ONE OR TWO SCREWS IN THE FRACTURE OF THE ODONTOID PROCESS? EVALUATION USING COMPUTED TOMOGRAPHY

UM OU DOIS PARAFUSOS NA FRATURA DO PROCESSO ODONTOIDE? AVALIAÇÃO PELA TOMOGRAFIA COMPUTADORIZADA

UNO O DOS TORNILLOS EN LA FRACTURA DEL PROCESO ODONTOIDES? EVALUACIÓN POR TOMOGRAFIA AXIAL COMPUTADORIZADA

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ABSTRACT

Objective: To evaluate the bone area of the odontoid process through computed tomography and its relation with the area of one and two screws in the male and female subjects. Methods: 188 CT scans of adults were analyzed. The isthmus area was selected and the transverse diameter was measured at 1.2 mm from the base of odontoid. Results: After placement of a screw, the odontoid area remains with 82% of free bone for both men and women. With two screws, 45.6% of women, had a free bone area of the odontoid process between 50% and 75% and 54.4% were above 75%. 26.6% men had percentage from 50% to 75% of free bone area and 73.4% above 75% (p=0.07). After the placement of two screws, the bone area was, in average, 77.3% in men and 75.4% in women. Using the Student t-test, the differences between the average of percentage of free bone area in men and women are significantly lower in women (p=0.0012). Conclusion: The pre-operative planning through CT can help to choose the number of screws in the odontoid process. The choice should be particularly careful when using two screws in women.

Keywords: Odontoid process; Tomography, X-ray computed; Bone screws; Spine.

RESUMO

Objetivo: Avaliar a área óssea do processo odontoide, por meio de tomografia computadorizada e sua relação com a área de um e dois parafusos em indivíduos do sexo masculino e feminino. Métodos: Foram analisadas 188 tomografias computadorizadas de adultos. A área do istmo foi selecionada e o diâmetro transverso foi medido a 1,2 mm da base do odontoide. Resultados: Após a colocação de um parafuso, a área do odontoide permanece com 82% de osso livre, tanto para homens quanto para mulheres. Com dois parafusos, 45,6% das mulheres, passaram a ter área óssea livre do processo odontoide entre 50% e 75%, e 54,4% ficaram acima de 75%. Entre os homens este percentual foi de 26,6% entre 50% a 75% de área óssea livre e 73,4% acima de 75% (valor de p = 0,07). Após a colocação de dois parafusos, a área óssea foi, em média, 77,3% nos homens e 75,4% nas mulheres. Utilizando o teste t de Student, as diferenças entre as médias de homens e mulheres dos percentuais da área óssea livre são significativamente menores nas mulheres (valor de p = 0,0012). Conclusão: O planejamento no pré-operatório, por meio de TC, pode ajudar na escolha do número de parafusos no processo odontoide. A escolha deve ser criteriosa, especialmente quando for necessária a utilização de dois parafusos no gênero feminino.

Descritores: Processo odontoide; Tomografia computadorizada por raios X; Parafusos ósseos; Coluna vertebral.

RESUMEN

Objetivo: Evaluar el área ósea del proceso odontoides por medio de la tomografía axial computarizada, y su relación con el área de uno y dos tornillos en individuos del sexo masculino y femenino. Métodos: Fueron analizadas 188 tomografías axiales computarizadas de adultos. Se seleccionó el área del istmo y el diámetro transversal fue medido en 1,2 mm de la base del odontoides. Resultados: Después de la colocación de un tornillo, el área de la odontoides queda con 82% de hueso libre, tanto en hombres como en mujeres. Con dos tornillos, el 45,6% de las mujeres tuvieron área de hueso libre en el proceso odontoides entre el 50% y el 75%, y 54,4% estaban por encima del 75%. Entre los hombres este porcentaje fue del 26,6% desde el 50% al 75% de área de hueso libre y el 73,4% por encima del 75%, (p = 0,07). Después de la colocación de dos tornillos, el área de hueso fue, en promedio, el 77,3% de los hombres y el 75,4% de las mujeres. Utilizando la prueba t de Student, las diferencias entre las medias de hombres y mujeres del porcentaje de área de hueso libre son significativamente más bajos en las mujeres (p = 0,0012). Conclusión: La planificación prequirúrgica mediante TC puede ayudar a elegir el número de tornillos a usar en el proceso odontoides. La elección debe ser cuidadosa, especialmente cuando se utilizan dos tornillos en las mujeres.

Descriptores: Apófisis odontoides; Tomografía computarizada por rayos X; Tornillos óseos; Columna vertebral.

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INTRODUCTION

Fractures of the odontoid process are responsible for 50% to 60% of C2 fractures, 7% to 27% of cervical spine fractures, and 1% to 2% of all spine fractures.[1] These injuries are most often caused by the mechanism of hyperextension or hyperflexion.[2-4] Odontoid fractures classified as type II by the Anderson and d'Alonso classification system are the most common fractures of the cervical spine, accounting for between 65% and 74% of these traumas, mainly in the geriatric population, and are often the result of low-energy traumas.[5,6]

Treatments of odontoid process fractures include anterior and posterior stabilization techniques. Anterior fixation is widely used as a treatment option for fractures classified as types II and III, maintaining the capacity for movements of rotation between segments C1 and C2.[7,8]

According to the literature, there is still controversy between the surgical treatment options of fixation with one or two screws.[8-11] Computed tomography reconstruction helps determine the measurements of the diameter and length of the odontoid process and assesses the bone quality. This enables preoperative planning of the length and number of screws required.[6] However, morphological studies suggest that in a large number of patients, the dimensions of the odontoid process are insufficient to accommodate two screws of 3.5 mm in diameter and that, therefore, only one screw is ideal.[10]

The objective of this study is to evaluate the bony area of the odontoid process by means of computed tomography and its relationship to the area of one and two screws in both male and female patients.

MATERIAL AND METHODS

During the period January 2014 to February 2015, 188 computed tomographies (CT) from the archives of the Hospital Santa Teresa, Petrópolis, Rio de Janeiro, were analyzed. All the exams were performed with the SOMATON Emotion 6 (Siemens Medical System) multichannel tomography device with the patient in the supine position and the neck in hyperextension, using a protocol of 1.25 mm thickness, collimation of 1.0 mm, with an increment of 0.8 mm. The slices were acquired in spiral mode, with coverage of 15 cm in 27 seconds, followed by multiplane reconstruction (MPR) of the odontoid process in the axial, sagittal, and coronal planes using a b-60 filter (moderate bone). The technique used was 130 KV 150 mAs. The exams were performed in a bone window (W 1500, L 450). These exams were analyzed based on the archives of the Radiology Service of the Hospital Santa Teresa and were performed for reasons other than odontoid fractures. None of the patients in this study underwent surgery. Only the areas of the screw in the odontoid were analyzed via tomography. For this reason, the Informed Consent Agreement was not used, nor was approval of the Ethics Committee required.

The exclusion criteria were computed tomographies of patients aged under 18 years of age, patients with degenerative changes that could interfere with the measurements, those with congenital changes, those with fractures of the odontoid process, and those with chronic inflammatory disease of the cervical spine. The area of the isthmus was selected because it is the most common region for fractures. The transverse diameter of the isthmus was measured 1.2 mm from the base of the odontoid. (Figure 1) The measurements, including the two external cortices of the odontoid process, were taken using the digital visualization ruler of the computer for reconstruction in the axial and frontal planes. For each patient, the area occupied by the screw with a radius of R_P =1,75 mm (diameter of 3.5 mm) was calculated as $AP = \pi.R_p^2$. The isthmus was estimated as a circular surface and the transverse measurement was established as the diameter of this surface. The area of the surface of the isthmus was calculated as $A_i = \pi.R_i^2$, where R_i is the radius of the isthmus, i.e., half of the transverse measurement. The percentages of the area of the odontoid process in the isthmus following the placement of one screw (S_1) and following the placement of two screws (S_2) were defined as:

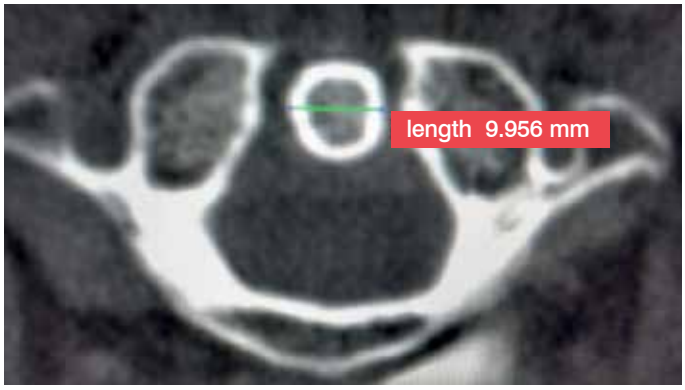

Figure 1. Image of a tomographic cut measuring the odontoid process.

$$S_1 = \frac{A_i - A_p}{A_i} \cdot 100 \quad \text{and} \quad S_2 = \frac{A_i - 2A_p}{A_i} \cdot 100$$

None of the tomographs showed fractures of the cervical spine. The areas of one and two 3.5 mm screws were measured in the odontoid of each tomography and separated into male and female groups.

Statistical methodology

For the characterization of the sample and the analysis of the behavior of these variables, the data were synthesized by means of descriptive statistics and frequency distributions. In the inferential analysis, the significance of differences in the classifications of percentages between groups was investigated using the Chi-square test. In the quantitative inferential analysis, the distribution normality hypothesis was verified by the Kolmogorov-Smirnov test. Once normal distribution was confirmed, the independent groups were compared using the Student's t-test. The equality of variances needed to perform the Student's t-test without correction was evaluated by the Levene test. All discussions were conducted taking a maximum level of significance of 5% (0.05) into account, i.e., the following decision rule was adopted in the tests: always reject the null hypothesis when the p-value associated with the test is less than 0.05.

RESULTS

The percentages of free bone area in the odontoid process following placement of one screw remains at 82% in both men and women. With two screws, bone loss was greater, especially in women (with less bone area). Table 1 shows that among the women, 45.6% ended up having a free odontoid process bone area of between 50% and 75% and 54.4% had greater that 75%. Among the men the percentages were 26.6% with between 50% and 75% and 73.4% with more than 75%, a figure statistically significant when we used the Chi-square test (p-value = 0.07).

Table 1. Percentages of odontoid process bone area after the placement of two screws.

p-value 0.007	Gender		Total
	Female	Male	
From 50% to 75%	36 (45.6%)	29 (26.6%)	65 (34.6%)
Higher than 75%	43 (54.4%)	80 (73.4%)	123 (65.4%)
Total	79 (100%)	109 (100%)	188 (100%)

Source: Hospital Santa Teresa, Petrópolis/RJ.

Table 2 shows the distribution by sex of the percentages of odontoid process bone after placement of one and two screws.

With the placement of one screw, the average bone area was 88.6% in the men and 87.7% in the women. The mean for the women is also lower. Figure 2 shows the distributions of these values across the sample. As the graph shows, despite two discrepancies in the distribution of the percentages in the group of males, the distribution of the values is quite homogeneous for both sexes (the coefficient of variation is very low, equal to 0.02). When compared by the t-test, we observed that there is a significant difference between the average percentages of the area of the odontoid process of the men and the women after placement of one screw, and the average area is significantly less in the women (p-value = 0.0012). In fact, the confidence intervals for the averages of the two groups do not intersect.

Table 2. Distribution of the percentages of the area of the odontoid process following the placement of one and two screws, by sex.

Statistics	Percentage of free bone area with one screw		Percentage of free bone area with two screws	
	Men	Women	Men	Women
Average	88.6	87.7	77.3	75.4
Confidence interval for the average	(88.3; 89.0)	(87.3; 88.1)	(76.5; 78.0)	(74.5; 76.2)
Mean	88.8	87.9	77.6	75.8
Standard deviation	2.0	1.9	4.0	3.8
Minimum	83.0	82.7	66.1	65.4
Maximum	92.5	92.1	85.0	84.2
Variation between the minimum and the maximum	9.5	9.4	19.0	18.8
Coefficient of variation	0.02	0.02	0.05	0.05
p-value of normality test	0.060	0.200	0.060	0.200
p-value of Student's t-test compared by sex	0.0012		0.0012	

Source: Hospital Santa Teresa, Petrópolis/RJ.

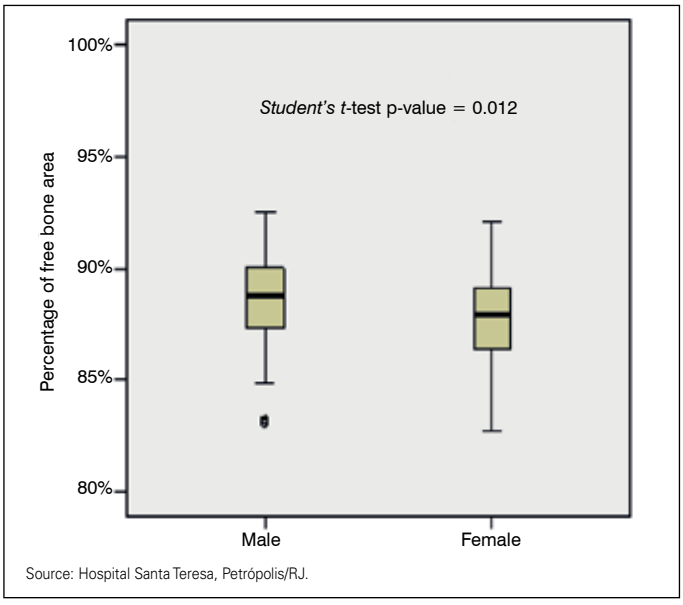

Figure 2. Distribution by sex of the percentages of the area of the odontoid process following placement of one screw.

When the distribution of the percentage of the area of the odontoid process after the placement of two screws was analyzed, the average bone area was 77.3% in men and 75.4% in women. The mean was also less for the women.

Figure 3 shows two discrepancies in the distribution of the percentage values in the male group, but in both groups the distribution of the values is quite homogeneous (the coefficient of variation is very low, equal to 0.05). When compared by the t-test, we observed that there is a significant difference, albeit a small one, between the average percentages of the area of the odontoid process of the men and the women after placement of two screws, and the average area is significantly less in the women (p-value = 0.0012). In fact, the confidence intervals for the averages of the two groups do not intersect.

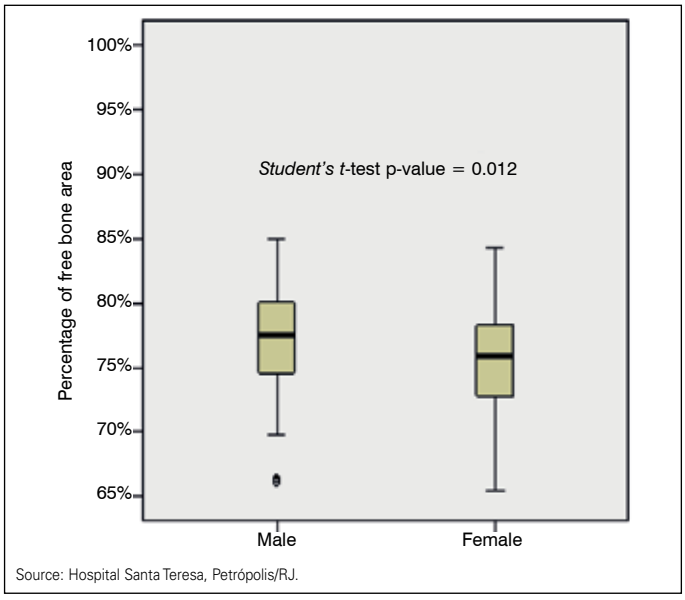

Figure 3.. Distribution by sex of the percentages of the area of the odontoid process following placement of two screws.

DISCUSSION

In this study, we analyzed the area of the odontoid process by means of CT in both males and females following the use of one or two screws.

There are various studies in the literature that assess the morphology of the odontoid process.[12] Daher et al.[12] studied the morphometry of the odontoid process in the Brazilian population using CT and measuring the lesser diameter in sagittal and transversal reconstructions. They reported a diameter of < 9 mm in the transverse plane in 30% of the population.

Fixation with screws in the anterior region of the cervical spine has become the treatment of choice, particularly in odontoid process fractures.[13-15] This technique provides immediate stabilization, restores the C1-2 joint, and preserves function, particularly rotation. In addition, fixation with a screw in the anterior region in a fracture of the odontoid process achieves high rates of consolidation with few complications, especially in young patients (< 60 years of age). Soejima et al.[16] showed that CT is useful in measuring the transverse diameter of the odontoid process, and that fixation with two 3.5 mm cortical screws would be possible in most of the men and women analyzed.

Although screws are used in the anterior region of C2 to treat type II fractures of the odontoid process, fixation with one or two screws is still widely discussed. Anterior fixation of the odontoid process with screws was originally described using two screws.[17] Later, biomechanical studies conducted in cadavers and clinical studies comparing the use of one or two screws demonstrated that there are no clinical, biomechanical, or radiographical differences in relation to the screws. Anatomical studies have shown that a minimum transverse diameter of 9 mm is required to accommodate two 3.5 mm

screws. However, radiographic investigations have reported that 66% of patients do not have this diameter.[18] Dantas et al.[19] used only a single cannulated screw, considering that the risk of introducing a second screw outweighs its benefits.

Recent studies point out that fixation with two screws has high consolidation rates and increased rigidity when the cervical spine undergoes an extension load.[20,21] Furthermore, fixation with two 3.5 mm screws (versus one 4.0 mm screw) offers a large area for perforation of the cortical bone on top of the odontoid that increases the fixation, especially in osteoporotic patients. However, estimating the available space is a prerequisite for the utilization of two screws.[6] Chang et al.[22] reported that Herbert's use of one 4.5 mm cannulated screw to stabilize type II fractures of the odontoid process increases torsional rigidity as compared to the use of two 3.5 mm screws in the anterior region of the odontoid process.

This study demonstrated that the bone area of the odontoid process following the placement of one screw remains at 82% of free bone, both in men and in women. With two screws, the bone loss is greater, especially in women, who have a smaller area: 45.6% of the women had an odontoid process bone area between 50% and 75%, and 54.4% had more than 75%. Among the men, only 26.6% had an odontoid process bone area between 50% and 75%, and 73.5% had more than 75%, a frequency significantly lower than that of the women (p-value = 0.07).

When we analyzed the distribution of the percentages of bone area of the odontoid process with one screw by sex, the average was 88.6% in the men and 87.7% in the women. However, when the average percentages of the area of the odontoid process in men and women were compared by the Student's t-test, we observed that the difference between the averages, though small, was significant (p-value = 0.0012). We concluded that the average bone area is significantly smaller in the women following placement of one screw. Similarly, when the distribution of the percentages of the bone area of the odontoid process was analyzed following the placement of two screws, the average was 77.3% in the men and 75.4% in the women. When the percentages of the area of the odontoid process in the men and in the women were compared by the Student's t-test, we observed that the difference between the averages, though small, was significant (p-value = 0.0012). We concluded that following the placement of two screws, the average free bone area is significantly smaller in the women.

CONCLUSION

This study demonstrated that preoperative planning using CT can assist in making a decision about the number of screws to use in the odontoid process. The decision on whether to use two screws in female patients must be carefully made.

All authors declare no potential conflict of interest concerning this article.

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