v. 2, n. 15, 2022

International Journal of Health Science

STUDY OF OBLIQUE LINE CONTRAST IN PANORAMIC RADIOGRAPHS AS A POSSIBLE METHOD OF ASSESSING BONE MINERAL DENSITY

Matheus Arazin Bitencourt
Department of Stomatology, Collective Health and Forensic Dentistry – FORP-USP

Giovani Antonio Rodrigues
Department of Stomatology, Collective Health and Forensic Dentistry – FORP-USP

Plauto Christopher Aranha Watanabe
Department of Stomatology, Collective Health and Forensic Dentistry – FORP-USP

Presentation: Research project presented to the Initiation Program in Technological Development and Innovation of the University of São Paulo for consideration in the Area of Technologies for Quality of Life, in the health sector.

Abstract: Osteoporosis is a chronic disease that affects bone mineral density (BMD), allowing for greater fragility of bone tissue and predisposing patients to a greater risk of fractures. The gold standard for the diagnosis of osteoporosis is dual-beam X-ray densitometry (DXA), a very expensive test. Research suggests the use of different indices in panoramic radiography as a way to assess BMD and to be able to detect changes in bone metabolism before fractures occur, however, no study to date has evaluated oblique line contrast (OLC) for this purpose. Therefore, the aim of this study is to evaluate the feasibility of using CLO as an auxiliary mechanism in the detection of low bone mineral density. This study was approved by the Research Ethics Committee of FORP/USP (CAAE: 0016.0.138.000-09).
Keywords: Oblique line, osteoporosis, panoramic radiograph.

INTRODUCTION

Osteoporosis is a chronic progressive systemic disease characterized by decreased bone mass and deterioration of the microarchitecture of bone tissue, leading to bone fragility and increasing the risk of fractures. (Link et al., 1999).

The imbalance of bone metabolism caused by osteoporosis leads to a decrease in bone mineral throughout the body. Like other bones in the body, the mandible can be affected by systemic diseases or drug treatments even though it is not directly involved with the disease (Çakur et al., 2014). Studies show that decreased bone mineral density affects the morphometric (Taguchi et al, 1995; Watanabe et al. 2007), densitometric (Horner & Devlin, 1998) and architectural (White & Rudolph, 1999) properties of the mandibular bone in osteoporotic patients in radiographs, and the main radiographic signs of this condition include a relative generalized radiolucency of the maxilla and mandible or bone rarefaction, decrease in the thickness of the lower mandibular cortex, in addition to erosions in this same cortex, in addition to generalized evidencing or accentuation of the corticals, maxillary sinus, mandibular canal, nasal cavity, oblique line, among others.

Currently, the diagnosis of osteoporosis is based on the identification of different risk factors, the most important being low bone mineral density (BMD) of the femur and lumbar spine (Kanis, 1994). Although double X-ray densitometry (DXA) is considered the gold standard for the diagnosis of osteoporosis (Lochmuller et al., 2003), its high cost and low availability preclude its use as a method of population screening (Lochmuller et al., 2003). Costa-Paiva et al., 2003).

Considering that dental patients are frequently referred for panoramic radiography, which is a widely available and low-cost exam capable of expressing morphological changes in the mandible due to age, it is necessary to study adequate indices to detect bone mineral loss and thus being able to correlate these findings with systemic bone loss, being, therefore, a simple way of predicting the disease.

One of the ways to assess the possibility that factors present in panoramic radiographs may indicate mineral bone loss is the use of different qualitative and quantitative indices (López-López et al., 2011).

Kim and colleagues (2014) studied the usefulness of panoramic radiographs in diagnosing osteoporosis in the Korean population. It is important to note that in this study, each observer had no knowledge of the DXA results of each patient, nor access to their personal information, as the authors understood that this could influence the final result. After analyzing the data, it was concluded that the three investigated indices (the mental index, the mandibular cortical index and a visual estimation index) presented themselves as useful tools for the diagnosis of osteoporosis (Kim et al., 2014).

Furthermore, the authors suggest that more studies are needed on this topic in order to obtain more accurate and reliable results and conclusions.

Therefore, it appears that panoramic radiographs can be used as tools to detect low bone mineral density, not for the purpose of diagnosing a particular disease, but to identify and properly refer the patient for investigation by bone densitometry, for example, allowing to intercept the progress of the disease.

Despite the vast literature on the subject, there are still radiographic signs that have not been studied, such as oblique line contrast. It is relatively common to observe on radiographs, an enhancement of the oblique line due to the marked loss of trabecular bone mass of the oblique line in women over 65 and edentulous, since there is an evident loss of trabecular bone mass from the body of the mandible and less loss of cortical bone. (Watanabe, Farman, Watanabe & Issa, 2008; Watanabe, 2009).

The growing development and technological advances in the imaging field have provided a quality radiographic image, facilitating the various types of diagnoses in the dental field. One of these gains is in the visualization of early signs of low bone mineral density, for example, as occurs in osteoporosis.

Thus, this study seeks to identify variations in bone mineral density through the contrast profile of the oblique line on panoramic radiographs and to be able to compare it to other methods already used for this purpose. Therefore, the potential benefits of this study are relevant, given that the knowledge to be produced involves issues that have been little studied, especially in a group of Brazilian women and men. In addition to offering subsidies for the knowledge of a new reliable qualitative and quantitative index for use as a low-cost method, capable of expressing morphological changes of the mandible as a function of age, and consequently enhancing the prevention and control of osteoporosis.

GOALS

GENERAL GOAL

To evaluate the feasibility of using the mandibular oblique line contrast level as a predictor of bone mineral loss (DMO)

SPECIFIC GOALS

- Compare the Oblique Line Contrast (OLC) and the Mandibular Panoramic Index to examine a possible correlation between them and bone mineral loss
- To analyze the accuracy of the oblique line contrast index to predict low BMD in men and women.
- Visually assess the presence of greater prominence of the oblique line in patients with osteoporosis on panoramic radiographs.

CASUISTRY AND METHODS

CASUISTRY

For this study, 270 radiographic images were used in JPEG format from the Radiology Service of the Hospital das Clínicas of the Faculty of Medicine of Ribeirão Preto (HCFMRP/USP) carried out between 2015 and 2021. These images belong to patients treated at the hospital for evaluation of osteoporosis and along with panoramic radiographs, DXA exams were also collected (exams previously performed in the years 2015 to 2021). After selection, the images were separated according to the inclusion and exclusion criteria of this work. 3 groups will be formed, one with images of

patients without changes in bone mineral densit (0), another containing images of **patients diagnosed with osteopenia (1)** and the third group with images of **patients with osteoporosis (2)**. For classification and separation of groups, the DXA exam will be used. This study was approved by the Research Ethics Committee of FORP/USP (CAAE: 0016.0.138.000-09)

Inclusion criteria:

- Radiographic images within quality standards;
- Patients of both sexes aged over 30 years;
- Radiographic images performed on a single panoramic x-ray machine (*Veraviewepocs of J. Morita Co)* with fixed exposure factors and performed by the same operator.

Exclusion criteria:

- Radiographic images where the oblique line is superimposed on other structures and difficult to assess;

MEHTODS

Analysis of radiographic images by the Mandibular Panoramic Index

To assess cortical bone thickness, the images were opened in Photoshop software and the mental foramen on each side of the mandible was identified. A tangent to the base of the mandible and a line perpendicular to the tangent of the mandibular cortex was drawn, which extends to the lower limit of the mental foramen as in the image on the right.

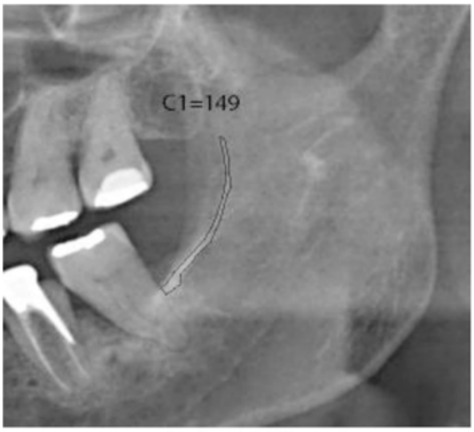
Then, the ratio between the thickness of the mandibular cortex and the distance between the lower limit of the mental foramen and the base of the mandible is calculated.

1.1 IPM measurement illustration

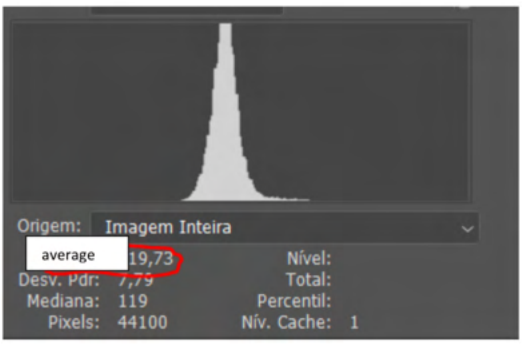
Analysis of radiographic images by Oblique Line Contrast

To analyze the Oblique Line Contrast (CLO), the Photoshop histogram tool was used. A histogram illustrates how pixels in an image are distributed by plotting the number of pixels at each color intensity level (Adobe Photoshop, 2020). In addition to this graph, the program determines the average color intensity in the selected area.

Therefore, in the same radiographic images, the contrast of the oblique line was measured by performing a ratio between the **average color intensity of the oblique line (C1) and average color intensity of the mandibular ramus region (C2)**. To define the area of C1, we used the Photoshop Pen tool. With the pen it is possible to delimit the outline of the oblique line and from its selection, generate a histogram that has the Average color intensity of that region.

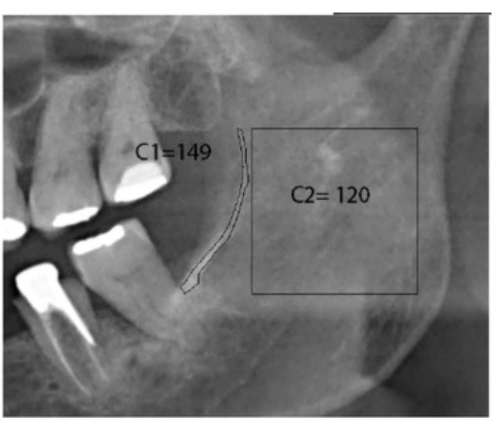


1.2. represents the contrast measurement area defined as C1 (slanted line region)

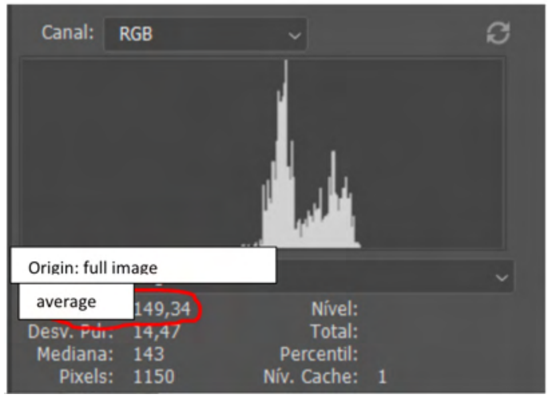


1.3. representation of the average color intensity of the selected region.

The C2 region was defined as a square area that starts from the region close to the highest point of the oblique line in the mandibular ramus and extends to an area close to the mandibular cortical bone.



1.4. represents the contrast measurement areas, defined as C1 (oblique line region) and C2 (mandibular ramus region).



1.5. illustration of the average color intensity of the selected region.

Lastly, **the contrast of the oblique line (C)** was obtained through the ratio between C2 and C1 (C2/C1). It is known that the oblique line, as it is more radiopaque, will present a value greater than the branch region, therefore, when we perform the division in which the divisor (C1) is greater than the dividend (C2) we will have a quotient smaller than 1 Furthermore, it is possible to state that the closer the quotient is to 1, the lower the contrast presented.

*Note: C1 and C2 values were approximated.

RESULTS

	Men	Women
No alteration	48 (33%)	52 (47%)
Osteopenia	76 (52%)	45 (41%)
Osteoporosis	21 (15%)	13 (12%)
Total	**145 (57%)**	**110 (43%)**

Table 1 – Sample distribution.

In the table above it is possible to verify how the sample was distributed in relation to the sex of the patients and bone condition.

	DXA Fêmur	Média Contraste	Média IPM
N	0	100	85
	1	121	94
	2	34	23
Mean	0	0.761	0.359
	1	0.724	0.344
	2	0.677	0.342
Median	0	0.765	0.370
	1	0.735	0.335
	2	0.683	0.330
Mode	0	0.700	0.370
	1	0.705 ª	0.350
	2	0.470 ª	0.330
Standard deviation	0	0.0879	0.0544
	1	0.100	0.0637
	2	0.135	0.0740
Minimum	0	0.380	0.200
	1	0.360	0.195
	2	0.395	0.210
Maximum	0	0.960	0.475
	1	0.925	0.560
	2	0.900	0.550
Shapiro-Wilk W	0	0.941	0.982
	1	0.972	0.985
	2	0.972	0.952
Shapiro-Wilk p	0	< .001	0.286
	1	0.013	0.385
	2	0.529	0.323

Table 2 – Study results.

The sample has a close amount of men and women (57% and 43%). Since proportionally, women had less bone alterations when compared to the group of men.

In table 2, we can see that the patients were classified according to the DXA result, in which the numbers 0, 1 and 2 refer to the bone status of each patient (healthy, with osteopenia and with osteoporosis), respectively.

According to the table, it is possible to verify that the average contrast and MPI average are slightly lower in patients with bone alterations. The same occurs when analyzing fashion. Thus, it is possible to interpret that the greater the contrast between the oblique line and the mandibular ramus, the greater the chance of the patient having a bone alteration, whether osteopenia or osteoporosis. However, as this is a small difference, it is difficult to state a strong correlation between these data.

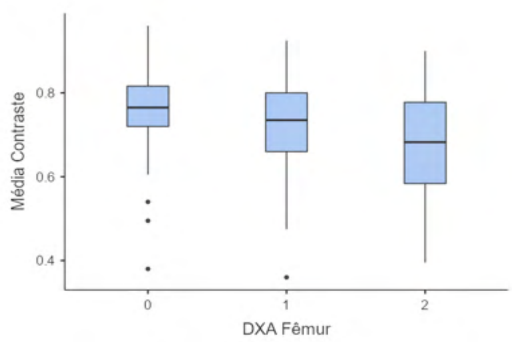


Table 3 – Contrast averag.

The graph below illustrates the MPI distribution in the different bone conditions presented by the Femur DXA.

	DXA Fêmur	Média Contraste	Média IPM
N	0	100	85
	1	121	94
	2	34	23
Mean	0	0.761	0.359
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	1	0.972	0.985
	2	0.972	0.952
Shapiro-Wilk p	0	< .001	0.286
	1	0.013	0.385
	2	0.529	0.323

Table 4 – IPM Average,

International Journal of Health Science ISSN 2764-0159 DOI 10.22533/at.ed.1592152215039

This other graph illustrates the distribution of the contrast average in the different bone conditions presented by the Femur DXA.

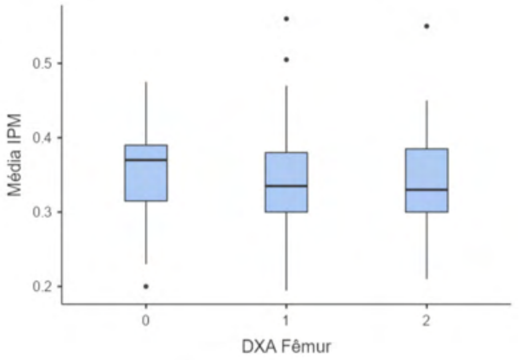

Table 5 – Correlation Matrix.

In this correlation matrix, it is possible to notice that between the femur DXA and the contrast mean the result was a weak negative correlation, that is, although it is possible to identify a difference in the contrast average between the different DXA groups, this is a small statistical difference. This may have occurred because the sample has a large number of men, who tend to have a less altered bone structure compared to women after menopause. When comparing DXA with average MPI it is not possible to find a correlation. Already between the average IPM and the average of contrast it is possible to find a weak positive correlation, that is, as the MPI increases, the average of contrast increases. This means that patients who have a higher MPI also tend to have a contrast average closer to 1, thus showing that they are a patient with less bone loss. Most of the values considered presented p<0.05 with a confidence interval of 95%.

Each point in the table above represents the result found in the average of Contrast and in the average of MPI of each patient, this distribution is made so that the correlation matrix can be made.

DISCUSSION

Osteoporosis detection by panoramic dental radiographs is a perennially investigated research topic with global contributions. Panoramic radiographs are considered tools for early detection and screening of osteoporosis by surveys around the world. (Yeung AWK; Mozos I, 2020)

Several articles suggest different ways of looking for a correlation between panoramic radiographs and osteoporosis. For example: The detection of trabecular landmarks for early osteoporosis screening on dental panoramic radiographs (Ren J et al, 2020), another study sought to identify variables that can be used for osteoporosis detection using supportive analysis, fractal dimension (DF) and gray

Correlation Matrix

		DXA Fêmur	Média Contraste	Média IPM
DXA Fêmur	Spearman's rho	—		
	p-value	—		
Média Contraste	Spearman's rho	−0.238 ***	—	
	p-value	< .001	—	
Média IPM	Spearman's rho	−0.157 *	0.097	—
	p-value	0.026	0.157	—

Note. * p < .05, ** p < .01, *** p < .001

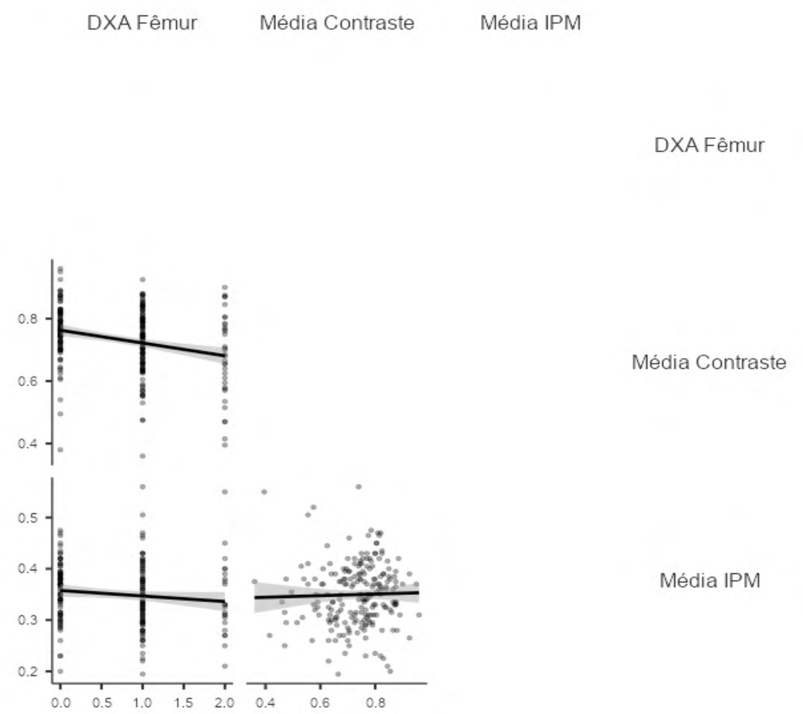

Table 5 - Plot.

level co-occurrence matrix (GLCM) using multiple regions of interest and to develop a model of osteoporosis detection. (Hwang jj et al, 2017), in addition, we found an article that evaluated mandibular radiomorphometric indices such as mandibular cortical width (MCW), mandibular inferior cortex morphology (MIC), tooth loss and alveolar bone loss as predictors of osteoporosis risk (Tanaka R et al, 2020), in addition, there is a study that proposes an automatic calculation of relevant mandibular indices (Mandibular Cortical Width, Panoramic Mandibular Index, Mandibular Ratio, Mandibular Cortical Index) in panoramic dental radiographs for early detection of osteoporosis (Aliaga I et al, 2020).

CONCLUSION

In addition to the studies mentioned, there are several others in the literature that seek to make this correlation, however none of them analyzed the oblique line contrast as a possible method of assessing bone mineral density. Thus, it is necessary to understand that this is an initial research for this evaluation method, therefore, it is important that future researches are carried out with a larger and more homogeneous database. In this study, it was possible to find a possible relationship between the Contrast average of the Oblique Line and the patient's bone condition, considering that the contrast average obtained by the ratio between C2 (branch region) and C1 (oblique line region), was lower in people who have osteoporosis. The lower this contrast average, it means that the oblique line is more radiopaque in relation to the branch, characterizing bone loss in the patient. However, this is a statistically small difference, raising the need for further studies.

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