Brazilian Dental Science
Ciência Odontológica Brasileira
unesp
UNIVERSIDADE ESTADUAL PAULISTA "JÚLIO DE MESQUITA FILHO"
Instituto de Ciência e Tecnologia
Campus de São José dos Campos

ORIGINAL ARTICLE

doi: 10.14295/bds.2019.v22i4.1839

Evaluation and Correlation between craniofacial bone densities and C1 and C2 cervical vertebrae using multislice computed tomography

Avaliação e Correlação entre as densidades ósseas craniofaciais e vértebras cervicais C1 e C2 por meio de tomografia computadorizada multislice.

Lucas MORITA[1], Vagner Braga da SILVA[1], Luciana MUNHOZ[1], Emiko Saito ARITA[1], Plauto Christopher Aranha WATANABE[2]

1 - Department of Stomatology - School of Dentistry - São Paulo University - São Paulo, SP - Brazil.

2 - Department of Stomatology - Public Oral Health, and Forensic Dentistry. - Ribeirão Preto Dental School – University of São Paulo - Ribeirão Preto - SP - Brazil.

ABSTRACT

Objective: To evaluate the use of computed tomography (CT) as an osteoporosis screening tool, evaluating the relation between the bone mineral density (BMD) from maxilla and mandible with the cervical vertebrae, using the Hounsfield units (HU). **Material and Methods:** It was included in this study a convenience sample of 118 multislice CT examinations from patients who underwent maxilla, mandible and cervical vertebrae (C1 and C2) simultaneously scans. For each patient, the following regions on both sides of head CT scans were assessed in sagittal slice: above maxillary central and lateral incisors apexes; maxillary tuberosity; mandible head; mandible body endosteum; mandible body trabeculae and vertebrae C1 and C2. HU were measured in each area using a 0.5 cm region of interest (ROI) positioned in the center of the slice. **Results:** It was verified that there is a correlation between the BMD of the C1 and C2 vertebrae and the anterior region of the maxilla. It was not found correlation between the vertebrae, C1 and C2, and the other structures analyzed. **Conclusions:** This study showed that this method can be a good screening tool to diagnosis of osteoporosis, when evaluated the correlation between C1 and C2 vertebrae and anterior region of maxilla. More studies are necessary to evaluate the possibility of using CT as an osteoporosis screening tool.

KEYWORDS

Bone mineral density (BMD); Osteoporosis; Computed tomography (CT); Hounsfield unit (HU).

RESUMO

Objetivos: Avaliar o uso da tomografia computadorizada como ferramenta de rastreamento da osteoporose, avaliando a relação entre a densidade mineral óssea da maxila e mandíbula com as vértebras cervicais, utilizando as unidades de Hounsfield. **Material e métodos:** Neste estudo foram incluidos uma amostra de 118 pacientes submetidos à exames de tomografia computadorizada multislice que apresentavam as estruturas anatomicas da maxila, mandibula e as vértebras cervicais (C1 e C2) simultaneamente. Para cada paciente, as seguintes regiões dos dois lados da tomografia computadorizada da cabeça foram avaliadas em corte sagital: acima dos ápices dos incisivos centrais e laterais superiores; tuberosidade maxilar; cabeça da mandíbula; endósteo do corpo da mandíbula; trabéculas do corpo da mandíbula e vértebras C1 e C2. As unidades de Hounsfield foram medidas em cada área usando uma região de interesse de 0,5 cm (ROI) posicionada no centro do corte. **Resultados:** Verificou-se uma correlação positiva entre a densidade mineral óssea das vértebras C1 e C2 e a região anterior da maxila. Não foram encontradas correlação entre as vértebras C1 e C2 e as demais estruturas analisadas. **Conclusão:** Este estudo mostrou que esse método pode ser uma ferramenta de triagem para o diagnóstico de osteoporose, quando avaliada a correlação entre as vértebras C1 e C2 e a região anterior da maxila. Mais estudos são necessários para avaliar a possibilidade do uso da tomografia computadorizada como ferramenta de rastreamento da osteoporose.

PALAVRAS-CHAVE

Densidade mineral óssea; Osteoporose; Tomografia computadorizada ; Unidade

INTRODUCTION

Osteoporosis is a chronic skeletal that affects mostly elderly individuals from both genders [1-3]. The disorder leads to reduction of bone mineral density and, consequently, strength reduction of overall bone architecture, which may result in osteoporotic fractures.[4, 5] Several factors also play an essential role in worsening the disease, such as nutrition, lifestyle, the chronic use of specific medications and heredity. [6].

The method of choice to diagnose osteoporosis is Dual X-ray absorptiometry (DXA), which measures bone mineral density (BMD) of specific skeletal areas. World Health Organizations (WHO) determined values to the BMD measured, named as T-scores, which allows to assess fracture risk [7]. Although DXA is the golden standard method to evaluate BMD, this examination is not widely available in many countries. In these countries, many imaging tools have been studies to substitute DXA, such as radiomorphometric indexes in panoramic radiographs [8] and the use of examinations performed with different purposes, as Multislice Computed Tomography (CT).

Using CT examinations, it is possible to determine bone Hounsfield values (HU). HU is proven to be a useful tool to evaluate BMD and assess osteoporosis risks.[9] Positive correlations has been observed between HU from vertebrae and skeletal BMD values. [10] HU is a coefficient that measure the absorption of x-rays from CT, the HU units ranges from 1000 to 0, values closer to 1000 HU means radiodensity of water and values next to 0 HU means a density close to the air [11-13].

Head CT examination is often requested by dentists and physicians, allowing the opportunistic screening for osteoporosis and early diagnosis of the disease, which may lead to a higher chance of a better prognosis (11). Therefore, the objective of this study is to evaluate the use of maxillary or mandibular CT as a screening tool for osteoporosis, verifying the correlation between the BMD of the maxilla or mandible structures and cervical vertebrae, using HU values.

MATERIAL AND METHODS

The present study has the approval of the Research Ethics Committee of FOUSP (School of Dentistry of São Paulo, Ribeirão Preto), under the Nº 544.527; CAAE: 25099614.2.0000.0075. The guidelines of Helsinki were followed in this investigation. All the patients signed an informed consent form.

The CT examinations used in this research were performed in a particular Radiology clinic. Head and neck CT examinations executed between years 2012 - 2013 were fully assessed.It was included in this study a convenience sample of 118 multislice CT examinations (56 males and 62 females) from patients who underwent maxilla, mandible and cervical vertebrae (C1 and C2) simultaneously scans. It wasn't considered for this study CT examinations of maxilla, mandible and cervical vertebrae (C1 and C2) that not showed all the anatomic areas necessary for the HU measurement and examinations with any artifacts with technical failures.

Anatomical regions analyzed were:

1) Above central and lateral maxillary incisors apexes, right and left side;

2) Right and left maxillary tuberosity;

3) Right and left mandible head;

4) C1 and C2 vertebrae;

5) Right and left mandible endosteoum;

6) Right and left mandible trabecular bone.

*All structures cited are illustrated in figures 1 and 2

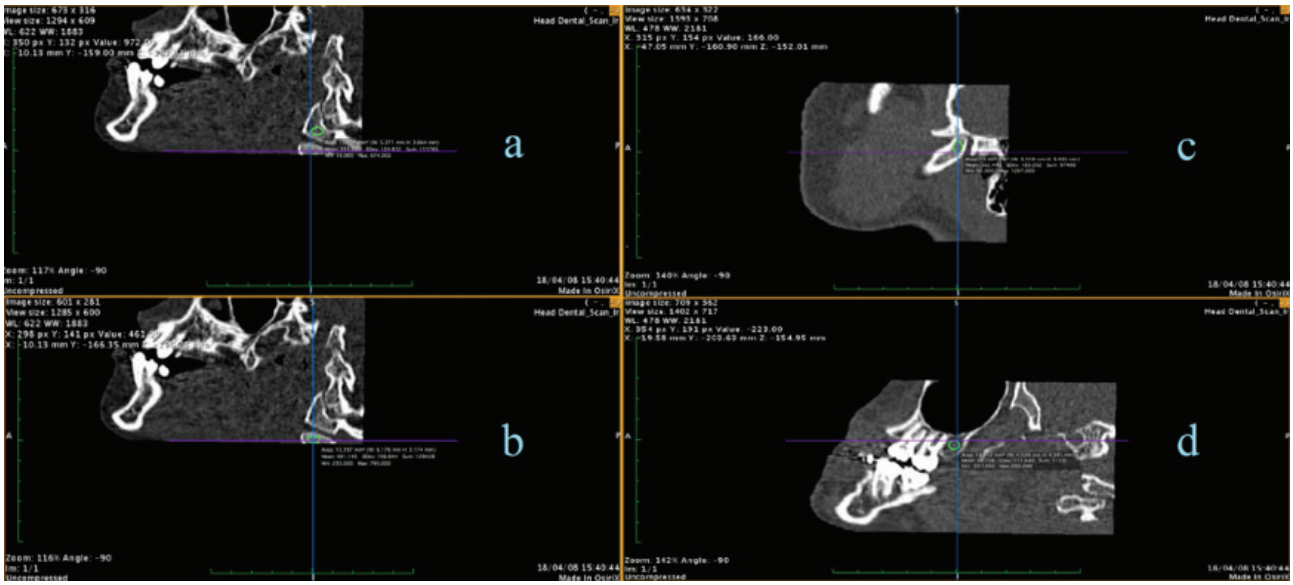

Figure 1 - Sagittal slice example showing C1 and C2 vertebrae (a,b), right mandible head (c) and right maxillary tuberosity (d) region of interest.

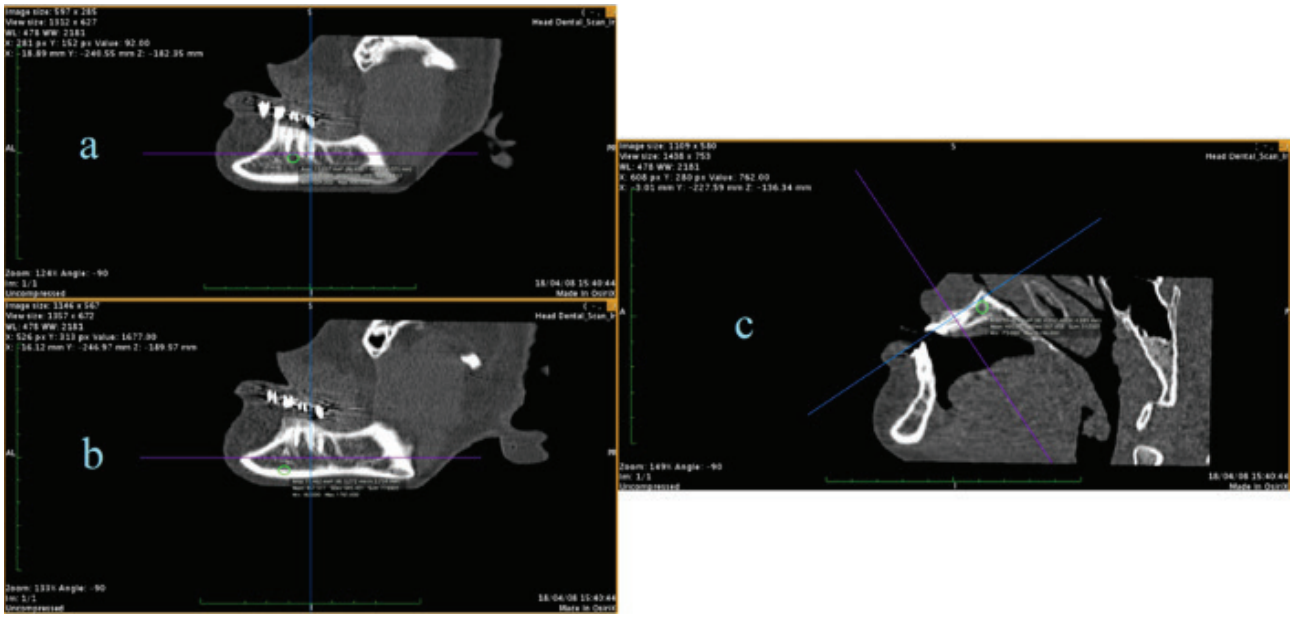

Figure 2 - Sagittal slice example showing right mandible trabecular bone (a), right mandible endosteum (b) and left maxillary incisors apexes (c) region of interest.

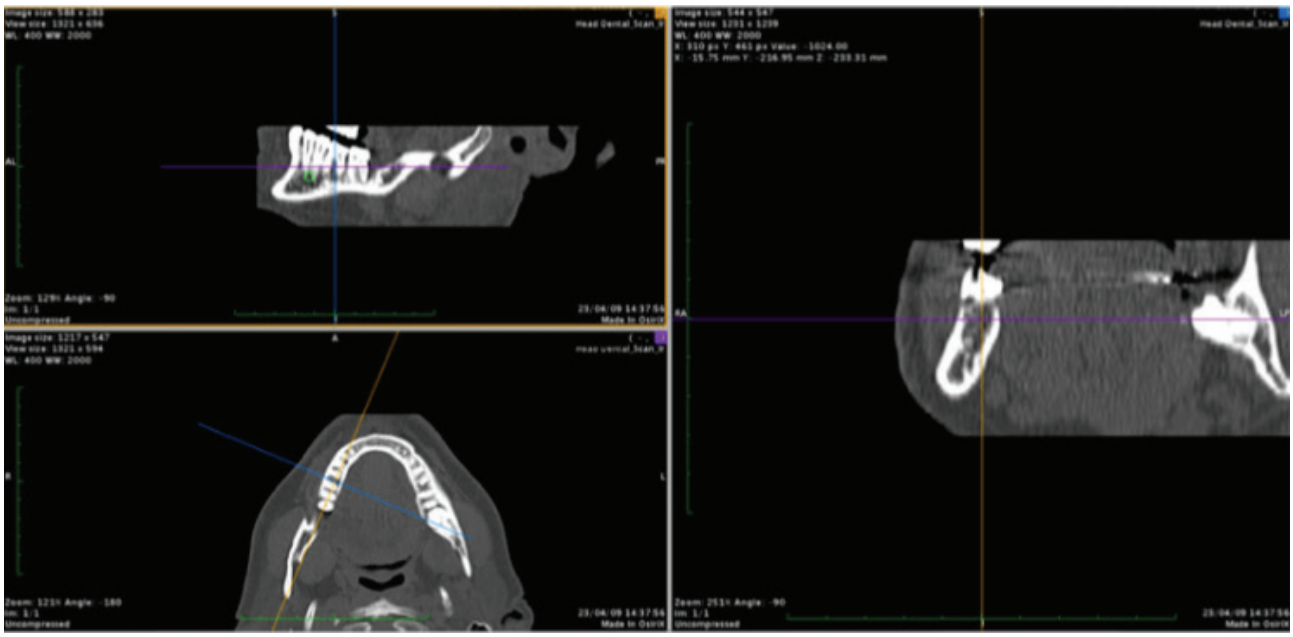

Figure 3 - Software screen shot demonstrating data collection from mandible assessing simultaneously sagittal and axial planes.

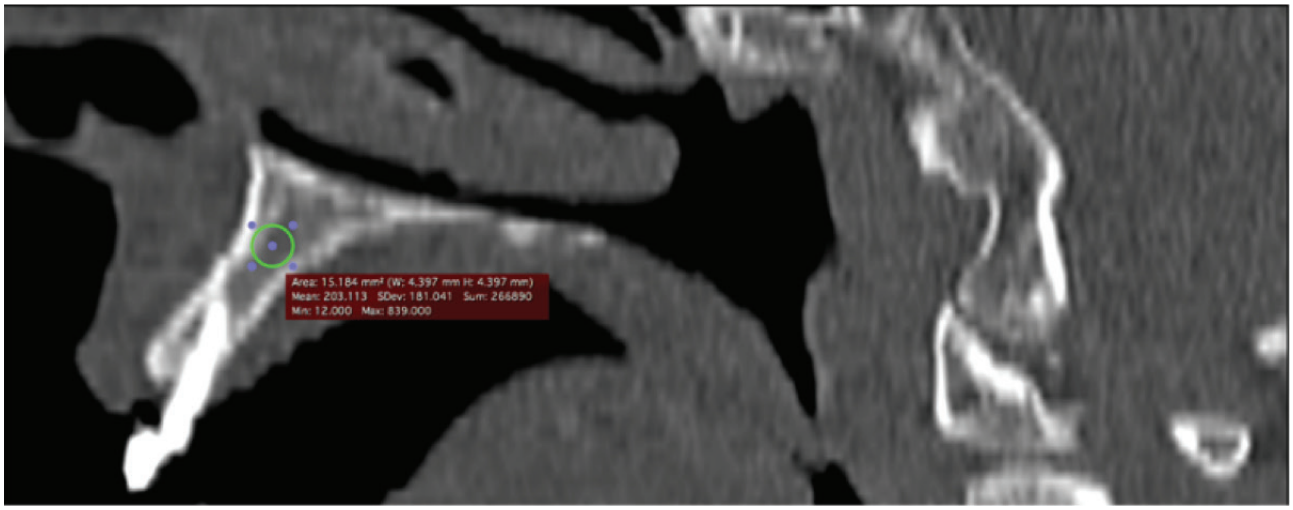

Figure 4 - Software screen shot demonstrating HU measurement from anterior maxilla region.

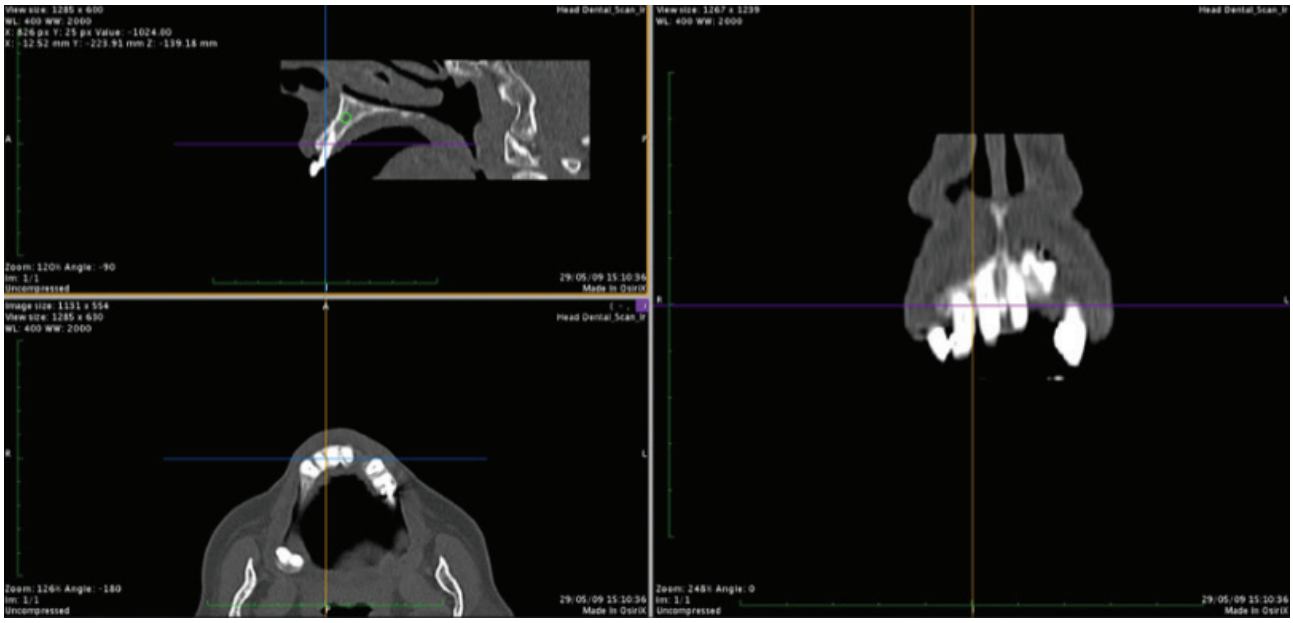

Figure 5 - Software screen shot demonstrating the use of sagittal and coronal sections simultaneously for ROI positioning.

The images were acquired in a helical multislice CT scanner equipment (Somatom Volume Zoom Siemens-brand, 16 channels – Erlangen, Germany) using 1.0 mm slices (time image reconstruction 16 images/s, 50KW). Patients were positioned in dorsal decubitus, and their heads were carefully positioned using the nasal/tragus line as a reference to be parallel to the equipment's Gantry. A scout image was performed to every patient to verify the correct positioning. Digital Imaging and communications in Medicine (DICOM) format images were assessed using OsiriX (eFilm, version 1.5.3, Merge Healthcare, Milwaukee, WI).

CT scans assessment

Two examiners lead the aforementioned analysis of CT scans. For each patient, the following regions on both sides of head CT scans were analyzed in sagittal slice: above apex of superior central incisors; above apex of superior lateral incisors; maxillary tuberosity; mandible head; mandible body endosteum; mandible body trabeculae and vertebrae C1 and C2. HU was obtained using a 0.5 cm region of interest positioned in the center of the slice. Angulations of selected slices were adjusted manually to reduce the differences in head position among patients sample. Axial and Coronal sections was used as a guide to the ROI demarcation in the corresponding anatomical area. *Figure 5

Statistical analyses

Normality was assessed using Shapiro-Wilk test. As the variables were not normal ($p < 0.05$), non-parametric correlation tests were performed (Spearman correlation text) in order to verify the correlation between the HU of anatomical areas selected and C1 and C2 vertebrae. All evaluations were carried out using SPSS Statistics version 24.

RESULTS

Mean, median, maximum and minimum HU values of all regions studied are demonstrated in Table 1.

Table 1 - Mean, median, maximum and minimum HU values of the regions studied, considering side and slice orientation

Anatomical region	Side	Slice orientation	Mean HU	Median HU	Maximum HU	Minimum HU
Above central and lateral maxillary incisors	Left	Sagittal	466872 (+285395)	416185 (IR437172)	1258916	38027
Above central and lateral maxillary incisors	Right	Sagittal	409795 (+231670)	384193 (IR326516)	1089284	28674
Maxillary tuberosity	Right	Sagittal	104929 (+181683)	62051 (IR239498)	670698	-121905
Maxillary tuberosity	Left	Sagittal	136263 (+199865)	86231 (IR227005)	855856	-149557
Mandible head	Right	Sagittal	326776 (+123399)	312368 (IR127963)	842235	127080
Mandible head	Left	Sagittal	312176 (+104333)	285385 (IR133253)	563910	114411
C1	NA	Sagittal	301115 (+140457)	301009 (IR228750)	679713	47579
C2	NA	Sagittal	467335 (+194954)	455329 (IR227693)	101000000	124439
Mandible endosteoum	Right	Sagittal	755631 (+262005)	756015 (IR351228)	1309702	64247
Mandible endosteoum	Left	Sagittal	812386 (+231587)	796452 (IR388840)	1279158	392566
Mandible trabecular bone	Right	Sagittal	233964 (+260181)	134663 (IR202857)	810128	-75589
Mandible trabecular bone	Left	Sagittal	255830 (+236831)	229399 (IR2368310)	1028202	-110101

Abbreviations: IR: interquartile range; NA: not applicable

Table 2 - Spearman correlation tests results

Anatomical area evaluated	Side	r	p
C1 vs above central and lateral maxillary incisors	Left	0.446	0.02*
C1 vs above central and lateral maxillary incisors	Right	0.263	0.07*
C1 vs maxillary tuberosity	Right	0.299	0.54
C1 vs maxillary tuberosity	Left	0.108	0.46
C1 vs mandible head	Right	0.083	0.58
C1 vs mandible head	Left	0.155	0.34
C2 vs above central and lateral maxillary incisors	Left	0.346	0.01*
C2 vs above central and lateral maxillary incisors	Right	0.048	0.07*
C2 vs maxillary tuberosity	Right	0.339	0.23
C2 vs maxillary tuberosity E	Left	0.255	0.87
C2 vs mandible head	Right	0.068	0.65
C2 vs mandible head	Left	-0.061	0.68
C1 vs mandible endosteum	Right	0.05	0.97
C1 vs mandible endosteum	Left	0.190	0.29
C1 vs mandible trabecular bone	Left	0.253	0.16
C1 vs mandible trabecular bone	Right	0.409	0.22
C2 vs mandible endosteum	Right	-0.095	0.60
C2 vs mandible endosteum	Left	-0.105	0.58
C2 vs mandible trabecular bone	Right	0.220	0.26
C2 vs mandible trabecular bone	Left	0.194	0.288

In Table 2 there are demonstrated the Spearman correlations tests results.
Abbreviations: vs: versus
*Significant if $p < 0.05$

The bone densities, expressed by HU, of the cervical vertebrae C1 were significantly correlated with the area above central and lateral maxillary incisors in the left side ($r = 0.446$; $p = 0.02$) and in the right side ($r = 0.623$; $p = 0.07$). Additionally, a significant correlation was found between C2 and the area above incisors in the left side ($r = 0.346$; $p – 0.02$) and the right side ($r = 0.048$; $p = 0.07$). Although the left side area above incisors presented a significant correlation with C2, this correlation was very week. The other regions evaluated did not present any significant correlations with cervical vertebrae

DISCUSSION

In this study, it was verified that there is a correlation between the BMD, represented by HU values in CT examinations, of the C1 and C2 vertebrae and the anterior region of the maxilla, above the central and lateral apexes maxillary incisors, on right and left sides. However, no correlations were found between the C1 and C2 vertebrae, and HU values from the other anatomical regions analyzed, such as mandibular endosteum, mandibular trabecular bone, maxilla tuber and mandibular condyle.

Osteoporosis reduces the BMD and changes overall skeleton, including the facial bones [14] and cervical vertebrae. [15, 16] Regarding osteoporosis in the jaws, low BMD is more pronounced in maxilla than mandible due to the differences in trabecular bone inherent to these bones. [17] Furthermore, maxilla in osteoporotic patients has lower BMD values than healthy patients; this was confirmed in Merheb, J et al study.[17,18] This condition has a huge importance in maxillofacial surgery due to higher risks of bone fractures.[19]

Cheade et al. (2019) [20] and Lee et al. (2013), [10] showed that the CT can be used with opportunistic screening to osteoporosis diagnosis; and the HU value and DXA-based bone mineral density demonstrated a significant correlation.[10] Through of the HU values obtained from CT scans, it is possible to estimate the BMD and posteriorly refer patients to the proper osteoporosis diagnose.[10] The opportunistic screening to evaluate bone quality has a potential to measure the bone quality, but still impracticable in clinical practice.[12]

Barngkgei et al. analyzed C1 and C2 vertebrae through cone beam computed tomography (CBCT) scans and concluded that radiographic density values relating with left lateral mass of C1 and the density of C2 correlates with DXA T-scores values from lumbar spine and were accurate in the prediction of osteoporosis. [21,22] Additionally, Woon et al.found a correlation between T-scores on DXA and HU values from CT, in the center of the anterior surface of the maxilla and mandible ramus.[23]

In the present study it was obtained a correlation between C1 and C2 vertebrae BMD and the anterior region of maxilla measurements from both sides. Cheade et al.[20] also found a correlation between cervical vertebrae HU values with the anterior maxilla measurements, similar to the results obtained from this study [20].

Several publications have already reported that there is no relationship in BMD between cervical vertebrae and the thoracic and lumbar vertebra. However, there are studies supporting that cervical vertebra has higher BMD values than the thoracic and lumbar vertebras.[24,25] A study showed that BMD values from cervical and lumber spine decreases with aging and degeneration, notwithstanding, the BMD cervical vertebrae of women has increased throughout aging and declined abruptly with menopause.[26]

These findings show that the cervical vertebrae may present higher BMD values comparing with lumbar vertebrae. Women before menopausal and postmenopausal can present different values of BMD in cervical spine in contrast to men.[26]

This study has several limitations, variations such as its retrospective nature and the small sample size. Another important fact is the variation between ROI positions due to authors and anatomical variation of patients.

Through comparison of maxilla and mandible with cervical vertebrae BMD information, possibly we are moving towards to

earlier diagnoses and treatment of osteoporosis in risk patients through opportunist screening. In addition, further studies are required to determine standard values to BMD in the facial bones to elect patients at risk for osteoporosis.

REFERENCES

1. Riggs BL, Melton LJ. The worldwide problem of osteoporosis: Insights afforded by epidemiology. Bone. 1995;17(5, Supplement 1):S505-S11.
2. Willson T, Nelson SD, Newbold J, Nelson RE, LaFleur J. The clinical epidemiology of male osteoporosis: a review of the recent literature. Clinical epidemiology. 2015;7:65-76. doi: 10.2147/CLEP.S40966.
3. Baccaro LF, Conde DM, Costa-Paiva L, Pinto-Neto AM. The epidemiology and management of postmenopausal osteoporosis: a viewpoint from Brazil. Clin Interv Aging. 2015;10:583-91. doi: 10.2147/CIA.S54614.
4. Billington EO, Reid IR. Pathogenesis of Osteoporosis. In: Huhtaniemi I, Martini L, editors. Encyclopedia of Endocrine Diseases (Second Edition). Oxford: Academic Press; 2019. p. 222-32.
5. Armas LAG, Recker RR. Pathophysiology of Osteoporosis: new Mechanistic Insights. Endocrinol Metab Clin North Am. 2012 Sep;41(3):475-86. doi: 10.1016/j.ecl.2012.04.006.
6. Yedavally-Yellayi S, Ho AM, Patalinghug EM. Update on Osteoporosis. Prim Care. 2019 Mar;46(1):175-190. doi: 10.1016/j.pop.2018.10.014.
7. Blake GM, Fogelman I. The role of DXA bone density scans in the diagnosis and treatment of osteoporosis. Postgrad Med J. 2007;83(982):509-17. doi: 10.1136/pgmj.2007.057505.
8. Munhoz L, Aoki EM, Cortes ARG, de Freitas CF, Arita ES. Osteoporotic alterations in a group of different ethnicity Brazilian postmenopausal women: an observational study. Gerodontology. 2018 Jun;35(2):101-109. doi: 10.1111/ger.12322.
9. Schreiber JJ, Anderson PA, Hsu WK. Use of computed tomography for assessing bone mineral density. Neurosurg Focus. 2014;37(1):E4. doi: 10.3171/2014.5.FOCUS1483.
10. Lee S, Chung CK, Oh SH, Park SB. Correlation between Bone Mineral Density Measured by Dual-Energy X-Ray Absorptiometry and Hounsfield Units Measured by Diagnostic CT in Lumbar Spine. J Korean Neurosurg Soc. 2013 Nov;54(5):384-9. doi: 10.3340/jkns.2013.54.5.384.
11. Lenchik L, Weaver AA, Ward RJ, Boone JM, Boutin RD. Opportunistic Screening for Osteoporosis Using Computed Tomography: State of the Art and Argument for Paradigm Shift. Curr Rheumatol Rep. 2018 Oct 13;20(12):74. doi: 10.1007/s11926-018-0784-7.
12. Gausden EB, Nwachukwu BU, Schreiber JJ, Lorich DG, Lane JM. Opportunistic Use of CT Imaging for Osteoporosis Screening and Bone Density Assessment: A Qualitative Systematic Review. J Bone Joint Surg Am. 2017 Sep 20;99(18):1580-1590. doi: 10.2106/JBJS.16.00749.
13. al-bahrani Z. Validity of Hounsfield Units from Computed Tomographic Images of Mandibular Bone in Detection of Osteoporosis. J Bagh College Dentistry. 2014;26(3):79-83.
14. Hildebolt CF. Osteoporosis and oral bone loss. Dentomaxillofacial Radiology. 1997;26(1):3-15. Doi: 10.1038/sj.dmfr.4600226.
15. Tay WL, Chui CK, Ong SH, Ng AC. Osteoporosis screening using areal bone mineral density estimation from diagnostic CT images. Acad Radiol. 2012 Oct;19(10):1273-82. doi: 10.1016/j.acra.2012.05.017.
16. Adams JE. Advances in bone imaging for osteoporosis. Nat Rev Endocrinol. 2013 Jan;9(1):28-42. doi: 10.1038/nrendo.2012.217.
17. Klemetti E, Vainio P, Lassila V. Mineral density in the mandibles of partially and totally edentate postmenopausal women. Scand J Dent Res. 1994 Feb;102(1):64-7.
18. Merheb J, Temmerman A, Coucke W, Rasmusson L, Kubler A, Thor A, et al. Relation between Spongy Bone Density in the Maxilla and Skeletal Bone Density. Clin Implant Dent Relat Res. 2015 Dec;17(6):1180-7. doi: 10.1111/cid.12228.
19. Hohlweg-Majert B, Schmelzeisen R, Pfeiffer BM, Schneider E. Significance of osteoporosis in craniomaxillofacial surgery: a review of the literature. Osteoporosis International. 2006;17(2):167-79. Doi: 10.1007/s00198-005-1967-4.
20. Cheade MCC ML, Arita ES, Watanabe PCA. Opportunistic screening for osteoporosis correlating the bone densities of jaws with multislice computed tomography for cervical vertebrae. Clin Lab Res Dent. 2019:1-6. doi: http://dx.doi.org/10.11606/issn.2357-8041.clrd.2019.155263.
21. Esmaeli F, Payahoo S, Mobasseri M, Johari M, Yazdani J. Efficacy of radiographic density values of the first and second cervical vertebrae recorded by CBCT technique to identify patients with osteoporosis and osteopenia. J Dent Res Dent Clin Dent Prospects. 2017 Summer;11(3):189-194. doi: 10.15171/joddd.2017.034.
22. Barngkgei I, Joury E, Jawad A. An innovative approach in osteoporosis opportunistic screening by the dental practitioner: the use of cervical vertebrae and cone beam computed tomography with its viewer program. Oral Surg Oral Med Oral Pathol Oral Radiol. 2015 Nov;120(5):651-9. doi: 10.1016/j.oooo.2015.08.008.
23. On SW, Kim HJ, Kim J, Choi JW, Jung YW, Song SI. Effect of Osteoporosis on Bone Density of Orthognathic Osteotomy Sites in Maxillofacial Region. J Craniofac Surg. 2016;27(7):e678-e83. doi: 10.1097/SCS.0000000000003064.
24. Yoganandan N, Pintar FA, Stemper BD, Baisden JL, Aktay R, Shender BS, et al. Bone mineral density of human female cervical and lumbar spines from quantitative computed tomography. Spine (Phila Pa 1976). 2006;31(1):73-6. doi: 10.1097/01.brs.0000192684.12046.93
25. Yoganandan N, Pintar FA, Stemper BD, Baisden JL, Aktay R, Shender BS, et al. Trabecular bone density of male human cervical and lumbar vertebrae. Bone. 2006;39(2):336-44. doi: 10.1016/j.bone.2006.01.160.
26. Zhang Y, Zhou Z, Wu C, Zhao D, Wang C, Cheng X, et al. Population-Stratified Analysis of Bone Mineral Density Distribution in Cervical and Lumbar Vertebrae of Chinese from Quantitative Computed Tomography. Korean J Radiol. 2016 Sep-Oct;17(5):581-9. doi: 10.3348/kjr.2016.17.5.581.

Lucas Morita
(Corresponding address)
Department of Stomatology, School of Dentistry, University of São Paulo. Av. Lineu Prestes, 2227, São Paulo, SP, Brazil
Zip code: 05508-000.
E-mail: lucas.morita@usp.br

Date submitted: 2019 Aug 02

Accept submission: 2019 Sep 23