



Original Article

Densitometric study of the clavicle: bone mineral density explains the laterality of the fractures^{☆,☆☆}



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ABSTRACT

Introduction: Epidemiological studies have shown laterality in clavicle fractures, such that the left side is more frequently fractured. The present study had the aim of evaluating whether the clavicle on the dominant side is denser and thus explaining the greater incidence of fractures on the non-dominant side.

Materials and methods: This was a descriptive study on 52 healthy patients, who were classified according to age, sex and whether the dominant or non-dominant side was affected. **Results:** The participants comprised 28 women (53.8%) and 24 men (46.2%). Regarding the dominant side, 30 were right-handed (57.7%) and 22 were left-handed (42.3%). The mean age was 25 years. In this study, it could be seen that the non-dominant side had greater bone mass than the dominant side. It was also observed that the bone density was greater in the middle and distal thirds on the non-dominant side, with a statistically significant difference. In the women, the density was also greater on the non-dominant side; this difference was not significant in relation to the dominant side, but there were significant differences between the middle thirds ($p < 0.001$) and the distal thirds ($p < 0.006$).

Conclusion: Variations in bone density, toward higher and lower bone mass, may have been responsible for the fractures. According to the findings from this study, fractures occur more in the middle third of the non-dominant clavicle, as a result of greater bone mineral mass, which gives rise to lower flexibility and fractures in the region.

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Estudo densitométrico da clavícula: a densidade mineral óssea explica a lateralidade das fraturas

R E S U M O

Palavras-chave:
Densitometria
Fratura óssea
Fisiopatologia
Clavícula

Introdução: Estudos epidemiológicos mostram uma lateralidade nas fraturas da clavícula, com o lado esquerdo mais frequentemente fraturado. O presente estudo tem como finalidade avaliar se a clavícula do lado dominante é mais densa e explicar, dessa forma, a maior incidência de fraturas no lado não dominante.

Material e métodos: Estudo descritivo de 52 pacientes hígidos, classificados quanto a idade, sexo e lado dominante ou não.

Resultados: Fizeram parte deste estudo 28 mulheres (53,8%) e 24 homens (46,2%); em relação ao lado dominante, 30 eram destros (57,7%) e 22, canhotos (42,3%); a idade média foi de 25 anos. Neste estudo, foi possível constatar que o lado não dominante teve maior massa óssea quando comparado ao lado dominante. Também observamos que a densidade óssea foi maior nos terços médios e distais no lado não dominante, com diferença estatisticamente significativa. Nas mulheres, a densidade também foi maior no lado não dominante; essa diferença não foi significativa quando comparado com o lado dominante, porém foi significativamente diferente entre os terços médio ($p < 0,001$) e distal ($p < 0,006$).

Conclusão: As variações da densidade óssea, tanto com maior como com menor massa óssea, podem ser responsáveis pelas fraturas. De acordo com os achados deste estudo, as fraturas ocorrem mais no terço médio da clavícula não dominante, em decorrência de uma maior massa mineral óssea, o que acarretaria uma menor flexibilidade da região e as fraturas.

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Introduction

Changes in therapeutic methods for clavicle fractures have led to epidemiological studies conducted more frequently.¹⁻³ Classically, conservative treatment was used with excellent results. However, some fracture patterns have been shown to be problematic with conservative treatment, independent of the management used. Thus, new studies have emerged, outlining the epidemiological profile and management of clavicle fractures.⁴

Clavicular fractures account for approximately 5% of all patients with fractures admitted to emergency services.⁵ Male children and adolescents up to the age of 20 years are the group most likely to suffer this type of fracture, and its incidence decreases with increasing age. Among female patients, the incidence is greatest during the adolescent years and diminishes in subsequent decades, but then increases again in old age.^{6,7}

In an epidemiological study conducted in Sweden, on 535 fractures of the clavicle alone, greater frequency was observed on the left side (60.7%) than on the right side (49.3%) and this difference was statistically significant. It is known that different bone densities may cause fractures.⁸⁻¹¹ Pycnodysostosis is a syndrome characterized by bone fragility and fracturing due to diffusely increased bone density. Osteoporosis, on the other hand, is a disorder characterized by diminished bone mass and increased risk of fractures.^{12,13}

This study has the aims of evaluating clavicular bone mineral density between the dominant and non-dominant sides and evaluating bone mineral mass in the middle and lateral thirds of the clavicle, so as to ascertain whether different bone

mineral densities could explain certain epidemiological characteristics of fractures of the clavicles.

Materials and methods

This was a cross-sectional study conducted in the imaging department of our hospital between May and June 2007 and between January and May 2012. Densitometric examinations were performed on both clavicles in a sample of 52 patients, comprising 24 males (eight left-handed and 16 right-handed) and 28 females (14 left-handed and 14 right-handed). The examinations were performed using bone densitometry apparatus and were analyzed by means of the Dual Femur software, adapted for the clavicle.

All university students aged between 20 and 30 years who were in a healthy condition were eligible for inclusion in the study. Professional athletes, individuals with previous clavicular fractures (whether congenital or not), individuals with osteometabolic diseases, cases of brachial plexus injury, ambidextrous individuals and cases of any orthopedic disorder that affects the shoulder were excluded.

The individuals analyzed were chosen by means of a questionnaire (Annex 1), which was applied before the densitometric examination on the clavicle, in order to assess whether potential subjects met the inclusion and exclusion criteria. All participants agreed with the free and informed consent statement. Following this, the population underwent bone densitometry examinations on the middle and distal thirds of both clavicles. One copy of the bone densitometry examination results was given to the research subject and

another was stored for subsequent studies. This had been laid out in the consent statement.

In this study, the nonparametric Wilcoxon test was used, with a significance level of 5%. To view the results obtained, boxplot graphs were used.

This study was approved by our institution's Research Ethics Committee, under protocol number 2006-064H.

Results

Among the 52 patients who underwent the densitometry examination on the clavicle, 24 (46.2%) were male and 28 (53.8%) were female. In relation to the dominant side, 30 were right-handed (57.7%) and 22 were left-handed (42.3%) (Table 1). The patients analyzed were between 20 and 30 years of age (mean age of 25 years).

Among these 52 university students who underwent the examination, the bone mineral density of the clavicle was greater on the non-dominant side, i.e. among the right-handed individuals, the bone mineral density was greater in the left clavicle than in the right clavicle; while in the left-handed individuals, the density was greater in the right clavicle than in the left clavicle. This difference between the dominant and non-dominant sides was statistically significant ($p < 0.001$), with greater density on the non-dominant side (Table 2).

Among the men, there was a statistically significant difference between the dominant and non-dominant sides both in the middle third ($p = 0.028$) and in the distal third ($p = 0.010$) of the clavicle, with greater density on the non-dominant side (Table 2). There was also a statistically significant difference between the middle and distal thirds, both on the dominant side ($p = 0.003$) and on the non-dominant side ($p = 0.002$). The middle third presented higher values in both clavicles (Figs. 1 and 2).

In the women, the dominant side had greater density, but there was no statistically significant difference between the dominant and non-dominant sides. There was only a difference between the middle thirds ($p = 0.001$) and between the distal thirds ($p = 0.006$). The middle thirds presented higher values (Table 2 and Figs. 1 and 2).

In general, we can affirm that the clavicle on the non-dominant side presented significantly greater values than shown by the clavicle on the dominant side, in the distal third ($p = 0.020$) and that the middle third presented significantly greater values than the distal third in both clavicles ($p < 0.001$).

Table 1 – Characterization of the sample.

Characteristics	n = 52
Sex – n (%)	
Male	24 (46.2)
Female	28 (53.8)
Dominance – n (%)	
Right-handed	30 (57.7)
Left-handed	22 (42.3)

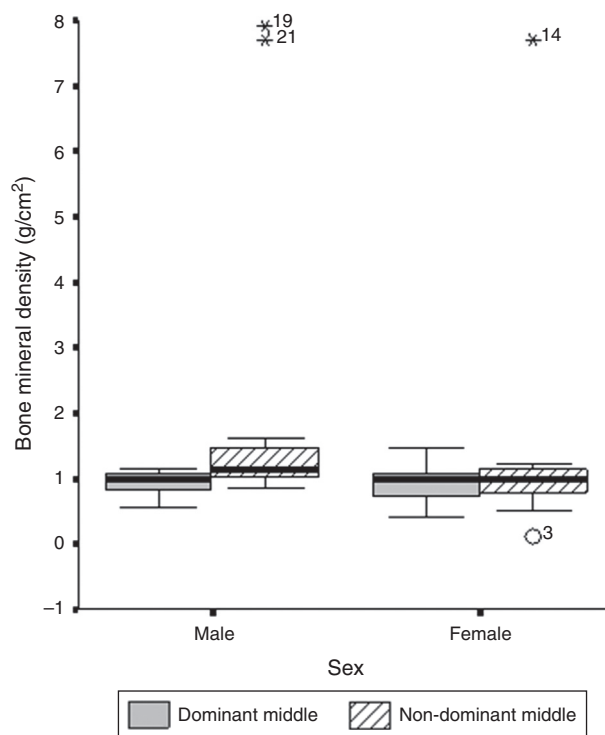


Fig. 1 – Evaluation of bone mineral density relating to the middle third of the clavicle, according to the patient's sex.

Discussion

It has already been well established that there is a strong relationship between bone mineral density and the dominant side. Bone mass varies according to use. Bone is deposited proportionally to the compressive load that it has to bear, and this is why athletes have greater bone mass than people who do not practice exercise. The latter tend to lose bone mass.¹⁴⁻¹⁶

The present study found significant data from a sample of 52 individuals who underwent examination. Since the study group was homogenous, the results found would not change with a larger or smaller sample than in the present study. This was proven when we added new cases to the study, given that the first sample was obtained in 2007 and the second, in 2012.

In a prospective study involving 213 patients, densitometry was performed on the radius and ulna of both forearms. It was observed that the dominant forearm had greater bone mass and also greater bone area. One possible explanation for the greater bone mass in the dominant limb was its greater use. The differences in the ulna were statistically significant.¹⁷

Gumustekin et al.¹⁴ conducted a cross-sectional study, similar to ours, with 32 right-handed and 26 left-handed individuals. All of them were university students. Bone densitometry was performed on the femur bilaterally in the neck, trochanteric and intertrochanteric regions and in Ward's triangle. They found bone mass indices in the right-handed individuals that were greater on the left side, and in the left-handed individuals on the right side, which indicated that the bone density of the femur was not related to the dominant side.

Table 2 – Evaluation of bone mineral density according to the dominant side.

Bone mineral density	Dominant median (p25–p75)	Non-dominant median (p25–p75)	p ^a
Men (n = 24)			
Middle	1.01 (0.80–1.10)	1.14 (1.02–1.54)	0.028
Distal	0.40 (0.17–0.65)	0.71 (0.51–1.06)	0.010
p ^a	0.003	0.002	
Women (n = 28)			
Middle	0.99 (0.73–1.11)	1.01 (0.78–1.15)	1.000
Distal	0.56 (0.17–0.69)	0.59 (0.42–0.73)	0.530
p ^a	0.001	0.006	
Total (n = 52)			
Middle	1.01 (0.79–1.09)	1.07 (0.93–1.24)	0.134
Distal	0.49 (0.17–0.69)	0.64 (0.45–0.92)	0.020
p ^a	<0.001	<0.001	

^a Value obtained through Wilcoxon test.

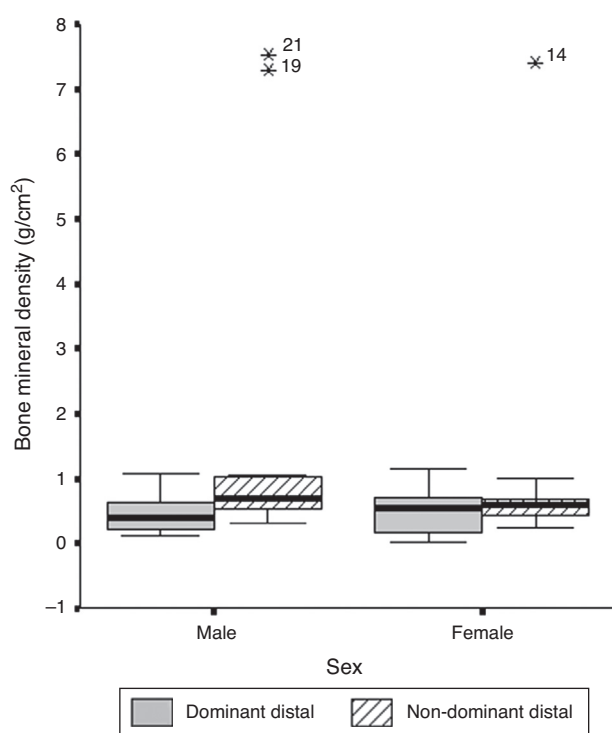


Fig. 2 – Evaluation of bone mineral density relating to the distal third of the clavicle, according to the patient's sex.

Our findings were similar to those of Gumustekin et al.,¹⁴ i.e. the bone mineral density of the clavicle was greater on

the non-dominant than on the dominant side. The clavicle on the dominant side presented lower bone mineral mass than shown by the clavicle on the non-dominant side. This difference was statistically significant.

Fractures of the clavicle are statistically more frequent on the left side and occur most often in the middle third of the left clavicle (81%), followed by the lateral third (17%) and medial third (2%).¹²

It could be seen that greater bone density on the non-dominant side could lead to greater bone fragility through loss of flexibility,^{18–20} since fractures of the clavicle occur most frequently in the middle third, precisely where the bone density is greatest, both in the dominant and in the non-dominant clavicle.

Conclusion

The clavicle on the non-dominant side is denser than the clavicle on the dominant side. Likewise, the middle third of the clavicles, both on the dominant and on the non-dominant side, is denser than the distal third. Thus, the occurrences of clavicular fractures more on the left side, as found in the present study, could be due to greater bone mineral density on the non-dominant side, which would diminish bone flexibility and, hypothetically, increase the propensity to fractures.

Conflicts of interest

The authors declare no conflicts of interest.

Annex 1. Questionnaire: Densitometric study on the clavicle: does bone density explain the laterality of fractures?

Name: _____	Reg. no.: _____
Date of birth: _____	Age: _____
Sex: () F () M	Course: () Medicine () Other: _____
Handedness: () Right-handed () Left-handed () Ambidextrous	
Do you have any chronic disease?	
() Yes: _____ () No	
Are you a professional athlete?	
() Yes () No	
Have you ever suffered a clavicular fracture? (Including fractures during childbirth)	
() Yes () No	
Have you ever undergone any surgical intervention in the clavicle or shoulder?	
() Yes () No	
Do you have any upper-limb deformity?	
() Yes () No	
Do you have or have you had any injury to the brachial plexus?	
() Yes () No	
Do you have any orthopedic disease of the shoulder?	
() Yes () No	
Do you have any osteometabolic disease?	
() Yes () No	
Do you have any type of restriction on upper-limb movement?	
() Yes () No	
For the researcher to fill out	
Was the volunteer selected for the study in accordance with the criteria?	
() Yes () No	
I agree with all the information expressed in this form.	

Signature of the research subject

REFERENCES

- Eskola A, Vainionpaa S, Myllynen P, Patiala H, Rokkanen P. Outcome of clavicular fracture in 89 patients. *Arch Orthop Trauma Surg.* 1986;105(6):337-8.
- Allman FL Jr. Fractures and ligamentous injuries of the clavicle and its articulation. *J Bone Joint Surg Am.* 1967;49(4):774-84.
- Craig EV. Fractures of the clavicle. In: Rockwood CA Jr, Green DP, Buchholz RW, editors. *Fractures in adults.* Philadelphia: JB Lippincott Company; 1996. p. 928-90.
- Nordqvist A, Petersson C. The incidence of fractures of the clavicle. *Clin Orthop Relat Res.* 1994;(300):127-32.
- Del Torto U, Bonaccorsi S. Considerazioni sulla terapia delle fratture della clavicola. *Orizz Ortop Odie Riabil.* 1963;8:135-54.
- Robinson CM. Fractures of the clavicle in the adult. *Epidemiology and classification.* *J Bone Joint Surg Br.* 1998;80(3):476-84.
- Nowak J, Mallmin H, Larsson S. The aetiology and epidemiology of clavicular fractures. A prospective study during a two-year period in Uppsala, Sweden. *Injury.* 2000;31(5):353-8.
- Mazess RB, Nord R, Hanson JA, Barden HS. Bilateral measurement of femoral bone mineral density. *J Clin Densitom.* 2000;3(2):133-40.
- Petley GW, Taylor PA, Murrills AJ, Dennison E, Pearson G, Cooper C. An investigation of the diagnostic value of bilateral femoral neck bone mineral density measurements. *Osteoporos Int.* 2000;11(8):675-9.
- Seeman E, Melton LJ 3rd, O'Fallon WM, Riggs BL. Risk factors for spinal osteoporosis in men. *Am J Med.* 1983;75(6):977-83.
- Yang RS, Chieng PU, Tsai KS, Liu TK. Symmetry of bone mineral density in the hips is not affected by age. *Nucl Med Commun.* 1996;17(8):711-6.
- Postacchini F, Gumina S, De Santis P, Albo F. Epidemiology of clavicle fractures. *J Shoulder Elbow Surg.* 2002;11(5):452-6.
- Fernandes CH, Matheus RC, Faloppa F, Albertoni WM. Alterações esqueléticas da mão na picnodisostose. *Rev Bras Ortop.* 1996;31(5):441-2.
- Gumustekin K, Akar S, Dane S, Yildirim M, Seven B, Varoglu E. Handedness and bilateral femoral bone densities in men and women. *Int J Neurosci.* 2004;114(12):1533-47.
- Dane S, Akar S, Hacibeyoglu I, Varoglu E. Differences between right- and left-femoral bone mineral densities in right- and left-handed men and women. *Int J Neurosci.* 2001;111(3-4):187-92.
- Guyton AC, Hall JE. *Tratado de fisiologia médica.* Rio de Janeiro: Guanabara Koogan; 1997.
- Walters J, Koo WW, Bush A, Hammami M. Effects of hand dominance on bone mass measurement in sedentary individuals. *J Clin Densitom.* 1998;1(4):359-67.
- Browner B, Jupiter J, Levine A, Trafton P. *Skeletal trauma.* Philadelphia: Saunders; 2003.
- Canale ST. *Campbell's operative orthopaedics.* St. Louis: Mosby; 2007.
- Herbert S, Xavier R. *Ortopedia e traumatologia.* Porto Alegre: Artmed; 1998.