

## Research Paper

# The Results of Orthotic Treatment in Patients With Hyperkyphosis Using Milwaukee Brace



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## ABSTRACT

**Background:** Nonsurgical treatment of hyperkyphosis can be very challenging. Limited information is available on the outcomes of treating this condition, especially postural hyperkyphosis with the Milwaukee brace.

**Objectives:** The present study aimed to evaluate the outcomes of treating hyperkyphosis (postural and Scheuermann disease) with the Milwaukee brace.

**Methods:** This study involved 54 patients, including 16 with Scheuermann disease, with an average age of  $12.6 \pm 2$  years. Their thoracic kyphosis (TK) and lumbar lordosis (LL) angles were measured before and after treatment using long-spine radiographs. Patients were divided into two groups: Group I had angles less than 70 degrees, while group II had angles greater than 70 degrees. The results of both groups were compared.

**Results:** The TK angle significantly decreased from an average of  $63.4 \pm 8.5$  degrees to  $42.7 \pm 13.4$  degrees, while the LL angle decreased from  $51.9 \pm 7.7$  degrees to  $49.4 \pm 5.5$  degrees ( $P < 0.001$ ). Three patients required fusion surgery due to the ineffectiveness of orthotic treatment. In groups I and II, the mean corrections in TK angle were  $22.6 \pm 7.9$  degrees and  $14.8 \pm 11$  degrees, respectively. The difference between these two groups was statistically significant ( $P = 0.016$ ). The corresponding values for LL were  $2.2 \pm 5.4$  degrees and  $3.6 \pm 3.6$  degrees ( $P = 0.895$ ). There was no significant correlation between changes in TK and LL angles and the patients' age.

**Conclusion:** The use of the Milwaukee brace for orthotic treatment can lead to a significant reduction in TK (either postural or Scheuermann disease). Patients with a kyphosis angle of less than 70 degrees show significantly better outcomes from this treatment compared to those with a kyphosis angle greater than 70 degrees.

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## Introduction

Orthotic treatment with the Milwaukee and Dupont braces has been widely studied in postural and Scheuermann hyperkyphosis [1, 2]. Evidence shows that patient age, initial kyphosis angle, deformity flexibility, and compliance strongly influence outcomes. While bracing generally reduces kyphosis and prevents surgery, partial loss of correction often occurs after discontinuation. Studies consistently highlight that regular and prolonged brace use until skeletal maturity yields the best results, whereas poor compliance or severe deformities may necessitate surgical intervention. Overall, bracing remains an effective and conservative option, particularly for patients with moderate, flexible curves and good adherence [3, 4]. This study evaluated the outcomes of Milwaukee brace treatment in patients with both postural and Scheuermann hyperkyphosis.

## Methods

### Study design

A multicenter before-and-after clinical trial was conducted from 2016 to 2019.

### Study participants

Patients with thoracic hyperkyphosis  $>45$  degrees (Scheuermann or postural type, Risser 1–2) were included. The exclusion criteria were congenital/neuromuscular deformities, atypical Scheuermann, scoliosis requiring surgery, prior brace or spinal surgery, systemic diseases, or kyphosis more than 80 degrees.

### Sampling and sample size

Convenience sampling was used; at least 33 patients per group were required.

### Study procedures

Diagnosis confirmed by clinical exam, x-ray (C1–S1, anteroposterior and lateral), and magnetic resonance imaging. Eligible patients gave informed consent. Custom Milwaukee braces were fabricated and prescribed for up to 16 h/d. Radiographic follow-up was performed at 1 month and every 4 months. Brace treatment continued until apical wedging resolved (Scheuermann) or Risser  $\geq 4$  (postural cases).

## Measurements

TK (T3–T12) and lumbar lordosis (LL) (L1–L5) were assessed using Cobb's method. Inter- and intra-observer reliability was more than 0.8. Patients also performed standard Scoliosis Research Society exercises.

## Data analysis

Quantitative data were expressed as Mean $\pm$ SD; qualitative data as frequency (%). Normality was tested by the Kolmogorov-Smirnov test. Paired t-test/Wilcoxon was used for within-group comparisons, and independent t-test/Mann-Whitney for between-group comparisons. Significance was set at  $P<0.05$  (SPSS software, version 16).

## Results

### Patients' characteristics

Ninety-one patients with thoracic hyperkyphosis were initially enrolled. During follow-up, 29 patients discontinued brace use, and 8 withdrew due to prolonged interventions beyond the planned study period. Consequently, 62 patients were eligible for analysis. Eleven patients were excluded due to insufficient response to bracing or incomplete treatment, leaving 51 patients who completed the full non-operative protocol.

Among these patients, 16(29.6%) were diagnosed with Scheuermann disease, and 35(70.4%) had postural hyperkyphosis. The mean age was 12.6 $\pm$ 2 years (range: 9–16), with 36 boys (66.7%) and 18 girls (33.3%).

### Treatment outcomes

Brace treatment resulted in a significant reduction in both thoracic kyphosis (TK) and LL ( $P<0.001$  for both; Table 1). The mean correction of TK was 20.7 $\pm$ 9.2 degrees, while LL decreased by 2.5 $\pm$ 5 degrees. Three patients exhibited poor correction: Two showed TK increases of 6 degrees and 10 degrees, and one had only a 4-degree reduction; all subsequently underwent spinal fusion. In the remaining patients, TK decreased by 6–35 degrees. LL increased in 10 patients, remained unchanged in 4, and decreased by 2–13 degrees in the others.

### Comparison by baseline kyphosis

Patients were stratified based on baseline TK: Group I ( $\leq 70$  degrees,  $n=41$ ) and group II ( $>70$  degrees,  $n=13$ ). TK correction was significantly greater in group I than in group II (22.6 $\pm$ 7.9 vs 14.8 $\pm$ 11 degrees,  $P=0.016$ ). No significant difference in LL correction was observed between groups ( $P=0.895$ ).

**Table 1.** Comparing TK and LL before and after Milwaukee brace treatment

Variables	Mean±SD		P
	Before Treatment	After Treatment	
TK (T3–T12)	63.4±8.5 (48–79)	42.7±13.4 (25–86)	<0.001
LL (L1–L5)	51.9±7.7 (25–62)	49.4±5.5 (34–63)	<0.001

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No significant correlations were found between age and changes in TK or LL in either group (Table 2).

## Discussion

The findings of the present study demonstrated that treatment of hyperkyphosis (both postural and Scheuermann types) with the Milwaukee brace can yield favorable outcomes. Orthotic management with the Milwaukee brace significantly reduced both kyphotic and lordotic angles, although the reduction in lordosis was not of clinical relevance. No significant correlation was observed between age and the degree of correction in patients with baseline kyphotic angles above or below 70°. However, patients with initial kyphotic angles less than 70 degrees experienced significantly better outcomes compared to those with angles greater than 70 degrees.

The most important finding of this study is that orthotic treatment with the Milwaukee brace, when patient compliance is adequate, can be an effective intervention for improving hyperkyphosis. Hyperkyphosis comprises various subtypes, each requiring a distinct therapeutic approach. Management is often paradoxical and, in some respects, even more challenging than scoliosis treatment [5, 6]. Current knowledge on conservative management of hyperkyphosis is particularly limited when compared with scoliosis, and the available evidence largely consists of retrospective studies with heterogeneous designs [6, 7]. Consequently, the data are insufficient to establish standardized protocols for bracing in hyperkyphosis, highlighting the urgent need for prospective studies.

Spinal deformities during adolescence are especially critical and challenging. In girls, these deformities can generate considerable concern due to cosmetic issues and are frequently associated with psychological consequences such as reduced self-esteem. Patients with hyperkyphosis, particularly those with Scheuermann disease, often present with compensatory hyperlordosis, anterior head protrusion, and, in some cases, back or shoulder pain. If untreated, progression of the deformity may necessitate invasive surgical procedures [8, 9]. Thus, timely diagnosis and conservative treatment are of paramount importance.

Although therapeutic strategies for hyperkyphosis—particularly in Scheuermann disease—vary depending on the severity, anatomical location, residual growth potential, neurological or cosmetic concerns, patient age, and pain intensity, the mainstay remains nonsurgical. Bracing is most effective in curves between 50 and 70 degrees, particularly those above 60 degrees. Some reports suggest that initiating orthotic treatment at angles exceeding 65° is associated with poorer outcomes, while others propose that starting treatment before 50 degrees leads to more favorable results [10–12].

Previous studies have included patients with thoracic hyperkyphosis ranging from 45 to 80 degrees and skeletal immaturity, treated with bracing [1, 13]. Consistent with this, the present study focused on deformities within this range and treated patients using the Milwaukee brace. The pathogenesis of Scheuermann's disease—characterized by impaired endochondral ossification of the vertebral body with intact marginal borders—provides a rationale for orthotic therapy, as bracing can prevent further anterior vertebral collapse and, in some cases, facilitate partial remodeling [14, 15].

**Table 2.** Comparing TK and LL before treatment between group I (≤70 degrees) and group II (>70 degrees)

Variables	Mean±SD		P
	Group I	Group II	
TK (°)	59.8±6.1	74.9±2.3	<0.016
LL (°)	50.6±8	56.1±4.8	0.895

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Despite the limited and dated literature, available evidence consistently demonstrates the effectiveness of the Milwaukee brace, supporting its role as the most reliable nonsurgical intervention for hyperkyphosis. Studies such as those by Montgomery and colleagues, all corroborate these findings, albeit with variable long-term stability and partial loss of correction after brace discontinuation [16].

In our study, kyphotic angles improved substantially, from an average of 63 to approximately 43 degrees, although three patients eventually required fusion surgery. Importantly, while no correlation between age and the degree of correction was observed, outcomes were significantly better in patients with baseline angles <70 degrees. This finding aligns with previous research indicating that bracing is most effective in skeletally immature patients with moderate deformities, though even in older patients or those with more severe curves, trial orthotic treatment may still be considered before surgical intervention [16, 17].

A notable point in our study is the evaluation of LL, which has rarely been reported in prior research. Although lordosis decreased significantly, the small magnitude of change ( $\approx 2.5$  degrees) is unlikely to be clinically relevant. The wide normal range of LL and its compensatory relationship with TK and pelvic orientation may explain this finding. Moreover, the possibility that long-term hyperlordosis may involve alterations in muscle balance and soft tissues warrants further attention in clinical management.

Like any treatment, bracing—especially with the Milwaukee brace—poses challenges, including discomfort, cosmetic concerns, and back pain with prolonged use, all of which can reduce compliance. Given that treatment success is highly dependent on adherence, part-time bracing has been explored as an alternative and may offer similar efficacy. The cumbersome design of the Milwaukee brace has also prompted the development of alternative orthoses, though their effectiveness requires further investigation [18].

One of the major concerns in orthotic treatment of hyperkyphosis remains the loss of correction after brace removal. While prior studies suggest that only partial and sometimes temporary correction can be expected, outcomes appear to be more stable in postural hyperkyphosis than in Scheuermann disease [19, 20]. In the present study, however, long-term post-bracing results could not be assessed, which constitutes a limitation of our work.

## Conclusion

The Milwaukee brace offers an effective non-operative approach to managing postural hyperkyphosis and Scheuermann disease in adolescents. Significant improvement in TK can be achieved, especially in patients with baseline kyphotic angles  $\leq 70$  degrees. Early identification, consistent brace wear, and long-term monitoring are essential to maximize treatment success and minimize the need for surgical correction.

## Ethical Considerations

### Compliance with ethical guidelines

All procedures followed routine clinical care, with confidentiality maintained and written informed consent obtained.

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### Authors' contributions

Supervision: Mani Mahdavi; Consulting: Hassan Ghandhari; Project administration: Moein Khaleghi Langroodi; Writing: Sepideh Safarpour.

### Conflict of interest

The authors declared no conflict of interest.

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