Patients with Adult Spinal Deformity with Previous Fusions Have an Equal Chance of Reaching Substantial Clinical Benefit Thresholds in Health-Related Quality of Life Measures but Do Not Reach the Same Absolute Level of Improvement

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■ BACKGROUND: **Substantial clinical benefit (SCB) represents a threshold above which patients recognize substantial improvement and represents a rational target for defining clinical success. In adult spinal deformity (ASD) surgery, previous fusions may impact outcomes after deformity correction.**

■ OBJECTIVE: **To investigate the impact of previous spinal fusion on the likelihood of reaching SCB thresholds for 2-year health-related quality of life (HRQOL) after ASD surgery.**

■ METHODS: **We conducted a retrospective review comparing baseline demographic, HRQOL, and radiographic features for patients with ASD undergoing primary versus revision procedures. The primary outcome measure was reaching SCB threshold in Oswestry Disability Index (ODI), SF-36 Physical Component Summary (PCS), and back and leg pain (numeric rating scale). Secondary outcomes included absolute and change scores in ODI, PCS, and back and leg pain.**

■ RESULTS: **In total, 332 patients achieved 2-year follow-up (228 primary; 104 revision cases). Those undergoing revision surgery had similar demographic features (age 58.3/55.9, female 80.8%/82.9%) to patients undergoing primary surgery. They had worse baseline HRQOL (ODI 48.5/41.2, PCS 29.5/33.4, back 7.5/7.0, and leg pain 4.9/4.3; *P* < 0.001) and radiographic deformity (sagittal vertical axis 111.4/45.1, lumbopelvic mismatch 26.7/11.0, pelvic tilt 29.5/21.0; *P* < 0.0001). Nevertheless, the number of patients who reached SCB for ODI (38.3/36.3%), PCS (48.5/53.4%), back (53.1/60.5%), and leg pain numeric rating scale (28.6/36.9%) did not significantly differ. Revision patients had worse 2-year HRQOL for all measures.**

■ CONCLUSIONS: **Patients undergoing revision surgery have worse baseline HRQOL and deformity. Although they do not achieve the same absolute level of 2-year HRQOL outcome, they have a similar likelihood of reaching SCB threshold for improvement in 2-year HRQOL.**

Key words
- Adult scoliosis
- Adult spinal deformity
- Health-related quality of life
- HRQOL
- Revision
- Substantial clinical benefit

Abbreviations and Acronyms
ASD: Adult spinal deformity
HRQOL: Health-related quality of life
MCID: Minimal clinically important difference
NRS: Numeric rating scale
ODI: Oswestry Disability Index
PCS: Physical Component Summary of Short Form 36 Health Questionnaire
PI-LL: Pelvic incidence minus lumbar lordosis
PT: Pelvic tilt
SCB: Substantial clinical benefit
SF-36: Short Form 36 Health Questionnaire
SRS-22r: Scoliosis Research Society 22 questionnaire, revised
SVA: Sagittal vertical axis

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INTRODUCTION

In adults, spinal deformity typically presents with pain and disability and is associated with impairment in health-related quality of life (HRQOL).[1-8] Recently, 2 large, prospective series have shown improvement in HRQOL, relief of pain, and a reduction in disability with operative treatment of adult spinal deformity (ASD).[3,9] Although these scores improve based on statistical comparisons, it is not always clear that such improvement corresponds to meaningful clinical improvement. To bridge the gap between statistical and clinical significance, thresholds have been established for a variety of HRQOL instruments, including the minimal clinically important difference (MCID) and substantial clinical benefit (SCB).

The most commonly used threshold is the MCID, which represents the smallest change in the domain of interest that patients perceive as beneficial.[10,11] The MCID has been reported for several HRQOL measures commonly used in assessing outcomes of lumbar spine surgery, including the Oswestry Disability Index (ODI),[12,13] Physical Component Summary (PCS)[12,13] of the Short Form of the Medical Outcomes Study (SF-36), back and leg pain numeric rating scales (NRS),[12,13] and Scoliosis Research Society 22r (SRS-22r).[12,14] Some authors argue that as the smallest detectable change, the MCID defines a threshold minimum rather than optimal clinical response.[12] SCB has been proposed as an alternative to MCID that represents a change in outcome that is not merely clinically detectable but also clinically important.[15] It thus likely represents a preferable target for defining clinical success.

Many adults with spinal deformity have had previous lumbar fusion procedures (Figure 1). Indeed, previous surgery may be the primary cause or a significant contributor to the development of the deformity, as in pathologic loss of lumbar lordosis (flatback).[16] Rates of previous arthrodesis in patients with operative ASD range from 14% to 34%[3,7,17] Compared with those undergoing primary surgery (Figure 1), revision correction of ASD is associated with a greater rate of perioperative complications and a longer hospital course.[17] It is therefore important when selecting patients for major thoracolumbar deformity surgery to consider how their previous operation(s) may impact their treatment course and ultimate outcome. However, there are few studies investigating the impact of previous lumbar instrumentation on HRQOL outcomes.

Our primary objective in the present study was to determine whether patients with ASD who undergo corrective surgery after previous instrumented fusion are as likely as those who have not

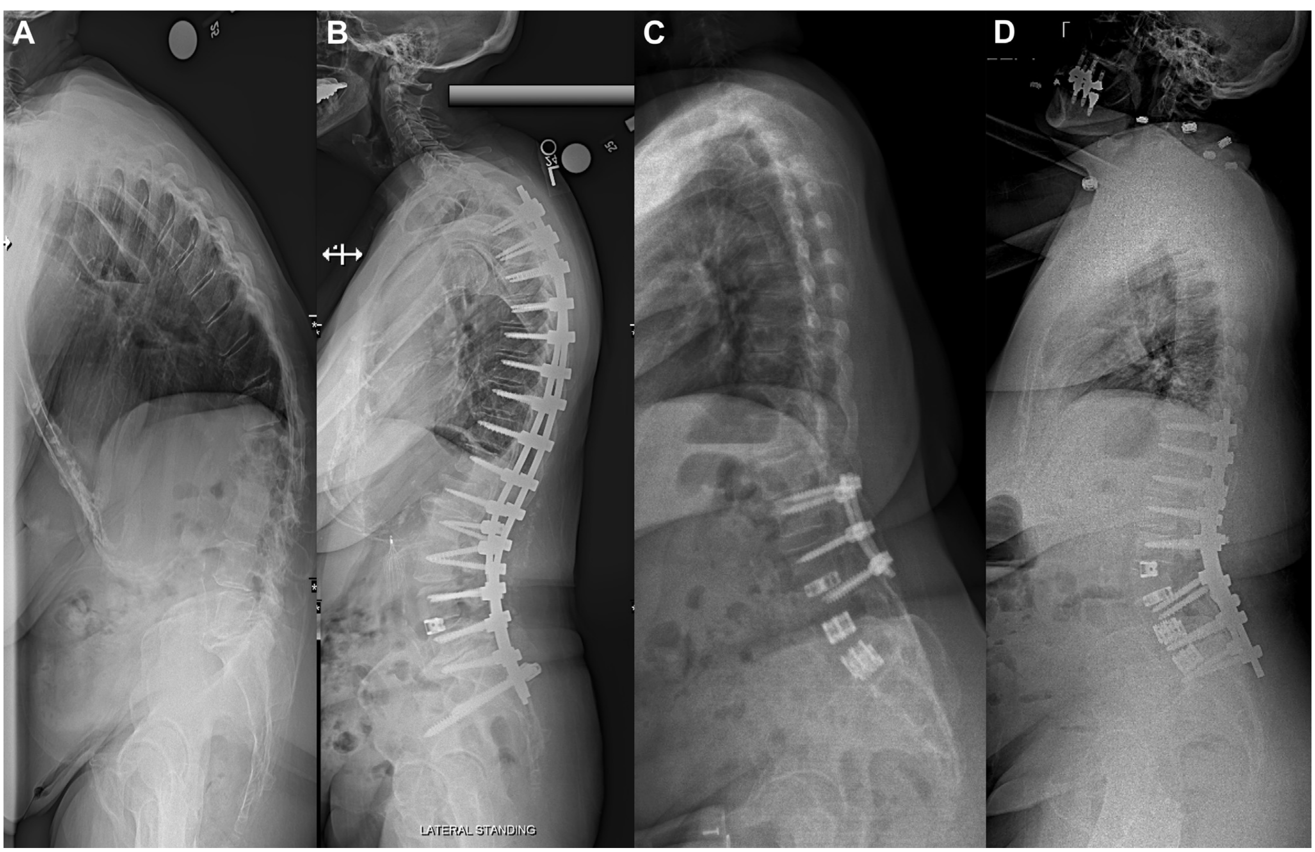

Figure 1. Preoperative (**A**) and postoperative (**B**) lateral standing radiographs of 72-year-old female patient with thoracolumbar deformity who underwent primary surgery. Preoperative (**C**) and postoperative (**D**) lateral standing radiographs of 65-year-old man with previous L2–S1 fusion and severe sagittal malalignment who underwent revision T10–S1 fusion with L3 pedicle subtraction osteotomy.

to reach SCB in HRQOL outcomes. We hypothesized that patients undergoing revision surgery would experience similar improvements in HRQOL outcomes to primary surgery cases and therefore be equally as likely to reach SCB thresholds.

MATERIALS AND METHODS

Patient Population

Consecutively enrolled adult (≥18 years old) patients with spinal deformity were entered into a prospective, multicenter database between 2009 and 2016. Institutional review board approval was obtained at each of the 11 involved sites across the United States. Patient consent for participation in the prospective database was obtained at the time of enrollment. For the purposes of this study, deformity was defined by the presence of 1 or more of the following: coronal curve cobb angle >20°, sagittal vertical axis (SVA) ≥5 cm, pelvic tilt (PT) >25°, or thoracic kyphosis >60°. Patients who underwent operative management of thoracolumbar spinal deformity including instrumentation of 4 or more contiguous spinal levels were included. Minimum follow-up of 2 years after surgery was required for inclusion in the present study. Patients with deformity secondary to neuromuscular, infectious, or neoplastic conditions were excluded.

Study Design, Data Collection, and Radiographic Assessment

We conducted a retrospective review of the aforementioned prospective database. Demographic, operative, and HRQOL scores were recorded at baseline and at 2-year follow-up. HRQOL data included ODI, SRS-22r, SF-36, and NRS score for back and leg pain. Demographic features included patient age, sex, Charlson Comorbidity Index, body mass index, smoking status, and presence of depression or diabetes. Surgical features included the number of levels fused and whether a 3-column osteotomy (pedicle subtraction osteotomy or vertebral column resection) was performed.

Full-length standing posteroanterior and lateral radiographs were obtained for all patients at baseline and 2-year follow-up. Radiographic measurements were performed centrally using validated software (Spineview; ENSAM Laboratory of Biomechanics, Paris, France).[18] These included SVA, PT, lumbo-pelvic mismatch (PI-LL, and curve type according to the SRS-Schwab adult thoracolumbar spinal deformity classification.[19,20]

Outcome Measures

We compared baseline demographic, HRQOL, and radiographic features for patients undergoing primary versus revision procedures. The latter included any patient who had undergone one or more instrumented fusions of the lumbar spine. Patients who had previously undergone lumbar decompression alone or cervical surgery were included in the primary group. The primary outcome measure was reaching SCB threshold in ODI, SF-36 PCS, and back and leg pain NRS score. Secondary outcomes included absolute and change scores in ODI, PCS, and back and leg pain NRS score. We used SCB thresholds previously reported for outcome after lumbar fusion including an ODI decrease of 18.8, PCS increase of 6.2, and a back and leg NRS score decrease of 2.5 (Table 1).[12] For comparison, the proportion of study patients reaching MCID was determined; MCID values from the same report were used.[12]

Table 1. Substantial Clinical Benefit and Minimal Clinically Important Difference Thresholds for Primary Outcome Measures[12]

	Substantial Clinical Benefit	Minimal Clinically Important Difference
Oswestry Disability Index	18.8	12.8
SF-36 physical component summary	6.2	4.9
Back pain numeric rating scale	2.5	1.2
Leg pain numeric rating scale	2.5	1.6

SF-36, Short Form 36 Health Questionnaire.

Data Analysis

Demographic, surgical, and radiographic data were tabulated and frequency distributions determined. For continuous data, the Kolmogorov–Smirnov test was used to test for normality. Normally distributed variables were compared with the Student paired t test and analysis of variance, whereas the Wilcoxon test was used for data that was not normally distributed. For categorical variables, the χ^2 or Fisher exact test was used, depending on cell numbers. All statistical tests were 2-tailed, and a P value < 0.05 was considered statistically significant. All statistical analyses were performed with IBM SPSS Statistics for Macintosh, Version 23.0 (IBM Corp., Armonk, New York, USA).

RESULTS

In total, 332 patients achieved 2-year follow-up including 228 primary and 104 revision cases. Figure 2 depicts the patient selection flow diagram. Baseline demographic, surgical, and

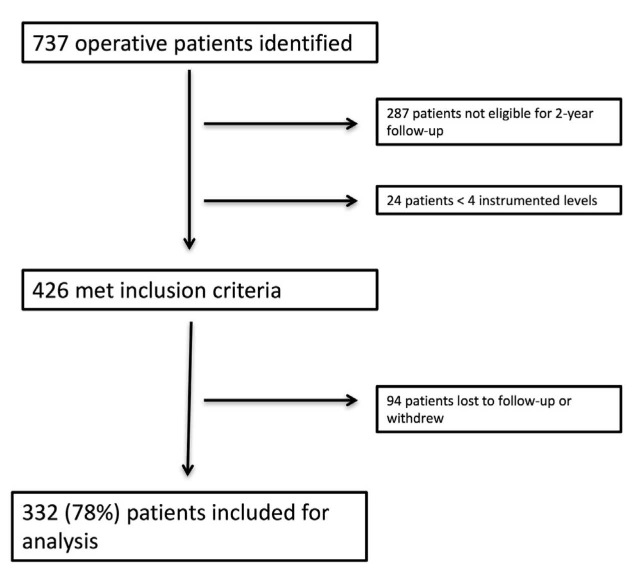

Figure 2. Flow diagram for patient selection.

Table 2. Baseline Demographic, HRQOL, Surgical, and Radiographic Characteristics of the Total Study Population and Primary and Revision Surgery Groups

	Total	Primary	Revision	*P* Value
n	332	228	104	
Demographics				
Age, years, mean (SD)	57.0 (14.8)	55.9 (15.3)	58.3 (13.5)	0.17
Female, *n* (%)	273 (82.2%)	189 (82.9%)	83 (80.8%)	0.64
CCI	1.7 (1.7)	1.6 (1.7)	1.9 (1.8)	0.19
BMI	27.3 (6.3)	27.0 (6.3)	28.0 (6.2)	0.19
Depression	81 (24.4%)	50 (22.9%)	31 (32.3%)	0.081
Diabetes	21 (6.3%)	17 (7.8%)	4 (4.2%)	0.24
Smoker	28 (8.4%)	19 (8.8%)	9 (9.4%)	0.87
HRQOL				
ODI	43.5 (18.9)	41.2 (19.3)	48.5 (16.9)	0.001
SF-36 PCS	32.2 (10.2)	33.4 (10.8)	29.5 (8.1)	<0.0001
Back pain (NRS)	7.2 (2.3)	7.0 (2.3)	7.5 (2.1)	0.051
Leg pain (NRS)	4.4 (3.4)	4.3 (3.4)	4.9 (3.3)	0.16
SRS-22r, total	2.8 (0.7)	2.9 (0.7)	2.6 (0.7)	0.003
Activity	2.9 (0.9)	3.0 (0.9)	2.6 (0.8)	<0.0001
Pain	2.4 (0.9)	2.5 (0.9)	2.2 (0.9)	0.011
Appearance	2.4 (0.7)	2.5 (0.7)	2.2 (0.8)	0.015
Mental	3.4 (0.9)	3.5 (0.9)	3.3 (1.0)	0.13
Satisfaction	2.8 (1.1)	2.8 (1.1)	2.7 (1.2)	0.69
Surgical characteristics				
Number of levels fused	11.9 (3.8)	11.7 (3.6)	12.3 (4.1)	0.23
Three-column osteotomy	0—256 (79.5)	0—128 (85.9%)	0—22 (28.6%)	<0.0001
	1—70 (21.7)	1—20 (13.4%)	1—50 (64.9%)	
	2—5 (1.6%)	2—1 (0.7%)	2—4 (5.2%)	
	3—1 (0.3%)	3—0 (0.0%)	3—1 (1.3)	
Radiographic measurements				
SVA, mm	65.6 (78.3)	45.1 (67.4)	111.4 (81.8)	<0.0001
PT, °	23.6 (11.1)	21.0 (9.8)	29.5 (11.6)	<0.0001
PI-LL, °	15.9 (22.0)	11.0 (20.0)	26.7 (22.4)	<0.0001
SRS Schwab curve type				
N	98 (29.5%)	49 (21.5%)	49 (47.1%)	
T	17 (5.1%)	15 (6.6%)	2 (1.9%)	<0.0001
L	128 (38.6%)	91 (39.9%)	37 (35.6%)	
D	89 (26.8%)	73 (32.0%)	16 (15.4%)	

HRQOL, health-related quality of life; CCI, Charlson Comorbidity Index; BMI, body mass index; ODI, Oswestry Disability Index; SF-36 PCS, Physical Component Summary of Short Form-36; NRS, numeric rating scale; SRS-22r, Scoliosis Research Society 22 questionnaire, revised; SVA, sagittal vertical axis; PT, pelvic tilt; PI-LL, pelvic incidence—lumbar lordosis mismatch.

Table 3. Likelihood of Reaching SCB and MCID Thresholds in HRQOL Measures for Primary Versus Revision Thoracolumbar Deformity Surgery

	Total	Primary	Revision	*P* Value
n	332	228	104	
ODI	Missing = 4			
SCB	121 (36.9%)	82 (36.3%)	39 (38.2%)	0.73
MCID	163 (49.7%)	113 (50.0%)	50 (49.0%)	0.87
PCS	Missing = 14			
SCB	165 (51.9%)	117 (53.4%)	48 (48.5%)	0.41
MCID	179 (56.3%)	122 (55.7%)	57 (57.6%)	0.76
Back pain	Missing = 111			
SCB	129 (58.4%)	95 (60.5%)	34 (53.1%)	0.31
MCID	149 (67.4%)	109 (69.4%)	40 (62.5%)	0.32
Leg pain	Missing = 112			
SCB	76 (34.5%)	58 (36.9%)	18 (28.6%)	0.24
MCID	92 (27.7%)	69 (43.9%)	23 (36.5%)	0.31

SCB, substantial clinical benefit; MCID, minimal clinically important difference; HRQOL, health-related quality of life; ODI, Oswestry Disability Index; PCS, Physical Component Summary of Short Form-36.

radiographic features are presented in Table 2. Those undergoing revision surgery had similar demographic characteristics at baseline. They did not differ significantly in mean age, sex distribution, Charlson Comorbidity Index, or body mass index. There were more patients with depression and with diabetes in the primary group; however, these differences were not significant. The proportion of smokers was similar between the primary and revision groups. As part of their deformity correction surgery, patients undergoing revision had approximately the same number of levels fused (12.3 vs. 11.7 levels; P = 0.23) but had significantly more 3-column osteotomies: 71.4% of revision procedures included at least one 3-column osteotomy as compared with only 14.1% of primary operations.

Patients in the revision group had worse baseline HRQOL as compared with the primary group (Table 2). This was significant for all HRQOL measures with the exception of the SRS-22r mental and satisfaction subdomains and back and leg pain scores. The severity of radiographic deformity was considerably greater in the revision patient group, including greater SVA, PI-LL, and PT (Table 2). The revision group comprised a greater proportion of patients with sagittal plane deformity (47.1% vs. 21.5%) alone (no major coronal curve; SRS-Schwab curve type "N"), whereas there were more primary patients with thoracic (6.6% vs. 1.9%; type "T") and double curves (32.0% vs. 15.4%; type "D").

Of the 104 patients in the revision group, the majority (79.8%) had undergone posterior-only lumbar arthrodesis; 2.9% and 13.5% underwent anterior-alone and combined anterior—posterior fusions, respectively, and the approach was not documented for 3.8%. Many (41.3%) had experienced a surgical complication from their original procedure, including new motor weakness (5.8%) and wound infection (4.8%). Thirteen patients (12.5%) had developed a pseudarthrosis after their original operation. Twenty-four patients (23.1%) in the revision group had previously undergone a revision operation before the present analysis.

Despite having worse baseline HRQOL and more severe radiographic deformity, the number of patients who reached SCB for ODI (38.2% vs. 36.3%), PCS (48.5% vs. 53.4%), back (53.1% vs. 60.5%), and leg pain (28.6 vs. 36.9%) ($P > 0.05$ for all) did not significantly differ between revision and primary operations (Table 3 and Figure 3). Similarly, the number who achieved MCID in the same outcome measures did not differ between groups.

Table 4 denotes the absolute 2-year follow-up HRQOL outcomes and the change from baseline to 2-year follow-up in ODI, PCS, and back and leg pain. Patients undergoing revision had worse absolute 2-year HRQOL scores for ODI (34.4 vs. 25.4; $P < 0.0001$), PCS (36.9 vs. 41.4; $P = 0.001$), back pain (4.3 vs. 3.3; $P = 0.02$), and less leg pain (3.4 vs. 2.4; $P = 0.027$) as compared with primary patients. As with the SCB thresholds, the change from baseline to 2-year follow-up in ODI, PCS, and back and leg pain did not significantly differ between groups. Patients undergoing primary thoracolumbar deformity operations reached a significantly greater SRS-22r total score and in all subdomains than those in the revision group (Table 4).

DISCUSSION

Comparing baseline characteristics of patients with ASD undergoing primary versus revision surgery, our results suggest that the latter group have worse baseline HRQOL and more severe radiographic deformity. The revision group had greater mean ODI and lower PCS and SRS-22r (total and the majority of subdomain scores). They also have more severe radiographic deformity, as indicated by greater SVA, PT, and PI-LL mismatch. The revision group had more than twice the proportion of patients (47.1% vs. 21.5%) with primarily sagittal plane deformity (SRS-Schwab curve type "N"). Several studies have demonstrated significant correlations between sagittal radiographic parameters and HRQOL

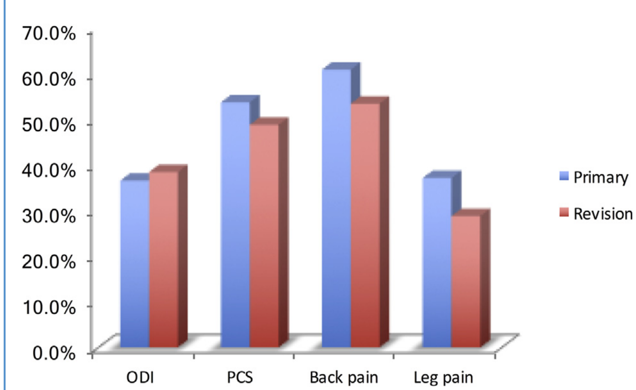

Figure 3. Likelihood of reaching substantial clinical benefit thresholds in health-related quality of life outcomes 2 years after surgical treatment of thoracolumbar spinal deformity. ODI, Oswestry Disability Index; PCS, Physical Component Summary of Short Form-36.

Table 4. Two-Year and Change from Baseline to 2-Year HRQOL Outcomes for Primary Versus Revision Thoracolumbar Deformity Surgery

	Total	Primary	Revision	*P* Value
n	332	228	104	
ODI (2-year)	28.2 (20.5)	25.4 (19.6)	34.4 (21.1)	<0.0001
ODI (change from baseline to 2-year)	−14.4 (17.3)	−14.3 (17.6)	−14.4 (16.5)	0.97
PCS (2-year)	40.0 (11.5)	41.4 (11.6)	36.9 (10.9)	0.001
PCS (change from baseline to 2-year)	7.9 (9.6)	8.1 (9.8)	7.5 (9.2)	0.62
Back pain NRS (2-year)	3.6 (3.1)	3.3 (3.1)	4.3 (2.9)	0.02
Back pain (change from baseline to 2-year)	3.4 (3.2)	3.5 (3.3)	3.1 (3.2)	0.44
Leg pain NRS (2-year)	2.7 (3.0)	2.4 (2.9)	3.4 (3.2)	0.027
Leg pain (change from baseline to 2-year)	2.7 (3.0)	1.7 (3.4)	1.2 (3.6)	0.31
SRS-22r total	3.6 (0.8)	3.7 (0.8)	3.4 (0.9)	<0.0001
Activity	3.5 (1.0)	3.6 (1.0)	3.2 (1.0)	0.001
Pain	3.4 (1.1)	3.5 (1.1)	3.0 (1.1)	<0.0001
Appearance	3.6 (1.1)	3.7 (0.9)	3.3 (1.0)	0.004
Mental	3.8 (0.9)	3.9 (0.8)	3.6 (1.0)	0.011
Satisfaction	4.2 (0.9)	4.3 (0.9)	4.0 (1.0)	0.02

HRQOL, health-related quality of life; ODI, Oswestry Disability Index; PCS, Physical Component Summary of Short Form-36; NRS, numeric rating scale; SRS-22r, Scoliosis Research Society-22 revised total and subdomain scores.

measures with lesser correlation to coronal measures.[5,6,21,22] It is therefore likely that the preponderance of sagittal deformity contributed to worse HRQOL in the revision as compared with the primary group. The revision group included several patients (41.3%) who had experienced complications from their original surgery, many of which contributed to the indication for the revision operation. These complications, failed previous lumbar surgery, and residual symptoms after the initial operation could explain the observed difference in HRQOL compared with the primary group.

This study demonstrates that despite inferior baseline HRQOL and more severe preoperative deformity, patients in the revision group experienced similar improvement in all HRQOL measures. Correspondingly, they were as likely to reach SCB and MCID thresholds for ODI, PCS, and back and leg pain NRS. Patients with ASD undergoing revision procedures did not, however, reach as good absolute scores in ODI, PCS, SRS-22r, or back or leg pain (i.e., they remained significantly worse than their primary surgery counterparts in all of these measures).

In a study comparing primary and revision surgery in the setting of ASD, Diebo et al.[17] reviewed 10,912 patients (9133 primary and 850 revision cases). They found that revision cases had a significantly greater incidence of procedure-related complications (72.0%) than primary cases (47.0%; $P = 0.001$) and a longer hospital stay (7.1 vs. 6.4 days, $P < 0.0001$). This study did not, however, include information on patient outcome. Hassanzadeh et al.[23] retrospectively reviewed 167 patients with ASD undergoing primary ($n = 59$) or revision ($n = 108$) surgery. As in the present study, they found a greater incidence of sagittal plane imbalance in the revision group as compared with more coronal plane deformity in the primary group. They also identified a greater rate of 3-column osteotomies in the revision group. Contrary to our findings, the baseline ODI and SRS-22 did not differ between revision and primary cases in their series. They did not specify what constituted "revision" and, given their high proportion of revision cases, it may have included patients who had undergone relatively minor previous lumbar operations (e.g., microdiscectomy). The authors identified significant and similar improvements in both the primary and revision groups in ODI and all SRS-22 domains. Interestingly, the incidence of major complications did not differ (20% vs. 21%) between groups. Allowing for differences in classification of revision versus primary cases, the present study and that of Hassanzadeh et al. both suggest that satisfactory and similar improvements in HRQOL are achievable in patients who have had previous lumbar surgery.

In a study of 84 patients with degenerative scoliosis who underwent primary ($n = 53$) versus revision ($n = 31$) surgery and had similar baseline characteristics, both groups experienced similar ($P > 0.05$) and significant improvement ($P < 0.001$) in ODI and visual analog scale scores at 2-year follow-up.[24] The primary and revision patient groups also had final radiographic measures that were comparable. Kasliwal et al.[25] investigated the impact of previous short-segment instrumentation on HRQOL outcomes in 30 matched pairs of patients undergoing scoliosis correction. They found no difference in clinical outcome based on ODI, SRS-22r, or SF-12 PCS ($P > 0.5$ for each). The complication rate was comparable between the matched cohorts as well. The present study provides further support that revision ASD surgery is as likely to provide significant benefit as primary surgery.

Carreon et al.[26] evaluated 1055 patients who underwent primary or revision lumbar fusion surgeries and derived MCID values for each group separately. This supports the use of patient-reported outcomes and in particular threshold values as a framework for interpreting clinical improvement in primary versus revision operations. Furthermore, it suggests that an individual's perception of clinical benefit from surgery may not be substantially influenced by their previous experience to operative care.[26]

An unintended consequence of the trend toward improved data collection and large database studies is that increased statistical power enhances the ability to detect a significant difference for even small differences in measured outcomes. These differences may not necessarily reflect a clinically meaningful change for an individual patient. The MCID seeks to establish a threshold for a change that is detectable by a patient. However, several limitations of MCID have been identified that may limit its utility. Copay et al.[13,27] describe 3 major problems: 1) it does not account for the cost of treatment; 2) MCID values can vary widely depending on the method by which they are determined; and 3) the change in score is contingent on the initial baseline value. The methods for deriving MCID values in spine surgery have been previously discussed and are outside the scope of the present study.[13] SCB is typically determined using an anchoring-based approach and represents the difference in score for a given instrument that corresponds to a difference between a patient reporting being "much better" versus "same" on a suitable anchor.[12,15] Whereas MCID represents a minimal detectable benefit, SCB corresponds to what a patient perceives as substantial improvement in function and thus likely represents a preferred target for clinical success.

In this light, it is important to note that only 36% of primary and 38% of revision patients in our study reached SCB in ODI. The number of patients that reached SCB in PCS (53.4% primary/48.5% revision) and in back pain NRS (60.5% primary/53.1% revision) was greater but still modest, particularly considering the magnitude, complexity and impact of these surgical procedures. The SCB values used in this study were derived by Glassman et al.[12] using 2 separate anchors, the SF-36 transition anchor and a combined satisfaction anchor. These anchors yielded very similar SCB values differentiating optimal from fair responses. However, the use of subjective anchors as a gold standard assumes that they represent an independent measure of the overall construct of an HRQOL measure, which may not be a valid assumption.[28] As argued by Glassman et al.,[12] no single clinical or radiographic measure can, in isolation, satisfactorily capture the value of a surgical procedure.

The SCB thresholds used herein were based on general lumbar fusion procedures and were therefore not specific to thoracolumbar deformity. As stated previously, SCB thresholds are both disease- and outcome-specific. Many patients undergoing short-segment lumbar fusions are able to maintain productive lives albeit with a degree of pain and disability. Conversely, patients with significant deformities may be debilitated to the point that even their basic activities of daily living are compromised. Thus, the former group may require a larger HRQOL improvement to appreciate a substantial benefit than the latter. This discrepancy also may explain the relatively low number of patients that reached thresholds for SCB in the present study. Notwithstanding the methodologic challenges of defining appropriate SCB values, the relatively low proportion of patients that achieved the SCB threshold for improvement in multiple HRQOL measures is an important finding. It serves as an impetus for future research to enhance patient selection and optimize surgical techniques to improve the likelihood of this treatment providing substantial benefit to patients.

This study provides information on outcomes for primary and revision ASD surgery in a large cohort of patients. The results, however, should be interpreted in the context of the potential limitations of the study's design. All participating institutions were high-volume spinal deformity centers with experienced surgeons; therefore, the results may not be directly generalizable to lower-volume, less-specialized facilities. The study was retrospective, and surgical selection was made at the discretion of the treating surgeon, introducing the potential for selection bias in the study population. As stated previously, SCB thresholds derived from a general lumbar degenerative population were used and may not accurately reflect the deformity population.

CONCLUSIONS

Patients undergoing revision ASD surgery have worse baseline HRQOL and radiographic deformity. Although they do not achieve as good 2-year absolute HRQOL outcome scores as primary surgeries, they have a similar likelihood of reaching SCB threshold for improvement in 2-year HRQOL.

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