

The Degree of Correction Correlate with Clinical Outcomes in Adult Scoliosis Patients after Posterior Instrumentation Surgery

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Introduction: Restoring sagittal and coronal parameters is a primary concern in adult scoliosis surgery, yet it remains challenging due to the matured bony structure. This study aims to analyze the relationship between clinical outcomes and the degree of correction achieved through posterior instrumentation surgery in adult scoliosis.

Materials and Methods: This study evaluated the clinical and radiological results of 27 adult scoliosis patients who underwent posterior instrumentation, decompression, and correction surgery. Preoperative and follow-up X-rays were performed to assess Cobb angle, sagittal balance, and coronal balance. Visual Analog Score (VAS) and Oswestry Disability Index (ODI) were evaluated preoperatively and at follow-up.

Results: The study comprised 27 patients (18 female, 9 male) with a mean age of 68.2 years. Preoperative Cobb angle averaged 42.4°, reducing to 5.9° at final follow-up. Sagittal balance decreased from 30.6 mm preoperatively to 9.7 mm at final follow-up. Coronal balance improved from 22.3 mm preoperatively to 10.5 mm at 2-year follow-up. Preoperative Cobb angle showed a strong correlation with preoperative ODI ($p=0.028$) and postoperative ODI ($p=0.014$). Preoperative sagittal balance also correlated strongly with pre and postoperative ODI. However, postoperative Cobb angle and sagittal balance did not correlate with postoperative ODI ($p<0.05$).

Conclusion: While restoring sagittal and coronal parameters is a primary concern in adult scoliosis surgery, the degree of correction achieved does not necessarily correlate with clinical outcomes. Surgeons should consider this when planning surgery, and patients should be informed accordingly.

Keywords: Posterior instrumentation, deformity correction, clinical outcome, Cobb angle, Scoliosis

Introduction

Adult scoliosis (AS) is a spinal deformity characterized by a Cobb angle exceeding 10 degrees, significantly impacting patients' quality of life (1). The prevalence of AS varies widely, ranging from 1.4% to 32% in different studies (2, 3). Advanced AS may experience significant pain and disability, together with the aesthetic

concern caused by the deformity (4-6). Over the past few decades, the treatment options for AS have expanded, with combined anterior-posterior fusion being a traditional approach (5-8). However, anterior approaches have drawbacks, such as affecting respiratory function and increasing operative time (9).

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Recent comparisons between posterior and combined anterior-posterior approaches have suggested that the posterior approach may result in less deformity correction, higher rates of pseudarthrosis and persistent spinal instability (10, 11). Pain and disability are common in AS when compared to adolescent idiopathic scoliosis (12, 13). In a study, the prevalence of scoliosis in people over 60 years of age was 68 percent (14). While some publications advocate conservative treatment, operative treatment has shown success in numerous studies (12-16).

We hypothesized that correlation degree and clinical outcomes correlate and may have an impact on the AS patients. The aim of this study is to demonstrate if less deformity correction with posterior instrumentation technique and the amount of correction in posterior instrumentation has a correlation with clinical outcomes in AS.

Materials and Methods

Subjects

This retrospective research analysed clinical record, demographic and radiological outcome of patients who underwent decompression, posterior instrumentation, and correction surgery for AS between February 2018 and January 2021. All procedures were performed by a single senior surgeon in a single center. A total of 30 patients were initially considered; however, two patients were excluded due to systemic connective tissue disorders, and one patient was excluded due to a neurological disease. The analysis involved a comprehensive review of radiological and clinical data extracted from medical records. All patients had signed an informed consent.

Methods

Surgical procedures were conducted under hypotensive anaesthesia, and intraoperative blood salvage techniques were employed. To ensure patient safety, routine intraoperative monitoring included somatosensory-evoked potential and the motor-evoked potential

assessments. Lenke-Silva classification was used in the treatment planning (17). Decompression and lumbar posterior instrumentation were performed in Type 3 patients; decompression + anterior fusion (TLIF) + posterior fusion in Type 4 patients; decompression + fusion extended to the thoracic vertebrae ± osteotomy in Type 5 patients; and Schwab Type 3 osteotomy was performed in non-flexible Type 6 patients (18). Laminectomy and decompression were performed at all stenotic levels, and a bilateral pedicle screw fixation was applied at all operated levels. The posterior decompression was followed by deformity correction, which included the cantilever method, in-situ bending and contouring, as well as compression and distraction maneuvers.

To assess functional outcomes, Visual Analog Score (VAS) and Oswestry Disability Index (ODI) scores were collected preoperatively, in the early postoperative period, and at the last follow-up. Spinal magnetic resonance imaging and multi-slice computed tomography were utilized to detect the presence of spinal stenosis, intraspinal anomalies, and tandem cervical and dorsal spinal stenosis. Radiographic parameters and scores were evaluated using data collected preoperatively, at the postoperative 3rd month, and at the 2nd-year follow-up. Patients were also queried about their daily activities and pain levels.

Statistical analysis

Statistical analysis was performed using SPSS version 22 software (SPSS Inc., Chicago, IL, USA). Data were analysed using the Wilcoxon matched-pairs signed-rank test for paired data, with statistical significance defined as $p < 0.05$ for all analyses.

Results

A total of 27 patients participated in the study, with 9 being male and 18 females. The mean age at the time of surgery was 68.2 years, with a range from 57 to 80 years. The average follow-up period lasted 28.3 months, ranging

from 24 to 43 months, and the mean duration of hospitalization was 5.2 days, with a range of 2 to 7 days. Perioperative blood loss averaged 554 cc, ranging from 460 to 738 cc. The mean duration of the surgical procedure was 231 minutes, with a range of 187 to 345 minutes. The distribution of major curve types is detailed in Table 1.

Table 1. Major curve types distribution

Major Curve Types	Patients (n)
Thoracolumbar only	8
Lumbar only	9
Thoracolumbar and lumbar	4
Double (thoracic and lumbar)	6

According to patient recall, the average age at the time of AS diagnosis was 51.5 years, with a range from 43 to 72 years. The mean time elapsed between scoliosis diagnosis and surgery was 39.2 years, ranging from 9 to 67 years. Conversely, the average interval between the onset of symptoms (back pain and neurogenic claudication) and surgery was 5.4 years, with a range of 1 to 18 years. The patients were classified according to the Lenke-Silva classification, with 12 classified as Type 3, 8 as Type 4, 4 as Type 5, and 4 as Type 6. Schwab Type 3 osteotomy was performed in 4 patients with Lenke-Silva Type 6 deformity.

The upper level of fusion was T10 in 16 patients, T9 in 8 patients, and T2 in 4 patients. The fusions terminated at L5 in 8 patients, S1 in 13 patients, and the iliac bone in 7 patients. The mean Cobb angle measured 42.4° preoperatively, decreasing to 6.2° in the early postoperative period and further to 5.9° at the 2nd-year final follow-up ($p<0.01$). Similarly, the mean sagittal balance was 30.6 mm preoperatively, 15.4 mm in the early postoperative phase, and 9.7 mm at the 2nd-year final follow-up ($p<0.01$). The mean preoperative coronal balance was 22.3 mm preoperatively, 12.7 mm in the early postoperative period, and 10.5 mm at the 2nd-year final follow-up ($p<0.01$) (Table 2).

ODI significantly improved from an initial score of 46.2, ranging from 38 to 49, to 25.8, with a range of 17 to 32, at the 2nd-year follow-up ($p<0.01$). Additionally, the preoperative Visual Analog Score (VAS) analogue score, averaging 7.8 with a range of 7 to 9, reduced to 2.8, ranging from 0 to 4, at the 2nd-year follow-up ($p<0.01$) (Table 3). Correlation analysis revealed no significant differences between changes in preoperative and 2nd-year follow-up Cobb angles and changes in preoperative and 2nd-year follow-up ODI and VAS values.

Notably, preoperative Cobb angle exhibited a strong correlation with both preoperative ODI ($p=0.028$) and postoperative ODI ($p=0.014$). Additionally, preoperative sagittal balance

Table 2. Radiological parameters between follow-up

Variables	Preoperative	Early Postoperative	Long-term Postoperative	P value
Cobb angle (°)	42.4 (22-64)	6.2 (0.9-15)	5.9 (0.6-13)	<0.001
Sagittal balance (mm)	30.6 (-58.4-153)	15.4 (-55.3-102)	9.7 (-52.8-64)	<0.001
Coronal balance	22.3 (5.2-82)	12.7 (0-25.7)	10.5 (0-24.9)	<0.001

Table 3. Clinical scores between follow-up

Variables	Preoperative	Early postoperative	Last follow-up	P value
VAS	7.8 (7-9)	4.2 (0-6)	2.8 (0-4)	<0.001
ODI	46.2 (38-49)	36.8 (31-44)	25.8 (17-32)	<0.001

VAS: Visual Analogue Score ODI: Oswestry Disability index

correlated with both preoperative and postoperative ODI. However, postoperative Cobb angle and sagittal balance showed no correlation with postoperative ODI ($p < 0.05$).

All patients who were employed before surgery were able to return to their previous jobs by the final follow-up assessment. None of the patients reported restrictions in their daily activities compared to their preoperative experiences. At the final follow-up assessment, all patients were physically independent in their daily activities. Only one patient among the cohort experienced a superficial infection, which was successfully treated with antibiotics and superficial debridement. At the end of the 2nd-year follow-up, no complications were observed in any of the patients.

Discussion

AS can manifest as a progression of adolescent scoliosis or develop *de novo* in adulthood. Unlike often-asymptomatic nature of idiopathic scoliosis, AS is typically characterized by pain as a predominant symptom. The main need for treatment mostly is for symptoms of excessive pain unlike balancing sagittal and coronal deformities in AS. The literature reports varying rates of pain incidence in AS, ranging from 40 to 90% (2,19,20). Smith et al. conducted a study of surgical and conservative treatments for AS and found that surgery significantly reduces pain (21). A systematic review by Yadla et al. demonstrated a decrease in the ODI score from 41.2 to 15.7, along with an average correction of 26.6 degrees in major curvature postoperatively (22). Another study by Ledonio et al. showed reductions in ODI and Visual Analog Score (VAS) from 34.2 and 4.5 to 20.1 and 1.98, respectively, after surgery, with an average Cobb angle reduction of 11.1 degrees (23). In our study, we observed a decrease in ODI scores from 46.2 to 25.8 and VAS scores from 7.8 to 2.8 postoperatively. Additionally, we achieved a substantial average correction of 36.5 degrees in the major curve.

Providing spinal balance is one of the primary goals in AS surgery. Coronal and sagittal balance were found to be associated with the patient's functional capacity, pain level and quality of life (24, 25). Ledonio et al. reported an average improvement of 7.7 degrees in coronal balance and 4.6 mm in sagittal balance in a review of 197 patients' post-surgery (23). In our study, we observed a decrease in coronal balance from 22.3 mm to 10.5 mm and sagittal balance from 30.6 mm to 9.7 mm in the final follow-up.

The interest in surgical treatment for AS has grown over time due to the potential problems untreated adults may face, including spinal osteoarthritis, progressive deformity, spinal stenosis leading to radiculopathy, muscle pain due to coronal and sagittal imbalance, and cosmetic concerns. The objectives of surgical treatment include pain reduction, halting curve progression, restoring respiratory function, and enhancing cosmetic appearance. Surgery in patients presents unique challenges compared to adolescents, including issues such as osteopenia or osteoporosis, disc degeneration, spinal rigidity, and sagittal-coronal imbalances, all of which necessitate thorough preoperative evaluation (16). An additional challenge is the spinal rigidity in adult patients, which can be mitigated through complete posterior decompression during surgery.

Spinal stenosis is a critical concern in the AS, leading to the nerve root ischemia due to compression (26). In the patients with scoliosis, spinal stenosis presents as a complex condition characterized by asymmetric collapse, rotation, lateral listhesis, spondylolisthesis, and facet joint hypertrophy. Notably, some studies have failed to establish a clear correlation between the severity of pain and the magnitude of the curvature (26, 27). The ideal treatment for spinal stenosis involves full decompression at the stenotic level, followed by rigid fixation. Clinical and radiological evaluation plays a primary

role in determining the decompression level. In our study, effective posterior decompression facilitated correction and reduced spinal rigidity. Subsequently, rigid fixation was achieved by placing pedicle screws bilaterally at each level. Laminectomy performed in the stenotic region was beneficial in alleviating leg pain, and low back pain relief was achieved through reduction and stabilization using instrumentation. Our conclusion from these findings is that the extent of correction may not correlate with clinical outcomes in AS, but the success of the surgery can be attributed to the stabilization and decompression of stenotic areas.

The limitations of our study are its retrospective design and a relatively small number of cases. However, the strengths of this study lie in its single-surgeon, single-center approach, as well as meticulous data collection throughout the study period, with no lost follow-up cases. Future randomized prospective studies with larger sample sizes will further contribute to the literature on this subject.

In summary, despite the primary focus on restoring sagittal and coronal parameters in AS surgery, our study suggests that the extent of restoration does not necessarily correlate with improvements in clinical outcomes. This conclusion should be taken into account when planning surgery and patients should be well-informed in term of outcomes. This study demonstrates the strategic importance of several points in AS surgery.

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Conflict of Interest

The Authors declare no conflict of interests.

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