

Does prior short-segment surgery for adult scoliosis impact perioperative complication rates and clinical outcome among patients undergoing scoliosis correction?

Clinical article

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Object. In many adults with scoliosis, symptoms can be principally referable to focal pathology and can be addressed with short-segment procedures, such as decompression with or without fusion. A number of patients subsequently require more extensive scoliosis correction. However, there is a paucity of data on the impact of prior short-segment surgeries on the outcome of subsequent major scoliosis correction, which could be useful in preoperative counseling and surgical decision making. The authors' objective was to assess whether prior focal decompression or short-segment fusion of a limited portion of a larger spinal deformity impacts surgical parameters and clinical outcomes in patients who subsequently require more extensive scoliosis correction surgery.

Methods. The authors conducted a retrospective cohort analysis with propensity scoring, based on a prospective multicenter deformity database. Study inclusion criteria included a patient age ≥ 21 years, a primary diagnosis of untreated adult idiopathic or degenerative scoliosis with a Cobb angle $\geq 20^\circ$, and available clinical outcome measures at a minimum of 2 years after scoliosis surgery. Patients with prior short-segment surgery (< 5 levels) were propensity matched to patients with no prior surgery based on patient age, Oswestry Disability Index (ODI), Cobb angle, and sagittal vertical axis.

Results. Thirty matched pairs were identified. Among those patients who had undergone previous spine surgery, 30% received instrumentation, 40% underwent arthrodesis, and the mean number of operated levels was 2.4 ± 0.9 (mean \pm SD). As compared with patients with no history of spine surgery, those who did have a history of prior spine surgery trended toward greater blood loss and an increased number of instrumented levels and did not differ significantly in terms of complication rates, duration of surgery, or clinical outcome based on the ODI, Scoliosis Research Society-22r, or 12-Item Short Form Health Survey Physical Component Score ($p > 0.05$).

Conclusions. Patients with adult scoliosis and a history of short-segment spine surgery who later undergo more extensive scoliosis correction do not appear to have significantly different complication rates or clinical improvements as compared with patients who have not had prior short-segment surgical procedures. These findings should serve as a basis for future prospective study.

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KEY WORDS • adult scoliosis • outcome • surgery • revision • complication • deformity

THE demographic shift toward an older population in the US has led to an increased prevalence of adult scoliosis, with reported rates as high as 70% among the elderly.^{1,6,11,35–38} Although the disease may have a rela-

tively benign course, some patients experience significant symptoms as a result of disc degeneration, facet arthropathy, and/or nerve root compression.^{22,26,41} Patients with symptomatic adult scoliosis typically present with pain and disability, and back pain and radiculopathy are the most common presentations.^{2,39,41–46}

Recent studies have shown the potential benefit of operative treatment for patients with scoliosis who have symptoms that fail to respond to nonoperative mea-

Abbreviations used in this paper: EBL = estimated blood loss; ODI = Oswestry Disability Index; SF-12 = 12-Item Short Form Health Survey; SRS = Scoliosis Research Society; SVA = sagittal vertical axis.

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ures.^{7,8,30,42-44} However, selecting the best surgical procedure for adults with symptomatic scoliosis may not be straightforward, with the spine surgeon often facing the challenge of whether it is necessary to surgically address the entire deformity.^{16,19,21,27,33,40,46,47,49} Short-segment procedures can involve less surgical morbidity and represent an attempt to preserve lifestyle and activity levels that could be affected by a definitive fusion of the entire deformity. However, even with careful selection, a subset of patients who undergo limited procedures can later become symptomatic because of deformity progression, worsening sagittal or coronal imbalance, failure of the previous fusion, new instability, or adjacent segment degeneration.^{6,32,51} A revision surgery rate as high as 67% has been reported following decompression and segmental fixation in patients with adult degenerative scoliosis.^{6,51} Considering that revision spine surgery for a deformity can be more challenging than the primary surgery, there may be greater risks of complications^{13,14,29} and at least theoretical chances of poorer clinical outcomes for more extensive scoliosis correction that follows prior short-segment procedures for scoliosis.

The objective in the present study was to assess differences in surgical parameters (for example, surgical time and blood loss), complication rates, and outcomes in adults undergoing spinal deformity correction who either did or did not have a history of a short-segment spinal procedure.

Methods

The respective institutional review boards of the participating institutions approved this study.

Patient Population

This study is a retrospective cohort analysis with propensity scoring, based on prospectively, consecutively collected patients from the Adult Deformity Outcomes multiinstitutional database of the Spine Deformity Study Group.^{7,8,10,44} At the time of entry into the database, patients were classified into either operative or nonoperative treatment groups, based on the initial management approach. The decision of whether to pursue operative or nonoperative treatment is complex and was ultimately based on patient input and physician counseling. The majority of patients with adult scoliosis seen in our surgical clinics have received nonoperative therapies, and many have undergone prior surgical intervention and are seen for further evaluation. At the time of database enrollment all patients completed a battery of health-related quality of life measures, including the ODI,²⁰ SRS-22r,³ and the SF-12⁴⁸ questionnaires. Patients were assessed both clinically and radiographically at regular intervals. Standardized forms were used to collect clinical, surgical, and radiographic data as well as complications data.

Inclusion criteria for the present study consisted of enrollment in the operative group of the Adult Deformity Outcomes database between January 2002 and February 2006, a patient age ≥ 21 years, a primary diagnosis of untreated adult idiopathic or degenerative (de novo) scoliosis (Cobb angle $\geq 20^\circ$), and availability of clinical

outcome measures at a minimum of 2 years following surgery. Patients with a history of prior long-segment (≥ 5 spinal levels) spine surgery for scoliosis correction were excluded from this study.

All patients underwent a detailed history and physical examination at the time of database entry. Clinical data extracted for the present study included patient age; baseline and follow-up health-related quality of life measures, including the ODI, SRS-22r, and SF-12; duration and details of surgery; details of any previous surgery; complications; EBL; and duration of hospital stay.

Imaging Parameters

Full-length scoliosis radiographs (anteroposterior and lateral) were obtained for all patients at the time of database enrollment. Curves were classified as thoracic, thoracolumbar/lumbar, or lumbosacral based on the largest Cobb angle. Coronal Cobb angle and SVA (C-7 plumb line offset from S-1) were assessed using standard techniques.³⁴

Statistical Analyses

Frequency distributions and summary statistics were calculated for all clinical, operative, and radiographic variables. Patients with a prior short-segment spine surgery were propensity matched¹⁵ to patients without prior surgery based on age and baseline ODI, Cobb angle, and SVA. In brief, propensity matching entails logistic regression modeling using the selected matching variables as independent variables for the model. The model is created based on all cases to be matched; in the present study this included both the patients with and those without a prior short-segment surgery. The resulting best-fit model is then used to calculate a score for each patient. Based on these scores, each patient with a history of prior short-segment surgery was matched with the patient without a history of prior surgery who had the closest numerical score. Age was selected as a matching variable, since the rate of complications associated with adult scoliosis surgery has been shown to substantially increase with age.⁴⁴ Baseline ODI was selected as a matching variable to control for the clinical and functional impact of the spinal deformity. The Cobb angle and SVA were included as matching parameters to control for the severity of baseline deformity. In addition, SVA was included based on the significant impact on disability and outcomes previously shown to be associated with this measure.^{23,24} Statistical comparisons of operative and outcome measures between the 2 matched cohorts were performed using the Wilcoxon signed-rank or Fisher exact tests. Statistical analyses were 2-sided, and a $p < 0.05$ was considered statistically significant.

Results

We identified 147 patients in the operative treatment arm in the database. Among these patients, 30 had a history of prior short-segment surgery and met the study inclusion criteria. These 30 patients were matched to 30 of the remaining 117 patients by using propensity scoring. Statistical comparison of baseline parameters (that is, age, ODI, Cobb angle, and SVA) demonstrated that the

2 cohorts were well matched (Table 1). The mean patient age was 64 years in each group, and the mean baseline ODI scores reflected moderate disability for both cohorts. The mean baseline Cobb angle and SVA reflect cohorts with moderate coronal curves and positive sagittal malalignment.

Among the 30 patients with prior short-segment surgery, 30% had received instrumentation, 40% had undergone arthrodesis, and the mean number of operated levels was 2.4 ± 0.9 (mean \pm SD). The mean number of prior procedures was 1.5 ± 0.7 (range 1–3). In the majority of patients (18), previous procedures consisted primarily of simple laminectomy for decompression without instrumentation or arthrodesis.

The 2 patient cohorts did not differ significantly with regard to operative parameters, including operative time and EBL (Table 1). In addition, the magnitude and complexity of surgical treatment did not differ significantly between the 2 groups, based on the use of staged procedures, combined anterior and posterior approaches, number of instrumented spinal levels, and the need to perform a pedicle subtraction osteotomy or vertebral column resection. Although there were trends toward greater operative blood loss and the need for a greater number of instrumented spinal levels in the group that had undergone previous short-segment surgery, these did not reach statistical significance.

There were no significant differences in the rates of

complications based on whether a patient did or did not have a history of prior spine surgery (Table 1). Specifically, the 2 cohorts did not have significantly different rates of durotomy, minor complications per patient, or major complications per patient ($p > 0.6$). Table 2 lists the complications observed in each of the cohorts, with the complications stratified as minor or major.

The mean ODI improved by approximately 20 points from baseline to follow-up in each of the 2 cohorts, and there was no significant difference in the mean ODI between the cohorts at the 2-year follow-up (Table 1). In addition, the clinical outcomes of the 2 cohorts did not differ significantly based on either the SRS-22 or the SF-12 Physical Component Score.

Discussion

For adults with symptomatic scoliosis that warrants surgical treatment, there is a tendency to address the entire deformity with a long-segment fusion at the time of the initial procedure. This tendency may result, at least in part, from concerns about the durability of short-segment procedures and the potential for greater complications should it be necessary to subsequently address the full deformity surgically. Although the rationale behind this approach may seem reasonable, it has not been proven. Revision deformity surgery can be challenging and may be associated with higher rates of complications.^{13,14,18,25,29,31,40}

TABLE 1: Comparison of operative measures and outcomes between matched cohorts of adults with or without a history of a short-segment spine procedure*

Factor	Value		p Value†
	No Prior Short-Segment Spine Op	Prior Short-Segment Spine Op	
mean baseline parameters used for propensity matching			
age in yrs	64 \pm 9	64 \pm 7	0.93
ODI score	49 \pm 14	46 \pm 15	0.67
Cobb angle	50 \pm 15	44 \pm 12	0.24
SVA	48 \pm 35	58 \pm 60	0.56
mean surgical time in hrs	8.3 \pm 2.7	9.1 \pm 2.4	0.25
no. of 2-stage procedures (%)	11 (37)	10 (33)	0.41
no. of ant & pst procedures (%)	15 (50)	12 (40)	0.59
mean no. of instrumented levels	9.2 \pm 4.2	11.0 \pm 4.2	0.07
no. of PSOs or VCRs performed (%)	3 (10)	3 (10)	0.28
mean EBL in ml	1497 \pm 1170	1934 \pm 1107	0.08
mean no. of minor complications/patient	0.3 \pm 0.5	0.3 \pm 0.6	0.87
mean no. of major complications/patient	0.2 \pm 0.4	0.4 \pm 1.0	0.61
no. of durotomies (%)	3 (10)	2 (7)	0.81
mean hospital stay in days	11.2 \pm 6.6	12.6 \pm 14.3	0.84
mean measures at 2-year follow-up			
ODI	30 \pm 17	26 \pm 20	0.51
SRS-22r	3.6 \pm 0.7	3.8 \pm 0.7	0.43
SF12-PCS	36 \pm 11	36 \pm 11	0.98

* ant = anterior; PCS = Physical Component Score; PSO = pedicle subtraction osteotomy; pst = posterior; VCR = vertebral column resection.

† Wilcoxon signed-rank or Fisher exact tests.

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TABLE 2: Comparison of complications in matched cohorts of adults with or without a history of short-segment spine procedure*

Factor	No. (%)	
	No Prior Short-Segment Spine Op	Prior Short-Segment Spine Op
total no. of patients	30	30
major complications	7	12
per patient	0.23	0.40
new neurological deficit		
acute	1 (3.3)	1 (3.3)
delayed	0	1 (3.3)
PE	0	2 (6.7)
cardiorespiratory (non-PE)/systemic	2 (6.7)	4 (13.3)
implant related†	2 (6.7)	1 (3.3)
vascular (intraop)	2 (6.7)	0
deep wound infection	0	1 (3.3)
sepsis	0	1 (3.3)
proximal junctional breakdown	0	1 (3.3)
death	0	0
minor complications	10	9
per patient	0.33	0.30
neurological (transient iliopsoas weakness)	1 (3.3)	0
DVT	0	2 (6.7)
durotomy	3 (10)	2 (6.7)
implant related‡	1 (3.3)	1 (3.3)
superficial wound infection	2 (6.7)	0
other§	3 (10)	4 (13)
total no. of patients w/ complication	13 (43)	13 (43)
total no. of complications	17	21
total no. of complications per patient	0.57	0.70

* DVT = deep vein thrombosis; PE = pulmonary embolism.

† Return to operating room for removal of iliac screw (1 patient) and instrumentation failure not otherwise specified (1 patient) in the group without prior spine surgery; instrumentation failure at L5–S1 level (1 patient) in the group with prior short-segment spine surgery.

‡ Asymptomatic rod fracture below S-1 (1 patient) in the no-history group; asymptomatic fractured rod (1 patient) in the history group.

§ Transient delirium (1 patient) and miscellaneous cutaneous complication (2 patients) in the group without prior spine surgery; ileus (1 patient), urinary tract infection (1 patient), thrombophlebitis (1 patient), and exacerbation of carpal tunnel syndrome requiring release (1 patient) in the group with prior short-segment spine surgery.

However, since focal decompression/short fusion may be all that is required in a significant number of patients, the approach of routinely advocating for long fusion with deformity correction up front may be too aggressive in the subset of patients that could otherwise benefit from short-segment procedures.

Although there is growing literature on revision de-

formity surgery in adults following the failure of primary deformity surgery,^{13,14,25,29,31} there remains a paucity of data on the impact of short-segment procedures on outcome following subsequent large reconstructive surgery. The present study was designed to address this deficiency and does not demonstrate any apparent impact on overall surgical complications or clinical outcomes in patients with adult scoliosis who require a longer fusion subsequent to short-segment decompression or fusion. This information could be useful in counseling patients on surgical treatment options.

It is important to recognize that the purpose of the present study was not to identify factors leading to failures of short-segment procedures or to assess the effectiveness or durability of these approaches. Currently, there are no standardized recommendations regarding which focal pathologies in the setting of adult deformity may justify the consideration of short-segment procedures. There are also no formal guidelines as to what the optimal procedures should be for these cases, how these procedures may impact deformity progression, and what should be the expected benefit and durability of the procedures. The assessment of pain and the overall contribution of a deformity to clinical symptoms, including the presence of sagittal malalignment and radiological features that may suggest the compromise of stability after adequate decompression, are important factors when contemplating a short-segment procedure to address focal pathology in the setting of adult deformity.

In the present study, 43% of the patients in each study group had one or more complications, and the complication rate did not significantly differ between the 2 groups ($p > 0.6$). This complication rate is comparable to those in prior reports on adult scoliosis surgery.^{2,4,17,29,44,50} In a recent meta-analysis by Yadla et al.,⁵⁰ in which 3299 patients were reviewed, a 41.2% overall complication rate was reported. In older adults, the complication rate was recently reported to be 71%.⁴⁴ Various risk factors have been associated with a greater risk of complications.¹³ Glassman and colleagues²⁵ reported that patients were more likely to have complications (62% vs 48%) if they had a history of previous scoliosis surgery. Cho et al.¹⁴ also reported a higher overall complication rate in revision versus primary deformity surgery. In contrast, other studies that have specifically compared patients who underwent primary and those who underwent revision surgery for adult deformity revealed equivalent short-term (within 6 months after surgery) and long-term (> 6 months after surgery) complication rates between the 2 groups.^{29,31} In the present study, the rates of durotomy were similar between the 2 groups, which is in contrast to the increased risks of durotomy reported in revision spine surgeries in the literature.^{9,28}

Future study is needed to determine which focal pathologies may benefit from short-segment procedures in the setting of adult deformity. The current literature offers only limited guidance, including studies that suggest indications for selecting patients for short-segment procedures, which consist of either decompression alone or short fusions for stenosis associated with deformity, as compared with those addressing the entire deformity.^{14,39,47,49} There are studies in the literature that have doc-

umented good outcomes in patients with lumbar stenosis associated with spinal deformity treated with either short- or long-segment fusion.^{12,19,27,46} Although good results have been described following decompression alone¹⁷ with the avoidance of fusion, a decompression at one or more levels has the potential to alter the dynamic balance in patients with preexisting deformity, as described by Benner and Ehni⁵ and by Simmons,⁴⁰ with resulting aggravation of symptoms and/or deformity.

The primary limitation of the present study is its retrospective design. In addition, given the relatively small number of cases available for study, there remains the possibility of a Type II error, and further study, preferably prospective, is warranted. Although the present study does not demonstrate any apparent negative impact of short-segment procedures in patients who subsequently require larger scoliosis reconstruction procedures, our data do not permit us to comment on the effectiveness or durability of these short-segment procedures. It is important for the treating surgeon who is contemplating a short-segment procedure designed to address focal pathology to carefully counsel the patient with regard to potential expectations of durability and the possible need for subsequent surgery.

Conclusions

The present study does not demonstrate any apparent impact on overall surgical complications or clinical outcome in patients with adult scoliosis who require a longer fusion subsequent to short-segment decompression or fusion. There was a trend toward greater blood loss during revision surgery, which is not surprising considering the presence of scarring, which can make surgical exposure more challenging. The importance of clinical symptoms and the contribution of the overall deformity should take priority in individualizing and appropriately directing the surgical treatment. Data from this study may prove useful for spine surgeons in the preoperative counseling of patients with adult deformity who may be candidates for short-segment spinal procedures. In addition, these findings should serve as a basis for future prospective study.

Disclosure

This study was conducted through the Spinal Deformity Study Group, which received funding from Medtronic. Dr. Shaffrey is a consultant for Medtronic, DePuy, Biomet, and Nuvasive; holds patents with Medtronic and Biomet; and receives non-study related support from the NIH, the Department of Defense, AOSpine, and NACTN. Dr. Bridwell is a consultant for DePuy Spine. Dr. Smith is a consultant for Biomet and Medtronic; received support from Medtronic for the study described; receives non-study related support from Medtronic, DePuy, and the AANS/CNS Spine Joint Section; and is a speaker for Globus. Dr. Glassman is an employee of Norton Healthcare, was a consultant for Medtronic, holds a patent with Medtronic, has received royalties from Medtronic, has received database support from Nuvasive, has received complimentary trips and travel from OREF, and is the vice president of SRS. Dr. Lafage has ownership in Nemaris, Inc., and is a consultant for Medtronic. Dr. Schwab is a consultant for DePuy and MSD and has ownership in Nemaris, Inc. Dr. Carreon is an employee of and receives grant support from Norton Healthcare and receives travel support for study meetings from OREF, the University of Louisville, and the Department of Defense. Dr. Fu is a consultant for Synthes.

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