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Baseline Patient Reported Outcomes Correlate Weakly with Radiographic Parameters: A Multicenter, Prospective NIH Adult Symptomatic Lumbar Scoliosis (ASLS) Study of 286 Patients

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Abstract

Study Design—Prospective, cross sectional study.

Objective—Determine which radiographic parameters drive patient-reported outcomes (PROs) in primary presentation adult symptomatic lumbar scoliosis (ASLS).

Summary of Background Data—Previous literature suggests correlations between PROs and sagittal plane deformity (sagittal vertical axis [SVA], pelvic incidence-lumbar lordosis [PI-LL] mismatch, pelvic tilt [PT]). Prior work included revision and primary adult spinal deformity patients. This study addresses only primary presentation ASLS.

Methods—Prospective baseline data were analyzed on 286 patients enrolled in an NIH RO1 clinical trial by nine centers from 2010–2014. Inclusion criteria: 40–80 years old, lumbar Cobb

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(LC) ≥30° and Scoliosis Research Society-23 (SRS-23) score ≤4.0 in Pain, Function or Self-Image domains or Oswestry Disability Index (ODI) ≥20. Patients were primary presentation (no prior spinal deformity surgery) and had complete baseline data: standing coronal/sagittal 36" radiographs and PROs (ODI, SRS-23, Short Form-12). Correlation coefficients were calculated to evaluate relationships between radiographic parameters and PROs for the study population and a subset of patients with ODI ≥40. ANOVA was used to identify differences in PROs for radiographic modifier groups.

Results—Mean age was 60.3 years. Mean spinopelvic parameters were: LL=−39.2°; SVA=3.1cm; sacral slope (SS)=32.5°; PT=23.9°; PI-LL mismatch=16.8°. Only weak correlations (0.2–0.4) were identified between population SS, SVA and SVA modifiers and SRS Function. SVA and SVA modifiers were weakly associated with ODI. While there were more correlations in subset analysis of high-symptom patients, all were weak. ANOVA identified significant differences in ODI reported by SVA modifier groups.

Conclusions—In primary presentation ASLS patients and a subset of 'high-symptom' patients (ODI ≥40), only weak associations between baseline PROs and radiographic parameters were identified. For this patient population, these results suggest regional radiographic parameters (LC, LL, PT, PI-LL mismatch) are not drivers of PROs and cannot be used to extrapolate impact on patient-perceived pathology.

Level of Evidence—2

Keywords

Adult symptomatic lumbar scoliosis; patient-reported outcomes; sagittal and coronal radiographic parameter

INTRODUCTION

Management of adult spinal deformity (ASD) continues to present a significant challenge to spine surgeons as prevalence increases in the aging population. Previous adult scoliosis rates have ranged from 1.4 to 32% and as high as 68% in asymptomatic adult volunteers over 60 years of age.[1]

There has been a shift in the assessment paradigm for ASD from a focus on coronal plane to evaluation of sagittal plane deformity. This is due to reports that increased sagittal plane deformity correlates with worse patient-reported outcomes (PROs).[2–5] In 2005, Glassman et al evaluated sagittal and coronal radiographic parameters and reported that restoration of sagittal parameters, specifically sagittal vertical axis (SVA), should be the aim of spinal deformity surgery.[3] Since then there has been a considerable amount of work published investigating the impact of sagittal spinopelvic parameters on PROs in ASD.[6–10] Schwab et al reported the most clinically important radiographic parameters with the strongest correlations to functional outcome measures to be SVA, pelvic tilt (PT) and pelvic incidence-lumbar lordosis (PI-LL) mismatch.[8]

Spinal deformity is a broad topic referring to any condition of the spine causing either regional or global spinal malalignment. Etiologies of spinal deformity include tumor,

trauma, degenerative, iatrogenic, as well as idiopathic pathologies. Very little is known about the relationship between and the impact of specific spine etiologies on PROs. Many prior studies[3–5,8] have combined primary and revision presentation ASD patients with a mixture of adult deformity diagnoses. By including all patients with spinal malalignment without differentiation of the etiology of the deformity, there is likely to be variation in the correlations between radiographic measures and PROs.

The objective of this study was to identify associations at baseline presentation to spinal deformity surgeons between radiographic parameters and PROs in patients who had not previously undergone operative treatment of adult symptomatic lumbar scoliosis (ASLS) in a multicenter patient population. Based on earlier work, [3–5,8] we hypothesized there would be relationships between baseline radiographic parameters and PROs, with more pronounced sagittal global and regional radiographic deformity associated with worse PROs.

MATERIALS AND METHODS

Study Design

This is a multicenter prospective analysis of a series of patients with ASLS enrolled by nine centers in the United States and Canada from 2010 to 2014. Patients were given the option of selecting operative or nonoperative treatment (Observational Cohort), or random assignment (Randomized Cohort) to operative or nonoperative treatment. One hundred forty-four patients were assigned or electively chose nonoperative management (33 Randomized, 111 Observational) and142 patients were assigned or electively opted for operative treatment (30 Randomized, 112 Observational). Funding was provided by the National Institutes of Health through an RO1 grant: A Multi-Center Prospective Study of Quality of Life in Adult Scoliosis (R01AR055176-01A2). Institutional Review Board approval was obtained at each participating center.

Inclusion Criteria

All patients were between 40 and 80 years of age. Radiographically, ASLS was defined as an idiopathic or de novo lumbar scoliosis with a Cobb measurement ≥30°. Symptomatic was defined as an ODI score of ≥20 and/or Scoliosis Research Society-23 (SRS-23) score ≤4.0 in the Pain, Function and/or Self-Image domains.

All patients, including nonoperative participants, had to be considered operative candidates by the site investigator at the time of enrollment. Patients were excluded if medical comorbidities existed which unacceptably increased the morbidity and mortality associated with an operative procedure. High grade (≥3) spondylolisthesis and prior thoracic or lumbar fusion, as well as prior multilevel thoracolumbar decompression, were exclusion criteria. Patients at high risk for osteoporosis were screened with dual-energy x-ray absorptiometry (DEXA) scan. Patients with severe osteoporosis (femoral neck t-score <−3.0) were excluded. Patients with neuromuscular scoliosis and congenital abnormalities of the lumbar spine were not enrolled in the study.

Evaluation Criteria

All patients underwent full-length standing coronal and sagittal spine radiographs and completed PROs: ODI, SRS-23 and Short Form (SF)-12 questionnaires at enrollment. Baseline radiographic measurements were recorded by two independent reviewers using Surgimap (Nemaris Inc., New York, NY). Coronal radiographic parameters consisted of Cobb angles (lumbar and fractional curves) and coronal vertical axis (CVA). Sagittal radiographic measurements included T12-sacrum lumbar lordosis (LL), SVA, pelvic incidence (PI), sacral slope (SS) and PT. PI-LL mismatch was calculated from these measurements. Once all data were collected, patients were grouped into radiographic modifier groups using the SRS-Schwab Adult Spinal Deformity Classification[9,10] for sagittal plane deformities (SVA, PT and PI-LL mismatch modifiers) and consensus amongst the authors for coronal plane deformities (lumbar Cobb and CVA modifiers).

Statistical Analysis

The population was analyzed as a single population regardless of the treatment arm the patient was randomly assigned or electively selected. Three statistical analyses were performed.

Pearson’s correlations were used to evaluate the relationship between PROs and continuous baseline radiographic parameters for the entire population. Spearman’s correlations were used to assess the relationship between PROs and the categorical ASD radiographic modifier groups. Evans' coefficient classifications were used to interpret correlation coefficient results (<0.20 is very weak, 0.20 to 0.39 is weak, 0.40 to 0.59 is moderate, 0.60 to 0.79 is strong and 0.80 or greater is a very strong correlation).[11] We are considering correlations <0.2 (“very weak”) to represent no correlation.

Baseline comparisons were performed using ANOVA to investigate differences in ODI and SRS Subscore values for each of the ASD radiographic modifier groups (LC, CVA, PI-LL mismatch, PT and SVA). This was followed by post-hoc analysis using Tukey’s HSD to determine if differences between any two of the three modifier groups were statistically significant. Level of significance was set at $p \leq 0.05$.

In addition, correlation analyses were performed on a subset of patients who presented with ODI ≥40. This was performed to identify relationships between baseline radiographic parameters and PROs in this group of patients with more severe impairment.

Correlation statistical analysis was performed using SAS 9.4 on the 64-bit Windows 7 Professional OS (operating system). ANOVA and Tukey’s analysis performed on SPSS 22 (IBM, New York, NY).

RESULTS

Demographic Data

Two hundred eighty-six patients, 258 females and 28 males, met inclusion criteria and consented to study participation. Mean patient age was 60.3 years of age (range 40.0–78.8 years).

PRO Scores

Population baseline PROs are shown in Table 1. SRS domain mean scores were: Pain 2.9; Function 3.3; Mental Health 3.7 and Self-Image 2.9. Mean SRS Subscore (average of all four SRS domain means) was 3.2 (range 1.1–4.4). Mean ODI was 34.8 (range 0–78.0). SF-12 Mental Component Score (MCS) and Physical Component Scores (PCS) means were 50.3 and 35.2, respectively.

Radiographic Data

Baseline radiographic descriptives are also presented in Table 1. The mean lumbar Cobb (LC) was 53°; mean CVA was 2.4 cm; mean LL was −39.2°; mean SVA was 3.1 cm. Spinopelvic parameter means were: PI 55.9°, SS 32.5° and PT 23.9°. Mean PI-LL mismatch was 16.8°.

Table 2 provides the frequencies and percentages of patients in rank ordered ASD coronal and sagittal radiographic modifier groups. Most patients fell within the least severe modifier group: LC (30–49° modifier)=46.5%, CVA (<2cm modifier)=53.8% and SVA (<4cm modifier)=62.6%. The exceptions were the PT modifier groups with 43.4% classified as moderate deformity (20–30°) and the PI-LL mismatch groups with almost equal distributions in non-pathologic (<10°, 37.8%) and marked deformity (≥20°, 39.5%) modifier groups.

Correlations

Results of population correlation coefficient analyses are shown in Table 3. Using Evans' classification, we found weak Pearson's correlation coefficients between SVA and SRS Function domain (r=−0.206) and ODI (r=0.236) and between SS and SRS Function domain (r=0.208). Spearman correlations netted similar results with the only association identified being between the SVA modifier groups and the SRS Function domain (r=−0.204) and ODI (r=0.230) scores.

Radiographic Coronal and Sagittal Group Differences

ANOVA population analysis of the radiographic coronal and sagittal modifier groups are found in Table 4. The only statistical differences were in the ODI ($p<0.001$) and SRS Subscore ($p=0.046$) reported by patients in the SVA modifier groups. Post-hoc analysis (Table 5) identified significant differences in the ODI scores reported by the 'Neutral' (<4cm, ODI=32.2) and 'Positive' (4–9cm, ODI=39.4) SVA modifier groups ($p=0.001$) and the 'Neutral' and 'Very Positive' (>9cm, ODI=40.0) SVA modifier groups ($p=0.033$). There were no differences in ODI scores between the 'Positive' and 'Very Positive' SVA modifier groups. Post-hoc analysis found no differences in SRS Subscores reported by the SVA modifier groups.

Correlations for Patients with ODI >40

Results for the subset of patients with ODI ≥40 (n=111) are presented in Table 6. While more correlations were identified, all were weak, with the strongest correlation between the SRS Self-Image domain and CVA (r=−0.313). The SRS Self-Image domain was also weakly

correlated with LC (r=−0.208). The SF-12 PCS had weak correlations with PT (r=−0.285), PI-LL mismatch (r=−0.224), SS (r=0.233) and LL (r=−0.209). Weak correlations were found between the CVA modifier groups and SRS Self-Image (r=−0.246), SVA modifier groups and SRS Function (r=−0.209) and PT modifier groups and SF-12 PCS (r=−0.214).

DISCUSSION

In this population of 286 patients presenting with primary ASLS there were no correlations between baseline radiographic parameters and PROs, with the exception of SS, SVA and SVA modifier group. The population primarily presented with substantial lumbar coronal curvatures (inclusion design) but had generally mild or moderate sagittal plane deformity. Previous reports have implicated sagittal plane alignment, both global and regional, as the principal driver of PROs.[2–5] Our findings are similar to results reported by authors[4] in a mixed ASD population with a positive SVA (mean 57.7mm). They found weak correlations between SVA and ODI (r=0.281) and SRS Function domain (r=−0.247), as well as SVA and SF12-PCS (r=−0.292) and SRS Pain domain (r=−0.207).[4]

Authors[8] have reported the three most clinically relevant radiographic parameters with weak to moderate correlation to functional outcomes, specifically ODI and SF 12 PCS, to be: PT (r=0.381 and −0.391), PI-LL mismatch (r=−0.450 and 0.467) and SVA (r=0.469 and −0.426), respectively. These correlations were not seen in our primary presentation population analysis. We did find PT and PI-LL mismatch correlated with the SF-12 PCS in our subset analysis of patients with ODI scores >40, but our correlations were much weaker. It is possible the differences are related to the wide spectrum of spinal deformity diagnoses included in their analysis of 178 operative and 314 nonoperative primary and revision presentation ASD patients.[8]

There does appear to be a relationship between SVA and ODI in this study population. There were appreciable statistical differences in the SRS Subscore and ODI when patients were divided into non-pathologic, moderate and marked deformity SVA modifier groups as seen in Table 4. Post-hoc analysis confirmed differences in ODI scores existed between the non-pathologic (<4cm) and moderate (4–9.5cm) SVA modifier groups, as well as between the non-pathologic (<4cm) and marked deformity (>9.5cm) SVA modifier groups. There were no differences between the moderate (4–9.5cm) and marked deformity (>9.5cm) SVA modifier groups. This suggests that in this population of primary ASLS, an SVA of 4 cm or greater is associated with worsened ODI.

We expected the fractional curves might impact outcomes more than the main curves. Most of these patients have both a basic lumbar curve (apex T11 to L1) and also a compensatory structural fractional curve below (L3 or L4 to the sacrum). This is one of the characteristics that separate adult from adolescent scoliosis. In the adolescent, the fractional curve is not structural, but it almost always is in the adult patient. In this series of patients, almost every patient had a structural fractional curve (278 out of 286 patients). One would expect if this fractional curve decompensated the patient in the coronal plane, this would change the patient’s health-related scores. Very few patients in this series presented with a major coronal decompensation. Only 3 patients presented with a substantial (>10cm) component of

coronal decompensation and only 32 patients were >5cm. Therein, the size of the fractional curve and coronal balance did not correlate with patient-reported health. Similarly, there were not sufficient numbers of patients with substantial negative sagittal balance (8 patients <−4cm) to perform any statistical analysis. There has been no implication in prior literature that negative balance would influence patient-reported health.

By analyzing only patients with primary presentation adult lumbar scoliosis, variables such as revision status and other etiologies seen in ASD are not considered. It is possible that while patients with primary deformity may have global alignment parameters similar to those with prior fusions, their ability to compensate global alignment through regional mobile motion segments may allow them to function with less impairment. We did not find strong associations between any radiographic parameters and PROs in our population of primary presentation ASLS, suggesting there are other factors contributing to PROs in this particular study population.

Limitations

The patients in this study were preselected for coronal plane deformity. This may result in less regional and global sagittal plane deformity than seen in previous ASD studies that mixed primary and revision presentations and many etiologies. Having smaller baseline sagittal plane deformity, but substantial coronal plane deformity in the lumbar region, may lead to a population with fewer correlations between sagittal radiographic parameters and clinical outcome measures.

CONCLUSIONS

Sagittal global and regional parameters have been correlated with patient-reported outcomes in previous studies of multiple etiology primary and revision presentation adult spinal deformity. The only baseline associations noted in this population of primary presentation ASLS with mild sagittal plane deformity overall were related to sacral slope and SVA and functional outcome measures (ODI and SRS Function domain) and the significant differences in ODI scores relative to the SVA modifier groups. Further analysis of a subset of more symptomatic patients (ODI >40) identified additional, but still weak, correlations with coronal and sagittal radiographic parameters. However, these correlations and relationships do not demonstrate that sagittal or coronal regional radiographic parameters can be utilized as isolated predictors of PROs in patients with primary presentation (no prior spinal deformity surgery) of ASLS.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The manuscript submitted does not contain information about medical device(s)/drug(s).

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Study data were collected and managed using REDCap electronic data capture tools hosted at Washington University.[12] REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources.

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TABLE 1

Demographic characteristics of the ASLS population - Frequencies, means, standard deviations and ranges for the study population at baseline

	N	Mean	Standard Deviation	Minimum	Maximum
Age at Enrollment (years)	286	60.3	9.3	40	78.8
Females	258				
Males	28				
Patient-Reported Outcomes					
SRS Pain Domain	286	2.9	0.7	1	5
SRS Function	286	3.3	0.7	1.4	4.8
SRS Mental Health Domain	286	3.7	0.8	1.2	5
SRS Self-Image Domain	286	2.9	0.7	1.2	4.8
SRS Subscore	286	3.2	0.5	1.4	4.4
ODI	286	34.8	15.3	0	78
SF-12 MCS	286	50.3	11	17.3	75.9
SF-12 PCS	286	35.2	9.9	15.4	58.3
Radiographic Parameters					
Lumbar Cobb (LC – degrees)	286	53	14.3	30	89
Fractional curve cobb (degrees)	278	22.4	9.9	0	61
Coronal Vertical Axis (CVA – cm)	285	2.4	2.2	0	14.9
T5-T12 (TK – degrees)	284	27.9	16.0	−7.0	71.0
T12 – Sacrum (LL – degrees)	286	−39.2	19.1	−83	25
Sagittal Vertical Axis (SVA – cm)	285	3.1	4.5	−8	22.2
Pelvic Incidence (PI – degrees)	277	55.9	12.2	21	93
Sacral Slope (SS – degrees)	286	32.5	10.7	3	63
Pelvic Tilt (PT – degrees)	269	23.9	9.5	2	54
PI-LL Mismatch (degrees)	277	16.8	18.6	−19	73

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Table 2

Rank Ordered Radiographic Modifier Groups - Frequencies and percentages of patients in rank ordered radiographic modifier groups

	Frequency	Percentage
Lumbar Cobb (LC)	286	
LC 30–49 degrees (Mild deformity)	133	46.5
LC 50–69 degrees (Moderate deformity)	111	38.8
LC ≥70 degrees (Severe deformity)	42	14.7
Coronal Vertical Axis (CVA)	286	
CVA <2cm (Non-pathologic)	154	53.8
CVA 2–4 cm (Moderate pathology)	85	29.7
CVA >4 cm (Marked pathology)	46	16.1
Unable to determine	1	.3
Pelvic Tilt (PT)	286	
PT <20 degrees (Non-pathologic)	83	29.0
PT 20–30 degrees (Moderate deformity)	124	43.4
PT >30 degrees (Marked deformity)	62	21.7
Unable to determine	17	5.9
PI-LL Mismatch	286	
PI-LL Mismatch <10 (Non-pathologic)	108	37.8
PI-LL Mismatch 10–19 (Moderate deformity)	56	19.6
PI-LL Mismatch ≥20 (Marked deformity)	113	39.5
Unable to determine	9	3.1
Sagittal Vertical Axis (SVA)	286	
SVA <4 cm (Non-pathologic)	179	62.6
SVA 4–9.5 cm (Moderate deformity)	80	28.0
SVA >9.5 cm (Marked deformity SVA)	26	9.1
Unable to determine	1	0.3

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Table 3

Population Correlation Coefficients between Baseline Radiographic Parameters and Radiographic Modifier Groups and Baseline PROs

		SRS Pain	SRS Function	SRS Mental Health	SRS Self-Image	SRS Subscore	ODI	SF-12 MCS	SF-12 PCS
Continuous Radiographic Variable Correlations (Pearson)									
Lumbar Cobb (LC-degrees) N= 286	r	.137	.128	.084	−.070	.094	−.112	.099	.117
Coronal Vertical Axis (CVA-cm) N=286	r	−.048	−.066	−.036	−.178	−.106	.109	−.061	−.081
Pelvic Tilt (PT-degrees) N=269	r	−.017	−.148	.042	−.099	−.069	.105	.093	−.162
PI-LL Mismatch (degrees) N=277	r	−.012	−.141	.040	−.144	−.080	.151	.068	−.169
Sagittal Vertical Axis (SVA-cm) N=285	r	−.052	**−.206**	−.009	−.191	−.146	**.236**	−.054	−.176
T12 – Sacrum (LL-degrees) N=286	r	−.089	−.192	−.023	−.165	−.151	.190	−.016	−.197
Pelvic Incidence (PI – degrees) N=277	r	.098	.077	.089	.026	.097	−.056	.107	.050
Sacral Slope (SS - degrees) N=286	r	.125	**.208**	.035	.111	.155	−.167	.033	.198
Radiographic Modifier Group Correlations (Spearman)									
Lumbar Cobb Group N=286	r	.121	.148	.078	−.024	.091	−0.130	.105	.101
CVA Modifier Group N=285	r	.012	−.048	−.012	−.144	−.057	0.081	−.062	−.025
PI-LL Mismatch Modifier Group N=277	r	−.016	−.151	.060	−.088	−.067	.137	.083	−.174
PT Modifier Group N=269	r	−.068	−0.163	−.027	−.061	−.101	0.142	.046	−.193
SVA Modifier Group N=285	r	−.069	**−.204**	−.049	−.166	−.155	**.230**	−.103	−.165

Greater sagittal imbalance was weakly correlated with higher (more pathology) ODI scores (r=.236) and lower (more pathology) SRS Function scores (−.206). This was also true for the SVA Modifier group as well. Greater sacral slope was weakly correlated with higher (less pathology) SRS Function domain scores.

Table 4

ANOVA analysis of ODI and SRS Subscore by Radiographic Modifier Groups

Radiographic Modifier Groups		SRS Subscore					ANOVA p	ODI					ANOVA p
		N	Mean	Std. Dev.	95% CI			N	Mean	Std. Dev.	95% CI		
					Lower	Upper					Lower	Upper	
Lumbar Cobb Modifier Groups	30–49°	133	3.1	0.5	3.0	3.2	0.222	133	37.1	15.2	34.5	39.7	0.084
	50–69°	111	3.2	0.5	3.1	3.3		111	33.3	15.0	30.5	36.1	
	≥70°	42	3.3	0.6	3.1	3.5		42	32.7	15.0	28.0	37.4	
CVA Modifier Groups	<2cm	154	3.2	0.5	3.1	3.3	0.508	154	33.9	15.9	31.3	36.4	0.376
	2–4cm	85	3.2	0.5	3.1	3.3		85	35.7	13.9	32.7	38.7	
	>4cm	46	3.1	0.5	2.9	3.3		46	37.2	14.9	32.7	41.6	
PI-LL Mismatch Modifier Groups	<10°	108	3.2	0.6	3.1	3.3	0.354	108	32.9	15.2	30.0	35.8	0.092
	10 to 19°	56	3.3	0.5	3.1	3.4		56	34.5	15.5	30.3	38.6	
	≥20°	113	3.1	0.5	3.0	3.2		113	37.3	14.5	34.6	40.0	
PT Modifier Groups	PT < 20°	83	3.2	0.5	3.1	3.4	0.350	83	31.6	14.3	28.5	34.8	0.058
	PT 20–30°	124	3.2	0.6	3.1	3.3		124	36.2	16.5	33.3	39.1	
	PT > 30°	62	3.1	0.5	3.0	3.2		62	36.6	12.2	33.5	39.7	
SVA Modifier Groups	SVA <4cm	179	3.2	0.5	3.2	3.3	**0.046**	179	32.2	14.9	30.0	34.4	**<0.001**
	SVA 4–9.5 cm	80	3.1	0.5	3.0	3.2		80	39.4	14.5	36.2	42.7	
	SVA >9.5cm	26	3.0	0.6	2.8	3.3		26	40.0	15.2	33.9	46.1	

ANOVA analysis found differences between baseline SRS Subscore and ODI in SVA modifier groups. There were no differences between the regional sagittal (PT, PI-LL) and coronal (lumbar Cobb) parameters.

Table 5

Tukey HSD Post Hoc analysis of SVA Radiographic Modifier groups

	Post Hoc Comparison		p value
ODI score	N: SVA < 4cm	P: SVA 4–9.5 cm	**.001**
	N: SVA < 4cm	VP: SVA >9.5cm	**.033**
	P: SVA 4–9.5 cm	VP: SVA >9.5cm	.985
SRS Subscore	N: SVA < 4cm	P: SVA 4–9.5 cm	.089
	N: SVA < 4cm	VP: SVA >9.5cm	.198
	P: SVA 4–9.5 cm	VP: SVA >9.5cm	.937

Post hoc analysis found significant differences in ODI scores between the non-pathologic and positive SVA modifier groups (0.001) and the non-pathologic and the very positive SVA modifier groups (p=0.033). There were no differences in the ODI scores between the positive and very positive SVA modifier groups nor were there any differences in the SRS Subscores.

Table 6

Subset Analysis: Correlation Coefficients between Baseline Radiographic Parameters and Radiographic Modifier Groups and Baseline PROs in Patients with ODI ≥40

		SRS Pain	SRS Function	SRS Mental Health	SRS Self-Image	SRS Subscore	ODI	SF-12 MCS	SF-12 PCS
Continuous Radiographic Variable Correlations (Pearson)									
Lumbar Cobb (LC-degrees) N=111	r	.033	−.002	−.027	**−.208**	−.081	−.013	−.038	.036
Coronal Vertical Axis (CVA-cm) N=111	r	.005	−.056	−.095	**−.313**	−.175	.023	−.114	−.045
Pelvic Tilt (PT-degrees) N=103	r	.062	−.124	.155	−.056	.032	−.043	**.228**	**−.285**
PI-LL Mismatch (degrees) N=107	r	.077	−.098	.102	−.184	−.031	.054	.156	**−.224**
T12-Sacrum (LL-degrees) N=111	r	.051	−.141	.022	−.175	−.083	.106	.038	**−.209**
Sacral Slope (SS-degrees) N=111	r	−.081	.161	−.062	.050	.014	−.097	−.050	**.233**
Radiographic Modifier Group Correlations (Spearman)									
CVA Modifier Group N=110	r	.072	−.069	−.054	**−.246**	−.128	−.051	−.159	.073
PT Modifier Group N=103	r	.015	−.122	.059	−.001	−.018	−.046	.196	**−.214**
SVA Modifier Group N=110	r	.086	**−.209**	.094	−.124	−.073	.179	−.011	−.118

In patients with ODI ≥40, only weak correlations were found: greater PT, PI-LL mismatch, LL, and PT Modifier groups weakly correlated with lower (more pathology) SF-12 PCS while higher SS produced weak correlations with higher (better) SF-12 PCS. Larger LC (r=−0.208), greater CVA (r=−0.313) and the CVA modifier groups weakly correlated with poorer SRS Self-Image. The SVA modifier group weakly correlated with lower (more pathology) SRS Function (r=−0.209).