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Clinical Studies

Comparative analysis of Boston and Cheneau braces in treating scoliosis: A 2-year follow-up study on curve reduction

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ABSTRACT

Background: Scoliosis, characterized by the lateral curvature of the spine, impacts the spine's alignment in three dimensions. Braces are commonly employed as a conservative treatment for individuals with scoliosis, particularly those with curves ranging from 20° to 40°. This treatment approach's primary objectives include arresting the deformity's progression, enhancing clinical appearance, alleviating pain, improving overall quality of life, and circumventing the need for surgical intervention. The aim of this study was to compare the effectiveness of Boston and Cheneau braces in individuals with scoliosis.

Methods: In this retrospective study, 51 subjects were included and monitored over 2 years. The primary parameters under evaluation encompassed the severity of both primary and secondary curves and compliance with the prescribed treatment. The subjects were classified into 2 groups: those utilizing the Cheneau brace and those employing the Boston brace.

Results: The initial mean values of the primary and secondary curves during the first visit were 37.6 (±7.4) and 30.1 (±9.7) degrees, respectively. However, the in-brace curve measurements for the primary and secondary curves were 31.5 (±1.3) and 22.3 (±13.3) degrees, respectively (p-value=.0). The mean compliance values of subjects using Boston and Cheneau braces were 16.8 and 17.3 h per day, respectively (p-value=.1). No significant difference was observed in the correction achieved with the Boston and Cheneau braces during the follow-up period.

Conclusions: The results of this study demonstrated a significant reduction in the scoliotic curve while under brace conditions. However, the degree of correction achieved did not significantly differ during the follow-up periods. Additionally, there was no notable variance in the correction obtained between the Boston and Cheneau braces.

Introduction

The term 'scoliosis' finds its root in the ancient Greek word 'Skolios', signifying 'curved'. Predominantly characterized by the lateral curvature of the spine, it influences the spine's alignment across three planes. Scoliosis is classified into structural and nonstructural (postural) categories. Structural scoliosis further delineates into idiopathic (cause unknown) and nonidiopathic (cause known) categories [1,2]. Depending on individuals' age, idiopathic scoliosis is stratified as infant (0–3 years), juvenile (4–10 years), and adolescent (11–18 years) [3,4].

Various therapeutic modalities have been employed to address idiopathic scoliosis to arrest the progression of the spinal curve [5,6]. These approaches encompass both conservative treatments and surgical interventions. Bracing stands out prominently among the conservative methods recommended for scoliosis patients [6,7]. Numerous braces, including but not limited to Milwaukee, Boston, Cheneau, Rigo Cheneau, Gensingen, ART, Wilmington, Sforzesco, Providence, Sibilia, Progressive Action Short Brace, Lyon, Lapadula, Spinalitia, Rosenberger, Mimami, Triac, SpineCor, Charleston, and Progressive Action Brace, have been specially designed and utilized in the treatment of scoliosis patients [5,7]. Existing literature posits that specific braces, like the Milwaukee and Boston braces, exhibit efficacy in retarding the progression of the scoliotic curve. However, their impact on curve correction may exhibit limitations [8]. The effectiveness of these braces is subject to

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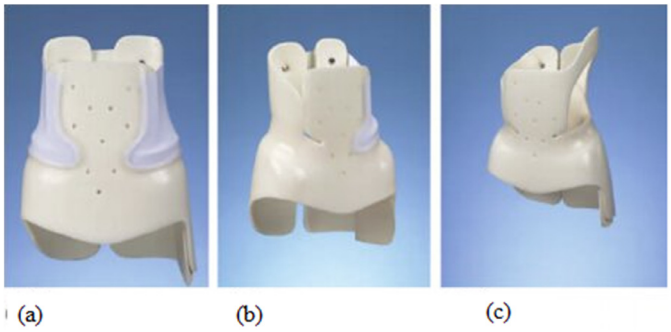

Fig. 1. Lumbar (A), thoracolumbar (B) and thoracic (C) Boston brace [15].

variables like the curve's severity and the patient's age. Substantial evidence supports the effectiveness of braces, such as the Milwaukee and Boston braces in the management of scoliotic curves [8,9].

Patients exhibiting spinal curves falling within the range of 20°–40° typically undergo bracing as the primary method of treatment. In cases where the curvature is within the 20°–30° range, the decision to implement bracing is contingent upon observing a 5-degree progression between consecutive visits [10]. The Cheneau brace is one of the recommended orthotic interventions for scoliosis patients due to its capacity to effect 3-dimensional correction. It is achieved by applying targeted pressure through multiple zones [10].

Conservative treatment for scoliosis is guided by multifaceted objectives, including addressing the deformity, impeding or partially rectifying the progression, enhancing clinical appearance, mitigating pain, improving the overall quality of life, and circumventing the necessity for surgery. Despite the heightened prevalence of low back pain in individuals with idiopathic scoliosis, the magnitude of the scoliotic curve does not inherently correlate with the severity of low back pain. Notably, lumbar and thoracolumbar curves carry an increased propensity for inducing low back pain [11]. Nevertheless, applying braces appears to mitigate the severity of pain within this subgroup of patients [11].

The quality of life in adolescents grappling with idiopathic scoliosis is subject to many influencing factors, including the extent of the scoliotic curve, the chosen treatment modality, and social determinants. Notably, bracing positively influences the quality of life, contributing to its enhancement [12–14]. Figures 1 and 2 show different styles of Boston brace and Cheneau braces, respectively.

Indications from existing literature suggest variations in the effectiveness of braces in controlling the progression of scoliotic curves, with some, such as the Boston and Cheneau braces, demonstrating heightened efficacy compared to other available options [8,17,18]. For instance, a study conducted by Kaelin et al. revealed that treatment with the Boston Brace System resulted in 49% of curves remaining unchanged (within ±5°), with 39% of scoliotic curves experiencing a permanent correction ranging from 5° to 15° [19]. Similarly, research conducted by Zaborowska-Sapeta et al. found that the Chêneau brace improved the condition in 24.7% of subjects, while the curve remained stable in 22.2% [10]. Notably, a singular study conducted by Minsk et al. [20]. directly compared the efficiency of Boston and Cheneau braces. This study did not reveal any significant differences between the 2 braces. However, the existing body of literature lacks sufficient evidence concerning the overall efficiency of these braces. Consequently, the primary objective of this study was to ascertain the effectiveness of Boston and Cheneau braces, with a specific emphasis on comparing the efficiency of the 2. This investigation's central hypothesis posited that the Cheneau brace would manifest superior effectiveness to the Boston brace.

Materials and methods

This retrospective study involved the examination of medical records pertaining to scoliotic subjects referred to an orthopedic clinic in XXX.

Fig. 2. Cheneau brace [16].

A total of 51 subjects met the inclusion criteria for participation, which were delineated as follows:

1. Diagnosis of idiopathic scoliosis.
2. Age ranging from 8 to 15 years.
3. Scoliotic curve size within the range of 25° to 45°.
4. Riser sign value between 0 and 2.
5. Treated by braces (Boston and Cheneau braces).
6. Subjects underwent follow-up for a minimum of 2 years after initiating brace treatment.
7. The absence of any other musculoskeletal disorders.

The primary parameters assessed in this study included the severity of the scoliotic curve (both primary and secondary curves) and the level of compliance as reported by the patients. The severity of the scoliotic curve was evaluated using the Cobb angle measurement. As reported by the patients, compliance with brace usage was determined by the number of hours the brace was worn daily. The subjects were regularly monitored at 6-month intervals, during which the same parameters were documented and recorded for analysis.

The difference between the Cobb angles of the in-brace condition and the first visit was evaluated using a paired T-test (SPSS 21.0, Statistical Package for Social Science, Chicago). Additionally, paired T-tests were employed to examine the differences between the Cobb angles for the primary and secondary curves in the in-brace condition at various points during the follow-up visits. A 2-sample T-test was applied to assess the variations in curve correction between the primary and secondary curves achieved with Boston and Cheneau braces. It's worth noting that the normal distribution of the parameters was confirmed using the Shapiro-Wilk test. The results are presented as means along with a 95% confidence interval (CI), and it should be emphasized that the

Table 1
The characteristics of the subjects recruited in this study.

Parameters	Brace type	
	Boston	Cheneau
Number of patients (Girl/boy)	29(23/6)	22(20/2)
Age	12.3	11.9
Follow up duration (month)	28	24
Primary curve type (thoracic/lumbar)	27/2	21/2
Compliance (h per d)	16.8	17.3

Table 2
The mean values of primary and secondary curves in various follow up periods. All comparison were done based on the magnitude of the curves in the first visit.

	Primary curve		Secondary curve	
	Curve magnitude	p-value	Curve magnitude	p-value
First visit	37.6(±7.9)		30.1(±9.7)	
First follow	31.5(±10.2)	.0	22.9(±13.3)	.0
Second follow	30.2(±10.6)	.01	22.5(±13.1)	.01
Third follow	30.2(±10.7)	.00	22.3(±13.7)	.01
Fourth follow	30.1(±11.6)	.00	20.7(±11.9)	.02
Fifth follow	25.2(±11.7)	.04	14.4(±9.3)	.03

Cobb angle measurements at different visits were taken in the in-brace condition.

Results

Table 1 presents the characteristics of the subjects included in this study. The mean values of the primary and secondary curves during the initial visit were 37.6 (±7.4) and 30.1 (±9.7) degrees, respectively (both measured in out-of-brace conditions). In contrast, the in-brace measurements for the primary and secondary curves were 31.5 (±1.3) and 22.9 (±13.3) degrees, respectively, with a significant p-value of 0.0. The mean compliance levels for subjects using Boston and Cheneau braces were 16.8 and 17.3 hours per day, respectively, with a p-value of .1.

Table 2 shows that the difference between the mean values of the primary and secondary in-brace curves during different visits and the initial visit was significant (p-value<.05). Although there was a significant difference in curve correction compared to the initial visit, the differences between the curves in subsequent visits were insignificant (p-value<.05).

Table 3 summarizes the correction results achieved for the scoliotic curves using Boston and Cheneau braces. As indicated in the table, the primary scoliotic curve decreased by 19.5% with the Boston brace compared to 15.5% with the Cheneau brace (the difference was insignificant). The mean correction achieved with Boston and Cheneau braces during the fifth follow-up period was 33.6% and 30.3% for the primary curve, respectively (both in-brace conditions). There was no significant difference in the correction achieved with Boston and Cheneau braces during the follow-up period.

Discussion

Scoliotic deformity should be controlled to improve the quality of life, reduce pain in affected individuals, and avoid surgery [5]. Various soft and rigid braces have been used to slow the progression of scoliotic curves [4]. Despite numerous studies on the effectiveness of different braces in controlling scoliosis, whether bracing can effectively slow curve progression remains a topic of debate. This study aimed to compare the effectiveness of the 2 most commonly used braces, Boston and Cheneau, over a period of time.

The results of this study indicated a significant decrease in both primary and secondary scoliotic curves during the initial visit (p-value=.0). However, the severity of the curves, as measured by the Cobb angle, did not change significantly during subsequent follow-up periods. Significant improvement was observed in the correction achieved with different designs of braces (Boston and Cheneau) during the initial follow-up period. Notably, the correction achieved in the initial follow-up period was not significantly different from that in the first visit for both primary and secondary curves.

The static structure of the braces may be a key reason for this observation. Braces like Boston and Cheneau have a rigid and static design that exerts corrective forces on the scoliotic curves [6,8,17]. They lack an active component, and the corrective force application point remains constant. The applied force must act at the curve's apex to achieve maximum efficiency in correcting scoliotic curves [21]. However, as the structure of these braces is rigid, the curve's apex may shift upward, and the point of force application may end below the apex after some time.

The limited effectiveness of static and passive braces in correcting scoliotic curves can be attributed to their inherent characteristics [22]. These braces lack the adaptability needed to respond to variations in curve correction that may occur over different follow-up periods. Their static nature implies a fixed structure that does not dynamically adjust to the evolving needs of the patient's spinal alignment [23]. This lack of adaptability might result in suboptimal correction outcomes, as scoliotic curves can change in magnitude and configuration during treatment. Therefore, these braces' rigidity and unyielding nature may hinder their ability to provide continuous and personalized support, potentially limiting their efficacy in achieving optimal scoliosis correction [22]. Consideration of more dynamic and adaptable brace designs could address these shortcomings and enhance the overall effectiveness of scoliosis treatment strategies. An innovative design with the concept of active and adjustable loads could potentially improve the effectiveness of scoliosis braces in correcting these curves. The new design should also be based on the concept that the configuration of the spine differs from an erect standing to a lying position. Therefore, the location and the force of the pads should be changeable to guarantee the efficiency of the brace.

The second question posed in this study was whether there is a difference in the performance of Boston and Cheneau braces. As shown in Table 3, the results indicated no significant difference between the corrections achieved with both braces during various follow-up periods. However, it does appear that the correction achieved with the Boston brace (for both primary and secondary curves) was slightly better than that achieved with the Cheneau braces.

It's important to note that the corrections achieved with both braces during the follow-up periods remained nearly the same as in the initial visit. This issue could be attributed to the passive mechanisms in the design of both braces, where the brace's structure exerts a force on the scoliotic curve. Moreover, the passive design of these braces may not effectively address the intricate biomechanical nuances associated with scoliosis. The condition involves 3-dimensional deformities that can change over time, making a rigid, one-size-fits-all approach less conducive to achieving optimal correction [22]. The inability of the brace's structure to adapt in real-time to the varying dynamics of the scoliotic curve may contribute to its limited efficacy.

Only one study in the literature directly compared the efficiency of the Boston brace with another brace (RIGO brace). According to the study conducted by Minsk et al., the mean initial in-brace curves were 22.6%±6.4% and 22.6%±7.2% in the RIGO and TLSO (Boston) groups, respectively. There was no significant difference in the corrections achieved by both braces. However, the authors concluded that the efficiency of the RIGO brace was slightly better than that of the Boston brace. They attributed this to the 3-dimensional corrective forces, lighter weight, and open structure of the RIGO brace compared to the Boston brace [24].

In conclusion, the results of the current study suggest that braces can effectively decrease scoliotic curves during the initial visit. However, the correction achieved with the braces does not change significantly in

Table 3
The percentage of the correction achieved with Boston and Cheneau braces in various follow up period.

	Boston		Cheneau		p-value
	Primary curve correction (%)	Secondary curve correction (%)	Primary curve correction (%)	Secondary curve correction (%)	
First follow	19.4	28.2	15.5	19.6	.08
Second follow	19.9	28.5	18.7	25.1	.2
Third follow	21.0	25.7	20.9	22.4	.3
Fourth follow	38.7	33.4	24.3	25.8	.1
Fifth follow	33.6	30.3	25.6	32.2	.2

follow-up periods. This lack of change in correction may be attributed to the passive structure of the braces [23]. As a result, introducing a new concept, such as using dynamic pads in the structure of the braces, may enhance their performance in correcting scoliotic curves.

Based on the review conducted by Karimi et al., the effectiveness of the Cheneau brace is primarily attributed to its ability to control the rotation associated with scoliosis [11]. However, the most accurate method to measure rotation in scoliosis deformity is through the use of CT scan images. Unfortunately, it would be unethical to obtain CT scan images from scoliotic subjects with curves less than 45°, as these images are typically reserved for surgical purposes. Since we did not have access to CT scan images of the subjects, it was impossible to determine the effects of the braces on rotation.

It's important to acknowledge some limitations associated with this study. The primary limitation is that it was a retrospective study. To further explore the performance of braces, it is recommended to conduct prospective studies with longer-term follow-up and larger cohorts of patients.

Conclusion

The results of this study indicate that both Boston and Cheneau braces effectively and significantly reduced scoliotic curves. However, the degree of correction did not exhibit significant differences in various follow-up periods. Importantly, there was no significant distinction in the level of correction achieved between Boston and Cheneau braces.

Ethical approval

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Declaration of competing interest

The authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or nonfinancial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

CRediT authorship contribution statement

Mohammad Karimi: Conceptualization, Methodology, Writing – original draft. **Azade Nadi:** Data curation, Project administration, Funding acquisition, Writing – review & editing, Methodology, Project administration.

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