

The Effects of Bracing on Pelvic Parameters in Adolescent Idiopathic Scoliosis

Kepeng Li

The second central hospital of Baiding

Jun Miao (✉ likepeng19801@163.com)

Tianjin hospital

Jingan Zhang

Tianjin Hospital

Xijie Wang

Tianjin Hospital

Ye Han

Tianjin Hospital

Research article

Keywords: Adolescent idiopathic scoliosis, bracing, spinopelvic parameters, pelvic rotation

Posted Date: February 24th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-240717/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background: This study aims to evaluate the effects of bracing on the Cobb's angle (CA) and spinopelvic parameters in adolescent idiopathic scoliosis (AIS) patients.

Methods: A total of 51 AIS patients who received bracing treatment between January 2018 and August 2019 were retrospectively analyzed. The pro-bracing and in-bracing radiographs were analyzed with regard to the spinopelvic parameters. The CA, pelvic coronal obliquity angle (PCOA), thoracolumbar kyphosis (TK), lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), sagittal vertical angle (SVA) and coronal vertical angle (CVA) were measured.

Results: The mean age at the initiation of bracing was 13.6 ± 1.5 years. The mean pro-bracing CA was $24.0^\circ \pm 6.3^\circ$. There were no statistically significant differences between pro-bracing and in-bracing measurements of SVA and CVA. However, there were statistically significant differences between the pro-bracing and in-bracing measurements of the CA, PCOA, TLK, LL, PT and SS. A significant correlation was observed between PT variation and TLK variation in the sagittal plane. In the coronal plane, the PCOA variation was correlated to pro-bracing PCOA.

Conclusion: Bracing effects of AIS can be extended to the pelvis. The pelvis should retro-rotate correspondingly to TLK hypokyphosis on sagittal plane, whereas in coronal plane, pelvic obliquity was improved independently.

Introduction

AIS is a three-dimensional deformity characterized by coronal, sagittal, and rotational deformities of the spine [1]. For moderate deformities, bracing is the most common treatment. Its efficiency in preventing the progression of curves is generally admitted [2].

In the most previous studies on bracing of AIS patients, CA was the main index used to evaluate the treatment effectiveness [3]. Recently, addition to the CA, other factors such as the curve pattern, LL, and pelvic parameters, have been taken into consideration for the evaluation of the outcomes of bracing in AIS [4,5].

Scoliosis is often associated with pelvic parameters [6], It has been shown that patients with AIS have an abnormal spinopelvic balance and pelvic morphology. Walker and Dickson [7] screened 5303 schoolchildren aged 10– 14 years old for scoliosis. Three hundred seventy-five (7.1%) children had curves of 5–9° inclusive and, of these, 138 (36.8%) had scoliosis secondary to a pelvic rotation. Pelvic rotation in AIS patients could be explained in part from a traction phenomenon created by paraspinal or abdominal muscle tension [8].

An evaluation of variation of pelvic parameters can provide a better understanding of the brace mechanisms of action in controlling the curve progression. Furthermore, a significantly higher prevalence

of pelvic rotation was observed in patients with thoracolumbar curves, than in thoracic curves. So we aimed to evaluate the effects of bracing on pelvic parameters in thoracolumbar AIS.

Materials And Methods

Approval of this retrospective study was obtained from the Second Central Hospital of Baoding. The medical records of eligible patients with AIS who underwent Chêneau bracing between January 2018 and August 2019 in our department were reviewed retrospectively. We excluded patients with congenital scoliosis, syndromic scoliosis, structural leg discrepancies, and patients aged 16 or more at the time of bracing.

Inclusion criteria for the indication of brace were: Lenke5 AIS, skeletal immaturity, premenarcheal or postmenarcheal by less than 1 year, a CA between 15° and 45°. receiving Chêneau brace (Figure 1); having ongoing bracing treatment for at least six months prior to study.

Radiographic assessment

Standing whole spine radiographs were ensured that patients were completely erect and their pelvis was not rotated. Radiological parameters were measured from anteroposterior and lateral standing radiographs of whole spinal, which were obtained pro-bracingly and in-bracingly. All of the measurements were performed by Surgimap Spine Software (New York, USA). Measurements were all conducted by two investigators independently and blinded to the clinical information to avoid bias. The list of patients for measurement were randomly allocated and provided by another investigator. An average score was used for any measurement with < 5 degrees of difference. Any difference beyond 5 degrees was discussed between the investigators with a final consensus on the measurement used for analysis. The cutoff of 5 degrees was used based on documented radiographic measurement errors in a scoliotic curve.

The spinopelvic parameters of pro-bracing and in-bracing radiographs were used to assess:

CA defined as the angle between the perpendicular lines from the upper endplate of the most tilted superior vertebra and lower endplate of the most tilted inferior vertebra.

PCOA defined as the angle between a line connecting the top of both iliac crests and the horizontal line was measured on standing AP radiographs.

TLK defined as the angle between the upper endplate of the T10 vertebra and lower endplate of the L2 vertebra

LL: The angle between the superior end plate of L1 and the superior end plate of S1.

PI: The angle between the line perpendicular to the sacral plate at its midpoint and the line connecting this point to the axis of the femoral heads.

PT: The angle between the line connecting the midpoint of the sacral plate to the femoral head axis and the vertical axis.

SS: The angle between the superior plate of S1 and a horizontal line. The lower arc of LL is geometrically equal to the sacral slope (SS).

SVA: The sagittal angle between the line from the center of the C7 vertebral body to the center of the upper sacral endplate and vertical line.

CVA: The coronal angle between the line from the center of the C7 vertebral body to the center of the upper sacral endplate and vertical line.

The pro-bracing and in-bracing radiographs of the patients were used to assess these parameters.

Statistical Analysis

The data was analyzed using SPSS Statistics 25 (IBM Corp, Armonk, New York, USA) Shapiro-Wilk test found that the data was normally distributed. Paired t-test was used to compare pro-bracing and in-bracing spinopelvic parameters. The Pearson correlation analysis was used to identify the relationships between the variations in the spinopelvic parameters. $P < 0.05$ was considered statistically significant.

Results

Demographics and baseline of main pelvic parameters

A total of 51 patients with AIS, 41 women and 10 men, were included in this study. The mean age at the initiation of bracing were 13.6 ± 1.5 (11–16) years. the mean initial curve magnitude was $24.0^\circ \pm 6.3^\circ$ (11.0° – 39.3°) the mean final curve magnitude was $10.8^\circ \pm 7.3^\circ$ (0° – 28.5°) the mean corrective rate was 57.1%. the mean brace wearing time was 14.9 ± 8.5 months. Overall, 29 patients (71%) had full brace compliance (20 to 23 h) and 12 (29%) patients had partial compliance (16 to 20 h).

The average PCOA was $1.0^\circ \pm 2.6^\circ$. Only 13 patients had a PCOA of 0° (25.5%). 12 patients (23.5%) had PCOA less than -1° , whereas 26 patients (51.0%) had PCOA of 1° or more.

The average PT was $6.1^\circ \pm 8.1^\circ$. 14 patients had a PT more than 10° (27.5%). 72.5% of patients had PT less than 10° , whereas 11 patients (21.6%) had PT of 0° or less.

Pro-bracing and in-bracing spinopelvic parameters comparement

Table 1 shows pro-bracing and in-bracing measurements of the sagittal parameters. According to the results, the TLK, LL, PT, SS had statistical significance ($p < 0.05$) (Table 1). Table 2 shows the pro-bracing and in-bracing measurements of the coronal parameters, the CA and PCOA were statistically significant ($p < 0.05$) (Table 2).

Table 1

Pro-bracing and in-bracing sagittal parameters (Mean \pm SD)

Variable	pro-bracing	in-bracing	paired t	P
TLK	8.9 \pm 8.9	6.0 \pm 6.8	3.35	0.00*
LL	46.5 \pm 10.6	43.3 \pm 8.9	2.16	0.04*
PI	38.6 \pm 11.7	39.9 \pm 8.8	1.15	0.26
PT	6.1 \pm 8.1	9.9 \pm 7.0	3.56	0.00*
SS	32.6 \pm 8.2	30.2 \pm 7.2	2.63	0.01*
SVA	1.1 \pm 3.6	0 \pm 3.5	1.87	0.07

Table 2

Pro-bracing and in-bracing coronal parameters (Mean \pm SD)

Variable	pro-bracing	in-bracing	paired t	P
CA	24.0 \pm 6.3	10.8 \pm 7.3	16.11	0.00*
PCOA	1.0 \pm 2.6	0.6 \pm 2.0	4.58	0.00*
CVA	1.5 \pm 1.6	1.4 \pm 1.6	0.28	0.78

Correlation analysis on variation of spinopelvic parameters

The correlation analysis on sagittal parameters variation was shown in Table 3. In the sagittal plane, PT variation had mild correlations with the TLK variation, whereas there was no statistically significant relationship between the other spinopelvic parameters and TLK values.

Table 3

Correlation analysis of sagittal parameters variation

Variable	Variation of TLK	
	Pearson	P
Variation of LL	0.17	0.22
Variation of PI	0.18	0.20
Variation of PT	0.29*	0.04
Variation of SS	0.06	0.66
Variation of SVA	0.19	0.18

The correlation analysis of coronal parameters variation were shown in Table 4. In the coronal plane, the PCOA variation was correlated to pro-bracing PCOA. However, CA variation had no statistically significant correlation with PCOA variation.

Table 4

Correlation analysis of coronal parameters variation

Variable	Variation of PCOA	
	Pearson	P
Variation of CA	0.14	0.31
Pro-bracing CA	0.09	0.52
Pro-bracing PCOA	0.67*	0.00
Pro-bracing CVA	0.27	0.06

Discussion

Scoliosis changes the spinal column in all three anatomical planes; therefore, all of the spinopelvic parameters are affected [9]. Restoring the balance in the spinopelvic parameters is an important aspect of AIS treatment, especially for Lenke5 AIS [10]. In these patients under bracing treatment, the sagittal and coronal rotation of pelvic is integrant to regulate the spinopelvic malalignment.

Most of bracing studies performed on the AIS were focused on the CA behavior and the goal of bracing treatment is to control the curve progression [11, 12, 13]. However, there is no study which assesses the behavior of pelvic parameters in patients with scoliosis under bracing treatment. The results of the

current study showed that the Chêneau bracing treatment did not have statistically significant effects on the whole balance parameter such as CVA and SVA, although it showed statistically significant effects on regional spinopelvic parameters such as CA, PT, SS, TLK, LL and PCOA. In a subsequent correlational analysis, there was no significant correlation between the variation of CA and the pelvic parameters. Therefore, our hypothesis regarding the direct effects of bracing on the pelvic parameter values was accepted.

The CA has been used as a main factor to determine the brace treatment effectiveness in AIS cases. In the present study, the mean degree of curve correction was 57.1% which was statistically significant between baseline and final measurements. This result is also in line with the study of Katz and Durrani [14] which found that a minimum of 25% correction of the primary scoliosis curve was needed to predict the positive outcome of brace treatment in AIS patients. Although it showed no statistically significant correlation between the pelvic parameter and corrective rate of CA, the rotational pelvic parameters were directly affected by brace treatment.

As sagittal rotational parameters of pelvis. The increased PT combined with decreased SS constituted the evidence of pelvic posterior rotation in the present study. In the subsequent correlation analysis, a negative correlation between TLK and PT was observed. Whereas correlation between TLK and LL was absent. This phenomenon suggests that the reduced TLK caused by corrective forces of braces is compensated by pelvic retro-rotation.

In prior study [15], there was a significantly higher prevalence of pelvic obliquity was observed in patients with lumbar curves, such as Lenke types 5 and 6, than in thoracic curves, such as Lenke types 1 and 2. Pelvic obliquity can be assessed by its anatomical origin, whether it is caused by a suprapelvic, intrapelvic, or infrapelvic problem or any combination of these problems [16]. Suprapelvic cause is secondary to the spinal deformity in which scoliosis may drive the pelvis into an asymmetrical position. In the present study, we observed a positive relationship between original PCOA and variation of PCOA. This mean that the more tilted toward the concave side of the lumbar curve the pelvis, the more influenced on pelvic obliquity of bracing. Bracing treatment could correct the scoliosis as well as pelvic obliquity simultaneously.

Nonetheless, this study had several limitations. Some of which are significant to the conclusions we are able to reach. The retrospective nature, as well as small cohort, make it difficult to draw definitive conclusions. Additionally, the short-term effects of bracing were analyzed for them. Although previous studies [17] showed that there was a significant correlation between immediate in-brace correction and outcome of brace treatment in AIS, long-term studies should be performed to evaluate the effect of immediate in-brace changes of pelvic parameters on outcome of brace treatment in AIS. Furthermore, the spinal axis radiographs were not centered on the pelvis and, therefore, there could be some parallax effect in the measurement of the pelvic parameters.

Conclusions

Bracing effects of AIS can be extended to the pelvis. The pelvis should retro-rotate correspondingly to TLK hypokyphosis on sagittal plane, whereas in coronal plane, pelvic obliquity was improved independently.

Abbreviations

CA Cobb's angle

AIS Adolescent idiopathic scoliosis

PCOA Pelvic coronal obliquity angle

TK Thoracolumbar kyphosis

LL Lumbar lordosis

PI Pelvic incidence

PT Pelvic tilt

SS Sacral slope

SVA Sagittal vertical angle

CVA Coronal vertical angle

Declarations

Ethics approval and consent to participate

Ethics approval was obtained from Second Central Hospital of Baoding,

Consent for publication

Written informed consent for publication was obtained from all participants

Availability of data and materials

Data available within the article or its supplementary materials

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable

Authors' contributions

JM conceived and designed the study. JAZ and YH analyzed the data. KPL wrote the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

References

1. Dunn J, Henrikson NB, Morrison CC, Blasi PR, Nguyen M, Lin JS. Screening for Adolescent Idiopathic Scoliosis: Evidence Report and Systematic Review for the US Preventive Services Task Force. *JAMA* 2018;319:173-87.
2. Negrini S, Minozzi S, Bettany-Saltikov J, Chockalingam N, Grivas TB, Kotwicki T, et al. Braces for Idiopathic Scoliosis in Adolescents. *Spine (Phila Pa 1976)* 2016;41:1813-25.
3. Bettany-Saltikov J, Turnbull D, Ng SY, Webb R. Management of Spinal Deformities and Evidence of Treatment Effectiveness. *Open Orthop J*. 2017 Dec 29;11:1521-1547.
4. Yamane K, Takigawa T, Tanaka M, Sugimoto Y, Arataki S, Ozaki T. Impact of Rotation Correction after Brace Treatment on Prognosis in Adolescent Idiopathic Scoliosis. *Asian Spine J* 2016;10:893-900.
5. Guo J, Liu Z, Lv F, Zhu Z, Qian B, Zhang X, et al. Pelvic tilt and trunk inclination: new predictive factors in curve progression during the Milwaukee bracing for adolescent idiopathic scoliosis. *Eur Spine J* 2012;21:2050-8.
6. Sullivan TB, Marino N, Reighard FG, Newton PO. Relationship Between Lumbar Lordosis and Pelvic Incidence in the Adolescent Patient: Normal Cohort Analysis and Literature Comparison. *Spine Deform* 2018;6:529-36.
7. Walker AP, Dickson RA. School screening and pelvic tilt scoliosis. *Lancet*. 1984;2:152-3.
8. Zhao Y, Qi L, Yang J, et al. Factors affecting pelvic rotation in idiopathic scoliosis: Analysis of 85 cases in a single center. *Medicine (Baltimore)* 2016; 95: e5458.
9. Illés TS, Burkus M, Somoskeőy S, Lauer F, Lavaste F, Dubousset JF. The horizontal plane appearances of scoliosis: what information can be obtained from top-view images? *Int Orthop*. 2017 Nov;41(11):2303-2311. doi: 10.1007/s00264-017-3548-5. Epub 2017 Aug 11. PMID: 28801800.
10. Cheung JPY. The importance of sagittal balance in adult scoliosis surgery. *Ann Transl Med*. 2020 Jan;8(2):35. doi: 10.21037/atm.2019.10.19. PMID: 32055626; PMCID: PMC6995914.
11. Kalichman L, Kendelker L, Bezalel T. Bracing and exercise-based treatment for idiopathic scoliosis. *J Bodyw Mov Ther*. 2016 Jan;20(1):56-64.
12. Zhang Y, Li X. Treatment of bracing for adolescent idiopathic scoliosis patients: a meta-analysis. *Eur Spine J*. 2019 Sep;28(9):2012-2019.

13. Heary RF, Bono CM, Kumar S. Bracing for scoliosis. *Neurosurgery*. 2008 Sep;63(3 Suppl):125-30.
14. Katz DE, Durrani AA. Factors that influence outcome in bracing large curves in patients with adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)* 2001;26:2354-61.
15. Schur M, Andras LM, Murgai R, Siddiqui AA, Gonsalves NR, Sponseller PD, Emans JB, Vitale MG, Skaggs DL; Growing Spine Study Group; Children's Spine Study Group. Pelvic Obliquity Correction in Distraction-Based Growth Friendly Implants. *Spine Deform*. 2019 Nov;7(6):985-991.
16. Sheha ED, Steinhaus ME, Kim HJ, Cunningham ME, Fragomen AT, Rozbruch SR. Leg-Length Discrepancy, Functional Scoliosis, and Low Back Pain. *JBJs Rev*. 2018 Aug;6(8):e6.
17. Clin J, Aubin CÉ, Sangole A, Labelle H, Parent S. Correlation between immediate in-brace correction and biomechanical effectiveness of brace treatment in adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)* 2010;35:1706-13.

Figures

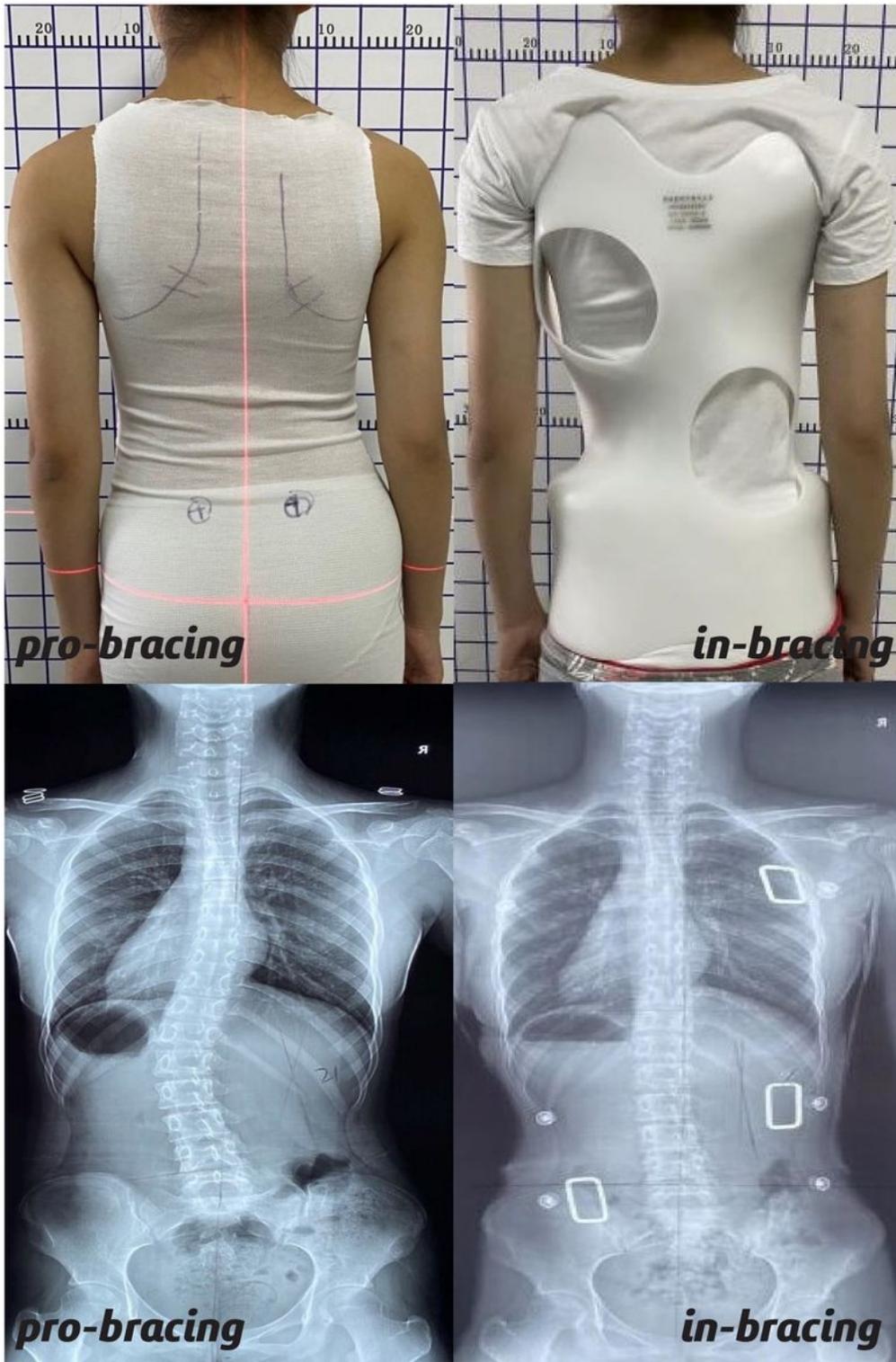


Figure 1

The Chêneau brace for adolescent idiopathic scoliosis.