Investigating the Effect of Providence nighttime Brace on Correction of Scoliosis in Patients with Adolescent Idiopathic Scoliosis: A Review Study

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Abstract

Introduction Scoliosis is a musculoskeletal disorder that can be treated by wearing full-time and part-time braces. It is not yet well understood whether part-time braces, such as Providence nighttime braces, are as effective as full-time braces in managing scoliotic curves. The aim of the present review study was to investigate the effect of Providence nighttime brace on correcting scoliosis in patients with adolescent idiopathic scoliosis (AIS). **Methods:** The search was performed using the keywords Scoliosis, Adolescent Idiopathic Scoliosis, Cobb angle, Nighttime Brace, Providence Brace, and Orthosis in PubMed, Science Direct, and ISI Web of Knowledge databases. **Findings**: A total of 10 relevant articles published between 2000 to December 2019 were selected for the final review according to the inclusion and exclusion criteria. Six articles investigated the effect of Providence brace before and after bracing treatment on the idiopathic scoliosis. Three artides compared the effect of Providence braces with full-time braces [Boston and Thoracic lumbar sacral Orthosis (TLSO)] on idiopathic scoliosis. One article also compared Providence brace with Charleston nighttime bending brace. **Conclusion**: Providence brace is an effective treatment approach to prevent the progression of scoliotic curves. However, it should be emphasized that its maximum effect is seen on the lumbar and thoracic curves< 35° with lower apex.

Keywords: Cobb Angle; Nighttime; Providence Brace; Scoliosis

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Introduction

Scoliosis is defined as a three-dimensional lateral curve of the spine of at least 10 degrees, which is associated with vertebral rotation (1-4). The overall prevalence of adolescent idiopathic scoliosis (AIS) in the general population is 0.9 to 12%, with approximately 10% of patients requiring various treatments and 0.1% of them being at risk for surgery (5). AIS is prevalent in 2-3% of adolescents aged 10 years and older (4). This disorder can be caused by congenital, neuromuscular, and idiopathic causes, and is idiopathic in 85% of cases (3). Idiopathic scoliosis is classified based on the age of onset, including infantile scoliosis (birth to 2 years of age), juvenile scoliosis (3 to 9 years of age), and adolescent scoliosis (10 years and older) (3). AIS is the most common form of scoliosis (3, 5). Curves > 50° are more likely to progressively worsen in adulthood and therefore require surgery (4). If left, untreated, large scoliotic curves can lead to reduced quality of life, disability, back pain, psychosocial disorders, appearance abnormalities, and lung complications (1, 5, 6). Factors associated with increased risk of curve progression include female sex, large primary curves, and early skeletal maturation (1, 3, 6). Recently, genetic factors have also been proposed (6). Girls usually mature earlier than boys and grow faster (1). The risk of scoliosis increases with a higher Cobb angle and a lower Risser grade (3). The Risser Sign measures the iliac apophysis, which is graded from one to five. A higher Risser Sign indicates more ossification, which reduces the potential for curve progression and development (3,4). Adam's forward bend test is a usual physical examination to diagnose scoliosis. In this test, the patient stands and lumbar region is bent forward, and the examiner evaluates the patient's back symmetry. Scoliosis patients have lateral bending of the spine, but the curve leads to spinal rotation and eventually rib protrusion, which can be seen on the examination (3).

Therapeutic strategies for idiopathic scoliosis include conservative and surgical treatments (6). The benefits of treatments such as physiotherapy, chiropractic, and electrical stimulation are discussed in preventing the development of

Table 1. Investigating the effect of providence brace and comparing it with other braces

Author	Participants	Orthotic interventions	Results
Yrjonen, 2005 (11)	72 women Average Cobb angle: 28.4 degrees Apex: below T10	-Providence: 36 patients -Boston :36 patients	The primary curve was corrected in 92% of cases using providence brace and 50% in-brace correction was achieved in the Boston group. Providence braces are recommended for patients with curves angles< 35° in the lumbar and thoracic-lumbar regions.
Amato, 2001 (10)	102 female patients Age: over 10 years of age Cobb angle: 42-20 degrees Risser sign: 0-2 Apex: at or below T9	Providence	The average in-brace correction was 96% for large curves and 98% for small curves. Successful correction was achieved for 94% of lumbar and 93% of lumbar-thoracic curves. It is more successful to prevent the progression of thoracic curves < 35 ° (*P*=0.03).
Janicki, 2007 (9)	83 patients Over 10 years of age Risser sign: 0-2 Cobb angle: 40-25 degrees	-Providence:35 patients -TLSO: 48 patients	Curve progression was not observed in 7 patients (15%) of the TLSO brace group (less than 5 degrees). In the providence brace group, 11 patients (31%) had no curve progression (*P*<0.05)
Bohl, 2014 (15)	34 patients Age: 10-15 years Riser sign: 2-0 Cobb angle: 40-20 degrees Apex: T8	Providence	A total of 17 patients (50%) had a curve progression > 5 ° and 9 patients (26%) had a progression> 45 °, which led to surgery. The effect of braces was confirmed (*P*=0.04).
Sattout, 2015 (2)	18 patients Age: 16-10 years Cobb angle: 45-20 degrees Apex: below T8	Providence	Providence brace can provide an average curve correction of 65% and 70% in the thoracic and the lumbar regions, respectively.
Quisth, 2015 (17)	62 patients (10 men and 52 women) Average Cobb angle 31.3 degrees 80 patients Apex: T7 and below	Providence	The post-intervention Cobb angle was 29.1° and the average in-brace correction was 81%. Acceptable curve control and high adaptation levels were achieved by using providence braces, and patients tolerate nocturnal braces well.
Simony, 2019 (18)	Age: Over 10 years Cobb angle: 20-42 degrees Apex: T7 or below	Providence	The average in-brace correction was 82% and the success rate of providence brace was 89%. The curve progression was observed in 9 patients (*P*=0.01).
Wessberg, 2009 (19)	66 patients (girls) Age: 10-16 years Cobb angle: 20-40 degrees Apex: T7 and below	-Providence:36 patients -Boston: 30 patients	The providence brace was effective for thoracic and lumbar curves with apex at T7 and curve angle of about 40 °. The success rate of providence brace was 77%, which was comparable to Boston brace.
Beuschau, 2014 (16)	55 patients (47 women, 8 men) Average Cobb angle: 31 degrees Apex: T7 and below	Providence	The average in-brace correction was 81% and post-treatment Cobb angle was 28°. Curve control and treatment failure rate were acceptable.
Paruch, 2009 (20)	52 patients Average Cobb angle: 27 degrees	-Providence: 26 patients -Charleston bending: 26 patients	The average brace correction for providence brace was 59%. Acceptable curve correction was obtained for the providence brace.

scoliosis. The use of braces and surgery are optional alternatives but there are limited evidence in this regard (3). In skeletally immature patients, care, brace, and surgery are recommended for curves< 25°, 25-45°, and >45°, respectively (6). Studies have shown that brace is an effective non-surgical treatment to prevent the curve from progressing as compared to non-bracing (1). Numerous studies have also suggested that braces reduce the risk of curve progression in AIS (4, 5, 7, 8). Several types of orthoses are used with varying degrees of success, including Milwaukee brace, thoracolumbosacral orthoses, and nighttime (nocturnal) orthoses such as Providence brace and Charleston brace. Most studies focused on Milwaukee brace, which are worn 22 to 23 hours a day. Previous studies have shown that this brace has the ability to prevent the progression of curves and eliminate the need to surgical procedures. New strategies recommend correction or sometimes over-correction using an invasive method. Charleston and Providence braces are the most common nocturnal orthoses that should be worn 8 to 10 hours at night (9). In order to be more effective in preventing the progression of scoliotic curves, braces are worn daily for more than 12 hours a day. It is difficult to wear and adapt to these braces. Patients usually wear their braces on average lower than half (46%) of the recommended time (2). Accepting full-time braces to treat IAS is a well-known problem. So, part-time braces and nighttime braces are used to cope with the stress associated with using full-time braces. Climent & Sanchez investigated the effect of different types of spinal orthoses on psychosocial functioning, sleep disorders, back pain, body shape, and back flexibility. They found that nighttime braces had the least negative effect on these parameters. One of the advantages of nighttime braces is that patients had the opportunity to perform their exercise therapy program during the day (2, 10). In cases where different braces have the same effect, it is recommended to use the brace with the least impact on the quality of life (2). Charleston brace operates using bending forces, but providence brace applies direct force to the scoliotic curves, pushes them to the body's midline and corrects the curve-induced pressure through a three-point system. This can reduce the risk of progression of secondary curves, which is a concern in bending braces (11). The three-point system can also help control double curves and allow the treatment of curves with an apex of T6 and below without the use of the cervical segment; however, the problem involved in using Charleston braces included lack of secondary curve management, lower in-brace correction and it usually treat single curves, but providence brace corrects better double curves (12). Therefore, the aim of the present review study was to investigate the effect of Providence nighttime brace on the correction of scoliosis in people with idiopathic scoliosis. The providence brace is a custom-made brace where correctional force is directly applied into the scoliotic curves by an acrylic frame. Plastering is performed while applying the correctional forces and is made of polypropylene plastic (10).

Method

The search strategy was carried out in PubMed, Science Direct, and ISI Web of Knowledge databases using Population, Intervention, Comparison, and Outcome (PICO) method and keywords of Scoliosis, Adolescent idiopathic scoliosis, Cobb angle, Nighttime brace, Providence brace, and Orthoses. Also, relevant articles published during 2000 to December 2019 were identified using OR, AND, and NOT keywords. Finally, the articles in which introduced providence brace as the treatment method were selected for the evaluation based on the inclusion and exclusion criteria. The scoliosis progression was measured by the Cobb angle in patients who had Cobb angle > 5°.

Inclusion criteria included patients diagnosed with idiopathic scoliosis (2, 10, 11), patients over 10 years of age (2, 6, 9, 10, 13, 14), the primary curve angles of 25 to 40 degrees (6, 9, 10, 13), measurement of the Cobb angle, no other pathological findings such as spondylosis, spondylolisthesis, and congenital disorders (11), skeletal immaturity (Risser sign 2 or lower) (6, 9, 13), and absence of a menstrual cycle or the onset of menstruation less than one year in girls (6, 9).

Exclusion criteria included patients who have previously received braces (6, 13), patients aged under 10 years (6), Risser sign 3 or 4 or skeletal maturity (6), musculoskeletal neurological disorders (6, 13), non-idiopathic scoliosis, and history of spinal surgery (2).

Findings

Finally, 10 articles were selected for final evaluation. The main goal of all studies was to investigate the effect of providence brace on the correction of scoliosis in patients with AIS. All articles showed that providence brace is an appropriate treatment for reducing scoliotic >< 35° (Table 1). Six articles investigated the effect of providence brace on the idiopathic scoliotic curve before and after bracing treatment. Three articles compared the effect of providence brace with full-time

braces on idiopathic scoliosis. Two articles compared providence brace with Boston brace and one article compared providence brace with TLSO. One article also compared providence brace with Charleston nighttime brace.

Studies examining the effect of providence brace on idiopathic scoliosis

Amato *et al.* investigated 102 female patients with idiopathic scoliosis between the years 2006 to 2012. The curve angle was between 20° and 42 °. They used providence braces. The average brace correction was 96% for large curves and 98% for small curves. A total of 74% of patients had curve progression of< 5°. A total of 26% of them had curve progression> 6° (10). Bohl *et al.* (2014) investigated 34 patients using providence brace. The average primary Cobb angle was 27 °and the average in- brace curve correction was 90%. A total of 17 patients had curve progression> 5°and 9 patients had curve progression>45° (15). Sattout *et al.* (2015) provided 18 patients with providence brace. Providence brace could provide an average in-brace correction of 65% and 70% in the thoracic and the lumbar regions, respectively. The bending forces exerted by the braces create pressure on the growth plates, which can reduce the asymmetrical growth of the spine. Supine position also led to 45% and 48% curve correction in the thoracic and lumbar regions, respectively (2). Beuschau *et al.* (2014) investigated 55 scoliosis patients with Cobb angle of 31° using providence brace. The results showed an appropriate management of curve and acceptable failure rate. They found that Providence brace is the best alternative to standard protective therapies (16). Quisth *et al.* (2015) investigated 62 patients with an average Cobb angle of 31.3° using providence brace. The post-intervention Cobb angle was 29.1° and the average in-brace correction was 81% (17). Simony *et al.* (2019) carried out a study on 80 patients with providence brace. The in-brace correction was 82%, which is an important factor in part-time braces, and these braces lead to at least 70% curve correction (18).

Studies comparing the effects of providence brace with other braces

Yrjonen *et al.* (2005) compared the effect of providence brace with Boston brace on idiopathic scoliosis. In this study, 72 women received braces with a Cobb angle of 28.42°. Curve correction was achieved in 92% of those who used providence braces; however, curve progression> 5° was achieved in 27% of patients. Providence braces are mainly recommended for curves< 35 ° in the lumbar and thoracic-lumbar regions (11). Janicki *et al.* (2007) prescribed providence brace and TLSO for patients with idiopathic scoliosis. In the providence group, curve progression was not observed in 31% of cases. Curve progression>6° degrees was seen in 69% of cases. Better results were obtained when the primary curve was between 25-35 ° upon the use of braces (9). Wessberg *et al.* (2009) investigated providence brace and Boston brace in 66 female patients with a curve angle of 20 to 40°. The providence brace was effective for thoracic and lumbar curves (≈40°) with apex at T7. The success rate of providence brace was 77% and comparable to Boston full-time brace (19). Paruch *et al.* (2009) compared providence brace and Charleston brace in 52 patients with an average curve angle of 27°. The average curve correction was 59% for providence brace, which was acceptable (20).

Discussion

The use of full-time spinal braces for 23 hours a day is recommended for the treatment of idiopathic scoliosis, especially for people with curve angle 20-45 ° and 0-2 Risser sign. These braces are prescribed according to parameters such as patient's age, curve degree, and curve type and position (21). Studies of Boston braces and other thoracolumbosacral orthoses have reported appropriate control of curve after using braces, but skin problems, psychological issues, and the patient's feeling of being imprisoned inside the brace during the day have also been reported (18). Some patients also prefer to wear their braces part-time or over nighttime to face less limitation while performing their daily activities (21). The impact of braces on quality of life, participation in social and school activities, and discomfort when wearing braces in the pelvis and armpits are the main problems associated with braces, which are less common in part-time or nighttime braces (22). These problems and other reasons led to the prescription of nighttime braces. There are studies focusing on nighttime braces. Among the nocturnal braces mentioned in the previous studies, providence brace was more effective in preventing surgery in curves less than 35° (20). Providence brace applies lateral and rotational forces directly into the spine and directs it toward the midline of the body (10, 18). The curve correction in this brace is obtained by combining the supine position with the brace pads. Also, the mechanical load exerted on the spine decreases at night and the highest rate of vertebral growth occurs at nighttime. These factors improve deformity at nighttime (2, 18).

Out of the studies reviewed, six articles investigated the effect of providence brace on the correction of scoliotic curves

before and after bracing treatment. All of these articles have referred to the positive effect of this brace. The results supported the role of providence brace in the prevention of curve progression in curves less than 35 ° (2,10, 18, 17,16,15). In Bohl's study, the curve progression was higher than other studies, but the effect of providence brace was still confirmed (15). The difference in the success rates reported in the previous studies may be due to differences in the curve type and position (21). Simony *et al.* reported in-brace correction of 82%, which is comparable to the results of studies by Amato *et al.* (10) and Yrjonen *et al.* (11). Simony *et al.* concluded that providence brace is effective in correcting curves with apex at T7 and below it with a range of Cobb angle 20 to 40 ° (18). Two studies compared providence brace with Boston brace. Yrjonen *et al.* reported that results of providence brace were comparable to Boston brace, and providence brace did not increase the risk of progression of secondary curves. Providence brace yielded a better primary correction in-brace correction than Boston brace (11). Wessberg *et al.* also found that providence brace is suitable for curves with apex at T7 and below up to a Cobb angle of 40°, and its success rate was comparable to Boston brace (19). Janicki *et al.* compared providence brace with TLSO. They showed that providence brace had a greater effect on preventing surgery and progression of curves between 25-35° than TLSO (9). Paruch *et al.* also compared providence brace and Charleston brace and found that providence brace was more effective in preventing surgery in curves< 35°. Providence brace performs better result in correcting smaller curves, but Charleston brace yields more correction percentage for larger curves (20).

Based on the studies mentioned in the results section, it can be concluded that providence brace is an effective treatment that affects the scoliosis progression. However, it should be noted that this brace is more effective on thoracic -lumbar curves with lower apexes and should not be used for curves with higher apexes and curves> 35° (21). According to studies, the success rate of the providence brace in controlling the progression of curves< 35° is comparable to the Boston brace; therefore, part-time braces can be a good alternative to full-time braces for management of curves< 35° (11, 19). In fact, Boston braces are more commonly prescribed for curves between 36-45°, and providence braces are more effective for curves< 35° (9).

There were few studies examining providence brace. Also, studies usually had small sample sizes. Therefore, we could not draw a more precise conclusion regarding the effect of providence brace on scoliosis curve. It is recommended to perform further studies on providence brace and other nocturnal braces to determine the exact effect of this brace and to achieve better results on the success rate of nocturnal braces. Studies with larger sample size and longer follow-up time are also recommended.

Conclusion

Providence nighttime braces are more recommended for lumbar and thoracic-lumbar curves< 35°. Since there were few articles on providence brace, it cannot be concluded that nighttime braces are a definitive alternative to full-time braces; however it seems that nighttime braces can be used to control the progression of scoliotic curves.

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