Are We Missing the Mark? Sagittal Malalignment in Nonoperative Adolescent Idiopathic Scoliosis Patients with Moderate Curves

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INTRODUCTION:

Adolescent idiopathic scoliosis (AIS) is typically managed based on coronal Cobb angle, with surgical intervention reserved for curves exceeding 50°. Patients with moderate curves (30°–50°) who reach skeletal maturity are often discharged from care without surgery. However, adult spine literature has established sagittal alignment—including sagittal vertical axis (SVA), pelvic incidence–lumbar lordosis (PI–LL) mismatch, and T1–pelvic angle (T1PA)—as critical predictors of long-term disability, pain, and spinal degeneration. While these sagittal parameters have revolutionized adult deformity management, their relevance in nonoperative AIS remains unclear.

Despite increased attention to sagittal alignment in surgical AIS populations, there is limited data on whether non-surgical patients harbor similar alignment abnormalities. Most long-term studies focus on curve progression, overlooking potential risks related to spinopelvic imbalance that may already be present at skeletal maturity. Identifying such abnormalities could improve risk stratification and guide earlier intervention.

This study aims to evaluate sagittal alignment in skeletally mature AIS patients with moderate coronal curves who did not meet traditional surgical criteria, and to quantify the prevalence of sagittal malalignment based on adult deformity thresholds.

METHODS:

We conducted a retrospective review of AIS patients treated at a freestanding tertiary pediatric center between January 2016 and December 2022. Inclusion criteria were: diagnosis of AIS, skeletal maturity (Risser grade 4–5), final Cobb angle between 30° and 50°, and no history of surgical intervention. Radiographic analysis was performed using standing lateral radiographs at final follow-up.

Sagittal alignment parameters included: sagittal vertical axis (SVA), pelvic incidence (PI), lumbar lordosis (LL), PI–LL mismatch, pelvic tilt (PT), T1–pelvic angle (T1PA), thoracic kyphosis (TK), cervical lordosis (CL), and Roussouly classification. Additional measurements included C2 pelvic angle (C2PA), T4 pelvic angle (T4PA), L1 pelvic angle (L1PA), and C2 slope.

Sagittal malalignment thresholds were defined as follows: SVA >5 cm, PI–LL mismatch >10°, T1PA >14°, PT >25°, TK <20°, CL <20°, C2PA >15°, T4PA >20°, L1PA >15°, and C2 slope >36°. Patients were also categorized based on the number of sagittal abnormalities present (range: 0 to 6). Roussouly mismatch was recorded when spinopelvic parameters deviated from the expected classification.

All data was analyzed using SAS v9.4. Descriptive statistics and frequency distributions were reported.

RESULTS:

Fifty-seven skeletally mature AIS patients met inclusion criteria (mean age: 14.7 years; mean Cobb angle: 38.9° ± 5.3°). Mean values for sagittal alignment were: thoracic kyphosis 39.7° ± 13.2°, lumbar lordosis 47.4° ± 11.0°, PI–LL mismatch 11.3° ± 12.6°, T1–pelvic angle 9.5° ± 6.6°, and SVA 2.3 cm ± 2.8 cm.

Prevalence of sagittal malalignment based on adult deformity thresholds:

PI–LL mismatch >10°: 38.6% (22/57)
T1–pelvic angle >14°: 14.0% (8/57)
SVA >5 cm: 1.8% (1/57)
Pelvic tilt >25°: 7.0% (4/57)
Thoracic kyphosis <20°: 3.5% (2/57)
Cervical lordosis <20°: 26.3% (15/57)

Sagittal burden ranged from 0 to 6 abnormalities per patient:

33.3% had 0
25.9% had 1
9.3% had 2
20.4% had 3
3.7% had 4
5.6% had 5
1.9% had 6

Patients with ≥2 abnormalities demonstrated significantly higher mean PI–LL mismatch (18.9° vs 7.1°, $p<0.01$) and T1PA (13.2° vs 7.4°, $p<0.01$) compared to those with 0–1 abnormality. Roussouly mismatch occurred in 17.5% (10/57) and was more common in patients with ≥3 abnormalities ($p=0.03$).

Prevalence of emerging sagittal parameters:

C2 pelvic angle >15°: 42.1% (24/57)
L1 pelvic angle >15°: 21.1% (12/57)
C2 slope >36°: 11.1% (6/54)
T4 pelvic angle >20°: 5.3% (3/57)

DISCUSSION AND CONCLUSION:

A striking proportion of skeletally mature AIS patients with moderate coronal curves exhibited sagittal malalignment patterns known to predict pain, disability, and progression in adult spinal deformity. Over 40% had two or more sagittal abnormalities, and 17.5% demonstrated spinopelvic profiles inconsistent with their Roussouly classification—despite not qualifying for surgical correction under current guidelines.

These findings challenge the adequacy of coronal Cobb angle alone in guiding AIS management. By overlooking sagittal imbalance, we may be discharging patients who harbor alignment profiles with biomechanical inefficiency and elevated long-term risk. Incorporating sagittal parameters into AIS decision-making frameworks could allow earlier, more targeted intervention in anatomically vulnerable patients.

As spinal surgery evolves toward precision alignment and long-term functional outcomes, this study highlights the need to redefine which deformities warrant correction—not just by how they curve, but by how they balance.