



Early Patient-Reported Outcomes Predict 3-Year Outcomes in Operatively Treated Patients with Adult Spinal Deformity

Amit Jain¹, Khaled M. Kebaish¹, Daniel M. Sciubba², Hamid Hassanzadeh³, Justin K. Scheer⁴, Brian J. Neuman¹, Virginie Lafage⁵, Shay Bess⁶, Themistocles S. Protopsaltis⁶, Douglas C. Burton⁷, Justin S. Smith⁸, Christopher I. Shaffrey⁸, Richard A. Hostin⁹, Christopher P. Ames⁴, and the International Spine Study Group

■ **BACKGROUND:** For patients with adult spinal deformity (ASD), surgical treatment may improve their health-related quality of life. This study investigates when the greatest improvement in outcomes occurs and whether incremental improvements in patient-reported outcomes during the first postoperative year predict outcomes at 3 years.

■ **METHODS:** Using a multicenter registry, we identified 84 adults with ASD treated surgically from 2008 to 2012 with complete 3-year follow-up. Pairwise *t* tests and multivariate regression were used for analysis. Significance was set at $P < 0.01$.

■ **RESULTS:** Mean Oswestry Disability Index (ODI) and Scoliosis Research Society-22r total (SRS-22r) scores improved by 13 and 0.8 points, respectively, from preoperatively to 3 years (both $P < 0.001$). From preoperatively to 6 weeks postoperatively, ODI scores worsened by 5 points ($P = 0.049$) and SRS-22r scores improved by 0.3 points ($P < 0.001$). Between 6 weeks and 1 year, ODI and SRS-22r scores improved by 19 and 0.5 points, respectively (both $P < 0.001$). Incremental improvements during the first postoperative year predicted 3-year outcomes in ODI and SRS-22r scores (adjusted $R^2 = 0.52$ and 0.42 , respectively). There were no significant differences in the measured or predicted 3-year ODI ($P = 0.991$) or SRS-22r scores ($P = 0.986$).

■ **CONCLUSIONS:** In surgically treated patients with ASD, the greatest improvements in outcomes occurred between

6 weeks and 1 year postoperatively. A model with incremental improvements from baseline to 6 weeks and from 6 weeks to 1 year can be used to predict ODI and SRS-22r scores at 3 years.

INTRODUCTION

Operative treatment of patients with adult spinal deformity (ASD) has been associated with significant improvements in radiographic and patient-reported outcomes, despite risk of major complications.¹⁻⁵ Studies have shown that the Scoliosis Research Society-22r (SRS-22r) patient questionnaire and the Oswestry Disability Index (ODI) are responsive tools for measuring improvements in patient-reported outcomes after ASD surgery.⁶⁻⁸

Glassman et al.⁹ showed that in operatively treated patients with ASD, changes in patient-reported outcomes occurred during the first postoperative year and stabilized at the 1-year postoperative interval. The investigators concluded that for most patients, 1 year after surgery was a reasonable time frame to anticipate maximal improvement. In contrast, Bridwell et al.¹⁰ hypothesized that longer follow-up may show a deterioration of patient-reported outcomes. However, these investigators found that radiographic and clinical outcomes did not deteriorate after 2 years for most patients.¹⁰ To our knowledge, few studies have focused on ASD with longer than 2-year patient-reported outcome data,¹⁰⁻¹⁴ and no study has investigated whether the incremental improvements

Key words

- Adult spinal deformity
- Oswestry Disability Index
- Patient-reported outcomes
- Scoliosis Research Society-22r

Abbreviations and Acronyms

ASD: Adult spinal deformity
MCID: Minimum clinically important difference
ODI: Oswestry Disability Index
SRS-22r: Scoliosis Research Society-22r

From the Departments of ¹Orthopaedic Surgery and ²Neurosurgery, The Johns Hopkins University, Baltimore, Maryland; Departments of ³Orthopaedic Surgery and ⁴Neurosurgery,

University of Virginia, Charlottesville, Virginia; ⁴Department of Neurosurgery, University of California San Francisco, San Francisco, California; ⁵Department of Orthopaedic Surgery, Hospital for Special Surgery, New York, New York; ⁶Department of Orthopaedic Surgery, New York University, New York, New York; ⁷Department of Orthopaedic Surgery, University of Kansas, Kansas City, Kansas; and ⁸Department of Orthopaedic Surgery, Baylor University, Waco, Texas, USA

To whom correspondence should be addressed: Khaled M. Kebaish, M.D.
 [E-mail: editorialservices@jhmi.edu]

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obtained in patient-reported outcomes persist during the 3-year time frame.

The aims of our study were to investigate when the greatest improvements in patient outcomes occur after surgery for ASD and if incremental improvements in patient-reported outcomes during the first postoperative year predict outcomes at 3 years.

METHODS

Institutional review board approval was received at each participating institution.

Database Query Criteria

A multicenter registry of patients with ASD was queried to identify all patients 18 years or older who were surgically treated for ASD from 2008 to 2012 and had at least 3 years of clinical and radiographic follow-up. ASD was defined as occurring in patients who were ≥ 18 years old and had scoliosis Cobb angle $\geq 20^\circ$, sagittal vertical axis ≥ 5 cm, pelvic tilt $\geq 25^\circ$, and/or thoracic kyphosis $\geq 60^\circ$. Patients with spinal deformity in the setting of neuromuscular causes, active infection, or malignancy were excluded. The primary indication for surgery was correction of spinal deformity, but at least 56% of patients had additional neurologic symptoms such as history of lower extremity paresthesias and/or weakness.

Radiographic and Patient-Reported Outcomes

Free-standing, full-length anteroposterior and lateral spine radiographs were obtained on 91.4-cm (36-inch) cassettes at baseline and at 6-week, 1-year, 2-year, and 3-year follow-up and were analyzed in a central location. Radiographic parameters of interest were measured using validated software (Spineview [ENSAM, Laboratory of Biomechanics, Paris, France]). Each patient also completed the SRS-22r and the ODI before surgery and at 6 weeks, 1 year, 2 years, and 3 years postoperatively.

Statistical Methods

Pairwise *t* tests were used to compare preoperative (baseline) and 3-year postoperative radiographic outcomes, as well as patient-reported outcomes at various postoperative intervals.

Multivariate regression models were constructed to assess the relationship between changes in baseline and 3-year postoperative outcomes as a function of incremental improvements from baseline to 6 weeks and from 6 weeks to 1 year. Pairwise *t* tests and Pearson correlation coefficients were used to compare predicted and measured 3-year postoperative scores. Significance was set at a *P* value less than 0.01 for all analyses.

RESULTS

Patient and Radiographic Characteristics

We identified 141 patients, of whom 84 (60%) had complete radiographic and patient-reported outcome data at 3-year follow-up and were included in the analysis. Patient and surgical characteristics are reported in **Table 1**. Mean age at surgery was 54 ± 17 years, and 85% of patients were women. The mean number of levels fused was 10.5 ± 4.5 . Forty-three patients (51%) were fused to the pelvis.

Table 1. Characteristics of 84 Operatively Treated Patients with Adult Spinal Deformity

Characteristic	Mean \pm Standard Deviation	Number (%)
Age at surgery (years)	54 ± 17	
Female sex		71 (85)
Body mass index (kg/m ²)	26.8 ± 6.4	
History of spine surgery		38 (45)
Charlson Comorbidity Index	1.2 ± 1.4	
American Society of Anesthesiologists physical status classification		
I		17 (20)
II		38 (45)
III		23 (27)
IV		2 (2)
Operative time (minutes)	389 ± 139	
Estimated blood loss (L)	1.98 ± 1.83	
Number of levels fused	10.5 ± 4.5	
Length of hospital stay (days)	8.3 ± 4.0	

Patients were stratified using the SRS-Schwab ASD classification. Preoperatively, 26% patients had SRS-Schwab T-type curves, 6% had L-type curves, 37% had D-type curves, and 32% had N-type curves. When classifying by Schwab pelvic tilt modifier, 42% of patients had a 0 modifier, 33% had a + modifier, and 25% had a ++ modifier. When classifying by Schwab global alignment modifier, 45% of patients had a 0 modifier, 25% had a + modifier, and 30% had a ++ modifier. Compared with baseline, at 3 years, there were significant improvements in mean thoracic Cobb angle ($P = 0.016$), lumbar Cobb angle ($P = 0.001$), T2-T12 thoracic kyphosis ($P < 0.001$), T12-S1 lumbar lordosis ($P < 0.001$), pelvic incidence–lumbar lordosis ($P < 0.001$), and sagittal alignment ($P = 0.001$) (**Table 2**).

Changes in ODI and SRS-22r

The mean improvements from baseline to 3 years in ODI and SRS-22r total scores were 13 ± 16 and 0.8 ± 0.7 points, respectively (both $P < 0.001$). There were also significant improvements in all SRS-22r domains (function, pain, self-image, mental health, and satisfaction; all $P < 0.001$) (**Table 3**).

From baseline to 6 weeks, the mean ODI score worsened by 5 points ($P = 0.049$) and the mean SRS total score improved by 0.3 points ($P < 0.001$). The greatest improvements occurred between 6 weeks and 1 year, with mean ODI score improvement of 19 points, and mean SRS-22r total score improvement of 0.5 points (both $P < 0.001$) (**Table 3**).

There were no significant changes in mean postoperative ODI scores from 1 year to 2 years ($P = 0.898$) or from 2 years to 3 years ($P = 0.373$). Similarly, there were no significant changes in the mean postoperative SRS-22r total scores from 1 year to 2 years ($P = 0.986$) or from 2 years to 3 years ($P = 0.228$).

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