

Immediate Biomechanical Effects of a 3D-Printed Scoliosis Brace on Coronal and Spinopelvic Alignment in Adolescent Idiopathic Scoliosis

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Introduction

Three-dimensional (3D)-printed scoliosis braces enable patient-specific correction strategies for the treatment of adolescent idiopathic scoliosis (AIS). While coronal plane correction is expected with bracing, the immediate biomechanical effects on spinopelvic sagittal alignment are less well characterized. This study aims to quantify immediate coronal and sagittal radiographic alignment changes following application of a 3D-printed scoliosis brace in adolescent idiopathic scoliosis.

Materials and Methods

Fifty-three adolescents with adolescent idiopathic scoliosis treated with a 3D-printed brace were analyzed. Standing full-spine radiographs were obtained before and after brace application (in-brace). The primary coronal parameter was Cobb angle of the main curve, and the primary sagittal parameter was pelvic incidence–lumbar lordosis (PI–LL) mismatch. Secondary parameters included pelvic incidence (PI), lumbar lordosis (L1–S1), pelvic tilt (PT), sacral slope (SS), T1–pelvic angle (TPA), spinopelvic angle (SPA), spinosacral angle (SSA), and vertebral rotation (Nash–Moe). Pre- and post-corset values were compared using paired t-tests or Wilcoxon signed-rank tests as appropriate ($\alpha=0.05$). As a secondary biomechanical analysis, PI–LL mismatch was categorized as balanced (-10° to $+10^\circ$) or imbalanced, and transitions in sagittal alignment status were assessed using the McNemar test.

Results

Mean Cobb angle improved from $33.68^\circ \pm 9.65$ to $14.33^\circ \pm 11.57$, representing a mean correction of $19.35^\circ \pm 10.25$ ($p<0.001$; Cohen's $d_z=1.89$), with a mean percent correction of $47.58\% \pm 28.81$. PI–LL mismatch improved from $-7.66^\circ \pm 13.97$ to $-0.29^\circ \pm 13.25$ ($\Delta +7.37^\circ \pm 14.84$; $p<0.001$). Using a $\pm 10^\circ$ threshold, the proportion of sagittally balanced patients increased from 41.5% pre-brace to 62.3% post-brace; among patients with pre-brace PI–LL imbalance, 58.1% transitioned to a balanced alignment state (McNemar $p=0.021$). Pelvic incidence remained unchanged ($p=0.521$). Secondary sagittal parameters demonstrated modest but statistically significant changes.

Conclusion

In adolescent idiopathic scoliosis, application of a 3D-printed scoliosis brace resulted in large immediate coronal correction and significant biomechanical changes in spinopelvic alignment. These findings support that customized 3D-printed bracing can influence both coronal deformity and sagittal alignment parameters in-brace, warranting further investigation of biomechanical mechanisms and longer-term radiographic and clinical follow-up.

Figure 2. Flow diagram illustrating patient selection for the study. Of 67 patients initially assessed, 14 were excluded due to inadequate radiographic quality preventing reliable measurement of alignment parameters, resulting in a final cohort of 53 patients with adolescent idiopathic scoliosis.

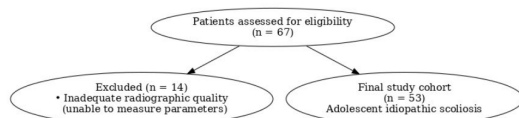


Figure 1

Sankey diagram illustrating transitions in sagittal alignment status based on pelvic incidence–lumbar lordosis (PI–LL) mismatch using a $\pm 10^\circ$ threshold before and after application of a 3D-printed scoliosis corset. Flow widths are proportional to patient counts, demonstrating a net increase in sagittally balanced alignment following corset application.

