ISSN: 2470-4539

Short Communication

Journal of Bone Biology and Osteoporosis

Detecting Patients with Low Bone Mineral Density during Cone-Beam Computed Tomography

Barra SG*, Kato CNAO, Pereira IG, Amaral TMP, Brasileiro CB and Mesquita RA

Department of Oral Surgery and Pathology, School of Dentistry, Federal University of Minas Gerais, Brazil

***Correspondence:** Sâmila Gonçalves Barra, Department of Oral Surgery and Pathology, School of Dentistry, Federal University of Minas Gerais, Av. Antonio Carlos, 6627-Pampulha, Belo Horizonte-MG, 31270-010, Brazil, Tel: +55-31- 334092499; E-mail: samilabarra@ufmg.br

Received date: September 05, 2019; Accepted date: October 18, 2019; Published date: October 23, 2019

Abstract

Population aging is a worldwide phenomenon that is often explained by improvements in living conditions. Common diseases in the older age group are investigated to improve their prevention and treatment. Osteoporosis, a silent disease characterized by the progressive decrease of bone mineral density, resulting in an increased risk of fractures, is one of the most common diseases that affect patients over 60 years of age. Dual-energy X-ray absorptiometry (DXA) is the gold standard test for the diagnosis of low bone mineral density. However, this test has a high cost and is not available to all populations. Previous studies have found that dental imaging can be used to identify low bone mineral density. Dental imaging examinations have lower costs and are more routine than DXA. Qualitative and quantitative radiomorphometric indices as well as mathematical methods are used to identify patients with low bone mineral density through dental imaging exams. In addition, the morphology of the mandibular bone cortex is the most studied panoramic radiography exam. Cone-beam computed tomography (CBCT) is a three-dimensional examination that produces high-quality images without distortion and magnification. This examination is widely used in dentistry and can be used for the evaluation of bone mineral density. However, CBCT is a low-cost examination, compared to DXA.

Keywords: Bone density, Cone beam computed tomography, Fractals, Mandible, Osteoporosis

Background

Osteoporosis is a skeletal disease characterized by a decrease in bone mass that predisposes patients to an increased risk of bone fractures [1]. Osteoporosis is one of the most common diseases that primarily affect post-menopausal women, and one-third of the women diagnosed with osteoporosis develop a fracture within five years. Therefore, early diagnosis can improve patients' prognosis and quality of life [1].

International guidelines recommend that all women aged 65 years or younger with associated risk factors undergo osteoporosis screening [1-4]. The most reliable way to quantify bone mineral density (BMD) is via the measurement of the proximal femur and lumbar spine using DXA [1-2]. The World Health Organization developed the following BMD diagnostic guidelines: normal (T-score ≥ -1.0), osteopenia (T-score between -1.0 and -2.5), and osteoporosis (T-score ≤ -2.5) [1-4]. Although DXA is the gold standard for BMD measurement, its routine use in population screening is limited [1-5]. To reduce the initial early detection cost, researchers have investigated exams that produce efficient low-BMD screening signals [6].

A few studies have evaluated osteoporosis of the jaw using the CBCT imaging technique and the mandibular index [3,7-15], while others have analyzed fractal dimension (FD) [10,15].

Discussion

Pioneering studies in panoramic radiographs

Benson et al. [11], proposed a routine dental examination measurement index for the possible identification of BMD changes. Panoramic radiographs were evaluated using a millimeter scale to identify the shortest distance between the lower border of the mandible and the upper and lower margin of the mental foramen. The panoramic mandibular index (PMI) was created using the ratio of cortical thickness to the distance between the edges of the mental foramen [11]. Benson et al. [11], used PMI as a variable to evaluate changes in the height of the mandible cortex.

Klemetti et al. [12] evaluated the mandibular cortex index (MCI) using panoramic radiographs. The authors stated that the projective variability of panoramic radiography excluded the possibility of comparing the exact absolute dimensions numeric found in quantitative indices. Klemetti et al. [12] used a qualitative method to evaluate the morphology of the mandibular bone cortex. Panoramic radiographs were classified as C1, C2, and C3, where C1 represented the endosteal margin of the flat, sharp cortex on both sides (Figure 1A); C2 represented the endosteal margin that showed semilunar defects (lunar reabsorption) or appears to form endosteal cortical residues (one to three layers) on one or both sides (Figure 1B); and C3 represented a cortical layer that formed heavy endosteal cortical residues and was clearly porous (Figure 1C), based on the visual and subjective evaluation of the mandibular cortex distally to the mental foramen on both sides. The authors concluded that BMD degrees could be observed using panoramic radiographs, but this method was not a strong predictor of the osteoporosis [12].

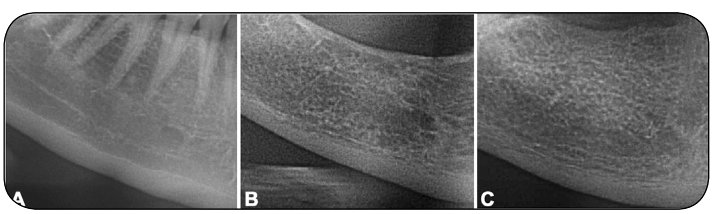

Figure 1: A: C1 represented the endosteal margin appears regular B: C2 represented the endosteal margin that showed semilunar defects (lunar reabsorption) or appears to form endosteal cortical residues (one to three layers) C: C3 represented a cortical layer that formed heavy endosteal cortical residues and was clearly porous.

Ledgerton et al. [13] evaluated Benson et al. [11] PMI accuracy level. Three measurements were conducted on both sides of the mental foramen, and a line was traced perpendicular to the tangent to the lower border of the mandible and through the center of the mental foramen. After the width of the cortical was measured, the distance between the lower border of the mandible and the inferior margin of the mental foramen and the distance between the lower border of the mandible and the upper margin of the mental foramen were measured. The authors found that Benson et al. [11], PMI accuracy was poor (15% to 36%). However, these results were found using statistical methods different from the other studies and differences in measurements in the mandibular cortex [13].

These previous validated and evaluated indices became the parameters for the creation of new indices observed on the CBCT images.

Studies in CBCT

Koh and Kim [7], published the first study that used CBCT in the evaluation of BMD. A quantitative classification was validated based on the panoramic radiograph measurements presented by Ledgerton et al. [13] and Klemetti et al. [12]. The indices were adapted for the volume-derived sections of the CBCT as well as an evaluation of the lower mandibular cortex morphology. These results were compared with the gold standard DXA test. The measurements evaluated in the sagittal plane included the following: CTI (S): computed tomography mandibular index (superior), the ratio of the width of the inferior cortex by the distance from the upper margin of the mental foramen to the lower border of the mandible (Figure 2A), and CTI (I): computed tomography mandibular index (inferior), the ratio of the width of the inferior cortex by the distance from the lower margin of the mental foramen to the lower border of the mandible (Figure 2B). CTMI: computed tomography mental index, created using the width of the inferior mandibular cortical (Figure 2C). CTCI: computed tomography cortical index, the cortical index of CBCT, classifies the lower mandibular cortex into type 1, where the cortical endosteal margin appears equal and regular; type 2, where the endosteal margin shows semilunar defects or 1 to 2 layers of cortical endosteal residues; and 3, where the cortical layer has numerous endosteal residues and is clearly porous, which correspond with the classification used by Klemetti et al. [12]. This study found that that CTI (S), CTI (I), and CTCI can be used to evaluate osteoporotic women [7].

Gomes et al. [9] compared the qualitative mandibular index (MCI) between panoramic reconstruction and cross-sectional images of CBCT. The morphology of the lower jaw cortex was observed, as in Klemetti et al. [12]. The results of the study showed that the classification evaluated in the panoramic reconstruction was comparable to that observed in the cross-sectional CBCT, validating the use of MCI in CBCT cuts [9].

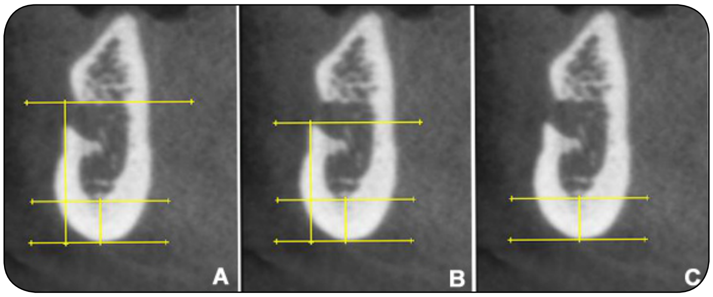

Figure 2: A: CTI (S): the ratio of the width of the inferior cortex by the distance from the upper margin of the mental foramen to the lower border of the mandible. B: CTI (I): the ratio of the width of the inferior cortex by the distance from the lower margin of the mental foramen to the lower border of the mandible. C: CTMI: the width of the inferior mandibular cortical.

Alonso et al. [14], analyzed the panoramic radiographs, panoramic reconstructions, and cross-sectional cuts of CBCT using the MCI. A greater agreement was found between the findings of panoramic reconstruction and panoramic radiography than the findings from cross-sectional cuts and panoramic radiography. However, the study only evaluated two cross-sectional cuts, which is a limitation. In these images, changes in the bone microarchitecture were observed without using overlapping images, but this technique had a greater risk of false positive BMD diagnoses. After this analysis, the authors concluded that the Klemetti index should not be used to evaluate osteoporosis using cross-sectional CBCT images, but they suggested that this type of image enables a strong analysis of bone quality and may be an important tool in the detection of low BMD in post-menopause patients [14].

Gungor et al. [8], used the same measurements proposed by Koh and Kim [7], (CTI (I), CTI (S), CTMI) for the evaluation of cross-sectional cuts of the mental foramen region. Other measures were verified in the study using fractal analysis and histogram analysis. The mandibular index value results were similar to previous studies about low BMD [8].

Several mandibular indices created using two-dimensional examinations and panoramic radiographs were validated for the identification of low BMD via CBCT. CBCT is less expensive than the DXA exam, which is the gold standard exam for this analysis. CBCT should not be performed solely for the purpose of evaluating low BMD, but because it is a more common examination than DXA, CBCT may be combined with radiomorphometric indices to screen low BMD.

Fractal dimension

Other studies have investigated BMD using nontraditional mathematical methods, such as fractal analysis. "Fractal" has been used to name self-similar forms in geometry. Fractal geometry is a quantitative tool used to characterize complex self-similar shapes. Fractal dimension (FD) is a quantitative parameter that measures complexity. Applications FD is observed in various areas of the dentistry: dental implants, root canal treatments, surgery, restorations, caries, and osteoporosis [15]. More recent research has used CBCT FD to evaluate several of the applications mentioned above, including the evaluation of BMD in postmenopausal patients. The results with regard to the loss of bone mass or whether FD analysis can be used to evaluate BMD have not been conclusive. Some parameters as compression image or size of region of interest may change the measurement. In addition to evaluating radiomorphometric indices, Gungor evaluated FD. FD has been proven to be strong predictors of bone status [8].

Mostafa et al. [10] evaluated CBCT using radiomorphometric indices and analyzed FD. The authors used the CTCI defined by Klemetti, CTMI defined by Ledgerton, and CTI defined by Koh and Kim. FD was performed in the same slices used for the radiomorphometric indices. The authors concluded that the radiomorphometric indices evaluated using CBCT may be a useful alternative for screening patients to identify changes in their BMDs, but FD's application needed to be further studied [10].

Conclusion

The CBCT may be used to detect low BMD in postmenopausal patients through different techniques, such as radiomorphometric indices and fractal dimension analysis. Less expensive, routine dental exams, when compared to DXA, which is the gold standard test for BMD analysis, may be used to screening early changes in patients' BMDs, resulting in a better prognosis for these patients.

Declaration

Author's contributions

Barra SG, Kato CNAO, Pereira IG, conceived the study and drafted the manuscript, Amaral TMP, Brasileiro CB and Mesquita RA, making critical revisions related to important intellectual content of the manuscript. The authors approved the final version of the editorial.

Conflict of interest

The authors have no conflict of interest to declare.

This article does not contain any studies with human or animal subjects performed by the any of the authors.

References

1. NIH Consensus Development panel on osteoporosis prevention, diagnosis, and therapy. *JAMA*. 2001;285(6):785-795. Doi: http://dx.doi.org/10.1001/jama.285.6.785
2. World Health Organization (WHO). Assessment of fracture risk and its application to screening for postmenopausal osteoporosis : report of a WHO study group. Vol 843. World Health Organization; 1994.
3. Nakamoto T, Taguchi A, Ohtsuka M, et al. Dental panoramic radiograph as a tool to detect postmenopausal women with low bone mineral density: untrained general dental practitioners' diagnostic performance. *Osteoporos Int*. 2003;14(8):659-664. Doi: http://dx.doi.org/10.1007/s00198-003-1419-y
4. Lane NE. Epidemiology, etiology, and diagnosis of osteoporosis. *Am J Obstet Gynecol*. 2006;194(2 Suppl):S3-11. Doi: http://dx.doi.org/10.1016/j.ajog.2005.08.047
5. Reginster JY, Burlet N. Osteoporosis: a still increasing prevalence. *Bone*. 2006;38(2 Suppl 1):S4-9. Doi: http://dx.doi.org/10.1016/j.bone.2005.11.024
6. White SC, Pharoah MJ. The evolution and application of dental maxillofacial imaging modalities. *Dent Clin North Am*. 2008;52(4):689-705. Doi: http://dx.doi.org/10.1016/j.cden.2008.05.006
7. Koh KJ, Kim KA. Utility of the computed tomography indices on cone beam computed tomography images in the diagnosis of osteoporosis in women. *Imaging Sci Dent*. 2011;41(3):101-106. Doi: http://dx.doi.org/10.5624/isd.2011.41.3.101
8. Güngör E, Yildirim D, Çevik R. Evaluation of osteoporosis in jaw bones using cone beam CT and dual-energy X-ray absorptiometry. *J Oral Sci*. 2016;58(2):185-194. Doi: http://dx.doi.org/10.2334/josnusd.15-0609
9. Gomes CC, de Rezende Barbosa GL, Bello RP, et al. A comparison of the mandibular index on panoramic and cross-sectional images from CBCT exams from osteoporosis risk group. *Osteoporos Int*. 2014;25(7):1885-1890. Doi: http://dx.doi.org/10.1007/s00198-014-2696-3
10. Mostafa RA, Arnout EA, Abo El-Fotouh MM. Feasibility of cone beam computed tomography radiomorphometric analysis and fractal dimension in assessment of postmenopausal osteoporosis in correlation with dual X-ray absorptiometry. *Dentomaxillofac Radiol*. 2016;45(7):20160212. Doi: http://dx.doi.org/10.1259/dmfr.20160212
11. Benson BW, Prihoda TJ, Glass BJ. Variations in adult cortical bone mass as measured by a panoramic mandibular index. *Oral Surg Oral Med Oral Pathol*. 1991;71(3):349-356. Doi: http://dx.doi.org/10.1016/0030-4220(91)90314-3
12. Klemetti E, Kolmakov S, Kröger H. Pantomography in assessment of the osteoporosis risk group. *Scand J Dent Res*. 1994;102(1):68-72. Doi: http://dx.doi.org/10.1111/j.1600-0722.1994.tb01156.x
13. Ledgerton D, Horner K, Devlin H, et al. Panoramic mandibular index as a radiomorphometric tool: an assessment of precision. *Dentomaxillofac Radiol*. 1997;26(2):95-100. Doi: http://dx.doi.org/10.1038/sj.dmfr.4600215
14. Alonso MBCC, Vasconcelos TV, Lopes LJ, et al. Validation of cone-beam computed tomography as a predictor of osteoporosis using the Klemetti classification. *Braz Oral Res*. 2016;30(1). Doi: http://dx.doi.org/10.1590/1807-3107BOR-2016.vol30.0073
15. Sánchez I, Uzcátegui G. Fractals in dentistry. *J Dent*. 2011;39(4):273-292. Doi: http://dx.doi.org/10.1016/j.jdent.2011.01.010