

Outcomes in Adult Scoliosis Patients Who Undergo Spinal Fusion Stopping at L5 Compared with Extension to the Sacrum

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Abstract

Study Design Systematic review.

Study Rationale Adult scoliosis is a common disorder that is associated with significantly higher pain, functional impairment, and effect on quality of life than those without scoliosis. Surgical spinal fusion has led to quantifiable improvement in patient's quality of life. However, for patients undergoing long lumbar fusion, the decision to stop the fusion at L5 or to extend to S1, particularly if the L5–S1 disc is healthy, remains controversial.

Objective The aim of the study is to evaluate if fusion stopping at L5 increases the comparative rates of revision, correction loss, and/or poor functional outcomes compared with extension to the sacrum in adult scoliosis patients who require spinal fusion surgery.

Materials and Methods A systematic review of the literature was performed using PubMed, the National Guideline Clearinghouse Database and bibliographies of key articles that evaluated adult scoliosis patients who required spinal fusion surgery and compared outcomes for fusions to the sacrum versus stopping at L5. Articles were included on the basis of predetermined criteria and were appraised using a predefined quality-rating scheme.

Results From 111 citations, 26 articles underwent full-text review, and 3 retrospective cohort studies met all inclusion and exclusion criteria. Revision rates in subjects who underwent spinal fusion to L5 (20.8–23.5%) were lower in two studies compared with those with fusion extending to the sacrum (19.0–58.3%). Studies that assessed deformity correction used different measures, making comparison across studies difficult. No significant differences were found in patient-reported functional outcomes across two studies that used different measures.

Conclusion The limited data available suggest that differences in revision rates did not consistently reach statistical significance across studies that compared spinal fusion to L5 versus extension to sacrum in adult scoliosis patients.

Keywords

- ▶ scoliosis
- ▶ spinal fusion
- ▶ sacrum
- ▶ lumbar
- ▶ adult

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Study Rationale and Context

Adult scoliosis (Cobb angle > 10 degrees) is a common disorder with reported prevalence up to 60 to 68%^{1,2} and appears to be more prevalent and more severe in women.^{1,3-5} The relationship between the magnitude of deformity and the severity and existence of symptoms has not been clearly established.^{1,5} However, adults with scoliosis report significantly higher pain, functional impairment, and effect on quality of life than those without scoliosis.^{1,5,6} In adults with scoliosis, sagittal balance has the most significant impact on pain, function, and progression of deformity compared with other radiographic parameters.⁷ The main goals of surgery are to achieve spinal balance, spinal stabilization, and neural decompression. For patients requiring long fusion into the lumbar spine with a relatively healthy L5–S1 motion segment in the absence of Spondylolisthesis, previous decompression, stenosis, or fixed obliquity of the L5–S1 motion segment,^{4,6,8-11} the decision to choose whether to stop the fusion at L5 or to extend to S1 remains controversial.⁸⁻¹¹

Objectives

The aim of the study is to evaluate if fusion stopping at L5 increases the comparative rates of revision, correction loss, and/or poor functional outcomes compared with extension to the sacrum in adult scoliosis patients who require spinal fusion surgery.

Materials and Methods

Study design: Systematic review.

Search: The databases included PubMed and National Guideline Clearinghouse Databases, as well as bibliographies of key articles.

Dates searched: The dates were searched from 1950 to April 2013.

Inclusion criteria: The patient should be 18 years or older at the time of surgery; diagnosis of adult idiopathic scoliosis or adult degenerative scoliosis and fusion of three or more segments were included in the study.

Exclusion criteria: Neuromuscular scoliosis, fusion for traumatic disorders, prior fusion surgery, less than 80% of study population with diagnosis of adult idiopathic/degenerative scoliosis or meeting other inclusion criteria; studies with less than 10 subjects and case series were excluded from the study.

Prognostic factors: The prognostic factors include the following: primary factor—length of fusion (spinal fusion stopping at L5 vs. extension to sacrum); secondary factors (potentially confounding factors)—age, number of fused segments, type of fusion (anterior, posterior, and combined), and patient comorbidities.

Outcomes: The outcomes include rate of revision surgery, loss of deformity correction (lumbar lordosis, sagittal balance), and poor functional outcome scores.

Analysis: Descriptive statistics; statistics and effect estimates as reported by the respective authors of each study included in this review.

Overall strength of evidence: Risk of bias for individual studies was based on using criteria set by *The Journal of Bone and Joint Surgery*,¹² modified to delineate criteria associated with methodological quality and risk of bias based on recommendation from the Agency for Healthcare Research and Quality (AHRQ).^{13,14} The overall strength evidence across studies was based on precepts outlined by the Grades of Recommendation Assessment, Development and Evaluation Working Group¹⁵ and recommendations made by the AHRQ.^{13,14}

Details about methods can be found in the online supplementary material.

Results

- The search yielded 111 citations, 26 of which underwent full-text review (► **Fig. 1**).
- Three unique studies of adult scoliosis patients evaluating outcomes following spinal fusion to L5 compared with extension to the sacrum met the inclusion criteria.
- There was one moderate quality retrospective cohort study (Class of Evidence [CoE] II),¹⁶ and two poor-quality retrospective cohort studies (CoE III).^{3,17}
- In addition, details regarding the critical appraisal and study exclusion criteria can be found in the online supplementary material.
- ► **Table 1** describes the characteristics of included studies including subject and treatment characteristics. The mean length of follow-up for included studies was 3.5 to 4.8 (range, 2.0–14.3) years. The mean age in one study was almost 20 years older than the other studies.³ ► **Table 2** summarizes outcomes evaluated and effect size estimates, if reported in the studies.

Revision

- Revision rates were assessed in all studies. Differences between groups did not consistently reach statistical significance across studies (► **Table 2**, ► **Fig. 2**).

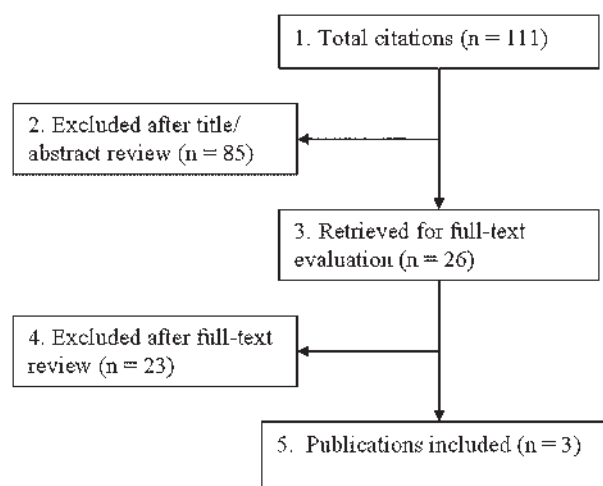


Fig. 1 Flowchart showing results of literature search.

Table 1 Characteristics of adult scoliosis studies comparing rates of revision, correction loss, and/or functional outcomes after spinal fusion to L5 compared with extension to the sacrum

Author (y)	Study design	Population	Inclusion/exclusion criteria	Subject characteristics	Treatment characteristics	Potential prognostic factors evaluated ^a	Follow-up (%)	Class of evidence
Mok et al (2009)	Retrospective cohort	N = 89; n = 54 ^b Mean age: 48.5 ± 15.5 y 79.8% female	Inclusion criteria • Age > 20 y • Fusions of ≥ 4 segments Exclusion criteria • History of prior fusion • Acute vertebral fracture • Spinal tumor • Active infection • Paraplegia • Neuromuscular scoliosis	<ul style="list-style-type: none"> • Mean segments fused: 9.1 ± 3.6 • Smokers: 33.3% (27/81)^c Diagnoses <ul style="list-style-type: none"> • Idiopathic scoliosis: 59.6% (53/89) • Degenerative scoliosis: 30.3% (27/89) • Kyphoscoliosis: 1.1% (1/89) • Ankylosing spondylitis: 2.2% (2/89) • Other: 6.7% (6/89) Approach <ul style="list-style-type: none"> • Anterior: 6.7% • Posterior: 43.8% (39/89) • Combined: 49.4% (44/89) 	Consecutive subjects who underwent primary fusion for non-paralytic adult spinal deformity (any major coronal, sagittal, or combined deformity requiring instrumented fusion) between August 1999 and December 2004. Of the 37 patients fused to the sacrum, 5 patients had circumferential fusion with anterior interbody fusion and iliac fixation posteriorly. For patients fused to the sacrum, 70% (26/37) had supplemental interbody fusion performed at L5–S1.	Demographic <ul style="list-style-type: none"> • Age • Smoking status • Patient comorbidities Clinical <ul style="list-style-type: none"> • Surgical approach • Number of fused segments • Surgeon experience • Fusion length (L5 vs. S1) • Rate of revision 	Mean 3.8 (2–6.9) years: 91%	II
Cho et al (2009)	Retrospective cohort	N = 45 Mean age: 64.4 (53–75) y 86.7% female	Inclusion criteria • Cobb angle > 10 degrees • Posterior fusions ≥ 4 segments • No evidence of adolescent idiopathic scoliosis • Age > 50 years at time of surgery Exclusion criteria • Sacropelvic fixation with iliac screws	<ul style="list-style-type: none"> • Mean levels fused (L5 group): 6.1 (4–8) levels • Mean levels fused (S1 group): 6.1 (4–9) levels • Number comorbidities (L5 group): 1.6 ± 0.8 • Number comorbidities (S1 group): 1.7 ± 0.6 Diagnoses <ul style="list-style-type: none"> • Degenerative lumbar scoliosis: 100.0% (45/45) Approach: NR	Subjects had undergone decompression and fusion with pedicle screw instrumentation from thoracolumbar to L5 (N = 24) or S1 (N = 21) for degenerative lumbar scoliosis. Of the 21 patients fused to the sacrum, 11 patients had supplemental interbody fusion performed at L5–S1.	Demographic <ul style="list-style-type: none"> • Age • Smoking status • Patient comorbidities Clinical <ul style="list-style-type: none"> • Number of fused segments • Fusion length (L5 vs. S1) • Rate of revision Deformity correction outcomes <ul style="list-style-type: none"> • Cobb angle • Lumbar lordosis • Coronal balance (C7 plumb) • Sagittal balance (C7 plumb) • Pelvic incidence • Sacral slope • Pelvic tilt Functional outcomes <ul style="list-style-type: none"> • Oswestry disability index 	Mean 3.5 ± 1.7 (2–8) y: % NR	III
Edwards et al (2004)	Retrospective cohort	N = 39 Mean age:	Inclusion criteria • No or mild degeneration of	<ul style="list-style-type: none"> • 17.9% smokers • Mean levels fused (L5 group): 10.4 	Consecutive adult spinal deformity subjects underwent	Demographic <ul style="list-style-type: none"> • Age • Smoking status 	Mean 4.8 (2.0–14.3) y: % NR	III

Table 1 (Continued)

Author (y)	Study design	Population	Inclusion/exclusion criteria	Subject characteristics	Treatment characteristics	Potential prognostic factors evaluated ^a	Follow-up (%)	Class of evidence
		44 (20–77) y 92.3% female	the L5–S1 disc preoperatively <i>Exclusion criteria</i> <ul style="list-style-type: none"> • Systemic neurologic or connective tissue disorders • Prior fusion surgery • Radiographic suggestion of L5 sacralization 	<p>(5–15) levels</p> <ul style="list-style-type: none"> • Mean levels fused (S1 group): 11.5 (7–16) levels <p><i>Diagnoses</i></p> <ul style="list-style-type: none"> • Adult scoliosis: 59% L5, 50% sacrum • Sagittal imbalance: 41% L5, 42% sacrum <p><i>Approach</i></p> <ul style="list-style-type: none"> • Anterior: 0.0% (0/39) • Posterior: 25.6% (10/39) • Combined: 74.4% (29/39) 	<p>spinal fusion procedures from the thoracic spine to L5 or the sacrum. The 95 eligible subjects were matched into two groups (L5, sacrum) on five criteria (healthy L5–S1 disc status, age, smoking status, preoperative C7 sagittal plumb translation, number of levels fused) for which prognostic criteria for the would be as similar as possible. This resulted in 2 cohorts: L5 ($n = 27$), sacrum ($n = 12$). For patients fused to the sacrum, distal fixation was obtained with bilateral bicortical S1 screws and bilateral iliac screws. Interbody fusion at L5–S1 was performed in 83% (10/12) of cases fused to the sacrum.</p>	<p><i>Clinical</i></p> <ul style="list-style-type: none"> • Number of fused segments • Fusion length (L5 vs. sacrum) • Rate of revision <p><i>Deformity correction outcomes</i></p> <ul style="list-style-type: none"> • Coronal curve correction • Coronal balance (C7 plumb) • Sagittal balance (C7 plumb) • Sagittal curve correction <p><i>Functional outcomes</i></p> <ul style="list-style-type: none"> • SRS-24 		

Abbreviations: NR, not reported; SRS-24, Scoliosis Research Society Instrument-24.

^aOnly reported outcome measures that related to study questions.

^bTotal study population was 89 subjects; 54 subjects underwent fusion to L5 ($n = 17$) or S1 ($n = 37$) and are included in this report.

^cSmoking status not available for eight subjects.

Table 2 Summary of outcome measures following spinal fusion to L5 or extension to the sacrum in adult scoliosis subjects

Outcome at last follow-up	Author (y)	Follow-up duration (mo)	CoE	Fusion to L5, % N = 17 (n)	Fusion to S1, % N = 37 (n)	Effect size (95% CI) ^a		
Revision	Mok et al (2009)	Mean 3.8 (2-6.9) y	II	Overall revision rate	23.5 (4)	0.8 (0.3-2.1)		
				Adjacent segment disease	11.8 (2)	11.1 (3)	1.5 (0.3-7.9)	
				Infection	5.9 (1)	11.1 (3)	0.7 (0.1-6.5)	
				Implant failure	5.9 (1)	5.4 (2)	1.1 (0.1-11.2)	
				Pseudarthrosis	0.0 (0)	11.1 (3)	NC	
Revision	Cho et al (2009)	Mean 3.5 ± 1.7 (2-8) y	III	Fusion to L5, % N = 24 (n)	Fusion to S1, % N = 21 (n)	Effect size (95% CI) ^a		
				Overall revision rate	20.8 (5)	19.0 (4)	1.1 (0.3-3.6)	
				Adjacent segment disease		12.5 (3)	NC	
				Loosening of screws		4.2 (1)	9.5 (2)	0.4 (0.1-4.5)
				Compression fracture		4.2 (1)	0.0 (0)	NC
				Junctional kyphosis		0.0 (0)	4.8 (1)	NC
				Pseudarthrosis		0.0 (0)	4.8 (1)	NC
Deformity correction				Mean ± SD	Mean ± SD	p value ^b		
				Change in Cobb angle (°)	17.3 ± 10.7	14.7 ± 7.4	0.34	
				Change in lumbar lordosis (°)	-6.6 ± 11.4	0.8 ± 10.5	0.03, favors S1	
				Change in coronal C7 plumb (mm)	7.1 ± 8.0	9.1 ± 7.1	0.42	
				Change in sagittal C7 plumb (mm)	-29.9 ± 28.5	-24.7 ± 36.2	0.62	
				Postoperative sacral slope (°)	20.7 ± 4.9	22.5 ± 6.2	0.27	
				Postoperative pelvic incidence (°)	57.6 ± 9.4	58.3 ± 10.2	0.83	
				Postoperative pelvic tilt (°)	37.4 ± 8.1	36.6 ± 8.8	0.62	
Functional outcomes				11.6	13.1	0.83		

Table 2 (Continued)

Outcome at last follow-up	Author (y)	Follow-up duration (mo)	CoE	Fusion to L5, % N = 17 (n)	Fusion to S1, % N = 37 (n)	Effect size (95% CI) ^a
Revision	Edwards et al (2004)	Mean 4.8 (2.0–14.3) y	III	22.2 (6)	58.3 (7)	0.4 (0.2–0.9)
Distal transition syndrome				14.8 (4)	0.0 (0)	NC
Early postoperative radiculopathy				3.7 (1)	0.0 (0)	NC
Early loss of fixation				3.7 (1)	0.0 (0)	NC
Proximal transition syndrome				3.7 (1)	8.3 (1)	0.4 (0.1–6.5)
Pseudarthrosis				3.7 (1)	33.3 (4)	0.1 (0.0–0.9)
Infection				0.0 (0)	16.7 (2)	NC
Postoperative coronal imbalance (%)				7.4 (2)	0.0 (0)	NC
Mean coronal curve correction (%)				Mean	Mean	P value ^b
Postoperative sagittal plumb (cm)				40	43	NS
Sagittal correction at last follow-up (cm)				0.9	3.2	0.03, favors S1
Mean postoperative SRS-24 score (range)				+4.0	+1.2	0.06, favors S1
Functional outcomes	89.2 (57–118)	87.2 (52–118)	NS			

Abbreviations: CI, confidence interval; CoE, Class of Evidence; NS, not significant; NC, not calculable; SD, standard deviation; SRS-24, Scoliosis Research Society Instrument-24.

^aEffect estimates were calculated; statistically significant results are bolded.

^bValues as reported by the authors; statistically significant results are bolded.

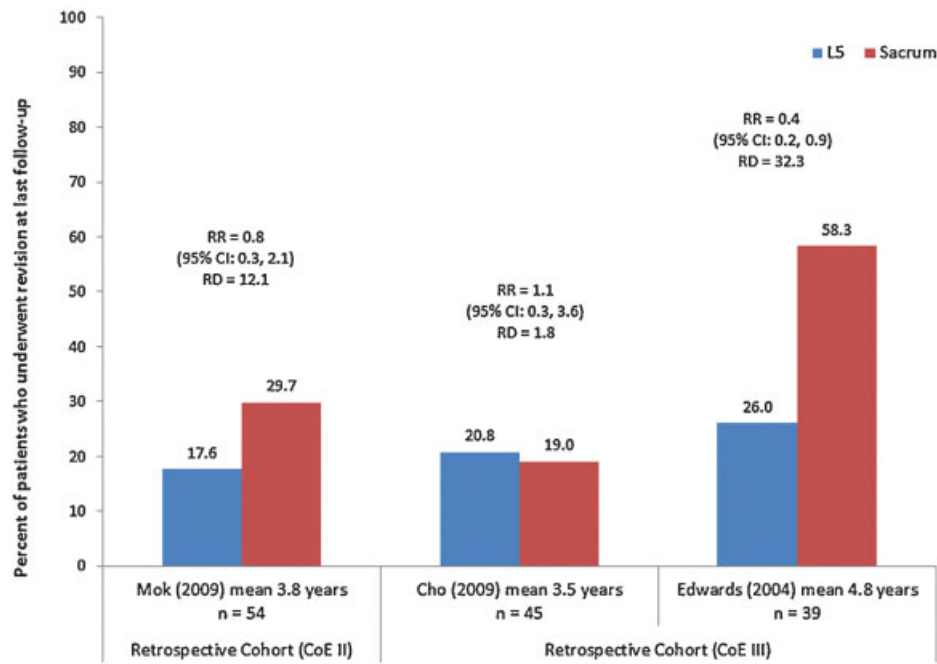


Fig. 2 Revision rates in adult scoliosis patients who underwent spinal fusion to L5 compared with S1.

- Revision rates among subjects with fusion to L5 (20.8–23.5%) were lower in two studies compared with those who underwent extension to the sacrum (19.0–58.3%).
- Revision due to pseudarthrosis was more frequent for those whose fusions extended to the sacrum (4.8–33.3%) across all studies compared with those having fusion to L5 (0.0–3.7%). Small sample sizes may preclude effective evaluation of statistical differences.
- Findings within individual studies:
 - A CoE II retrospective cohort study of adult spinal deformity subjects found a lower but nonstatistically significant difference in revision rates between the L5 and S1 fusion groups (L5 = 23.5%, S1 = 29.7%; RR 0.8, 95% CI: 0.3–2.1).¹⁶
 - One CoE III retrospective cohort study of degenerative lumbar scoliosis, subjects older than 50 years at the time of surgery found no significant differences in revision rates between the L5 and S1 fusion groups (L5 = 20.8%, S1 = 19.0%; RR 1.1, 95% CI: 0.3–3.6).³
 - In another CoE III retrospective cohort study of adult spinal deformity subjects who were matched into two cohorts (fusion to L5, fusion to sacrum) based upon five criteria (healthy L5–S1 disc status, age, smoking status, preoperative C7 sagittal plumb translation, and number of levels fused), revision rates were significantly lower in the fusion to L5 compared with fusion to sacrum group (L5 = 22.2%, sacrum = 58.3%; RR 0.4, 95% CI: 0.2–0.9).¹⁷
- One study of degenerative lumbar scoliosis subjects older than 50 years at the time of surgery found that lumbar lordosis was significantly improved at last follow-up in the S1 compared with L5 fusion groups ($p = 0.03$). There were no statistically significant differences between groups in other deformity correction measures: Cobb angle, coronal balance, sagittal balance, pelvic incidence, sacral slope, or pelvic tilt.³
- The study of adult spinal deformity subjects who were matched into two cohorts reported a statistically significant improvement in sagittal balance ($p = 0.03$), and sagittal correction was marginally significant ($p = 0.06$), favoring the sacrum compared with L5 group. There were no significant differences in coronal balance or coronal curve correction measures between groups.¹⁷

Functional (Patient-Reported) Outcomes

- There were no significant differences between groups in functional outcomes across two studies using different measures.
 - In the study of degenerative lumbar scoliosis subjects older than 50 years at the time of surgery, there were no differences between groups in Oswestry disability index score changes between preoperative and last follow-up.³
 - The study of adult spinal deformity subjects who were matched into two cohorts found no differences in mean postoperative Scoliosis Research Society-24 (SRS-24) scores.¹⁷

Deformity Correction

- Deformity correction was evaluated in two CoE III retrospective cohort studies. Each used different measures, making comparison across studies difficult.

Clinical Guidelines

No relevant clinical guidelines were identified.

Table 3 Evidence summary

Outcome	Strength of evidence	Conclusions and comments
Key question: In adult scoliosis patients who require spinal fusion, does fusion stopping at L5 compared with extension to the sacrum increase the comparative rates of revision, correction loss, and/or poor functional outcomes?		
Revision		<ul style="list-style-type: none"> Two studies (CoE II and CoE III) found no significant difference in revision rates between treatment groups, while one CoE III cohort study reported revision rates that were significantly lower in the fusion to L5 compared with the fusion to sacrum group.
Correction loss		<ul style="list-style-type: none"> One CoE III study reported a significant improvement in lumbar lordosis at last follow-up in the S1 compared with L5 fusion groups, and no significant differences were found in other deformity correction measures. Another CoE III study found significant improvements in sagittal balance and sagittal correction in the fusion to the sacrum compared L5 group, while there were no significant differences in coronal balance or coronal curve correction between groups. Each study used different measures making comparison across studies difficult.
Functional outcomes		<ul style="list-style-type: none"> One study found no significant differences in Oswestry disability index scores between treatment groups, while another study found no differences in postoperative SRS-24 scores between the groups.

Abbreviations: CoE, Class of Evidence; SRS-24, Scoliosis Research Society Instrument-24.

Evidence Summary

- In adult scoliosis patients who underwent spinal fusion to L5 compared with extension to the sacrum, the overall strength of evidence was graded as insufficient for drawing conclusions regarding comparative rates of revision, correction loss, and functional outcomes (► **Table 3**). We have very little confidence in the effect estimate: The true effect is likely to be substantially different than the estimated effect.

Discussion

- Although there is limited data available, differences in revision rates between groups did not consistently reach statistical significance across studies. Studies that assessed deformity correction used different measures, making comparison across studies difficult. There were no significant differences in functional outcomes across two studies that used different measures.
- However, contrary to clinical suspicion, none of the studies showed a higher revision rate if the fusion was stopped at L5 instead of extending the fusion to S1. It is more important to note that both the treatment groups were associated with a high revision rate.
- Conclusions from this systematic review are limited by the paucity of high-quality studies that assessed the comparisons of interest. Furthermore, because of small sample sizes, studies may not have been sufficiently powered to detect differences between treatment groups, particularly

for rare outcomes. An additional limitation included variability in outcome measures used to evaluate deformity correction across studies.

- Considering these unequivocal results, we emphasize the importance of involving the patient in the decision-making process and making them aware of the risk of revision surgery regardless of whether the fusion is stopped at L5 or extended to S1.
- Future research should be aimed at high-quality studies that prospectively assess the comparators of interest, with sufficient sample size to detect differences between treatment groups. Furthermore, spinal construct survivorship should be studied and factors influencing survivorship could be a better way to attempt to answer this clinical dilemma.

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Editorial Perspective

The authors received praise from our reviewers for their clinically relevant topic selection. Although limited by a small number of publications, the authors could not find any difference in the (relatively high) revision rates of patients where a caudal fusion stopped at the sacrum or at L5, provided this was a healthy motion segment. Our reviewers pointed out some significant treatment variables, which had not been addressed in the source materials of the included studies.

- Does the type of L5-S1 arthrodesis, instrumentation to the ilium, and possible addition of rhBMP-2, possibly lower the nonunion rates in patients fused to the sacrum?

- Does age, gender, body mass, and restoration of sagittal balance at the time of the fusion influence the outcome of patients with caudal fusion ending at L5?

The authors of this systematic review have shown vividly that, by asking a simple question with a somewhat counterintuitive null-hypothesis, somewhat surprising results may emerge from a formal, well-performed, and objectively based systematic review such as was done here. This, in turn, challenges us to take the next steps in studying these findings further and looking to find explanations from longer term survivorship analyses and by taking some of the variables mentioned into consideration when planning future comparison studies.