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Opportunistic screening for osteoporosis correlating the bone densities of jaws with multislice computed tomography for cervical vertebrae

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ABSTRACT | *Objectives*: to evaluate the correlation of the bone mineral density (BMD) from maxilla and mandible with that of the cervical vertebrae, using Hounsfield units (HU) and multislice computed tomography (CT) to verify whether CT could be a useful osteoporosis screening tool. *Methods*: 79 multislice CT examinations from patients who underwent CT examinations of maxilla, mandible and cervical vertebrae simultaneously were included. The following left and right anatomical regions were assessed: mandible ramus; mandible head; the area below the inferior first molar and the area below the upper cuspids. HU were measured in each area using a 0.1 cm region of interest (ROI) positioned in the center of the slice. *Results*: a significant correlation between the cervical spine and the posterior region of the mandible was found, as well as a significant correlation between the anterior maxilla and the cervical spine. However, no correlation was found between the cervical spine and other parts of the mandible, such as ramus and head of mandible. *Conclusions*: As anterior maxillary bone and posterior mandible bone HU values correlate with cervical bone HU values, this examination may be applied as osteoporosis screening tool.

DESCRIPTORS | Osteoporosis; Computed tomography; Hounsfield Unit; Bone Mineral Density.

RESUMO | **Utilização exames de tomografia computadorizada da maxila e mandíbula e sua correlação com as vértebras cervicais objetivando o rastreamento de pacientes com risco de osteoporose** • *Objetivos*: avaliar a correlação da densidade mineral óssea (DMO) da maxila e mandíbula com as vértebras cervicais, utilizando unidades de Hounsfield (HU), utilizando tomografia computadorizada (TC) multislice, para verificar se a TC pode ser útil como ferramenta de rastreamento da osteoporose. *Métodos*: 79 exames de tomografia computadorizada multislice de pacientes que foram submetidos a CTs de maxila, mandíbula e vértebras cervicais simultaneamente foram incluídos. As seguintes regiões anatômicas esquerda e direita foram avaliadas: ramo da mandíbula; cabeça mandibular; a área abaixo do primeiro molar inferior e a área abaixo das cúspides superiores. HU foram medidos em cada área usando uma região de interesse (ROI) de 0.1cm posicionada no centro do corte tomográfico. *Resultados*: Foi encontrada uma correlação significativa entre a coluna cervical e a região posterior da mandíbula, bem como uma correlação significativa entre a região anterior da maxila e a coluna cervical. No entanto, nenhuma correlação foi encontrada entre a coluna cervical e outros locais da mandíbula, como o ramo mandibular e a cabeça. *Conclusões*: Como os valores de HU do osso anterior e posterior da mandíbula se correlacionam com os valores de HU do osso cervical, este exame pode ser aplicado a ferramentas de rastreio da osteoporose.

DESCRITORES | Osteoporose; Tomografia Computadorizada; Unidade de Hounsfield; Densidade Mineral Óssea.

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INTRODUCTION

Along with the worldwide phenomenon of increase in elderly population, osteoporosis has becoming a major public health concern.[1] Osteoporosis is typically characterized by an age-related reduction in bone strength, which predisposes the individuals affected to low-energy fractures. Osteoporosis is a common disease with enormous implications for the individuals affected and society as a whole. Information regarding bone mineral density obtained opportunistically from computed tomography (CT) performed with different imaging objectives may provide useful data to screen patients at osteoporosis risk.[2]

Early diagnosis of osteoporosis is essential. However, the silent nature of osteoporosis delays diagnosis.[3] In Dentistry, its early detection is important because patients with osteoporosis may suffer from higher failure rates of dental implant placement[4] and complications with other dental procedures wose results are associated with bone healing or remodelation.

Dual X-ray absorptiometry (DXA) is currently the standard for assessing osteopenia, osteoporosis or bone mineral density (BMD) and has been highly correlated with fracture risk and treatment efficacy.[5] The use of Hounsfield unit (HU) from CT scanning to assess BMD of the vertebrae has recently been described, and several subsequent studies exploring its utility in assessing fracture risk and prognostic success.[6,7]

The use of Hounsfield units (HU) from CT scanning to assess regional BMD of the column has recently been studied and the correlations between HU and BMD have been established,[6] mainly because they are directly related to tissue attenuation coefficients. The information provided by a simple HU measurement can be valuable to detection of patients who need DXA examination referral.[8]

In Dentistry, many researchers advocate that dental radiographs are useful to osteoporosis screening[2,9,10] as morphologic alterations in jaws are observed.[11] Considering CT, the correlation between the BMD of the cervical vertebrae and the lumbar vertebrae, also between the BMD of the cervical vertebra and mandible, has already been stablished.[12] Also, the correlation between BMD and HU using tomographic images may be a method for diagnosing patients with mineral bone disease and assessing risk factors for fracture.[7,13]

Thus, this investigation aimed to evaluate the correlation of BMD from maxilla and mandible with the cervical vertebrae, using HU from CT examinations to verify whether CT scans from maxilla and mandible could be useful as an osteoporosis screening tool.

METHODS AND MATERIALS

This research 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.

The CT examinations were performed in a private Radiology clinic, which performs approximately one thousand head and neck CTs each year for medical and dentistry purposes. Head and neck CT examinations performed from 2012-2013 were fully assessed. A convenience sample of 79 multislice CT examinations (35 males and 44 females) from patients who underwent maxilla, mandible and cervical vertebrae (C1, C2 and C3) scans simultaneously were included in this study. CT examinations whose maxilla, mandible and cervical vertebrae (C1, C2 and C3) were not scanned simultaneously and examinations with any technical failure or artifacts that would not allow the correct measurement of the HU in the anatomical area selected were excluded from this study.

Patients filled out a form with personal characteristics, lifestyle habits, and medical history. Patients with diabetes, thyroid disorders, osteometabolic diseases (other than osteopenia and osteoporosis), alcohol, and tobacco chronic use were excluded. None of participants had suffered any previous fracture in either the lumbar vertebrae or the femoral neck.

The images were obtained in 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. All the scans were executed from the Glabella region to the hyoid bone to evaluate the entire maxilla, mandible and cervical vertebrae. Digital Imaging and communications in Medicine (DICOM) format images were assessed using *E-film* (eFilm, version 1.5.3, Merge Healthcare, Milwaukee, WI).

Analysis of the CT scans

For each patient selected, the following left and right regions of CT scans were assessed: mandible ramus; mandible head; the area below the inferior first molar and the area below the upper cuspids using coronal slices except for the area below upper cuspids. Vertebrae C1, C2 and C3 were analyzed using sagittal slices. HU were measured in each region selected using a 0.1cm region of interest (ROI) positioned in the center of the slice. Angulations of the slices selected were adjusted manually to reduce the differences in head position among patient sample. Axial sections were used to guide the ROI placement in the correct anatomical area. In Figure 1, an example of the HU measurements methodology is provided.

One examiner,[14,15] a PhD candidate in Oral Radiology with 8 years of experience, carried out the aforementioned analysis of CT scans. This analysis was repeated for a randomly selected subsample of 8 CT images (about 10% of the overall study sample) to establish intra-examiner agreement. For each ROI, the examiner repeated the evaluations three times in three different weeks to avoid memory bias.

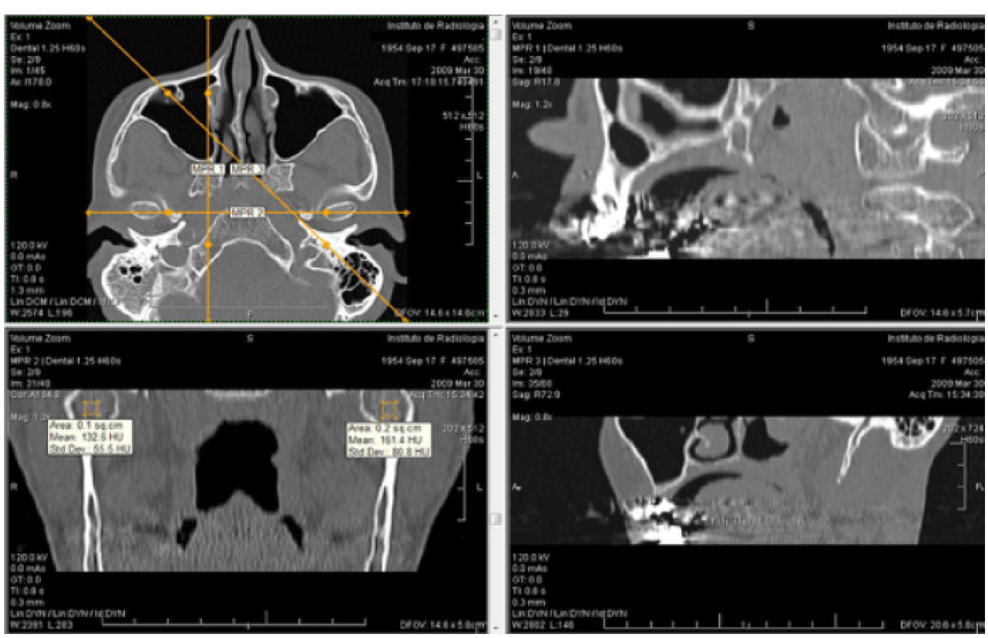

Figure 1 | Example of mandible head HU measurement using coronal slices. Axial and sagittal slices were used to guide the positioning of the ROIs in the correct anatomical area.

Statistical analyses

All analyses were performed in the MedCalc program (Ostend, Belgium). Correlations were analyzed using the Pearson correlation test, considering significant if $p < 0.05$. The correlation tests were performed arranging C1, C2, and C3 HU values in a single group, as well as HU values of right and left size of the anatomical regions evaluated.

RESULTS

The data are shown as mean and standard deviation. The mean age of the patients studied was 58 years old (40 to 84 years old).

Mean HU of each region analyzed is demonstrated in Table 1, as well as the maximum and minimum HU value obtained.

The bone densities of the cervical spine (C1, C2, and C3) were significantly correlated with the anterior maxilla measurements ($r = 0.27$; $p = 0.01$) and the posterior region of the mandible ($r = 0.25$; $p = 0.02$). No correlation was found between mandible head and cervical spine ($r = 0.20$; $p = 0.06$), as well as mandible ramus and cervical spine ($r = 0.14$; $p = 0.21$). The results of correlation tests are shown in Table 2.

Table 1 | Mean, maximum and minimum Hounsfield values obtained in each region assessed (C1, C2, C3, mandible ramus and mandible head, area below the inferior first molar, area above the cuspid).

	C1	C2	C3	Ramus R	Ramus L	Head R	Head L	Inferior molar R	Inferior molar L	Upper cuspid R	Upper cuspid L
Mean	222	258	394	102	91	292	303	182	173	378	349
SD	143	159	174	221	210	136	135	181	175	223	252
CV (%)	64	61	44	216	230	46	44	99	101	58	72
Min	-48	-16	18	-323	-254	-26	-2	-128	-99	-9	-134
Max	591	703	994	1018	809	755	695	624	755	921	1092

Abbreviations: SD: Standard deviation; CV: Coefficient of variation; R: right; L: left.

Table 2 | Correlation between Hounsfield units of the cervical spine (C1, C2, and C3 vertebrae) with different maxillofacial regions.

Region evaluated	r	p value
Anterior maxilla	0.27	0.01
Posterior mandible	0.25	0.02
Mandible head	0.20	0.06
Mandible ramus	0.14	0.21

r: Pearson correlation coefficient. Significant when p value < 0.05.

DISCUSSION

The dental practitioner should be able to screen systemic diseases that can also affect oral cavity, such as osteoporosis. By recognizing the disease risk and referring the patient to proper treatment in early phases, the dentist may improve patient's quality of life and reduce the risk of tooth loss,[2,16] as well as assist society in controling the financial burden associated with osteoporosis.

Currently, the most accepted method for measuring BMD is DXA.[3] However, DXA is not widely available in many countries; thus, many screening techniques using other imaging examinations have been studied. The use of CT scans of mandible and maxilla could be an useful osteoporosis screening tool. Previously, using cone beam computed tomography (CBCT), one found the radiodensity of cervical vertebrae (particularly C1 and C2) correlates strongly with DXA T-scores values obtained from lumbar spine; accordingly, the cervical radiodensity obtained from CBCT could be beneficial to predict osteoporosis status.[17]

HU values obtained from multislice CT examinations had also correlated with DXA previously.[6,13] Strong correlation between the HU values from the lumbar spine and BMD had already been observed.[18] Additionally, T-scores from femur has also been associated with HU values from cervical vertebrae[19], and HU from maxillary and mandibular sites were lower in patients with osteopenia or osteoporosis.[8] Mean maxillary HU values in distinct sites reported in literature by Woon et al,[8] which indicates a difference in HU values between patients with low BMD and normal patients, confirmed by BMD, were similar to the mean HU values obtained in this investigation, particularly in the mandible ramus of osteoporotic patients (227.01+195.22). This may indicate that the patients assessed in this study should be evaluated individually to be referred to DXA.

Similarly to bone in other parts of the spine, the cervical spine is affected by physiological processes such as aging and degeneration. As one get older, cervical spine BMD decreases.[20,21] Maxillofacial area, specially mandible, is proven to be affected by the systemic BMD decrease.[22,23]

In this study, a significant correlation was found between the cervical spine and the posterior region of the mandible, as well as a significant correlation between the anterior maxilla and the cervical spine. However, no correlation was found between the cervical spine and other parts of the mandible, such as mandible ramus and mandible head. This may suggest the bone nearby alveolar bone or the alveolar bone itself could have higher remodeling rates than the bone in the mandible ramus or mandible head.

CONCLUSIONS

Within the limitations of this study, the conclusion was that anterior maxillary bone and posterior mandible bone HU values correlate with cervical bone HU values, which may indicate that HU values obtained in maxillary or mandibular CT obtained for other examinations purposes could help in screening patients with osteoporosis, providing proper referring for these patients. Further most comprehensive prospective studies should be performed to evaluate this opportunistic imaging tool further.

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