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DEFORMITY

Does Achieving Global Spinal Alignment Lead to Higher Patient Satisfaction and Lower Disability in Adult Spinal Deformity?

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Study Design. Multicenter retrospective review of prospective database.

Objective. The aim of this study was to investigate potential associations between postoperative alignment and satisfaction.

Summary of Background Data. Achieving high satisfaction is the main goal of any treatment, including adult spinal deformity (ASD) surgery. Despite being one of the key elements, literature is sparse regarding postoperative factors influencing patient satisfaction.

Methods. ASD patients with 2-year follow-up were retrospectively reviewed. Patients without revision after the index procedure were stratified according to deformity type: sagittal (T1 pelvic angle >22°), coronal (C7 plumb line [C7PL] >5 cm or MaxCobb >50°), or mixed. Bivariate correlation between satisfaction and postoperative data was conducted on the entire cohort as well as by type of preoperative deformity. Multivariate regression controlling for pre-op alignment and demographic information was used to identify independent predictors of 2Y satisfaction.

Results. A total of 509 patients were included in the analysis (58.7 ± 14.8, 80% females). The quality of life significantly improved between pre- and 2-year (ΔOswestry Disability Index [ODI]: 17.6, $p < 0.001$). At 2 years, SRS22 satisfaction was 4.27 ± 0.89 (median 4.5). Significant associations were found between satisfaction and disability (ODI, $r = -0.50$) and global coronal (C7PL $r = -0.15$) and sagittal (sagittal vertical axis [SVA], $r = -0.10$) alignment (all $p < 0.01$) but not with the coronal clavicle angle. Stratification by preoperative deformity revealed significant associations between satisfaction and SVA for sagittal deformity only, C7PL and MaxCobb for coronal only, and C7PL for combined deformity. In the multivariate analysis controlling for demographic and pre-op deformity, 2-year ODI and 2-year C7PL were independent predictors of satisfaction. Multilinear regression demonstrated 2-year SVA, pre-op ODI and patient's age were the independent predictors 2-year ODI.

Conclusion. The ability to restore global alignment depends on the severity of the preoperative deformity as well as the correction of the main aspect of the deformity. Achieving global coronal and sagittal alignment is an independent predictor of both satisfaction and disability at 2 years post-op. Patients who continue to be disabled are also not satisfied.

Key words: adult spinal deformity, alignment, disability, outcomes, patient satisfaction.

Level of Evidence: 3

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In the era of increasing focus on cost efficiency, and the shift from high volume to high-quality care,[1] patient-driven surgical outcomes are increasingly becoming important. The patient experience, such as patient satisfaction with care, is a critical metric providing incremental information on the quality of care.[2–4] Satisfaction scores permit the evaluation of outcomes from a patient perspective.

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Better patient satisfaction has been correlated with better patient adherence to treatment plans and less inpatient morbidity and mortality. Furthermore, low satisfaction can have a negative financial impact on the medical institution.[1,5]

Adult spinal deformity (ASD) is a debilitating condition associated with substantial pain and functional disability.[6,7] Some reports have noted the prevalence of ASD to be as high as 68% in the elderly population.[8] Although surgical management of ASD is associated with improved health-related quality of life (HRQoL) measures,[9] the elective nature of ASD surgery in addition to the high complication rates make the decision-making process complex. In this context, there is a need to focus on optimizing patient-centered outcome measures, including satisfaction, following surgical management.[10,11] Recognizing factors that can predict satisfaction can significantly aid in the shared decision-making process and subsequently increase patient satisfaction.

Previous ASD-related reports revealed that satisfaction is multifactorial, and is associated with lifestyle, cultural expectations, baseline mental status, as well as HRQoL components such as self-image, social life, or improvement in the ability to stand.[12–15] In recent years, sagittal spino-pelvic alignment has been a cornerstone of surgical planning and outcomes assessment, with numerous studies indicating global malalignment as a critical driver of disability and suboptimal outcomes.[16] To our knowledge, there are limited data in the literature regarding the potential associations between radiographic alignment and patient satisfaction with their care.

Our objectives of this study are to investigate the association between shoulder balance represented by the clavicle angle and patient satisfaction. Second, we sought to provide a comprehensive analysis of the interplay between global alignment parameters, disability, and patient satisfaction while taking into consideration the type of preoperative deformity. We hypothesize that achieving good global alignment in the sagittal plane (based on the SVA), and coronal plane (based on C7PL and clavicle angle) with emphasis on correcting the main type of presenting deformity results in better disability scores and a more satisfied patient. Understanding deformity correction effect on patient satisfaction can help in planning a surgical strategy that results in better outcomes.

METHODS

Cohort Definition

This study was a retrospective review of a prospective multicenter database of patients who underwent surgical management for ASD. After IRB approval at each of the 13 participating sites across the United States, patients were enrolled if they met the following criteria: age >18 years and spinal deformity confirmed by at least one of the following measures: scoliosis Cobb angle >20°, sagittal vertical axis (SVA) >5 cm, pelvic tilt (PT) >25°, and/or thoracic kyphosis (TK) >60°. Patients who had an active infection, malignancy, or whose spinal deformity was due to neuromuscular conditions were excluded. Additional specific inclusion criteria for this current analysis were no subsequent revision surgery, the availability of minimum 2 years of follow up data, and having a fusion spanning four or more vertebral levels.

Data Collection

Demographic information (age, sex, body mass index [BMI], smoking status), as well as surgical characteristics, were collected. Standing posteroanterior and lateral spine radiographs were analyzed at baseline and 2 years after surgery using validated software[17,18] (Spineview; Laboratory of Biomechanics, ParisTech, Paris, France) to measure the following radiographic parameters: pelvic tilt (PT), mismatch between pelvic incidence [PI] and lumbar lordosis [LL] (PI-LL), sagittal vertical axis (SVA), T10-L2 kyphosis, coronal max Cobb angle (Max Cobb), coronal C7 plumb line (C7PL), and coronal clavicle angle. Standardized HRQOL measures such as the Oswestry Disability Index (ODI) and Scoliosis Research Society-22r questionnaire (SRS-22r) were used to quantify surgical outcomes. Assessment of patient satisfaction was measured using the SRS-22r patient satisfaction score.

Statistical Analysis

After describing the cohort in terms of demographic, preoperative, and 2-year postoperative HRQOL and radiographic alignment, associations between patient satisfaction and radiographic data were investigated using Pearson correlations. Multilinear stepwise regression was carried out to identify independent predictors of 2-year satisfaction score.

Patients were stratified based on 2-year satisfaction score as either: high satisfaction if the SRS-22 satisfaction score was at least 4.5, or low satisfaction if the SRS satisfaction score was <4.[19,15] Low and high satisfaction patients were compared in terms of preoperative information, surgical data, and postoperative outcomes using independent *t* test or Mann–Whitney *U* test as appropriate. Logistic regression was used to identify independent predictors of high satisfaction versus low satisfaction.

To investigate the effect of deformity type on the association between radiographic parameters and postoperative satisfaction, patients were stratified by type of deformity: large sagittal deformity if T1 pelvic angle >22° and/or large coronal deformity if C7PL >50 mm or maximum coronal Cobb >50°. Previous correlation and regression analysis were repeated within each type of deformity group.

Finally, a subanalysis investigating independent prediction of 2-year disability was performed using a multilinear stepwise regression.

RESULTS

A total of 509 patients were included in this analysis. The mean age for the entire cohort was 58.7 ± 14.8, 80% were female, mean BMI was 27.5 ± 6.1, and 228 (44.8%) had a history of previous spine surgery.

TABLE 1. Sagittal and Coronal Alignment Parameters of the Study Population at Baseline and 2-year Follow-up

	Pre-op		2 –y		*p-value*
	mean	StD	mean	StD	
PT	23.6	10.6	20.7	9.9	<0.001
PI-LL	15.2	20.1	2.5	14	<0.001
SVA	61.3	70.8	24.5	49.9	<0.001
C7PL	40.0	29.1	26.3	21.5	<0.001*
Max Cobb	41.4	20.8	21.6	15.9	<0.001*
Clavicle Angle	2.5	2.0	2.4	2.0	0.244*

PI-LL indicates mismatch between pelvuc incidence and lumbar lordosis; PT, pelvic tilt; SVA, sagittal vertical axis.
**Wilcoxon Signed Ranks test for non-normally distributed parameters.*

As per the SRS-Schwab classification,[20] preoperative alignment demonstrated a moderate to severe deformity with respectively 63.7%, 57.6%, and 62.1% of the patients presenting a modifier grade of + or ++ in PT, SVA, or PI-LL. In terms of coronal alignment, 36.9% had an SRS Type L, 26.1% had Type D, and 33.4% had Type N. Overall, these patients exhibited a severe disability with a mean ODI of 42.2 ± 18 and a mean SRS Total score of 2.84 ± 0.64.

At 2 years, sagittal and coronal alignment improved significantly (Table 1) (all $p < 0.001$), as well as patient-reported outcomes with a 2-year ODI value of 24.5 ± 19.2, and SRS22 total score of 3.79 ± 0.77 (all $p < 0.001$). Postoperative SRS22 satisfaction was 4.27 ± 0.9, with 61.3% of the patients having a value of $\geq$4.5, and 38.7% with a satisfaction score of $\leq$4.

Correlation analysis demonstrated significant but weak association between lower 2-year satisfaction and greater 2-year sagittal alignment (SVA: $r = -0.103$, $p = 0.020$), worse 2-year coronal alignment (C7PL: $r = -0.145$, $p = 0.001$), whereas a moderate correlation was found with 2-year disability (ODI: $r = -0.496$) (all $p < 0.001$). Clavicle angle was not associated with 2-year satisfaction ($p = 0.848$). Multilinear regression, controlling for preoperative demographics, baseline global deformity, and 2-year disability demonstrated that 2-year C7PL was an independent predictor of satisfaction ($p = 0.010$). Compared to the low satisfaction group, patients with high satisfaction had less coronal and sagittal deformity at 2-years, a larger correction of the maximal Cobb angle, a lower preoperative ODI, and a greater ODI improvement (Table 2). No significant difference in the clavicle angle was identified ($p = 0.877$).

Logistic regression predicting high satisfaction while controlling for preoperative demographics, baseline global deformity, and 2-year disability demonstrated similar results as multilinear regression, with C7PL being the only independent predictor (odds ratio: 0.987, $p = 0.022$).

Stratification by Pre-op Deformity

After stratification by pre-operative deformity, 138 patients (27.1%) were categorized as "severe sagittal deformity," 128 (25.1%) as "severe coronal deformity," 108 (21.2%) as "severe combined deformity," and 135 (26.5%) as "mild deformity." Comparison revealed no significant difference in satisfaction between these four groups (Kruskal-Wallis, $p = 0.661$).

Correlation analysis within each group demonstrated a different association between satisfaction and radiographic parameters. As illustrated (Table 3), satisfaction significantly correlated with 2-year SVA ($r = -0.182$) among the "severe sagittal deformity" group, with 2-year C7PL

TABLE 2. Comparison of Patient Postoperative and Change in Alignment and Disability Score Between High Satisfaction and Low Satisfaction Groups

		Low Satis.		High Satis.		*p-value*
		Mean	StD	Mean	StD	
Age		58.9	14.7	58.6	14.9	0.832
2 –y	ODI	35.5	18.4	17.3	16.1	0.000
	C7PL	30.2	23.7	23.9	19.6	0.002
	Max Cobb	23.4	18.5	20.5	13.9	0.069
	SVA	32.3	52.6	19.6	47.6	0.006
Change pre-to-2 y	ODI	−9.1	17.4	−23.0	16.3	0.000
	C7PL	−5.9	28.6	−8.8	28.5	0.264
	Max Cobb	−16.4	15.0	−22.4	15.9	0.000
	SVA	−37.9	66.9	−36.0	61.6	0.744

ODI indicates Oswestry Disability Index; SVA, sagittal vertical axis.

TABLE 3. Correlation Between Satisfaction Score and Radiographic Parameters and Disability Score, Based on the Preoperative Deformity Type

			All Patients	Mild Deformity	Sagittal Only	Coronal Only	Combine
Age		*r*	−0.009	0.013	0.099	−0.026	−0.041
		P	0.843	0.881	0.249	0.775	0.671
2 −y	ODI	*r*	−0.496	−0.424	−0.567	−0.486	−0.489
		P	0.000	0.000	0.000	0.000	0.000
	C7PL	*r*	−0.145	−0.030	−0.070	−0.264	−0.212
		P	0.001	0.728	0.414	0.003	0.028
	Max Cobb	*r*	−0.064	−0.103	0.117	−0.293	−0.032
		P	0.159	0.252	0.186	0.001	0.743
	SVA	*r*	−0.103	0.006	−0.182	−0.099	−0.057
		P	0.020	0.940	0.033	0.267	0.560
Change pre-to-2 y	ODI	*r*	−0.422	−0.408	−0.493	−0.445	−0.412
		P	0.000	0.000	0.000	0.000	0.000
	C7PL	*r*	−0.041	0.020	−0.049	−0.143	−0.018
		P	0.354	0.819	0.569	0.108	0.853
	Max Cobb	*r*	−0.114	−0.142	0.120	−0.190	−0.159
		P	0.011	0.115	0.175	0.032	0.099
	SVA	*r*	0.011	0.037	−0.129	−0.014	0.131
		P	0.807	0.668	0.132	0.874	0.176

ODI indicates Oswestry Disability Index; SVA, sagittal vertical axis.

($r = -0.264$) and maximum cobb ($r = -0.293$) among the "severe coronal deformity" group, and with C7PL only for the "severe combined deformity" group. ODI was significantly associated with satisfaction within each group with an *r* values ranging from −0.424 to −0.567.

Multilinear regression within each type of deformity showed similar results with 2-year ODI and 2-year SVA being the only two independent predictors of satisfaction for patients with sagittal deformity only. For the three other types of deformity, only 2-year ODI was a significant predictor of 2-year satisfaction. Logistic regressions showed that 2-year C7PL, change in Max cobb and 2-year ODI were independent predictors of low versus high satisfaction for combined sagittal and coronal deformity. Two-year ODI was the only independent predictor of low versus high satisfaction in the three other groups.

Subanalysis on 2-year Disability

Correlations analysis between 2-year ODI and demographics demonstrated a significant association with age ($r = 0.129$, $p = 0.004$). Larger postoperative SVA ($r = 0.200$, $p < 0.001$) was also associated with a larger disability while max cobb and C7PL were not associated with 2-year ODI ($P = 0.692$ and $p = 0.059$, respectively). Multivariate analysis demonstrated that baseline ODI ($p < 0.001$), patient age ($p = 0.009$), and 2-year SVA ($p = 0.033$) were independent predictors of 2-year ODI, with an r^2 value of 0.303.

DISCUSSION

Presently, patient care evaluation is in the midst of shifting its focus from the health care provider's perspective to a model that is more inclusive of the patient's experience. Factors influencing patient satisfaction are gaining more interest in ASD surgery as satisfaction metrics are emerging as the center of the pay-per-performance model for spine care. In this multicenter study of surgical ASD patients, we demonstrated that radiographic parameters improved dramatically postoperatively, and this was associated with significant improvement in quality of life outcomes. Using the SRS22 satisfaction subdomain we identified the radiographic parameters correlated with patient satisfaction at 2 years after ASD surgery. Patients who had a large postoperative sagittal (SVA) or coronal (C7PL) malalignment tended to report lower overall satisfaction. Furthermore, examining patients with high satisfaction scores found that they have smaller overall deformity at 2 years compared to their low satisfaction counterparts. This agrees with recently published data by Hayashi *et al*[15] looking at 422 ASD patients who underwent four or more levels of fusion. They found that inadequate restoration of sagittal alignment (SVA) was one of the main factors that may be responsible for low satisfaction at 2 years. This is also consistent with the previous reports highlighting the correlation of radiographic outcomes with HRQoL measures.[16,21]

This analysis did not find any association between clavicle angle and satisfaction at 2 years; the clavicle angle has been an accepted radiographic parameter to assess shoulder balance.[22] Adolescent idiopathic scoliosis (AIS) literature shows that cosmesis of the back and shoulders as well as coronal correction has a substantial contribution to better outcomes. Specifically, the achievement of shoulder balance is one of the most important measures of a successful surgery, as it influences not only the surgeon's degree of satisfaction with the procedure, but more importantly the

patient's satisfaction with surgery, cosmetic appearance, and their psychological well-being afterward.[23–28] A potential explanation for the lack of association in ASD patients may be the age difference and influence of pain and disability in the ASD population which can drive ASD surgical outcomes. This hypothesis is supported by observing disability scores having the strongest correlation with satisfaction. Dividing the cohort based on the SRS22-satisfaction score showed that high satisfaction patients had a significantly lower ODI than patients who reported lower satisfaction. In a previous study, Yang *et al*[14] identified four classes in 430 ASD patients based on their ODI change at 2 years, and determined the association between class membership in terms of functional changes and patient satisfaction. Patients in the most improved class had the highest probability of achieving better levels of satisfaction. The same findings were reported in a study investigating spine surgery in general. Chotai *et al*[29] enrolled 1645 patients in a longitudinal registry who underwent elective spine surgery; they found that patient satisfaction may predict the effectiveness of surgical care with respect to 1-year improvement in pain and disability.[21]

Stratification of our cohort based on the preoperative deformity found that patients were more likely to be satisfied when the surgery was more successful in correcting the main global aspect of the deformity. For example, patients with severe dominant sagittal deformity were more likely to be satisfied when radiographic outcomes found an improvement in the sagittal component (represented by SVA). The same observation for dominant coronal deformity patients were seen when C7PL improved. However, in the group wherein the radiographic deformity is not severe, global radiographic parameters were not significantly correlated with satisfaction anymore. Disability scores remained an independent factor predicting higher satisfaction in all groups. ASD is a heterogeneous pathology; the clinical presentation of it is dominated by pain and disability rather than cosmetic complaints and curve progression which are more common in AIS.[7] The main drivers of surgical management of ASD when nonoperative methods fail are improving disability, neurologic symptoms, and quality of life independently from the radiographic deformity.[30,31] However, many studies have implemented HRQoLs to show the strength of the correlation between radiographical alignment and disability and pain in patients with spinal deformity.[16,21,32] Our study is in line with previous studies as we found that sagittal alignment represents an independent parameter affecting ODI. Of course, other parameters may also affect the surgical outcomes, such as quality of the decompression, pain-free postoperative status, and overall maintenance of function.

Despite the finding that satisfaction is affected by postoperative disability, other studies indicate that satisfaction is a multifactorial parameter affected by other patient-reported outcomes such as self-image and appearance, in addition to many nonsurgical factors related to the whole treatment experience.[33–35] Self-image is one of the best predictive variables of satisfaction after ASD surgery. In a 5-year follow-up study, Gum *et al*[36] demonstrated that SRS-22R Appearance sub-score and ODI correlate most with patient satisfaction in adult deformity patients undergoing five or more level fusion to the sacrum. Furthermore, in a recent study, global alignment was found to be a potential explanatory component of SRS22 self-image/appearance subdomain at baseline. Also, among preoperative low self-image candidates, larger global sagittal alignment restoration was helpful to achieve a high self-image at 2 years.[37] As demonstrated by this study and by previous analyses alignment has a relatively small but significant impact on satisfaction, and based on our previous discussion we can argue that a potential explanation of those findings is the interplay and indirect effect of alignment on disability and appearance, and subsequently patient satisfaction.

This study has limitations. First, the retrospective analysis introduces susceptibility to unidentified confounders, and both selection and information bias. However, these biases were at least partially mitigated by the fact that the data were collected prospectively. Secondly, the study population was limited to patients who completed both baseline and 2-year follow-up PROMs. Satisfaction over longer follow-up periods after surgery could not be assessed in this retrospective analysis. Also, it is possible that patients who were lost to follow-up had worse functional outcomes or less satisfaction which can compromise the generalizability of our results. Finally, this analysis only includes parameters directly affected by the surgery. Many other aspects can influence the satisfaction, such as the availability of the medical staff, the hospital facility environment, or patient education.[33–35] These factors may play an even more important role in patient satisfaction than the surgery itself.

CONCLUSION

Global alignment restoration is a key surgical goal to improve disability, and our results found that correcting the main driver of the deformity was associated with higher patient satisfaction. Also, improving the patient's disability score can help reach superior satisfaction. Patient-specific drivers of satisfaction can allow surgeons to focus on the aspects of the surgical correction that are more valuable in optimizing patient-reported satisfaction following surgical management.

➢ Key Points

- ❑ Global alignment restoration is a key surgical goal to improve disability.
- ❑ At 2 years following index surgery, achieving global coronal and sagittal alignment is an independent predictor of higher patient satisfaction and lower disability.
- ❑ Patient satisfaction is a multifactorial parameter, recognizing surgical factors affecting satisfaction can be valuable in optimizing patient-centered outcomes.

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