# Chiropractic rehabilitation plus nighttime bracing for progressive adolescent idiopathic scoliosis: a case-controlled series

**Mark Morningstar,[1] Dan Oslin[2]**

**[1]Natural Wellness & Pain Relief Center; [2]Oakland Orthopedic Appliances, Bay City, MI, USA**

## Abstract

Non-operative treatments for scoliosis include various types of scoliosis-specific exercise therapies, as well as dynamic and rigid spinal orthoses. Although there are many studies evaluating various types of bracing-only constructs for scoliosis treatment, few have evaluated bracing when combined with chiropractic care. The present study analyzed the data of 18 patients from the initiation a chiropractic rehabilitation program combined with nighttime bracing. Patients were managed through the end of growth, and results were compared to baseline. Their collective results were compared to a similar group of previously published patients who participated in the same chiropractic rehabilitation program, but did not perform concurrent bracing treatment. Patients initiating the combined chiropractic and bracing treatment achieved a correction of 6° or more 81% of the time, while the remaining 19% remained within 5° of their baseline measurements. The average curve improvement was 9.4°. This was compared to a correction rate of 51.7%, a stabilization rate of 38.3%, and a progression rate of 10% in the group performing chiropractic rehabilitation only.

## Introduction

Conservative treatment for adolescent idiopathic scoliosis typically involves observation for curves up to 20°, rigid bracing for curves above 20°, and surgical consultation for curves exceeding 50°.[1] Exercise therapies have historically not been included in this treatment pathway, since older studies on physical exercises[2] and manual therapy[3] have not demonstrated a significant benefit in curve reduction. A survey of 263 members of the Scoliosis Research Society found that only 22% of respondents prescribe scoliosis-specific exercises for scoliosis.[4] Lack of high-quality research was the main reason cited by most of those members who do not prescribe it. The more common outcomes reported for exercise-based scoliosis treatments are functional in nature, such as esthetics, disability, back pain, progression into adulthood, psychological well-being, and breathing function.[5]

Various bracing concepts for adolescent idiopathic scoliosis have been previously studied. Bracing technologies in the United States may be broadly categorized by the time of day in which they're worn. There are full-time braces, such as a TLSO brace, as well as nighttime constructs, such as the Providence brace. In the BrAISt study by Weinstein *et al.*,[1] bracing was recently reported effective at preventing progression to the 50° surgical threshold in compliant patients but did not tend to produce curve improvements. In a 2016 systematic review by Negrini *et al.*,[6] they identified 7 total prospective studies and RCTs showing that braces prevented curve progression.

More recently, newer exercise-based studies[7,8] have suggested that using a combined approach of scoliosis-specific exercises plus bracing may be a superior treatment option than bracing or observation alone. For example, Schreiber *et al.*[7] found that adding Schroth exercises to the observation and bracing stages of the usual standard of care improved the Cobb angle correction by an average of 3.5° in those with the largest curves in the cohort. A 2014 study by Negrini *et al.* showed that adding scoliosis-specific exercises to bracing protocols resulted in about half of their entire cohort achieving an improvement in their Cobb angles of at least 6°.[8]

The purpose of the present study was to document the results of patients who were prescribed nighttime Providence bracing. In addition to this bracing, the patients opted to concurrently participate in a chiropractic rehabilitation program. Their results at the end-of-growth are reported. The chiropractic rehabilitation program in which they participated has been previously reported.[9] However, in that study, those patients did not concurrently perform rigid bracing. Results of the present study are reported according to the established Scoliosis Research Society/Society on Scoliosis Orthopedic and Rehabilitation Treatment (SRS/SOSORT) joint criteria for non-operative treatments.[10]

## Materials and Methods

We established the following inclusion criteria based upon consecutively selected patient files from a single medical clinic. These included: i) a history of adolescent idiopathic scoliosis >10°; ii) initiated and completed the initial chiropractic rehabilitation treatment at the medical clinic; iii) were prescribed home exercises to continue thereafter; iv) patient incorporated a nighttime brace into his/her management strategy, and v) completed at least one follow-up visit at end of growth (Risser 4), or at skeletal maturity (Risser 5). Patient files were then consecutively selected if they met the inclusion criteria. Once these files were selected, we excluded those patients who wore a different type of nighttime brace, wore a full-time brace, or a brace made and fitted by another orthotist. From these exclusion criteria, a total of 18 patient charts were subsequently selected. Those patients whose files were selected provided their written informed consent to use their non-identifying information. We applied for, and received, Institutional Review Board (IRB) exemption for this study through IntegReview IRB.

All selected patients completed a short-term chiropractic rehabilitation program. The treatment approach provided to the selected patient population takes advantage of central postural, reflexive, neuromotor control. To engage these automatic neuromotor reflexes, external vector weighting was used in specific

Correspondence: Mark Morningstar, 8293 Office Park Dr, Grand Blanc, MI, USA 48439.
Tel.: (810).694.3576 - Fax: (810).694.9544.
E-mail: drmorningstar@nwprc.com

Key words: Scoliosis; rehabilitation; bracing; adolescent; pediatric.

Acknowledgments: the authors declare no potential conflict of interest.

Contributions: MWM delivered the treatment administration, and wrote the manuscript. DO provided the bracing treatment for patients, and collected data.

Conflicts of interest: the authors declare no conflicts of interest.

Further information: written informed consent was obtained from all patient whose files were used in this study. This study was granted IRB exemption through IntegReview IRB.

Received for publication: 16 August 2019.
Revision received: 8 November 2019.
Accepted for publication: 11 November 2019.


*Clinics and Practice 2019; 9:1191*
*doi:10.4081/cp.2019.1191*

directions, relative to each patient's curve pattern. This vector weighting purposely alter the centers of mass of the head, torso, and pelvis in specific directions to cause postural adaptive responses to counterbalance the weight in a predictable opposite direction. Previous studies have also described the use of vector weighting in scoliosis patients.[9,11] All selected patients were prescribed their own vector weights for use in the office and at home thereafter. Patients performed proprioceptive balancing on a 24-inch vestibular disc while using the vector weights. The conscious attention paid to the proprioceptive balancing is thought to create a neuromotor response that more intensely engages the hindbrain without overt cortical input. Hindbrain abnormality is one of the theories of scoliosis etiopathogenesis.[12] The vector weights can be made more difficult by increasing the distance of the weight from the patient's torso, thereby increasing leverage. As patients progressed through care, many increased the difficulty of the exercise by performing this activity while balancing on the vestibular disc on top of a whole body vibration platform set at 30Hz, as outlined previously.[9] Inversion therapy on an inversion table, supine positional traction, core stability isometrics, rotary torso exercise performed supine on an exercise ball, convex side planks, and myofascial release were performed by, or administered to, patients as well. Supine positional traction and related exercises were performed to promote a normal sagittal contour, providing a biomechanical baseline from which to perform specific core spinal stabilization exercises.[9] Chiropractic manipulation was not performed on any of the patients. These therapies were created and performed for each patient based upon his or her curve pattern. The therapies described in the present study were performed for approximately 25 hours per each week for 1 or 2 weeks, depending upon their baseline Cobb angle measurement and Risser stage. Patients with baseline Cobb angles below 40° participated in a 1-week therapy program, while those above 40° completed a second week. Upon discharge, patients were given an individualized home care exercise prescription, consisting of the same in-office exercises, to continue on an ongoing basis. Typical home exercise recommendations included twice daily sessions lasting 25-35 minutes each. These home exercise sessions were performed on an ongoing basis, with follow-up monitoring once every 4-6 months to modify each patient's home care routine based upon their respective growth stage, strength, and height. Each patient's brace was also modified or replaced during these interval follow-ups as the patient grew. Once they reached Risser 4 or 5, an end-of-growth radiographic study was collected. Participants were not allowed to wear their Providence braces for at least 24 hours prior to the final radiograph, nor were they permitted to perform any of their exercises. They were then dismissed from active management, and instructed to continue their home therapy session 1-2 days weekly for maintenance if their curves were higher than 30° at final re-evaluation. Brace weaning began at that time, progressively reducing wear time over the subsequent 6 months. The patients in the present study received a Providence nighttime brace (Spinal Technology; West Yarmouth, MA, USA) for one of two reasons: i) Their calculated progression factor was ≥2.5, or ii) the patient's parents decided to participate in bracing for progression factors <2.5. Therefore, after each patient was measured for a Providence brace on a Providence board, and subsequently fitted for the brace, they were referred for a supine in-brace radiograph to evaluate the immediate correction in-brace. Since initial correction rate in a rigid scoliosis brace is highly predictive of bracing outcome,[13] the radiograph was measured to verify that a 50% minimum in-brace correction was achieved. If it wasn't, the padding in the brace, or the structure of the brace was modified to increase the corrective benefit.

## Results

In accordance with the SRS/SOSORT[10] criteria for non-operative treatments, we calculated the following outcomes from those patient files who met all the inclusion criteria: the percentage of those who corrected ≥6°, the percentage of those who progressed more than 6°, and the percentage of patients whose curves remained within ±5° of the initial baseline measurement. The cohort was composed of 15 females and 3 males. All the patients selected resided in the United States Midwest region, consisting of Michigan, Ohio, Indiana, Kentucky, and Illinois. There were 13 Caucasians, 3 African Americans, and 2 Latino-Americans in the group. The average age at the beginning of treatment was 13 years, 4 months. The average treatment duration for each child was 2 years, 2 months. The cohort was comprised of 18 total patients, 9 double major curves, 6 thoracic curves, 1 thoracolumbar curve, and 2 lumbar curves, totaling 27 curves. The average baseline Risser score was 2. For the entire patient sample, 81% achieved a correction (22/27), while 19% remained unchanged (5/27). The average thoracic curve correction for the entire group was 7 degrees, and 9 degrees for the lumbar curve. Both curve corrections were statistically significant ($P<0.05$). For those patients who achieved a curve correction at final follow-up, the average curve correction was 9.4°

When examining each curve pattern, patients with double major curves began treatment with an average thoracic curve of 43° and an average lumbar curve of 45°. After 2 years and 2 months of management, their curves were both reduced an average of 8° ($P<0.05$). Thoracic curves were reduced from an average 44°±7 to 37°±7 ($P<0.05$). Lumbar curves were reduced by an average of 9° ($P=0.205$), and the single thoracolumbar case saw her curve reduced by 18°. A total of 78% of patients with double major curves achieved an improvement of at least 6°, and the remaining 22% remained unchanged. For the thoracic group, these values were 83% and 17%, respectively. Both patients with lumbar curve, as well as the lone patient with a thoracolumbar curve, achieved an improvement of >6° by the end of therapy. Figure 1 shows an illustration of these changes based upon curve pattern.

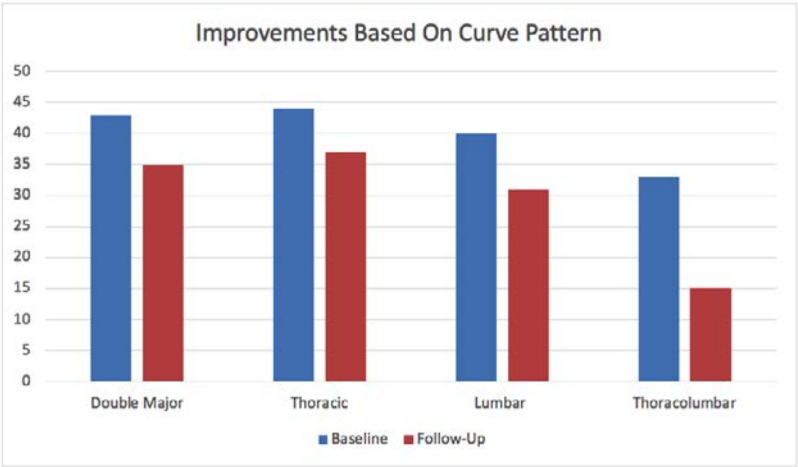


**Figure 1. Curve Changes By Scoliosis Curve Pattern.**

The SRS/SOSORT Guidelines also recommend analyzing data according to the starting Risser stage. When broken down in this manner, there were a total of 5 patients who began therapy at Risser 0-1, 7 patients at Risser 2, and 5 patients at Risser 3. There was 1 patient who began treatment at Risser 4. Patients initiating treatment at Risser 0-1 achieved a correction 71% of the time, with the remaining 29% unchanged. In the Risser 2 group, 91% of the group achieved a >6° correction. Four of the five Risser 3 patients achieved a curve reduction, with 1 remaining unchanged. The single Risser 4 patient had a curve improvement of 6°. Figure 2 illustrates the changes observed in patients starting treatment at different Risser stages.

Across the entire cohort, the average in-brace correction was 59%. For each curve pattern, in-brace correction was 53% in the thoracic curves, 58% in the double major curves, 66% in the thoracolumbar curve, and 78% in the lumbar curves. Table 1 illustrates the amount of in-brace correction for each curve type.

## Discussion

Providence nighttime bracing was selected for specific reasons. Data show that the Providence brace may provide a better chance to prevent surgery than TLSO bracing for curves up to 35°.[14] Another study showed that curves above 35° could be stabilized with the Providence brace 79% of the time if the curve apex was below T9.[15] The Providence brace also provides for a substantial in-brace correction,[16] which is a recognized predictor of bracing outcome.[13] Providence bracing induces bending moments that can help reduce asymmetric vertebral growth,[16] a benefit not reported by any exercise-based treatment. Therefore, the combination of these two modalities may provide for a more robust clinical approach that addresses multiple facets of AIS. Nighttime bracing may produce increased compliance, since patients do not wear the brace to school or elsewhere during the day.[17] Compliance rates are more variable with full-time bracing.[18] It may also decrease the impact on self-esteem and mental health parameters as compared to full time bracing. Full time TLSO bracing also causes an immediate reduction in vital capacity, residual volume, functional residual capacity (FRC), total lung capacity, and forced expiratory volume.[19] Since studies have not shown significant outcome differences between nighttime and part-time bracing,[20,21] a nighttime protocol was selected.

The decision to brace was based upon the progression factor. The progression factor is a calculation based upon data from 727 AIS patients followed from diagnosis through curve progression or skeletal maturity, whichever occurred first.[22] It was calculated using the three strongest correlations available at initial examination: the magnitude of the curve, the Risser sign, and the patient's chronological age.[22] The progression factor calculates the percent risk that a patient's curve will increase by 5° or more from baseline assessment through skeletal maturity. SOSORT created bracing guidelines beginning in 2006 based upon the progression factor, recommending brace treatment at a progression factor of 2.5.[23] Therefore, our decision to brace was, in part, based upon those guidelines. Figure 3 provides an illustration of the progression factor as well as respective treatment recommendations.

Progressive scoliotic curves above 30° increase an average of 0.9°/month, with a range of 0.3° to 1.6°/month.[24] Therefore, it is possible that the average curves in the present cohort may have increased by approximately 2° over the average course of the total management time (2 years, 2 months). However, there was a 7° average overall improvement for all thoracic curves and 8° improvement for lumbar curves in that same timeframe, instead of the expected 2° progression due to natural history.

When based upon Risser staging, a previous study by Morningstar *et al.*[9] showed that the chiropractic rehabilitation treatment employed in that study, as well as in the present study, produced a 45% correction rate, a 38% stabilization rate, and 17% progression rate in Risser 0-1 patients. However, the patients in that study did not concurrently participate in any bracing treatment, unlike the present study. The addition of the Providence brace in the present study eliminated the progression rate and increased the correction rate in Risser 0-1 patients to 71%. For Risser 2 patients completing the chiropractic rehabilitation treatment alone,[9] 53% corrected by 6° or more, 35% remained unchanged to within ±5°, and 12% failed. This compares to 91% corrected and 9% unchanged in the present study. Of note, when comparing patients who performed only the chiropractic rehabilitation treatment, the average amount of correction in those who achieved it was 12.75°, compared with 9.4° in the present study. Future studies should attempt to identify those patients in which higher levels of correction can be achieved without the need for bracing treatment if possible.

This study does carry specific limitations that must be noted. The small sample size overall, as well as for each Risser stage

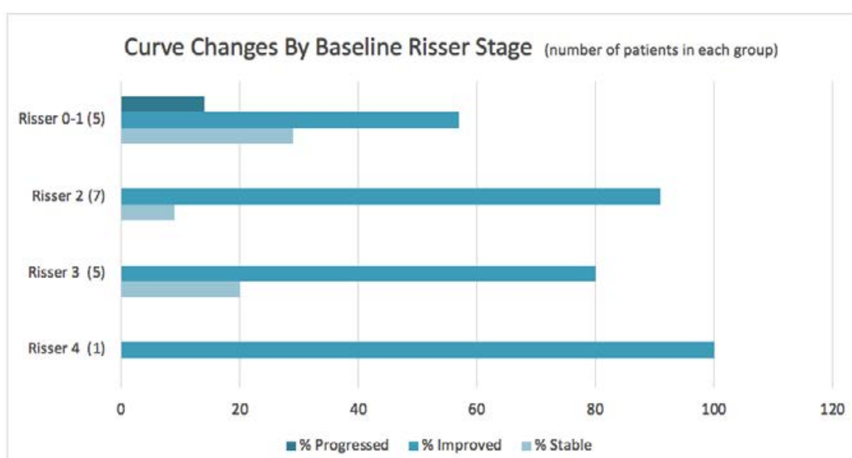


**Figure 2. Curve Changes By Risser Score.**

**Table 1. In-brace correction by curve type.**

| Curve type | Baseline (avg) | In-brace (avg) | % Correction (avg) |
|---|---|---|---|
| Double Major | 44° | 18° | 59 |
| Thoracic | 44° | 21° | 53 |
| Lumbar | 41° | 9° | 78 |
| Thoracolumbar | 33° | 11 | 66 |

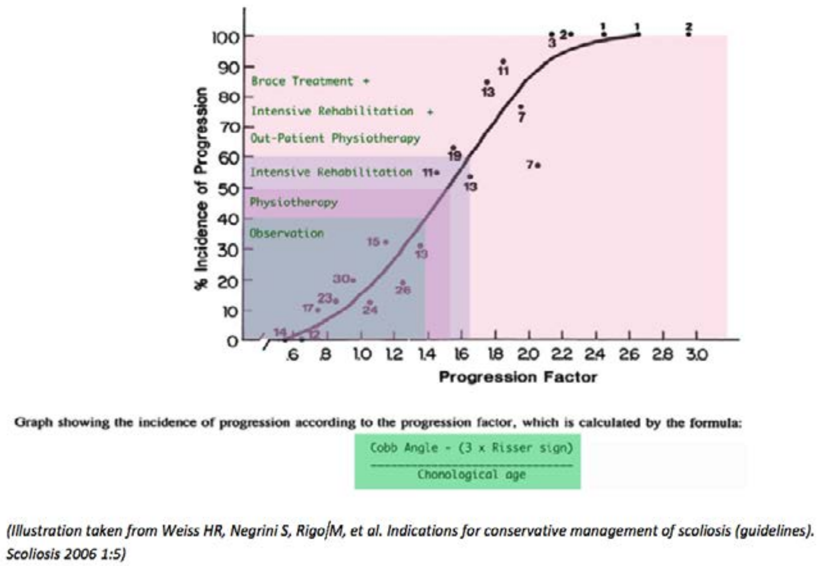


**Figure 3. Treatment Recommendations Based Upon Progression Factor (Illustration taken from Weiss HR, Negrini S, Rigo M, et al. Indications for conservative management of scoliosis (guidelines). Scoliosis 2006 1:5).**

and/or curve type, prevents generalizing the present data to broader populations. While every caution was taken to consecutively select patients who fit the inclusion and exclusion criteria, we cannot discount selection bias for contributing to our results.

## Conclusions

When Providence nighttime bracing was added to the treatment program in patients with adolescent idiopathic scoliosis, there was an overall improvement in the percentage of patients who achieved a correction at end of growth, when compared to a group who performed only the chiropractic rehabilitation treatment program. In those who were followed through end of growth for an average of 2 years, 2 months, 81% achieved curve correction of 6° or more. None of the cohort progressed by 6° or more. The results of this study suggest that in children who meet the SRS/SOSORT criteria for bracing, using a combined approach of nighttime Providence bracing plus chiropractic rehabilitation provided improved results when compared to chiropractic rehabilitation alone in adolescent patients Risser 0-2 at treatment initiation. Prospective trials are needed to confirm these results.

## References

1. Negrini S, Donzelli S, Aulisa AG, et al. 2016 SOSORT guidelines: orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth. Scoliosis Spinal Disord 2018;13:3.
2. Romano M, Minozzi S, Bettany-Saltikov J, et al. Exercises for adolescent idiopathic scoliosis. Cochrane Database Syst Rev 2012;15:CD007837.
3. Romano M, Negrini S. Manual therapy as a conservative treatment for adolescent idiopathic scoliosis: a systematic review. Scoliosis 2008;3:2.
4. Marti CL, Glassman SD, Knott PT, et al. Scoliosis Research Society members attitudes towards physical therapy and physiotherapeutic scoliosis specific exercises for adolescent idiopathic scoliosis. Scoliosis 2015;10:16.
5. Negrini S, Grivas TB, Kotwicki T, et al. Why do we treat adolescent idiopathic scoliosis? What we want to obtain and to avoid for our patients. SOSORT 2005 Consensus paper. Scoliosis 2006,1:4.
6. Negrini S, Minozzi S, Bettany-Saltikov J, et al. Braces for idiopathic scoliosis in adolescents. Spine 2016;41:1813-5.
7. Schreiber S, Parent EC, Khodayari Moez E, et al. Schroth Physiotherapeutic Scoliosis-Specific Exercises added to the standard of care lead to better cobb angle outcomes in adolescents with idiopathic scoliosis - an assessor and statistician blinded randomized controlled trial. PLoS One 2016;11:e0168746.
8. Negrini S, Donzelli S, Lusini M, et al. The effectiveness of combined bracing and exercise in adolescent idiopathic scoliosis based on SRS and SOSORT criteria: a prospective study. BMC Musculoskelet Disord 2014;15:263.
9. Morningstar MW, Dovorany B, Stitzel C, Siddiqui A. Chiropractic rehabilitation for adolescent idiopathic scoliosis: end-of-growth and skeletal maturity results. Clin Pract 2017;7:911.
10. Negrini S, Hresko TM, O'Brien JP, et al. Recommendations for research studies on treatment of idiopathic scoliosis: Consensus 2014 between SOSORT and SRS non–operative management committee. Scoliosis 2015;10:8.
11. Dovorany B, Morningstar M. A long-lever spinal orthosis for idiopathic scoliosis: corrective potential in 10 patients. Scoliosis 2013;8:O53.
12. Burwell RG, Aujla RK, Grevitt MP, et al. Pathogenesis of adolescent idiopathic scoliosis in girls - a double neuro-osseous theory involving disharmony between two nervous systems, somatic and autonomic expressed in the spine and trunk: possible dependency on sympathetic nervous system and hormones with implications for medical therapy. Scoliosis 2009;31:4:24.
13. Xu L, Qin X, Qiu Y, Zhu Z. Initial correction rate can be predictive of the outcome of brace treatment in patients with adolescent idiopathic scoliosis. Clin Spine Surg 2017;30:E475-9.
14. Janicki JA, Poe-Kochert C, Armstrong DG, Thompson GH. A comparison of the thoracolumbosacral orthoses and providence orthosis in the treatment of adolescent idiopathic scoliosis: results using the new SRS inclusion and assessment criteria for bracing studies. J Pediatr Orthop 2007;27:369-74.
15. D'Amato CR, Griggs S, McCoy B. Nighttime bracing with the Providence brace in adolescent girls with idiopathic scoliosis. Spine 2001;26:2006-12.
16. Sattout A, Clin J, Cobetto N, et al. Biomechanical assessment of Providence nighttime brace for the treatment of adolescent idiopathic scoliosis. Spine Deform 2016;4:253-60.
17. Schiller JR1, Thakur NA, Eberson CP. Brace management in adolescent idiopathic scoliosis. Clin Orthop Relat Res 2010;468:670-8.
18. Yrjonen T, Ylikoski M, Schlenzka D, Poussa M. Results of brace treatment of adolescent idiopathic scoliosis in boys compared with girls: a retrospective study of 102 patients treated with the

Boston brace. Eur Spine J 2007;16:393-7.
19. Katsaris G, Loukos A, Valavanis J, et al. The immediate effect of a Boston brace on lung volumes and pulmonary compliance in mild adolescent idiopathic scoliosis. Eur Spine J 1999;8:2-7.
20. Yrjönen T, Ylikoski M, Schlenzka D, et al. Effectiveness of the Providence nighttime bracing in adolescent idiopathic scoliosis: a comparative study of 36 female patients. Eur Spine J 2006;15:1139-43.
21. Schiller JR, Thakur NA, Eberson CP. Brace management in adolescent idiopathic scoliosis. Clin Orthop Relat Res 2010;468:670-8.
22. Lonstein JE, Carlson JM. The prediction of curve progression in untreated idiopathic scoliosis during growth. J Bone J Surg Am 1984;66:1061-71.
23. Weiss HR, Negrini S, Rigo M, et al. Indications for conservative management of scoliosis (guidelines). Scoliosis 2006;1:5.
24. Sanders JO, Browne RH, McConnell SJ, et al. Maturity Assessment and Curve Progression in Girls with Idiopathic Scoliosis. J Bone Joint Surg 2007;89:64-73.