The effectiveness of orthosis as a treatment for adolescent idiopathic scoliosis

Pan Li Yao [1] Zhang Chen Chao [1]

[1] University of Ottawa, Ottawa, Ontario

Abstract Orthosis is a non-invasive method of treatment for patients with scoliosis, in which prescribed individuals undergo correction of spinal misalignment with the support of a brace. For Adolescent Idiopathic Scoliosis (AIS) specifically, which occurs in youth during critical stages of bone development, it is essential to improve the spine's condition as much as possible before the body fully matures. Although orthosis does not aim to correct the misalignment, it has been proven that bracing will aid in slowing down the progression of deformity. However, a common concern is that the spinal curve will regress back to its original state upon removal of the brace at the end of the treatment period. The aim of this paper therefore is to determine the capabilities of orthosis as a standalone intervention for patients with AIS. A systematic review was performed by consulting the search engines of PubMed Google Scholar and JSTOR, as well as the databases of Medline and OVID. Clinical studies were limited to cohort trials published within the last twenty years which targeted populations of youth to determine the Cobb angle's rate of progression, regression, and spinal curvature of these patients. When comparing orthosis treatment conditions to the absence of intervention in both short-term and long-term cases, it was evident that there are benefits to the corrective forces applied by the brace that outweigh potential drawbacks. Thus, orthosis has been found to significantly decrease the Cobb angle, making it an effective tool for spinal correction.

INTRODUCTION

Characterized as a deformity that causes the vertebrae to rotate and create an irregular curve, scoliosis is a condition in which the body has a spinal angulation of ten degrees or more (Alman and Janicki, 2007). The difference in distance from healthy spinal alignment is measured using the Cobb angle, which determines the severity of scoliosis. This is done by drawing lines from the upper and lower vertebrae of the curve, extending those lines, and measuring the angle at which they intersect (Alman and Janicki, 2007). Deviation from the normal curvature of the spine along the sagittal plane can result in an elongated "S" or "C" shaped curve (Alman and Janicki, 2007). Physical manifestation of the condition includes uneven shoulders and waist, with more prominent ribs, and often with one hip higher than the other (Alman and Janicki, 2007).

The causes of scoliosis can be categorized into three main categories: congenital, neuromuscular, and idiopathic (de Baat et al., 2012). Congenital scoliosis occurs when the condition presents in infants at birth, which is likely inherited from the parents (de Baat et al., 2012). Neuromuscular scoliosis results as a side effect of other conditions such as cerebral palsy or paralysis (de Baat et al., 2012). In most cases, however, the cause of scoliosis is unknown and is thus labelled as idiopathic (de Baat et al., 2012).

One of the most frequent presentations of spinal deformity is Adolescent Idiopathic Scoliosis (AIS), found in patients between the ages of ten and eighteen, with the majority of cases being female (Choudhry et al., 2016). Diagnosis of the condition typically occurs before the onset of menstruation and progresses during puberty. The severity of the condition is determined based on the type of scoliosis, the magnitude of the curve, and the number of years of growth remaining for skeletal bones to fully develop (Choudhry et al., 2016). Although the symptoms of AIS are fairly mild, it is common for patients to experience some level of back pain, and in

Published online
19 May 2021

Citation
Pan, L.Y. & Zhang, C.C. (2021), The effectiveness of orthosis as a treatment for adolescent idiopathic scoliosis, *CJUR* 6(1), 33-36.

Address correspondence to cjur.ca

more severe cases, further complications related to their internal organs. As such, scoliosis patients should be aware of the treatment options available, which include continuous observation, orthosis, and surgery.

One of the few non-surgical treatments for scoliosis is orthosis, which is correcting disorders related to the misaligned limbs or spine with the use of a brace. This treatment method in the short term provides lower back support and prevents further worsening of the spinal deformity (Grivas and Tsiligiannis, 2012). In general, the aim is to prevent the spine from passing fifty degrees of curvature, and from various clinical studies it has been shown the usage of bracing can halt this progression (Grivas and Tsiligiannis, 2012). However, the efficiency of orthosis treatment can still be controversial as some physicians question the ability of bracing to truly alter the natural course of spinal deformity (Grivas and Tsiligiannis, 2012). The main concern is the possibility of the spine returning to its original state after the treatment period due to a lack of specifically targeted interventions. In this systematic review, an analysis was conducted on the varying treatment strategies using orthosis to determine the effectiveness of braces in both short-term and long-term periods.

METHODS

Clinical and longitudinal studies were analyzed in order to determine the overall effectiveness of orthosis for individuals with AIS. A follow-up period must be included within the study to observe any changes over time. This review was performed on November 21, 2019 by compiling information from various search engines including PubMed, the University of Ottawa library database, and Google Scholar. The final screening consisted of results from the databases Medline, OVID, and JSTOR. Different combinations of keywords (scoliosis, brace, treatment, Cobb angle, progression rate, correction), were incorporated in the electronic search strings. To limit the number of articles obtained, only those that were published within the last twenty years were used.

A total of two hundred fifty-six articles were found on Medline, OVID, and JSTOR with the required search criteria. These were then filtered by the type of study to include cohort studies as the primary design. Of the results available, a screen was conducted based on the title of the articles, followed by a secondary screen based on the abstract provided and whether the full articles were easily accessible. The final screen was performed after reviewing the entirety of the texts, narrowing down the options to five articles that will be referenced in this review.

ANALYSIS

When left untreated, the condition of scoliosis will worsen over time because of the compressive forces of the vertebrae. Intervertebral discs have properties that allow them to resist any one-sided compression force by enlarging the opposite side, resulting in an asymmetrical spine due to the imbalance between the spaces of the discs (Stokes et al., 2011). With the assistance of orthosis however, opposing forces to counteract the stress experienced by the vertebrae will be applied. This theory is the basis for orthosis; the usage of a brace will counteract the compressive forces and prevent progression of the Cobb angle.

In practice, orthosis has been shown to be effective in treating AIS in the short-term. A study conducted on adolescents aged ten years or older with a Cobb angle of twenty-five to forty degrees concluded that the average brace correction rate was 48% (Kuroki, 2018). During this study period, participants were expected to wear the brace for eighteen hours every day and the best outcomes were recorded by those who had their brace on for twenty hours or more (Kuroki, 2018). This confirmed that longer use of orthosis in daily life was more beneficial and had better immediate results. Furthermore, skeletally immature patients who were still developing and thus had more malleable bones experienced a significant decrease in the progression of their scoliosis (Kuroki, 2018). In total, there were six cases where the spinal curve improved and fifteen participants with Cobb angles that remained unchanged—an overall positive conclusion (Kuroki, 2018).

During long-term treatment plans, the issue occurs when the brace is eventually removed, as AIS patients typically only follow orthosis prescriptions until the age of eighteen. It has been recorded that the use of braces in adolescent years does not necessarily provide benefits to an existing case of scoliosis; the condition will continue to worsen once the patient no longer has any external support for their spine (Kotwicki and Cheneau, 2008). However, despite the fact that the Cobb angle may further increase over time, the short-term benefits can still be considered worthwhile for many.

Compared to AIS patients who do not undergo any kind of treatment, the spinal curves of treated patients increase three degrees every year before the age of twenty, and one degree after the age of twenty (Aulisa et al., 2017). Those who experienced further deterioration of their spine and those who had no changes to their condition were only a small percentage of patients. A ten-year follow-up to one study revealed that the average deterioration of spinal curvature between participants was only three degrees (Aulisa et al., 2017). This is significantly lower than the regular rate of decline, suggesting that the use of a brace was overall beneficial. After another five years, fifteen years post the initial date of the treatment, patients' curves did not regress past their original Cobb angles of thirty degrees or more (Aulisa et al., 2017).

The reduced deterioration of spinal curvature in AIS patients who experience scoliosis as they grow through puberty and into adulthood can be accredited to the fact that orthosis treatment is especially effective during the critical period of bone development. By wearing a brace to push against the thoracic and lumbar regions of the spine in the opposite direction of the curve, the pressure applied on the body will balance the forces and aid in stabilizing the spine's misalignment (Cheneau and Kotwiki, 2008). There are two mechanisms that work in combination to properly adjust the acting forces on the spine: the passive and active mechanisms.

The passive mechanism involves pushing perpendicularly on the body's surface against the highest point of convexity, allowing maximum pressure to be directed at the most deformed region of the spine (Cheneau and Kotwiki, 2008). This action of displacing body tissues from the convex to concave parts of the torso is known as tissue transfer, where pushing forces specifically affect the surrounding sections of the thoracic apex including the spinal vertebrae (Cheneau and Kotwiki, 2008). Pressure can also be applied through trunk distraction forces, known as the cherry stone effect, which counteracts the force of gravity in order to elongate the body and straighten the spine (Cheneau and Kotwiki, 2008).

In contrast, the active mechanism consists of forces that are produced from within the body, such as muscle contractions, vertebral growth, and various pressures affecting posture (Cheneau and Kotwiki, 2008). Vertebral growth is an especially important factor for those with AIS as treatment options for this condition depend on improved development of the spine. The critical period for adolescents is during a growth spurt when vertebral remodelling takes place. With continuous spinal reloading, the breakdown of the asymmetric vertebrae is done by osteoclasts, cells that function to break down bone tissue in the process of maintenance and repair (Cheneau and Kotwiki, 2008). Meanwhile, osteoblasts are responsible for synthesizing collagen for the matrix of bone formation and serve to modify the shape of the vertebrae, allowing for the buildup of stronger bones (Cheneau and Kotwiki, 2008). There is also an anti-gravitational effect involved, using the postural control system which shifts one's axis of balance (Cheneau and Kotwiki, 2008) allowing for the locomotor system to regain equilibrium and maintain an upright posture. The active mechanism will help to apply the necessary forces onto patients' bodies and manipulate the balance of the spine (Cheneau and Kotwiki, 2008). This results in successful corrective properties on the spinal misalignment of AIS patients through the use of orthosis.

DISCUSSION

As shown from the clinical studies conducted, the overall effectiveness of orthosis is still a concern amongst many scientists despite having some success in treating scoliosis. Once vertebrae have reached full maturity, the goal is to make the spine strong enough to stand alone without any support from braces. In clinical practice, however, it is still common to see the Cobb angle continuing to increase over time. This regression, although present, ultimately does not take away from the benefits of orthosis overall.

Positive results of long-term studies indicate that patients who wear braces had an increase of spinal angulation by three degrees over ten years (Aulisa et al., 2017). In comparison, individuals without treatment experienced the same change in Cobb angle in only a single year (Aulisa et al., 2018). Thus, the application of orthosis has allowed spinal deformity to degrade ten times slower than its natural rate of development (Aulisa et al., 2017).Therefore, orthosis may be effective both during treatment and over long periods of time, although it is important to remember that these numbers are only an average, and individual outcomes varied greatly.

Overall, there are three possible outcomes of scoliosis treatment: an increase in spinal curvature, a decrease in spinal curvature, and no change in Cobb angle. A major factor determining which category a patient falls under is the lifestyle choices they make over the years (Berdishevsky, 2016). It is often recommended that physiotherapy should be incorporated into the treatment plan and those who attend weekly sessions with exercises specifically for managing scoliosis are likely to notice more improvement in the end (Berdishevsky, 2016). It is also important for patients to be mindful of their body as incorrect posture and excess loading pressure in their daily lives can cause their scoliosis to worsen and speed up the rate at which the condition progresses.

The majority of studies state that the best results of improving spinal curvature through the use of orthosis were obtained by individuals who wore their brace for twenty hours or more every day during the trial period. However, researchers usually do not take into consideration or mention in their reports the patient's compliance toward wearing a brace daily for multiple months. Over time, patients might not keep the brace on for the required amount of time due to lifestyle complications or general discomfort (Weinstein, 2013). Despite orthosis being tailored to each individual, it should be expected that there will always be a level of unease as pressure has to be applied onto the spine in order for the brace to be effective in correcting the misalignment (Weinstein, 2013). Physical alterations such as pressure sores and skin colour changes may occur as well due to friction caused by movements (Weinstein, 2013). All of these physical stressors, combined with psychological factors that could affect the patient's perceived image, will influence how often they wear the brace and should be accounted for when determining the effectiveness of orthosis. For this reason, modern braces are built with consideration of the patient's comfortability in mind, using less rigid materials such as lightweight plastic rather than metal like they did in the past (Fayssoux et al., 2010). With the flexibility of plastic, it allows for partial movement to accommodate for growing adolescent bodies, as well as the development of new and varying orthotic models that encourage patient compliance.

Strain in other areas of the patient's life, such as personal routines and physiotherapy needs specific to each individual, would also impact the outcome of orthosis (Weinstein, 2013). Future prospects to consider should focus on how lifestyle factors influence the effectiveness of the braces and how they can be used to explain the variability of the results obtained. Over time, patients may become less diligent in wearing their brace due to a multitude of reasons and examining this will explain the reasons why some people experience a positive change to their spinal curvature while others remained unchanged. Treatment plans can then be adjusted to give patients a better chance at improving their Cobb angle based on their own circumstances.

CONCLUSION

The use of orthosis yields a positive result in both short-term and long-term treatments, effectively reducing the progression of the Cobb angle in the majority of cases. In this regard, the use of orthosis has demonstrated to be effective in correcting the deformed vertebrae for those suffering from scoliosis, slowing the rate of deterioration of AIS in many patients compared to those without treatment. The active and passive mechanisms of orthosis oppose the compression forces of the vertebrae; this procedure is found to be most beneficial to the youth population as their bones have not yet fully developed, allowing the spine to better adjust to the brace for improved support. Despite this, the process of spinal correction through orthosis is not instantaneous and will require long-term commitment before significant results can be achieved.

This paper was derived from an assignment completed for a course taught by* Dr François Beaulieu, *University of Ottawa.

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