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Original Article

Evaluation of changes in kyphosis angle, apex and quality of life of patients with Scheuermann kyphosis using Kyphologic brace

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Abstract: Introduction: Kyphosis treatment aims to prevent curve progression and deformity correction. This study aimed to evaluate the long-term beneficial effects of Kyphologic brace treatments in patients with Scheuermann kyphosis. Methods: This retrospective case series study was performed on patients with Scheuermann kyphosis treated with a Kyphologic brace from 2013-2020. Demographic data, including age, gender, and duration of treatments, were extracted. Mean kyphosis angles before, one month and 1 year after treatments were collected. Patients were followed for at least 18 months after treatments. The location of kyphosis apex was also noted and classified into the following groups: upper thoracic, mid thoracic, lower thoracic, and thoracolumbar. Results: 48 patients with Scheuermann kyphosis enrolled in the present study. The mean age of the patients was 12.95 ± 1.4 years. The average follow-up time in this study was 23.02 ± 11.8 months. The mean kyphosis angle before treatments was 63.66 ± 9.51°, which decreased significantly after one month (to 43.33 ± 8.7°) and after 1 year (to 37.6 ± 9.4°) of treatments with Kyphologic brace compared to before treatments ($P < 0.001$). The most common location of kyphosis apex was in mid-thoracic with 77% frequency. Conclusions: In this study, we showed that using a Kyphologic brace was associated with a significant reduction in kyphosis angle in patients. Our results emphasized the effectiveness of this brace in patients with Scheuermann kyphosis.

Keywords: Scheuermann kyphosis, Kyphologic brace, brace

Introduction

Scheuermann kyphosis is the most common type of pathological kyphosis and is defined by wedging at least three vertebrae at the apex or deformity and endplate irregularities [1, 2]. This type of kyphosis is rigid and commonly seen in males [3, 4].

The prevalence of Scheuermann's disease varies depending on inclusion criteria and has been reported to be between 0.4% and 8% [5]. A large study by Wassman reviewed screening evaluations of more than 580,000 Danish army recruits and estimated the frequency to be between 4% and 5% percent. Scheuermann's disease is rarely diagnosed before age 10 or 11; however, radiographic diagnosis may first be made by age 12 to 13 years [6, 7].

Therapeutic strategies for treating Scheuermann's disease varies based on the severity and flexibility of the curve. Treatment options for Scheuermann's kyphosis are conservative, brace, and surgery [8, 9]. Kyphosis less than 50° without significant progression is managed by observation. Patients with curve progression should be managed by either surgical or brace treatments [3, 10]. The efficacy of bracing in scoliosis and kyphosis is still being questioned. However, it has become established as the most effective non-surgical method of treatment for mild to moderate kyphosis [11, 12]. Surgery is usually the only definitive treatment if the arch is more than 75 degrees or when the patient is mature [13, 14].

It should also be noted that treatment with braces such as Milwaukee is effective only in

Table 1. Demographic characteristics of the participants in the present study

Variable	Mean	SD
Age	12.95	1.4
Gender	Number	Percentage
Female	23	47.9%
Male	25	52.1%

SD: standard deviation.

that patient who is still growing. To date, limited studies have been performed on brace treatments' efficacy and beneficial effects in patients with Scheuermann kyphosis [14, 15]. Although previous studies evaluated the efficacy of brace treatment of Scheuermann's kyphosis with different angles, this study has focused on the effectiveness of brace angles [16, 17].

Here in the present study, we aimed to evaluate the long-term beneficial effects of Kyphologic brace treatments in patients with Scheuermann kyphosis. Current knowledge is that no previous studies have been performed on this issue.

Materials and methods

Study design

This is a retrospective case series study, which was performed in Isfahan, Iran. The current study was conducted on patients with Scheuermann's kyphosis that were treated with a Kyphologic brace from 2013-2020. The study was approved by the Research and Ethics Committee of IRB of Isfahan University of Medical Sciences (Ethics code: IR.MUI.MED.REC.1400.062). This study was performed in 2021 on data of previously treated patients after the study protocol was approved by the Ethics Committee.

Inclusion and exclusion criteria

The inclusion criteria were diagnosis of Scheuermann's kyphosis, referring to clinics affiliated to author's institution for treatments with Kyphologic brace, referring to the clinics from 2013 until 2020, clarity of pre-treatments information in the files, availability of the patient for examination and follow-ups and signing the written informed consent to participate in this study. The exclusion criteria were incomplete data, less than 1.5 years to skeletal maturity, chronological age > 15 years, non-compliance with the brace (less than 16 hours a day) and inadequate follow up (less than one year).

Study population

A total of 48 patients with kyphosis were enrolled in the current study. The demographic characteristics of the patients participating in the study are presented in **Table 1**. As the results of **Table 1** show, the mean age of the patients participating in the present study was 12.95 ± 1.4 years. In addition, 52% of patients were men and 48% were women (**Table 1**).

Data collection

Demographic data, including age, gender, Cobb's angle, location of apex, and duration of treatments, were extracted. Cobb's angle is the most widely used measurement to quantify the magnitude of spinal deformities. This angle was measured by specifying the end and the middle vertebrae of the curve. Cobb suggested that the angle of curvature be measured by drawing lines parallel to the upper border of the upper vertebral body and the lower border of the lowest vertebra of the structural curve, then erecting perpendiculars from these lines to cross each other, the angle between these perpendiculars being the 'angle of curvature'. In this study, we considered Cobb's angle as the kyphosis angle.

Mean kyphosis angles before and one month after treatments were collected from the patient's files. Patients were examined every three months, and anterior-posterior (AP), Lateral standing X-rays were taken. In the present study, we extracted data regarding the kyphosis angle of patients before treatment, at one month after treatment, and at 1 year after treatment. Patients were also followed for at least 18 months after interventions. Because the kyphosis angle does not change significantly after 1-year post-treatments [17], we considered this time as the study endpoint. A single orthotist performed any necessary braces adjustments and visited them every two months. The procedure of brace weaning was also shown to the patients. The brace is shown in **Figure 1**.

Patient's quality of life (QOL)

We also reviewed patients' data regarding QOL assessments before and after brace treat-

Figure 1. The Kyphologic brace that was used in our study.

ments. The QOL was measured using the 36-Item Short Form Survey (SF-36). SF-36 is a set of generic, coherent, and easily administered quality-of-life measures covering eight domains of health [16]. Each scale is directly transformed into a 0-100 scale, assuming that each question carries equal weight. Rand and colleagues first developed this questionnaire. These measures rely upon patient self-reporting and are now widely utilized by managed care organizations and Medicare for routine monitoring and assessment of care outcomes in adult patients. The QOL of patients were measured before the interventions, 1 month after treatments and were compared to 1 year after treatments with brace.

Statistical analysis

The obtained data were entered into the Statistical Package for Social Sciences (SPSS) version 24. Independent t-test, one-way ANOVA and chi-square test were used. *P*-value < 0.05 was considered as a significance threshold.

Results

Duration of treatment and location of kyphosis apex

Table 2 examines the duration of treatment and location of kyphosis apex in patients participating in the present study. According to the results, the average follow-up time of the patients was 23.02 ± 11.8 months. Also, the highest frequency of apex kyphosis was in mid-thoracic with 77% frequency (**Table 2**).

Table 2. Duration of treatment and location of kyphosis apex

Variable	Mean	SD
Duration of treatment	23.02	11.8
Location of apex	Number	Percentage
Upper thoracic	3	6.3%
Mid thoracic	37	77%
Lower thoracic	6	12.5%
thoracolumbar	2	4.2%

SD: standard deviation.

Analysis of kyphosis angle

Table 3 examines and compares the mean kyphosis angle before the treatments, at one month after treatments and at the time of visiting the studied patients using repeated measures analysis test. As the results of the present study show, the mean kyphosis angle decreased significantly at one month after treatments and at the time of visiting compared to before treatments (P < 0.05). These data are summarized in **Table 3** and **Figure 2**.

Patient's QOL and follow-up

By evaluating the patient's documents, it was observed that the mean patient's QOL was 61.20 ± 7.44, which improved to 81.77 ± 6.35 after 1 year of treatments with a Kyphologic brace (P < 0.001). Follow-up of cases showed that only two patients (4.2%) required spinal correction surgeries, and the rest of the cases entirely improved after treatments with a Kyphologic brace. These data are presented in **Table 3**.

Discussion

Here in the present study, we showed that the average duration of treatment in the study patients was 23.02 ± 11.8 months. In addition, the highest frequency of apex kyphosis was in mid-thoracic with 77% frequency. Furthermore, we indicated that the mean kyphosis angle decreased significantly at one month and at 1 year after treatments compared to before treatments. These data show the effectiveness of the Kyphologic brace in

Table 3. Mean kyphosis angle before treatment, at one month after treatment, and at 1 year after treatment

Kyphosis angle	Mean	SD	*P*-Value*
Before the treatments	63.66	9.51	0.001
After 1 month after treatments	43.33	8.7	
After 1 year	37.6	9.4	
Quality of life	Mean	SD	*P*-value*
Before the treatments	61.20	7.44	< 0.001
At 1 month after treatments	75.33	7.11	
At 1 year	81.77	6.35	

*: Using ANOVA test, SD: standard deviation.

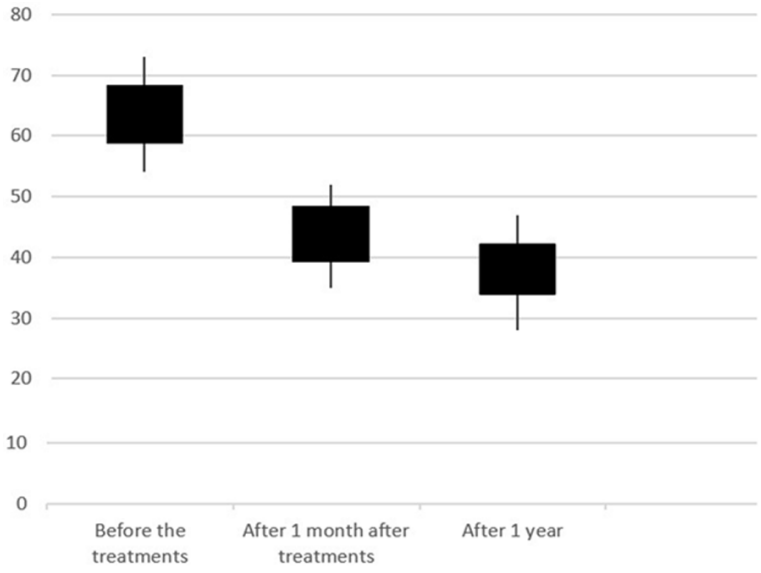

Figure 2. Treatment response of patients to Kyphologic brace.

treating patients with Scheuermann kyphosis after 1 year of follow-up.

The use of braces in patients with Scheuermann kyphosis has been previously investigated. Orthotic treatment of Scheuermann's Kyphosis is indicated for painful and/or mild kyphosis (45° < Thoracic kyphosis° < 65°), while its efficacy in the management of severe kyphosis, greater than 70°, still matters of debate. Different types of brace have been proposed in the management of SK, including Milwaukee brace, plaster brace and antigravity brace. The efficacy of Milwaukee brace in the management of SK relies on very robust data. Nonetheless, patients' compliance is the primary concern of Milwaukee brace treatment, mainly because of the aesthetic and psychological impact of the neck ring [18].

A few studies have evaluated the results of brace usage and their beneficial effects. In 2009, Weiss performed a review study and colleagues in Germany that assessed the use of a Kyphologic brace in 56 adolescents with thoracic Scheuermann kyphosis. Based on their results, the average in-brace correction was 16.5 degrees. They concluded that conservative treatments with Kyphologic brace in patients with Scheuermann kyphosis were generally regarded as a practical treatment approach. It was also stated that physiotherapy and bracing are the first-line treatments for this condition [19, 20].

Another review article by Pizzutillo and others was performed in 2004. They explained that exercising to relieve lower extremity contractures and strengthen the abdominal musculature could also be effective therapeutic strategies associated with braces [21]. The results of our study were in line with these findings. We showed significantly reduced kyphosis degrees after treatments with a Kyphologic brace. Tsirikos and Jain also performed a review study on various therapeutic strategies for Scheuermann kyphosis. It was declared that the use of braces could be beneficial, but it depends on multiple factors such as initial kyphosis angle and the age of patients. They mentioned that long term usage of braces could be associated with a significant decrease in kyphosis angle in younger patients [22].

We should also note that an advantage of this brace compared to other braces is the higher patient compliance with the brace. We observed no significant complaints from patients and all of them had proper compliance. An important point of our study was that we observed significantly improved kyphosis angle

in patients treated with a brace. As mentioned in previous research, both operative and non-operative surgical procedures could have high efficacy in Scheuermann kyphosis but most physicians tend to treat the patients with operative surgeries. It is believed that the development of new non-surgical treatment methods with similar efficacy to surgical procedures could increase the therapeutic results for patients.

Lowe discussed identical results in 2007 in a case study suggesting that orthopedic surgeons should consider other therapeutic options such as braces in patients with kyphosis degrees less than 70° [23]. Bradford and others reviewed 155 patients with Scheuermann's disease in a literature review treated through Milwaukee brace and reported that the average kyphosis decreased from 59° to 39° after 34 months [24]. The current study showed that the mean kyphosis angle decreased from 63.66° to 37.6° after 1 year. These data are consistent with previous findings.

Another review study by Karimi and others supported using a Kyphologic brace on kyphosis curve management. In this review article, the effectiveness of the Kyphologic brace was evaluated. They mentioned that surgical procedures are the best therapeutic option in patients with extreme kyphosis, but conservative management, including a Kyphologic brace, could also bring acceptable results in mild cases. This study also showed that Milwaukee orthosis carries higher efficiency to reduce the kyphosis curve compared to other orthoses [25]. As we showed, the kyphosis curve of patients that used the Kyphologic brace decreased significantly after one month after the brace administration and after 1 year of follow-up.

An important point of the current study was that we collected and analyzed data of patients treated with this brace for the first time in our country. The use of Kyphologic braces is increasing among orthopedic surgeons, and researchers believe that this brace can improve the condition of patients. However, few studies have been done in this field and so far, no study has been done in our country. Furthermore, this study measured the patient's QOL, which showed significant improvement after treatments with a Kyphologic brace. This issue could also have high clinical significance.

Based on the results of our study, the mean kyphosis angle decreased significantly at one month and at 1 year after treatments compared to before treatments. We believe that clinicians and surgeons should consider the usage of this brace more often in patients with eligible conditions. The most important limitations of the current study was a restriction in the study population and limited evaluated factors. This study's main limitation was the lack of a control group. Most of the previous studies have also been conducted on small populations and therefore, more studies on larger populations seem to be required.

In this study, we evaluated only one group of patients and assessed the efficacy of the Kyphologic brace. The results of our study showed that the Kyphologic brace was helpful in the treatments of these patients. The main limitation of this study was the lack of grouping and comparisons with other therapeutic methods, including surgical corrections or different types of braces. The other limitations were restricted study population and conducting this study in a single center. We suggest that further multicentric studies on larger populations should be performed.

Conclusion

Here, we showed that using a Kyphologic brace was associated with a significant reduction in kyphosis angle in patients. Our results emphasized the effectiveness of this brace in patients with Scheuermann kyphosis under the supervision of orthopedic surgeons. These results were consistent with the findings of previous studies; however, more studies on larger populations are necessary.

Disclosure of conflict of interest

None.

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