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MORPHOMETRIC STUDY OF THE C6 AND C7 PEDICLE: A COMPUTERIZED TOMOGRAPHY ANALYSIS

ESTUDO MORFOMÉTRICO DO PEDÍCULO DE C6 E C7: UMA ANÁLISE POR TOMOGRAFIA COMPUTADORIZADA

ESTUDIO MORFOMÉTRICO DEL PEDÍCULO C6 Y C7: ANÁLISIS POR TOMOGRAFÍA COMPUTARIZADA

GUILHERM OTTO MARTIN-SCHUTZ[1], CARLOS ALEXANDRE BOTELHO AMARAL[1], PEDRO JOSE LABRONICI[1,2], LUCAS ALVES SARMENTO PIRES[2]

1. Hospital Santa Teresa, Orthopedics and Traumatology Service, Spine Group, Petropolis, RJ, Brazil.
2. Universidade Federal Fluminense, Niteroi, RJ, Brazil.

ABSTRACT

Objective: Measure the diameter and thickness of the C6 and C7 pedicles using computed tomography, to analyze the security of the act surgery and the difference between males and females. Methods: This is a retrospective study. Two hundred computerized tomography scans of the cervical spine, one hundred male and one hundred female, from the Hospital Santa Teresa Radiology sector were evaluated. The pedicle thickness was measured in the axial plane, and the height was measured in sagittal slices. The student's t-test was used to compare differences between the sexes, and a p-value lower than 0.05 was considered significant. Results: The mean age of the individuals included in the sample was 35±9 years. The mean height of the C6 and C7 pedicles were 7.1±0.9 mm and 7.8±0.9 mm, respectively. The mean thickness of the C6 and C7 pedicles were 5.2±0.7 mm and 5.9±0.8 mm, respectively. The statistical test showed that the values were significantly lower for female patients. Conclusions: The present study demonstrated parameters that can be used and can be the rule for preoperative planning of transpedicular cervical fixation surgeries, both in C6 and C7. As it is a procedure that can cause iatrogenic damage to important structures, the screw size must be chosen with care in pre-operative planning to avoid vessel rupture or damage to adjacent nerves. ***Level of Evidence III; retrospective study.***

Descriptors: Spine; Orthopedics; Tomography; Anatomy.

RESUMO

Objetivo: Mensurar o diâmetro e a espessura do pedículo de C6 e C7 por meio de tomografia computadorizada para analisar a segurança no ato cirúrgico e a diferença entre o sexo masculino e feminino. Métodos: Trata-se de um estudo retrospectivo. Foram avaliadas 200 tomografias computadorizadas da coluna cervical, sendo 100 do sexo masculino e 100 do sexo feminino, provenientes do setor de Radiologia do Hospital Santa Teresa. Foram inclusos exames de pacientes acima de 18 anos e menores que 70 anos. A espessura do pedículo foi mensurada no plano axial e a altura foi mensurada em cortes sagitais. O teste t de Student foi utilizado para comparar diferenças entre os sexos, e um valor de p menor que 0,05 foi considerado significante. Resultados: A média de idade dos indivíduos incluídos na amostra foi de 35±9 anos. Em geral, a média da altura dos pedículos de C6 e C7 foram de 7,1±0,9 mm e 7,8±0,9 mm, respectivamente. A média da espessura dos pedículos de C6 e C7 foram de 5,2±0,7 mm e 5,9±0,8 mm, respectivamente. Os valores foram significativamente menores para pacientes do sexo feminino. Conclusões: O presente trabalho demonstrou parâmetros que podem ser utilizados para o planejamento préoperatório de cirurgias de fixação transpedicular cervical, tanto em C6 quanto em C7. Como é um procedimento que pode acarretar lesão iatrogênica em estruturas importantes, o tamanho do parafuso deve ser escolhido com cautela, dentro de um planejamento minucioso pré-operatório de modo à evitar ruptura de vasos ou lesões em nervos adjacentes. ***Nível de evidência III; Estudo retrospectivo.***

Descritores: *Coluna vertebral; Ortopedia; Tomografia; Anatomia.*

RESUMEN

Objetivo: Medir el diámetro y grosor del pedículo C6 y C7 mediante tomografía computarizada para analizar la seguridad en el procedimiento quirúrgico y la diferencia entre hombres y mujeres. Métodos: Este es un estudio retrospectivo. Se evaluaron un total de 200 tomografías computarizadas de columna cervical, 100 del sexo masculino y 100 del femenino, del sector de Radiología del Hospital Santa Teresa. Se incluyeron exámenes de pacientes mayores de 18 años y menores de 70 años. El grosor del pedículo se midió en el plano axial y la altura en cortes sagitales. Se utilizó la prueba de la t de Student para comparar las diferencias entre sexos, y se consideró significativo un valor de p inferior a 0,05. Resultados: La edad media de los individuos incluidos en la muestra fue de 35±9 años. En general, la altura media de los pedículos C6 y C7 fue de 7,1±0,9 mm y 7,8±0,9 mm, respectivamente. El grosor medio de los pedículos de C6 y C7 fue de 5,2±0,7 mm y 5,9±0,8 mm, respectivamente. Los valores fueron significativamente más bajos para las pacientes femeninas. Conclusiones: El presente estudio demostró parámetros que pueden ser utilizados para

Study conducted by the Hospital Santa Teresa, Petropolis, Rua Paulino Afonso, 477, CEP 25684-900. RJ, Rio de Janeiro, Brazil.
Correspondence: Pedro José Labronici. 187 Roberto Silveira Ave, apt 601, Petrópolis, RJ, 25685-040, Brazil. plabronici@globo.com

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la planificación preoperatoria de cirugías de fijación cervical transpedicular, tanto en C6 como en C7. Al ser un procedimiento que puede causar lesiones iatrogénicas en estructuras importantes, el tamaño del tornillo debe elegirse cuidadosamente, dentro de una minuciosa planificación preoperatoria para evitar la ruptura de vasos o daño de nervios adyacentes. ***Nivel de Evidencia III; Estudio retrospectivo.***

Descriptores: *Columna vertebral; Ortopedía; Tomografía; Anatomía.*

INTRODUCTION

The study of the morphology of the cervical vertebrae pedicles is of extreme importance in orthopedic surgeries in this region—the greater the precision in surgical technique, the lower the likelihood of risks to adjacent neurovascular structures. Injuries to the vertebral artery, nerve roots, joint facets, and even the spinal cord have been previously reported in the literature.[1]

Cervical spine surgeries are becoming more and more frequent in the population. These techniques aim not only to correct a certain pathology, such as tumors, infections, or fractures but also to stabilize the spine due to degenerative lesions or cervical fractures. Transpedicular fixation is one of the most studied and used to correct spinal instabilities. In this surgery, a screw is inserted from the mass lateral to the vertebral body, passing through the entire interior of the pedicle, using probes and drills smaller than the core of the screw to check the integrity and non-laceration of the pedicle boundaries before the standard locking screw. A rod is placed to connect the screws and stabilize the cervical segment.[2]

The success of this procedure is proportional to the knowledge of the region's content and the three-dimensional study of the pedicles of the cervical vertebrae by imaging examinations. It is a very complex surgery due to the small size of the pedicles and variability between individuals.[3, 4]

The size of the pedicle, the thickness of the cortical that composes its boundaries, and its angulation are relevant to the safety of using transpedicular screws. Cortical disruption during screw insertion can put noble structures such as the spinal cord, vertebral artery, and nerve roots at risk.[5]

According to the literature, the size of the screw used varies from 3.5 to 4.5 mm.[6] So the study of the morphometry of the pedicles of the cervical vertebrae is important to choose the ideal screw diameter. Still, a margin of 0.5 mm is recommended to avoid any possible injury.[7]

Despite the risks, transpedicular fixation at C7 is anatomically possible in most cases. The pedicles of C7 have larger dimensions than those of the more cranial levels. At C7, the vertebral artery has a path outside the transverse foramen in 95% of patients, making the procedure safer regarding the risk of arterial injury.[8-10]

Due to the importance of vertebral pedicle morphometry, the present study aims to measure the pedicles of C6 and C7 in Brazilian adult patients using CT scans.

METHODS

This is a retrospective study taken from the cervical spine CT scan database. CT scans of the cervical spine from the Hospital Santa Teresa radiology service from the urgency and emergency sector with a diagnosis of polytrauma were evaluated.

Exclusion criteria were previous cervical spine surgery, tumors, infections, ankylosing spondylitis, and other degenerative spine diseases. The inclusion criteria were patients over 18 and under 70 with no previous spinal diseases or surgeries.

The images were reconstructed using 2 mm slices for the axial plane and 3 mm for the sagittal and coronal planes. The reading and reproduction of the images and their reconstructions will be obtained using the imaging program OsiriX MD, version 7.0.2 (Pixmeo SARL, Bernex, Switzerland). The software has tools for linear and angular measurements and allows the simultaneous visualization of the three planes (sagittal, coronal, and axial) of the images.

The thickness (diameter) of the pedicles in the axial plane and the height of the pedicles in the sagittal plane were measured on the right side because previous studies have shown no significant difference between the sides.[8,11] Data were expressed as mean and standard deviation (±). The unpaired Student's t-test was used to compare the measurements between the patients.

For all statistical analyses, a p-value of less than 0.05 was considered significant. Statistical analysis was performed with the help of GraphPad software.

Prism 6.

RESULTS

The sample consisted of 200 scans, 100 males and 100 females. The average age of the male patients was

35±9 years and the mean age of the female patients was 41.7±13.9 years ($p = 0.0035$). In all, the overall mean age of the patients was 38.8±13.9 years.

In the entire sample, the average height of the C6 pedicle was 7.1±0.9 mm in the sagittal plane, and the thickness was 5.2±0.7 mm in the axial plane. The average height of the C7 pedicle was 7.8 ± 0.9 mm in the sagittal plane, and the thickness was 5.9 ± 0.8 mm in the axial plane.

In male patients, the mean height of the C6 pedicle was 7.5±0.8 mm in the sagittal plane, and the mean thickness was 5.5±0.7 mm in the axial plane. The average height of the C7 pedicle was 8.3 ± 0.7 mm in the sagittal plane, and the average thickness was 6.2 ± 0.8 mm in the axial plane.

In female patients, the mean height of the C6 pedicle was 6.6±0.8 mm, and the mean thickness was 4.9±0.6 mm. The average height of the C7 pedicle was 7.2 ± 0.8 mm, and the average thickness was 5.5 ± 0.6 mm.

There was a significant difference between the genders when comparing the data

referring to C6 (sagittal and axial) and C7 (sagittal and axial) ($p < 0.001$).

All this data is arranged in Table 1.

DISCUSSION

The present study analyzed the diameter and height of the pedicles of C6 and C7 using CT scans in a Brazilian population.

Pudles et al. (2014)[12] demonstrated that screw diameter is of greater importance than the seizure force of the screw in the vertebra; increasing screw diameter by 1mm increases the strength of fixation by 62-85% in the vertebra.

Sakamoto et al. (2004)[13] observed in axial sections that the C6 pedicle, in general, had a thickness of 6.7 mm, being on average greater in men (7.2 mm) than in women (6.1 mm), a statistically significant difference. Also, the authors reported in axial sections that the pedicle of C7 had a thickness of 7.4 mm overall and was greater in men (7.7 mm) than in women (7.0 mm) but without statistical significance.

Table 1. Averages (in mm and standard deviation±) of the measured pedicle values. The minimum and maximum values are in parentheses.

	Men		Women		All	
	C6	C7	C6	C7	C6	C7
Height	7,5±0,8 (5,3-9,4)	8,3±0,7 (5,9-9,8)	6,6±0,8 (4,6-8,7)	7,2±0.8 (5,7-9,2)	7,1±0,9 (4,6-9,4)	7,8±0,9 (5,7-9,8)
Thickness	5,5±0,7 (4,1-7,5)	6,2±0,8 (4,9-8,6)	4,9±0,6 (3,2-6,7)	5,5±0,6 (3,3-7,1)	5,2±0,7 (3,2-7,5)	5,9±0,8 (3,3-8,6)

*P value was less than 0.05 for all comparative analyses between genders.

Also, Koller et al. (2008)[8] observed no statistical differences between the sexes regarding mean pedicle thickness and height, nor differences regarding the side. The authors identified an average thickness of 5.9 mm for C6 and 6.63 mm for the pedicle of C7, an average height of 7.1 mm for the pedicle of C6, and 7.6 mm for the pedicle of C7.

Ruofu et al. (2008)[14] found a mean height for the pedicle of C6 and C7 of 6.9 mm and 7.2 in men and 6.7 mm and 6.9 mm in women, respectively. As for the thickness of the pedicles of C6 and C7, the authors observed an average of 5.8 mm and 6.7 mm in men and 5.4 mm and 6.3 mm in women, respectively. These measures showed no statistically significant differences.

The studies above conflict with the results, which showed significant differences between the sexes.

The study by Rao et al. (2008)[15] observed significant differences between the sexes. The authors found a mean height of 6.6 mm for the C6 pedicle in men and 5.6 in women and a mean thickness of 6.5 mm in men and 5.7 mm in women. The averages for the pedicle of C7 were: 7.0 mm high in men and 6.0 mm high in women, 7.6 mm thick in men, and 6.5 mm thick in women, which is in line with the present work.

Onibokun et al. (2009)[16] observed in 122 CT scans an average thickness of 5.77 mm and an average height of 6.6 mm for the C6 pedicle and an average thickness of 6.5 mm and an average height of 7.0 mm for the C7 pedicle. Larger values than those presented here. Furthermore, the authors also noted differences significant between the sexes.

On sagittal sections, Reinhold et al. (2007)[17] observed an average of 6.7 mm for the C6 pedicle and an average of 7.2 for the C7 pedicle. The authors did not differentiate the patients by sex.

The review by Chazono et al. (2012)[9] included studies of various ethnicities. It was considered that the values were different according to the population studied.[18] The authors,[9] however, demonstrated that there is no significant difference in pedicle thickness between distinct populations but that the pedicle thickness of C7 is the greatest and that it is thicker in men than in women, this difference being statistically significant in about 80% of the studies included in the review. Nevertheless, studies suggest that values extracted from other populations should be used cautiously as they may not be applicable on a universal scale.[19]

Chanplakorn et al. (2014)[11] observed in a Malaysian population that the thickness of C6 and C7 pedicles in the axial plane were 5.50 mm and 6.54 mm, respectively, while the average height of C6 and C7 pedicles in the axial plane was 5.90 mm and 6.83 mm, with no significant gender differences.

The study conducted by Herrero et al. (2016)[19] in a Brazilian sample demonstrated that the thickness of the pedicles of C6 and C7 was 5.4 mm and 6.4 mm, respectively. The pedicles of C6 and C7 were 6.5 mm and 7.1 mm. The authors noted significant differences between the sexes in that both the thickness and height of the pedicles of the males were greater. We notice slightly different data about the general average of the data presented in this study, which suggests heterogeneity of the Brazilian population regarding these measures.

Also, regarding C7, Teixeira et al. (2008)[20] observed a height of 6.2 mm, a mean value considerably lower than that found in the present study. The authors justify that transpedicular fixation at C7 is anatomically possible in most cases.

Our results showed that the pedicle could differ individually, so the screw diameter should be appropriate for each case. If the screw diameter is too large, fracture/explosion of the pedicle and damage to the neurovascular structures can occur. For this reason, the minimum dimensions of pedicle height and thickness need to be evaluated. For example, a 3.5 mm screw could not be considered for the whole sample since the minimum pedicle value of C6 and C7 in women was 3.2 mm and 3.3 mm, respectively (Table 1), without taking into account the safety margin of 0.5 mm.

Since the present study showed lower pedicle height and diameter values in women, transpedicular screw fixation is riskier in the female population. Based on these findings, preoperative CT evaluation is recommended before any fixation, and transpedicular screw fixation should be further analyzed in the female population.

CONCLUSIONS

It was observed in the sample studied that the height and diameter of the pedicles of C6 and C7 were smaller in the female population. Our results reinforced the need for adequate preoperative planning through imaging examinations for procedures involving the vertebral pedicle with careful preoperative choice of the transpedicular screw.

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

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