

COMPARISON OF RADIOGRAPHIC METHODS FOR MEASURING CERVICAL SPINE CURVATURE

COMPARAÇÃO DOS MÉTODOS RADIOGRÁFICOS PARA A MENSURAÇÃO DA CURVATURA DA COLUNA CERVICAL

COMPARACIÓN DE LOS MÉTODOS RADIOGRÁFICOS PARA LA MEDICIÓN DE LA CURVATURA DE LA COLUMNA CERVICAL

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ABSTRACT

Objectives: Compare three methods for evaluating the curvature of the cervical spine (Cobb, Jackson and Harrison method) considering the morphological types of cervical curvature (lordotic, straightened, sigmoid and kyphotic). **Method:** Ten lateral radiographs of each type of cervical curvature (lordotic, rectified, sigmoid and kyphotic) were used to measure the curvature of the cervical spine using the Cobb, Jackson and Harrison methods. The results were compared. **Results:** the methods for assessing cervical curvature showed statistical differences in the assessment of the group of individuals and in the individualized assessment of each morphological type of cervical spine curvature. **Conclusion:** the methods for assessing cervical spine curvature present differences in relation to angular measurement and the difference in measurement was also observed in the different morphological types of cervical spine curvature. **Evidence level III, retrospective comparative study.**

Keywords: Spine; Spinal Curvatures; Postural Balance.

RESUMO

Objetivo: Comparar três métodos de avaliação da curvatura da coluna cervical (método de Cobb, Jackson e Harrison) considerando os tipos morfológicos da curvatura cervical (lordótica, retificada, sigmoide e cifótica). **Método:** Dez radiografias em perfil de cada tipo de curvatura cervical (lordótico, retificado, sigmoide e cifótico) foram utilizadas para a mensuração da curvatura da coluna cervical pelos métodos de Cobb, Jackson e Harrison. **Os resultados foram comparados. Resultados:** os métodos de avaliação da curvatura cervical apresentaram diferença estatística na avaliação do grupo de indivíduos e na avaliação individualizada de cada tipo morfológico da curvatura da coluna cervical. **Conclusão:** Os métodos de avaliação da curvatura da coluna cervical apresentam diferenças com relação a mensuração angular e a diferença da mensuração também foi observada nos diferentes tipos morfológicos da curvatura da coluna cervical. **Nível de evidência III, estudo retrospectivo comparativo.**

Descritores: Coluna Vertebral; Curvaturas da Coluna Vertebral; Equilíbrio Postural.

RESUMEN

Objetivo: Comparar tres métodos de evaluación de la curvatura de la columna cervical (métodos de Cobb, Jackson y Harrison) teniendo en cuenta los tipos morfológicos de curvatura cervical (lordótica, rectificada, sigmoidea y cifótica). **Método:** Se utilizaron diez radiografías laterales de cada tipo de curvatura cervical (lordótica, rectificada, sigmoidea y cifótica) para medir la curvatura de la columna cervical utilizando los métodos de Cobb, Jackson y Harrison. **Se compararon los resultados. Resultados:** Los métodos utilizados para evaluar la curvatura cervical mostraron diferencias estadísticas al evaluar el grupo de individuos y al evaluar individualmente cada tipo morfológico de curvatura de la columna cervical. **Conclusión:** Los métodos utilizados para evaluar la curvatura de la columna cervical diferían en cuanto a la medición angular y la diferencia de medición también se observó en los distintos tipos morfológicos de curvatura de la columna cervical. **Nivel de evidencia III, estudio comparativo retrospectivo.**

Descriptores: Columna Vertebral; Curvaturas de la Columna Vertebral; Equilibrio Postural.

INTRODUCTION

The curvature of the cervical spine appears before birth and can be visible around the 9.5th week of gestation in 83% of fetuses.¹ So far, there is no consensus on the definition of physiological cervical curvature.² Unlike the lumbar spine, which is always kyphotic, the curvature of the cervical spine varies according to the need to maintain horizontal vision and changes in the alignment of other segments of the spine.^{3,4}

It has been reported a significant percentage of normal individuals who do not present lordotic curvature of the cervical spine. In the meta-analysis covering 15,364 normal individuals, it was observed that 36% did not have cervical spine lordosis.² The evidence of the correlation of different types of cervical spine curvature with clinical symptoms has been inconclusive.⁴

In the composition of the C1-C7 lordosis of normal individuals,

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the C1-C2 represents 77% of its composition and C3-C7 with 23%.⁵ However, the angle of the inferior plate of C2 and C7 has been the most used measure for assessing the curvature of the cervical spine.⁶ Different methods have been proposed for measuring the curvature of the cervical spine: Cobb method, Jackson's physiological stress lines, Harrison's posterior tangent method, and Ishihara index.^{7,8} (Figure 1)

The Cobb method assesses the angle formed by the inferior edge of C2 and C7, and the Jackson method assesses the angle formed by the lines of the posterior wall of the body of C2 and C7. Harrison's method uses the sum of the angles formed by the posterior wall of the C2 to C7 vertebrae. The Ishihara index uses the distance from the posteroinferior edge of C3, C4, C5, and C6 to the perpendicular line that connects the posteroinferior edge of C2 to C7. The sum of the 4 lines is divided by the length of the line that joins C2.

The curvatures of the cervical spine were classified into four types (kyphotic, lordotic, sigmoid, and straightened), according to the distance from the centroid of the C3-C7 vertebrae to the line that connects the midpoint of C2 and C7. (Figure 2) The curvature of the cervical spine is classified as lordotic in individuals who have the centroids of C3-C6 located anteriorly to the C2-C7 line ≥ 2 cm; kyphotic when located posteriorly ≥ 2 cm; sigmoid when they are located anteriorly or posteriorly ≥ 2 cm; and straightened when they are located anteriorly < 2 cm.⁹

The study conducted considered the methods of evaluating the curvature of the cervical spine that use the angular measurements of C2 and C7 (Cobb method, Jackson method, and Harris method) and the types of cervical spine curvature (lordotic, straight, sigmoid, and kyphotic).

The objective of the study was to compare the methods of evaluating the curvature of the cervical spine (Cobb, Harris, and Jackson methods) in the different morphological types of cervical spine curvature (kyphotic, lordotic, sigmoid, and straightened).

MATERIAL AND METHODS

The study was approved by the Ethics Committee of HCFMRP-USP under no. CAEE 81185724.4.0000.5440.

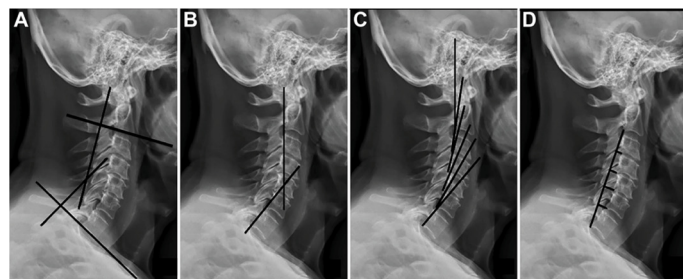


Figure 1. Methods for measuring the curvature of the cervical spine. Cobb method (A), Jackson method (B), Harrison method (C), and Ishihara index (D).

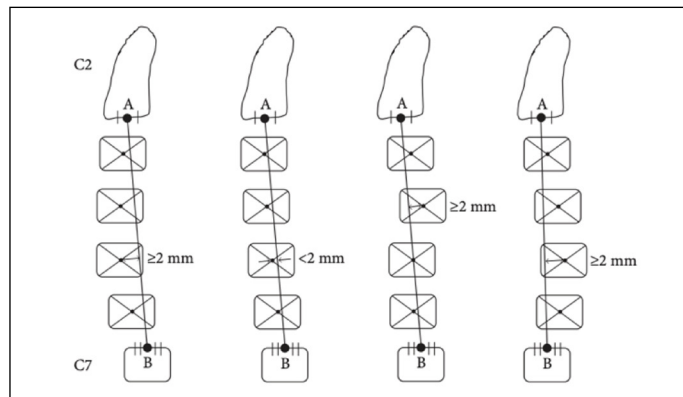


Figure 2. Classification of cervical spine curves. From left to right: lordotic, rectified, sigmoid, and kyphotic.

Lateral cervical spine radiographs of 40 individuals were evaluated, with 10 individuals from each subgroup: 10 kyphotic cervical columns, 10 lordotic, 10 sigmoid, and 10 rectified. The subgroups were considered according to the method that considers the distance from the centroids of C3-C6 to the line that connects the midpoint of the distal vertebral plate of C2 and the upper vertebral plate of C7. (Figure 2)

The curvature of the cervical spine was measured using the Cobb method, Harris method, and Jackson method in the total group of 40 patients and in the subgroups (kyphosis, lordosis, sigmoid, and straightened). Negative values (-) correspond to lordotic curvature and positive values (+) to kyphosis.

The statistical study was conducted using descriptive statistics, and the Kolmogorov-Smirnov test was used to assess the normality of the sample. The comparison of different methods was performed using the ANOVA test, Friedman test, and a significance level of 5% ($p < 0.05$) was established.

RESULTS

Twenty-four individuals were female and 16 were male. In the kyphosis subgroup, 6 were female, 4 in the lordosis subgroup, 7 in the sigmoid subgroup, and 7 in the rectified subgroup. The average age of the 40 individuals was 40.63 ± 16.29 years. In the group with lordotic curvature, it was 32.70 ± 11.88 years; 49.40 ± 14.56 in the rectified; 46 ± 18.94 years in the sigmoid and 34.40 ± 14.38 years in the kyphotic. No statistical difference was observed between the ages of the different types of kyphosis (ANOVA- $p < 0.05$).

The measurement values of all individuals and the different types of cervical spine curvature (lordosis, straightened, sigmoid, and kyphosis) by the three assessment methods are illustrated in Table 1.

The distribution of measurement values by the Cobb, Jackson, and Harris methods showed a normal distribution (Kolmogorov-Smirnov test) and are represented in Figures 3, 4, and 5.

The comparison of the measurement of the curvature of the cervical spine of the entire group of individuals using the three methods showed a statistical difference between the Cobb method and the Jackson and Harrison method (ANOVA - $p < 0.05$). The measurement using the Jackson and Harris method showed no statistical difference. (ANOVA- $p = 0.1909$) (Figure 6)

In the subgroup with kyphosis, no difference was observed between the Cobb, Jackson, and Harris methods for evaluating the curvature of the cervical spine (ANOVA and Friedman test- $p > 0.05$)

In the subgroup with lordosis, a difference was observed in the measurement of the cervical spine curvature using the Cobb, Jackson, and Harris methods. (ANOVA test- $p < 0.05$). (Figure 8)

In the sigmoid subgroup, no statistical difference was observed between the measurement by the Cobb, Jackson, and Harris methods (ANOVA - $p < 0.05$). No statistical difference was observed between the measurement using the Jackson and Harris method. (ANOVA- $p > 0.05$) (Figure 9)

In the rectified subgroup, no statistical difference was observed between the Cobb and Jackson methods for measuring the curvature of the cervical curve (ANOVA- $p < 0.05$). (Figure 10)

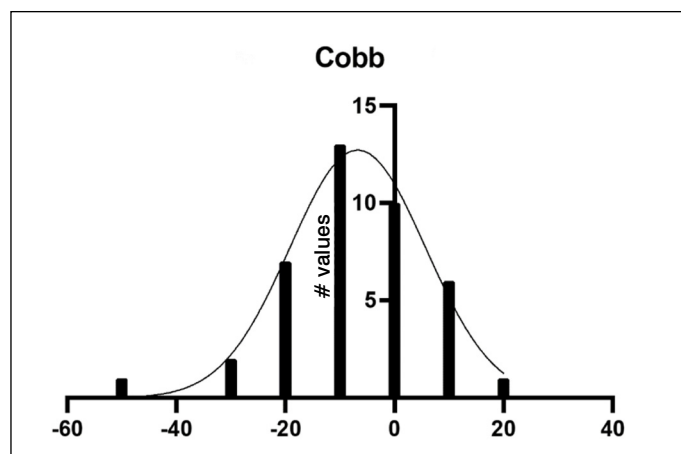
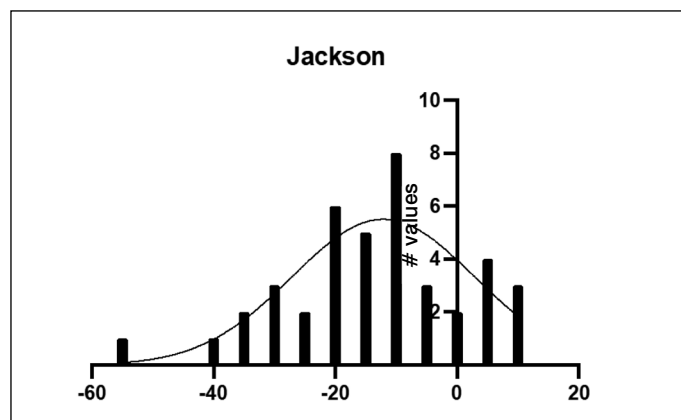
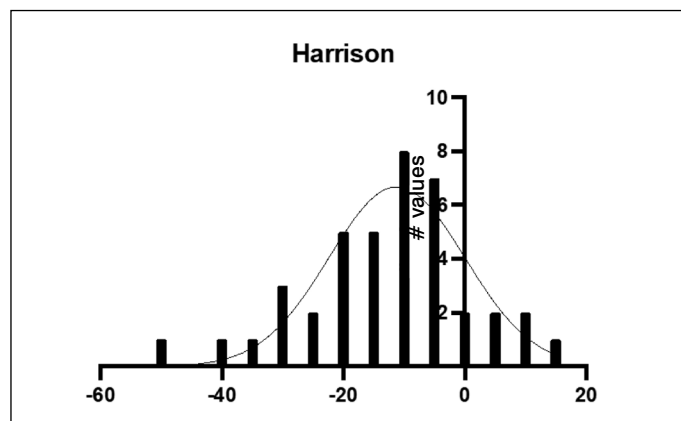
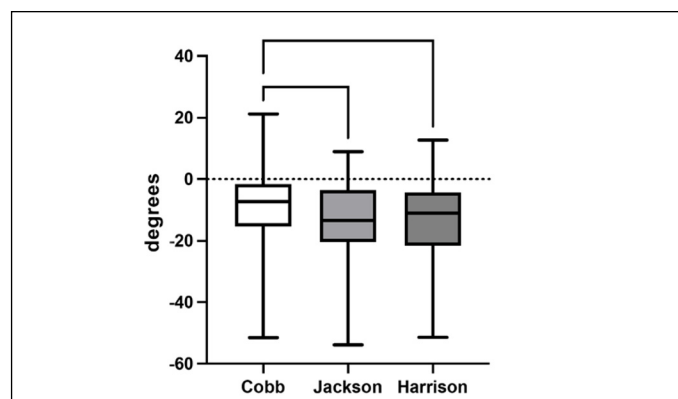
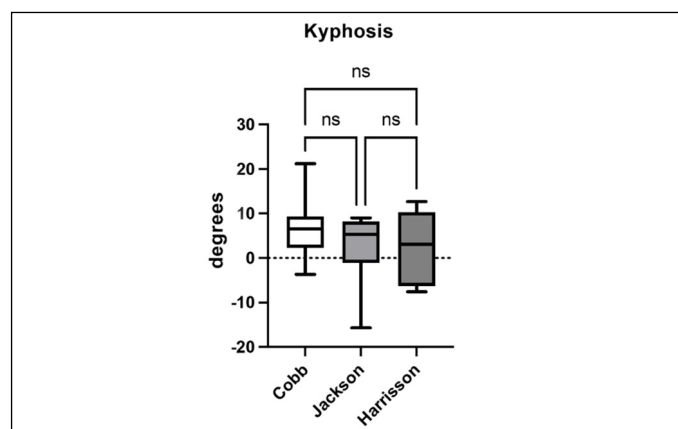
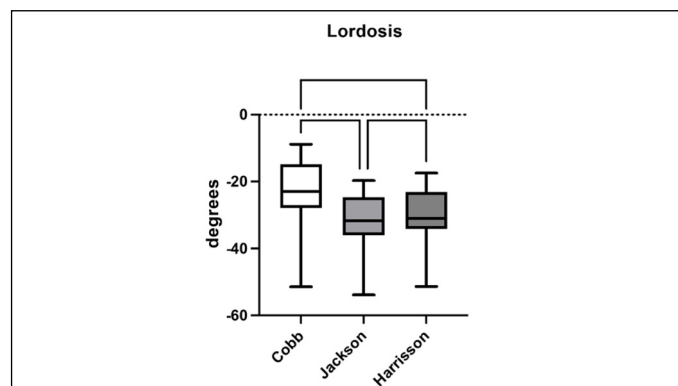
The evaluation methods showed a significant difference in measuring the curvature of the cervical spine in the group of individuals evaluated considering all types of cervical spine curvature. The evaluation of specific types of cervical spine curvature showed differences in the lordotic, sigmoid, and straightened types. No difference was observed between the evaluation methods in the kyphotic type.

DISCUSSION

A difference was observed in the measurement of the curvature of the cervical spine with the three methods used (Cobb, Jackson, and Harrison methods). Differences were also observed in the subgroups of cervical spine curvature (kyphosis, lordosis, sigmoid, and straight) highlighting the influence of cervical spine curvature morphology on measurement using different assessment methods.

Table 1. Values for measuring the curvature of the cervical spine using the Cobb, Jackson, and Harrison methods.

	Cobb					Jackson					Harrison				
	All	Kyphosis	Lordosis	Sigmoid	Rectified	All	Kyphosis	Lordosis	Sigmoid	Rectified	All	Kyphosis	Lordosis	Sigmoid	Rectified
Number	40	10	10	10	10	40	10	10	10	10	40	10	10	10	10
Minimum	-51.5	-3.7	-51.5	-18.6	-15	-53.9	-15.7	-53.9	-28.4	-17.3	-51.4	-7.6	-51.4	-22.3	-21.7
Maximum	21.2	21.2	-8.9	-3.4	-0.3	9	9	-19.7	-9.3	-1.2	12.7	12.7	-17.5	-7.5	1.7
Range	72.7	24.9	42.6	15.2	14.7	62.9	24.7	34.2	19.1	16.1	64.1	20.3	33.9	14.8	23.4
Average	-8.245	6.7	-23.47	-11.28	-4.93	-14.01	2.19	-31.91	-16.96	-9.35	-12.84	2.45	-30.36	-14.88	-8.57
Standard Deviation	13.23	7.08	11.87	4.668	4.166	14.51	8.254	10.13	5.706	5.2	14.02	8.006	9.662	5.205	6.455

**Figure 3.** Distribution of the values of the measurement of the curvature of the cervical spine by the Cobb method.**Figure 4.** Distribution of cervical spine curvature measurement values using the Jackson method.**Figure 5.** Distribution of cervical spine curvature measurement values using the Harrison method.**Figure 6.** Graph illustrating the comparison of cervical curvature measurement using the Cobb, Jackson, and Harris methods in the group of individuals. The asterisk (*) indicates statistical difference. (ANOVA- $p < 0.05$).**Figure 7.** Graph illustrating the comparison of cervical curvature measurement using the Cobb, Jackson, and Harris methods in the group of individuals with kyphosis. (ANOVA test- $p < 0.0\%$).**Figure 8.** Graph illustrating the comparison of cervical curvature measurement using the Cobb, Jackson, and Harris methods in the group of individuals with kyphosis. The asterisk (*) indicates a statistical difference (ANOVA test- $p < 0.05\%$).

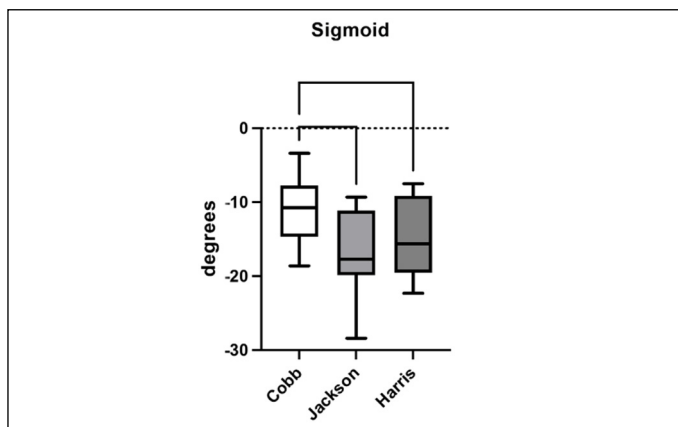


Figure 9. Graph illustrating the comparison of cervical curvature measurement using the Cobb, Jackson, and Harris methods in the group of individuals with sigmoid-type cervical curvature. The asterisk (*) indicates a statistical difference (ANOVA test- $p < 0.05\%$).

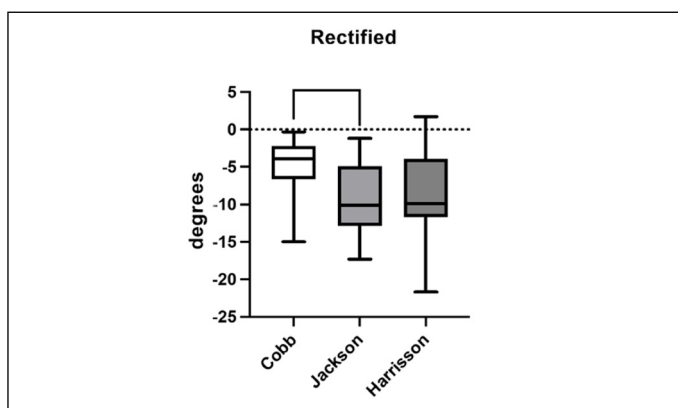


Figure 10. Graph illustrating the comparison of cervical curvature measurement using the Cobb, Jackson, and Harris methods in the group of individuals with rectified-type cervical curvature. The asterisk (*) indicates a statistical difference (ANOVA test- $p < 0.05\%$).

The comparison of the measurement method considering the total of evaluated radiographs and not separated into subgroups showed a statistical difference between the Cobb method and the Jackson and Harrison method. The average of the values was higher in the evaluation by the Cobb method.

The difference in the values of cervical spine curvature in the evaluation of different methods has been reported.² The measurement using the Cobb method shows lower values than the tangent method.^{2,7} However, in our sample of individuals studied, the measurement using the Cobb method showed the highest values, which may be related to the composition of the different subgroups by which the study sample was formed.

The comparison of the Cobb, Jackson, and Harris methods showed differences in the different morphological types of cervical

spine curvature. In the kyphotic type, no difference was observed between the three methods. In the lordotic type, a statistical difference was observed between the three methods. In the sigmoid type, a difference was observed between the Cobb method and the Jackson and Harris method. In the rectified type, a statistical difference was observed only between the Cobb method and the Jackson method.

The Cobb method and the Harrison tangent method show good reliability in inter and intra-observer measurements^{7,10} it has been reported that the Harrison method has a smaller measurement error, and a more accurate assessment by considering all the inclinations of the vertebrae and not just the inclination of C2-C7, which are the extremes of the curvature.^{7,11}

A strong correlation between the three methods was observed in the lordotic curves, and a weak correlation in the kyphotic or straightened curves.¹² We observed a statistical difference between the Cobb and Jackson methods in the straightened curves, and all three methods showed a statistical difference in the lordotic curves.

The clinical importance of cervical spine curvatures is related to clinical outcomes. Cervical lordosis has been considered the physiological curvature of the cervical spine and associated with the best clinical outcomes,^{13,14,15} and kyphosis with poor outcomes resulting from post-laminectomy kyphosis.^{16,17} In normal individuals, the largest percentage of cervical lordosis occurs at the C1-C2 level (77%), and the C2-C7 segment accounts for the remaining 23% (5). Cervical spine kyphosis has been observed in about 35% of normal individuals, and does not necessarily represent misalignment of the cervical spine.¹⁸ There are reports indicating the weak correlation between cervical spine curvature and clinical outcomes in patients undergoing surgical treatment, and they recommend that the C2-C7 curvature should be considered along with other parameters (C1-C2, C2-C7 SVA).^{9,15,16}

Study limitations

The study presents limitations due to the sample size and its heterogeneity. The sample was composed for convenience and the difference between sexes, age of individuals, and clinical condition was not considered. The positioning of the body, posture, and thoracic kyphosis affect the curvature of the cervical spine, and these parameters were not considered in the evaluation.^{4,6,19}

CONCLUSION

It was possible to observe the different types of morphology of the cervical spine, corroborating reports that the curvature of the cervical spine is not lordotic in all individuals. The methods used in the evaluation of spinal curvature show differences in the results of cervical spine curvature, and the morphology of the cervical spine also influences the difference between the Cobb, Jackson, and Harrison methods. The variations in cervical curvature morphology and the different assessment methods should be considered in patient evaluation and therapeutic planning.

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

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