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ROTATIONAL EFFECT OF THE 3D BRACE IN THE TREATMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS

EFEITO ROTACIONAL DO COLETE 3D NO TRATAMENTO DA ESCOLIOSE IDIOPÁTICA DO ADOLESCENTE

EFECTO ROTACIONAL DEL CORSÉ 3D EN EL TRATAMIENTO DE LA ESCOLIOSIS IDIOPÁTICA DEL ADOLESCENTE

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ABSTRACT

Objective: To evaluate the axial correction capacity of the 3D brace in treating Adolescent Idiopathic Scoliosis (AIS). Methods: A retrospective study was carried out with 61 patients with AIS who obtained the 3D brace, between 2019 and 2022, in a laboratory that manufactures orthotics and orthopedic prostheses. These individuals underwent independent analysis of radiographic parameters by evaluating vertebral rotation using the Nash and Moe classification. The analyzed radiographs were taken in orthostasis before and after treatment with the 3D vest. Patients were divided into groups I and II-IV according to the Nash and Moe radiographic classification. Corrective capacity was estimated by assessing the degree of vertebral rotation before and after treatment. Results: Of the 61 patients evaluated, 36 (59%) had Nash and Moe grade I, and 25 patients grade II-IV before treatment. After treatment, 13 (21%) had grade II-IV, and 48 had grade I. Of the patients categorized as II-IV, 64% had improvement in the rotational profile. None clinical studies or radiographic parameter was associated with a change in rotational profile other than brace use (p=0.012). Conclusion: In the studied sample, treatment with the 3D vest promoted a change in vertebral rotation according to the Nash and Moe classification. The majority showed improvement in this parameter of evaluation of treatment of AIS. ***Level of Evidence III; Retrospective Study.***

Keywords: Scoliosis; Conservative Treatment; Analysis of Variance.

RESUMO

Objetivo: Avaliar a capacidade de correção axial do colete 3D no tratamento da Escoliose Idiopática do Adolescente (EIA). Métodos: Realizou-se estudo retrospectivo com 61 pacientes com EIA que obtiveram o colete 3D, entre 2019 e 2022, em um laboratório de confecção de órteses e próteses ortopédicas. Esses indivíduos foram submetidos à análise independente dos parâmetros radiográficos através da avaliação da rotação vertebral pela classificação de Nash e Moe. As radiografias analisadas foram realizadas em ortostase antes e após o tratamento com o colete 3D. Os pacientes foram separados em grupo I e grupo II-IV de acordo com a classificação radiográfica de Nash e Moe. A capacidade de correção foi estimada pela avaliação do grau de rotação vertebral antes e depois do tratamento. Resultados: Dentre os 61 pacientes avaliados, 36 (59%) apresentavam grau I, e 25 pacientes grau II-IV de Nash e Moe, antes do tratamento. Após o tratamento, 13 (21%) apresentavam grau II-IV e, 48 pacientes apresentavam grau I. Dos pacientes categorizados como II-IV, 64% tiveram melhora no perfil rotacional. Nenhum parâmetro clínico ou radiográfico estudado esteve associado com a mudança no perfil rotacional além do uso do colete (p=0,012). Conclusões: Na amostra estudada, o tratamento com o colete 3D promoveu mudança na rotação vertebral pela classificação de Nash e Moe. A maioria dos pacientes apresentou melhora neste parâmetro de avaliação de tratamento da EIA. ***Nível de Evidência III; Estudo Retrospectivo.***

Descritores: *Escoliose; Tratamento Conservador; Análise de Variância.*

RESUMEN

Objetivo: Evaluar la capacidad de corrección axial del corsé 3D en el tratamiento de la Escoliosis Idiopática del Adolescente (EIA). Métodos: Se realizó un estudio retrospectivo con 61 pacientes con EIA que obtuvieron el corsé 3D, entre 2019 y 2022, en un laboratorio que fabrica ortesis y prótesis ortopédicas. Estos individuos se sometieron a un análisis independiente de los parámetros radiográficos a través de la evaluación de la rotación vertebral utilizando la clasificación de Nash y Moe. Las radiografías analizadas se tomaron en ortostasis antes y después del tratamiento con el corsé 3D. Los pacientes se dividieron en grupo I y grupo II-IV según la clasificación radiográfica de Nash y Moe. La capacidad correctora se estimó evaluando el grado de rotación vertebral antes y después del tratamiento. Resultados: De los 61 pacientes evaluados, 36 pacientes (59%) tenían grado I de Nash y Moe, y 25 grado II-IV antes del tratamiento. Después del tratamiento, 13 (21%) tenían grado II-IV, y 48 grado I. De los pacientes categorizados como II-IV, el 64% tuvo mejoría en el perfil rotacional. Ningún

Study conducted by the Hospital das Clínicas and Hospital Mater Dei, Belo Horizonte, MG, Brazil.
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parámetro clínico o radiográfico estudiado se asoció con el cambio en el perfil de rotación que no sea el uso de aparatos ortopédicos (p = 0,012). Conclusiones: En la muestra estudiada, el tratamiento con el corsé 3D promovió un cambio en la rotación vertebral según la clasificación de Nash y Moe. La mayoría mostró mejoría en este parámetro de evaluación del tratamiento de la EIA. Nivel de Evidencia III; Estudio Retrospectivo.

Descriptores: *Escoliosis; Tratamiento conservador; Análisis de Varianza.*

INTRODUCTION

The Milwaukee and Boston vests have been the most widely used orthoses in the conservative treatment of AIS over the last few decades.[1] Both orthoses, due to their mechanism of action, do not act on vertebral rotation and tend to rectify the physiological curves in the sagittal plane, with the potential to produce what we know as *flatback*.[2,3]

Multi-planar correction vests first appeared in the early 1990s with the work of Chêneau. The Chêneau brace provided the biomechanical basis for multiplanar correction for other orthoses developed later, such as the Wood-Chêneau-Rigo (WCR®),[4] the Sforzesco, the *Dynamic Derotation Braces* (DDBs), S4D, etc. In Brazil, these orthoses are generically known as 3D vests, whose main purpose is to transfer multifocal corrective forces to the spine, acting on the scoliotic curve in the sagittal, coronal, and axial planes.[2,5] The 3D brace's ability to correct vertebral rotation in the axial plane is a major advantage over the braces used in previous decades.[6] Controlling the rotation of the curve is fundamental to controlling the progression and imbalance of vertebral alignment.[7] However, to date, no study has evaluated the rotational corrective effect of the 3D brace.[8]

Therefore, this study aims to evaluate the effect of the 3D vest on vertebral rotation in patients with adolescent idiopathic scoliosis.

METHOD

Research design

A retrospective study was carried out to evaluate the effect of the 3D vest on the vertebral rotation of scoliotic curves in patients with AIS using the Nash and Moe method.

Ethics

This work is part of the EIA research line and was approved by our institution's Research Ethics Committee, with the CAAE identification number: 44775621.1.0000.5128.

Place and period of the study

The study was carried out between January 2019 and January 2022 with patients diagnosed with AIS who came to an orthosis and prosthesis laboratory in Belo Horizonte-MG.

Main event

The main event of this study was the variation in the rotational profile of the apex of the scoliotic curve assessed by the Nash and Moe method before and after treatment with the 3D vest. The adjacent vertebra with the highest degree of rotation was used when the curve's apex was in an intervertebral disc.

Secondary variables

The secondary variables studied were: gender, age, side of the convexity of the main curve, the apex of the main curve, location of the curve, type of curve, Risser classification, and magnitude. Table 1 describes the name and operational definition of each variable studied.

Sample

Sixty-two patients with AIS were admitted during the study period to evaluate the degree of vertebral rotation after using the vest. Of the 62 patients evaluated, one was excluded due to insufficient data or because he was not in the 10-17 age group. Sixty-one patients made up the final sample of this study.

Development of the study

We selected only patients diagnosed with AIS, aged between 10 and 17 years, who had panoramic anteroposterior radiographs of the spine in orthostasis taken before and after treatment with the 3D vest.

Two investigators collected data, both orthopedic surgeons who are members of the Brazilian Society of Orthopaedics and Traumatology. The degree of apical vertebral rotation using the Nash and Moe classification was identified using the tools in the Surgimap® software (Figure 1). The following secondary variables were then analyzed about scoliotic curves: apex of the main curve, location of the curve, type of curve, Risser classification, and magnitude. Risser's sign has also been grouped into type A (0,1,2) and type B (3,4,5).[9,10]

Data analysis

After selecting the data and radiographic images of the 61 patients, they were all classified according to Nash and Moe before the use of the 3D vest and immediately after its use, and a descriptive statistical analysis of the profile of the study participants was carried out. An association study of the secondary variables with the Nash and Moe classification change, stratified into two categories, was also carried out – grade I and grade II-IV categories of vertebral rotation.

The mean, standard deviation, median, quartiles, minimum and maximum were calculated to describe the continuous variables. For categorical variables, the absolute and relative frequency. The

Table 1. Description of the secondary variables studied.

Variable	Characterization
1. Sex	Male or female.
2. Age	Age in years at the time the vest was made.
3. Side of the curve	According to the location of the convexity of the main curve: right or left.
4. Apex of the main curve	Vertebra or disc furthest from the midline belongs to the main curve's convexity. After defining the apex of the main curve, the Scoliosis Research Society (SRS) topographic classification was used[8]: thoracic (T2 to T11-T12 disc), thoracolumbar (between T12 and L1), lumbar (L1-L2 disc to L4-L5 disc).
5. Location of curves	Defined according to the topographic classification of the SRS8 and the side of the curve, subdivided into right thoracic, left thoracic, right thoracolumbar, left thoracolumbar, right lumbar, and left lumbar.
6. Type of curve	According to the number of structured curves: single (one curve), double (two curves), and triple (three curves).
7. Risser	Degree of Risser's sign in the AP radiological view of the iliac crest. Grades 0, 1, 2, 3, 4, and 5. Grouping of the Risser classification: group A (Risser sign 0, 1, or 2) and Group B (Risser sign 3, 4, and 5).
8. Magnitude	The magnitude of the curves was measured by the Cobb method. Magnitude stratification: group 1 (curve $\leq$ 24.9°), group 2 (25° to 40°), and group 3 (> 40°).

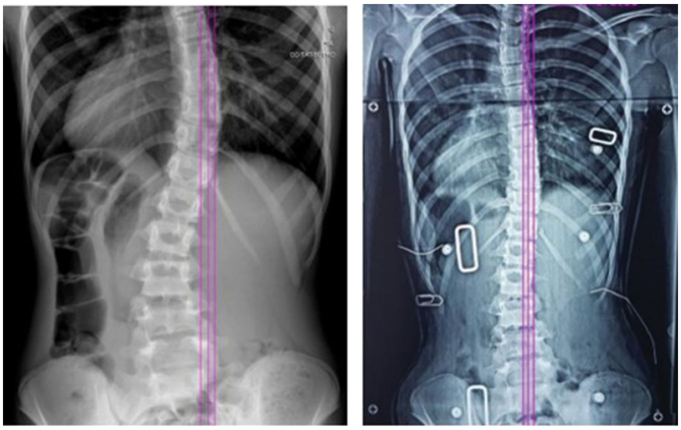

Figure 1. T10 apical vertebra was marked before and after using the vest, and the change from II to I in the Nash and Moe classification was observed.

Chi-Square test and Student's t-test were used to evaluate the change in classification. The analyses were carried out using Stata software version 16, and the tables were prepared using Microsoft Excel software (2019).

RESULTS

Tables 2 and 3 describe the characteristics of the sample studied. In this study, females predominated (81.97%), with the convexity of the curve to the right (57.38%). The apical vertebra was located in the thoracic region in 45.9% of patients, Risser category A in 59.02%, and double curve in 54.10%. The average age of the participants was 13.1 years.

Grade I vertebral rotation was predominant both before and after treatment. (Table 4)

Table 5 shows the frequency distribution of the variables studied according to categories I and II-IV of the Nash and Moe classification before using the 3D vest. The average age did not differ between the categories, with an average of 12.8 ± 1.6 in category I and 13 ± 1.9 in categories II-IV (p=0.196). The apex of the curve in the thoracic region predominated in rotation category I, while in categories II-IV, there was no predominance in the location of the apexes in the thoracic, thoracolumbar, and lumbar regions. Table 6 shows the frequency distribution of the variables studied according to categories I and II-IV of the Nash and Moe classification after using the 3D vest.

Table 7 compares the change in classification before and after wearing the vest (reduced: II→I, III→II, IV→III, IV→II; remained or increased: I→I, I→II, II→II, III→IV). The average age of the patients who had reduced spinal rotation was 13.8 ± 1.9, while the average age of those who had no change or increased the degree of rotation was 12.7 ± 1.6, with a statistically significant difference (p-value = 0.018).

Table 8 shows that of the 25 patients classified as category II-IV before using the 3D vest, 16 had a reduction in the degree of vertebral rotation after using the 3D vest and were now classified as category I, representing 64% of the patients (p=0.012). And of the 36 patients who were in Category I, four (11.1%) moved to Category II-IV.

DISCUSSION

The purpose of 3D vests is to correct scoliosis in all three planes of the deformity.[4,6,11] The correction in the axial plane seems to be the most notable feature of these vests, differentiating them from the Boston and Milwaukee vests. Freitas Junior et al., in a study of 138 patients treated with the 3D vest, demonstrated the corrective capacity in the coronal plane but did not evaluate the impact of these vests on rotation.[8] Other studies corroborate the effectiveness of these vests in the conservative treatment of scoliosis with curves between 20-45 degrees in terms of the magnitude of the curve measured by the Cobb degree in the frontal plane. Still, no study to date has demonstrated the effect of vertebral rotation of these vests in the treatment of scoliosis.[1,12]

This study evaluated the effect of the 3D vest on spinal rotation in a retrospective analysis involving 61 patients, with the measurement of the degree of rotation assessed by the Nash and Moe classification as the main outcome. The Nash and Moe system is the most widely used method for assessing vertebral rotation in daily orthopedic practice.[13] The results showed that 64% of patients categorized as grade II-IV significantly reduced the degree of vertebral rotation, indicating a possible defeat effect in curves with higher degrees of vertebral rotation (p=0.018). On the other hand, in patients with grade I, 11.1% of them had an increase or no change in vertebral rotation. The data collected in this study did not allow us to identify the possible causes of increased or unchanged vertebral rotation. The progression of rotation or absence of change in grade I can be attributed, albeit speculatively, to the low reliability of the Nash and Moe classification, to a possible initial progression, or the failure of treatment with the vest in this group.

This study has limitations. This is a retrospective study in which the main event studied was vertebral rotation, the assessment of which undergoes variations related to image quality, anatomical variations of the scoliotic vertebrae, and factors inherent to the reliability of the Nash and Moe classification.[13] Intra- and inter-observer

Table 2. Descriptive characteristics of the sample profile (categorical variables).

	n	%
Sex		
Female	50	81.97
Male	11	18.03
Convexity side		
Right	35	57.38
Left	26	42.62
Apex		
Lumbar	14	22.95
Thoracic	28	45.90
Thoracolumbar	19	31.15
Location		
Right lumbar	2	3.28
Left Lumbar	12	19.67
Right Thoracic	26	42.62
Left Thoracic	1	1.64
Right thoracolumbar	7	11.48
Left thoracolumbar	13	21.31
Risser		
A	36	59.02
B	25	40.98
Magnitude		
Group 1	10	16.39
Group 2	27	44.26
Group 3	17	27.87
Type of curve		
Simple Curve	28	45.90
Double Curve	33	54.10

Table 3. Descriptive characteristics of the sample profile (continuous variables).

Variable	n	Average	Standard Deviation	Minimum	1st Quartile	Median	3rd Quartile	Maximum
Age	60	13.1	1.8	10	12	13	14	17
Risser	61	2.0	2.0	0	0	2	4	5

Table 4. Distribution of vertebral rotation frequencies before and after treatment according to the Nash and Moe classification.

Ranking before	(n)	(%)
1	36	59.02
2	20	32.79
3	3	4.92
4	2	3.28
Ranking after		
1	48	78.69
2	11	18.03
3	1	1.64
4	1	1.64

Table 5. Frequency distribution of the variables studied according to categories I and II-IV of the Nash and Moe classification before using the 3D vest.

Variables	Classification Before				p-value
	I		II-IV		
	n	%	n	%	
Sex					
Female	31	86.11	19	76.00	0.312
Male	5	13.89	6	24.00	
Convexity side					
Right	23	63.89	12	48.00	0.217
Left	13	36.11	13	52.00	
Apex					
Lumbar	5	13.89	9	36.00	0.085
Thoracic	20	55.56	8	32.00	
Thoracolumbar	11	30.56	8	32.00	
Location					
Right lumbar	1	2.78	1	4.00	0.392
Left Lumbar	4	11.11	8	32.00	
Right Thoracic	18	50.00	8	32.00	
Left Thoracic	1	2.78	0	0.00	
Right thoracolumbar	4	11.11	3	12.00	
Left thoracolumbar	8	22.22	5	20.00	
Risser					
A	22	61.11	14	56.00	0.690
B	14	38.89	11	44.00	
Magnitude					
Group 1	7	22.58	3	13.04	0.662
Group 2	15	48.39	12	52.17	
Group 3	9	29.03	8	34.78	
Type of curve					
Simple Curve	16	44.44	12	48.00	0.784
Double Curve	20	55.56	13	52.00	

variations in the classification are only known in controlled radiographs taken on biomechanical test specimens.[13] Furthermore, this study did not compare the defeating effect of the 3D vest with the Boston or Milwaukee vests. Another important limitation was the one-off assessment of the vest's immediate defeating effect on the first control X-ray after starting treatment. The study suggests some defeating effects on turns with higher degrees of rotation while wearing the vest. Although this immediate defeating effect is positive in the conservative treatment of scoliosis, nothing can be concluded about its long-term effect, especially after you stop using it. It is unknown whether the gain in the rotation is definitive or transitory, nor the importance of rotational control with the 3D vest in the long-term results of conservative scoliosis treatment. The authors of this study are conducting a long-term line of research aimed at analyzing the results after discontinuing the use of the vest. Comparative prospective studies are needed to shed light on this relatively new form of conservative treatment for scoliosis.

Table 6. Frequency distribution of the variables studied according to categories I and II-IV of the Nash and Moe classification after using the 3D vest.

Variables	Ranking after				p-value
	I		II-IV		
	n	%	n	%	
Sex					
Female	39	81.25	11	84.62	0.780
Male	9	18.75	2	15.38	
Convexity side					
Right	30	62.50	5	38.46	0.120
Left	18	37.50	8	61.54	
Apex					
Lumbar	10	20.83	4	30.77	0.173
Thoracic	25	52.08	3	23.08	
Thoracolumbar	13	27.08	6	46.15	
Location					
Right lumbar	2	4.17	0	0.00	0.515
Left Lumbar	8	16.67	4	30.77	
Right Thoracic	23	47.92	3	23.08	
Left Thoracic	1	2.08	0	0.00	
Right thoracolumbar	5	10.42	2	15.38	
Left thoracolumbar	9	18.75	4	30.77	
Risser					
A	27	56.25	9	69.23	0.399
B	21	43.75	4	30.77	
Magnitude					
Group 1	10	23.81	0	0.00	0.103
Group 2	21	50.00	6	50.00	
Group 3	11	26.19	6	50.00	
Type of curve					
Simple Curve	24	50.00	4	30.77	0.217
Double Curve	24	50.00	9	69.23	

Table 7. Change in Nash and Moe classification before and after wearing the 3D vest.

Variables	Nash and Moe's classification				p-value
	Remained or Increased		Reduced		
	n	%	n	%	
Sex					
Female	36	87.80	14	70.00	0.090
Male	5	12.20	6	30.00	
Convexity side					
Right	24	58.54	11	55.00	0.793
Left	17	41.46	9	45.00	
Apex					
Lumbar	8	19.51	6	30.00	0.459
Thoracic	21	51.22	7	35.00	
Thoracolumbar	12	29.27	7	35.00	
Location					
Right lumbar	1	2.44	1	5.00	0.858
Left Lumbar	7	17.07	5	25.00	
Right Thoracic	19	46.34	7	35.00	
Left Thoracic	1	2.44	0	0.00	
Right thoracolumbar	4	9.76	3	15.00	
Left thoracolumbar	9	21.95	4	20.00	
Risser					
A	27	65.85	9	45.00	0.120
B	14	34.15	11	55.00	
Magnitude					
Group 1	7	19.44	3	16.67	0.846
Group 2	17	47.22	10	55.56	
Group 3	12	33.33	5	27.78	
Type of curve					
Simple Curve	18	43.90	10	50.00	0.654
Double Curve	23	56.10	10	50.00	

* Student's t-test significant at 5%.

Table 8. Classification ratio before and after.

Classification Before	Rating After				p-value
	I		II-IV		
	n	%	n	%	
I	32	88.9	4	11.1	0.012*
II-IV	16	64.0	9	36.0	

* McNemar's test is significant at 5%.

CONCLUSION

The results of this study demonstrate an immediate defeating effect on the apical vertebra in the treatment of idiopathic scoliosis using the 3D vest. Further studies are needed to assess its long-term effect after discontinuing the vest use.

All authors declare no potential conflict of interest related to this article.

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