COMPENSATORY MECHANISMS OF LOWER LIMB IN ADULT SPINAL DEFORMITY - IS THE ANKLE DORSIFLEXED OR PLANTER-FLEXED?

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Introduction
Patients with adult spinal deformity (ASD) compensate their spinal using their lower-limb compensatory mechanisms (LCMs). When a patient has a decreased lumbar lordosis (LL), the center of gravity (COG) shifts anteriorly. Anteriorly shifted COG is corrected backward and its vertical position is kept on the feet by LCMs (such as hip extension and knee flexion). As for LCMs by ankle, planter flexion also induces posterior translation of COG (Barrey, et al, 2011). However, recent studies based on the full-body (head to toe) radiographic evaluation indicate that ASD patients dorsiflex their ankle. The aim of this study is to clarify the detail of LCMs to explain this contradiction using a simple mathematical model.

Methods
This full-body mathematical model consists of 15 segments (i.e., head, upper trunk, lower trunk, upper arms, anterior arms, hands, thighs, lower legs, and feet), which were connected by 14 joints. We defined the base of the feet (12 cm anterior from heels) as the coordinates of the origin of sagittal plane [(y, z)=(0cm, 0cm)]. The coordinates of the COG were calculated based on the weight and the relative location of each segment, which were determined based on the previous literatures and our original data. First, we developed a healthy model (model-H, PI=52, LL=−60), second a lumbar kyphosis model (model-LK, PI=52, LL=0), and finally compensated lumbar kyphosis models. In compensated models, at first, the degrees of hip extension (He=0, 10, 20) and ankle dorsiflexion (Ad=−5, 0, 5, 15) were determined. Then, in each model, the vertical position of COG is corrected backwards and restored on the feet (y = 0cm) by knee flexion, and the degree were recorded. We also calculated each of sagittal parameters and the moments of forces (MOFs) at the posterior corner of sacrum, hip, and knee joint.

Results
Representative results are shown in figure. Five-degree ankle dorsiflexion causes 8-degree increase in knee flexion, resulting in 3-degree PT increase, 2 cm SVA decrease and 50-70 cm*Kg decrease in MOF at sacrum and hip joints. Ten degree hip extension causes 3-degree decrease in knee flexion, resulting in 7-degree PT increase, 4 cm SVA decrease, and 80-150 cm*Kg decrease in MOF at sacrum and hip joints. More than 5-degree ankle dorsiflexion shifts knee joints anteriorly to COG, resulting in increased MOF at knee joints.

Conclusion
Ankle dorsiflexion causes additional knee flexion, resulting in increased PT and decreased SVA and MOF at sacrum and hip joints.
Figure: Representative results. Model-LK: lumbar kyphosis model. In compensated models, "He" indicates degree of hip extension, and "Ad" indicates degree of ankle dorsiflexion. Moment (sum): sum of moments of forces at sacrum, hip and knee joints.

<table>
<thead>
<tr>
<th>Model</th>
<th>Healthy Model</th>
<th>Model-LK (No CMs)</th>
<th>Compensated models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>He0 Ad5</td>
<td>He0 Ad5</td>
</tr>
<tr>
<td>Knee flexion</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Ankle dorsi.</td>
<td>0</td>
<td>0</td>
<td>-5</td>
</tr>
<tr>
<td>Hip ext.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PT</td>
<td>16</td>
<td>16</td>
<td>26</td>
</tr>
<tr>
<td>SVA</td>
<td>0cm</td>
<td>32cm</td>
<td>28cm</td>
</tr>
<tr>
<td>Moment (sum)</td>
<td>460kгcm</td>
<td>2105kgcm</td>
<td>1904kgcm</td>
</tr>
</tbody>
</table>

Disclosures:
author 1: none; author 2: none
GAIT ASSESSMENT IS IMPORTANT FOR POSTOPERATIVE EVALUATION OF CORRECTIVE FUSION FOR ADULT SPINAL DEFORMITY: A 2-YEAR FOLLOW-UP

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Introduction:
Standing radiographic parameters and health related QOL are typically used to evaluate ASD patients. It is also important to investigate how patients’ gait actually improves. In this study, we investigated walking posture and speed before surgery and one and two years postoperatively, and determined the relationship between walking parameters and health-related QOL in ASD patients.

Method:
Of 151 ASD cases, 31 patients (5 men, 26 women; mean age, 71 years [range, 58-82 years]) who underwent extensive corrective fusion between 2011 and 2013 were included, and underwent gait analysis before surgery, and one and two years postoperatively. All patients underwent fusion from the thoracic spine to the pelvis. A 4-meter walk was recorded at pre-op, and one and two years post-op. Gait-trunk tilt angle, the maximum knee extension angle during 1 gait cycle, step length (cm), and walking speed (m/s) were measured. Radiographic parameters [lumbar lordosis (LL), pelvic tilt (PT), pelvic incidence (PI), and sagittal vertical axis (SVA)], and health-related quality-of-life score [(scoliosis research society (SRS)-22r questionnaire, Oswestry disability index (ODI) score) were analyzed.

Results:
There was statistically significant improvement in both radiographic and health related QOL scores at 2-year follow-up compared to baseline (Table 1). In gait analysis, the mean preoperative gait-trunk tilt angle was 13.0°, which significantly improved to 5.6° and 6.1° at one year and two yrs post-op. The mean preoperative walking speed was 37.8 m/s, which improved to 42.5 m/s and 41.6 m/s at one and two yrs post-op. Although ODI did not correlate with SVA, PI minus LL, and PT two yrs post-op, ODI did correlate with walking speed 2 yrs post-op (r = - 0.419, P = 0.021) In addition, the ODI change did not correlate with SVA change and PI minus LL change, but correlated with walking speed change (r = - 0.551, P = 0.001).

Conclusions:
Corrective fusion surgery for ASD improved walking posture and knee extension restriction 2 years postoperatively. The post-op health-related QOL is related to walking speed rather than radiographic parameters. Therefore, it is important to properly assess not only radiograph results but also the patient’s walking state.
Table 1. Radiographic findings, clinical outcome findings and gait analysis findings

| Parameters                                      | Baseline   | One yr post-op | Two yrs post-op | p value*  
|------------------------------------------------|------------|----------------|-----------------|-----------
| Radiographic parameters                        |            |                |                 |           
| Lumbar lordosis (°)                             | 11.6 ± 17.4| 38.7 ± 12.4    | 41.7 ± 11.6     | <0.001    
| Pelvic tilt (°)                                 | 35.1 ± 8.7 | 24.5 ± 0.0     | 25.8 ± 9.2      | <0.001    
| Pelvic incidence minus lumbar lordosis (°)      | 40.3 ± 17.5| 13.3 ± 15.3    | 12.1 ± 15.3     | <0.001    
| Sagittal vertical axis (mm)                     | 127.5 ± 79.6| 50.6 ± 49.7   | 52.4 ± 51.5     | <0.001    
| Clinical outcome parameters                     |            |                |                 |           
| SRS-22R Activity                               | 2.48 ± 0.60| 3.26 ± 0.82    | 3.33 ± 0.71     | <0.001    
| SRS-22R Pain                                   | 2.43 ± 0.85| 3.76 ± 0.83    | 3.78 ± 0.86     | <0.001    
| SRS-22R Self-image                             | 2.17 ± 0.83| 3.62 ± 0.73    | 3.54 ± 0.74     | <0.001    
| SRS-22R Mental                                 | 2.45 ± 0.67| 3.31 ± 0.66    | 3.26 ± 0.61     | <0.001    
| Oswestry Disability Index                      | 50.5 ± 14.9| 28.8 ± 20.7    | 30.5 ± 20.7     | <0.001    
| Gait Parameters                                |            |                |                 |           
| Gait-trunk tilt angle (°)                       | 13.0 ± 10.5| 5.6 ± 4.8      | 6.1 ± 5.7       | 0.002     
| Maximum knee extension angle (°)                | ±13.5 ± 6.6| ±9.3 ± 6.6     | ±9.0 ± 6.3      | 0.008     
| Step length (cm)                                | 40.2 ± 9.0 | 48.7 ± 9.5     | 42.1 ± 9.5      | 0.314     
| Walking speed (m/min)                           | 37.8 ± 10.8| 42.3 ± 10.2    | 41.8 ± 11.4     | 0.147     

* Mean values are presented as mean ± SD. Bold type indicates statistical significance. †Comparison between baseline and two year postoperative parameters. SRS, scoliosis research society

Disclosures:  
APPROPRIATE RESTORATION OF THE INDIVIDUALIZED SAGITTAL PLANE (GAP SCORE) AND PRESENCE OF SACROILIAC FIXATION INDEPENDENTLY DETERMINE MECHANICAL COMPLICATIONS AFTER 3-COLUMN OSTEOTOMIES

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Summary
In 81 patients that had undergone 3-Column osteotomy (3CO) procedure, reconstruction of the sagittal plane according to the individualized shape and alignment, and sacroiliac (SI) fixation was found to be independent predictors of mechanical complications.

Hypothesis
There are certain independent risk factors that cause mechanical complications after 3CO.

Design
Retrospective analysis of a prospectively collected data of adult spinal deformity pts.

Introduction
3CO performed for sagittal plane deformities have been associated with a higher rate of mechanical complications. Several preventing techniques (double rod, interbody fusion etc.) have been suggested to decrease mechanical complication rates. The aim of this study was to analyze the independent risk factors that influence mechanical complications after 3COs.

Methods
Inclusion criteria: having a 3CO, and ≥2y f/up. Mechanical complications: PJK/PJF, DJK/DJF, rod breakage and implant-related complications. >25 factors that have been reported to influence mechanical complications were evaluated. Univariate (Chi-square test and Mann Whitney U) and multivariate analyses (Multiple Logistic Regression following stepwise backward elimination) were conducted to determine independent factors that influence mechanical complications.

Results
81 pts (60F, 21M) were included. Mean age: 59.1±15.1(22-80) years. Mean f/up: 31.2±10.6(24-61) months. 67 patients had a PSO, and 14 had a VCR. 33 osteotomies were performed in the lower, while 30 were in the upper lumbar arc and 18 were in the thoracic. Univariate analysis revealed age, BMI, ASA, Prior Spine Surgery, Rod Diameter, SI fixation, osteotomy type and level, and GAP Score (individualized sagittal plane shape and alignment) to be significant (p <0.05) and near-significant (p> 0.25) as factors to be included in multivariate analysis. Multivariate regression revealed GAP score and SI fixation to be independent factors that influence mechanical complications. The association between the GAP score, SI fixation and mechanical complications are given in Fig 1.

Conclusion
The GAP Score and presence of SI fixation are two independent risk factor for mechanical complications after 3COs. Planning surgeries according to individualized sagittal plane shape and alignment may decrease mechanical complication rates especially in patients fused to sacrum or pelvis.
Disclosures:
IMPACT OF ADULT SCOLIOSIS ON THE TYPE OF SAGITTAL PROFILE

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Introduction. Roussouly described a 4-type sagittal profile classification in healthy individuals, which has been also applied to patients with degenerative spinal disease. However, it remains uncertain if its principles can be applied to adult scoliosis (AS) patients. The aim of this study was to determine the impact of AS on the type of Roussouly’s sagittal profile in terms of classification applicability, scoliosis modification of a patient theoretical sagittal profile, and coronal-sagittal deformity associations.

Methods. Retrospective analysis of data collected prospectively in an adult spine deformity multicenter database. Only AS patients were included. Preoperative sagittal radiographs were analyzed using the KEOPS software to measure pelvic parameters, global sagittal alignment, and the various criteria used for the Roussouly classification. The different sagittal profile types were compared using the chi-square test, ANOVA (Bonferroni posthoc correction), and Pearson’s correlation coefficient.

Results: The classification was applicable to all of the 190 analyzed AS patients. In addition to Roussouly’s criteria, 2 parameters helped differentiate the different profiles: T10-L2 angle (24°±19 type-1; 14°±15 type-2; 3°±15 type-3; 0.4°±14 type-4; P<0.001), and L4-S1 percentage contribution to total lordosis (90%±17 type-1; 83%±16 type-2; 73%±21 type-3; 63%±16 type-4; P<0.001). AS changed the theoretical profile in 34% of the patients (P<0.001, kappa=0.55). Curve etiology and curve pattern were not associated with any particular type of sagittal profile (P>0.05). Type-1 was associated with older patients (P=0.02), degenerative curves (P=0.02), and greater PI-LL mismatch (P=0.012). Types 3-4 were associated with younger age and idiopathic etiology (P<0.001).

Conclusions: Roussouly’s 4-type sagittal profile classification could be applied to AS patients. AS modified the theoretical profile in 1 of every 3 patients. No particular association was found between the sagittal types and specific coronal deformities. However, degenerative curves were associated with older age and type 1 profile, while idiopathic (thoracic and double curves) were associated with younger age and type 3-4 profiles. This information can be useful when planning the surgical restoration of patients’ proper sagittal profile.
Disclosures:
THE STRATEGY OF TREATMENT SEVER ADULT SPINAL DEFORMITY (SASD) WITH RESPIRATORY FAILURE

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Background: The cobb angle of ASD is positively correlative with the extent of pulmonary function impairing and it seriously threaten patient with quality of life and safety of surgery. However, it has been rarely reported that strategy of treating sASD with respiratory failure.

Objective: To summarize effective surgical strategy for sASD with respiratory failure.

Methods: Accepting criteria: arterial blood gas analysis (ABGA) of PO2<60mmhg, The ASD coronal and/or sagittal Cobb angle more than 100°. We prospectively evaluated 12 cases of sASD with respiratory failure (mean age: 28.2years ,9 cases of respiratory failure type I and 3 cases of typeII) who were mean ABGA of PO2 55.3mmhg and PCO2 46mmhg from 2013-2015. 41.7%(5/12) patient suffered from pneumonia. All patients were treated by traction (Halo gravity traction (HGT) for 8.2 weeks and then skull-femoral traction(SFT) for 2weeks) combine respiratory and nutrition therapy before operation.

Results: The mean coronal Cobb improved from 115.4° to 95.7° after traction and to 55.1 post-op. The mean sagittal Cobb improved from 91.8° to 71.9° after traction and to 41.3° post-op. There were only 7 patients (58%) required a vertebral column resection. 5 patients with pneumonia were controlled by antibiotic. Mean HGT and SFT weight was 25 and 56% of total body weight. After traction and respiratory and nutritional treatment prior to surgery, AGSA demonstrated that 44.4% (4/9) respiratory failure of type I were corrected respiratory failure, 66.7% (2/3) of respiratory failure of type II were improved to type I, AGSA was improved to 59.4 mmhg, PCO2 43.5mmhg, all patients consciously felt symptom of dyspnea improved. And mean body weight increased 8.1%. The post-op mean ICU retention time was 109h and tracheal tube retention time was 44h. At 2yrs follow-up, AGSA was improved to PO2 76.5 mmhg, PCO2 41.5mmhg and their activity obviously increased.

Conclusions: Preoperative traction combined with respiratory and nutritional treatment effectively improved curve magnitude, respiratory failure and nutritional status of sASD and increased safety of surgery, but it needed a long time to treatment and adjust. The sASD with respiratory failure were often accompanied by pneumonia and anti-infection therapy was necessary pre-op. The respiratory failure was achieved to spontaneous correction at post-op.
Table 1. Comparison of the changes in pre-op, after traction, post-op, 2yrs follow up.

<table>
<thead>
<tr>
<th></th>
<th>Pre-operation</th>
<th>After traction combined respiratory and nutritional treatment prior to surgery</th>
<th>Post-operative weeks</th>
<th>2</th>
<th>2 years follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>coronal Cobb angle</td>
<td>115.4±18.2°</td>
<td>95.7±14.8° *</td>
<td>55.1±8.3° *</td>
<td>55.4±7.7° *</td>
<td></td>
</tr>
<tr>
<td>sagittal Cobb angle</td>
<td>91.8±33.4°</td>
<td>71.9±26.7° *</td>
<td>41.3±12.1° *</td>
<td>45.7±11.0° *</td>
<td></td>
</tr>
<tr>
<td>PO2</td>
<td>55.3±2.3mmHg</td>
<td>59.4±1.9mmHg *</td>
<td>58.7±2.5mmHg *</td>
<td>76.5±5.9mmHg *</td>
<td></td>
</tr>
<tr>
<td>PCO2</td>
<td>46±4.4mmHg</td>
<td>43.5±5.7mmHg *</td>
<td>42.7±3.7mmHg *</td>
<td>41.5±3.2mmHg *</td>
<td></td>
</tr>
<tr>
<td>respiratory failure</td>
<td>Type I 9 cases</td>
<td>Type I 7 cases Type II 1 case (4 cases correct respiratory failure)</td>
<td>Type I 19 cases</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>body weight</td>
<td>37.1±6.9 Kg</td>
<td>40±7.0 Kg *</td>
<td>40.2±6.7 Kg *</td>
<td>42±6.5 Kg *</td>
<td></td>
</tr>
</tbody>
</table>

* Significantly different from the pre-operation (p < 0.05).

Disclosures:
SURGICAL VERSUS NON-OPERATIVE TREATMENT OF ADULT SPINAL DEFORMITY: A SYSTEMATIC REVIEW AND META-ANALYSIS
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Introduction
Adult spinal deformity encompasses a spectrum of disorders including adult degenerative and adult idiopathic deformities affecting the coronal and sagittal planes. They present a significant burden of disease with pain and disability. While the number of publications in the field has constantly been rising in the past years, there is a paucity of good quality articles specifically comparing surgical to non-operative treatment. We therefore aimed to review the literature and assess the evidence for either treatment using techniques of meta-analysis.

Methods
A systematic literature search of clinical studies published until 31 December 2017 reporting outcomes after surgery for adult spinal deformity was performed in PubMed and SCOPUS according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Clinical studies of adults over 18 years of age with surgery for adult spinal deformity (degenerative or adult idiopathic) were included for full text review if they reported clinical outcomes at least ODI, SRS-22/-24 or VAS with mean or mean difference and standard deviation. Meta-analysis with calculation of effect sizes based on the mean difference and standard deviation of each treatment arm and meta-regression analysis were carried out using Stata 13 for Mac.

Results
The literature search using the search term as outlined above yielded a total of 1582 records, of which 731 duplicates were removed and 786 were out of scope. After full text review of 65 studies, 12 studies had a non-operative control group and 5 reported outcomes adequately and could be included in the meta-analysis. Only the ODI was reported in all 5 studies and was therefore used for further analysis. All studies together included 1066 patients with 604 patients having had surgical and 462 non-operative treatment. Four of the 5 studies reported outcomes from the International Spine Study Group (ISSG). Publication bias likely related to selection and reporting bias was identified. In the surgical groups, the ODI improved -15.8% (WMD, CI: -18.6, -13.0; p<0.0001), whereas no significant change was noted in the non-operative groups (0.44% WMD, CI: -1.70, 2.58; p=0.686). The studies yield a pooled treatment effect of 0.9 (SMD, CI: 0.74,1.06) favouring surgery which is significantly higher than the MCID (p<0.0001). Meta-regression showed that neither age nor length of follow up had a significant effect as a covariate on outcome.

Conclusion
No high-quality prospective observational or randomised study was found and a publication bias in the literature was identified, including a lack of structured non-operative treatment. Whereas the surgical patients had a significant improvement, non-operatively treated patients had no
improvement compared to baseline.

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>SMD (95% CI)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li et al.</td>
<td>2009</td>
<td>1.30 (0.82, 1.78)</td>
<td>9.48</td>
</tr>
<tr>
<td>Scheer et al.</td>
<td>2015</td>
<td>0.89 (0.68, 1.09)</td>
<td>34.77</td>
</tr>
<tr>
<td>Scullica et al.</td>
<td>2016</td>
<td>1.45 (0.59, 2.31)</td>
<td>3.24</td>
</tr>
<tr>
<td>Smith et al.</td>
<td>2016</td>
<td>0.83 (0.54, 1.12)</td>
<td>21.27</td>
</tr>
<tr>
<td>Smith et al.</td>
<td>2013</td>
<td>0.79 (0.57, 1.01)</td>
<td>31.24</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td>0.90 (0.74, 1.06)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

NOTE: Weights are from random effects analysis

Disclosures:
author 1: other financial report: Speaker's bureau: Nuvasive, Medtronic, Depuy Synthes; author 2: none; author 3: none
DEVELOPMENT OF DEPLOYABLE PREDICTIVE MODELS FOR MCID OF 2 YEAR OUTCOMES ACROSS ALL COMMONLY USED HRQOL INSTRUMENTS IN ADULT SPINAL DEFORMITY SURGERY: RESULTS IN 570 PATIENTS FROM 17 HOSPITALS


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Introduction

ASD surgery is costly with variable outcomes; in some series only 50% of patients achieve MCID improvements. Predictive analytics may accurately model HRQOL improvements after ASD surgery. Predictive modeling may be useful in shared-decision making and surgical planning. The objective of this study was to model health-related quality of life (HRQOL) overall improvement, including the likelihood of achieving clinically important improvement, at 2 years postoperatively.

Methods

Two prospective observational cohorts were queried for ASD patients with SRS-22 / ODI / SF-36v2 data at baseline, 1 year and 2 years after surgery. 75 variables were used in the training of the models including demographic data, enrollment HRQOL, and modifiable surgical data. 8 different prediction algorithms were trained with 3-time horizons: baseline to 1-yr, baseline to 2-yr and 1-yr to 2-yr. External validation was accomplished via an 80/20 data split for training and testing each model, respectively. 5-Fold cross validation within the training sample was performed. Accuracy was measured as the mean average error (MAE; smaller is better) and R² values.

Results

570 patients were included in the analysis. Models with the lowest MAE for each of the 5-time points were selected; ultimately the model had 82.4% predictive power. Patients with lower enrollment HRQOL were likely to appreciate the greatest improvements in HRQOL at 2-yr followup. Addition of surgeon and site to preoperative data increased the predictive power 1.8%. Site and surgeon fixed-effects played a crucial role in explaining outcome variance.

Conclusion

We present an accurate and consistent way of predicting outcome scores for ASD surgery in the largest-to-date prospective operative multicenter cohort with 2-year follow-up. This study has significant clinical implications for shared-decision making, surgical planning and postoperative counseling. Surgeon and site were important components of the model, explaining variance in predicted 2-yr HRQOL.
Table 1: Sample patient output from outcome predictor with simulation of delaying surgery 5 and 10 years

<table>
<thead>
<tr>
<th>HRQL instrument</th>
<th>Baseline Score</th>
<th>Baseline probability to achieve surgical improvement</th>
<th>10% higher baseline HRQL scores</th>
<th>Waiting 5 years with a reduction of 10% HRQL</th>
<th>Waiting 10 years with a reduction of 20% HRQL</th>
<th>Number of Levels from 10 to 15</th>
<th>Range of variation across options</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODI</td>
<td>68</td>
<td>54.4%</td>
<td>43.9%</td>
<td>67.6%</td>
<td>72.9%</td>
<td>54.4%</td>
<td>39.1%</td>
</tr>
<tr>
<td>SRS22 function</td>
<td>3.2</td>
<td>35.4%</td>
<td>28.4%</td>
<td>32.3%</td>
<td>34.3%</td>
<td>24.2%</td>
<td>21.1%</td>
</tr>
<tr>
<td>SRS22 pain</td>
<td>3.2</td>
<td>35.4%</td>
<td>28.4%</td>
<td>32.3%</td>
<td>34.3%</td>
<td>24.2%</td>
<td>21.1%</td>
</tr>
<tr>
<td>SRS22 SI</td>
<td>2</td>
<td>61.4%</td>
<td>47.1%</td>
<td>52.9%</td>
<td>56.8%</td>
<td>43.1%</td>
<td>36.5%</td>
</tr>
<tr>
<td>SRS22 subtotal</td>
<td>2.38</td>
<td>58.6%</td>
<td>45.7%</td>
<td>52.9%</td>
<td>56.8%</td>
<td>43.1%</td>
<td>36.5%</td>
</tr>
<tr>
<td>SF-36 MCS</td>
<td>21.20</td>
<td>50.7%</td>
<td>38.5%</td>
<td>43.2%</td>
<td>47.1%</td>
<td>33.9%</td>
<td>27.5%</td>
</tr>
<tr>
<td>SF-36 MCS</td>
<td>38.18</td>
<td>61.5%</td>
<td>48.6%</td>
<td>54.7%</td>
<td>58.7%</td>
<td>45.8%</td>
<td>39.7%</td>
</tr>
</tbody>
</table>

Note: Patient Female with 1 prior spine surgery, with loss of balance, without comorbidities, employed, steady gait, 65 years old, 187 cm height, 83.5 kg weight, 71.69 sagittal balance, 11.9° of major curve Cobb angle, 50° pelvic tilt. Surgery: pelvic fusion, 7 fused vertebrae, posterior instrumentation, 1 PSO, 0 SPO, no PLF, no ALIF. 10 levels between LV and LV and intervertebral fusion.

Disclosures:
SUCCESSFUL CREATION OF DEPLOYABLE PREOPERATIVE PREDICTIVE RISK CALCULATORS FOR INDIVIDUAL PATIENT EVENT-FREE SURVIVORSHIP FOR MAJOR COMPLICATIONS, HOSPITAL READMISSIONS AND UNPLANNED SURGERY FOLLOWING ADULT SPINAL DEFORMITY (ASD) SURGERY

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Introduction
Accurate preoperative risk stratification in Adult Spinal Deformity (ASD) surgery is indispensable to improve patients’ selection, accordingly adjust surgical invasiveness and optimize outcomes. Few predictive models allow for proper patient selection, adjustment of invasiveness and patient frailty optimization to predict and reduce postoperative Major Complications (MC), hospital readmissions (READMIT) and unplanned surgery (UNPLAN). We aim to create accurate predictive models for the occurrence and timing of these MC, READMIT and UNPLAN following ASD surgery.

Methods
Surgically treated ASD patients with >2 year follow up were identified. Patient demographic, radiographic, operative, baseline PROMs, and complications data were analyzed to build event free survival curves for MC, READMIT and UNPLAN, and to create predictive models by means of a random survival forest with 80/20 train/test sets. A total of 101 variables were used to train the models. Goodness of fit was assessed in the test set. Missing value imputation was performed with the miss-Forest package. R software was used for analysis (Vienna 2016).

Results
1,018 ASD patients operated before September 2014 (77.7% women, 55.5 mean age, 10.7 levels fused segments, 55.5% pelvic fixation, 21.2% 3CO) by 57 surgeons at 24 sites in 5 countries (2 continents), with 2,047.9 observation-years, were included in the analysis used to build MC, READM and UNPLAN risk calculating models with proved successful model fit. Missing value imputation was 14.59%. C-statistic value (70.6%) proved successful model fit. Models demonstrate that 87.9% of patients are MC-free at 10 days postop, 78.5% at 90 days and 63% at 2 years. Surgical invasiveness (LIV-pelvic fixation, length of fusion, prior surgery), age, magnitude of sagittal deformity, patient frailty (walking and lifting capacity) and blood loss most strongly predict MC. Surgeon and site most strongly predict READMIT and UNPLAN. Curves show a continued survivorship decrease for event free MC, READMIT and UNPLAN beyond >2yFU.

Conclusion
Risk calculating models for event free MC, READMIT and UNPLAN following ASD surgery demonstrate that patient-related factors, >1/3 of which are modifiable, account for 55% of the MC predictive model weight. Surgeon and site represent 4% for MC, but are most relevant for READMIT and UNPLAN.
Disclosures:
WOULD SCREW-BASED LONG INSTRUMENTATION WITH S2AI LIMIT THE IMPROVEMENT OF HRQOL?

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Objective: This study was designed to evaluate health-related quality of life of patient after pelvic fixation utilizing S2AI and investigate whether long instrumentation with S2AI will limit the improvement of HRQoL.

Methods: We retrospectively review all patients who underwent placement of S2AI screws at our institution between Jan 2015 and Jan 2016. 26 patients underwent spinal fusion with S2AI pelvic fixation who had complete radiographic data including Computed Tomography scan of sacroiliac joint were enrolled in this study. All patients have received CT scans preoperatively and at last follow-up. CT scans were reviewed to determine whether there was sacroiliac joint fusion, screw lucency or screw fracture. According to the previous study, we chose and applied five tests with high sensitivity and specificity to diagnose sacroiliac joint dysfunction. These tests were administered to all patient at the last follow-up. Three tests resulting positive was regarded as dysfunction. The tests applied were as follows: The Gillet Test, Standing Flexion Test, Distraction Test, Gaenslen's Test and Sacral Thrust Test. Short form-36 (SF-36), Oswestry disability index (ODI), visual analog scale (VAS) and Lumbar Stiffness Disability Index (LSDI) were collected from patients at baseline and again at last follow-up.

Results: twenty-six patients were enrolled (mean age, 50.25±17.05 years), seventeen of them are female. The mean Cobb angle was 36.35° (SD 8.97°) preoperatively and 16.75° (SD 9.24°) postoperatively. The follow-up period ranges from 36 to 42 months. There were no instances of osseous fusion across the sacroiliac joint on the last follow-up CT. All patients resulted negative in the physical exam. There were significant difference between baseline and last follow-up in SF-36 PCS score (35.72 ± 15.71 vs 65.22 ± 18.11; P < 0.05), SF-36 MCS score (44.26±16.83 vs 71.23 ± 15.34; P < 0.05), VAS (5.61 ± 1.63 vs 1.43 ± 1.10; P < 0.05), ODI score (56.16 ± 13.85 vs 17.81±13.46; P < 0.05), LSDI score (52.43 ± 14.80 vs 34.36 ± 8.83; P < 0.05).

Conclusion: S2Al seems to be a superior spinopelvic fixation technique with minor adverse effect on daily life based on our retrospective study. SF-36, ODI, VAS improved significantly after surgery. Meanwhile LSDI score decreased after surgery which indicate the long instrumentation may not stiffen the patients' spine. Sacroiliac joint remains normal function and no observation of osseous fusion across this joint.

Disclosures:

RADIOGRAPHIC OUTCOME AND COMPLICATIONS AFTER SINGLE-LEVEL LUMBAR EXTENDED PEDICLE SUBTRACTION OSTEOTOMY FOR FIXED GLOBAL SAGITTAL MALALIGNMENT: A RETROSPECTIVE ANALYSIS OF 55 ADULT SPINAL DEFORMITY PATIENTS WITH MINIMUM 2-YEAR FOLLOW-UP

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Introduction: Various three-column osteotomy techniques, including the extended pedicle subtraction osteotomy (ePSO), may correct global and regional malalignment in adult spinal deformity (ASD) patients. In contrast to the traditional PSO (Schwab grade 3 osteotomy), there is limited literature reporting outcomes for ePSO (Schwab grade 4 osteotomy) in ASD surgery. The objective of this study was to provide focused investigation of radiographic outcomes and complications for patients undergoing single-level lumbar ePSO for ASD.

Methods: Fifty-five consecutive ASD patients in whom sagittal malalignment was treated with single-level lumbar ePSO at our institution between 2010 and 2015 were analyzed. Radiographic analyses included assessment of segmental lordosis through the ePSO site (sagittal Cobb’s angle measured from the superior endplate of the vertebra above and inferior endplate of the vertebra below the ePSO), lumbar lordosis (LL), pelvic tilt (PT), pelvic incidence and LL mismatch, thoracic kyphosis (TK), and sagittal vertical axis (SVA) on standing long-cassette radiographs. Patients with minimum 2-year follow-up were included and complications were analyzed for the entire group.

Results: Overall, the average postoperative increase in ePSO segmental lordosis and overall LL was 41 ± 14° (range: 7-69°, p<0.001) and 38 ± 11° (range: 9-58°, p<0.001), respectively. The average SVA improvement was 13 ± 7 cm (range of correction: -33.6-+3.4 cm, p<0.001). These measurements were maintained when comparing early postoperative measurement to last follow-up, respectively (mean follow-up 52 months, range: 26-97 months): ePSO segmental lordosis (34° vs 33°, p=0.270), LL (47.3° vs 46.7°, p=0.339), and SVA (4 cm vs 5 cm, p=0.330). Rod fracture (RF) at the ePSO site occurred in 18.2% (10/55), and pseudarthrosis (PA) was confirmed by CT imaging or during rod revision surgery in 14.5% (8/55) of patients overall. Accessory supplemental rods across the ePSO site, a more recently employed technique, significantly reduced occurrence of RF/PA on univariate (p=0.004) and multivariate analyses (OR=0.012, 95% CI 0.0-0.735, p=0.035); this effect approached statistical significance on Kaplan-Meier analysis (log rank test, p=0.053). Interbody cage placement at the ePSO site resulted in greater ePSO segmental lordosis correction (45° vs 35°, p=0.007) without significant change in RF/PA (p=0.304). Transient and persistent motor deficits occurred in 14.5% (8/55) and 1.8% (1/55) of patients, respectively.

Conclusions: ePSO is an effective technique to correct sagittal malalignment in ASD. In comparison to traditional PSO techniques, ePSO may allow greater focal correction with comparable complication rates, especially with interbody cage placement at the ePSO site and use of accessory supplemental rods.
Table 1: Pre- and postoperative sagittal plane radiographic parameters for 55 adult spinal deformity patients treated with single-level lumbar extended P5O.

<table>
<thead>
<tr>
<th></th>
<th>Preop</th>
<th>Early postop</th>
<th>Delta</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL (°)</td>
<td>22.6 ± 12.1</td>
<td>11.9 ± 10.2</td>
<td>64.7 ± 13.3</td>
<td>0.001</td>
</tr>
<tr>
<td>PEL (°)</td>
<td>23.9 ± 14.5</td>
<td>15.6 ± 13.0</td>
<td>89.3 ± 4.0</td>
<td>0.001</td>
</tr>
<tr>
<td>SAG (°)</td>
<td>14.9 ± 7.3</td>
<td>4.4 ± 3.4</td>
<td>32.5 ± 9.0</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Values are expressed as the mean ± SD for continuous variables.

Comparison of preop and postop measurements analyzed with paired samples t-test (two-tailed).

disclosures:

EFFECT OF SATELLITE RODS CONSTRUCTION TO PREVENT ROD FRACTURES FOLLOWING 3-COLUMN OSTEOTOMY IN PATIENTS WITH ADULT SPINAL DEFORMITY

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Objective
Rod fracture (RF) is a frequent implant-related complication following 3-column osteotomy (3-CO) surgery in patients with adult spinal deformity (ASD). Especially, incidence of rod fracture in patients who underwent corrective fusion surgery with pelvic fixation was significantly higher. We started to put satellite rod constructs from 2013, because of high incidence of rod fracture in patients with conventional 2-rod constructs. Two types of satellite rod constructs were utilized to prevent RF. The objective was to verify the effect of satellite rods and to determine the optimal type of satellite rod to prevent RF in patients with 3-CO and pelvic fixation.

Methods
This study was a retrospective case series of patients with 3-CO using a prospectively collected single center database. We retrospectively evaluated consecutive patients who underwent 3-CO from 2013 to 2015 in patients with ASD. The inclusion criteria were patients with a fused pelvis and a minimum of 2-year follow-up. Patients were classified into two groups depending on rods constructs: conventional 2-rod (2R) and 2-rods with satellite rods (SRs). SRs were constructed on the inside from one or both side regular rods using 3 or 4 connectors. The satellite rod constructs were also stratified into two groups according to the location, they covered, only osteotomy site (Short SR) or osteotomy site and lumbosacral junction (Long SR). We analyzed the effect of the SR constructs and determined which model was the best to prevent RF via investigation of the incidence of RF.

Results
A total of 48 patients (average age 67.6 years; follow up rate: 90.6%) were included in this study. Patients with 2R and SR constructs included 25 and 23 cases, respectively. No significant difference was observed in age (2R: 68.9, SR: 66.4), fusion levels (9.3, 9.4), operation time (437 min, 442 min), blood loss (2174 g, 1893 g), and rod composition except radiographic follow-up periods (45.9 months, 33.5 months; p<0.05). The incidence of RF in SR (9 cases, 36%) was significantly lower than that in 2R (17 cases, 68%). Comparing the SR constructs, RF occurred in 7 cases (64%) in short SR and 2 cases (17%) in long SR. RF occurred at the level below the SR construct in 6 of 7 RF cases with short SR.

Conclusions
Satellite rods covering the osteotomy site and lumbosacral junction reduced the incidence of RF following 3-CO surgery. On the other hand satellite rod covering only the osteotomy site did not reduce the incidence of RF.
ISYQOL DISCRIMINATES ADOLESCENTS WITH SPINAL DEFORMITIES SUBGROUPS BETTER THAN THE SRS-22 QUESTIONNAIRE

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Background: Quality of life (QoL) is evaluated in spinal deformities by several questionnaires. Rasch analysis is a statistical methodology to develop good QoL questionnaires, and make them interval instead of ordinal measures. ISYQOL (Italian Spine Youth Quality of Life questionnaire) is the first questionnaire developed through Rasch analysis.

Purpose of the study: To check the discriminative validity of ISYQOL versus the actual gold standard questionnaire (SRS-22).

Materials and Methods: Design: Cross sectional study
Setting: Tertiary clinic specialized in conservative treatment of spinal deformities
Consecutive outpatients were asked to complete SRS-22 (22 items, 5 categories per item) and ISYQOL (20 items, 3 categories per item) questionnaires before consultation. Inclusion criteria: age 10-18; idiopathic scoliosis and hyperkyphosis. Written informed consents were collected, and ethical committee approval obtained.

Multiple linear regressions were computed to predict ISYQOL measure or SRS-22 score (independent variables: age, gender, diagnosis, and bracing). A subgroup analysis was performed through linear regression modelling (variables: age, gender, Cobb degrees, brace dosage and type) to check if each questionnaire was able to discriminate QoL changes according to specific influencing factors.

Results: 1677 participants (1251 females), median age 14 years (1-3 quartile: 11-14).
SRS-22 and ISYQOL scores correlate (Spearman -0.68, R2 0.43, p<0.001) but the best fit is a parabole (R2 0.51). With ISYQOL above 80% SRS-22 does not change (higher ceiling effect). SRS-22 and ISYQoL detect the effect of age, gender, diagnosis (scoliosis vs hyperkyphosis) and bracing (brace vs no brace) on QoL: F=92.42 (p<0.001) for ISYQOL and F=85.59 (p<0.001) for SRS-22. The variables explained 19% and 14% of the variability for ISYQOL and SRS-22 respectively.

The QoL measured by ISYQOL is explained by: age (years), gender, Cobb degrees, brace hours per day and brace type (soft vs hard) (F=10.69; p<0.001; R2=0.11 ); SRS-22 by age and Cobb degrees only (F=13.66; p<0.001; R2=0.05).

Conclusion: ISYQOL is correlated to SRS-22 but with less ceiling effect. It is influenced and described by a greater number of parameters when described by ISYQOL. Thus, despite having considerably less items and categories, ISYQOL appears to be a better measure of QoL during growth in spine deformity individuals in a conservative setting.

OUTCOMES OF SYNDROMIC SCOLIOSIS PATIENTS TREATED WITH MAGNETICALLY CONTROLLED GROWTH RODS
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Introduction - Magnetically controlled growth rods (MCGR) are used in the management of children presenting with Early Onset Scoliosis. Most articles on this subject have published results of a mixed group of patients. This article intends to examine the outcome of purely syndromic children treated with MCGR and compares them to a cohort of idiopathic scoliosis group.

Patients and Methods - All patients who underwent MCGR in our spinal unit were analysed. Data was collected prospectively for operative length of surgery, intraoperative blood loss, any changes in neuromonitoring, change in Cobb coronal and sagittal angles, Proximal Junctional Kyphosis (PJK) T1-T12 height, T1-S1 height and any complications which occurred.

A cohort of syndromic patients was compared to a cohort of idiopathic scoliosis patients.

Results - Nineteen children (M:F = 6:13) of syndromic scoliosis origin were managed surgically with MCGR from December 2011 to October 2015. Their mean age at time of surgery was 101.4 months (range 43 to 171 months) with a mean follow up of 45.5 months (minimum of 24 - 69 months). Eleven patients were primary cases with eight being conversions from Traditional Growing Rods (TGR). The mean length of procedure was 195.2 minutes (range 136 to 305 minutes). The mean blood loss intraoperatively was 459 ml (range 200 to 1112 ml). Neuromonitoring results were normal throughout procedures. The major Cobb coronal angle significantly improved from 55.9° preoperatively to 42.4° at latest follow-up (p = 0.001). The T1-T12 height improved significantly from 169.2 mm preoperatively to 191.2 mm at final follow-up (p=0.0017). T1-S1 height significantly improved from 289.6 mm preoperatively to 333.3 mm at final follow-up (p=0.0001). Six children of our syndromic cohort were determined to have PJK (>10° difference from postoperative to latest follow up. The average PJK angle was 31.4° (range - 17°-57.3°). In total six patients experienced a non-medical related complication.

Nine children (M:F = 7:2) of idiopathic origin were managed surgically with MCGR from December 2011 to October 2015. Their mean age at time of surgery was 94.6 months (range 35 to 133 months) with a mean follow up of 34.2 months (minimum of 24 - 52 months). Seven procedures were primary cases. Data was collected for all parameters as was performed with the syndromic cohort and analysed in detail.

The syndromic group was noted to have a longer procedure (p value 0.0001) and increased blood loss (p value 0.0001 and increased complications as compared to the idiopathic group.

Discussion - Syndromic scoliosis presentations are known to present early, progress rapidly and respond poorly to nonoperative treatment methods. Operative intervention is known to be a higher risk for complications as compared to idiopathic EOS presentations. Management of this group of children
requires a multidisciplinary approach with thorough planning, anticipating complications to ensure a good result.

Disclosures:
author 1: none; author 2: none; author 3: none; author 4: none
CLINICAL AND RADILOGIC OUTCOMES OF POSTERIOR ONLY HEMIVERTEBRA RESECTION AND SHORT SEGMENT FUSION WITH PEDICLE SCREW FIXATION IN CHILDREN YOUNGER THAN 5 YEARS: MINIMUM 10 YEARS FOLLOW-UP

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Design: Retrospective study.

Introduction: Previous studies evaluated midterm outcomes of posterior hemivertebra resection and short-segment fusion technique in patients under age 5 years, however there are few studies with long term outcomes. This study evaluates long term outcomes of 13 patients with congenital scoliosis who underwent this technique under 5 years and had min. 10 years of follow-up.

Methods: 13 (8F/5M) patients under age of 5 years during surgery and had min 10 years follow-up were included. All patients underwent post hemivertebrectomy and short-segment fusion with pedicle screw fixation. Mean age was 3.5 (1-5) years during surgery. Main and compensatory curves and sagittal parameters were measured on pre, post, follow-up x-rays. Follow-up x-rays were reviewed for occurrence of new curve development. SRS22 score was evaluated at follow-up.

Results: Mean follow-up was 11.5 (10-17) years. 8 patients had pure scoliosis and 5 patients had kyphoscoliosis. The location of hemivertebra was 10 thoracic, 2 thoracolumbar and 5 lumbar. Main curve of 32.2° was corrected to 3.8° and 9.6° at follow-up (70.2%). Compensatory curve of 13.8° was corrected to 2.1° and 6.2° at follow-up. Local kyphosis improved from 31.2° to 5.3° (83.1%). Sagittal alignment was restored and maintained (mean SVA:+21mm). There were no pseudoarthrosis or neurovascular complications. A new C-shaped, long, flexible curve with the apex at the level of the resected hemivertebra developed in 5 patients (38%). Mean age at new curve diagnosis was 11.2(6-14) years. Mean new C-shaped curve was 21°(16-30). No additional surgery was performed. 1 patient was treated with brace. Mean SRS22 score was 4.5 at final follow-up.

Conclusion: Posterior hemivertebra resection and short-segment fusion technique under 5 years provided satisfactory correction on both planes. However, a new C-shaped, long, flexible curve with its apex at the level of the resected hemivertebra was observed at long term follow-up in 38% patients. This study suggests that patients with congenital scoliosis who undergo post hemivertebra resection and short-segment fusion under 5 years should be followed up closely till the end of adolescence growth spurt.

Disclosures:
SPINAL GROWTH TETHERING AROUND THE APICAL VERTEBRAE LEADS TO ASYMMETRIC GROWTH AS A MECHANISM OF SPINAL DEFORMITY CORRECTION IN KYPHOSIS AND SCOLIOSIS

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Introduction A non-fusion method aims to create growth in the apical vertebrae that results in gradual deformity correction and prevent crankshaft. This method utilizes a posterior approach around the peaked wedged vertebrae in early onset scoliosis. Methods retrospective review of the X-rays and 3D CT scans of 17 EOS patients Patients underwent posterior tethering proximal and distal to the peak of the deformity as an adjunct to distraction-based growth-friendly, or the Shilla implants. The rate of change was calculated for the wedged apical vertebrae at the concave and convex heights in scoliosis and kyphosis. Control group had the same parameters measured for the vertebrae outside the tethering effect. Cobb angle and spinal height were also measured. Results Mean follow up time: 50.8 months Mean age at surgery: 61 months For wedged vertebrae within the tether Average preop concave/convex height ratio: 0.55 while average last follow up ratio was 0.76 p < 0.005 For the control vertebrae outside the tether Average pre-op concave/convex height ratio: 0.80 while average last follow up ratio was 0.82. p =0.064 Average pre-op scoliosis cobb angle was 51, became 43.8 in last follow up p = 0.057 Average pre-op kyphosis cobb angle was 56.1 became 21.5 in last follow up. p < 0.005 Pre-op Spine length was 250.1mm, in last follow up became 292.27mm. p < 0.005 Conclusion: Posterior tethering in EOS will asymmetrically modulate the apical vertebrae, correcting the deformity with non-fusion technique

Disclosures:
author 1: none; author 2: none; author 3: not indicated