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Correlation of bone density and loss of bone level in patients over 45 years of age

Abstract

Panoramic radiography is a complementary diagnostic tool, it is easy to access, its execution is very simple and its cost is reduced, through them it is possible to evaluate periodontal disease and bone loss through radiomorphometric indexes and fractal dimension analysis the low bone density. Several studies have demonstrated that low bone density is a risk factor in the progression of periodontal disease. Therefore, this study aimed to investigate the correlation between bone density, assessed by panoramic radiographs and loss of bone level in patients over 45 years of age. We evaluated 27 patients divided into three groups, osteoporotic, osteopenic and without disease, the bone density was evaluated through two radiomorphometric indices, a qualitative mandibular cortical index (MCL) and a quantitative Mental Index (MMI) and also through analysis of fractal dimension. We evaluated the level of periodontal bone loss and were compared with the values found in bone densitometry considered the gold standard in the evaluation of bone density. After all the analyzes the only correlations were found between analysis of the fractal density of the cortical and the trabeculated that was already expected. Therefore we concluded in our study that it is not possible to correlate the bone density with the bone level.

Keywords: radiography, panoramic, densitometry, bone and bones

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Introduction

In the Dentistry the panoramic radiography is considered an important tool in the complementary diagnosis, through the radiographs it is possible to follow the evolution of periodontal disease and periapical lesions.[1–5] The panoramic radiography is an examination of great accessibility to the population, of simple execution and relatively an examination of accessible cost. Through it it is possible to evaluate the bone quality, using radiomorphometric indices, aiding in the diagnosis of low bone density.[6–11] Several studies have shown that these panoramic radiographs, which mainly analyze the thickness and quality of the mandibular cortex, can predict the densitometric diagnosis of osteoporosis.[12–15] One of the indexes used to evaluate bone quality is the mandibular cortical index (BMI), which evaluates the qualitative condition of the lower mandibular cortical.

Currently, the diagnosis of osteoporosis is based on the identification of different risk factors, the most important being the low bone mineral density (BMD) of the femur and the lumbar spine.

In Brazil, the high cost of bone densitometry prevents not only its use as a screening tool, but also as a diagnosis for a large portion of the population served by the Health System. Patients without a densitometric diagnosis are at higher risk of fracture, and a high percentage of fractures may occur in patients with osteopenia or even with a normal densitometric diagnosis. Some other factors should be taken into consideration, such as clinical factors, as well as macro and microarchitecture of the bone.

Osteoporosis alters bone microarchitecture. The low bone density decreases the thickness and the number of bone trabeculae and increases the spacing between these trabeculae. Thus, it changes the attenuation of X-radiation in the bone, changing the density and texture of the image. As one of the most important factors contributing to bone resistance is its microarchitecture, fractal analysis of radiographs has been used to evaluate the structure of trabecular bone and biomechanical properties in various bones.

Some authors have shown that the analysis of the fractal dimension of radiographs of the proximal femur provided additional information to the bone mineral density to analyze the biomechanical properties of the bone. Recent studies have shown that bone texture parameters, including fractal dimension analysis, can predict the risk of bone fracture when combined with bone mineral density analysis.[16,17]

Few studies compared the trabecular pattern of patients with osteoporosis and normal bone mineral density by calculating the fractal dimension on panoramic radiographs and the results were divergent.[16,17] Although fractal analysis proved to be effective in evaluating bone quality, one of the main parameters of bone fragility in several bones, there is still no scientific evidence for the application of fractal dimension analysis in panoramic radiographs.

In investigations on the relationship between osteoporosis and periodontal disease, a greater propensity for alveolar bone loss in individuals with osteoporosis is suggestive.[18,19] In other words, osteoporosis or low systemic bone mineral density (BMD) should be considered a risk factor for the progression of periodontal disease.[20] However, there are a variety of confounding factors, such as age, genetics, bacterial infections, systemic disease, stress, socioeconomic status, oral hygiene and smoking.[21,22] Patients with osteoporosis are more likely to have lower mandibular BMD than controls.[23–25] The aim of the present study was to investigate the correlation between bone density, assessed by panoramic radiographs and the loss of bone level.

Methodology

Digital panoramic radiographs of 27 female patients aged above 45, among them normal, with osteopenia or osteoporosis were evaluated. The inclusion criteria were female; age up to 45 years; absence of considerable infection or bone pathology (Cysts, tumors). Cement-enamel junction clearly visible (No destruction due to cavities or restorations).

All panoramic radiographs were taken on a single ORTHOPHOS 5G Radiographic Apparatus (Sirona, Germany). Panoramic Radiography with 69kVp, 15mA and exposure time 14.1s. Cone Beam Computed Tomography with 16 bits, FOV of 8cm x 8cm, 85kVp, 07mA and exposure time 5.1s and voxel size of 0.16mm.

The region-of-interest selection software (ROI) was Adobe Photoshop CC 2015.5, the evaluation software was Image J64® to visualize the images to evaluate the radiomorphometric index, measures to assess bone level and for fractal analysis.

The radiomorphometric index used was the Cortical Mandibular Index (BMI) and the Mental Index (MI). The ICM describes the appearance of the normal mandibular cortical inferior part (C1), with small semilunar (C2) or porous (C3) erosions.

IM corresponds to the thickness of the inferior cortical of the mandible in a line below the mental foramen, perpendicular to the mandibular plane. The bone level was expressed as a percentage and calculated as follows: $A/B \times 100$ with "A", the distance (in mm) from the cement-enamel junction to crista alveolar. The measurement point at the alveolar crest was defined as the most coronal site of the bone adjacent to the margin the space of the ligament. "B" means the distance (in mm) from the cement-enamel junction to the apex.

Measurements were made between the premolars, more specifically the distal first and second mesial of the second premolar. These data were able to relate data from local bone density measurements. The percentages express the loss of bone level, relative to root length. The mean of the obtained results were sent to the analysis. Due to normal anatomy variation, a loss of up to 10% was not considered "bone loss" for statistical analysis.

For the fractal dimension analysis, 2 regions of interest (ROIs) were chosen: One of the inferior mandibular cortical with ROI of 2mm following a perpendicular line in the region of the mental foramen and a trabecular in the inferior region of the mental foramen with the ROI of 2mm.

For the fractal dimension analysis in the Image J64 software the digital images were segmented to binary image in a similar way described by Lane D.[16]

According to specifications[17] the ROI were duplicated and obscured by a Gaussian filter with a diameter of 35 pixels. At this stage the whole structure was removed in fine and medium scale and only large variations of density were maintained. After this process, a series of steps were performed for the analysis of bone trabeculation.

First it was subtracted from the original image the resulting heavily blurred image. After this step, in the resulting image, 128 grayscale was added to the result at each pixel location. This generated an image with an average value of 128, regardless of the initial intensity of the image.

The "binarization" was performed, which transformed the result into a binary image, so that afterwards, it can perform the erosion step, which will place each pixel with a minimum value of the neighboring pixel values. After the image dilation was performed, each pixel is replaced with the maximum value of the pixels of the neighborhood.

After the inversion was performed, a reverse image of the previous result was created, where the bone trabeculae were changed from white to black, which enabled them to be counted, and the background of the image turned white. Next, skeletonization was performed, whereby the edge pixels of the objects of the images were removed until the image was reduced to a single wide single pixel skeleton. In the skeletonized images analysis was performed in the ImageJ64 software, providing the values of the Fractal Dimension.

The data were tabulated in spreadsheets of Microsoft Excel 2013 software (Microsoft Corp., USA) and analyzed statistically. For this, the data were submitted to statistical analysis with a significance level of 95% ($p < 0.05$) and 99% ($p < 0.01$). The Shapiro Wilk test was performed to evaluate the normality of the sample in which a non-parametric sample was determined, therefore non-parametric tests were used. Comparisons of averages of the continuous measurements were performed using the Kruskal Wallis test. Correlations were performed using the Spearman correlation test.

Results

The normality test was performed using the Shapiro Wilk test, where a non-parametric sample was observed. Therefore, for the correlation evaluation, the Spearman test was used because it was a non-parametric sample.

In this study it was observed according to Table 1 a moderate correlation between the bone densitometry of the lumbar spine and that of the femoral neck (,427) and with that of the total femur (,421) there was also a strong correlation between femoral neck densitometry and that of the total femur (,884). There was a strong correlation between fractal density of the cortical and trabecular (634). Among the other variables evaluated there was no correlation between them.

Table 1 Correlation between the bone densitometry of the lumbar spine and that of the femoral neck and that of the total fêmur. Sperman correlation.

	Densitometry lumbar spine	Densitometry femur's neck	Densitometry total femur	Total absent	IM	Bone loss	Analysis fractal density cortical	Analysis trabecular fractal density
Densitometry Lumbar Spine	1,000	,427*	,421*	,173	,173	,284	,243	,221
Densitometry Femur's Neck	,427*	1,000	,884**	,052	,125	-,123	,110	,030
Densitometry total Femur	,421*	,884**	1,000	-,009	,144	-,095	,130	,279
TOTAL ABSENT	,173	,052	-,009	1,000	,187	,130	,068	,042
IM	,173	,125	,144	,187	1,000	-,089	-,308	-,256

Table Continued....

	Densitometry lumbar spine	Densitometry femur's neck	Densitometry total femur	Total absent	IM	Bone loss	Analysis fractal density cortical	Analysis trabecular fractal density
Perda óssea	,284	-,123	-,095	,130	-,089	1,000	,145	-,037
Analysis Fractal Density Cortical	,243	,110	,130	,068	-,308	,145	1,000	,634**
Analysis Trabecular Fractal Density	,221	,030	,279	,042	-,256	-,037	,634**	1,000

The Kruskal Wallis test was used to compare the variables, in Table 2 the variables age, total of missing teeth, Mentual index (MI), bone loss, fractal density of the cortical and trabecular density were compared with total bone densitometry found significant differences. In Table 3 the variables age, total of missing teeth, Mentual index (MI), bone loss, fractal density analysis of the cortical and trabecular with the densitometry of the Lumbar Spine were compared, and also no significant differences were found.

Table 2 Evaluation of total bone densitometry with the variables

	Age	Total absent	IM	Bone loss	Analysis fractal cortical	Analysis trabecular fractal
Densitometry total	,128	,096	,473	,828	,217	,589

Table 3 Evaluation of the densitometry of the lumbar spine with the variables

	Age	Total absent	IM	Bone loss	Analysis fractal cortical	Analysis trabecular fractal
Densitometry Lumbar Spine	,213	,764	,310	,663	,976	,552

In Table 4, the variables, age, total of missing teeth, Mentual index (MI), bone loss, fractal density analysis of the cortical and trabecular with the densitometry of the femoral neck were compared, and no significant differences were found either.

Table 4 Femoral neck densitometry evaluation with variables

	Age	Total absent	IM	Bone loss	Analysis fractal cortical	Analysis trabecular fractal
Densitometry colo fêmur	,185	,730	,287	,554	,966	,183

Discussion

Osteoporosis is a systemic skeletal disease characterized by low bone mass and deterioration of the micro architecture of bone trabeculation resulting in increased bone fragility and susceptibility to fracture. It is one of the most common diseases of the elderly and is estimated to reach 75 million people in Europe, Japan and the USA. The goal of osteoporosis screening is to identify individuals who are amenable to treatment. The fact that regular radiographs are taken by a large part of the adult population makes its potential use as a marker of skeletal health an interesting route of research.

In the last four decades, numerous research groups have reported oral radiographic examinations associated with osteoporosis. The preponderance of the evidence shows that the jaws of individuals with osteoporosis present reduced bone mass and altered morphology. Clinically useful predictions of individuals most likely to develop osteoporotic fractures will require a multifactorial model including both radiographic and clinical examinations. Future assessments should continue to look for oral radiographic signs with high sensitivity and specificity for osteoporosis, identify available clinical signs associated with osteoporosis, develop multidisciplinary classification methods, including both clinical and radiological parameters, and radiographic examinations and clinical analyzes as much as possible to minimize the involvement of the dentist, as well as to standardize the collection of data.

In a study by Elders et al.,[18] there was no significant relationship between measurements of bone mass and height of alveolar bone, therefore, systemic bone mass is not an important factor in the pathogenesis of periodontitis.[18] Contradicting this study, other authors show in their results that severe osteoporosis significantly reduces the mineral content of jaw bone and may also be associated with lower insertion level and becomes favorable for periodontal disease.[7,25]

White and Rudolph, evaluated periapical radiographs obtained from 11 patients with osteoporosis and 12 control subjects, the images were scanned at 600 dpi. A computer program was used to verify the morphological characteristics of the trabecular architecture. The mean values for each characteristic were determined for the osteoporosis and control groups and compared by the anatomical region. Twenty-four morphological characteristics of the trabecular and cortical regions were examined in each anatomical region. Patients with osteoporosis presented a significantly altered morphological pattern in the anterior maxilla (P = 0.019) and posterior mandible (P = 0.013) compared to the control group. The data support the hypothesis that patients with osteoporosis have an altered trabecular pattern in the jaws compared to normal individuals.[16]

Contradicting the other study authors of this study say that panoramic radiographs may show the thinning of the mandibular cortical inferior but has no connection with vertebral fragility fractures and the decrease of the cortical mandibular.[14]

In another study, a statistically significant relationship was found between CPITN and radiographic measurement of the enamel-cement junction at the alveolar margin of the bone crest. There was a close correlation between CPITN and bone loss measured on panoramic radiography.[3]

Compared with the toothed individuals, lumbar BMD and thickness of the mandibular cortical of edentulous women were not significantly different. In dentate individuals, no significant correlation was observed between periodontitis clinical parameters (mean depth of probing, occurrence of bleeding after probing and number of missing teeth) and bone mass parameters (lumbar BMD and MCT); there was no significant relationship between measurements of bone mass and alveolar bone height. We suggest, therefore, that systemic bone mass is not an important factor in the pathogenesis of periodontitis.

The results of this and other studies suggest that simple visual estimation of mandibular lower cortical on panoramic radiographs may be useful in identifying postmenopausal women with low bone mineral density.

Conclusion

According to the results of this study, it can be affirmed that it is not possible to correlate the bone density with the bone level.

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None.

Conflicts of interest

The author declares that there is no conflicts of interest.

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