Journal of Frailty, Sarcopenia and Falls

Review Article

Diagnosis of osteoporosis in dental patients

Theodora S. Tounta

General Dentist

Abstract

Osteoporosis is a severe skeletal disease that leads to bone fractures, even disability, if it remains undetected. However, osteoporosis remains frequently unnoticed until a fracture occurs. It is possible for dental practitioners to screen patients at risk of osteoporosis and refer them for an osteoporosis evaluation. Screening can be achieved mainly through dental radiographs and especially panoramic x-rays, where several radiographic indices, such as Mandibular Cortical Width (MCW), Mandibular Cortical Index (MCI), Gonial Index (GI), Antigonial Index (AI), Panoramic Mandibular Index (PMI) and alveolar crest resorption degree (M/M ratio) can be assessed. Furthermore, patients with osteoporosis develop changes in the trabecular bone of their jaws and those alternations can be detected by dentists through periapical and panoramic x-rays. Moreover, periodontitis, which is a major reason for tooth loss, deteriorates when the patient also suffers from osteoporosis. Dentists can thus screen their patients who are possibly unaware of their osteoporosis, and refer them further for dual-energy X-ray absorptiometry (DXA) examination. However, all the above indices are merely indicative of low skeletal bone mineral density and the dentist must always take into account the medical history and clinical risk factors of osteoporosis before further referring to an osteoporosis specialist.

Keywords: Osteoporosis, Panoramic x-rays, Mandibular cortex, Periodontitis, Tooth loss

Introduction

Osteoporosis is a major health problem worldwide, as not only does it deteriorate the quality of life, but it may also lead to severe disability and eventually death. Osteoporosis has been defined as a skeletal disease characterized by low bone mass, microarchitectural degradation of bone tissue leading to enhanced bone fragility and a consequent increase in fracture risk[1]. The WHO scientific group on the assessment of osteoporosis claims that osteoporosis affects more than 75 million people in the United States, Europe and Japan and causes more than 8.9 million fractures annually worldwide[2]. Despite its high incidence and severe consequences on the patient's life, osteoporosis often remains unnoticed, until a fracture occurs, due to the absence of pain, patient's lack of information on the subject and frequently because of the limited availability of dual-energy X-ray absorptiometry (DXA) scanners in many areas, owing to their high cost.

On the contrary, dental care services are much more common and easy to access. Age is a common risk factor for both dental problems and osteoporosis and frequently the elderly who seek dental care may also be at risk of suffering from undetected osteoporosis. It is possible for dentists to screen those patients, through x-ray and clinical dental examination and refer them for a DXA test.

Panoramic x-rays

Dental panoramic x-ray or orthopantomogram (OPG) is a routine examination in everyday dental practice. It is estimated that millions of patients undergo dental x-ray examination annually, whereas dental radiological examinations are among the most common reason for x-ray exposure[3]. Several indices assessed in OPGs are used in the literature in order to correlate mandibular changes and BMD[4-6]. For most of them, the cortical margin of the lower jaw is used, as it is more obvious and easy to detect compared to the trabecular bone. Furthermore, the area below the mental foramina is mostly studied, due to (1) the usual lack of muscle attachment there and (2) the fact that the distance between the mental foramen and the inferior

The author has no conflict of interest.

Corresponding author: *Theodora S. Tounta, 29 K.Varnali Street, N. Erythrea 14671, Athens, Greece*

E-mail: *theodoratounta@gmail.com*

Edited by: *George Lyritis*

Accepted *10 May 2017*

Authors	Population	MCW or MI	MCI	AI	GI	PMI	M/M ratio
		Mandibular Cortical Width or Mental Index (Cortical Width)	Mandibular Cortical Index (Cortical Erosion)	Antigonial Index (Thickness of the mandible at the antigonial region)	Gonial Index (Thickness of the mandible at the gonial region)	Panoramic Mandibular Index (Ratio of Cortical Width to distance from mental foramento inferior cortical margin)	Ratio of Mandibular height to the distance from center of Mental foramen to inferior mandibular margin)
Klemetti E, Kolmakow S [7]	77 postmenopausal women		Significantly related to buccal cortex BMD				
Cakur B et al.[8]	25 osteoporotic women		Significantly related to vertebral BMD				
Devlin H, Horner K[10]	74 otherwise healthy women	Significantly related to low skeletal BMD		Significantly related to low skeletal BMD	No significant relationship with skeletal BMD		
Horner K, Devlin H[11]	40 edentulous female patients	Significantly correlated with mandibular BMD				Significantly correlated with mandibular BMD	
Ledgerton D et al.[13]	500 OPGs of females	Significant correlation with age		Significant correlation with age	Significant correlation with age	Significant correlation with age	
Devlin H et al.[14]	671 women	Significant correlation with total hip, femoral neck and lumbar spine T-score	Significant correlation with total hip, femoral neck and lumbar spine T-score				
Dagistan S, Bilge OM[17]	40 healthy and osteoporotic men	Significantly related to osteoporosis	No significant relationship	Significantly related to osteoporosis		Significa-ntly related to osteoporosis	
Damilakis J, Vlasiadis K[18]	151 postmenopausal women aged 38-80	Significantly related to T-score				Not significantly related	Not significantly related

Table 1. OPG Indices description and relationship with osteoporosis.

Figure 1. Segments from patient's OPG depict degree of porosity of the inferior border of the mandible (Klemetti Index) and mandibular cortex width (MCW or MI index). Normal cortical porosity and width in a patient without osteoporosis (on the left) and more porous and thinner inferior mandibular cortex of female patient with osteoporosis (on the right).

margin of the mandibular cortical bone remains relatively stable during the lifespan, irrespective of the alveolar bone resorption following tooth extraction or inflammation.

One of the firstly described radiographic indices is the Mandibular Cortical Index (MCI), also referred to as the Klemetti index or Cortical Erosion which describes the porosity of the inferior border of the mandible and is related to the mandibular bone mineral density. This index involves measurements at the inferior mandibular cortex at the distal to the mental foramina part of the mandible, bilaterally, and findings are separated into three groups. In the first group (C1) the inferior mandibular cortical bone margins are even, while in the second group (C2) moderate erosion exists, as assessed by semilunar findings along the mandibular margin, and also by residues of the cortical bone one to three layers in thickness. The third group (C3) refers to cases with major erosion and cortical porosity[7]. Klemetti et al studied 77 postmenopausal women and found that changes in the mandibular cortex, as shown in OPGs, are significantly related to buccal cortex BMD of lower jaw[7]. These results are similar with the research by Cakur and others, who found that MCI is correlated to vertebral BMD[8]. However, the MCI index validity is limited due to its poor reproducibility and significant intra- and inter-examiner variability[9].

A more valuable and well-studied index is the Mandibular Cortical Width (MCW) index or Mental Index (MI), or Cortical Width which refers to the width of the lower border of the mandible below the two mental foramina[10] (Figure 1). Other indices used in the literature are the Panoramic Mandibular Index (PMI), which describes the ratio of the width of the mandibular cortex to the distance from the mental foramen to the inferior margin of the mandibular cortex[11], the Gonial Index (GI) and Antigonial Index (AI), which depict the thickness of the mandible at the angle, and at the antigonial region respectively[10], and finally, the M/M ratio, which is calculated by dividing the total Mandibular Height by the height from the center of the Mental foramen to the inferior mandibular border[12] (Figure 2). The MCW, PMI and M/M ratio indices are usually measured bilaterally and each value is then averaged.

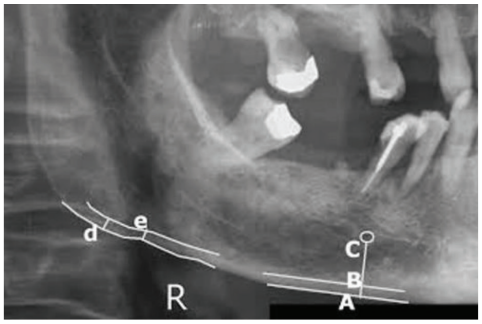

Figure 2. Measurements estimated in panoramic X-rays: Mandibular Cortical Width (MCW) or Mental Index or Cortical Width Index: line AB; Panoramic Mandibular Index (PMI): ratio AB/AC; Gonial Index (GI): line d; Antigonial Index (AI): line e; white circle: mental foramen.

Table 1 describes each index and its correlation with osteoporosis as shown in several studies. The MCW or MI index or Cortical Width is the most studied index and has the highest impact on screening osteoporosis, whereas the Gonial and Antigonial Indices are difficult to determine and their reproducibility is lower and consequently are less frequently used in the bibliography[13].

Delvin and Horner (2002) in their study, using 74 women who underwent DXA examination, showed that the Cortical Width is significantly correlated to diagnosis of reduced skeletal BMD (T-score ≤-1) and a value of ≤3mm was suggested for DXA referral[10].

A very important study was the Osteodent project, a three year study with the participation of five European countries, aiming to find a reliable x-ray index for the diagnosis of osteoporosis in dental practice[14]. Six hundred seventy-one postmenopausal women 45 to 70 years of age were recruited for this study. It was shown that the cortical porosity of the mandible (Cortical Erosion or MCI or Klemetti index) was inferior in predicting osteoporosis compared to

Authors	Population	Association of tooth loss with	Results
Taguchi A et al.[32]	64 women aged 50-70 years	thoracic spine fracture probability	Significant association
Inagaki K et al.[33]	356 Japanese women	Metacarpal BMD	Significant association only in older postmenopausal women
Erdogan O et al.[34]	108 postmenopausal women	Lumbar BMD	Significant correlation
Jang KM et al.[35]	7315 Korean women	total femur (TF), femur neck (FN), and lumbar spine (LS)	Significant association especially with FN
Darcey J et al.[36]	359 women aged between 45-68 years	Osteoporosis	Significant but weak correlation
Nicopoulou-Karayianni K et al.[37]	651 women aged 45-70 years	Osteoporotic status	Significant association
Slaidina A et al.[39]	79 women aged 49-81 years	Osteoporotic status	No correlation
Singh A et al.[40]	78 postmenopausal women	BMD	No correlation

Table 2. Relationship between tooth loss and osteoporosis.

Cortical Width. Furthermore, the authors suggested that only these patients with the thinnest mandibular cortices, e.g Cortical Width ≤3 mm, would benefit from DXA examination and therefore only those patients should be referred, as they are at higher risk of suffering from osteoporosis. Those results are in accordance with the findings by Delvin and Horner above. In addition, if software assessment tools such as OsiriX radiographic viewer are used in combination with measurements of the Cortical Width in x-rays, specificity improves but with a small reduction in sensitivity[15].

Taguchi et al. (2005) showed that Cortical Width and Cortical Erosion can also be used to detect postmenopausal osteoporosis in younger women, aged less than 65 years[16], whereas another study claims that the MI, PMI and AI indices may be useful for screening osteoporosis in men as well, although no significant correlation was found between Cortical Erosion and BMD[17]. In a more resent study, Damilakis and Vlasiadis (2010) measured the MCI, PMI, and M/M ratio in panoramic x-rays of 151 postmenopausal women who underwent DXA examination at the lumbar spine and hip. The results of this study are in accordance with previous studies detecting significant correlation between MCW and osteoporosis, although PMI and M/M ratio results were poorer and no significant relationship was found[18]. Cakur et al. also showed that MCI, which as said describes Cortical Erosion, is significantly correlated with vertebral BMD[8].

Changes in trabecular bone

Apart from alternations in the cortical bone, many studies suggest that the trabecular bone of the jaws especially at the premolar region, can be used for screening patients who may potentially suffer from osteoporosis, although this topic is less well-studied. Changes in the trabecular bone can be detected through periapical mostly and also panoramic x-rays. Intraoral periapical x-rays are a common diagnostic tool for dentists, especially since they demand a small amount of time and their cost is relatively low. It is possible to determine even small modifications in the bone density through digital intraoral x-rays, and therefore early signs of osteoporosis[19].

White et al. in their study suggested that apart from low bone mineral density of the jaws, patients who suffer from osteoporosis also show alternations in the trabecular pattern, and more specifically, fewer number and thinner trabecular plates. In their study, the maxilla performed better in screening osteoporosis compared to the mandible, probably because of the greater ratio of trabecular to cortical bone[20].

In addition, part of the scope of the previously mentioned Osteodent Project was to analyse the trabecular morphology in panoramic and intraoral x-rays and define whether there is a correlation with osteoporosis. It was suggested that the visual determination of the pattern of the trabecular bone in the premolar region can potentially be used for the screening of osteoporosis in dental patients[21]. Moreover, density of the trabecular bone in the premolar region can also contribute to detecting patients with osteoporosis[22]. However, intraoral periapical x-rays were found to have poorer results, compared to panoramic x-rays, with periapical x-rays of the lower jaw outperforming those of the upper jaw[23]. In another paper by the same authors, it was found that upper and lower jaw intraoral x-rays predicted femoral and spinal BMD equally well, but better results occurred when both radiographs were used in combination[24]. As far as periapical x-rays are concerned, studies indicate that higher results occur when jaw trabecular patterns are analysed, rather than when only bone density of the jaws is examined[25]. Meanwhile, other studies suggest that panoramic x-rays are mostly useful in the screening of osteoporosis when both trabecular morphology and age, are studied together[26]. Similarly, another study suggests that trabecular pattern and age have comparable performance in sensitivity and specificity in predicting the presence of osteoporosis, underlying that the combination

of age and trabecular pattern analysis significantly increases specificity[25]. In addition, as far as the region of interest is concerned, certain authors find that parts of neighboring teeth can be included in the area of interest, which simplifies the procedure[24], whereas the results of the quantitative analysis of the trabecular pattern are highly reproducible[27].

It is established that oral BMD can demonstrate the osteoporosis status, as it is significantly correlated with vertebral and forearm BMD, as well as with total body calcium. It was shown that postmenopausal women suffering from vertebral fractures had lower mandibular bone mass, compared to fracture free subjects of the same age. In addition, DXA measurements of the mandible assessing the bone mineral content (BMC), demonstrated that the mass of the mandibular bone decreases 1.5% per year in old women, and 0.9% in old men, and it is associated with BMD in the forearm. Similarly, a significant relationship between mandibular and lumbar spine bone mass was confirmed by computed tomography (CT) examinations[28].

Periodontitis and tooth loss

Periodontitis is a chronic inflammatory disease which affects periodontal tissues and leads to alveolar bone resorption and eventually tooth loss and it is a very common reason why patients, especially the elderly, seek dental care. As periodontitis and osteoporosis share many mutual risk factors such as age, smoking, alcohol consumption and low calcium and vitamin D intake[29-31], frequently the two conditions coexist. Many studies that seek a relationship between osteoporosis and tooth loss have been conducted with controversial findings (Table 2).

Taguchi et al. have shown a relationship between remaining teeth number and the possibility of thoracic spine fractures, concluding that the use by dentists of an equation involving the patient's age and number of teeth, may assist in the screening of undetected osteoporosis[32]. In accordance with Taguchi findings, Inagaki et al. associated extensive tooth loss with osteoporosis, suggesting the number of remaining teeth as an indicator of low metacarpal bone mineral density, although they claimed that it should not be used alone. The correlation was stronger in older patients, which suggests that tooth loss is greater when osteoporosis exists for many years[33]. Similarly, another research studying postmenopausal women showed that the number of remaining teeth, as well as their clinical attachment loss (CAL), which strongly indicates the presence of periodontitis, are correlated with osteoporosis, as greater CAL values and fewer teeth were found in women with low BMD of the lumbar spine[34]. Other studies also confirm the correlation between tooth loss and skeletal bone mineral density[35-37] and more severe periodontitis is found in patients with osteoporosis rather that those with normal BMD[38].

However, other studies failed to find a significant relationship between tooth loss and osteoporosis, although they do suggest that there is a positive correlation between periodontitis and skeletal BMD[39,40]. Yet, some authors assume that failure to prove a significant relationship between tooth loss and osteoporosis may be attributed to the small study population used in the survey[39].

Therefore, it is recommended that dentists inform their patients about the higher possibility of more rapid progression of periodontitis, and eventually tooth loss, if they also suffer from osteoporosis, compared to patients with normal BMD. However, it is not clear whether it is advisable for all patients with severe tooth loss to undergo DXA examination. Tooth loss is a multifactorial phenomenon, with reduction of BMD having only a small part in its cause, as oral hygiene, periodontitis and caries are the dominant causes for it. As a consequence, osteoporosis alone cannot be safely determined as the main reason for tooth loss. Nevertheless, when clinical history and dental x-ray findings coincide with low bone mineral density, severe tooth loss is an additional positive indicator that the patient would benefit from DXA examination.

Conclusion

It is clear that the dentist has a role in screening undetected osteoporosis in patients who seek dental care, without additional x-ray exposure or time consuming clinical examination, but only by performing the necessary tests for the dental treatment. The major contributor for the low BMD screening is the panoramic x-ray. However, frequently OPG x-rays are of low quality, due to the use of outdated x-ray equipment or the patient's malpositioning[41]. In this case, they have low diagnostic value for diagnosing osteoporosis. Furthermore, in most studies with positive diagnostic results, dental radiology experts or dentists who underwent special training on the subject took part, but results varied greatly amongst untrained general dentists[42]. This can partially be attributed to the variation in panoramic x-ray quality, the absence of illuminator and magnifying graticules in many instances, and most importantly by the dentists' ability to recognize the exact points of anatomical radiomorphometric indices.

However, these problems could be surpassed, as suggested by literature[43,44], by using automated digital radiological software programs, which reduce the dentist's participation and produce highly repetitive results compared to the analog x-ray method[45]. Furthermore, special training of dental practitioners is advisable, concerning screening of osteoporosis in dental patients, as well as their further familiarization with digital x-ray practice. Finally, automated digital software for osteoporosis screening could be included in the purchase of new panoramic x-ray machines, so that dentists can help in the detection of osteoporosis.

It should be emphasized that diagnosis of osteoporosis can be safely assessed only by DXA examination, and signs in the oral cavity and dental x-rays can only be used for primary screening. Dentist's contribution may be more important in areas with reduced DXA scanners availability and it is

always necessary to take into account cost-effectiveness. Furthermore, dentists should consider all aspects including medical history and risk factors of osteoporosis before further referring to an osteoporosis specialist for evaluation and possible DXA examination.

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