Turk J Phys Med Rehab 2020;66(4):452-458
DOI: 10.5606/tftrd.2020.4955
Available online at www.turkishjournalpmr.com

Original Article

The effects of bracing on sagittal spinopelvic parameters and Cobb angle in adolescents with idiopathic scoliosis: A before-after clinical study

Marjan Saeedi[1], Mojtaba Kamyab[1], Taher Babaee[1], Hamid Behtash[2], Mohammad Saleh Ganjavian[2]

[1]Prosthetics and Orthotics, Iran University of Medical Sciences, Tehran, Iran
[2]Department of Orthopaedic Surgery, Iran University of Medical Sciences, Shafa Yahyaiian Hospital, Tehran, Iran

Received: June 24, 2019 **Accepted:** September 30, 2019 **Published online:** November 09, 2020

ABSTRACT

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

Patients and methods: A total of 25 adolescents (2 males, 23 females; mean age 12.7±1.6; range, 10-15 years) with AIS who received bracing between January 2000 and June 2017 were retrospectively analyzed. The initial and final out-of-brace radiographs of 25 AIS patients were analyzed with regard to the spinopelvic parameters. The pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), Cobb angle, thoracic kyphosis (TK), and lumbar lordosis (LL) were measured.

Results: The mean age at the initiation of bracing was 12.7±1.6 years. The mean initial Cobb angle was 31.8°±5.9°. There were no statistically significant differences between the baseline and the final measurements of the PI, PT, and SS. However, there were statistically significant differences between the baseline and the final measurements of the TK, LL, and Cobb angle. A significant correlation was observed between the PI and Cobb angle and TK and between the LL and SS.

Conclusion: Our study results show significant associations between the sagittal pelvic parameters and the spinal parameters during the brace treatment of adolescents with idiopathic scoliosis.

Keywords: Adolescent idiopathic scoliosis, brace, parameters, pelvic incidence, pelvic tilt, sacral slope, spinopelvic.

Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformity of the spine with a lateral curvature of more than 10° combined with vertebral rotation. The AIS prevalence ranges from 0.5 to 5.2% in children between 10 and 18 years old.[1]

In the most previous studies on bracing of AIS patients, the Cobb angle was the main index used to evaluate the treatment effectiveness.[2-4] Recently, in addition to the Cobb angle, other factors such as the curve pattern,[5] vertebral rotation,[6] Risser sign,[7] lumbar lordosis (LL), thoracic kyphosis (TK), and pelvic parameters,[8,9] have been taken into consideration for the evaluation of the outcomes of bracing in AIS.

Several studies have examined the pelvic parameters individually in patients with spinal deformities and reported the relationships between these parameters and spinopelvic section. The pelvic parameters in the sagittal plane determine the sagittal balance, which is one of the elements used to determine the effectiveness of bracing treatments.[8] Previous studies have evaluated the relationships between the pelvic parameters, LL, and TK in different spinal deformities using different treatment methods.[10]

In addition to the prognostic factors used while evaluating the AIS bracing outcomes such as the

Corresponding author: Mojtaba Kamyab, MD. Department of Orthotics and Prosthetics, School of Rehabilitation Sciences, Iran University of Medical Sciences, Madadkaran Avenue, Shahnazari St., Madar Square, Mirdamad Blvd., 158754391 Tehran, Iran.

e-mail: kamyab.m@iums.ac.ir

Cite this article as:
Saeedi M, Kamyab M, Babaee T, Behtash H, Ganjavian MS. The effects of bracing on sagittal spinopelvic parameters and Cobb angle in adolescents with idiopathic scoliosis: A before-after clinical study. Turk J Phys Med Rehab 2020;66(4):452-458.

curve correction, brace compliance, Risser sign, and spine flexibility, an evaluation of the pelvic parameters can provide a better understanding of the brace mechanisms of action in controlling the curve progression. Guo et al.[9] reported that the pelvic tilt (PT) and trunk inclination were predictive factors for the curve progression in scoliosis patients treated with Milwaukee braces; however, the relationships between the pelvic incidence (PI), PT, and sacral slope (SS) and Cobb angle have not yet been investigated. In the present study, therefore, we aimed to evaluate the effects of Milwaukee brace on the Cobb angle and pelvic parameters of AIS patients based on the hypothesis that bracing could alter the pelvic parameters, LL, TK, and lateral curvature of the spine in AIS cases.

PATIENTS AND METHODS

In this before-after clinical study, patients with AIS who received Milwaukee braces between January 2000 and June 2017 were retrospectively analyzed. *Inclusion criteria were as follows:* AIS patients with 10 years old and before skeletal maturity at the initiation of bracing; receiving Milwaukee brace (Figure 1); having ongoing brace treatment for at least six months prior to study;[11] and an initial curve magnitude of 20° to 45°. Exclusion criteria were as follows: having a history of any surgery on the spine or pelvic girdle; lacking appropriate standing full-length lateral and posteroanterior out-of-brace radiographs of acceptable quality at the baseline and final assessment; and a history of any prior treatment. Of 27 patients screened at baseline, two were excluded due to insufficient clarity of radiographs. The brace compliance was measured subjectively through patients' medical reports and appearance of the brace. Finally, a total of 25 adolescents (2 males, 23 females; mean age 12.7±1.6; range, 10-15 years) with AIS were included in the study. A written informed consent was obtained from each patient and/or his/her legal guardians. The study protocol was approved by the Iran University of Medical Sciences Ethics Committee (No. 1396.9411502004). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Figure 1. The Milwaukee brace for adolescent idiopathic scoliosis.

Radiographic measurements

The full-length upright standing lateral and posteroanterior radiographs of each patient were evaluated with regard to the following measurements:

1. The PI defined as the angle between the perpendicular line to the sacral plate and line joining the midpoint of the sacral plate and axis of the femoral heads.[8]
2. The SS defined as the angle between the sacral plate and horizontal line.[8]
3. The PT defined as the angle between the vertical line and line joining the midpoint of the sacral plate and axis of the femoral heads (Figure 2). The PT is positive when the hip axis lies in front of the sacral plate midpoint.[8]
4. The TK defined as the angle between the upper endplate of the T4 vertebra and lower endplate of the T12 vertebra.[12]
5. The LL defined as the angle between the upper endplate of the L1 vertebra and upper endplate of the S1 vertebra.[12]
6. The scoliosis Cobb angle 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.

The initial and final out-of-brace radiographs of the patients who completed their treatments were used to assess these parameters. For the patients who did not complete their treatments, the initial and post-treatment six-month out-of-brace radiographs

Figure 2. Spinopelvic parameter measurements.

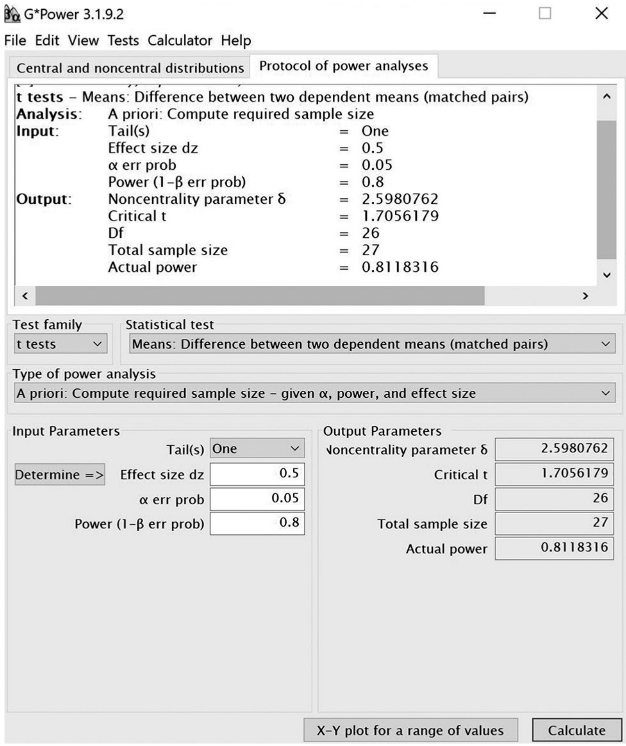

Figure 3. The protocol of power analysis for the sample size.

were included in the analysis. All measurements were obtained by a single investigator under the supervision and training of an orthopedic surgeon.

Statistical analysis

Power analysis was performed using the G*Power 3.1.9.2 version (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) software (Figure 3). The sample size was calculated on a priori analysis of differences between two dependent means (matched pairs).[13] A priori analysis showed that for a minimum power of 0.8, an alpha (α) error of 0.05, and an effect size of 0.5, a total of 27 cases were required.

Statistical analysis was performed using the PASW version 17.0 software (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency. The normality of the data was evaluated using the Shapiro-Wilk test. To compare the mean values of the PI and the PT at baseline and final measurements, the Wilcoxon signed-rank test was used. The differences in the SS, Cobb angle, LL, and TK values between the baseline and the final measurements were assessed using the paired samples t-test. The Spearman correlation analysis was used to identify the relationships between the variations in the spinal parameters, such as the Cobb angle, TK, and LL, and the variations in the pelvic parameters. A p value of <0.05 was considered statistically significant.

RESULTS

The mean age at the initiation of bracing was 12.7±1.6 years, the mean initial curve magnitude was 31.8°±5.9°, and the mean brace wearing time was 17.1±12.5 months. The baseline curve types were as follows: three (12%) patients had double major curves and 22 (88%) patients had a single thoracic curve pattern. Overall, 18 patients (72%) had full brace compliance (20 to 23 h) and seven (18%) patients had partial compliance (16 to 20 h).

Table 1 shows baseline and final measurements of the pelvic parameters. According to the results, none of the three pelvic parameters were statistically significant. According to the statistical analysis, the pelvic parameters were not statistically significantly different from the baseline values (p>0.05) (Table 1). In contrast, the mean spinal parameter values were statistically significantly different between the baseline and final measurements (p<0.05) (Table 1). In addition, the baseline and final measurements of the spinal parameters, including the Cobb angle, LL, and TK, were statistically significant (Table 2).

TABLE 1
Pelvic parameters at baseline and final measurements

	Baseline		Final follow-up		
Variable	Mean±SD	Range	Mean±SD	Range	*p*
PI (°)	49.2±16.4	30-82	51.8±16.0	27-89	0.57
PT (°)	10.9±7.5	0-26	11.1±7.5	2-29	0.29
SS (°)	38.3±10.8	23-62	37.7±8.6	21-53	0.74

SD: Standard deviation; PI: Pelvic incidence; PT: Pelvic tilt, SS: Sacral slope.

TABLE 2
Spinal parameters at baseline and final measurements

	Baseline		Final follow-up		
Variable	Mean±SD	Range	Mean±SD	Range	*p*
Cobb angle (°)	31.8±5.9	22-44	22.5±6.9	11-38	<0.001
LL (°)	56.7±8.8	35-75	50.6±9.4	24-68	0.006
TK (°)	55.9±15.3	20-84	38.5±6.4	30-53	<0.001

LL: Lumbar lordosis; TK: Thoracic kyphosis; PT: Pelvic tilt, SS: Sacral slope.

TABLE 3
Correlations between the variations of spinal and pelvic parameters values

Variable	Variation of PI	Variation of PT	Variation of SS
Variation of Cobb angle			
r	0.4	0.2	0.0
p	0.04	0.16	0.84
Variation of LL			
r	0.3	0.1	0.40
p	0.13	0.55	0.03
Variation of TK			
r	-0.4	-0.0	-0.1
p	0.03	0.93	0.55

PI: Pelvic incidence; PT: Pelvic tilt; SS: Sacral slope; LL: Lumbar lordosis; TK: Thoracic kyphosis.

The results of the correlation analysis of the variations in the degrees of the spinal parameters with regard to the variations in the degrees of the pelvic parameters are shown in Table 3. Accordingly, the Cobb angle and TK values had strong correlations with the PI value, and there was a statistically significant relationship between the LL and SS values. However, none of the spinal parameters were statistically significantly associated with the PT value.

DISCUSSION

Scoliosis changes the spinal column in all three anatomical planes; therefore, all of the spinopelvic parameters are affected.[14-17] Restoring the balance in the spinopelvic parameters is an important aspect of AIS treatment. In these patients, the PT and SS rotate around the femoral head to regulate the sagittal malalignment.[18-20] As the PI value is fixed, the changes in the PT and SS values are reversed to maintain the consistency of this parameter; however, the PI value can be changed by spinopelvic deformities, such as scoliosis.[19]

The natural history studies which were performed on the AIS were focused on the Cobb angle behavior and reported that left untreated scoliosis curves tend to progress after skeletal maturity. Thus, the goal of brace treatment is to control the curve progression during adolescent. However, there is no study which assesses the natural history of pelvic parameters in patients with untreated scoliosis. The results of the current study showed that the Milwaukee brace treatment did not have statistically significant effects on the pelvic parameter values of the AIS patients, although it showed statistically significant effects on all of the spinal parameter values. Therefore, our hypothesis regarding the direct effects of bracing on the pelvic parameter values was rejected. In the present study, the means pre-brace and in-brace PI values were not significantly different due to the bracing. In contrast to the results of other studies demonstrating that the PI values were greater in AIS patients,[9] the mean of the initial PI values in the current study was lower than the mean of the final measurements. Moreover, the mean initial and final PT and SS values did not change significantly; while considering their relationship (PI= PT + SS), this makes sense. The Milwaukee brace is indicated for the treatment of either single or double major scoliosis curve patterns in which the apex of the curve is located above to T8.[21] According to the Mac-Thiong et al.,[15] there was no significant relationship between the curve type and behavior of the pelvic parameters. However, further research is needed to evaluate the brace-related behavior of pelvic parameters in different curve patterns of AIS cases.

The Cobb angle 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 30% which was statistically significant between baseline and final measurements. This result is also in line with the study of Katz and Durrani[22] 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. Additionally, the TK and LL are the other spinal parameters that are affected by brace treatment, and their decreased final value means were the evidence of these effects. The LL, as a sagittal spinal parameter, is regulated by the TK, and the TK, itself, undergoes changes due to the influence of a Milwaukee brace in AIS cases.[23,24] According to a previous research, TK decreased in AIS patients after brace treatments due to decreased LL. The reduction in the mean LL as a strategic orthotic maneuver in the brace treatment of AIS would lead to a reduction in TK; hence, with reduction of TK, the corrective force would be applied more effectively on scoliotic curves in these patients.

The skeletal system is a close chain; therefore, the changes in one part can alter the normal balance of the other parts. The AIS changes in the spinal column cause certain changes in the pelvic parameters to maintain the sagittal balance of the spinopelvic section. The results of the current study showed that, in the AIS patients, the LL was correlated with the SS and the TK and Cobb angle were associated with the PI. These relationships between the spinal and pelvic parameters were positive, indicating that, while decreasing the LL, Cobb angle, and TK, the SS and PI decrease in a corresponding manner after Milwaukee bracing. This may be due to the compensatory action of the pelvis during brace treatment in AIS patients.[9]

According to the previously published results, the LL, itself, is closely associated with the pelvic parameters.[8] Le Huec et al.[20] showed that the LL was associated with the sacral plate so that its position was affected by the pelvic position. Consequently, the pelvic parameters affected the sagittal balance of the spine. The results of the study by Vialle et al.,[14] who performed a radiographic analysis of the sagittal alignment of the spine, revealed that the SS influenced the LL,[14] consistent with our study results. Another study showed a strong relationship between the LL and SS in the surgical correction of AIS cases.[25] However, the present study evaluated Milwaukee bracing treatments. Wang et al.[26] showed the same correlation between the LL and SS as in the current study. Despite the results of the present study, Wang et al.[26] found that this correlation only occurred in patients with a high degree of LL, and they emphasized that all of the spinopelvic parameters, except for the TK, exhibited significant correlations with the PI. In the current study, the TK and Cobb angle exhibited relationships with the PI, and the LL was correlated with the SS. The relationship found between the LL and SS in the current study was consistent with the results of previous studies, suggesting that bracing influences the SS value in the regulation of the LL due to the changes that occur due to the sagittal malalignment in AIS cases.[9] Geometrically, the sum of the SS and PT values is always equal to the PI value (PI = SS + PT).[14] With regard to this relationship and the relationship between the LL and SS, the LL value changes caused by bracing can alter the PT and PI values.[27] All of the studies conducted on the pelvic parameters have reported that there are relationships between the spinal and pelvic parameters and that the pelvic morphology has an influence on the sagittal balance.[8] Briefly, the greater the PI, the greater the SS and the higher the degree of LL.

According to previously published results, the effects of the Milwaukee bracing can be indirectly extended to the pelvic parameters.[9] Therefore, while wearing a brace to control the progression of scoliosis in AIS cases, the TK and LL changes should make corresponding changes to the pelvic parameters.[9] In the present study, the means of all of the spinal angles (Cobb, TK, and LL) decreased after the brace treatment. In other words, the bracing did not have a direct significant effect on the pelvic parameters, but it affected the spinal parameters. Moreover, with regard to the positive correlations between the variations in the spinal and pelvic parameters, the Milwaukee brace treatment effects on the pelvic parameters, particularly the PI and SS, cannot be underestimated. One of the first studies of the pelvic parameters on the regulation of the spinal sagittal curve reported that the effects of the pelvic anatomy on the sagittal balance were obvious, and that the PI was a reliable value for determining the variations in the SS and LL.[28] Another study evaluating the PI in the prediction of LL proved that there was a relationship between the SS and the PI in predicting the degree of LL needed to maintain the sagittal balance.[27] Based on the results of the current study showing the correlations between the Cobb angle and TK and PI and between the LL and SS, it can be concluded that the pelvic parameters, particularly the PI and SS, may be important factors for predicting the effectiveness of Milwaukee brace treatments in AIS patients.

Nonetheless, the current study has some limitations. First, we were unable to measure the cervical sagittal parameters, as the craniovertebral junctions of the patients were not included in the radiographs. However, the Milwaukee brace neck ring can affect the cervical parameters of AIS patients. Therefore, further research is needed to evaluate the effects of the Milwaukee brace on the cervical spine parameters, including the C7 or T1 slope, cervical sagittal vertical axis, and spine cranial angle.[29] Additionally, at the time of data gathering, there were some cases who were under treatment and, therefore, the immediate effects of bracing were analyzed for them. Although previous studies[30,31] 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.

On the other hand, the clinical applications of this study are as follows: pelvic parameters, particularly the PI and SS, should be evaluated as spinal parameters in radiographic periodic evaluations of patients with scoliosis. According to the results which showed that there were significant relationships between spinal and pelvic parameters, we can reference pelvic parameters as Cobb angle in the effectiveness of brace treatment in AIS patients.

In conclusion, the results of the present study have provided additional information about the bracing mechanisms of action with regard to the spinopelvic parameters in AIS patients. Pelvic parameters, particularly the PI and SS, can be evaluated as spinal parameters in radiographic periodic evaluations of patients with scoliosis.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

This study was supported by the research committee of Iran University of Medical Sciences.

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. Carr WA, Moe JH, Winter RB, Lonstein JE. Treatment of idiopathic scoliosis in the Milwaukee brace. J Bone Joint Surg [Am] 1980;62:599-612.
4. Olafsson Y, Saraste H, Söderlund V, Hoffsten M. Boston brace in the treatment of idiopathic scoliosis. J Pediatr Orthop 1995;15:524-7.
5. Thompson RM, Hubbard EW, Jo CH, Virostek D, Karol LA. Brace Success Is Related to Curve Type in Patients with Adolescent Idiopathic Scoliosis. J Bone Joint Surg [Am] 2017;99:923-8.
6. 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.
7. Karol LA, Virostek D, Felton K, Jo C, Butler L. The Effect of the Risser Stage on Bracing Outcome in Adolescent Idiopathic Scoliosis. J Bone Joint Surg [Am] 2016;98:1253-9.
8. Vrtovec T, Janssen MM, Likar B, Castelein RM, Viergever MA, Pernuš F. A review of methods for evaluating the quantitative parameters of sagittal pelvic alignment. Spine J 2012;12:433-46.
9. 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.
10. 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.
11. Vergari C, Courtois I, Ebermeyer E, Pietton R, Bouloussa H, Vialle R, et al. Head to pelvis alignment of adolescent idiopathic scoliosis patients both in and out of brace. Eur Spine J 2019;28:1286-95.

12. Mac-Thiong JM, Labelle H, Roussouly P. Pediatric sagittal alignment. Eur Spine J 2011;20 Suppl 5:586-90.
13. Faul F, Erdfelder E, Lang A, Buchner A. G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007;39:175-91.
14. Vialle R, Levassor N, Rillardon L, Templier A, Skalli W, Guigui P. Radiographic analysis of the sagittal alignment and balance of the spine in asymptomatic subjects. J Bone Joint Surg [Am] 2005;87:260-7.
15. Mac-Thiong JM, Labelle H, Charlebois M, Huot MP, de Guise JA. Sagittal plane analysis of the spine and pelvis in adolescent idiopathic scoliosis according to the coronal curve type. Spine (Phila Pa 1976) 2003;28:1404-9.
16. Vaz G, Roussouly P, Berthonnaud E, Dimnet J. Sagittal morphology and equilibrium of pelvis and spine. Eur Spine J 2002;11:80-7.
17. Roussouly P, Pinheiro-Franco JL. Biomechanical analysis of the spino-pelvic organization and adaptation in pathology. Eur Spine J 2011;20 Suppl 5:609-18.
18. Lazennec JY, Brusson A, Rousseau MA. Hip-spine relations and sagittal balance clinical consequences. Eur Spine J 2011;20 Suppl 5:686-98.
19. Upasani VV, Tis J, Bastrom T, Pawelek J, Marks M, Lonner B, et al. Analysis of sagittal alignment in thoracic and thoracolumbar curves in adolescent idiopathic scoliosis: how do these two curve types differ? Spine (Phila Pa 1976) 2007;32:1355-9.
20. Le Huec JC, Aunoble S, Philippe L, Nicolas P. Pelvic parameters: origin and significance. Eur Spine J 2011;20 Suppl 5:564-71.
21. Hsu JD, Michael JW, Fisk JR. Orthoses for spinal deformities. In: Katz DE, editor. AAOS Atlas of Orthoses and Assistive Devices. 4th ed. Philadelphia: Elsevier; 2008. p. 125-39.
22. 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.
23. Clément JL, Geoffray A, Yagoubi F, Chau E, Solla F, Oborocianu I, et al. Relationship between thoracic hypokyphosis, lumbar lordosis and sagittal pelvic parameters in adolescent idiopathic scoliosis. Eur Spine J 2013;22:2414-20.
24. Yong Q, Zhen L, Zezhang Z, Bangping Q, Feng Z, Tao W, et al. Comparison of sagittal spinopelvic alignment in Chinese adolescents with and without idiopathic thoracic scoliosis. Spine (Phila Pa 1976) 2012;37:E714-20.
25. Tanguay F, Mac-Thiong JM, de Guise JA, Labelle H. Relation between the sagittal pelvic and lumbar spine geometries following surgical correction of adolescent idiopathic scoliosis: a preliminary study. Stud Health Technol Inform 2006;123:299-302.
26. Wang H, Ma L, Yang DL, Ding WY, Shen Y, Zhang YZ. Radiological analysis of degenerative lumbar scoliosis in relation to pelvic incidence. Int J Clin Exp Med 2015;8:22345-51.
27. Boulay C, Tardieu C, Hecquet J, Benaim C, Mouilleseaux B, Marty C, et al. Sagittal alignment of spine and pelvis regulated by pelvic incidence: standard values and prediction of lordosis. Eur Spine J 2006;15:415-22.
28. Legaye J, Duval-Beaupère G, Hecquet J, Marty C. Pelvic incidence: a fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. Eur Spine J 1998;7:99-103.
29. Ling FP, Chevillotte T, Leglise A, Thompson W, Bouthors C, Le Huec JC. Which parameters are relevant in sagittal balance analysis of the cervical spine? A literature review. Eur Spine J 2018;27(Suppl 1):8-15.
30. 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.
31. Landauer F, Wimmer C, Behensky H. Estimating the final outcome of brace treatment for idiopathic thoracic scoliosis at 6-month follow-up. Pediatr Rehabil 2003;6:201-7.