

Revision Extension to the Pelvis versus Primary Spinopelvic Instrumentation in Adult Deformity: Comparison of Clinical Outcomes and Complications

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Key words

- Complications
- Instrumentation
- Pelvis
- Revision
- Spine deformity
- Surgery

Abbreviations and Acronyms

ISSG: International Spine Study Group

SRS: Scoliosis Research Society

SVA: Sagittal vertical axis



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INTRODUCTION

The treatment of adult spinal deformity, in both the coronal and the sagittal planes, often requires long fusions that may end in the distal lumbar spine. Previous studies have demonstrated that some patients treated with long fusions to the distal lumbar spine subsequently develop painful degeneration below the level of the fusion (2, 3, 5, 10, 13-15). Manifestations of this degeneration can include stenosis, listhesis, and loss of lumbar lordosis, which may require a challenging revision operation. Some surgeons

■ **OBJECTIVE:** To evaluate the outcomes and complications of patients with adult spinal deformity treated in a primary versus revision fashion with long fusions to the sacropelvis.

■ **METHODS:** A retrospective review was performed of a multicenter consecutive series of patients with adult spinal deformity requiring fusion to the sacropelvis, either primarily or as revision, with minimum 2-year follow-up. Clinical (Scoliosis Research Society [SRS] 22 questionnaire) and radiographic parameters (including sagittal vertical axis [SVA], coronal Cobb angle, lumbar lordosis, and thoracic kyphosis) were compared between the groups.

■ **RESULTS:** There were 63 patients who met inclusion criteria; mean patient age was 51.9 years, and mean follow-up was 43 months. Patients requiring primary fusion were older (58.0 years vs. 49.5 years, $P = 0.01$) and at baseline had a lower SVA (2.1 cm vs. 6.8 cm, $P = 0.01$) and greater thoracolumbar Cobb angle (51.2 degrees vs. 36.5 degrees, $P = 0.003$). At last follow-up, patients undergoing primary fusion and patients undergoing revision treatment had similar SVA (2.9 cm vs. 1.8 cm, $P = 0.32$) and lumbar lordosis (-42.3 degrees vs. -43.4 degrees, $P = 0.82$); patients undergoing revision treatment had more favorable SRS 22 scores (3.65 vs. 3.14, $P = 0.005$). There was no statistical difference in complication rates between the groups (44.4% vs. 35%, $P = 0.68$).

■ **CONCLUSIONS:** Patients requiring revision extension of instrumentation to the pelvis can be treated with the same expectation of radiographic and clinical success as patients treated primarily with fusion to the sacropelvis. The complication rate for the revision procedure is not insignificant and may be similar to a primary procedure that includes pelvic fixation.

advocate a lower threshold for extending long fusions to the pelvis in a primary fashion. Arguments for this approach include the essential preclusion of distal degeneration and the potential to avoid a revision surgery (5). Arguments against primary extension to the pelvis include increased surgical time and morbidity, loss of an important motion section (L5-S1), and the relatively high rate of pseudarthrosis at the L5-S1 level in long fusions (17, 19).

This controversy surrounding long fusions to the distal lumbar spine has been long-standing, with many studies seeking to define the optimal approach of when to fuse to the sacropelvis (1, 4-6, 9, 18). However, few studies have

specifically compared the surgical complication rates and radiographic and clinical outcomes between patients treated with revision surgeries to extend prior fusions to the pelvis and patients treated primarily with fusions to the sacropelvis.

Our objective in the present study was to assess whether adults requiring revision extension to the pelvis achieve similar radiographic and clinical outcomes as patients treated primarily with instrumentation to the pelvis. In addition, we sought to compare the complication rates of the revision procedure with the complication rates of the procedures that primarily included pelvic fixation. These findings may prove useful for patient counseling and surgical planning, especially in situations in which

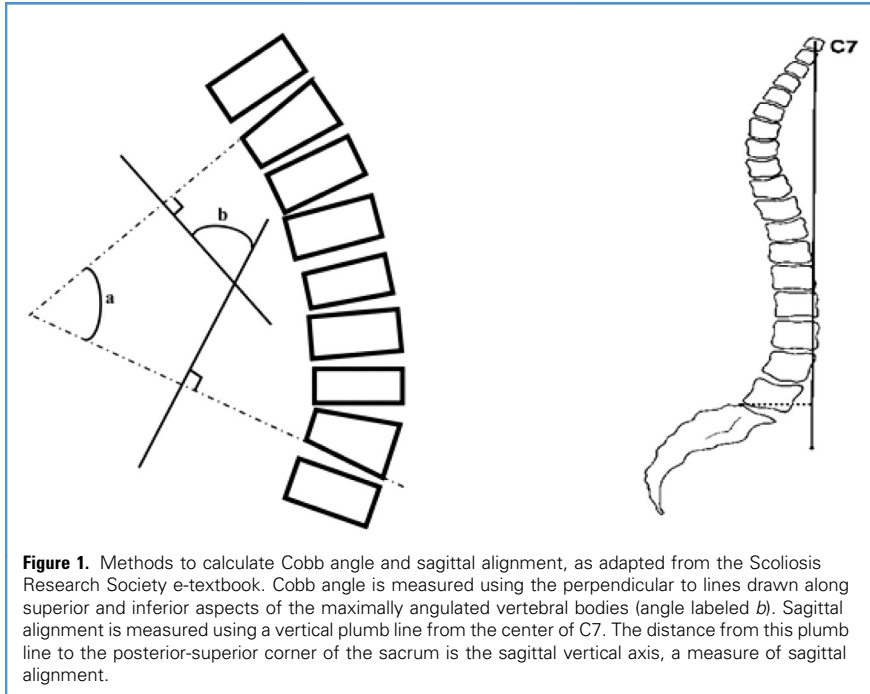


Figure 1. Methods to calculate Cobb angle and sagittal alignment, as adapted from the Scoliosis Research Society e-textbook. Cobb angle is measured using the perpendicular to lines drawn along superior and inferior aspects of the maximally angulated vertebral bodies (angle labeled *b*). Sagittal alignment is measured using a vertical plumb line from the center of C7. The distance from this plumb line to the posterior-superior corner of the sacrum is the sagittal vertical axis, a measure of sagittal alignment.

the decision of whether to extend instrumentation to the pelvis is not clearly driven by the pathology.

MATERIALS AND METHODS

This study was conducted through the International Spine Study Group (ISSG), a multicenter group consisting of 11 sites at which complex adult spinal deformity surgery is commonly performed. Participating sites contributed consecutive cases of long-segment posterior thoracolumbar fusions for spinal deformity treatment that either included pelvic fixation at the time of the initial procedure (primary group) or did not include sacral or pelvic fixation at the time of primary procedure but were later revised to include pelvic fixation (revision group). Before initiation of the present study, institutional review board approval was obtained at each study site.

Inclusion criteria for the primary group were age >18 , spinal deformity treated with a posterior spinal fusion of >5 spinal levels that included pelvic fixation, and availability of radiographic imaging and clinic outcomes at a minimum of 2 years after surgery. Inclusion criteria for the revision group were age >18 ; spinal deformity treated with a posterior instrumented spinal fusion during the years 1995–2006 that included >4 spinal levels

with caudal extension to L3, L4, or L5 and did not include sacral or pelvic fixation, subsequently treated with a revision spinal procedure that included extension of prior instrumentation to include the sacrum and pelvis; and availability of radiographic imaging and clinical outcomes at a minimum of 2 years after surgery. Patients were excluded from both groups if spinal fusion was performed for neuromuscular deformity, tumor, or infection.

Data collected included operative data, preoperative and postoperative radiographic data based on full-length standing radiographs (Figure 1) (including sagittal vertical axis [SVA], coronal Cobb angle, lumbar lordosis, and thoracic kyphosis), health-related quality-of-life information (Society for Scoliosis Research [SRS] 22 questionnaire), and perioperative and postoperative complications. Information on gender, age, and body mass index was also recorded from the time of revision or primary surgery. Radiographic data were collected from last follow-up, which was at a minimum of 2 years after revision or primary operation, depending on the group. SRS 22 scores were obtained along with radiographic parameters at the time of follow-up.

Data on operative technique (osteotomy) and approach (combined anterior and posterior or posterior only) were

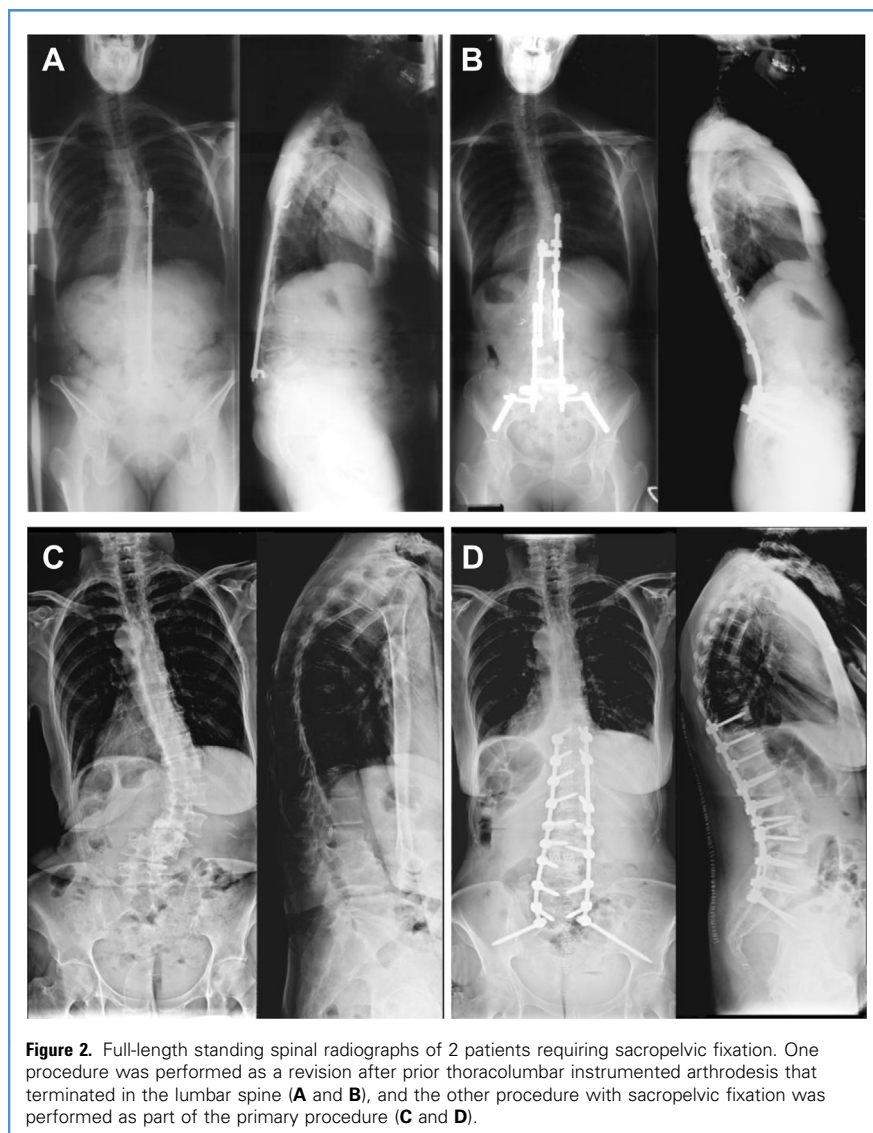
reviewed. Posterior lumbosacral instrumentation included standard pedicle screw fixation and hook-screw constructs in some patients undergoing revision. In these revision cases, extension to the pelvis was performed with screw fixation. Revision graft material varied but generally consisted of local autograft, morcellized allograft, and iliac crest in some cases. Number of levels fused was determined by the entire length of the construct whether revised or primary.

Normal distribution of the data was confirmed using Kolmogorov-Smirnov tests. Descriptive statistics were performed to determine means, medians, and standard deviations. Comparisons between independent groups were performed using t tests. Comparisons of categorical variables between the groups were performed with Fisher exact tests. Analyses were performed using SPSS statistical software (SPSS Inc, Chicago, Illinois, USA). Significance was set at $P < 0.05$.

RESULTS

The preoperative, postoperative, and follow-up clinical records and radiographs of 75 consecutive patients (55 undergoing revision treatment and 20 undergoing primary fusion) were reviewed. Of these 75 consecutive patients, 63 (84%), including 45 revision and 18 primary cases, had the requisite minimum 2-year radiographic and clinical follow-up. The radiographs shown in Figure 2 are representative of the patients from the primary and revision groups. Only 3 patients were <30 years old. The mean age of the patients was 52.0 years (SD, 11.8 years; range, 21–81 years), and 57 (88%) patients were women. The mean body mass index was in the overweight category at 25.5 (SD, 5.7; range 16–44). The mean length of follow-up was 43 months (range, 24–135 months).

Patients treated primarily with fusions extending to the sacropelvis were older than the mean age of patients undergoing revision treatment (58.0 years vs. 49.5 years, $P = 0.01$) and had a lower mean body mass index (22.9 vs. 26.5, $P = 0.024$). Of the 18 patients in the primary group, 11 (61%) were treated with a combined anterior and posterior procedure, and 7 (39%) were treated with a posterior-only procedure (Table 1). Of the 45 patients in the revision group, 15 (33.3%) were treated



with posterior-only surgery, and 30 (66.7%) were treated with combined anterior and posterior procedures ($P = 0.45$). Primary patients had a mean

number of 10.2 levels fused versus 12.9 levels fused for the revision patients ($P = 0.01$). There was no significant difference in the number of patients in whom

osteotomies were performed between the groups (4 in the primary group and 24 in the revision group, $P = 0.33$).

In terms of preoperative radiographic parameters, patients in the primary group were similar to patients in the revision group in terms of lumbar lordosis (-29.3 degrees vs. -29 degrees, $P = 0.95$) and thoracic kyphosis (32.1 degrees vs. 33.6 degrees, $P = 0.8$). Primary and revision patients differed significantly with regard to preoperative SVA and thoracolumbar Cobb angle (Table 2). Specifically, primary patients had better preoperative sagittal balance than revision patients (2.1 cm vs. 6.8 cm, $P = 0.01$) and had greater thoracolumbar Cobb angles (51.2 degrees vs. 36.5 degrees, $P = 0.003$).

Assessments of radiographic measures at last follow-up demonstrated several differences between the primary and revision groups. Revision patients had greater residual thoracolumbar Cobb angle (29.1 degrees vs. 20.1 degrees, $P = 0.03$), despite the primary group having started with a greater Cobb angle (Table 2). At last follow-up, there was no significant difference in the lumbar lordosis ($P = 0.75$) or in the SVA ($P = 0.32$); however, the revision group demonstrated a significantly greater magnitude of improvement in the SVA from preoperatively to last follow-up measurement (3.7 cm vs. 0.12 cm, $P = 0.04$).

Clinical outcomes at last follow-up were compared between the primary and revision groups based on the SRS 22 total score. Of the 63 patients studied, SRS 22 assessment was available for 54 (86%), including 36 of 45 (80%) from the revision group and 18 of 18 (100%) from the primary group. Patients in the primary group had a mean SRS 22 score of 3.14, whereas patients in the revision group reported a higher score of 3.65 ($P = 0.005$), suggesting that patients in the primary group had a modestly, but significantly, worse health-related quality of life based on the SRS 22 (Table 3).

There were no statistically significant differences between the primary and revision groups in terms of perioperative complication rates. In the revision group, 16 patients had 17 complications; in the primary group, 8 patients had 10 complications ($P = 0.58$). Complication rates were high in both groups: 44.4% of the

Table 1. Summary of Surgical Approaches and Numbers of Instrumented Spinal Levels

	Revision Group	Primary Group	P Value
Approach group			
Anterior-posterior (<i>n</i>)	30 (66.7%)	11 (69%)	
Posterior only (<i>n</i>)	15 (33.3%)	7 (31%)	0.77
Mean number of levels fused	12.9	10.2	0.01
In 63 adults with spinal deformity treated with either primary inclusion of pelvic fixation ($n = 18$) or instrumentation termination in the distal lumbar spine with subsequent revision extension to the pelvis ($n = 45$).			

Table 2. Patient Age and Baseline Radiographic Parameters

	Revision Group	Primary Group
Age (years)	49.5	57.9
Lumbar lordosis (degrees)	-29.0	-29.3
Thoracic kyphosis (degrees)	33.6	32.1
SVA (cm)	6.8*	2.1*
Thoracolumbar Cobb angle (degrees)	36.5*	51.2*

In 63 adults with spinal deformity treated with either primary inclusion of pelvic fixation ($n = 18$) or instrumentation termination in the distal lumbar spine with subsequent revision extension to the pelvis ($n = 45$).

SVA, sagittal vertical axis.

*Comparison between revision and primary group statistically significant with $P < 0.05$.

primary patients and 36% of the revision patients experienced a complication. Major morbidity in the primary group related to the posterior approach included 2 sacral fractures and 1 deep wound infection. Major morbidity related to the anterior approach consisted of an abdominal hematoma, a splenic laceration, and a pneumothorax. In the revision group, major complications included 4 infections and 4 neurologic injuries. Pseudarthrosis was reported in 1 primary case and in 4 revision cases ($P = 0.68$). When the follow-up SRS 22 data were compared, there was no statistically significant difference between patients with complications and patients with no complications (3.3 vs. 3.6, $P = 0.06$).

DISCUSSION

The surgical management of adult spinal deformity often requires long fusions that may end in the distal lumbar spine or be extended to include the sacrum along with pelvic instrumentation. In many cases, the decision of whether to end in the distal lumbar spine or to extend to the pelvis is made relatively straightforward by the spinal pathology. In cases with a symptomatic fractional curve at the lumbosacral junction or with a significant spondylolisthesis or need for decompression at L5-S1, the need for inclusion of sacropelvic fixation may be readily apparent. In cases in which there is no pathology at the lumbosacral junction, the decision may be easily made to end the fusion in the distal

lumbar spine. However, there are many cases in which the decision is less clear, such as a L4-5 or L5-S1 disk that shows early degeneration, in which the surgeon may be tempted to end the fusion in the distal lumbar spine but left to wonder what the patient may face with regard to outcomes and complications should it be necessary to extend the fusion to the pelvis at a later time.

Previous studies have demonstrated a high rate of degeneration distal to such long fusions ending in the distal lumbar spine (2, 3, 14, 15), which may require extension of instrumentation and fusion to the sacropelvis. Revision procedures are often challenging in nature and subject to high rates of complications and pseudarthrosis (4, 10, 13). Eck et al. (5) retrospectively analyzed 58 patients treated with long fusions ending at L4, L5, or the sacrum. This study reported distal degeneration of 16% in patients with fusions ending at L4 or L5. These patients had worse pain and function than patients treated with fusions to the sacrum. The authors concluded that long fusions short of the sacrum had unpredictable results. However, patient outcomes after a potential revision extension were not evaluated.

Primarily ending a long fusion in the sacrum may preclude distal degeneration but is not without potential problems. Sacral fractures have been reported (16), and pseudarthrosis rates are high in studies from multiple groups, with long-term rates

Table 3. SRS 22 Questionnaire Scores and Radiographic Parameters at Last Follow-Up

	Revision Group	Primary Group
Last follow-up*		
Thoracolumbar Cobb angle (degrees)	29.1†	20.1†
Change in Cobb angle (degrees)‡	-7.1†	-33.3†
Lumbar lordosis (degrees)	-43.4	-42.3
Change in lumbar lordosis (degrees)‡	-14.4	-12.6
SVA (cm)	2.9	1.8
Change in SVA (cm)‡	3.7†	0.12†
SRS 22 total score	3.65†	3.14†

In 63 adults with spinal deformity treated with either primary inclusion of pelvic fixation ($n = 18$) or instrumentation termination in the distal lumbar spine with subsequent revision extension to the pelvis ($n = 45$).

SRS, Scoliosis Research Society; SVA, sagittal vertical axis.

* >2 years.

†Comparison between revision and primary group statistically significant with $P < 0.05$.

‡From preoperative period to last follow-up.

approaching 25% (11, 12, 19). In addition, concerns about instrumentation failure and prominence, along with infection, have been raised (6, 18). In a matched cohort analysis, Edwards et al. (6) compared patients fused to L5 and the sacrum and reported >2-year radiographic and clinical follow-up. They reported better radiographic outcomes (in terms of correction of sagittal alignment) for patients fused to the sacrum, but these patients had a higher rate of complications and had a greater risk of requiring subsequent surgical procedures. However, patient outcomes based on self-assessment were statistically similar. Techniques such as the use of iliac screws and interbody arthrodesis can lessen complications related to pseudarthrosis at the L5-S1 junction.

Not addressed by these previous studies is the question of how patients who require a revision extension compare in follow-up with patients treated primarily with fusions to the sacropelvis. In the present study, we compared the clinical and radiographic outcomes of adults with spinal deformity that were treated either with a posterior fusion that included pelvic fixation or with a fusion that ended in the distal lumbar spine but subsequently required extension to the pelvis. At last follow-up, the two groups had similar radiographic outcomes, including SVA, one of the most critical radiographic outcomes measures (7, 8). The two groups had a modest but significant difference in mean SRS 22 scores at last follow-up, with the primary group having lower scores, which could reflect the significantly older age of the patients in the primary group. The complication rates did not differ significantly between the primary and revision groups, suggesting that the risk of complications for the revision procedure to extend to the pelvis was just as high as the full primary procedure that included pelvic instrumentation. These findings may prove useful for patient counseling and surgical decision making, especially in circumstances in which the decision of whether to include pelvic fixation is not straightforward.

Not all patients with radiographic evidence of degeneration have significant symptoms, and the patients requiring revision extensions to the pelvis constitute a relatively small subset of patients treated with fusions to the distal lumbar spine.

This study suggests that patients who need revision can be treated with the same expectation of radiographic and clinical success as patients treated primarily with fusion to the sacropelvis, but the complication rate is not insignificant and can be expected to be similar to that encountered for a full primary procedure that includes pelvic fixation.

The primary limitation of the present study is the retrospective design. A prospective analysis would be beneficial in determining the method for achieving the best results in these challenging patients. In addition, the two groups demonstrated significant differences at baseline, most notably a significantly older age in the primary group compared with the revision group, which may at least partly account for the poorer SRS 22 scores in the primary group. The nature of this study did not allow for the ability to determine which patients treated with a primary fusion ending in the distal lumbar spine may require an extension in the future.

CONCLUSIONS

The surgical management of adult spinal deformity often requires long fusions that may end in the distal lumbar spine or be extended to include the sacrum along with pelvic instrumentation. In many cases, the decision of whether to end a fusion in the distal lumbar spine or extend it to include pelvic fixation is not straightforward, and each approach has advantages and disadvantages. This study suggests that patients who need revision extension of instrumentation to the sacropelvis can be treated with the same expectation of radiographic and clinical success as patients treated primarily with fusion to the sacropelvis. However, the complication rate for the revision procedure is not insignificant and can be expected to be similar to that encountered for a full primary procedure that includes pelvic fixation. Although this study addresses just one aspect of the decision of whether to include pelvic fixation, these findings may prove useful for patient counseling and surgical decision making.

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