance Tests to Better Assess Recovery Following Discectomy for Lumbar Disc Herniations

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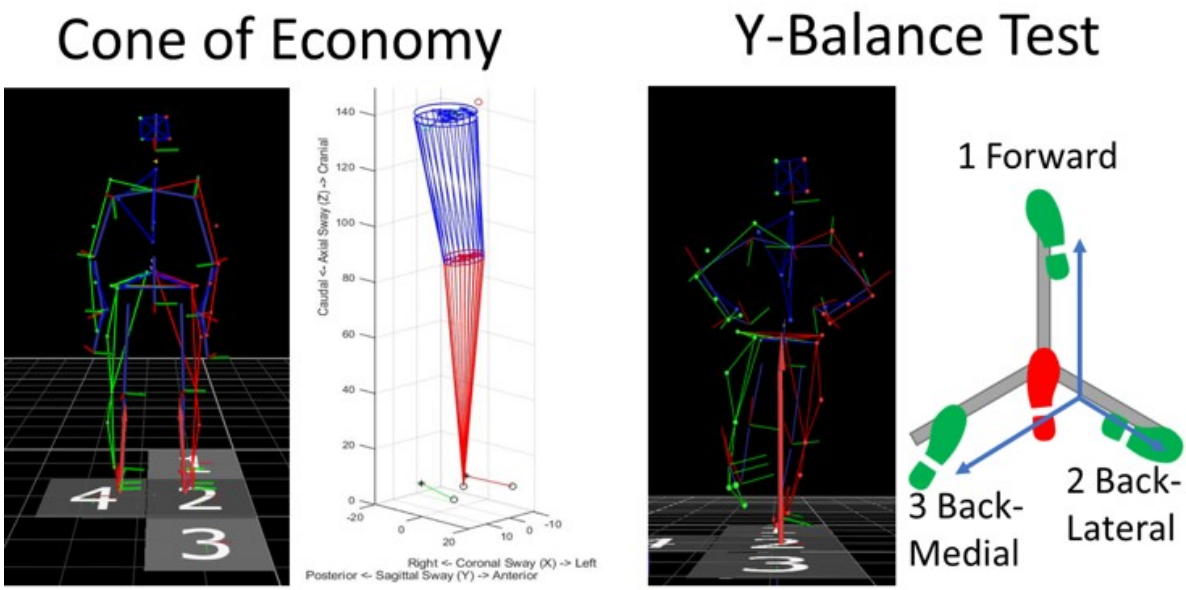
Introduction: Functional assessment of lumbar disc herniation (LDH) patients can provide valuable information on postoperative recovery rate and physical performance level following discectomy surgery. "Cone of Economy" (COE) balance measures have been used to evaluate balance following lumbar surgery, but it is unclear whether they are applicable to more demanding balance situations. The y-balance test (YBT) is another clinical balance test which poses greater demands on postural coordination and may be more indicative to changes in balance during more strenuous activity. The purpose of this study was to compare COE and YBT balance measures among LDH discectomy patients and to determine whether YBT provides better insight into overall balance capacity. We hypothesized that YBT would show greater sensitivity to changes in dynamic balance when compared to COE range-of-sway (ROS) and total sway distance (TSD) measures following lumbar discectomy.

Methods: This was a preliminary non-randomized retrospective review of LDH patients treated with single-level discectomies and healthy (H) controls who underwent functional balance assessments. LDH patients were evaluated four times: before (P0), 2 weeks after (P2w), 6 weeks after (P6w) and 3 months after (P3m) surgery. Subjects completed patient-reported outcome measures (PROMs) for pain (VAS low back, leg) and disability (ODI), a COE balance test, and YBT. COE balance measures included coronal and sagittal ROS and TSD at the center-of-mass (COM) and head. YBT measures the forward (F), back lateral (BL), and back medial (BM) leg reach distance of the dominant leg normalized by leg length. Kinematic data was collected during all balance tests using three-dimensional motion tracking.

Results: 26 LDH (4F/11M, 43±14yr, 93±20kg, 1.8±0.1m, 30±6kg/m^2) and 15 H (11F/4M, 29±14yr, 66±10kg, 1.7±0.1m, 24±3kg/m^2) subjects were included. Patients reported significant improvements in VAS low back, VAS leg, and ODI at all follow-ups compared to P0 (VAS low back=3.5±2.7; VAS leg= 5.8±2.7; ODI= 40.2±16.3) with the exception of VAS low back at P3: P2w (VAS low back=0.9±1.1, p=0.001; VAS leg=1.2±1.9, p<0.001; ODI=16.1±13.3, p<0.001), P6w (VAS low back=0.5±0.8, p=0.002; VAS leg=0.6±1.3, p<0.001; ODI= 7.8±13.3, p<0.001), and P3m (VAS low back=0.9±1.7, p=0.067; VAS leg=1.5±3.0, p=0.007; ODI=9.0±18.0, p=0.001). All LDH COE measures showed no significant differences at follow-ups compared to P0 or H (all p>0.05). All LDH YBT reach distances showed significant improvements at all follow-ups relative to P0 (F=55±10%; BL=76±10%; BM=55±13%) with the exception of BL at P3m: P2w (F=61±10%, p=0.046; BL=83±12%, p=0.044; BM=67±17%, p=0.020), P6w (F=67±8%, p=0.001; BL=85±11%, p=0.024; BM=73±19%, p=0.005), P3m (F=65±5%, p=0.043; BL=84±14%, p=0.147; BM=72±16%, p=0.033). Compared to H (F=72±7%, BL=100±7%, BM=89±8%), LDH YBT reach distances showed recovery of F at P6w (p=0.141) and P3m (p=0.075), however all other directions remained significantly shorter at all other follow-ups (all p<0.05).

Discussion: LDH discectomy patients showed greater improvement in the more demanding YBT than during the quiescent COE balance test. This suggests YBT has greater sensitivity to dynamic balance among active LDH patients which may already have elevated COE balance compared to other spinal pathologies. YBT may be a valuable assessment for patients who seek accelerated return to work or sporting activity.



Using full-body kinematic trajectory patterns to distinguish chronic low back pain patients based on underlying pathology and persisting symptoms

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Introduction

Patients with chronic low back pain (cLBP) are typically burdened with compromised physical function. As a result, patients adopt compensatory movement patterns which could be diagnostic of pain etiology and severity. The sit-to-stand (STS) maneuver is a discriminant functional test for cLBP, as it requires considerable postural control and places relatively high loads on the spine. While prior studies focused on discrete values such as peak joint angles, our study quantifies posture change across the entire STS maneuver using a point-of-care 3D motion analysis. Using principal component analysis (PCA) of 3D joint positions, we introduce a kinematic deviation index (KDI). We hypothesized that 3D kinematic time-series data reduced to a singular metric, KDI, could discriminate patients based on symptoms, underlying pathology, and persistence of pain, potentially representative of a biomechanical biomarker for cLBP.

METHODS

Following IRB approval, 29 cLBP patients and 22 controls were recorded performing STS during routine clinic visits by a markerless motion capture device. Filtered joint position data for the bilateral shoulders, hips, and knees were transformed in a generalized Procrustes analysis, and projected from shape space into Euclidean tangent space for statistical analysis. Subject motion during STS was represented as ordered sequences of postures in shape space over time. To assess the relationship between posture and disease state, controlled Procrustes linear models were generated using a residual randomization permutation procedure. PCA was performed on Procrustes shape coordinates in the tangent plane. Path distance, shape, and orientation were compared between disease states using Mantel tests. KDI, a novel metric representing overall postural control during the assessment, was calculated as the sum of squared distances between corresponding postures along the observed motion trajectory and a theoretical motion trajectory with the least amount of overall postural change. KDI was compared between groups using Wilcoxon tests, Kruskal-Wallis tests, and correlated with patient reported health measures using a Pearson's correlation coefficient.

RESULTS

The overall shape of the posture change trajectory was significantly different between patients with cLBP and controls (Procrustes distance 0.27, $p<0.05$). Patients with cLBP were found to have significantly higher KDI than controls during both stand-to-sit (5.10 vs 3.40, $p<0.001$) and sit-to-stand (8.47 vs 7.22, $p<0.05$). Although there was no relationship between pain severity and treatment response ($p = 0.15$), there was significant variation in KDI among cLBP patients who responded to treatment within three months (4.79), those who did not (5.34), and controls (3.39) during stand-to-sit ($p < 0.001$), but not during sit-to-stand ($p=0.07$). There was no relationship between pain intensity scores and KDI ($R=-0.03$, $p=0.88$). During stand-to-sit, there were significant relationships between cLBP patients with disc pathology (5.31) versus other etiologies (5.02) and controls (3.39, $p<0.001$) as well as those with nerve compression (5.12) versus those without (4.96) and controls (3.39, $p<0.01$) but not during sit-to-stand.

Discussion

Dimensionality reduction techniques such as KDI may have clinical utility for cLBP patients for identifying underlying pathologies and predicting treatment response. This approach could distill large amounts of biomechanical data to a singular biomechanical biomarker for cLBP.

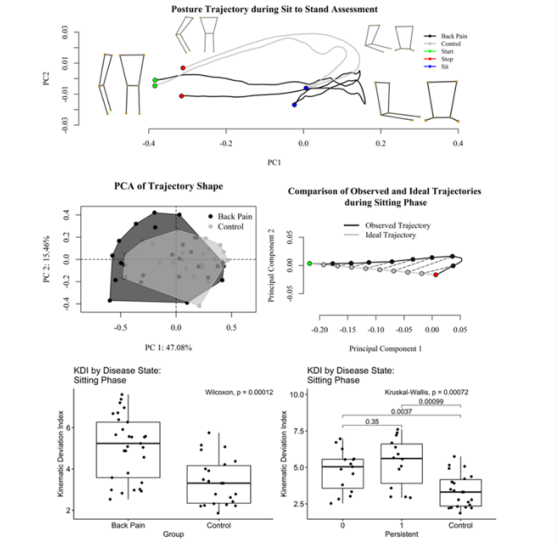

Figure 1. Analysis of Three-Dimensional Posture Trajectory during STS Assessment using Kinematic Deviation Index

Top: Mean motion trajectories for the entire STS movement are plotted for cLBP patients (black) and controls (grey) in principal component space. Three-dimension figures represent mean posture corresponding to location along the trajectory. Middle left: Individual cLBP and control motion trajectories are plotted in principal component space. Each point represents an entire trajectory during the assessment. Middle right: Calculation of KDI is represented graphically with depictions of the observed trajectory (black) and theoretical ideal trajectory (grey) representing the path of least overall posture change. Distances between corresponding postures are dashed. Bottom left: Histograms representing KDI between cLBP patients and controls. Bottom right: Histograms representing KDI among patients with cLBP who had a treatment response within three months, patients with persistent symptoms beyond three months, and healthy controls.

A collaborative regional multi-site and multi-departmental initiative for improving consensus on clinical outcomes data in spine surgery

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Introduction: There has been an effort to improve standardization of health care data collection to optimize patient care, follow up, documentation, and care reimbursement. Creating centralized and accurate data through which treatment outcomes can be compared is a powerful tool for studies on treatment efficacy and effectiveness. The purposes of this project were to: 1) define current practice and established outcome measurements across various spine practice settings, and 2) determine data collection needs with the future goal of standardizing collection guidelines across spine care practitioners.

Methods: Surgeons from local spine centers were invited to social and academic meetings to encourage participation commitment. Data sharing agreements and a database infrastructure were established across orthopaedic and neurosurgical departments in private practice and academic institutions. Surgeons were surveyed regarding patient populations treated, length of follow up, and medical record system utilized. Charts from 20-30 patients per site with single level degenerative or isthmic lumbar spondylolisthesis were reviewed for prevalence of demographic, surgical, operational, and outcomes variables. Based on the prevalence of variables, a consensus-based data review and needs assessment was performed to check for errors in data, missing data, and to identify uncollected variables of interest.

Results: Sequential charts for 95 adult and 20 pediatric patients were reviewed, representing 10 surgeons in orthopaedic or neurosurgical divisions across 4 sites. Variables with >90% collection rates across sites included age, gender, BMI, smoking status, diagnosis, surgery type, operating room time, estimated blood loss, discharge disposition, length of stay, 90-day readmission rate, and pre-operative back pain severity. In the pediatric population, the most common surgical approach was laminectomy with posterior fusion (53.6%). In the adult population, surgery type varied by site, with lateral approach fusions being most common (18-75%). However, this data contained errors due to heterogeneity in coding and interpretation, with 90% of surgeons identifying inconsistencies between the coded procedure and type of surgery performed. Prevalence of patient reported outcomes (PROMs) for back pain and disability varied by site, duration of follow up, and patient population (adult vs pediatricss). Back pain severity was collected in 70% of cases at 3 months, but only in 45% by 1 year. Disability was collected in 16% of cases at 3 months and remained consistent over 1 year. It was not collected in pediatric patients. Medication use, prior treatments, and skin to skin time for staged surgeries was available for 3-23% of cases. After initial data extraction, consensus on coding and surgical type definition, and documentation of skin-to-skin time for staged surgeries were identified as areas for improvement. Variables recommended as high priority for addition included leg pain severity for adult patients, and a single metric for comorbidity assessment.

Discussion: A successful multi-site collaborative data sharing infrastructure was established for individuals with single level lumbar spondylolisthesis. Despite high collection rates, errors and site variability in surgical coding may have a significant impact on interpretability of study designs involving chart review. Additionally, sparsity of PROMs highlights a need for improving standardized data collection procedures for long term follow up.

Spine and walking biomechanics of patients with symptomatic lumbar spinal stenosis after decompression surgery

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Introduction: Lumbar spinal stenosis (LSS) is symptomatic in 10-14% of the adult population and is the leading cause of pain and disability, and the most frequent indication for spinal surgery in older adults. While laminectomy surgery with or without fusion is effective in many patients; approximately one-third of the patients are not satisfied with the postoperative outcomes in long-term, mainly in terms of residual leg pain and poor function. We have recently evaluated walking biomechanics of patients prior to surgical treatment and found that LSS symptoms (neurogenic claudication) cause increased pelvic tilt and lumbar loading. However, biomechanical assessment of spine posture and gait changes with surgical treatment are lacking in this population. The purpose of this study was to investigate the effects of laminectomy (decompression surgery) with or without fusion on spinal posture and loading in standing and walking in patients with LSS.

Methods: Six participants (4F, 2M) with symptomatic LSS, aged 50 to 82, underwent a 3D optoelectronic motion analysis of standing and walking in 2 states (with and without LSS symptoms present) 2-10 days before surgery and 4-6 months after surgery. To provoke LSS symptoms, participants performed a standard walking capacity test. Passive reflective marker clusters were attached to participants at spinal levels, head, pelvis, and extremities. A whole body patient-specific musculoskeletal model was created for each participant and then inverse kinematics and static optimization analysis were performed to evaluate body positions and estimate maximum spine compressive loading, respectively. Fusion surgery was simulated by applying rigid constraints at the fused intervertebral segments, allowing no motion but full force and moment transmission. Primary outcome variables were average pelvic tilt, lumbar flexion, and lumbar compressive loads. Mixed effects regression models were used for statistical analysis.

Results: Following surgery, average pain score significantly decreased from 5.5 to 0.25, and walking capacity time and distance increased from 7.6 min to 15 min, and 798 m to 1020 m, respectively. 5 out of 6 patients underwent lumbar spine fusion along with laminectomy. After surgery, subjects had less pelvic tilt (vs a posterior pelvic tilt pre-surgery) and less spine flexion during walking, and lower spine loading during standing ($p < 0.05$). Prior to surgery, symptoms tended to cause more forward pelvic tilt and greater spine loading (both $p < 0.1$), but these effects were not seen after surgery. However, following surgery patients showed increased spine flexion during symptomatic walking ($p < 0.05$).

Discussion: This is the first biomechanical study of the effects of surgical treatment on spine posture and loading in patients with LSS. Results showed that surgery significantly change spine and pelvis posture during walking, but had limited effect on spinal loading. Treatment seems to mitigate previously noted effects of claudication symptoms on pelvic tilt and spinal loading, but a new effect on spinal flexion was observed in post-surgical testing. Understanding walking biomechanics and its contribution to the post-treatment changes in patient outcomes is essential for informed decision-making on surgical treatments and developing novel rehabilitation techniques to improve patients' walking and physical activity.

Opioid Use After Spine Surgery: How Much Are We Over-prescribing?

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Introduction: Due to the opioid epidemic in the United States, there is increasing awareness of prescribing practices and the potential for unused prescriptions to contribute to the ongoing crisis. Spine surgery is associated with substantial postoperative analgesia requirements and opioid consumption. However, there is a lack of understanding of postoperative opioid consumption and standardized prescribing practices with respect to the type of spine surgery (i.e. anterior cervical and lumbar decompression/fusion). The primary objective was to determine postoperative 90-day opioid consumption in patients undergoing elective spine surgery. The secondary objectives were to identify differences in opioid consumption between spine surgery subgroups and to determine the distribution of opioids consumed to achieve sufficient postoperative pain control up to the 90th percentile of patients within the 90-day period.

Methods: This is a prospective observational cohort study at a multi-surgeon, single center. Consecutive, adult (>18 years) patients undergoing elective spine surgery were eligible for inclusion. Surgeries were divided into subgroups: anterior cervical, posterior lumbar decompression, and short-segment (< 4 levels) circumferential fusion. During the 90-day postoperative period, prescribed MMEs were calculated from opioid prescriptions and consumed MMEs were calculated from pill counts. Preoperative opioid status was recorded as: opioid tolerant (opioid use within 3 months of surgery) or opioid naïve (no opioid use within 3 months of surgery). Prescribed and consumed 90-day MMEs were compared between the three surgical subgroups. Consumed MME distributions were analyzed by the preoperative opioid status (tolerant or naïve) to identify the 50th, 75th, and 90th percentiles within each surgical subgroup.

Results: A total of 117 patients with a mean age of 52 years-old (48.7% male) completed the 90-day follow-up. Across all surgical subgroups (n=48, cervical; n=28, lumbar decompression; n=41, lumbar fusion), 41.9% were opioid tolerant. The mean 90-day MMEs prescribed was 2188.4 and consumed was 1648.5, giving a difference of 540.0 MMEs not consumed. The mean difference in 90-day MMEs prescribed and consumed was significantly different between the surgical subgroups: 388.4 cervical, 375.6 lumbar decompression, and 839.7 lumbar fusion (p=0.002). The percentage of unused opioids at 90-days was on average: 22.5% cervical, 33.7% lumbar decompression, and 23.7% lumbar fusion. The 90th percentile for MMEs consumed in each subgroup were: 660 opioid naïve cervical, 6728 opioid tolerant cervical, 300 opioid naïve lumbar decompression, 2490 opioid tolerant lumbar decompression, 4995 opioid naïve lumbar fusion, and 7710 opioid tolerant lumbar fusion.

Discussion: This study showed that across all surgical subgroups, greater than 20-30% of total MMEs prescribed were unused at 90 days. This suggests that there is a need for the development and adoption of standardized prescribing practices for postoperative opiates. While the results of this study suggest that the number of MMEs prescribed can be reduced to mitigate the effects of leftover pills, larger studies with multiple high-volume centers could help in standardizing opioid prescribing practices across elective spine surgeries.

Prospective study for risk factors of postoperative complication of surgery for spinal metastasis

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[Introduction] Surgery for spinal metastasis contributes to maintaining and improving the patients' quality of life (QOL), which is the goal of multidisciplinary treatment of cancer. However, the deterioration of QOL due to postoperative complications could be more serious in patients whose life expectancy is limited due to cancer. The aim of this study was to clarify risk factors for postoperative complications of spinal metastasis surgery.

[Methods] We prospectively analyzed 241 patients with spinal metastasis who underwent palliative surgery from 2015 to 2020due to progressive neurological deficits or intractable pain. Postoperative complications were assessed by Clavien-Dindo classification and Grade Ⅱ or higher was defined as complications except blood transfusion based on the nature of patients and surgery itself. The following variables at pre-operation were recorded; age, sex, Body Mass Index, smoking history, primary tumor malignancy (the category of primary lesion in New Katagiri score), Total New Katagiri score, Frankel classification, Eastern Cooperative Oncology Group Performance Status, chemotherapy history, radiotherapy history, Spinal Instability Neoplastic score, modified Frailty Index-11 (mFI), diabetes, steroids, serum albumin levels, and Prognostic Nutritional Index. Logistic regression analysis was performed to identify risk factors for postoperative complications ($P<0.05$). For the identified risk factors, the cut-off value was calculated from the receiver operating (ROC) curve using the Youden's index. In addition, chi-square test was used to compare the complication rate between patients with a cut-off value or more and patients with a lesser value than a cut-off value.

[Results] The mean age was 66.8 ± 11.8 years and 62.7% of patients were male. Complications occurred in 19.5% patients (n=47; Grade Ⅱ, 27; Grade Ⅲ, 15; Grade Ⅳ, 2, Grade Ⅴ, 3), whereas not occurred in 80.5% patients (n=194). The most common complication was surgical site infections in 16 patients. Three patients were died within one month after surgery; two sepsis after urinary tract infection and wound infection and one respiratory failure after pneumonia. From a logistic regression analysis, preoperative radiotherapy ($P=0.007$; odds ratio, 3.3; 95% confidence interval [CI], 1.4–7.9) and mFI ($P=0.002$: odds ratio, 2.1; 95% CI, 1.3–3.3) were identified as significant risk factors (**Figure**). From the ROC curve and Youden's index, the cut-off value of mFI was 0.23 (sensitivity, 55.3%; specificity, 80.2%). Postoperative complication rate in patients with mFI≥0.18 (2 items) (39 of 152, 25.7%) was significantly higher than those with mFI<0.18 (≤1 item) (8 of 89, 9.0%) ($P=0.006$). In addition, postoperative complication rate in patients with mFI≥0.27 (3 items) further increased (26 of 63, 41.3%).

[Conclusion] Postoperative complications rate of surgery for spinal metastasis was approximately 20%, which was similar to prior reports. Interestingly, preoperative radiotherapy history and mFI≥0.18 (2 items) were associated with postoperative complication. The mFI provides a reliable objective measurement of frailty, an aging-related syndrome, and has been useful to predict outcomes and complications in various surgeries. We have demonstrated that the mFI was also useful to guide perioperative decision making in such complicated patients with spinal metastasis.

Predicting recovery after lumbar spinal stenosis surgery: a historical cohort study using data from the Canadian Spine Outcomes Research Network (CSORN)

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Introduction: Decompressive surgery, with or without spinal fusion, is recommended for persons with symptomatic lumbar spinal stenosis (SLSS) symptoms for whom conservative management has failed. However, significant persistent pain, functional limitations, and narcotic use can affect up to one third of patients post-surgery. The aim of this study was to identify predictors of outcomes 1-year post SLSS surgery with a focus on modifiable predictors.

Methods: The Canadian Spine Outcomes Research Network (CSORN) is a database of prospectively collected data on pre- and postsurgical outcomes among surgical patients. We included participants with a diagnosis of SLSS undergoing their first spine surgery. The primary outcomes collected 12 months after surgery included back and leg pain, disability (Oswestry Disability Index (ODI)), walking capacity (ODI item 4) and quality of life (EQ-5D-5L). Recovery was identified using a composite score of leg and back pain (NRS 0-3) and ODI less than 30. Predictors included demographics, physical activity level, smoking status, previous rehabilitation, medication intake, depression, expectations, and number of comorbidities. A multivariate partial least squares (PLS) model was used to identify predictors of outcomes. One of the strengths of the PLS is that it allows for the inclusion of multiple outcomes in one model. Analysis was conducted separately for men and women.

Results: Patient data collected between January 2015 to September 2019 were included. A total of 1868 participants were eligible for inclusion, however; after excluding participants with missing data for the outcomes or 20% of the predictors (less than 7 out of 27), our final sample size included 1068 participants (654 men and 414 women) after multiple imputation for missing predictors. Of the total sample, 466 participants (44%) (311 men and 155 women) were identified as recovered (a per our composite score) at 1-year follow-up. The percentage of variance in the outcomes explained by the PLS model ranged between 0.16-0.24 with the lowest value corresponding to the women in the non-imputed dataset and the highest being related to the men in the imputed dataset. The variance importance in projection (VIP) scores for men identified higher depression (PHQ9), higher number of comorbidities and high disability (ODI) at baseline as important predictors of worse outcomes in the PLS models. The variables that predicted worse outcomes for women were higher BMI, higher depression, and higher disability baseline. Results without imputation included the same predictors with the addition of BMI for men, symptom duration and previous treatment with a physical trainer for women. For both men and women in imputed and non-imputed data ODI at baseline (with the VIP score of more than 3) was the most significant contributor in the PLS model to predict all outcomes.

Discussion: The results demonstrate that higher depression and disability at baseline are associated with worst outcomes post-surgery for men and women. Higher number of comorbidities for men and high BMI for women were also associated with worse outcomes. The majority of predictors are modifiable so future studies should evaluate whether modifying these parameters prior to surgery can improve outcomes.

Impact of Navigation on 30-Day Outcomes for Pediatric Deformity Surgery

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Introduction: Navigation has increasingly been used to treat degenerative disease, with improved radiographic accuracy and positive clinical outcomes[1,2]. However, short-term outcomes research on treating pediatric deformity with navigation is limited[3]. This is the first large-scale database study to compare short-term outcomes in pediatric deformity with and without navigation.

Methods: Deformity surgery patients were identified in the 2012-2018 pediatric-NSQIP datasets (CPT 22800-22804). Patients with severe preoperative comorbidities, infection, or anterior, revision, lesion, or nonelective surgery were excluded. Regression was used to compare readmission, reoperation, morbidity, and specific complications between navigation and conventional, and to control for predictors.

Results: 16,950 patients (356 with navigation) were included. Navigated cases had greater preoperative hematocrit (40.5 vs 39.9, p=0.005) and OR time (352 vs 284 min, p<0.001), but similar RVUs (58.4 vs 60.1) and fewer RVUs per minute (0.21 vs 0.23, p<0.001) (Table 1).

Navigation group had greater reoperation (6.2 vs 3.1%, p=0.001), morbidity (75.6 vs 67.5%, p=0.001), deep-wound infection (2.5 vs 0.8%, p=0.003), transfusion (73.6 vs 65.9%, p=0.002), and sepsis (2.2 vs 0.7%, p=0.007) rates. Readmission was similar (5.9 vs 3.9%, p=0.055). In multivariate analysis, navigation predicted reoperation (OR=1.920, p=0.019), deep-wound infection (OR=2.926, p=0.009), and sepsis (OR=3.192, p=0.010).

Obesity (OR=2.472), developmental delay (OR=1.926), OR time (OR=1.002), hospital stay (OR=1.040), and total RVUs (OR=1.005) predicted reoperation (p<0.001) (Table 2). Black race (OR=1.193, p=0.002), Hispanic ethnicity (OR=1.401, p<0.001), seizure (OR=1.384, p=0.004), OR time (OR=1.005, p<0.001) and total RVUs (OR=1.009, p<0.001) predicted morbidity. Female gender was protective of readmission (OR=0.787, p=0.021).

Conclusion: Navigation cases were longer and had fewer RVUs-per-minute. Navigation had 92% greater odds of reoperation and predicted deep wound infection and sepsis despite controlling for patient-related factors and case complexity. This is explained, in part, by greater OR time and transfusion. Site-related factors played the largest role in reoperation.

Table 1. Baseline differences in patient demographic, comorbidity, laboratory, and procedural factors, and primary outcomes by presence or absence of computer assisted surgery.

	With CAS, *n* (%)	Without CAS, *n* (%)	*P*	Cases available
	N = 356	N = 16,594		16,950
Demographics				
Mean age (years; SD)	13.8 (2.8)	13.8 (2.7)	0.866	16,950
African American race	39 (11.8%)	2,696 (18.2%)	**0.003**	15,120
Hispanic ethnicity	31 (8.8%)	1,625 (10.6%)	0.292	15,712
Female gender	245 (68.8%)	11,575 (69.8%)	0.704	16,950
Comorbidities				
Obese	56 (16.3%)	2,416 (15.3%)	0.619	16,132
Pulmonary comorbidity	69 (19.4%)	2,795 (16.8%)	0.206	16,950
Cardiac comorbidity	26 (7.3%)	1,453 (8.8%)	0.337	16,950
Esophageal/GI disease	33 (9.3%)	1,692 (10.2%)	0.567	16,950
Developmental delay	79 (22.2%)	3,505 (21.1%)	0.625	16,950
Seizure disorder	31 (8.7%)	1,580 (9.5%)	0.605	16,950
Cerebral palsy	30 (8.4%)	1,571 (9.5%)	0.507	16,950
Structural CNS abnormality	49 (13.8%)	2,202 (13.3%)	0.786	16,950
Neuromuscular disorder	72 (20.2%)	3,668 (22.1%)	0.397	16,950
Preoperative steroid use	3 (0.8%)	179 (1.1%)	1.000[2]	16,950
Nutritional support	26 (7.3%)	1,274 (7.7%)	0.793	16,950
Hematologic disorder	10 (2.8%)	309 (1.9%)	0.193	16,950
Congenital malformation	86 (24.2%)	5,077 (30.6%)	**0.009**	16,950
Childhood malignancy	5 (1.4%)	166 (1.0%)	0.450	16,950
ASA-class ≥3	108 (30.4%)	5,055 (30.5%)	0.977	16,932
Lab Values (mean; SD)				
White cell count	7.0 (2.3)	6.9 (2.3)	0.758	14,089
Hematocrit	40.5 (3.6)	39.9 (3.4)	**0.005**	14,481
INR	1.1 (0.1)	1.1 (0.1)	0.672	9,657
Procedural Factors				
Operative time	352 (134)	284 (108)	**<0.001**	16,940
Length of stay	5.7 (7.3)	5.3 (5.7)	0.304	16,909
Total RVUs	65.2 (23.8)	60.1 (26.7)	**<0.001**	16,950
RVUs per minute	0.21 (0.09)	0.23 (0.12)	**<0.001**	16,940
Total RVUs subtracting CAS	58.4 (24.8)	60.1 (26.7)	0.238	16,948
Unadjusted Primary Outcomes				
Readmission	21 (5.9%)	647 (3.9%)	0.055	16,950
Reoperation	22 (6.2%)	513 (3.1%)	**0.001**	16,950
Mean days to reoperation	16.3 (7.4)	14.1 (8.4)	0.229	
Morbidity	269 (75.6%)	11,199 (67.5%)	**0.001**	16,950

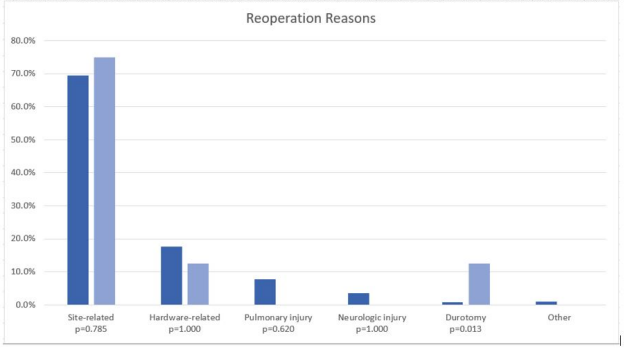
[2]Fisher's Exact Test. Bold values indicate significance (*P*<0.05). ASA, American Society of Anesthesiologists. RVU, Relative value unit. CAS, computer assisted surgery. GI, gastric/intestinal. CNS, central nervous system. SD, standard deviation. Pulmonary comorbidities include ventilator dependence, asthma, chronic lung disease, chronic oxygen support, tracheostomy, or structural pulmonary or airway abnormalities. Cardiac comorbidities include previous cardiac surgery and cardiac risk factors.

Table 2. Univariate and multivariate analysis of predictors of reoperation.

	Univariate			Multivariate	
	Reoperation (N = 535)	No reoperation (N = 16,415)	*P*	OR (95% CI)	*P*
Demographics					
Mean age (years; SD)	13.4 (3.1)	13.8 (2.7)	**0.002**	1.012 (0.970, 1.056)	0.586
African American race	88 (18.3%)	2,647 (18.1%)	0.922	1.083 (0.813, 1.444)	0.585
Hispanic ethnicity	53 (10.6%)	1,603 (10.5%)	0.989		
Female Gender	325 (60.7%)	11,495 (70.0%)	**<0.001**	0.947 (0.745, 1.203)	0.947
Comorbidities					
Obese	131 (26.7%)	2,341 (15.0%)	**<0.001**	2.472 (1.901, 3.214)	**<0.001**
Pulmonary comorbidity	175 (32.7%)	2,689 (16.4%)	**<0.001**	1.216 (0.922, 1.604)	0.166
Cardiac comorbidity	77 (14.4%)	1,402 (8.5%)	**<0.001**	1.067 (0.764, 1.490)	0.704
Esophageal/GI disease	119 (22.2%)	1,606 (9.8%)	**<0.001**	0.847 (0.608, 1.179)	0.326
Developmental delay	260 (48.6%)	3,324 (20.2%)	**<0.001**	1.926 (1.414, 2.622)	**<0.001**
Seizure disorder	132 (24.7%)	1,479 (9.0%)	**<0.001**	1.230 (0.861, 1.758)	0.255
Cerebral palsy	125 (23.4%)	1,476 (9.0%)	**<0.001**	1.064 (0.739, 1.534)	0.738
Structural CNS abnormality	138 (25.8%)	2,180 (12.9%)	**<0.001**	1.171 (0.883, 1.554)	0.273
Neuromuscular disorder	244 (45.6%)	3,496 (21.3%)	**<0.001**	1.533 (1.162, 2.021)	**0.002**
Preoperative steroid use	13 (2.4%)	169 (1.0%)	**0.002**	1.056 (0.491, 2.271)	0.889
Nutritional support	106 (19.8%)	1,194 (7.3%)	**<0.001**	0.867 (0.588, 1.277)	0.470
Hematologic disorder	23 (4.3%)	296 (1.8%)	**<0.001**	0.913 (0.487, 1.711)	0.777
Congenital malformation	272 (50.8%)	4,891 (29.8%)	**<0.001**	1.091 (0.846, 1.406)	0.502
Childhood malignancy	4 (0.7%)	167 (1.0%)	0.539		
ASA-class ≥3	321 (60.0%)	4,842 (29.5%)	**<0.001**	1.519 (1.123, 2.055)	**0.007**
Lab values (mean; SD)					
White cell count	7.4 (2.7)	6.9 (2.3)	**<0.001**	1.024 (0.981, 1.069)	0.284
Hematocrit	39.8 (4.3)	39.9 (3.8)	0.551	0.982 (0.954, 1.010)	0.195
INR	1.1 (0.1)	1.1 (0.1)	0.882		
Procedural factors					
Computer assistance					
With CAS	22 (6.2%[1])	334	**0.001**	1.920 (1.115, 3.306)	**0.019**
Without CAS	513 (3.1%[2])	16,081			
Operative time	333 (122)	284 (108)	**<0.001**	1.002 (1.001, 1.003)	**<0.001**
Length of stay	10.7 (12.7)	5.2 (5.3)	**<0.001**	1.040 (1.031, 1.050)	**<0.001**
Total RVUs	67.8 (29.4)	60.0 (26.5)	**<0.001**	1.005 (1.001, 1.003)	**0.010**

[1]Percent of patients with CAS who returned to the operating room. [2]Percent of patients without CAS who returned to the operating room. [3]Fisher's Exact Test. Bold values indicate significance (*P*<0.05). ASA, American Society of Anesthesiologists. RVU, Relative value unit. CAS, computer assisted surgery. GI, gastric/intestinal. CNS, central nervous system. SD, standard deviation. Pulmonary comorbidities include ventilator dependence, asthma, chronic lung disease, chronic oxygen support, tracheostomy, or structural pulmonary or airway abnormalities. Cardiac comorbidities include previous cardiac surgery and cardiac risk factors.

IMAGES AND TABLES: Figure 1. Reasons for reoperation amongst navigated and conventional posterior-only pediatric deformity fusion patients.



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Natural History of Adult Spinal Deformity: How do patients with Less than Optimal Surgical Outcomes Fare Relative to Non-Operative Counterparts?

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Introduction: Management of adult spinal deformity (ASD) has increasingly favored operative intervention, however the incidence of complications and reoperations is high and patients may fail to reach optimal realignment parameters. While non-operative interventions have varying rates of efficacy, these patients presumably approximate the natural history of ASD. The objective of this study is to compare health-related quality of life (HRQL) metrics of patients with suboptimal surgical outcomes to those undergoing non-operative management (i.e. natural history).

Methods: ASD patients > 18 considered for operative intervention with full baseline (BL) and up to 1-year (1Y) follow-up HRQL and radiographic data were included. All patients ≥1 of the following BL radiographic parameters for ASD: pelvic tilt (PT) >25°, Cobb angle >20°, sagittal vertical axis (SVA) > 5cm, and thoracic kyphosis (TK) >60°. While all patients were offered operative intervention, for those in the non-operative group, the decision to forego operative management was ultimately made by the patient. Operative patients were selected for "suboptimal outcomes," defined as any reoperation, major complication, or ≥2 severe (i.e. ++) SRS-Schwab modifiers at follow-up. Patients were separated into two groups: suboptimal operative (SOp) vs. natural history, i.e. non-operative (NH). SOp and NH patients were then propensity score matched (PSM) by BL age, deformity, Oswestry Disability Index (ODI), and Charlson Comorbidity Index (CCI). Means comparison tests analyzed differences between groups in outcomes of interest, including ODI and Scoliosis Research Society-22 (SRS-22) domains.

Results: 370 patients met inclusion criteria, 284-SOp and 86-NH. After PSM, the resulting groups included 67 "SOp" and 67 "NH" patients. Cohort and group demographics, HRQLs, and radiographic parameters can be found in Table 1. After PSM the SOp and NH groups were not significantly different in demographics, HRQLs, or deformity (pelvic tilt (PT), SVA, pelvic-incidence-minus-lumbar-lordosis (PI-LL)). However, NH group had significantly higher baseline SRS-activity and SRS-satisfaction ($p<.05$ for both). Additionally, there were no significant differences in percent of patients with severe (i.e. ++) BL SRS-Schwab modifiers ($p<.05$). At 1Y, SOp group had a mean improvement in ODI from BL (-9.16) vs. NH group (-0.51), $p<.002$ and significantly more SOp patients (39.7%) gained ≥1 MCID in ODI compared to NH patients (2.9%), $p<.001$. At 1Y, the SOp group had a significantly higher SRS-22 satisfaction domain score and demonstrated significantly greater improvement in SRS-Activity, SRS-Pain, SRS-Satisfaction, and SRS-Total (all p-values <.05). Finally, significantly more SOp patients gained ≥1 MCID in SRS-Activity (40.7%) and SRS-Pain (57.6%) compared to the NH patients, 17.1% and 31.4% respectively, $p<.02$ for both values.

Discussion: When compared to the natural history of non-operative ASD patients, operative patients with suboptimal outcomes still experience significantly greater improvements in HRQLs after surgical intervention. Such divergent outcomes seen at 1Y, highlight the stagnation and deterioration in outcomes associated with the natural history of ASD. While additional investigation should be conducted to explore these differences, spine surgeons and patients should consider the outcomes associated with the non-operative course when weighting risk and benefits of operative intervention for ASD.

Table 1: Baseline Demographics	NH	SOp	Cohort	*p* value
Age (years)	58.28±13.8	57.05±15.13	57.67±14.44	>.05
Gender (% Female)	91.05%	82.09%	85.67%	>.05
BMI (kg/m^2)	26.02±5.61	26.08±5.02	26.05±5.27	>.05
CCI	1.40±1.43	1.42±1.61	1.41±1.51	>.05
Baseline HRQLs	NH	SOp	Cohort	*p* value
ODI	31.06±15.56	31.67±14.76	31.36±15.11	>.05
SRS Activity	3.6±0.75	3.31±0.87	3.45±0.82	0.043
SRS Pain	2.95±0.89	2.9±0.91	2.92±0.89	>.05
SRS Total	3.29±0.61	3.16±0.58	3.23±0.60	>.05
Baseline Radiographic Characteristics	NH	SOp	Cohort	*p* value
BL PT (°)	21.54±10.02	22.95±11.28	22.26±10.66	>.05
BL SVA (mm)	37.40±61.70	40.93±57.28	39.16±59.33	>.05
BL PI-LL (°)	9.11±17.86	11.27±20.64	10.22 ±19.29	>.05
Severe (++) PT Modifier (%)	17.5	23.9	20.6	>.05
Severe (++) SVA Modifier (%)	13.4	17.9	15.7	>.05
Severe (++) PI-LL Modifier (%)	26.6	37.3	32.1	>.05
1Y HRQLs	NH	SOp	Cohort	*p* value
ODI	26.63±13.47	21.26±18.46	23.28±16.88	>.05
ODI Difference from BL	-0.51±8.14	-9.16±17.71	-5.91±15.38	0.002
Gained > 1 MCID for ODI (%)	2.9	39.7	25.8	$X^2(1)=15.437, p<.001$
SRS-22 Activity	3.63±0.79	3.51±0.84	3.55±0.82	>.05
SRS-22 Pain	3.20±0.89	3.55±0.95	3.42±0.94	0.075
SRS-22 Total	3.44±0.71	3.71±0.70	3.61±0.71	0.073
SRS-22 Activity - Difference from BL	-0.15±0.49	0.13±0.83	0.46±0.88	0.01
SRS-22 Pain - Difference from BL	0.24±0.77	0.56±0.90	0.92±0.97	<.001
SRS-22 Satisfaction - Difference from BL	0.34±1.00	1.72±1.25	1.52±1.32	<.001
SRS-22 Total - Difference from BL	0.05±0.44	0.49±0.63	0.74±0.73	<.001
Gained > 1 MCID for SRS-22 Activity (%)	17.1	40.7	31.9	$X^2(1)=5.600, p=.018$
Gained > 1 MCID for SRS-22 Pain (%)	31.4	57.6	47.9	$X^2(1)=6.042, p=.014$
1Y Radiographic Characteristics	NH	SOp	Cohort	*p* value
PT (°)	20.82± 9.03	20.12± 10.94	20.35±10.30	>.05
SVA (mm)	16.14±43.61	20.17±58.31	18.83±53.63	>.05
PI-LL (°)	5.99±14.80	1.77±16.98	3.17±16.32	>.05
PT Difference from BL (°)	0.21±2.74	-3.09±7.36	-1.99±6.39	0.003
SVA Difference from BL (mm)	2.56±34.69	-22.07±59.54	-13.86±53.65	0.017
PI-LL Difference from BL (°)	2.01±6.64	-10.04±19.38	-6.02±17.20	<.001
Severe (++) PT Modifier (%)	13.8	20.7	18.4	X^2 (2)=3.230, p>.05
Severe (++) SVA Modifier (%)	6.9	13.8	11.5	X^2 (2)=1.034, p>.05
Severe (++) PI-LL Modifier (%)	13.8	13.8	13.8	X^2 (2)=1.163, p>.05

The Cost of Alignment – How do alignment criteria impact cost effectiveness of surgical intervention for adult spinal deformity?

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Introduction: Several systems have been developed to classify thoracolumbar alignment in adult spinal deformity (ASD), however with increasing focus on value-based healthcare, the cost effectiveness of meeting additional alignment criteria has yet to be explored. The objective of this study is to compare cost effectiveness of meeting additional alignment criteria.

Methods: This is a retrospective study of a prospective, single-center ASD-database. Operative patients who met criteria for ASD with baseline (BL) and 1-year (1Y) radiographic and health related quality of life (HRQL) data were included. At BL and 1Y, patients were assessed using four published alignment systems: SRS-Schwab (includes: Pelvic-Tilt(PT), Sagittal-Vertical-Axis(SVA) and Pelvic-Incidence minus-Lumbar-Lordosis(PI-LL)); GAP Score, a sagittal disproportion score out of 13; Age-Adjusted Alignment, which adjusts SRS-Schwab parameters to age-adjusted ideal; Roussouly Type, assessed as 'Match' or 'Mismatch' their theoretical type. Patients were classified as meeting SRS-Schwab if 1Y PT, PI-LL, or SVA decreased in severity or maintained a score of 0 at 1Y. Patients were classified as meeting GAP, if 1Y GAP score decreased in severity or maintained a score between 0 and 2 at 1Y. Meeting age-adjusted and Roussouly were based on matching at 1Y. Patients were separated into 5 groups by number of criteria (0 – 4) met at 1Y and cost per Quality-Adjusted-Life-Year(QALY) was calculated by group. Within groups meeting 1, 2, or 3 criteria, cost/QALY was calculated overall, regardless of which combination of criteria were met and by specific combinations of criteria met. ANCOVA estimated marginal means of complications and reoperations adjusting for BL age, deformity, approach and invasiveness. ANCOVA also estimated marginal means for ODI, adjusting for BL age, gender, deformity, Charlson Comorbidity Index (CCI) and frailty index (FI). A cost analysis was completed on the PearlDiver database accounting for approach, revisions, complications and comorbidities. For QALY analysis, utility was calculated using ODI converted to SF-6D. A 3% discount rate was applied to account for residual decline to life expectancy (LE), 78.70 years. Trendline analysis noted changes over time.

Results: 364 patients were included (58.90±14.55yrs, 81.54%-female, 26.85±5.42kg/m^2). Of these, 15-met 0-of-4, 62-met 1-of-4, 130-met 2-of-4, 125-met 3-of-4, & 32-met all 4 alignment systems. Controlling for BL age, deformity, approach & invasiveness, patients meeting 0-of-4 had higher rates of major complications than all other groups, p=.004. 1Y cost was highest in patients meeting 0-of-4 and lowest in patients meeting any 1-of-4,p=.009 (Figure 1). Patients that met 0-of-4 had lowest QALYs gained at 1Y(0.10) whereas 1/4 had the highest(0.20) (Table 1). Cost/QALY at LE was highest in pts that met 0/4($113,583.41) and lowest in those meeting 1-of-4 ($41,990.58),p<.05. Of those meeting any 1 system, patients meeting age-adjusted had lowest Cost/QALY at LE ($41,559.31).

Discussion: Patients that improved in any one of the alignment systems at 1Y had lower complication rates, lower cost, higher QALYs gained and lowest Cost/QALY at 1Y. Of patients meeting only 1 criteria, age-adjusted proved to be most cost-effective. These data suggest that in terms of maximizing cost effectiveness, it may not be necessary to realign patients all 4 classification systems.

Figure 1

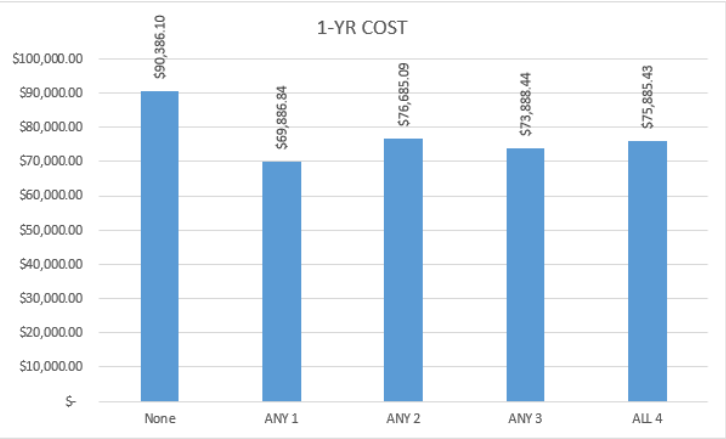

Table 1

	1Y COST	N	1Y QALYs Gained	LE QALYs Gained	1Y COST /QALY	LE COST /QALY
None	$90,386.10	15	0.104	0.796	$870,003.91	$113,583.41
ANY 1	$69,886.84	62	0.201	1.664	$348,330.23	$41,990.58
ANY 2	$76,685.09	130	0.161	1.265	$474,982.38	$60,612.31
ANY 3	$73,888.44	125	0.151	1.228	$487,927.69	$60,174.10
ALL 4	$75,885.43	32	0.168	1.627	$451,660.25	$46,653.95

Does trunk muscle mass measured by DXA reflect trunk muscular strength?

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INTRODUCTION

To date, it has been shown that muscle cross-sectional area is a major predictor of force production, while the relationship between muscular strength and muscle volume measured by whole-body dual-energy X-ray absorptiometry (DXA) was unclear. We investigated that the relation between DXA-derived regional muscle mass and muscular strength.

METHODS

A total of 48 healthy volunteers participated in this study. They were 22 men and 26 women with a mean age of 47.1±11.9 years, and underwent whole-body DXA and muscle strength measurements. Each part of the muscle mass was defined as the respective value of lean body mass measured by DXA. Each muscular strength was defined as the average value of three times measurements. We investigated (1) relation between upper limb muscle mass (ULM) and grip strength, (2) relation between lower limb muscle mass (LLM) and knee extensor/flexor strength, and (3) relation between trunk muscle mass (TM) and trunk extensor/flexor strength separately in men and women. In the region of upper and lower limbs, left and right mean values were compared respectively. Spearman's rank correlation coefficient was employed for statistical comparison, and $P < 0.05$ indicated statistical significance.

RESULTS

ULM was 2.65kg in men and 1.60kg in women. LLM was 8.17kg in men and 5.65kg in women. TM was 23.45kg in men and 18.14kg in women. Grip strength was 394N in men and 237N in women. Knee extensor strength was 508N in men and 308N in women. Knee flexor strength was 210N in men and 151N in women. Trunk extensor strength was 602N in men and 359N in women. Trunk flexor strength was 498N in men and 267N in women. ULM and grip strength were moderately correlated in men ($r = 0.60$, $P < 0.0001$), and strongly correlated in women ($r = 0.76$, $P < 0.0001$). LLM and knee extensor strength were weakly correlated in men ($r = 0.43$, $P = 0.0038$), and moderately correlated in women ($r = 0.54$, $P < 0.0001$). LLM and knee flexor strength were not correlated in men ($r = 0.23$, $P = 0.1370$), and weakly correlated in women ($r = 0.39$, $P = 0.0047$). There was no correlation between TM and trunk extensor strength both in men ($r = -0.04$, $P = 0.8762$) and women ($r = 0.19$, $P = 0.3443$). TM and trunk flexor strength were not correlated in men ($r = 0.12$, $P = 0.6096$), and weakly correlated in women ($r = 0.44$, $P = 0.0232$).

DISCUSSION

In the evaluation of DXA-derived regional muscle mass and muscular strength, correlation between ULM and grip strength, and correlation between LLM and knee extensor strength were statistically significant. Alternatively, TM and trunk extensor/flexor strength were not correlated except TM and trunk flexor strength in women. These data suggested that ULM was closely related to grip strength, and LLM was closely related to knee extensor strength, whereas TM was not related to trunk muscular strength. Additionally, higher correlation coefficients in women showed that DXA-derived muscle mass and correspondence muscular strength were more closely related in women.

Evaluation of the Clinical and Radiographic Degenerative Spondylolisthesis (CARDS) and Degenerative Spondylolisthesis Instability Classification (DSIC) Systems

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Introduction

The role of fusion in degenerative spondylolisthesis (DS) is controversial. The CARDS and DSIC systems were developed to assist surgeons in surgical technique selection based on individual patient characteristics. These systems have not been clinically validated. The goal of this study was to determine if outcomes vary with different surgical techniques across the CARDS and DSIC categories.

Methods

DS patients undergoing surgery were enrolled at 2 institutions in Switzerland and the United States and classified according to the CARDS and DSIC systems. The Core Outcomes Measure Index (COMI) was completed at baseline, 3 months, and 12 months post-operatively. Due to small numbers in some subgroup analyses, patients treated with decompression alone or decompression with uninstrumented fusion were combined for analysis (uninstrumented group) as were patients treated with decompression and posterolateral instrumented fusion or decompression with posterolateral and interbody instrumented fusion (instrumented group). Unadjusted analyses and mixed effect models compared COMI scores between the two surgery technique groups (uninstrumented vs. instrumented), stratified by CARDS and DSIC category over time. Re-operation rates were also compared between the surgery technique groups stratified by CARDS and DSIC category.

Results

508 patients were enrolled in the study, 460 had sufficient data to be classified according to CARDS, and 459 could be classified according to DSIC. Seven percent were classified as CARDS A, 28% as CARDS B, 48% as CARDS C, and 17% as CARDS D (CARDS A most “stable”, CARDS D least “stable”). 2% were classified as DSIC 1, 80% as DSIC 2, and 17% as DSIC 3 (DSIC 1 most “stable, DSIC 3 least “stable”). 133 patients (26%) underwent decompression alone, 30 (6%) underwent decompression and uninstrumented fusion, 42 (8%) underwent decompression and posterolateral instrumented fusion, and 303 (60%) underwent decompression with posterolateral and interbody instrumented fusion. Patients in the least “stable” categories tended to be less likely to be treated with an uninstrumented technique (CARDS D 19% and DSIC 3 21% vs. 32% for the other categories, p=0.10 for CARDS, p=0.02 for DSIC). There were no significant differences in 3 or 12 month COMI scores between surgical technique groups stratified by CARDS or DSIC category in the unadjusted or adjusted analyses. In the unadjusted analyses, there was a trend towards less improvement in 12 month COMI change score in the CARDS D patients in the uninstrumented group compared to the instrumented group (-3.01 vs. -3.88, p=0.10). Reoperation rates were not significantly different between the surgical technique groups stratified by CARDS and DSIC category.

Discussion

In general, outcomes for uninstrumented and instrumented surgical techniques were similar across the DSIC and CARDS categories. There was a trend towards less improvement in the CARDS D patients treated with uninstrumented techniques, suggesting that in patients with kyphosis (the defining feature of the CARDS D category) better outcomes may be associated with instrumentation. The major limitation of this study was the low numbers in the CARDS D (n=15) and DSIC 3 (n=17) uninstrumented groups, likely due to surgeons choosing to avoid uninstrumented techniques in these patients.

Intradiscal injection of autologous bone marrow aspirate concentrate improves low back pain at one year

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Introduction: Chronic low back pain is one of the leading causes of disability and poor quality of life in the US and worldwide. A common cause of chronic low back pain is degenerative disc disease. Current nonsurgical treatments for degenerative disc disease-associated low back pain are typically effective. However, for patients who fail these treatments, surgical fusion is often used as last line treatment. Surgical treatment is associated with higher healthcare expenditures and a more invasive procedure. As such, there is growing interest in the field of regenerative medicine and stem cell therapy as a less invasive treatment for low back pain.

Methods: A total of 32 consecutive patients over the age of 18 years diagnosed with discogenic low back pain clinically or by discography who underwent injection of autologous intradiscal BMAC at a single multi surgeon orthopedic spine center were included in this study. Active smokers and patients who had pain generators other than purely discogenic pain were excluded. For primary analysis, patients completed baseline and 1 year post-injection ODI, VAS back, VAS leg, and EQ-5D-5L questionnaires; their scores were compared over time. Preprocedural lumbar MRIs were reviewed for Modic changes and assigned a Pfirrmann grade. 13 postprocedural MRIs were available and reviewed using the same parameters.

Results: Thirty-two patients (56.3% male) with a mean age of 45.9 (range 19-65) underwent BMAC injection between 1 and 6 levels completed 1 year follow up. Mean VAS back and leg scores improved from 54.0 to 30.4 ($p<0.001$) and 27.9 to 13.3 ($p=0.005$), respectively. Mean ODI scores decreased from 33.5 to 21.1 ($p<0.001$), and EQ-5D-5L scores improved from 0.69 to 0.78 ($p=0.001$). Using established minimum clinically important difference values, 59.4% of patients saw a clinically significant improvement in VAS back pain, 43.8% in VAS leg pain, and 56.3% in ODI scores. On pre-procedural MRIs, 62.5% of patients had a Modic score of 1 or 2 and 93.8% had a Pfirrmann grade of 3 or higher. Postprocedural MRIs were available for 13 patients, and 61.5% had no measurable change in Pfirrmann grade. Three patients worsened by one Pfirrmann grade and one improved by 1 grade.

Discussion: Intradiscal injection of autologous BMAC was shown to significantly improve pain and quality of life at one year. Additionally, this study meets 88% of recently published AAOS reporting standards for studies relating to mesenchymal stem cells. The results of this study suggest that intradiscal injection of autologous BMAC has the potential to be an effective non-surgical treatment for chronic discogenic low back pain.

The protective role of the posterior elements of the spine against endplate fractures in a porcine model

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INTRODUCTION: Previous studies have shown that the posterior elements/facet joints provide strength to the overall functional spine unit by taking 3-25% of vertical compressive load off the intervertebral disc [1]. However, little is known regarding whether this offloading has a protective effect against endplate fracture. Interestingly, studies which used spinal units with the posterior elements removed tended to report failure after a lower number of loading cycles when compared to studies that used intact FSUs [2-4]. Therefore, the purpose of this study was to investigate if the posterior elements provide a protective role to the endplate in porcine cervical spines under fracture-inducing conditions.

METHODS: Twenty-two cervical porcine functional spine units (C5/6 level) were randomized into two groups: 1) a control group which had their posterior elements left intact (n=11); 2) an experimental group which had the posterior elements removed (n=11). Each spinal unit underwent a previously reported rapid disc pressurization protocol in order to create endplate fractures [5]. Briefly, hydraulic fluid was rapidly injected into the disc via a standard inflation needle inserted through the anterior annulus which was connected in series to a hydraulic pump and pressure transducer. From the pressure-time tracing, rate of pressurization and peak pressure were determined for each specimen. Following rapid pressurization, each spinal unit was dissected axially though the disc to determine the presence and size of endplate fracture. Fracture area was quantified from axial images of the transected disc using ImageJ.

RESULTS: Peak pressurization and rate of pressurization were not found to differ between intact and cut specimens ($p=0.313$ and 0.101, respectively). Despite this, significantly more cut spinal units sustained an endplate fracture (11/11) compared to intact spinal units (5/11); $p=0.012$. Further, in the specimens which sustained a fracture, cut spinal units resulted in a fracture area 1.91 times greater in size compared to the fractures observed in the intact FSUs ($p=0.011$).

DISCUSSION: The current study found that a significantly greater number of specimens sustained an endplate fracture following rapid intradiscal pressurization when the posterior elements were removed compared to when the posterior elements were intact. This difference was not due to greater rates of pressurization or higher peak pressures reached within the disc as these were not found to differ between the two groups. Further, in these fractured specimens, the overall size of the fracture was greater in cut specimens compared to intact specimens. This study provides evidence to support the notion that the posterior elements lend mechanical strength and support to the endplate and subsequently the entire spinal unit likely as a result of a redistribution of force across the whole endplate/vertebra.

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2. Gordon et al (1991) Spine 16(4), 450–456
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Disc-targeted disruption of autophagy promotes moderate age-associated disc degeneration in mice

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INTRODUCTION: Aging is a consequence of time-dependent accumulation of stochastic cellular molecular damage. Cellular division dilutes the amount of accumulated damage, so proliferative cells have less molecular damage than non-proliferative ones. Long-lived and non-proliferative, disc cells reside in a chronically deprived nutrient microenvironment of the intervertebral disc. How the disc cells uniquely adapt metabolically to limited nutrients and minimize accumulation of cellular damage remains unclear. Autophagy is a universal quality control cellular process that removes damaged cell components by a recycling mechanism to provide raw building blocks for biosynthesis and energy production. In this study, we investigated whether autophagy is important for disc health by creating the *Col2-cre;Atg7$^{fl/fl}$* mice to knock out an essential autophagy gene targeted to the nucleus pulposus (NP) tissue.

METHODS: Floxed *Atg7* mice (*Atg7$^{fl/fl}$*) were crossed with collagen 2 alpha 1 Cre (*Col2a1-Cre*) transgenic mice to generate NP-targeted ATG7 knockout mice (*Col2-cre;Atg7$^{fl/fl}$*). Intervertebral disc degeneration (IDD) in *Col2-cre;Atg7$^{fl/fl}$* mice and *Atg7$^{fl/fl}$* control mice at 3, 6, 12 months old was assessed by disc H&E histology, and disc aggrecan immunofluorescence (IF). Disc cell death (TUNEL assay) and cellular senescence (RT-PCR for senescence markers p21 and p16 genes) were measured. Western blot was used to measure expression of key autophagy protein markers, ATG7, p62 and LC3-II, to confirm autophagy ablation in *Col2-cre;Atg7$^{fl/fl}$* mice. Student's t-test was used for significance, n=3.

RESULTS: Western blots demonstrated ATG7 ablation primarily in NP, but not AF, paraspinal muscle, or vertebral bones of *Col2-cre;Atg7$^{fl/fl}$* mice, confirming specificity of the knockout model. Autophagy was also disrupted mainly in NP tissue as evidenced by accumulation of p62 and LC3-II proteins in NP tissue of *Col2-cre;Atg7$^{fl/fl}$* mice. At 3 months of age, *Col2-cre;Atg7$^{fl/fl}$* mice compared to control mice exhibited no significant differences in histological disc degeneration score, percent of TUNEL-positive disc cells, p21 or p16 gene expression, or disc aggrecan IF. At 6 and 12 months of age, *Col2-cre;Atg7$^{fl/fl}$* mice compared to *Atg7$^{fl/fl}$* control mice exhibited abnormal NP morphology, greater histological disc degenerative score, higher gene expression of the senescence p21 marker, but no differences in TUNEL positive disc NP cells or NP aggrecan IF.

DISCUSSION: Disc autophagy is not essential for intervertebral disc development and maturity as *Col2-cre;Atg7$^{fl/fl}$* mice showed no detectable IDD features compared to control mice at 3 month of age. However, inhibition of autophagy in NP tissue promotes moderate NP degeneration and cellular senescence with age in older mice (6 and 12 month old) without causing disc cell death or marked loss of matrix proteoglycan. Hence, autophagy is not a vital for disc development and maturation but may serve as an important mechanism to maintain healthy aging of intervertebral disc.

Progression of adjacent-level degeneration and disease 7 years after lumbar total disc replacement, a post hoc analysis of 7-year data from a prospective clinical trial

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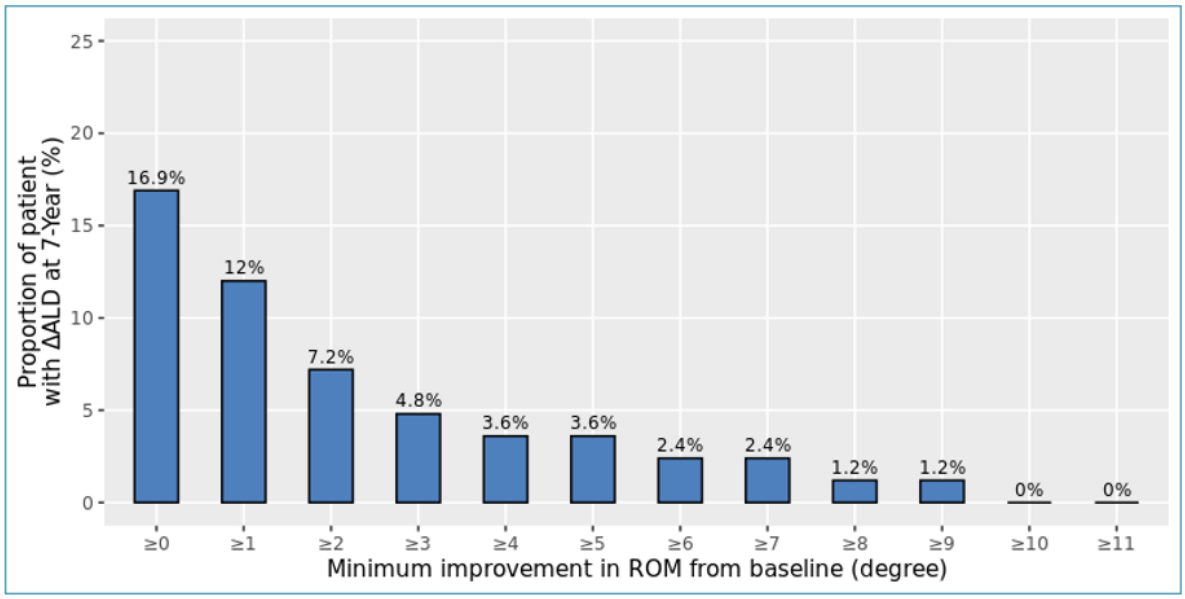
Objectives: To understand the progression of radiographic adjacent-level degeneration (ALDeg) seven years after lumbar TDR and the relationship of these changes with ROM and symptomatic adjacent-level disease (ALDis) using the seven-year follow-up data from the prospective, multicenter activL FDA IDE randomized controlled trial.

Methods: Patients with single-level, symptomatic lumbar disc degeneration who were unresponsive to ≥6 months of nonoperative care, received activL or ProDisc-L, and had radiographs available were analyzed for the incidence for ALDeg, incidence of ALDis, and progression of ALDeg (ΔALDeg). ALDeg presence was determined using a modified, 4-point, Kellgren-Lawrence scale. ALDis was defined as the need for reoperation at the segment adjacent to the index segment. The possible relationship between ROM and ΔALDeg was also investigated.

Results: At baseline, 16% of patients had ALDeg. By seven-year follow-up, this increased to 33%, with 80% showing no ΔALDeg. More patients experienced severe ALDeg by seven-year follow-up. Severity of ΔALDeg by seven years was mostly mild (76%) or moderate (21%); 3.4% of ΔALDeg was severe. Incidence of ALDis was identified in 4 patients through seven-year follow-up. Three patients received fusion at an adjacent level and one patient underwent fusion at the index and adjacent levels to treat stenosis at both levels along with symptomatic disc degeneration at the adjacent level. Improvement in ROM ranged from 0° at baseline to 16.4° at seven-year follow-up. For each minimal degree in ROM gained at the TDR level, there was a consistent decrease in the percent of patients with ΔALDeg. In patients having any improvement in ROM at the TDR level, 16.9% had ΔALDeg, whereas in patients with a ≥10° change or more in ROM (ie, ≥11°, ≥12°, etc.), 0% of patients had ΔALDeg (Figure).

Conclusions: Results of this post hoc analysis of seven-year data from the activL trial confirm that the rates of ALDeg, ALDeg progression, and clinical ALDis after TDR are relatively low over the long-term. Improvement in ROM may be associated with reduced ΔALDeg.

Figure: Relationship between ΔALDeg with TDR and improvement in ROM at TDR level at seven-year follow-up



Abbreviations: ΔALDeg = change in radiographic adjacent-level degeneration; ROM = range of motion; TDR = total disc replacement.

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

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Introduction

Early mobilization after surgery reduces complications and is associated with improved survival, decreased length of hospitalization, and improved psychological well-being [1]. However, current methods for evaluating the mobility and outcomes of spine surgery patients are limited and rely on patient-reported outcome measures (PROMs) that are subjective and may be influenced by psychiatric comorbidities and chronic pain.

There are numerous commercially available wearable activity monitors, including the Apple Watch, that allow for real-time tracking of objective that may allow patients and surgeons to better monitor post-operative mobility and outcomes.

Objectives:

(1) To determine feasibility of wearing the Apple Watch before/after spine surgery to assist with surgical recovery; (2) To determine whether objective patient metrics correlate with PROMs before/after spine surgery; (3) To evaluate whether spine surgery improves objective activity measures tracked by the Apple Watch; and (4) To investigate whether patients are more satisfied with their care and have a better understanding of their post-operative recovery by using the Apple Watch.

Methods

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

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

Our study is approved by the Stanford IRB and actively enrolling as of Sep 1, 2020. Further details are available at <spinetrak.stanford.edu> and <clinicaltrials.gov/ct2/show/NCT04379921>. Target enrollment is 100 intervention and 100 control patients, which is powered at alpha 0.05 and power 80% to detect a 15% difference in ODI.

Results

To date, we have enrolled 101 patients (n=50 intervention; n=51 control) in SpineTrak. On average, intervention participants have worn their Apple Watch 91.5% of the days since enrollment and for 14.2 hours (+/- 4.5) per day.

At their 6 week post-operative visit, 71% of patients in the intervention group responded that they were very satisfied with the use of the Apple Watch in their spine care and that seeing their Apple Watch activity tracking data at their post-operative visit was extremely helpful. 83% of their neurosurgeons strongly agreed that the Apple Watch summary helped them understand how their patient was doing post-operatively.

Discussion

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

SpineTrak: Quality of Life Surveys	Before Surgery	After Surgery: ~6 weeks	After Surgery: ~3 months	After Surgery: ~6 months	After Surgery: ~1 year
SF-36					
Physical Function	50	45 (↓)	60 (↑)	70 (↑)	
Role Limitations, Physical Health	0	0 (↔)	25 (↑)	75 (↑)	
Role Limitations, Emotional Problems	100	0 (↓)	100 (↑)	100 (↔)	
Energy/Fatigue	20	70 (↑)	35 (↓)	60 (↑)	
Emotional Well-being	68	88 (↑)	92 (↑)	92 (↔)	
Social Functioning	25	25 (↔)	50 (↑)	100 (↑)	
Pain	23	33 (↑)	45 (↑)	68 (↑)	
General Health	45	70 (↑)	60 (↓)	65 (↑)	
EQ-5D					
Mobility	50	100 (↑)	100 (↔)	100 (↔)	
Self-care	100	100 (↔)	100 (↔)	100 (↔)	
Usual Activities	50	25 (↓)	75 (↑)	75 (↔)	
Pain/Discomfort	25	50 (↑)	50 (↔)	75 (↑)	
Anxiety/Depression	75	100 (↑)	100 (↔)	100 (↔)	
Back or Neck Disability Index					
ODI	58	60 (↑)	66 (↑)	80 (↑)	
PROMIS					
Physical Function	63	56 (↓)	88 (↑)	88 (↔)	
Anxiety	69	100 (↑)	100 (↔)	100 (↔)	
Depression	81	100 (↑)	100 (↔)	100 (↔)	
Fatigue	25	69 (↑)	56 (↓)	75 (↑)	
Sleep Disturbance	69	56 (↓)	69 (↑)	88 (↑)	
Ability to Participate in Social Roles & Activities	25	13 (↓)	38 (↑)	75 (↑)	
Pain Interference	25	31 (↑)	56 (↑)	75 (↑)	

• All scores are converted to scale 0 (worst imaginable health) to 100 (best imaginable health)
• Colors: red (maximum disability), light red (severe disability), yellow (moderate disability), light green (some disability), dark green (minimal disability)

Figure 1: Progress report demonstrating survey results for a SpineTrak study patient before and after L4-5, L5-S1 anterior lumbar interbody fusion and L4-S1 posterior instrumentation and fusion.

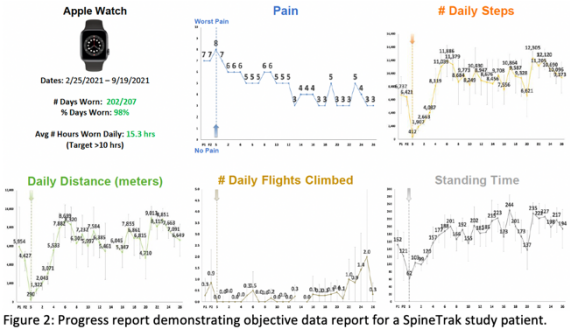

Figure 2: Progress report demonstrating objective data report for a SpineTrak study patient.

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Machine-learning based model predicts significantly inferior postoperative outcome in patients who drop out at follow-up

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INTRODUCTION

Lack of compliance with follow-up can threaten the validity of outcomes reported in clinical studies. The baseline characteristics of "drop-outs" differ from those of responders (1) and these same characteristics are often also predictors of outcome. We evaluated the impact of attrition by comparing the predicted outcomes of patients failing to return a questionnaire 12 months after surgery (non-responders) with the outcomes of those that did return one (responders).

METHODS

The data of all patients with degenerative spinal disorders of the thoracic or lumbar spine included in our in-house spine outcomes registry from 1.1.2006 to 31.12.2017 were analysed. Using the data of responders (8374/9189 (91%) cases), a model was developed to predict the multidimensional outcome of surgery (COMI, and its domain scores) at 12 months' post-surgery based on 20 key baseline variables (Müller et al 2021). This was used to predict the outcome of both responders and non-responders. The groups were compared using paired t-tests (for the predicted vs actual scores in those that responded, to check the fidelity of the model) and unpaired t-tests (for the predicted scores of responders and non-responders).

RESULTS

The predicted outcome scores of the responders did not differ significantly ($p>0.05$) from their actual outcome scores, suggesting the model was sufficiently accurate. The mean baseline scores of non-responders were significantly ($p < 0.05$) worse than those of respondents for most domains. The predicted outcome of non-responders at 12mo FU was significantly ($p< 0.001$) worse than that of the responders, for all domains.

DISCUSSION

Non-response at follow-up introduced significant and consistent bias in reported outcomes. Although the size of the effect was small in this particularly compliant cohort (with 91% follow-up at 12mo), when evaluating healthcare providers with less good follow-up rates the bias may be sufficiently large to threaten the validity of comparisons. The bias would overestimate the performance of hospitals with lower follow-up rates (perhaps also failing to detect poorly performing hospitals) and underestimate that of hospitals with high follow-up rates. If using spine surgery registries to perform benchmarking activities, the difference in follow-up rates between hospitals must be considered and adjusted for.

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Comparison of Free-hand and O-arm Navigation Guided Pedicle Screw Placement in the Lumbar Spine: A Prospective, Randomized Controlled Trial

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Introduction:

The use of image-guided navigation for pedicle screw placement has been on the rise in the past decade – with its proponents citing an increased accuracy of screw placement leading to a lower risk of clinical complications. The high upfront cost of image-guided navigation systems deter its widespread use in developing countries, particularly due to the absence of Level-1 studies demonstrating definite superiority of navigation-guided pedicle screw placement over free-hand pedicle screw placement. The objective of this prospective, randomized controlled study was to compare free-hand (FH) and O-arm navigation guided (ON) pedicle screw placement in the lumbar spine.

Methods:

Adult patients undergoing single-level lumbar interbody fusion by an open, posterior approach were prospectively recruited – patients with lumbar scoliosis, pedicle dysmorphia or high-grade spondylolisthesis were excluded. All patients were operated upon by a single chief surgeon with more than 5 years of experience in spine surgery. Patients were randomly assigned to either free-hand (FH) pedicle screw placement or O-arm navigation guided (ON) pedicle screw placement. The outcome measures compared between the two groups were: i) accuracy of pedicle screw placement – assessed using Gertzbein-Robbins classification of pedicle screw position and deviation from the 'ideal' coaxial intrapedicular trajectory (in degrees), ii) surgical time taken by the surgeon exclusively for pedicle screw placement (minutes), iii) radiation exposure (seconds fluoroscopy), iv) incidence of cranial facet violation (%) and, v) clinical complications attributable to malpositioned pedicle screws.

Results:

A total of 80 patients (45 males, 35 females) comprised the study population – 40 patients were randomly allocated to each group (FH and ON); a total of 160 pedicle screws (4 per patient for single-level lumbar fusion) were inserted by each of the two techniques. The two groups were comparable with regards to baseline demographic and clinical variables as well as the indications for surgery. Although the accuracy of screw placement (ON: 97% v/s FH: 93%) and incidence of cranial facet violation (ON: 12% v/s FH: 22%) was better in the ON group, this difference was not statistically significant. However, placement of screws in the FH group deviated significantly more (FH: 11.8° v/s ON: 3.6°) from the ideal coaxial intrapedicular trajectory. Both the surgical time for screw placement (ON: 28 ± 14.4 minutes v/s FH: 15.6 ± 7.5 minutes) and radiation exposure (ON: 54.2 seconds v/s FH: 32.2 seconds) were significantly more in the ON group. Two patients in the FH group and one patient in the ON group had radicular pain in the postoperative period due to screw malpositioning and underwent revision surgery for the same.

Discussion:

In the hands of an experienced surgeon, O-arm navigation guided pedicle screw placement in the lumbar spine provides no added advantage over free-hand pedicle screw placement, despite increasing the surgical time for screw placement and the radiation exposure to the patient.

Development of a Hierarchical Approach to SRS-Schwab Modifier Realignment in ASD Surgery

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Table 1. Baseline Demographics, Surgery Details, and Radiographic Parameters

Baseline Characteristic	Mean Value±SD
Age	59.3±15 years
Body Mass Index (BMI)	26.9±5.5 kg/m2
Charlson Comorbidity Index (CCI)	1.52±1.6
ASD Frailty Index (FI)	3.09±1.6
Surgical/Admission Characteristic	**Mean Value±SD**
Length of Stay (LOS)	7.3±3.9 days
Number of Levels Fused	11.1±4.6 levels
Estimated Blood Loss (EBL)	1522±1275 mL
Operative Time	337±124 min
Baseline Radiographic Modifier	**Mean Value±SD**
Pelvic Tilt	23.82±10.9
PI-LL	15.5±21.6
SVA	64.2±72.3 mm
T4-T12	-34.2±20.3

Table 3. Low Deformity at 1 years versus HRQL

	SVA	PT	PI-LL
ODI	<0.001	0.820	0.013
PCS	<0.001	0.282	<0.001
SRS-Activity	<0.001	0.630	0.002
SRS-Pain	<0.001	0.603	0.591
SRS- Appearance	<0.001	0.014	0.129
SRS-Mental	<0.001	0.653	0.764
SRS-Satisfaction	0.001	0.668	0.433
SRS-Total	<0.001	0.268	0.162
EQ5D Total	0.007	0.754	0.680
EQ5D VAS	0.075	0.106	0.611
SF-36 Physical	<0.001	0.058	<0.001
SF-36 RL Physical	<0.001	0.811	0.002
SF-36 Body Pain	0.004	0.883	0.866
SF-36 General Health	<0.001	0.052	0.006
SF-36 Vitality	<0.001	0.249	0.048
SF-36 Social	<0.001	0.135	0.039
SF-36 RL Emotional	<0.001	0.911	0.610
SF-36 Mental Health	0.001	0.250	0.773

Table 5. Complication Rates by Age-Adjusted Alignment at 1 Year

	Age-Aligned Modifier at 1Y	Any Comp	Major Comp	Minor Comp	PJK	PJF	Reoperation
PI-LL	Matched (51)	49%	20%	16%	24%	2%	20%
	Overcorrected (76)	68%	30%	38%	37%	8%	26%
	Undercorrected (46)	63%	24%	35%	15%	0%	4%
		Any Comp	**Major Comp**	**Minor Comp**	**PJK**	**PJF**	**Reoperation**
PT	Matched (59)	61%	25%	31%	31%	4%	18%
	Overcorrected (65)	57%	22%	34%	26%	6%	13%
	Undercorrected (54)	67%	28%	28%	24%	6%	24%

Table 4. Meeting MCID based on Age-Adjusted Alignment at 1 Year

	Age-Aligned Modifier at 1Y	ODI	p-value	SRS-Total	p-value
PI-LL	Matched (51)	67%	.406	68%	.433
	Overcorrected (76)	59%		59%	
	Undercorrected (46)	53%		55%	
PT	Matched (59)	65%	.552	70%	.197
	Overcorrected (65)	56%		58%	
	Undercorrected (54)	56%		53%	

Introduction: Patient-reported outcome measures have become ubiquitous for assessing improvement after corrective spine surgery. There remains a paucity of literature regarding the order of addressing SRS-Schwab modifiers during corrective surgery for ASD.

Objective: To investigate which SRS-Schwab modifier-combinations, if any, produce better 1-year HRQL metrics and decrease the risk of junctional failure when realigned. Secondly, to determine a hierarchical approach to modifier realignment during ASD surgery.

Study Design/Setting: Retrospective cohort study of a prospective adult spinal deformity (ASD) database.

Methods: Descriptive analysis identified cohort demographics, radiographic parameters, and surgical details. Significant differences in outcomes between patients who achieved age-aligned match in SRS-Schwab criteria and those with deformities at 1 years (1Y) were isolated. Multivariate analysis controlling for baseline disability assessed which SRS-Schwab criteria had the greatest impact on outcomes and the patients matching in that parameter were isolated. The following parameters were assessed for differences in complication rates and meeting MCID in either ODI or SRS-Total at one year via multivariate analysis.

Results: 445 ASD patients who underwent surgery were included. Patients had the following mean BL Schwab modifier measurements: SVA 64.2±72.3 cm, PI-LL 15.5±21.6 cm, PT 23.82±10.9 cm, and T4-T12 -34.2±20.3 cm. Age-aligned match SVA at one year was most significantly correlated with lower complication rates and improved outcomes when compared to being overcorrected or undercorrected. After isolating patients matching in 1Y SVA, there were no significant differences based on realignments in PT at one year in either complication rates or clinical outcomes. Similar rates of meeting MCID in either ODI or SRS-Total were seen when comparing PI-LL realignments. However, SVA-matched patients developed more PJK/PJF, minor complications, and a higher rate of reoperation when overcorrected in PI-LL (all p<.05).

Conclusion: Correction of SVA to ideal age-adjusted values should be prioritized during ASD surgery. The analysis of correction in PI-LL or PT following realignment in SVA improves our understanding of the interplay of various radiographic parameters and enables spine surgeons to provide more tailored corrections based on the presentation of ASD patients.

Cumulative burden of underweight (BMI < 18.5) on the risk of vertebral fracture

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Introduction: Underweight is associated with the development of vertebral fractures. However, the impact of time-burden of underweight on the risk of vertebral fractures is unknown. We investigated the effect of the cumulative longitudinal burden of underweight on the development of vertebral fracture.

Methods: We included 561,779 individuals without vertebral fracture who underwent four annual health examinations during 2009–2012 from the database of the Korean national health insurance service. Underweight burdens were evaluated in the following way: cumulative number of underweight (body mass index < 18.5) diagnosed at each health examination (0–3 times). Baseline (index date) demographic data including age, sex, smoking, drinking, regular exercise, low income, height, weight, BMI, waist circumference, and comorbidities (diabetes, hypertension, dyslipidemia, and chronic renal failure) was also evaluated. The risk of vertebral fractures according to the underweight and underweight burden was estimated using Cox proportional-hazards models.

Results: During a mean follow-up of 8.3 years, 7049 new vertebral fracture was occurred. The incidence rate per 1000 person years was 1.5. The proportions of the underweight, normal, overweight, stage 1 obesity, and stage 2 or 3 obesity populations at the index date were 1.8% (n=10,121), 35.8 % (n=201,152), 28.3 % (n=159,052), 31.5 % (n=177,198), and 2.5% (n=14,256), respectively. In the Cox proportional hazards model, the risk of vertebral fractures in the underweight population increased approximately 1.2 fold compared to normal body weight population (p = 0.02). Of all individuals, 97.2%, 1.2%, 0.7%, and 0.9% met the underweight diagnostic criteria 0, 1, 2, and 3 times, respectively. The incidence of vertebral fractures decreased when underweight occurred once compared to reference (no underweight), but the incidence of vertebral fracture increased when underweight was accumulated twice (1.4 times) or three times (1.2 times).

Discussion: Given the positive correlations between the cumulative underweight burdens and the risk of vertebral fracture, maximal effort to detect and correct underweight might be important to prevent vertebral fracture.

Fracture level is a risk factor for implant failure in thoracolumbar and lumbar fractures treated with posterior long segment instrumentation

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Introduction: Posterior long segment instrumentation (PLSI, instrumentation above and below 2 levels of fractured vertebrae) for acute unstable thoracolumbar fractures (TLFx) is known as a stable method and is widely used. In severe fractures, implant failure and related complications such as pain and kyphosis sometimes occur even in PLSI. There are very few studies on implant failure rates and related risk factors in PLSI. The aims of this study was to identify the incidence and risk factors for implant failure in TLFx treated with PLSI

Methods: This study reviewed 130 consecutive patients with TLFx treated with PLSI and followed up more than one year (All patients had 6 or more load sharing classification score). Implant failure rate, type, time of onset, presence of acute pain or progressive kyphosis, and subsequent revision surgery were analyzed. We evaluated the risk factor using multivariate regression analysis including age, gender, neurologic deficit, fracture level (thoracolumbar [T11-L2] vs. mid to low lumbar [L3-5]), AO fracture type, thoracolumbar injury classification and severity score, load sharing score, bi-segmental Cobb angle (CA), anterior compression ratio (ACR), and time to surgery.

Results: Even after PLSI for thoracolubmar and lumbar factures, there were 15 cases (11.5%) of implant failure. There were 5 rod fractures, 4 rod displacement, and 6 screw breakage. The mean time of onset was 21.7 ± 11.5 months after the operation. Among 15 cases, two patients had progressive kyphosis. One patient had temporary mild pain and there was no progression of kyphosis. The other underwent revisional surgery due to progressive kyphosis combind with severe pain. Multivariate logistic regression identified mid to low lumbar level facture (adjusted odds ratio=11.5, 95% confidence interval = 1.0-128.0) as independent predictors of a implant failure.

Discussion: In TLFx treated with PLSI, the implant failure rate was not lower than expected, but the incidence of acute pain or reoperation rate were very low. Mid to low lumbar fracture was the only risk factor for the implant failure in PLSI for thoracolumbar and lumbar fractures. In mid-to-lumbar fracuture, more attention should be paid to fusion during PLSI, or additional anterior fusion should be considered at an early stage.

Lower Hounsfield Units and Severe Multifidus Sarcopenia are Independent Predictors of Increased Risk for Proximal Junctional Kyphosis and Failure following Thoracolumbar Fusion

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Introduction

Several studies have identified potential risk factors for proximal junctional kyphosis (PJK) and proximal junctional failure (PJF) following thoracolumbar posterior instrumented fusion including low bone mineral density (BMD), persistent sagittal plane deformity, and severe frailty. However, no study has investigated the interplay between these variables or the impact of paraspinal sarcopenia on the development of PJK and PJF. The purpose of the present study was to determine demographic and radiographic variables that predict an increased risk of PJK or PJF.

Methods

We retrospectively reviewed a cohort of patients greater than 50 years of age who underwent posterior instrumented fusion with pelvic fixation and a construct that terminated proximally between T10 to L2 between the years 2013-2020. Patient demographic information was collected and the Modified Frailty Index (mFI) and Charlson Comorbidity Index (CCI) scores were calculated for each patient. Patients were subdivided into three groups: (1) no PJK or PJF, (2) PJK without PJF, and (3) PJF. Preoperative and 1-year postoperative sagittal alignment parameters were compared between subgroups. Bone mineral density (BMD), based upon both DEXA scan measurements and Hounsfield Units (HU) at the upper instrumented vertebra (UIV) and UIV+1, was compared between subgroups. Paraspinal sarcopenia was assessed using both qualitative (cross-sectional area) and quantitative (Goutalier grade) methodologies and compared between subgroups. We utilized student's T-test and ANOVA to compare means within and between groups, respectively. Multivariable analyses were performed to determine risk factors for PJK and PJF. P values <0.05 were considered significant.

Results

We identified 150 patients for inclusion in this study with a mean age of 67.0 years and an average follow-up of 32 months. There was no difference in baseline demographic variables or radiographic variables between subgroups, except that patients with PJF had a higher preoperative and postoperative pelvic tilt. The subgroup of patients with no PJK/PJF demonstrated a significantly higher HU at the UIV (148.3±34.5) than patients who developed PJK (117.8 ±41.9) or PJF (118.8 ±41.8; P<0.001). There was a much higher rate of severe multifidus fatty infiltration observed in patients who developed PJF (78.9%) or PJK (76.0%) than in patients who did not develop PJK/PJF (34.0%; P<0.001). Furthermore, no patient that developed PJK or PJF had normal multifidus quality. Multivariate analysis comparing patients without PJK/PJF to those who developed PJK demonstrated that both mean UIV HU (0.80, 95% CI 0.69-0.93; P<0.001) and moderate-severe multifidus sarcopenia (5.40, 95% CI 1.8-16.1; P<0.001) were independent predictors of increased risk of PJK. Similarly, mean UIV HU (0.79, 95% CI 0.66-0.94; P=0.01) and moderate-severe multifidus sarcopenia (7.69, 95% CI 1.96-30.18; P<0.001) were identified as independent risk factors predicting an increased risk of developing PJF.

Discussion

Patients with lower mean HU at the UIV and a higher degree of paraspinal multifidus fatty infiltration are at increased risk of PJK and PJF following thoracolumbar fusions that terminate proximally between T10 and L2.

TABLE 1: Comparison of Demographics between Patients with and Without PJK*

	No PJK/PJF (n=103)	PJK (n=28)	PJF (n=19)	All Patients (n=150)	P value
Demographics					
Age	66.5	68.8	66.8	67.0 (7.4)	0.35
Sex (Female)	50 (48.5%)	15 (53.6%)	15 (78.9%)	80 (53.3%)	0.051
BMI* (m/kg^2)	29.9 (5.2)	30.7 (5.3)	30.9 (5.1)	30.2 (5.2)	0.67
Smoking	5 (4.9%)	1 (3.6%)	1 (5.3%)	7 (4.7%)	0.95
Diabetes	18 (17.5%)	4 (14.3%)	4 (21.1%)	26 (17.3%)	0.83
Chronic steroid use	4 (3.9%)	2 (7.1%)	2 (10.5%)	8 (5.4%)	0.06
Inflammatory arthritis	8 (7.8%)	3 (10.7%)	5 (26.3%)	16 (10.7%)	0.06
Modified Frailty Index (%)	13.2 (13.2)	12.9 (9.4)	13.1 (11.5)	13.1 (12.3)	0.99
Charlson Comorbidity Index	3.3 (1.7)	3.4 (1.8)	3.2 (1.4)	3.3 (1.7)	0.97
UIV*					0.11
T10	22 (21.4%)	5 (17.9%)	6 (31.6%)	33 (22.0%)	
T11	22 (21.4%)	4 (14.3%)	4 (21.1%)	30 (20.0%)	
T12	2 (1.9%)	0 (0.0%)	2 (10.5%)	4 (2.7%)	
L1	11 (10.7%)	6 (21.4%)	4 (21.1%)	21 (14.0%)	
L2	46 (44.7%)	13 (46.4%)	3 (15.8%)	62 (41.3%)	

*PJK: Proximal Junctional Kyphosis; BMI: Body Mass Index; UIV: Upper Instrumented Vertebra; HU: Hounsfield Unit; VB: Vertebral body

TABLE 2: Comparison of Sagittal Alignment between Patients with and without PJK* N=150

	No PJK/PJF (n=103)	PJK (n=28)	PJF (n=19)	P Value
C2 Sagittal Vertical Axis (cm)				
Preop	7.0 (5.1)	5.5 (4.5)	7.4 (6.1)	0.51
Postop	5.2 (3.9)	1.9 (2.6)	4.4 (4.7)	**0.02**
Δ	-1.8 (5.6)	-3.6 (6.7)	-3.0 (4.0)	0.51
Pelvic Incidence (degrees)				
Preop	55.5 (14.2)	59.1 (10.7)	57.1 (15.4)	0.60
Postop	54.8 (11.5)	57.8 (13.2)	53.2 (14.6)	0.23
Δ	-0.7 (7.5)	-1.3 (8.0)	-3.9 (8.9)	0.29
Pelvic Tilt (degrees)				
Preop	24.7 (9.8)	26.5 (9.0)	31.3 (10.1)	**0.04**
Postop	18.3 (9.1)	20.0 (8.6)	27.4 (11.2)	**0.02**
Δ	-6.4 (8.9)	-6.5 (5.4)	-3.9 (5.5)	0.90
Sacral Slope (degrees)				
Preop	32.4 (10.6)	30.8 (10.9)	28.3 (9.0)	0.33
Postop	35.4 (10.9)	33.7 (9.1)	33.9 (10.6)	0.76
Δ	3.0 (10.2)	2.9 (10.5)	5.6 (14.4)	0.723
Lumbar Lordosis (degrees)				
Preop	35.9 (15.7)	32.1 (15.6)	34.5 (13.8)	0.52
Postop	46.4 (13.5)	40.7 (11.9)	50.4 (14.3)	0.051
Δ	10.5 (14.6)	8.6 (17.4)	15.9 (14.7)	0.31
L2-T10 Lordosis (degrees)				
Preop	0.3 (12.0)	-0.8 (11.2)	0.1 (10.0)	0.92
Postop	-2.9 (10.2)	-7.8 (10.9)	-4.3 (6.8)	0.40
Δ	-3.4 (14.3)	-7.0 (12.7)	-4.4 (11.5)	0.70
PI-LL Mismatch Lordosis (degrees)				
Preop	19.9 (16.6)	25.7 (16.0)	24.2 (14.0)	0.23
Postop	6.6 (12.0)	11.1 (10.2)	12.2 (14.8)	0.16
Δ	-13.3 (14.4)	-14.6 (17.2)	-12.0 (13.9)	0.80
Proximal Junctional Angle^ (degrees)				
Index Postop	4.8 (6.8)	4.6 (7.2)	8.9 (6.9)	0.06
12 Months Postop	5.9 (8.7)	19.6 (8.3)	24.2 (12.8)	**<0.001**
Mean Time to PJF (months)			18.8 (18.0)	

*Abbreviations: Proximal Junctional Kyphosis (PJK); Proximal Junctional Failure (PJF); Pelvic Incidence Lumbar Lordosis (PI-LL)

^Proximal Junctional Angle was measured on postoperative films obtained (1) during the index hospitalization and (2) at 12 months postoperatively

TABLE 3: Comparison of BMD* between Patients with and Without PJK/PJF* N=150

	No PJK/PJF (n=109)	PJK (n=28)	PJF (n=19)	P Value
Hounsfield Units				
UIV*	148.3 (34.5)	117.8 (41.9)	118.8 (41.8)	**< 0.001**
UIV + 1	150.6 (44.8)	115.2 (34.6)	118.7 (38.7)	**< 0.001**
L3	141.2 (37.7)	120.0 (42.9)	105.7 (44.2)	**0.01**
L4	147.2 (41.3)	114.1 (42.8)	116.3 (66.9)	**0.02**
DEXA				
Lumbar BMD	1.23 (0.21)	1.06 (0.21)	1.06 (0.18)	0.13
Lumbar T-score	0.6 (1.6)	-1.0 (1.5)	-0.6 (0.6)	0.07
Total Hip BMD	0.89 (0.13)	0.85 (0.17)	0.79 (0.09)	0.13
Total Hip T-score	-1.0 (0.9)	-1.3 (1.2)	-1.7 (0.6)	0.19
Femoral Neck BMD	0.97 (0.14)	0.92 (0.17)	0.86 (0.10)	0.13
Femoral Neck T-score	-0.6 (0.9)	-0.8 (1.3)	-1.2 (0.8)	0.27
Preoperative Osteoporosis Treatment				
No	48 (46.6%)	13 (46.4%)	67 (44.7%)	0.47
Yes	51 (49.5%)	13 (46.4%)	77 (51.3%)	
Uncertain	4 (3.9%)	2 (7.1%)	6 (4.0%)	

*Abbreviations: Proximal Junctional Kyphosis (PJK); Proximal Junctional Failure (PJF); Bone Mineral Density (BMD); Upper Instrumented Vertebra (UIV)

TABLE 4: Comparison of Paraspinal Sarcopenia between Patients with and Without PJK* N=150

	No PJK (n=103)	PJK (n=28)	PJF (n=19)	P value
Hounsfield Units				
Preoperative				
Psoas at L3	45.042 (13.886)	42.389 (20.584)	47.408 (13.066)	0.535
Multifidus at L3	29.694 (24.809)	34.028 (24.976)	22.529 (25.309)	0.316
Multifidus at UIV+2	30.788 (20.039)	32.425 (21.505)	28.154 (22.477)	0.827
Erector Spinae at L3	30.008 (23.394)	32.200 (23.188)	28.368 (19.872)	0.853
Erector Spinae at UIV+2	38.552 (22.218)	42.050 (15.307)	38.064 (21.019)	0.753
Postoperative				
Psoas at L3	57.884 (34.860)	56.438 (21.009)	53.928 (10.607)	0.875
Multifidus at L3	33.642 (43.410)	57.558 (37.584)	28.287 (19.405)	0.055
Multifidus at UIV+2	34.723 (34.794)	31.568 (16.175)	34.957 (30.926)	0.903
Erector Spinae at L3	13.279 (32.861)	15.812 (34.516)	10.162 (26.213)	0.873
Erector Spinae at UIV+2	31.171 (21.494)	34.474 (12.741)	35.730 (12.015)	0.579
Cross Sectional Area				
Preoperative				
Psoas at L3	887.859 (353.510)	895.567 (368.852)	774.132 (337.505)	0.416
Multifidus at L3	359.714 (174.155)	408.880 (219.947)	346.826 (132.615)	0.411
Multifidus at UIV+2	251.713 (94.615)	271.171 (100.651)	261.064 (108.375)	0.671
Erector Spinae at L3	1476.583 (519.613)	1509.696 (470.672)	1469.647 (524.458)	0.954
Erector Spinae at UIV+2	954.065 (407.536)	1058.892 (472.218)	837.521 (525.149)	0.307
Postoperative				
Psoas at L3	987.497 (428.940)	955.920 (341.554)	907.117 (307.242)	0.724
Multifidus at L3	312.462 (161.031)	354.694 (183.628)	276.267 (167.476)	0.395
Multifidus at UIV+2	239.291 (87.479)	269.992 (77.293)	276.947 (99.600)	0.137
Erector Spinae at L3	1105.835 (419.594)	968.195 (279.335)	958.481 (521.197)	0.235
Erector Spinae at UIV+2	926.513 (434.914)	964.200 (332.396)	751.720 (336.843)	0.244
*Fatty Infiltration of the Multifidus^*				
Preoperative				
Normal	7 (7.2%)	0 (0.0%)	0 (0.0%)	**< 0.001**
Moderate	57 (58.8%)	6 (24.0%)	4 (21.1%)	
Severe	33 (34.0%)	19 (76.0%)	15 (78.9%)	

*Abbreviations: Proximal Junctional Kyphosis (PJK)

^Fatty infiltration of the Multifidus was determined at L3 using the Fuchs Modification of the Goutalier Grading system

TABLE 5. Odds Ratios for Development of Proximal Junctional Kyphosis

Variable	Odds Ratio	95% Confidence Interval	P value
Age	1.05	0.96 - 1.15	0.28
Gender (Female)	0.97	0.3 - 2.9	0.95
BMI	1.10	0.97 - 1.22	0.14
Smoking	0.80	0.05 - 12.8	0.88
Modified Frailty Index Percentage	1.00	0.96 - 1.07	0.64
Charlson Comorbidity Index Points	0.86	0.6 - 1.3	0.50
Mean UIV HU	0.80	0.69 - 0.93	**<0.001**
Moderate-Severe Multifidus Sarcopenia	5.40	1.8 - 16.1	**<0.001**

*Abbreviations: BMI (Body Mass Index), UIV (upper instrumented vertebra), HU (Hounsfield Units)

TABLE 6. Odds Ratios for Development of Proximal Junctional Failure

Variable	Odds Ratio	95% Confidence Interval	P value
Age	1.01	0.92 - 1.1	0.87
Gender (Female)	3.4	0.86 - 13.36	0.08
BMI	1.11	0.98 - 1.25	0.10
Smoking	4.7	0.39 - 57.49	0.23
Modified Frailty Index Percentage	1.01	0.95 - 1.08	0.72
Charlson Comorbidity Index Points	0.87	0.48 - 1.58	0.65
Mean UIV HU	0.79	0.66 - 0.94	**0.01**
Moderate-Severe Multifidus Sarcopenia	7.69	1.96 - 30.18	**<0.001**

*Abbreviations: BMI (Body Mass Index), UIV (upper instrumented vertebra), HU (Hounsfield Units)

The trend of prophylactic perioperative antibiotic usage in instrumented lumbar surgeries: A narrative review of nationwide population-based cohort of 9 years.

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INTRODUCTION

Perioperative prophylactic antibiotic (PPA) use in spine surgery is known to reduce the rate of surgical site infections (SSI) and it has been routine perioperative management. The rate of SSIs ranges from 0.7% to 10% and they are directly linked to post-operative health-related quality of life (HRQOL) and economic burden to patients. It is also one of the common cause of readmission within thirty-days and the hospitalization cost was nearly 2 to 3 times greater than that of patients without complications. Therefore PPA usage has always been of great interest to spine surgeons.

METHODS

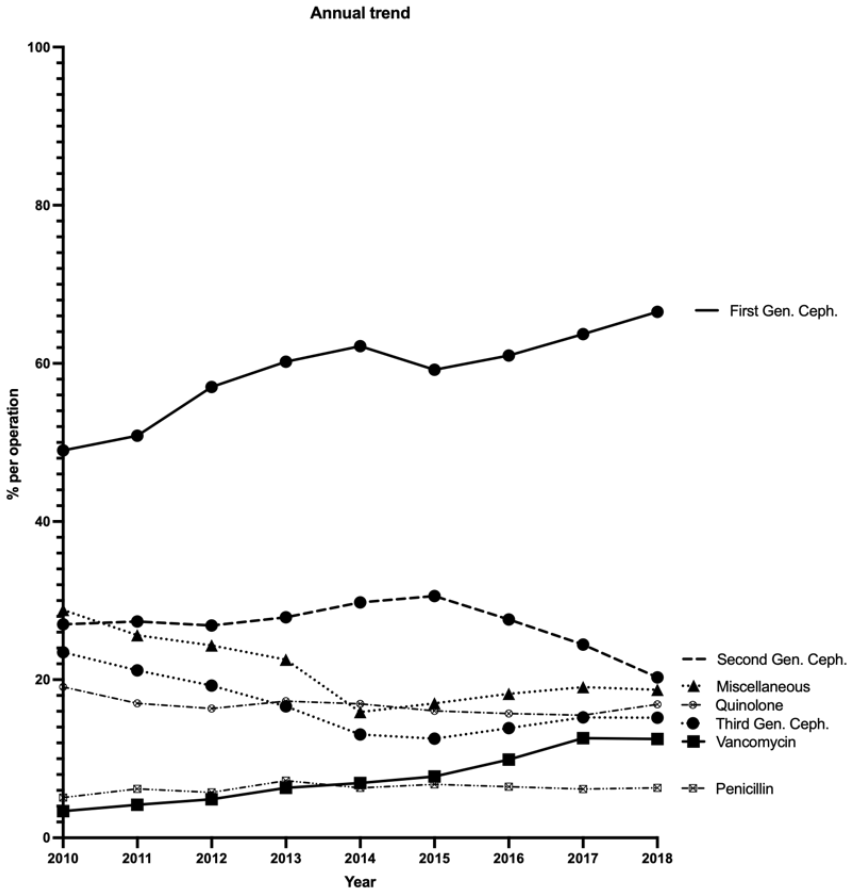
This is a narrative review of PPA usage during instrumented lumbar spinal surgeries in adult patients (age 19 or more) from year 2010 to 2018, using South Korean population-based cohort data from Korean Nation Health Insurance (KNHI) and Korean Health Insurance Review and Assessment Service (HIRA). All patients assigned with the code for instrumented lumbar surgery were included. Patients with two or more instrumented lumbar surgeries assigned on a single day were counted as one. All codes for intravenous antibiotics that were prescribed on the day of operation were counted as one. Each prescriptions were reviewed for underlying disease, such as diabetes mellitus and renal disease, which was diagnosed within 1 year prior to the operation.

RESULTS

A total of 294,354 instrumented lumbar surgery were performed in 278,815 patients from 2010 to 2018, out of which 292,598 (99.40%) received PPA. A constant increase in first generation cephalosporin prescriptions was observed from 48.99% in 2010 to 66.52% in 2018. Second most frequent PPA was second generation cephalosporin. From 2010 to 2016, it was prescribed on average of 28.15% of all instrumented lumbar surgeries without major increasing or decreasing trend. However, from the year 2016 the prescribing trend abruptly decreased to 20.30% by 2018. The use of third generation cephalosporin and other miscellaneous antibiotics showed clearly decreasing trend from 2010 to 2014. Vancomycin prescriptions increased by almost 4-folds during the studied period. In renal disease patients, less first generation cephaloporin was prescribed, whereas prescription for third generation increased.

DISCUSSION

Appropriate use of PPA has clearly decreased the incidence of SSI in spine surgeries. In early days, the use of PPA were mostly based on expert's opinion, but series of guidelines have been published with cumulative evidences on PPA use in spine surgeries since the late 90s'. Furthermore, surveillance systems for appropriate use of antibiotics were developed and conducted among medical institutes nationwide. In concordance to guidelines and action plans for surveillance system, PPA regimen is becoming more uniform in South Korea.



Invasive dental procedures as risk factors for postoperative spinal infection and the effect of antibiotic prophylaxis

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INTRODUCTION

Since invasive dental procedure causes temporary bacteremia, antibiotic prophylaxis is recommended in patients with prosthetic cardiac valves who are at high risk of developing endocarditis. However, there are few studies on the risk of postoperative spinal infection following dental procedure and the effectiveness of antibiotic prophylaxis. Some experts recommended avoiding dental procedure until 3 months after spinal surgery, and administering prophylactic antibiotics if necessary. However, these recommendations have not been proven in clinical studies. The purpose of this study is to identify invasive dental procedure as risk factor of postoperative spinal infection and to evaluate the effect of antibiotic prophylaxis.

METHODS

We analyzed 229,235 patients over 50 years of age who underwent spinal fusion or fixation from 2010 to 2017 using the Health Insurance Review and Assessment Service (HIRA) data. The incidence of spinal infection with 2 years after surgery was identified. Invasive dental procedure and antibiotic prophylaxis as risk factors for postoperative spinal infection during this period were also analyzed. Time dependent cox regression analysis was performed to identify risk factors for postoperative spinal infection.

RESULTS

A total of 15,346 patients (6.7%) were diagnosed with postoperative spinal infection. Of the patients who underwent spinal surgery, 70,650 (30.82%) received invasive dental procedure within 2 years, of which 18,267 (25.9%) patients received antibiotic prophylaxis. It was confirmed that the old age, male, and high Charlson Comorbidity Index Score were risk factors for postoperative spinal infection. The risk of postoperative spinal infection is not increased following dental procedure (adjust HR : 0.892, P=0.0006) and is not affected by antibiotic prophylaxis. (adjust HR: 1.037, P=0.5243)

DISCUSSION

Invasive dental procedures in patients who underwent spinal surgery with instrumentation are not risk factors for postoperative infection. It was also confirmed that early dental treatment was not associated with the risk of postoperative infection. In addition, antibiotic prophylaxis following dental procedures was not effective in preventing spinal infection. Therefore, we believe that patients undergoing spinal surgery with instrumentation should not avoid dental treatment after surgery, and prophylactic antibiotics may not be necessary.

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Adjunct Pelvic Fixation in Short-to-Medium Segment Degenerative Fusion Constructs Independently Predicts Readmission and Morbidity

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Introduction: Pelvic fixation (PF) has traditionally been utilized in long-construct deformity surgery to achieve greater control over sagittal and coronal imbalance and construct stability and to improve solid arthrodesis rates[1,2]. As the incidences of both operative degenerative lumbar disease requiring short-to-medium length fusions as well as osteoporosis have increased with an aging patient population, the role of adjunct PF has become increasingly relevant. However, outcomes associated with adjunct PF in the degenerative population has not been studied sufficiently. This is the first large-scale database study to compare 30-day readmission, reoperation, and morbidity following short-to-medium length multilevel lumbar fusion with and without adjunct PF for the treatment of degenerative lumbar disease.

Methods: This is a retrospective database study using the 2005-2018 NSQIP datasets. Adults who underwent multilevel degenerative lumbar fusion were identified using CPT codes 22612, 22630, 22633, and 22558 with ≥1 entry of a corresponding additional level CPT code (22614, 22632, 22634, 22585). Short-to-medium length fusion was specifically isolated by excluding patients with >4 additional level codes. Patients were classified into groups with and without PF using CPT code 22848. Patients were excluded if they underwent single level, traumatic, deformity, non-elective, tumor, or revision surgery; had evidence of prior infection; or underwent additional procedures including osteotomy, arthroplasty, or cervical or thoracic procedures. Univariate and multivariate regression analyses were used to compare readmission, reoperation, morbidity, and specific complications between patients with and without PF, and to control and evaluate for significant predictors and baseline differences between patients.

Results: We identified 38,413 patients (818 with PF). PF independently predicted readmission (p=0.001, OR=1.546) and morbidity (p<0.001, OR=2.740). PF had greater reoperation rates in univariate analysis (p<0.001), but not in multivariate analysis (p=0.119, OR=1.298). Multivariate analyses of readmission, reoperation, and morbidity are provided in Tables 1-3. PF had greater rates of wound complication (p=0.015, OR=1.533), transfusion (p<0.001, OR=3.299), DVT (p=0.002, OR=2.054), and sepsis (p=0.038, OR=1.713). Length of stay was longer in the PF group (8 vs 4 days, p<0.001).

Obesity (OR=1.210), chronic steroids (OR=1.631), and ASA-class ≥3 (OR=1.297) predicted readmission (p<0.001). Obesity (p=0.021, OR=1.164), steroids (p=0.024, OR=1.324), and preoperative transfusion (p=0.037, OR=1.829) predicted reoperation. Male gender (p=0.027, OR=0.861) and inclusion of ALIF within the fusion construct (p<0.001, OR=0.759) were protective against reoperation. African American race (OR=1.212), decreased hematocrit (OR=0.938), and bleeding disorder (OR=1.516) predicted morbidity (p<0.001). Inclusion of ALIF within the fusion construct (p<0.001, OR=0.644) and navigated surgery (p=0.010, OR=0.855) were protective against morbidity.

Conclusion: PF was associated with a 1.5-times increased-odds of readmission and a 2.7-times increased-odds of morbidity, with significantly greater rates of transfusion, DVT, sepsis, and wound-related complications, despite controlling for patient and procedural-related factors. There were no differences in 30-day reoperation. Thus, these findings suggest that PF may achieve greater construct stability in the degenerative spine population, but at a significantly elevated risk of medical and surgical morbidity. The benefits of navigated surgery and anterior column support manifested as protective against poor outcomes. Increased age, ASA-class ≥3, obesity, and other demographic factors and medical comorbidities predicted poorer 30-day outcomes.

Table 1. Univariate and multivariate analysis of predictors of readmission.

	Univariate			Multivariate	
	Readmitted (N = 2,214)	Not readmitted (N = 29,808)	*P*	OR (95% CI)	*P*
Demographics					
Mean age (years; SD)	64 (13)	61 (13)	**<0.001**	1.016 (1.012, 1.021)	**<0.001**
Obese	1,219 (58.8%)	15,887 (53.5%)	**<0.001**	1.210 (1.095, 1.340)	**<0.001**
African American race	215 (10.3%)	2,266 (8.1%)	**<0.001**	1.209 (1.027, 1.423)	**0.022**
Hispanic ethnicity	123 (5.8%)	1,547 (5.5%)	0.596		
Male Gender	993 (44.9%)	13,804 (46.3)	0.183	1.048 (0.946, 1.162)	0.368
Comorbidities					
Smoker	440 (19.9%)	5,889 (19.8%)	0.894	1.157 (1.016, 1.318)	**0.028**
Dyspnea	175 (7.9%)	1,774 (6.0%)	**<0.001**	1.034 (0.862, 1.240)	0.720
Diabetes mellitus	548 (24.8%)	5,337 (17.9%)	**<0.001**	1.125 (1.000, 1.266)	0.050
COPD	148 (6.7%)	1,325 (4.4%)	**<0.001**	1.169 (0.954, 1.433)	0.132
Heart failure	16 (0.7%)	107 (0.4%)	**0.008**	1.337 (0.748, 2.393)	0.327
Hypertension	1,491 (67.5%)	17,248 (57.9%)	**<0.001**	1.015 (0.906, 1.137)	0.799
Disseminated cancer	68 (3.1%)	267 (0.9%)	**<0.001**	2.494 (1.835, 3.390)	**<0.001**
Open wound infection	20 (0.9%)	153 (0.5%)	**0.016**	0.982 (0.583, 1.652)	0.944
Chronic steroid use	179 (8.1%)	1,204 (4.0%)	**<0.001**	1.631 (1.360, 1.956)	**<0.001**
Bleeding disorder	58 (2.6%)	465 (1.6%)	**<0.001**	1.221 (0.904, 1.650)	0.194
Preop transfusion	17 (0.8%)	107 (0.4%)	**0.003**	1.023 (0.580, 1.804)	0.937
ASA-class ≥3	1,429 (64.6%)	14,866 (49.9%)	**<0.001**	1.297 (1.161, 1.449)	**<0.001**
Lab values (mean; SD)					
Creatinine	1.0 (0.5)	0.9 (0.4)	**<0.001**	1.089 (1.003, 1.182)	**0.043**
White cell count	7.7 (2.6)	7.4 (2.5)	**<0.001**	1.035 (1.018, 1.052)	**<0.001**
Hematocrit	39.7 (5.0)	40.8 (4.4)	**<0.001**	0.965 (0.954, 0.976)	**<0.001**
Platelet	245 (74)	246 (69)	0.427		
Procedural factors					
Pelvic fixation	84 (12.4%[1])	592 (2.0%)	**<0.001**	1.546 (1.183, 2.019)	**0.001**
Has ALIF	546 (24.7%)	7,740 (26.0%)	0.176		
Has ALIF (PF only)	12 (14.3%)	115 (19.4%)	0.259		
Has CAS	163 (7.4%)	2,067 (6.9%)	0.445		
Has CAS (PF only)	19 (22.6%)	119 (20.1%)	0.592		
Mean levels fused	2.5 (0.9)	2.4 (0.9)	0.199	0.999 (0.941, 1.061)	0.980
Mean interbody fusions	1.1 (1.2)	1.2 (1.1)	0.449	1.046 (0.985, 1.110)	0.140
Length of stay	5.2 (4.8)	4.3 (4.9)	**<0.001**	1.007 (1.000, 1.014)	0.059

[1]Percent of patients readmitted within pelvic fixation. *Fischer's exact test. Bold values indicate significance (*P*<0.05). ASA, American Society of Anesthesiologists. ALIF, anterior lumbar interbody fusion. CAS, computer assisted surgery. COPD, chronic obstructive pulmonary disease. SD, standard deviation. PF, pelvic fixation.

Table 2. Univariate and multivariate analysis of predictors of reoperation.

	Univariate			Multivariate	
	Reoperation (N = 1,415)	No reoperation (N = 36,998)	*P*	OR (95% CI)	*P*
Demographics					
Mean age (years; SD)	62 (13)	61 (13)	**0.001**	1.000 (0.994, 1.006)	0.988
Obese	823 (58.9%)	19,765 (53.7%)	**<0.001**	1.164 (1.023, 1.326)	**0.021**
African American race	137 (10.4%)	2,946 (8.5%)	**0.016**	1.185 (0.970, 1.447)	0.097
Hispanic ethnicity	87 (6.5%)	1,983 (5.6%)	0.160		
Male Gender	601 (42.5%)	17,171 (46.4%)	**0.004**	0.861 (0.755, 0.983)	**0.027**
Comorbidities					
Smoker	261 (18.4%)	7,234 (19.6%)	0.302	0.888 (0.750, 1.051)	0.168
Dyspnea	122 (8.6%)	2,229 (6.0%)	**<0.001**	1.191 (0.953, 1.489)	0.124
Diabetes mellitus	340 (24.0%)	6,788 (18.3%)	**<0.001**	1.090 (0.937, 1.268)	0.262
COPD	88 (6.2%)	1,619 (4.5%)	**0.002**	1.094 (0.841, 1.423)	0.502
Heart failure	7 (0.5%)	142 (0.4%)	0.510	1.695 (0.670, 4.292)	0.265
Hypertension	880 (62.2%)	21,665 (58.6%)	**0.006**	1.105 (0.959, 1.274)	0.169
Disseminated cancer	24 (1.7%)	380 (1.0%)	**0.015**	2.309 (1.316, 4.065)	**0.004**
Open wound infection	10 (1.3%)	176 (0.5%)	**<0.001**	1.065 (0.573, 1.980)	0.842
Chronic steroid use	91 (6.4%)	1,519 (4.2%)	**<0.001**	1.324 (1.038, 1.690)	**0.024**
Bleeding disorder	41 (2.9%)	578 (1.6%)	**<0.001**	1.495 (1.044, 2.140)	**0.028**
Preop transfusion	18 (1.3%)	129 (0.3%)	**<0.001**	1.829 (1.037, 3.226)	**0.037**
ASA-class ≥3	896 (63.4%)	18,758 (50.8%)	**<0.001**	1.338 (1.162, 1.540)	**<0.001**
Lab values (mean; SD)					
Creatinine	1.0 (0.6)	0.9 (0.4)	**0.002**	1.021 (0.916, 1.138)	0.708
White cell count	7.7 (3.0)	7.4 (2.5)	**<0.001**	1.033 (1.013, 1.054)	**0.001**
Hematocrit	40.0 (4.7)	40.8 (4.4)	**<0.001**	0.994 (0.980, 1.008)	0.411
Platelet	249 (76)	247 (70)	0.388		
Procedural factors					
Pelvic fixation	60 (7.3%[2])	758 (2.0%)	**<0.001**	1.298 (0.935, 1.802)	0.119
Has ALIF	301 (21.3%)	9,628 (26.0%)	**<0.001**	0.759 (0.653, 0.882)	**<0.001**
Has ALIF (PF only)	7 (11.7%)	152 (20.1%)	0.114	0.549 (0.219, 1.378)	0.202
Has CAS	109 (7.7%)	2,575 (7.0%)	0.282	1.012 (0.796, 1.286)	0.924
Has CAS (PF only)	18 (30.0%)	147 (19.4%)	**0.049**	1.362 (0.598, 3.102)	0.462
Mean levels fused	2.5 (0.9)	2.4 (0.8)	**<0.001**	1.108 (1.035, 1.186)	**0.003**
Mean interbody fusions	1.1 (1.2)	1.2 (1.1)	0.158	0.982 (0.923, 1.044)	0.557
Length of stay	8.0 (8.0)	4.2 (4.5)	**<0.001**	1.085 (1.074, 1.096)	**<0.001**

[2]Percent of patients who required reoperation within pelvic fixation. *Fischer's exact test. Bold values indicate significance (*P*<0.05). ASA, American Society of Anesthesiologists. ALIF, anterior lumbar interbody fusion. CAS, computer assisted surgery. COPD, chronic obstructive pulmonary disease. SD, standard deviation. PF, pelvic fixation.

Table 3. Univariate and multivariate analysis of predictors of morbidity.

	Univariate			Multivariate	
	Morbidity (N = 8,525)	No morbidity (N = 29,888)	*P*	OR (95% CI)	*P*
Demographics					
Mean age (years; SD)	64 (12)	60 (13)	**<0.001**	1.011 (1.008, 1.013)	**<0.001**
Obese	4,634 (54.8%)	15,954 (53.6%)	0.055	1.065 (1.003, 1.132)	**0.041**
African American race	705 (8.8%)	2,378 (8.5%)	0.339	1.212 (1.092, 1.346)	**<0.001**
Hispanic ethnicity	399 (4.9%)	1,651 (5.8%)	**0.001**	0.761 (0.653, 0.886)	**<0.001**
Male Gender	3,585 (42.1%)	14,187 (47.5%)	**<0.001**	0.949 (0.890, 1.012)	0.114
Comorbidities					
Smoker	1,393 (16.3%)	6,102 (20.4%)	**<0.001**	0.921 (0.849, 0.998)	**0.046**
Dyspnea	694 (8.1%)	1,657 (5.5%)	**<0.001**	1.201 (1.074, 1.343)	**0.001**
Diabetes mellitus	1,879 (22.0%)	5,240 (17.6%)	**<0.001**	1.048 (0.973, 1.129)	0.217
COPD	458 (5.4%)	1,289 (4.3%)	**<0.001**	1.076 (0.941, 1.232)	0.281
Heart failure	64 (0.8%)	85 (0.3%)	**<0.001**	1.017 (0.662, 1.565)	0.937
Hypertension	5,601 (65.7%)	16,944 (56.7%)	**<0.001**	1.071 (1.001, 1.146)	**0.046**
Disseminated cancer	211 (2.5%)	193 (0.6%)	**<0.001**	1.125 (0.864, 1.464)	0.382
Open wound infection	104 (1.2%)	91 (0.3%)	**<0.001**	1.022 (0.693, 1.511)	0.909
Chronic steroid use	526 (6.2%)	1,124 (3.8%)	**<0.001**	1.238 (1.089, 1.407)	**0.001**
Bleeding disorder	240 (2.8%)	379 (1.3%)	**<0.001**	1.516 (1.244, 1.846)	**<0.001**
Preop transfusion	96 (1.1%)	51 (0.2%)	**<0.001**	1.455 (0.969, 2.185)	0.070
ASA-class ≥3	5,288 (62.1%)	14,366 (48.1%)	**<0.001**	1.182 (1.108, 1.261)	**<0.001**
Lab values (mean; SD)					
Creatinine	1.0 (0.5)	0.9 (0.4)	**<0.001**	1.029 (0.963, 1.099)	0.398
White cell count	7.4 (2.6)	7.4 (2.4)	0.823		
Hematocrit	39.2 (5.0)	41.2 (4.2)	**<0.001**	0.938 (0.931, 0.944)	**<0.001**
Platelet	245 (77)	248 (67)	**0.003**	0.999 (0.999, 1.000)	**0.001**
Procedural factors					
Pelvic fixation	465 (56.8%[3])	353 (43.2%)	**<0.001**	2.740 (2.307, 3.254)	**<0.001**
Has ALIF	1,628 (19.1%)	8,301 (27.8%)	**<0.001**	0.644 (0.600, 0.692)	**<0.001**
Has ALIF (PF only)	78 (16.8%)	81 (22.9%)	**0.027**	0.703 (0.481, 1.071)	0.101
Has CAS	589 (6.9%)	2,095 (7.0%)	0.748	0.855 (0.759, 0.962)	**0.010**
Has CAS (PF only)	81 (17.4%)	84 (23.8%)	**0.024**	0.640 (.400, 1.026)	0.064
Mean levels fused	2.6 (1.0)	2.4 (0.8)	**<0.001**	1.276 (1.232, 1.321)	**<0.001**
Mean interbody fusions	1.1 (1.2)	1.2 (1.1)	**0.020**	1.042 (1.012, 1.073)	**0.006**
Length of stay	6.4 (6.6)	3.7 (3.8)	**<0.001**	1.179 (1.167, 1.190)	**<0.001**

[3]Percent of patients who experienced morbidity within pelvic fixation. *Fischer's exact test. Bold values indicate significance (*P*<0.05). ASA, American Society of Anesthesiologists. ALIF, anterior lumbar interbody fusion. CAS, computer assisted surgery. COPD, chronic obstructive pulmonary disease. SD, standard deviation. PF, pelvic fixation.

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Posterolateral versus posterior interbody fusion for the management of lumbar degenerative spondylolisthesis : Analysis from the Canadian Spine Outcomes and Research Network (CSORN) prospective lumbar degenerative spondylolisthesis propensity score matched study

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Introduction: The benefit of interbody fusion (IF) over posterolateral fusion in the treatment of spondylolisthesis is controversial. Little evidence focuses on the treatment of degenerative spondylolisthesis. The objective of this study was to compare post-operative patient rated outcomes (PROs) of posterolateral fusion (PLF) versus IF surgery in patients with lumbar degenerative spondylolisthesis.

Methods: This is a retrospective analysis of data from a CSORN multi-centred prospective study on the assessment and management of lumbar degenerative spondylolisthesis patients. Inclusion criteria included: lumbar degenerative spondylolisthesis at one or two levels, age ≥ 18 years, IF or PLF surgery, minimum one year follow up post-surgery. A propensity-score matching was used to similar cohorts of IF and PLF patients based on baseline patient characteristics including: sex, age, primary symptom type (radiculopathy vs. claudication back pain), BMI, SF-12 MCS, spondylolisthesis grade, disc angle (lordotic vs. kyphotic/neutral), smoking status, levels fused, back pain, and presence of neurologic deficit (motor or sensory). PROs including NRS back pain, NRS leg pain, ODI, SF-12 MCS and PCS were compared over time using repeated measures mixed effects modeling.

Results: Eight centers participated in the study. Of the 567 enrolled patients, 278 (PLF=56; IF=222) met the inclusion criteria. After propensity score matching, 48 patients were included in each group. Follow up rate was 80% at 1 year. Study participants mostly were female, had grade I spondylolisthesis in a single level, neurogenic claudication, and symptom duration greater than 2 years. At 3 and 12 months there were no significant differences in the intensity of back pain, leg pain, ODI, MCS, or PCS scores between PLF and IF groups. Operation time, blood loss, adverse events, and length of stay were equal between groups.

Discussion: Our study found equivalence in PROs between PLF and IF in propensity matched patients with degenerative spondylolisthesis at 12 months. Longer term follow up and focused investigation are required to determine if specific indications exist for IF in the management of degenerative spondylolisthesis.

Evaluation of sleep disturbance in patients with degenerative lumbar diseases and its related factors

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INTRODUCTION: Sleep disturbance is one of the symptoms in patients with chronic pain syndrome. It has been reported that the severity of pain is related to sleep length and quality. There were few reports about the relationship between neurological symptoms, including low back pain and sleep disturbance in patients with degenerative lumbar diseases. The purpose of this study was to elucidate the prevalence of sleep disturbance in patients with degenerative lumbar diseases and to analyze its related factors.

METHODS: In our institution, this study included eighty-four patients (male: 52, female: 32, average age: 68.5 years) who received surgical treatment for degenerative lumbar diseases from July 2019 to September 2020. There were 12 patients with lumbar disc herniation, 44 patients with lumbar canal stenosis, 16 patients with spondylolisthesis, and 12 patients with other diseases. Clinical symptoms (low back pain VAS, leg pain VAS, and numbness in the lower extremity), health-related QOL (EQ-5D), low back pain associated QOL (ODI and RDQ), and central sensitivity index (CSI) were evaluated preoperatively. Sleep disturbance was assessed by MOS 12-Item Sleep Scale in which Sleeping Time (ST), Sleep Quality (SQ), and Somnolence (SL) were used in this study. Correlation between these three outcome measures in MOS 12-Item Sleep Scale and preoperative clinical parameters were statistically assessed, and the factors affecting sleep disturbance were evaluated using multiple regression analysis.

RESULTS: Average sleeping time of subjects was 6.2 hours in this study cohort. There was no significant difference in ST, SQ, SL by gender and lumbar diseases. ST was significantly correlated with CSI ($P<0.05$). SQ was correlated significantly with EQ-5D, CSI, leg VAS ($P<0.01$), and low back pain VAS, ODI, RDQ ($P<0.05$). SL has a significant correlation with EQ-5D, CSI, low back pain VAS, ODI, RDQ ($P<0.01$). Multiple regression analysis revealed that ST was significantly associated with RDQ, CSI, and EQ-5D. SQ was significantly associated with CSI and age, SL with CSI.

DISCUSSION: The results of this study revealed that sleep disturbance was correlated with the extent of neurological symptoms, health-related QOL, and central sensitization, and most significantly associated with the central sensitization evaluated by CSI.

Preoperative disc angle is an important predictor of segmental lordosis after degenerative spondylolisthesis fusion

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Introduction: Maintenance of sagittal balance is largely dependent upon lumbar lordosis, the majority of which is derived from the lower lumbar motion segments and specifically the segmental disc angles. Lumbar degenerative spondylolisthesis (LDS) with associated spinal stenosis is a common indication for spinal surgery, often treated with fusion surgery with or without the use of an interbody. It is important to understand the effects of spinal fusion on the index spinal segment prior to surgery so as not to induce iatrogenic deformity by changing previously lordotic disc spaces to kyphotic or failing to address a preoperatively kyphotic disc space. The objective of this study was to determine the effect of interbody cages inserted via posterior approach on segmental lordosis in the setting of preoperative lordotic versus kyphotic/neutral disc spaces in patients with LDS.

Methods: Five consecutive years of retrospective data from the Canadian Spine Outcomes and Research Network (CSORN) prospective study on the assessment and management of LDS patients was collected from two contributing centres of consecutively enrolled patients. Patients were analyzed preoperatively and at 12-month follow-up with standing lumbar radiographs. At the spondylolisthesis level, segmental lumbar lordosis (SLL) was measured from the upper end plate of the proximal vertebra to the lower end plate of the distal vertebra. Patients were stratified into four groups based on index level disc angle and the type of procedure performed: preoperative lordotic posterolateral fusion (PLF) (Group 1); preoperative neutral/kyphotic PLF (Group 2); preoperative lordotic interbody fusion (IF) (Group 3); preoperative neutral/kyphotic IF (Group 4).

Results: A total of 100/111 (90%) patients completed one-year follow-up. Twenty-three patients underwent PLF with 18 (18%) in group 1 and only five (5%) in group 2. Eighty-eight patients underwent IF, with 40 (40%) in group 3 and 48 in group 4 (48%). Among patients with preoperatively lordotic disc angles, group 3 had a greater magnitude of worsening in SLL than group 1 patients, with significant differences persisting at one-year (mean difference 2.3^0, 95% CI, 0.3, 4.3, P=0.029). Patients in group 4 were more likely to achieve improvement in SLL at one year than group 3 (67% vs. 44%, p=0.046), with similar mean improvement magnitude between groups 3 and 4 (-1.1, 95% CI, -3.7, 1.6, P=0.415).

Discussion: In the setting of an index-level preoperative lordotic disc angle, the magnitude of segmental lordosis worsening was more pronounced when an interbody cage was used versus PLF. Patients who have a kyphotic or neutral disc space preoperatively are more likely to gain lordosis when an interbody cage is used.

A guide for standardized interpretation of lumbar multifidus ultrasonograpy; an observational study.

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INTRODCUTION: In Lumbar Multifidus (LM) studies, previously, inconsistent descriptions of morphology were identified, especially in ultrasonography and electromyography research, hampering its clinical applicability with regard to diagnosis and therapy (1). The aim of this study was to describe the lumbar multifidus (LM) sonoanatomy by comparing high-resolution reconstructions from a 3-D digital spine with a healthy participants' standard LM ultrasonography and set a basis for evidence-based research methodology.

METHODS: An observational study was carried out and comparisons with high impact literature were made. From three deeply frozen human tissue blocks of the lumbosacral spine a large series of consecutive high-resolution photographs with 78 µm interval were acquired that were reformatted into 3-D tissue blocks (voxel size 78 µm) (2). This enabled the reconstruction of (semi-)oblique cross-sections that could match standard ultrasound (US) images obtained from a healthy volunteer. The volunteer was matched to the specimen based on gender and age. Transverse and oblique short-axis views were compared from the most caudal insertion of LM to L1.

RESULTS: Based upon the anatomical reconstructions we could clearly distinguish LM from the adjacent erector spinae (ES) in the standard US imaging of the lower spine (Fig_1A;B). At the lumbosacral junction, LM is the only dorsal muscle facing the surface. From L5 upwards, ES progresses from lateral to medial, to completely cover LM at about L2. A clear distinction between deep and superficial LM could not be discerned. Only in caudal anatomical cross-sections, but not in the standard US images, we could identify five separate bands between every lumbar spinous process and the dorsal part of the sacrum, with a medio-lateral and superficial-deep orientation.

DISCUSSION: The detailed cross-sectional LM anatomy and reconstructions facilitate the interpretations of standard LM US imaging, position of the separate LM-bands, details of deep interspinal muscles, and demarcation of LM versus ES. Clear identification of deep versus superficial versus lateral LM as described earlier (3) could not be verified. Limitation of the study is that only two human specimens were used to construct the High-Resolution 3-D tissue blocks, which may limit external validity. The use of a more detailed sonoanatomy improves interpretation of standard LM US-imaging. In this manner guidelines for studies using ultrasonography and electromyography can be developed, which eventually should also be implemented in evidence-based research and therapy.

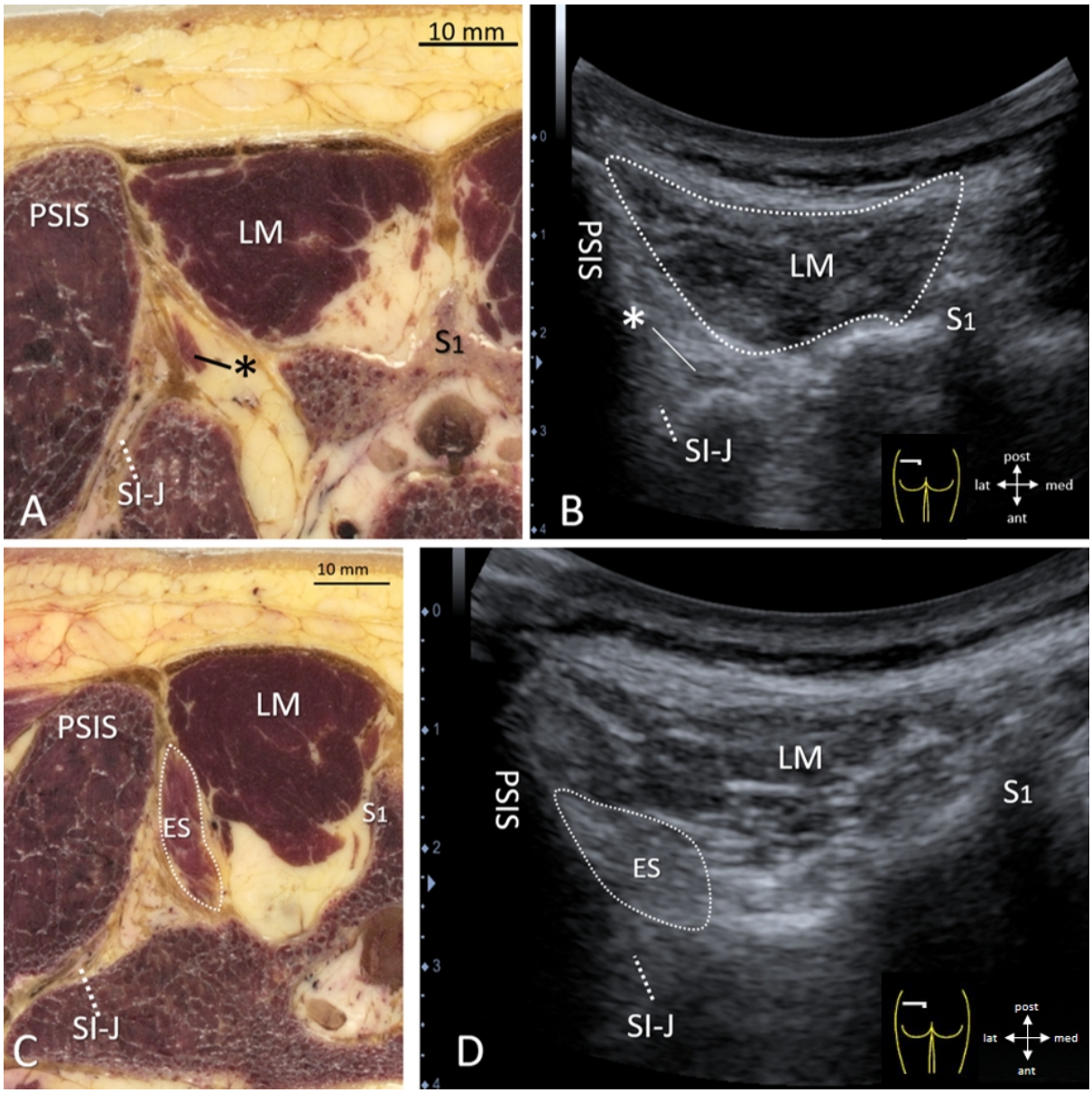

Figure 1. *Transversal cross-sections (A, C) and matched ultrasonographic (US) views (B, D) at the level of the posterior superior iliac spine (PSIS). ES originates from the PSIS and from the dorsal ligaments of the sacro-iliac joint (SI-J).* ***(A)*** *S1= dorsal spine S1.* ***(B)*** *Matched US view in human volunteer. At this level, LM is the only superficial muscle (demarcated by white dotted line). Deep to it the origin fibers of ES (*) can be discerned at the dorsal part of the sacro-iliac joint (SI-J) as separate structure.* ***(C)*** *S1= dorsal spine S1.* ***(D)*** *Same curvilinear view as in Fig. B showing the different ultrasonographic composition of the ES fibers (demarcated by white dotted line), deep and lateral to LM.*

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Lumbar multifidus characteristics in university level athletes: Possible predictors of low back pain and lower limb injury

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Introduction: Low back pain (LBP) is more prevalent in athletes compared to the general population. Previous studies in athletes with LBP have reported a decrease in lumbar multifidus (LM) cross-sectional area (CSA) and increase in side-to-side CSA asymmetry. Similar change in LM morphology were also associated lower limb injury (LLI) in athletes. However, previous studies mostly investigated small samples in a single sport at a time. Therefore, the primary aim of this study was to examine LM morphology and function across a general sample of male and female university level varsity athletes. A secondary aim was to investigate if LM morphology and function were predictors of LBP and LLI.

Methods: A total of 134 university varsity athletes (50 female, 84 male) from hockey, rugby, soccer, and football were included in this study. A self-reported questionnaire was used to acquire player demographics information and history of LBP and lower limb injury in the previous 3 months and 12 months, respectively. Ultrasound images of LM at L5 were obtained bilaterally, and measurements of interest included: CSA, echo-intensity (EI) and thickness at rest and contracted, and % thickness change (from rest to contracted) in both prone and standing positions. DEXA was used to assess body composition. Paired t-tests were used to examine difference in LM measurements between the right and left side, and independent t-tests were used to compare LM measurements between sex. Univariate and multivariate logistic regression analyses were performed to assess if LM characteristics were predictors of LBP and LLI. Sex and players' body composition measurements were tested as possible covariates.

Results: Males had significantly larger LM CSA and thickness at rest and contracted in both prone and standing positions (all $p<0.001$). Females had significantly higher EI than males ($p<0.001$). The left LM CSA was significantly larger in both males and females in prone and standing (all $p<0.05$). Similarly, LM thickness at rest and contracted was significantly larger on the left side both in males ($p<0.001$) and females ($p<0.05$) in prone, while contracted in standing was significant for males only ($p<0.05$). There was no significant difference in the % change in thickness between or within males and females in prone or standing. Increased weight (OR= 1.03 [1.01, 1.06], p=0.007) and years played at the university level (OR=1.32 [1.02, 1.71], p=0.03) were associated with a 3% and 32% increased odds of having LBP in the previous 3 months, respectively. Increased LM CSA asymmetry (OR=1.14 [1.01, 1.28], p=0.03) in prone and type of sport (OR=1.44 [1.04, 1.96], p=0.02) were associated with 14% and 44% increased odds of having a LLI in the previous 12 months, with football having the strongest association.

Conclusion: The results provide novel insights regarding LM morphology and function in a large sample of male and female university-level athletes. Significant differences in LM morphology in prone and standing were observed between male and female athletes. While LM characteristics were not predictors of LBP history in the previous 3-months, increased LM CSA asymmetry was a significant predictor of LLI.

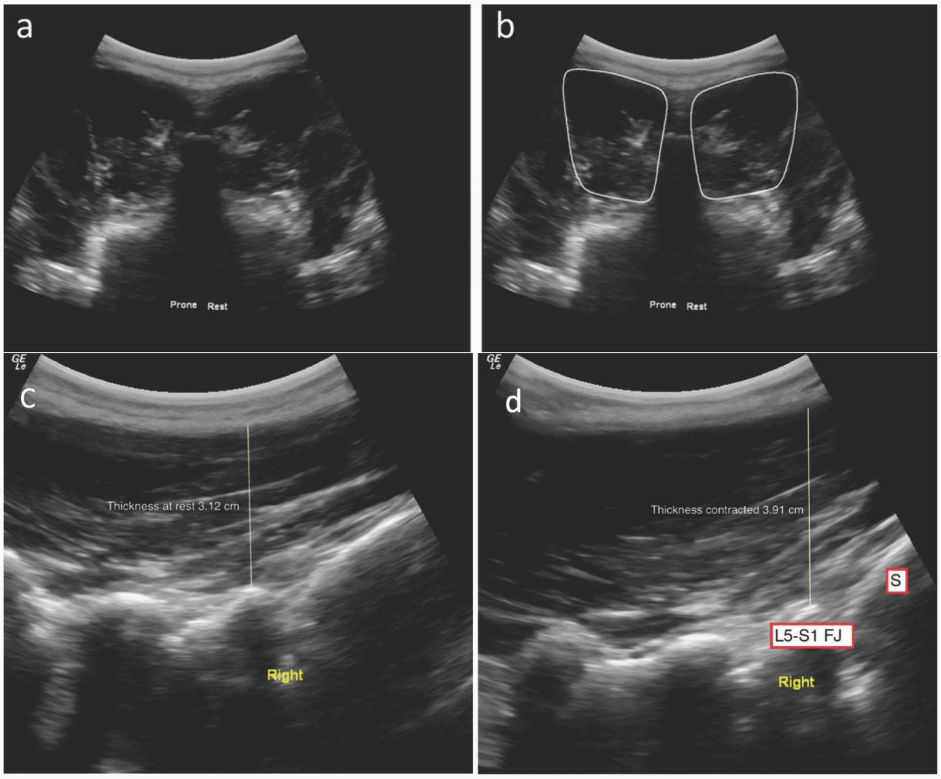

Figure 1: a) Bilateral transverse image at L5 vertebral level in the prone position showing the right and left LM, b) bilateral CSA measurements of the LM of the same participant in image a), c) LM thickness measurement at rest in the prone position at the L5 vertebral level, d) LM thickness measurement during contraction in the prone position at the L5 vertebral level.

A "crosswalk" for converting scores between two commonly used condition-specific, patient-reported spine outcome measures, the Oswestry Disability Index (ODI) and the Core Outcome Measures Index (COMI)

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INTRODUCTION

Cross-walking is a method of mapping scores on different patient-reported outcome instruments that measure similar domains. It requires that changes in outcomes from two measures in the same individuals should be correlated and similarly responsive to change. The Oswestry Disability Index (ODI) and the Core Outcome Measures Index (COMI) are two commonly used self-rating outcome instruments in patients with spinal disorders. However, there is currently no formal cross-walk between the two that would otherwise allow the scores of one to be interpreted in terms of the other. This study aimed to create such a cross-walk.

METHODS

We performed a secondary analysis of data from conservative and operative patients with spinal disorders, from 2 observational studies and a registry (N = 3324 patients; 57±17y; 60% female), that had completed both an ODI and COMI at baseline and 1-year follow-up (FU). Correlations between the two instruments' baseline scores, FU scores and change-scores (baseline and 1y FU) were computed, and linear regression equations were created to allow calculation of one score in terms of the other. The Cohen's κappa for agreement (κ) was calculated with respect to achievement of the minimal clinically important change (MCIC) score on each instrument (ODI, 12.8 (Copay et al 2008) points; COMI, 2.2 points (Mannion et al 2006)). It was hypothesized that, for the cross-walk to be meaningful (Morris et al 2015), baseline, FU, and change-scores for the two instruments should be at least moderately correlated (r>0.5) and have moderately similar responsiveness (kappa >0.4 for agreement in % reaching MCIC).

RESULTS

All pairs of measures were significantly positively correlated (baseline, 0.73; 1yr FU, 0.84; change-scores, 0.73). Overall, 53.9% patients achieved MCIC based on COMI change-scores and 52.4%, based on ODI change-scores; on an individual basis, there was 78% agreement between them regarding whether MCIC had been achieved or not, with a kappa coefficient of 0.56. Regression equations for predicting ODI from COMI were: baseline, ODI=COMI x 7.1 – 4.2; 1yr FU, ODI=COMI x 6.3 + 2.7; change-scores, ODIchange = COMIchange x 5.1 + 1.9; those for predicting COMI from ODI were: baseline, COMI=ODI x 0.08 + 3.6; 1yr FU, COMI=ODI x 0.11 + 1.0; change-scores, COMIchange = ODIchange x 0.10 + 1.1). The standard errors for the regression slopes were low, but the RMSresiduals were relatively high (COMI predicting ODI, 11-14; ODI predicting COMI, 1.42-1.96) when compared with the MCICs for the instruments.

DISCUSSION

Many institutions exhibit a preference for the use of one outcome instrument over another, and have a history of data collection with their chosen instrument; the ability to share data via the developed crosswalk, to convert mean scores between the two scales, should open up more centres/registries for collaboration and facilitate the pooling of data in meta-analyses. However, caution is advised if using the conversions for individual treatment decisions, due to the relatively large individual error of prediction.

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PHLPP Inhibition Maintains a Healthy NP Cell Phenotype via FOXO1 Activation

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Introduction: IVD degeneration (IDD) is characterized by apoptosis, inflammation, structural deterioration, and extracellular matrix (ECM) degradation[1]. The phosphatase pleckstrin homology domain leucine-rich repeat protein phosphatase (PHLPP) isozymes, PHLPP1 and PHLPP2 both promote apoptosis and inactivate AKT, which is a major regulatory upstream of transcription factor FOXO1. FOXO1 has been recently demonstrated to be essential to maintain IVD health in mice[2]. The aim of this study was to identify if pharmacological inhibition of PHLPP activity can promote IVD health by mitigating pro-inflammatory and catabolic responses via FOXO1 in the nucleus pulposus (NP) of degenerating IVDs.

Methods: Human degenerated NP cells (n=3, Pfirrmann grade 4-5) were extracted following IRB approval. After reaching 85% confluency, NP cells (passage 1-2) were serum deprived (0.2% FBS) for 2 hours, followed by PHLPP Inhibitor treatment (25, 50 & 100mM of the small molecule PHLPP inhibitor NSC45586) for 30 minutes (immunoblotting for AKT and ERK phosphorylation and FOXO1 expression) or 24 hours (cell viability (MTT) and gene expression for *KRT19, ACAN, MMP13, IL6)*. To investigate if PHLPP acts via FOXO1, a FOXO1 inhibitor (200nM, small molecule FOXO1 inhibitor AS1842856) was added to the culture media 1 hour before PHLPP inhibitor (100mM) treatment. Data were analyzed using Kruskal-Wallis-Testing (Graphpad Prism 8) with a statistical significance of $p<0.05$.

Results: PHLPP Inhibitor treatment of degenerated human NP cells promoted cell viability in a dose dependent manner (Figure 1A). PHLPP inhibitor treatment further increased gene expression of *KRT19* and *ACAN*, while it decreased *MMP13* and *IL6*(Figure 1B). Immunoblotting for AKT, ERK, as well as FOXO1 demonstrated an inhibitor dependent increase in AKT phosphorylation and FOXO1 deposition but a decrease in ERK phosphorylation (Figure 1C+D). Increased FOXO1 expression induced by the PHLPP inhibitor was further confirmed by immunofluorescent staining (Figure 1E). Combination of the inhibitors for PHLPP and FOXO1 demonstrated that inhibition of FOXO1 reversed the effects of PHLPP inhibition on FOXO1 protein expression (Figure 1E) and gene expression of *KRT19, ACAN* and *MMP13* (Figure 1F).

Discussion: Our study demonstrated that the small molecule PHLPP inhibitor NSC45586 promoted NP cell health in degenerated human NP cells. PHLPP inhibition increased ECM synthesis and decreased pro-inflammatory responses. In degenerated human NP cells, the inhibitor promoted FOXO1 deposition and AKT phosphorylation while decreasing ERK phosphorylation. Activated FOXO1 and AKT and inactivated ERK play important roles in maintaining IVD health[2,3]. These findings were somewhat surprising because it is known that AKT signaling inactivates FOXO1. It's possible that PHLPP regulates FOXO1 expression independent of AKT. Our findings are also supported by others demonstrating evidence of AKT-independent FOXO1 in hematopoietic stem and progenitor cells[4]. Notably, inhibition of FOXO1 reversed the protective effects of PHLPP inhibitor on IDD, warranting further investigation in the correlation of PHLPP and FOXO1.

Acknowledgement: Funded by NIH R21 AR072222 and the Department of Orthopaedics at Emory University.

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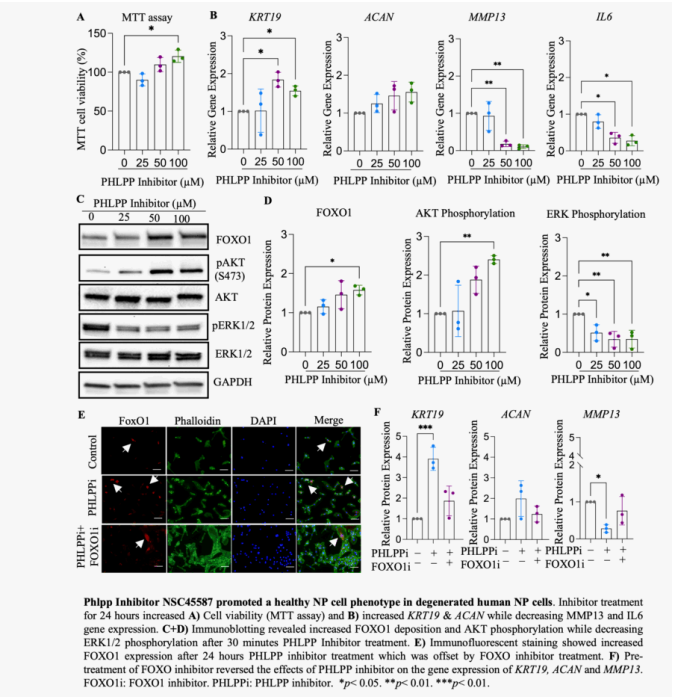

Phlpp Inhibitor NSC45587 promoted a healthy NP cell phenotype in degenerated human NP cells. Inhibitor treatment for 24 hours increased **A)** Cell viability (MTT assay) and **B)** increased *KRT19* & *ACAN* while decreasing MMP13 and IL6 gene expression. **C+D)** Immunoblotting revealed increased FOXO1 deposition and AKT phosphorylation while decreasing ERK1/2 phosphorylation after 30 minutes PHLPP Inhibitor treatment. **E)** Immunofluorescent staining showed increased FOXO1 expression after 24 hours PHLPP inhibitor treatment which was offset by FOXO inhibitor treatment. **F)** Pre-treatment of FOXO inhibitor reversed the effects of PHLPP inhibitor on the gene expression of *KRT19, ACAN* and *MMP13*. FOXO1i: FOXO1 inhibitor. PHLPPi: PHLPP inhibitor. *$p<0.05$. **$p<0.01$. ***$p<0.01$.

Prevalence of facet joint degeneration preceding the intervertebral disc: an epidemiological study in community

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【Introduction】

The facet joints constitute a joint complex with the intervertebral discs and contribute to load distribution and control of excessive rotation. In most cases, degeneration of the lumbar spine occurs in the discs before the facet joints at the same spinal level, however, in a few cases, the facet joints degeneration (FJD) precedes the disc degeneration (DD) (FJD>DD). The purpose of this study was to investigate the prevalence of FJD>DD using epidemiological data.

【Methods】

This is community-based cross-sectional study. The subjects were 437 community residents (142 males and 295 females, mean age 65.0 years) who underwent lumbar spine MRI in the 2004. We evaluated the left and right FJD from L1-L2 to L5-S using the Weishaupt classification (4 grades from 0-3). Disc degeneration was measured by the Schneiderman classification (4 grades from 0-3). We defined FJD>DD as Weishaupt grade ≥2 in either the left or right facet joint, and Schneiderman grade=0 at the same spinal level. We investigated the distribution of FJOA>DD at each spinal level from L1-2 to L5-S in three age groups: <50 years old, 50-60, and ≥60. Chi-square test was used for statistical examination, and $P<0.05$ was considered as statistically significant.

【Results】

A total of 219 subjects were enrolled, excluding those with compression fractures, scoliosis or degenerative spondylolisthesis. The distribution of FJD>DD at each spine level is as follows: L1-L2 (7/218=3.2%), L2-L3 (4/219=1.8%), L3-L4 (1/219=0.5%), L4-L5 (5/219=2.3%), L5-S (5/203=2.5%), p=0.34. The distribution between 3 age groups was as follows: L1-L2 (<50 vs 50-60 vs ≥60, 1/20=5.0% vs 4/37=10.8% vs 2/161=1.2%, p=0.01), L2-L3 (2/20=10.0% vs 2/37=5.4% vs 0/162=0.0%, p=0.001), L3-L4 (0/20=0.0% vs 1/37=2.7% vs 0/162=0.0%, p=0.09), L4-L5 (1/20=5.0% vs 1/37=2.7% vs 3/162=1.9%, p=0.66), L5-S (1/19=5.3% vs 2/34=5.9% vs 2/150=1.3%, p=0.04). The distribution between males and females for each level was as follows: L1-L2 (male vs female, 4/77=5.2% vs 3/141=2.1%, p=0.22), L2-L3 (3/77=3.9% vs 1/142=0.7%, p=0.09), L3-L4 (1/77=1.3% vs 0/142=0.0%, p=0.17), L4-L5 (5/77=6.5% vs 0/142=0.0%, p=0.002), L5-S (3/74=4.1% vs 2/129=1.6%, p=0.27).

【Discussion】

In the present study, subjects with FJD>DD were found in very small numbers at each lumbar level, and younger males tended to have FJD>DD. The pathogenesis and clinical significance of this condition need to be investigated in the future.

The association of abdominal trunk muscle weakness and the development of osteoporotic vertebral fracture in the middle-aged and older adult women: a three-year prospective longitudinal cohort study

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Introduction: It is well known that future incidence of osteoporotic vertebral fracture (OVF) increases with age, low bone mineral density (BMD), and fracture history. Neuromuscular function of the trunk muscles and spinopelvic alignment could play an important role in the etiology and they are important but poorly understood. In this study, potential risk factors associated with the development of OVF, namely, poor muscle strength and spinopelvic alignment, were prospectively investigated in the middle-aged and older adult women.

Methods: We enrolled 197 female patients aged ≥50 years who were scheduled to undergo surgery for lower extremities degenerative diseases at our hospital. Preoperatively, patient's anthropometric and muscle strength measurements, BMD measurement of the lumbar spine (L-BMD), and full-spine standing radiographs were obtained. Muscle strengths measured in this study included grip power, knee extensor muscle strength, and abdominal trunk muscle strength (ATMS) using an exercise device designed for abdominal trunk muscles (RECORE: presented in Figure). Based on full-spine standing radiographic findings, sagittal vertical axis, lumbar lordosis (LL), pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), and PI-LL were measured, and the presence of OVF were determined. This study evaluated a total of 141 patients who performed another full-spine standing radiography three years postoperatively to identify new non-traumatic OVFs after 54 without the second examination and two with new traumatic OVFs were excluded. To identify factors associated with the occurrence of new OVFs, univariate and multivariate analyses were performed. Finally, the receiver operating characteristic (ROC) curve analysis was used to determine the optimal cutoff of the occurrence of OVF.

Results: Ten (7.1%) patients had new non-traumatic OVFs during the three-year study period (the fracture group). The remaining 131 patients did not have new OVFs (non-fracture group). The fracture group had lower ATMS and L-BMD, smaller SS, and larger PT than the non-fracture group. The fracture group had a higher prevalence of old OVFs than the non-OVF group. In a multivariate analysis, weak ATMS ($p = 0.037$), low L-BMD ($p = 0.011$), and the presence of old OVFs ($p = 0.023$) were significant risk factors for the occurrence of new OVFs for the three years. ROC analyses showed that AMTS ≤4.0 kPa (95% confidence interval 0.643-0.909, $P = 0.004$, area under curve 0.776) and L-BMD ≤1.11 g/cm2 (95% confidence interval 0.575-0.833, $P = 0.032$, area under curve 0.704) best predicted the occurrence of OVF in the study cohort.

Discussion: Abdominal trunk muscle weakness in the middle-aged or older women was associated with future OVF. One previous study showed that the device used in this study can quantify ATMS and abdominal trunk muscles-strengthening exercise using the device increased ATMS and activated the abdominals, diaphragm, and pelvic floor muscles. Coordinated and isometric muscle contraction of these muscles creates a semirigid cylinder surrounding the spinal column with an increase in intra-abdominal pressure, which can reduce some of the imposed stress on the vertebral column in the lower thoracic or lumbar spine. ATMS measurement can be used to assess the risk of OVF occurrence.

The quantity and quality of lumbar muscles and lumbopelvic parameters in patients with degenerative spondylolisthesis

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Introduction

Lumbar degenerative spondylolisthesis (DS) is one of the most common causes of low back pain. The lumbar muscles, such as the psoas major (PM), erector spinae (ES), and multifidus (MF) muscles, play an important role in the stability and functional movement of the lumbar spine. The quantities and qualities of these muscles may be related to the occurrence of DS and lumbopelvic parameters, such as lumbar lordosis (LL) and sacral slope (SS). However, the influence of lumbar muscles on DS and lumbopelvic alignment is not well understood.

Methods

Consecutive patients who underwent CT scans of the abdominal or lumbar regions for reasons other than low back disorders were included. Patients with prevalent vertebral fractures, previous lumbar spinal fusion surgery, and bilateral and unilateral spondylolysis were excluded. The patients were divided into two groups. The first group (DS group) consisted of patients with L4 DS. For the second group (non-DS group) patients were extracted from patients without vertebral slip who were matched for age and sex with the DS group.

Using sagittal reconstructed CT images, LL, upper lumbar lordosis ([ULL] L1-L4), lower lumbar lordosis ([LLL] L4-S1), and SS were examined. To evaluate the quantity and quality of lumbar muscles, the gross cross-sectional area (GCSA), functional cross-sectional area (FCSA), and fat infiltration (FI) of the PM, ES, and MF muscles were measured by axial reconstructed CT images. The lumbopelvic parameters, FCSA, GCSA, and FI of lumbar muscles were compared between the two groups. Then, each lumbar muscle parameter was analyzed for correlation with DS and lumbopelvic parameters.

Results

This study included 708 consecutive patients. After exclusion, a total of 545 patients were enrolled. Of the patients, 25 (mean age: 74.7±9.3 years; 13 males/12 females) had L4 DS. Another 25 patients (mean age: 74.7±9.3 years old; 13 males/12 females) without DS were extracted. The degree of vertebral slip in all patients in the DS group was classified as grade I. DS patients displayed significantly greater ULL and lower FI of the PM and ES muscles than non-DS patients ($p=0.0078$, 0.031, and 0.010, respectively). The FI of the ES muscle was significantly correlated with the presence of DS ($p=0.010$). The FCSA of the ES and MF muscles and the GCSA of the MF muscle showed a significant correlation with LL and SS in the non-DS group ($p<0.05$), but not in the DS group.

Discussion

ULL was greater in L4 DS patients, possibly related to the better quality of the ES muscle. All DS patients showed mild (grade I) spondylolisthesis, suggesting the possibility that lumbar muscle quality is better in patients with mild DS than in those without DS. The ES and MF muscles may play an important role in maintaining the lumbar lordotic angle in non-DS patients but not in DS patients.

Is clinical result of posterior lumbar interbody fusion for the elderly in the 80s inferior to that in the 60s patients?

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【INTRODUCTION】Although the indications for posterior lumbar interbody fusion (PLIF) have been expanded for the elderly, there are few reports comparing the surgical outcomes of patients aged 80 years or older with those of other ages. The purpose of this study is to compare the surgical outcomes of PLIF in the 80s and 60s patients using Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ), which is a patient self-administered questionnaire.

【METHODS】This study is a retrospective study conducted at two institutions in Japan. We reviewed a total of 1061 consecutive patients who underwent PLIF for lumbar degenerative surgery. Patients with failed back syndrome or lumbar spinal stenosis with osteoporotic vertebral fracture were excluded. In order to focus on the clinical characteristics of the 80s patients, we compared them with the 60s patients, who are apart in age with the 80s patients. We investigated patient demographics, American society of anesthesiologists physical status (ASA-PS), and Charlson comorbidity index (CCI) preoperatively. In addition, visual analog scale (VAS) for low back pain, leg pain, and leg numbness and JOABPEQ were analyzed preoperatively and at 1-year follow-up. Statistical analyzes were performed using Mann-Whitney U-test, Pearson's chi-square test, and Wilcoxon signed-rank test.

【RESULTS】Of 1061 patients, 52 were in the Group 80s (mean age: 82.0 ± 2.2 years) and 322 were in the Group 60s (mean age: 64.8 ± 2.7 years). There was no statistical difference between the 2 groups in sex (%male: 44.2% vs. 40.2%, $P = 0.648$). Preoperative ASA-PS (8 Grade 1 patients (15%), 33 Grade 2 (64%), 11 Grade 3 (21%) vs. 135 Grade 1 (42%), 168 Grade 2 (52%), 20 Grade 3 (6%), $P < 0.001$) and CCI (0.92 ± 1.19 vs. 0.46 ± 1.19, $P = 0.007$) in the Group 80s were higher than those in the Group 60s. Preoperative VAS scores for low back pain were significantly higher in the Group 80s than in the Group 60s (5.8 ± 2.9 vs. 4.9 ± 2.8, $P = 0.024$). Although all postoperative VAS scores at 1-year follow-up were significantly improved compared with preoperative scores in both of the 2 groups ($P< 0.001$), postoperative VAS scores for leg numbness were higher in the Group 80s than in the Group 60s (3.4 ± 3.2 vs. 2.0 ± 2.6, $P = 0.004$). The effective rates of the pain disorder (62.5% vs. 82.0%, $P = 0.002$), walking ability (70.6% vs. 83.9%, $P = 0.022$), and social life domain (47.1% vs. 63.7%, $P = 0.023$) in the JOABPEQ were lower in the Group 80s than in the Group 60s.

【DISCUSSION】Elderly patients aged 80 years or older had more comorbidities, severer postoperative residual low back pain and leg numbness, and poorer improvements in walking ability and social life disorders compared with the 60s patients. However, the therapeutic effect of PLIF was obtained even in the 80s patients, there were no differences in surgical outcomes of lumbar function and psychological disorders. Further investigation of risk factors that reduce surgical therapeutic effect in the 80s patients is crucial in the future.

Sagittal imbalance and need for future care in elderly adults: Locomotive Syndrome and Health Outcomes in the Aizu Cohort Study (LOHAS)

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INTRODUCTION: Spinal deformity with the sagittal imbalance in the elderly causes impairments in standing and gait, and is a possible risk factor for future care needs. The purpose of this study was to clarify whether sagittal imbalance was a risk factor for the condition of needed care in the community setting.

METHODS: This study included 607 participants of the Locomotive Syndrome and Health Outcomes in Aizu Cohort Study (LOHAS) in 2010. The primary outcome was a new certification of needing support or care in the national long-term care insurance system during 5-year follow-up. The sagittal vertical axis (SVA: mm) was measured on a standing whole-spine lateral radiograph. Bodily pain and depression were assessed using SF-12. The 3 minutes timed up and go (TUG) test was performed to evaluate the physical function. Comorbidities such as hypertension, diabetes, brain disease, heart disease, and smoking and drinking habits were investigated. Statistical analysis was performed using the chi-square test and Wilcoxon test. The association between SVA and new care-needs certification was evaluated by logistic regression analysis with adjustment for confounding factors.

RESULTS: During five years, 49 participants were newly certified for care needs. New care-needs certification was made in 6.1% in the SVA<40 group, 8.5% in the SVA 40-95 group, and 25.7% in the SVA>95 group. The odds ratio [95% CI] of SVA>95 group against SVA<40 group was 5.5 [1.9-15.4] and against SVA 40-95 group was 4.9 [1.7-14.7] adjusted with age (75≥), body pain, TUG (≥11 seconds), and body mass index (BMI:≥25).

DISCUSSION: The results of this study indicated that severe sagittal imbalance with SVA>95 was associated with the new certification of long-term care needs. In other words, the sagittal imbalance was a risk factor of disabilities that impair the independence of the elderly. Prevention and treatment of sagittal imbalance were considered essential to prevent future care needs for the elderly. Further study is needed to clarify whether surgical treatment for adult spinal deformities with sagittal imbalance prevents future care needs.

An Artificial Intelligence Powered Platform for Auto-Analyses of Spine Alignment Irrespective of Image Quality with Prospective Validation

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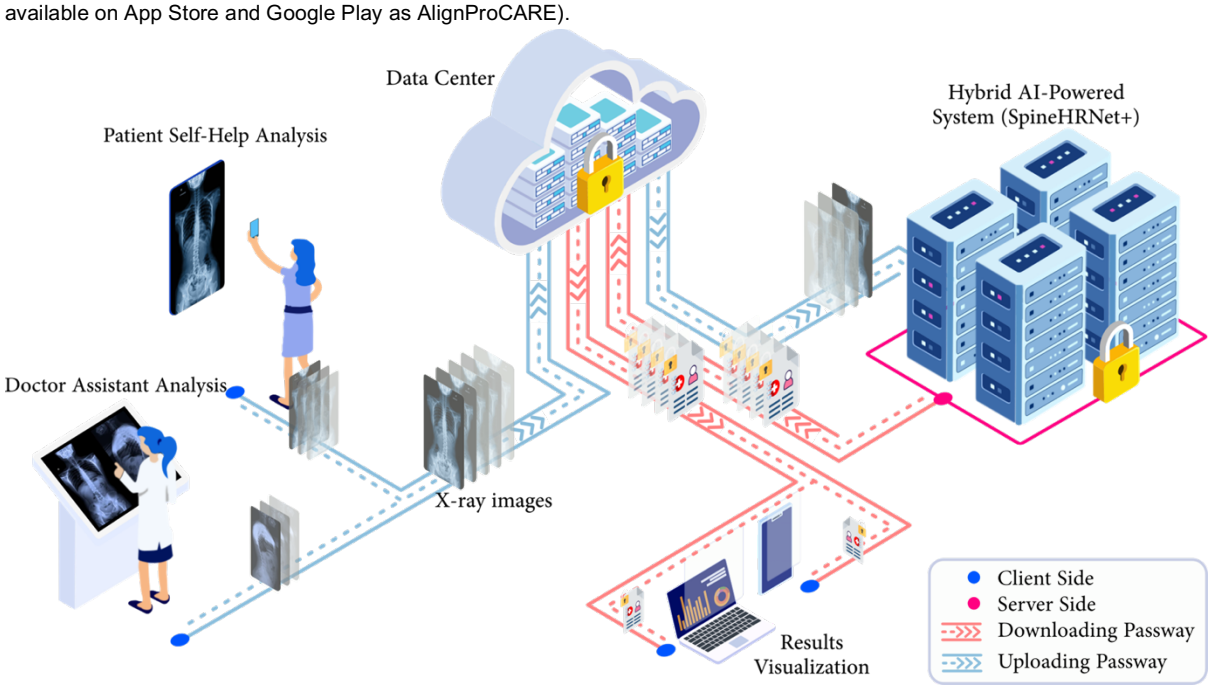
INTRODUCTION: Assessment of spine alignment is crucial in the management of scoliosis, but current auto-analysis of spine alignment suffers from low accuracy. We aim to develop and validate a hybrid model named SpineHRNet+, which integrates AI and rule-based methods to improve auto-alignment reliability and interpretability.

METHODS: 1,542 consecutive patients attending two scoliosis clinics were recruited with written informed consent. Their radiographs were recaptured using smartphones or screenshots, with deidentified images securely stored. Manually labelled landmarks and alignment parameters by a spine surgeon were considered as ground truth (GT). The data were split 8:2 to train and internally test SpineHRNet+ respectively. This was followed by a prospective validation on another 337 patients. Quantitative analyses of landmark predictions were conducted, and reliabilities of auto-alignment were assessed using linear regression and Bland-Altman plots. Deformity severity and sagittal abnormality classifications were evaluated by confusion matrices.

RESULTS: SpineHRNet+ achieved accurate landmark detection with mean Euclidean distance errors of 2.78 and 5.52 pixels on posteroanterior and lateral radiographs, respectively. The mean angle errors between predictions and GT were 3.18° and 6.32° coronally and sagittally. All predicted alignments were strongly correlated with GT ($p<0.001$, $R^2>0.97$), with minimal overall difference visualised via Bland-Altman plots. For curve detections, 95.7% sensitivity and 88.1% specificity was achieved, and for severity classification, 88.6-90.8% sensitivity was obtained. For sagittal abnormalities, greater than 85.2-88.9% specificity and sensitivity were achieved.

DISCUSSION: The auto-analysis provided by SpineHRNet+ was reliable, fast, and continuous. It offers the potential to assist clinical work and facilitate large-scale clinical studies (https://www.aimed.hku.hk/alignprocare; password: alignprocare; also available on App Store and Google Play as AlignProCARE).



Utility of the Decubitus or the Supine Rather Than the Extension Lateral Radiograph in Evaluating Lumbar Segmental Instability

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Utility of the Decubitus or the Supine Rather Than the Extension Lateral Radiograph in Evaluating Lumbar Segmental Instability

Abstract

Objective: To determine the superiority of decubitus and supine radiographs for the reduction of olisthesis instead of the extension radiograph, and the inconsistency of the CT scout view, 3D-reconstruction and MR image in evaluating segmental instability.

Methods: A cohort of 154 low-grade lumbar degenerative spondylolisthesis patients with the average age of (60.9±8.6) years were enrolled. Slip percentage was measured on the the flexion, upright and extension radiographs, the decubitus lateral radiograph, CT scout view, the supine median sagittal 3D-reconstruction and MR image.The translational range of motion was calculated, and segmental instability was defined as translational motion ≥ 8%.

Results: The flexion radiograph showed higher slip percentage than upright radiograph ($p<0.001$). The slip percentage of the MR image was lower than CT scout view ($p=0.003$) and CT sagittal radiograph ($p=0.001$) on the basis of statistical differences among three groups ($p=0.002$). The slip percentage of the CT scout view, decubitus radiograph, and extension radiograph was statistically different ($p=0.01$). The CT scout view and sagittal reconstruction had lower slip percentage than the extension radiograph ($p=0.042$; $p=0.003$, respectively). Both the flexion-supine and flexion-decubitus modality had larger translational motion than the flexion-extension modality ($p=0.007$; $p<0.001$, respectively).

Conclusion: Many modalities and techniques are used to show the vertebral displacement and its possible change and any cane used in the daily practice. In this study, supine and decubitus lateral radiography have larger reduction of olisthesis than the extension radiograph. The flexion radiograph coupled with a supine or decubitus radiograph reveals greater mobility than the flexion-extension modality.

Key words decubitus, supine, translational motion, segmental instability, lumbar degenerative spondylolisthesis

Needle tract seeding after computed tomography-guided percutaneous needle biopsy

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Introduction

Currently, computed tomography (CT)-guided percutaneous needle biopsy is the gold standard diagnostic method for patients with newly diagnosed spinal tumors. Although the advantage of CT-guided spinal biopsy has been well recognized, needle tract seeding (NTS), that tumor contamination occurs on the needle tract during tumor collection, is one of the terrible complications. While complete resection of the needle tract to prevent local recurrence (LR) from NTS is possible in extremity tumors, resection of the biopsy tract is difficult in spinal tumor surgery because of the character of surgical procedure. Therefore, more attention to the LR from NTS has to be paid after CT-guided biopsy of the spine. However, there are very few articles describing NTS after CT-guided biopsy of the spine, and its incidence and risk factors remain vague. The purpose of this study was to investigate LR from NTS after biopsy of the spine.

Methods

The postoperative LR from NTS in consecutive 171 patients who underwent spinal tumor surgery at single institution from Apr 2010 to Apr 2018 were reviewed. Inclusion criteria was as follows; 1) preoperative needle biopsy has been performed, 2) tumor has been surgically removed entirely and 3) postoperative observation period is more than 12 months. No resection of the biopsy tract was performed in all surgeries. LR from NTS was defined as follows; 1) tumor recurrence site was located on biopsy tract and 2) tumor recurrence has no relation with intraoperative tumor exposure.

Results

Forty-one (20 males and 21 females) patients were included in this study and mean observation period was 50.7 (13-110) months. Twenty cases were primary tumors and 21 cases were metastatic carcinomas. One patient with primary chondrosarcoma had postoperative LR from NTS. The incidence of LR from NTS was 5% (1/20) for primary tumors, 20% (1/5) for primary malignant tumors and 0% (0/21) for metastatic carcinomas.

Case presentation

A 57-year-old woman. Preoperative CT-guided needle biopsy was performed for spinal tumor at T6 and pathological result was grade 2 chondrosarcoma. In surgery, the tumor was entirely removed piece by piece via posterior approach with instrumented fusion. Four months after the surgery, magnetic resonance imaging revealed tumoral lesion suspected LR in the subcutaneous tissue on right back. Pathological result of biopsy was LR of chondrosarcoma. The tumor was located on biopsy tract, where there was no intraoperative tumor exposure, indicating LR from NTS. After resection of the recurrent tumor, the patient has progressed without local re-recurrence within the 3-year postoperative follow-up period.

Conclusion

In this study including 41 cases, one case of primary chondrosarcoma developed LR from NTS. While more attention for LR from NTS is needed after needle biopsy for primary malignant spine tumors, the risk of LR from NTS is expected to be low in spinal metastatic carcinomas that are more common in clinical practice.

Prevalence and risk factors for development of venous thromboembolism after spinal tumor surgery

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Introduction

In treatment of spinal tumors, surgical treatment plays a critical role. Surgical approaches to spinal tumors often necessitate extensive reconstruction of the spinal column and may require adjuvant therapy. Hence, perioperative complication rates after spinal tumor surgery are higher than in other spinal operations.

Among the perioperative complications, venous thromboembolism (VTE), including deep vein thrombosis (DVT) and pulmonary thromboembolism (PTE) is deleterious complication that can be fatal. Therefore, it is important to take measures effective for preventing and countering VTE during perioperative period of spinal tumor surgery.

However, the prevalence and underlying risk factors for VTE after spinal tumor surgery are still not well defined.

Methods

Between 2008 and 2015, a total of 103 consecutive patients undergoing surgery for spinal tumors with postoperative screening for DVT/PTE at the authors' institution were reviewed. Exclusion criteria was as follows; (1) patients who were received 2 staged surgeries, 2) patients who were treated with heparin for VTE which was detected in preoperative examination and 3) patients whom we could not collect complete medical data.

All patients received mechanical prophylaxis, including compression stockings and intermittent pneumatic compression devices from induction of general anesthesia to postoperative ambulation. No anticoagulation medications were used for prophylaxis against VTE. All patients were examined with duplex ultrasonography of both lower extremities to check DVT. Furthermore, to screen PTE, all patients also underwent lung perfusion scintigraphy or multidetector computed tomography. All examination was performed 7-10 days after surgery.

In this study, we evaluated the relationship between postoperative VTE and following factors: age, sex, height, weight, body mass index, location of tumor, type of tumor (primary or metastasis), type of operation (excisional surgery or palliative surgery), surgical approach (posterior or combined), operative time, intraoperative blood loss, perioperative transfusion, amount of transfusion, duration of postoperative bed rest (<7 days or >7 days), preoperative paralysis and postoperative neurological worsening.

Results

The present study included data from 96 eligible patients. The overall prevalence of VTE was 25.0% (24/96). The rate of DVT and PTE were 20.8% (20/96) and 6.3% (6/96), respectively. No patient had symptomatic DVT, and only one patient had symptomatic PTE. Of 24 VTE-positive patients, distal DVT only was identified in 14 (58.3%), proximal DVT only was identified in 4 (16.7%), PTE only was identified in 4 (16.7%), and both PTE and DVT were identified in 2 (8.3%). In univariate analysis, duration of postoperative bed rest was significantly longer in VTE groups than that in non-VTE groups (P=0.03). In multivariate logistic regression analysis, only prolonged duration of postoperative bed rest was significant independent risk factor for postoperative VTE (Odds ratio, 3.22; P=0.036).

Conclusion

The prevalence of VTE after spinal tumor surgery is 25.0%. Prolonged duration of postoperative bed rest was a significant risk factor for developing VTE in spinal tumor surgery. No DVT was found in 4 of 6 patients with positive PTE, suggesting screening for PTE itself is also needed in the high-risk cases of VTE.

Factors Associated with an Increased Risk of Developing Postoperative Symptomatic Lumbar Spondylolisthesis after Decompression Surgery: A Two-centre International Cohort Study

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Introduction: Symptomatic lumbar spinal stenosis can be treated with decompression surgery. A recent review reported that, after decompression surgery, 1.6-32.0% of patients develop postoperative symptomatic spondylolisthesis, and may subsequently be indicated for lumbar fusion surgery. The latter can be more challenging due to the altered anatomy and scar tissue formation. It remains unclear why some patients develop postoperative symptomatic spondylolisthesis, though some risk factors have been suggested. This study evaluates the association between key demographic, biological and radiological factors and postoperative symptomatic spondylolisthesis after lumbar decompression.

Methods: This retrospective cohort study included patients who had undergone lumbar spinal decompression surgery between January 2014 and December 2016 at one of two specialist Spine Centres in the Netherlands or Switzerland. Patient characteristics and details of the surgical procedure were extracted from patient charts. Preoperative MRI-scans and X-rays of the lumbar spine were evaluated for multiple morphological and pathological characteristics. Patients with and without postoperative spondylolisthesis, confirmed with postoperative MRI-scans, were compared. Univariate and multivariable logistic regression analyses were used to identify statistical predictors of postoperative spondylolisthesis for single and multilevel surgeries.

Results: 1094 surgical levels in 741 patients, were included in the analyses. Preoperative X-rays were available for 488 patients, while MRI was available for all. ICCs for intraobserver and interobserver reliability of measurement of X-ray and MRI variables were all >0.60 (range intra 0.81-0.99, range inter 0.67-0.97). In the group of single level decompression surgery, 52/420 surgical levels (12.4%) developed postoperative symptomatic spondylolisthesis. In the group of multilevel decompression surgery, 48/685 surgical levels (7.0%) in 39/295 patients developed postoperative symptomatic spondylolisthesis. Multivariable logistic regression identified six significant independent risk factors in patients with single level decompression surgery: female sex (odds ratio (OR) 3.639, 95%CI 1.559-8.492), lower BMI (OR 0.868, 95%CI 0.789-0.956), Rheumatoid Arthritis (OR 3.601, 95%CI 1.075-12.067), preoperative spondylolisthesis (OR 7.124, 95%CI 3.194-15.888), and increased cross-sectional area of M. psoas (OR 68.155, 95%CI 4.505-1031.160). Facet degeneration grade 2 resulted in a lower risk compared to grade 3 (OR 0.419, 95%CI 0.182-0.963). Multivariable logistic regression identified one significant independent risk factor in patients with multilevel decompression surgery: preoperative spondylolisthesis (OR 38.857, 95%CI 16.499-91.515). The Hossner and Lemeshow test (P=0.937 in single level surgeries) and Nagelkerke R-square (P=0.315 in single level surgeries and P=0.396 in multilevel surgeries) showed a good model fit.

Discussion: Being female and having lower BMI, Rheumatoid Arthritis, higher facet degeneration grade, preoperative spondylolisthesis and an increased cross-sectional area of M. psoas were associated with a higher risk of having postoperative symptomatic spondylolisthesis after single level decompression surgery. Preoperative spondylolisthesis was associated with a higher risk of having postoperative symptomatic spondylolisthesis after multilevel decompression surgery. These associations can be used for shared-decision making when deciding for decompression surgery versus lumbar fusion surgery in patients with lumbar spinal stenosis.

Small Preoperative Dural Sac Cross-Sectional Area and Anteriorly Placed Fusion Cages Are Risk Factors for Indirect Decompression Failure after Oblique Lateral Interbody Fusion (OLIF)

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Introduction It is unclear what factors are associated with failed indirect decompression with OLIF surgery. We aim to investigate the clinical and radiological parameters associated with revision posterior decompression surgery.

Methods From February 2015 to December 2019, 103 consecutive patients (206 levels) who underwent OLIF with or without posterior instrumentation were studied. Of these, 11 patients (18 levels) were excluded due to missing postoperative MRI scans. 92 patients (aged 69.4±8.5 years; 188 segments) were included for analysis. Radiographic variables measured pre- and postoperatively included disc height, segmental lordosis, foraminal height and area, diameter of the bulging disc, spinal canal diameter and area, dural sac diameter and area, left and right axial subarticular diameter, left and right ligamentum flavum (LF) thickness, and LF area. Cages with different heights (10mm, 12mm, or 14 mm) and different positions (anterior or posterior) were compared for radiographic results. Visual Analogue Scale (VAS), revision surgery and persistent neurological symptoms were recorded. Indirect decompression failure (IDF) was defined as revision surgeries within 6 months and persistent compressive symptoms 6 months after the surgery.

Results Taller cages were associated with more shrinkage of the bulging disc (10-mm cages: -0.1±1.1 mm; 12-mm cages: -0.2±1.1 mm; 14-mm cages: -0.9±1.3 mm; p=0.020) and better dural sac diameter increase (10-mm cages: 1.4±1.5 mm; 12-mm cages: 1.6±1.7 mm; 14-mm cages: 2.7±2.1 mm; p=0.011). Anteriorly placed fusion cages are associated with better segmental lordosis correction (anterior cage: 1.2±4.3 degrees; posterior cage: -0.1±3.9 degrees; p=0.045), while surgical levels treated with cages placed in posterior positions showed larger postoperative left (anterior cage: 2.3±1.3 mm; posterior cage: 2.7±1.3 mm; p=0.048) and right subarticular diameter (anterior cage: 2.3±1.4 mm; posterior cage: 2.8±1.4 mm; p=0.013). 12 patients (16 levels) had IDF, among which 15 levels underwent reoperation for posterior decompression. Multivariate logistic regression showed that after adjusting for age, sex, and BMI, small preoperative dural sac cross-sectional area (CSA) (OR 0.967 [95% CI 0.933 to 0.995]; p = 0.037) and anteriorly positioned cage (OR 0.293 [95% CI 0.088 to 0.886]; p = 0.034) were independent risk factors for IDF. For preoperative dural sac CSA, ROC curve showed that the most appropriate threshold for preoperative dural sac CSA was 44.1 mm2 (sensitivity 91.3%, specificity 81.3%).After adjusting anteroposterior diameter of the lower endplate of each surgical level into a 0-10 scale, ROC curve showed that the most appropriate threshold for cage center position was 4.913 (sensitivity 62.5%, specificity 80.8%).

Discussion In OLIF surgery, taller cages provide more stretch to the disc space and ligamentum flavum while posteriorly placed cages provide more symptom relief in patients with subarticular stenosis. To maximize symptom relief and to avoid reoperation, surgeons should aim to place the center of the cage at the posterior half of the disc space when performing OLIF. Surgical levels with a preoperative dural sac CSA < 44 mm^2 may not be suitable for indirect decompression.

Mast cells and smoking interaction in intervertebral disc degeneration

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Introduction: Both smoking and low back pain (LBP) are common conditions worldwide. However, the correlations and molecular mechanisms between them are lacking.

Methods: Prospective observational study was conducted to evaluate the clinical outcomes in 56 discectomy patients who are smokers, former smokers, and never smokers. Tightly controlled amounts of cigarette smoke were delivered to the airways of mice, development of spinal pain and intervertebral disc degeneration (IVDD) were assessed by micro-CT, differentiation assay, proteomics analysis, and histology. These models showed hallmark features of mast cell (MC) activation. The functions of human bone marrow-derived MCs from LBP patients who are smokers and never smokers were analyzed in vitro. The role of MCs tryptase in IVDD pathogenesis were evaluated by *in vivo* and *in vitro* studies. MCs tryptase potential targeting for nucleus pulposus cells was examined using methylated RNA immunoprecipitation sequencing (MeRIP-seq) and transcriptomic RNA sequencing (RNA-seq). The MCs tryptase regulated RNA stability and binding target gene were assessed by RNA stability assay and RNA immunoprecipitation assays. The MCs tryptase targeted protein-protein interaction were explored by co-immunoprecipitation and proteomics.

Results: Current smoking status showed poor back pain VAS and ODI scores compared with never smokers. The in vivo study showed smoking exposure can induce disc degeneration in mouse models. Smoking exposure can induce mast cells activation and tryptase release inside the disc tissues. Tryptase-beta promotes nucleus pulposus (NP) degeneration via N6-Methyladenosine (m6A)-mediated upregulation of DIX Domain Containing 1 (DIXDC1) which is m6A “writer” protein, METTL14, regulated. The upregulated DIXDC1 were revealed to impact NP cells senescence and cell cycle.

Discussion: This study provided clues that smoking can induce disc degeneration as a single factor. It also revealed the detailed molecular mechanisms of how smoking exposure has effect on human NP cells. This study provided therapeutic targets for low back pain patients, especially those smokers.