STUDY OF VARIATION OF THE DIAMETER OF THE SPINAL CANAL AND THE FORAMINA IN SPONDYLOLISTHESIS

ESTUDO DA VARIAÇÃO DO DIÂMETRO DO CANAL E DOS FORAMES VERTEBRAIS NA ESPONDILOLISTESE

ESTUDIO DE LA VARIACIÓN DEL DIÁMETRO DEL CANAL Y DE LOS FORÁMENES VERTEBRALES EN ESPONDILOLISTESIS

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ABSTRACT

Objective: To define and quantify the degree of change of the spinal canal diameter in patients with degenerative and spondylolytic spondylolisthesis. Methods: We studied CT scans of 54 patients. Of this total, 37 (29 women and 8 men) had degenerative type and 17 (7 women and 10 men) had spondylolytic type. Results: In the degenerative spondylolisthesis group, the average diameter of the spinal canal at the injured vertebra level was 17.35 mm and 17.64 mm for the upper vertebra level. The average diameter of the foramen at the level of the affected vertebra was 14.61 mm to left side and 15.00 mm to the right side. The average diameter of the foramen at the upper vertebra level was 16.82 mm to the left side and 16.51 mm to the right side. In the spondylolytic group, the average diameter of the spinal canal at the level of the affected vertebra was 23.25 mm and at the upper vertebra level was 18.66 mm. The average diameter of the foramen at the level of the affected vertebra was 11.98 mm to the left side and 12.34 mm to the right side. The average diameter of the foramen at the level of the upper vertebra was 16.97 mm to the left side and 15.58 mm to the right side. Conclusion: The diameter of the spinal canal in the sagittal plane showed no statistically significant increase in the spondylolytic spondylolisthesis group, in contrast to what is found in the degenerative spondylolisthesis group. It was also observed a reduction in vertebral foramina of the injured level in both groups.

Keywords: Spondylolisthesis; Spinal stenosis; Spinal canal.

RESUMO

Objetivo: Definir e quantificar o grau de alteração do diâmetro do canal vertebral em pacientes portadores de espondilolistese degenerativa e espondilolítica. Métodos: Tomografias de 54 pacientes foram estudadas. Desse total, 37 (29 mulheres e 8 homens) apresentavam o tipo degenerativo e 17 (7 mulheres e 10 homens) apresentaram o tipo espondilolítico. Resultados: No grupo de espondilolistese degenerativa, o diâmetro médio do canal no nível da vértebra lesada foi 17,35 mm e 17,64 mm no nível da vértebra superior. O diâmetro médio do forame no nível da vértebra lesada foi 14,61 mm à esquerda e 15,00 mm à direita. O diâmetro médio do forame no nível da vértebra superior foi 16,82 mm à esquerda e 16,51 mm à direita. No grupo espondilolítico, o diâmetro médio do canal no nível da vértebra lesada foi 23,25 mm e no nível da vértebra superior foi 18,66 mm. O diâmetro médio do forame no nível da vértebra lesada foi 11,98 mm à esquerda e 12,34 mm à direita. O diâmetro médio do forame no nível da vértebra superior foi 16,97 mm à esquerda e 15,58 mm à direita. Conclusão: O diâmetro do canal vertebral no plano sagital não apresentou aumento estatisticamente significante no grupo espondilolistese espondilolítica, ao contrário do que se observou no grupo espondilolistese degenerativa. Observou-se também a redução dos forames no nível da vértebra lesada em ambos os grupos.

Descritores: Espondilolistese; Estenose espinal; Canal vertebral.

RESUMEN

Objetivo: Definir y cuantificar el grado de cambio del diámetro del canal espinal en pacientes con espondilolistesis degenerativa y espondilolítica. Métodos: Hemos estudiado las TC de 54 pacientes. De este total 37 (29 mujeres y 8 hombres) tenían el tipo degenerativo y 17 (7 mujeres y 10 hombres) tenían el tipo espondilolítico. Resultados: En el grupo espondilolistesis degenerativa, el diámetro medio del canal en el nivel de la vértebra lesionada fue 17,35 mm y 17,64 mm para el nivel de la vértebra superior. El diámetro medio del foramen en el nivel de la vértebra lesionada fue 14,61 mm a la izquierda y 15,00 mm a la derecha. El diámetro medio del foramen en el nivel de la vértebra superior fue 16,82 mm a la izquierda y 16,51 mm a la derecha. En el grupo espondilolítico, el diámetro medio del canal en el nivel de la vértebra lesionada fue 23,25 mm y en el nivel de la vértebra superior fue 18,66 mm. El diámetro medio del foramen en el nivel de la vértebra lesionada fue 11,98 mm a la izquierda y 12,34 mm a la derecha. El diámetro medio del foramen en el nivel de la vértebra superior fue 16,97 mm a la izquierda y 15,58 mm a la derecha. Conclusión: El diámetro del canal vertebral en el plano sagital no mostró ningún aumento estadísticamente significativo en el grupo espondilolistesis espondilolítica, contrariamente a lo que se observó en el grupo espondilolistesis degenerativa. También se observó reducción en los forámenes vertebrales en el nivel lesionado en ambos grupos.

Descriptores: Espondilolistesis; Estenosis espinal; Canal Vertebral.

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INTRODUCTION

Anterior or posterior slippage of one spinal segment to the detriment of an adjacent segment is called spondylolisthesis. Herbineaux, a Belgian obstetrician, is credited with the first description of spondylolisthesis when, in 1782, he noted a bony prominence in front of the sacrum that caused problems in delivery. The term was used by Kilian in 1854 and is derived from the Greek *spondylos* (vertebra), *olisthesis* (slippage), and *schisis* (breakage).[1,2]

The incidence of spondylolisthesis and its predominance by sex both vary by age group. The etiology is debated, with numerous theories having been proposed, among which trauma and dysplasia stand out. It has great clinical significance for its prevalence as one of the main causes of lower back pain in adolescents.

It can be accompanied by a fracture of the *pars articularis* and appears to result from a stress fracture, which occurs in children with a genetic predisposition for the disease, given that the defect was not noticed at birth, or in chronically bedridden patients. In a classic study published in 1976, a widely used classification system based on etiology and comprised of five types was established.[3] The degenerative and isthmic types are the most commonly observed forms in this classification system.[4-8] The degenerative type is more prevalent in females in the older age groups, while in the isthmic type, this relationship is inverted, with young males being the main group affected.[9,10]

The Meyerding classification quantifies the anterior translation of the superior vertebral body. The calculation is based on the percentage of displacement of the damaged vertebra on a scale from I to V.

The anterior displacement of the vertebral body, together with the posterior displacement of the posterior arc of the inferior vertebra, promote an increase in the anteroposterior diameter of the spinal canal, and in the most severe cases a "double canal" aspect may be encountered. [2,11,12]

Currently, the proper treatment of spondylolisthesis is controversial and depends on the degree of slippage and on the symptoms presented. In many publications, the presence of a neurological deficit is the most precise indication for surgical treatment, which involves the decompression of the affected nerve root.[4]

MATERIALS AND METHODS

Fifty-seven tomographs of patients diagnosed with the two most common types of spondylolisthesis, isthmic and degenerative, were referred by spine surgeons to an imaging study clinic for study and vertebral analysis. Three cases were excluding for lack of data. The study was approved by the Institutional Review Board as number CAA:13736413.1.0000.5138.

Of these 54 patients, 37 (29 women and 8 men) had the degenerative form of the disease and 17 (7 women and 10 men had the spondylolytic form.

The vertebral canal and the foramens of the slipped vertebra and of the adjacent superior vertebra were measured. (Figures 1 and 2)

First, an exploratory analysis was conducted with the goal of characterizing the patient sample using the frequency distributions for the qualitative variables and descriptive measurements (average, standard deviation) for the quantitative variables.

Contingency tables were used to associate the type of listhesis variable (degenerative and spondylolisthesis) with the clinical variables of interest. Pearson's chi-squared test or Fisher's exact test were used to test the statistical significance of the association between these variables.

For the evaluation of the differences between the diameters of the damaged vertebra and the vertebra above it, we used the Wilcoxon non-parametric test, which is applied when there is a comparison of measurements of a continuous variable between two paired groups. This test was applied to the measurements of both groups.

The research data were processed using the PASW Statistics, version 18. In all the statistical tests performed, a 5% significance level was used, whereby associations with values of p less than 0.05 are considered to be statistically significant.

Figure 1. Example of the measurement of the vertebral canal.

Figure 2. Example of the measurement of the vertebral foramen from the right.

RESULTS

Among the 37 patients with degenerative spondylolisthesis included in the study, 29 (78.4%) were women and 8 (21.6%) were men.

As regards the level of the vertebra, displacement of L4 was prevalent in 67.6% of the patients in the degenerative group, while displacement at level L5 was observed in 29.7% of the sample.

It was also confirmed that all patients (100%) in this group had discoarthrosis.

Facet and arthritic changes were observed in 34 (91.9%) patients with degenerative spondylolisthesis.

Among the 17 patients with the spondylolytic type included in the study, 7 (41.2%) were women and 10 (58.8%) were men.

In terms of the vertebral level, L5 was most the most affected, at 82.4%, while L4 was affected in 17.2% of the sample.

It was also confirmed that most of the patients (82.4%) did not have discoarthrosis, but it was present in 17.6% of the patients.

Facet and arthritic changes were absent in all 17 patients.

The data obtained from the sample showed that 76.5% had slippage identified as grade 1 or grade 3 while 17.6% had grade 2 slippage.

No statistically significant correlation between the type of listhesis and the degree of the slippage was observed.

The ages of the degenerative group ranged from 45 to 94 years with an average of 66.3 years of age. (Table 1)

The average diameter of the canal was 17.35mm at the level of the damaged vertebra and 17.64mm at the level of the superior vertebra.

The average diameter of the left foramen at the level of the damaged vertebra was 14.61mm. The average diameter of the right foramen at the level of the damaged vertebra was 15.00mm.

The average diameter of the left foramen at the level of the vertebra above the damaged vertebra was 16.82mm, and that of the right foramen was 16.51mm. (Table 2)

The ages of the spondylolytic group ranged from 10 to 64 years.

The average diameter of the canal at the level of the damaged vertebra was 23.25mm and at the level of the superior vertebra was 18.66mm.

The average diameter of the left foramen at the level of the damaged vertebra was 11.98mm. The average diameter of the right foramen at the level of the damaged vertebra was 12.34mm.

The average diameter of the left foramen at the level of the vertebra above the damaged vertebra was 16.97mm, and that of the right foramen was 15.88mm. (Table 3)

Table 4 shows the results of the comparison of the diameters of the damaged vertebra and the superior vertebra by type of listhesis.

In the group of spondylolytic patients, the diameter of the canal of the damaged vertebra was greater than that of the superior vertebra.

We observed a mean left foramen diameter of 14.54mm at the level of the damaged vertebra in the degenerative group, while that of the superior vertebra was 16.5mm. A comparison of these two instances yields an increase in diameter of approximately 13.5%.

This increase is even more evident in the spondylolytic group when the left foramen of the damaged vertebra is compared to that of the superior vertebra, representing an increase in diameter of approximately 31.3%.

In the degenerative group, the mean diameter of the right foramen was 15.16mm for the damaged vertebra and 16.54mm for the superior vertebra, representing an approximate increase of 9.1% compared to the damaged vertebra.

This increase is greater in the spondylolytic group in a comparison of the right foramens of the damaged and superior vertebrae, with an increase in the diameter of approximately 15.2%.

Table 1. Frequency distribution of the 37 degenerative-type patients and the 17 spondylolytic-type patients by clinical and demographic characteristics.

Variables	Degenerative		Spondylolytic		P-value
	N	%	N	%	
Sex					
Female	29	78.4	7	41.2	0.012
Male	8	21.6	10	58.8	
Degree of slippage					
Grade 1	34	91.9	13	76.5	0.283
Grade 2	2	5.4	3	17.6	
Grade 3	1	2.7	1	5.9	
Vertebra					
L3	1	2.7	0	0	0.001
L4	25	67.6	3	17.6	
L5	11	29.7	14	82.4	
Discoarthrosis					
No	0	0	14	82.4	0.000
Yes	37	100	3	17.6	
Facet and arthritic changes					
No	3	8.1	17	100	0.000
Yes	34	91.9	0	0	
Total	37	100	17	100	

Note: p-value: descriptive level of the chi-squared test

DISCUSSION

The increase in the anteroposterior diameter of the canal at the level of the defect can be seen as the result of both the anterior displacement of the vertebral body in relation to the posterior elements and the posterior displacement of the neural arc of the vertebrae above and below the damaged vertebra.[2] Although there

Table 2. Descriptive statistics of the 37 degenerative-type patients by clinical and demographic characteristics.

Variables	Descriptive measurements						
	Average	SD	Min	Max	P25	Mean	P75
AGE	66.35	9.43	45.00	94.00	60.50	68.00	71.00
SDDV	17.35	1.64	14.06	20.93	16.01	17.15	18.83
SDSV	17.64	1.86	13.90	22.52	16.10	17.57	18.79
DLFDV	14.61	2.83	8.69	20.74	13.12	14.54	16.13
DLFSV	16.82	2.57	12.63	23.09	14.62	16.50	19.08
DRFDV	15.00	2.50	9.54	19.85	13.46	15.16	16.81
DRFSV	16.51	2.03	12.04	20.05	15.44	16.54	18.20

Note: SDDV – sagittal diameter of the damaged vertebra; SDSV – sagittal diameter of the superior vertebra; DLFDV – diameter of the left foramen of the damaged vertebra; DLFSV – diameter of the left foramen of the superior vertebra; DRFDV – diameter of the left foramen of the damaged vertebra; DRFSV – diameter of the right foramen of the superior vertebra

Table 3. Descriptive statistics of the 17 spondylolytic-type patients by clinical and demographic characteristics.

Variables	Descriptive measurements						
	Average	SD	Min	Max	P25	Mean	P75
AGE	38.06	14.23	10.0	64.0	27.50	41.0	47.50
SDDV	23.25	5.22	14.83	35.79	20.72	22.75	25.06
SDSV	18.66	2.78	14.07	23.58	15.81	18.77	20.72
DLFDV	11.98	3.62	5.69	18.21	9.56	12.39	14.72
DLFSV	16.97	3.02	12.80	23.55	14.23	16.27	18.84
DRFDV	12.34	3.83	4.37	16.91	9.68	13.21	15.53
DRFSV	15.58	2.86	9.09	21.50	13.80	15.22	17.68

Note: SDDV – sagittal diameter of the damaged vertebra; SDSV – sagittal diameter of the superior vertebra; DLFDV – diameter of the left foramen of the damaged vertebra; DLFSV – diameter of the left foramen of the superior vertebra; DRFDV – diameter of the left foramen of the damaged vertebra; DRFSV – diameter of the right foramen of the superior vertebra

Table 4. Evaluation of the values of the diameters of the damaged vertebra and the superior vertebra by type of listhesis.

Clinical Variables	Group	Mean		P-value	Conclusion
		Damaged Vertebra	Superior Vertebra		
Diameter of the Canal	Degenerative	17.15	17.57	0.301	SDDV = SDSV
	Spondylolytic	22.75	18.77	0.003**	SDDV > SDSV
Diameter of the Left Foramen	Degenerative	14.54	16.5	0.000**	DLFDV < DLFSV
	Spondylolytic	12.39	16.27	0.002**	DLFDV < DLFSV
Diameter of the Right Foramen	Degenerative	15.16	16.54	0.010**	DRFDV < DRFSV
	Spondylolytic	13.21	15.22	0.025*	DRFDV < DRFSV

Note: - The probabilities of significance (p-value) are in reference to the Wilcoxon test – The significant results were identified with asterisks according to the level of significance, namely: p-value < 0.01** (99% confidence level) and p-value < 0.05 * (95% confidence level) Source: Study data

is consensus in the literature around the increase in the diameter of the vertebral canal in spondylolytic spondylolisthesis, we did not find any quantitative evaluation of the degree of the increase, or the relationship between this increase to the degree of slippage, as defined by the Meyerding classification.[6]

In terms of any linkage between the type of listhesis and discoarthrosis in the patients, we observed that these variables are interdependent. This is supported by the fact that 100% of the degenerative group patients had discoarthrosis in contrast to 82.4% of the spondylolytic group patients who did not present discoarthrosis. (Table 1)

Regarding the type of listhesis and the vertebra affected, we observed a dependency between these variables and the p-value was less than 0.05. This is due to the fact L4 was involved in 67.6% of the degenerative group whereas 82.4% of the spondylolytic group were affected in L5. (Table 1)

Facet changes were present only in the degenerative group.

The pertinent results from a comparison of the values of the diameters of the damaged vertebra and the superior vertebra showed that patients in both the degenerative and spondylolytic groups had smaller foraminal diameters in the vertebra at the damaged level. There was no statistical difference between the diameter of the vertebral canal at the damaged level and the vertebral canal at the superior level. (Table 4)[9-11]

Considering that this work prioritized the study of bone measurements, an opportunity is open for new studies that include the "soft tissues" and allow higher accuracy in measuring the real variation in the sagittal and transverse diameters of the vertebral canal.

CONCLUSION

We concluded that there was a statistically significant increase in the diameter of the canal in the sagittal plane in the spondylolytic group that was not observed in the group with degenerative spondylolysis. We also observed a reduction in the foramens at the damaged level in both groups.

All the authors declare that there are no potential conflicts of interest regarding this article.

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