

Review Article

Osteoporosis and jawbones in women

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Abstract

Osteoporosis is a major health problem affecting one in three women over the age of 50 and may not be detected until fractures occur. Since osteoporotic fractures are a health burden worldwide, identifying subjects with a high risk of osteoporosis and preventing osteoporosis-related mortality and morbidity are a very important health strategy. Women show an estrogen-related bone loss starting at menopause, predominantly occurring in trabecular bone. Diagnosis of osteoporosis is usually based on the bone mineral density measurement, but this is not a practical and economical technique for early detection. Therefore, investigators are interested in the possibility of detecting osteoporosis from the panoramic radiographs. Mandibular cortical bone undergoes resorptive activity in osteoporotic patients, leading to a decreased thickness and more porous inferior border. Therefore, studies have demonstrated the usefulness of cortical width and shape, determined from panoramic radiographs, in identifying elderly individuals with undetected osteoporosis, especially postmenopausal women. In conclusion, postmenopausal women with C3 category, Mental Index (MI) <3 mm, and panoramic mandibular index (PMI) <0.3 may be considered for further osteoporosis investigation.

Key words: *Mandibular indices, osteoporosis, panoramic-based indices, panoramic radiography, postmenopausal women, women*

INTRODUCTION

Osteoporosis is a common metabolic bone disease characterized by low bone mass, microarchitectural weakening leading to bone fragility, and increased fracture risk.^[1] Osteoporosis affects one in three women and one in five men over the age of 50 and may not be detected until symptoms or fractures occur.^[2-4] White women over the age of 50 have a 50% chance of fracturing in their lifetime and these fractures result in increased morbidity and mortality risks. Approximately 40% of the patients with osteoporotic hip fractures die within 5 years after their fractures occur.^[1,5] Osteoporosis is a preventable and treatable disease; but because of no signs present prior to a fracture,

many people are not being diagnosed in time to receive effective therapy.^[2] The National Osteoporosis Foundation has identified many risk and predisposing factors for osteoporosis and related fractures in postmenopausal women. Some of the important factors are: History of fractures in adulthood, smoking, estrogen deficiency at an early age, low body weight, poor health, low calcium intake, physical inactivity, little exposure to sunlight, alcohol abuse, and use of oral glucocorticoid therapy for more than 3 months.^[2,6]

Osteoporosis predominantly affects elderly women.^[4] While bone loss starts at about 35 years of age, the rate of bone loss increases after menopause in women.^[7,8]

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How to cite this article: Gulsahi A. Osteoporosis and jawbones in women. *J Int Soc Prevent Communit Dent* 2015;5:263-7.

Access this article online	
Quick Response Code:	Website: www.jispcd.org
	DOI: 10.4103/2231-0762.161753

Women show an estrogen-related bone loss starting at menopause, predominantly in trabecular bone, followed by a slower loss of both trabecular and cortical bones 4–8 years later. After this period, the rate of bone loss declines at a more gradual rate.^[7,9-12] In women, changes related to age generally consist of disconnections of the trabecular network; but in men, thinning of the trabeculae is seen.^[9]

Since osteoporotic fractures are a health burden worldwide, resulting in reduced physical activity, increased risk of mortality, and increased medical costs, health promotion strategies focus on identifying subjects at a high risk of the disease. Before a fracture occurs, osteoporosis is characterized by decreased bone mineral density (BMD) in the preclinical stage. BMD testing using dual-energy X-ray absorptiometry (DXA) is a vital component in the diagnosis and management of osteoporosis. According to the World Health Organization (WHO) criteria, BMD values are divided into the following diagnostic guidelines: Normal (T-score > -1.0), osteopenia (T-score between -1.0 and -2.5), and osteoporosis (T-score < -2.5).^[2,6,13,14]

FRAX[®] was also developed to calculate the 10-year probability of a major osteoporotic fracture taking into account femoral neck BMD and the clinical risk factors. FRAX is intended for postmenopausal women and men aged 50 and older; it is not intended for use in younger adults. Studies concluded that it is most useful in patients with low femoral neck BMD.^[1,2]

Osteoporosis affects an enormous number of people, of both sexes and all races, and its prevalence increases as the population ages.^[2] Since DXA is the gold standard for the diagnosis of osteoporosis worldwide, BMD testing for the entire elderly population by DXA may be an useful option for early detection of the disease.^[14] However, this is not a practical method. Therefore, investigators are interested in the possibility of detecting osteoporosis from the dental radiographs, especially panoramic images.

Osteoporosis and panoramic-based indices

Panoramic radiography is used for the early detection of osteoporosis due to its low cost and the large numbers of osteoporotic patients attending the dental clinics as a result of higher life expectancies. It would be economical and beneficial if the radiographs could be used for triaging individuals with undetected osteoporosis.^[14] Another advantage of using these radiographs is that these are often taken repeatedly, with

similar projection and exposure parameters, making them very suitable for comparison.^[13,14]

It is well known that the mandibular cortical bone undergoes resorptive activity in osteoporotic patients, leading to a decreased thickness and more porous inferior border, characteristics that can be determined by panoramic radiographs.^[10,11,14-16] Dutra *et al.*^[4] also showed that a reduced skeletal BMD can alter the mandibular shape. Studies focusing on identifying the elderly individuals with osteoporosis, especially postmenopausal women, have demonstrated the usefulness of mandibular cortical indices from panoramic radiographs. Three indices were reported by most of the studies: Mandibular cortical shape [Mandibular Cortical Index (MCI) or Klemetti index (KI)] and width [Mental Index (MI)], and panoramic mandibular index (PMI).

MCI or KI refers to the appearance of the inferior cortex of the mandible and is classified as follows: C1: the endosteal margin of the cortex is even and sharp on both sides [Figure 1]; C2: The endosteal margin presents semilunar defects (lacunar resorption) and/or appears to form endosteal cortical residues on one or both sides [Figure 2]; and C3: The cortical layer forms heavy endosteal cortical residues and is clearly porous [Figure 3].^[17] Some studies have reported that women with a mild to moderate and severe eroded cortex are considered to have an increased likelihood of osteoporosis.^[1,11,18-20] However, others indicated no usefulness of the MCI.^[8,21,22] A recent study showed that approximately 95% of Japanese women identified by trained dentists using cortical shape findings did have osteopenia or osteoporosis.^[14] As a result, studies concluded that the sensitivity of MCI in the diagnosis



Figure 1: C1 category of MCI

of osteoporosis (T-score < -2.5) varied from 35.9 to 90.9%.^[1,6,8,18,19,21,23-26] The differences among the results is considered to be due to the heterogeneity of the studies.^[23]

MI or mandibular cortical width (MCW): Measurement of the cortical width at the mental foramen region is done according to the technique previously described [Figure 4].^[27,28] The mental foramen is identified and a line is traced that passes perpendicular to the tangent of the lower border of the mandible and through the center of the mental foramen. The cortical width is measured at this point. The correlation between MI and skeletal BMD increases in the postmenopausal period owing to the rapid decrease in both MI and skeletal BMD after menopause.^[29] In fact, studies showed a rapid decline in MI after the age of 50, which is the mean age of menopause worldwide.^[30,31] Roberts *et al.*^[29] revealed that cortical thinning normally starts in women at age 42.5 years and accelerates thereafter. In another study, it was found that the MI increased rapidly between 10 and 20 years and decreased rapidly between 50 and 60 years in females only.^[31] The MI increases rapidly in the second decade in women, while it increases gradually from the second to third decade in men.^[30] The maturation of the entire skeleton in young women, including jawbones, is influenced by several factors, such as the age of menarche, menstruation cycle, nutritional intake, and physical activity.^[30] Since occlusal function due to the permanent teeth is established during the second decade, this might affect the formation of the cortical bone of the mandible locally and individually.

The threshold values to find the highest sensitivity/specificity ranged from 2.69 to 5 mm.^[8,20,29-36] While a few studies reported high sensitivity ($>95\%$),^[33-35] others did not find a sensitivity of even 20%.^[32,36] Horner *et al.*^[32] recommended that women having an MI below the mental foramen of less than 3 mm should be referred for investigation of osteoporosis. However, in another study which used a more lateral measurement site than mental foramen on the mandible, the threshold value was 2.75 mm.^[29] Considering the results of the studies, asymptomatic dental patients with an MI of less than about 3 mm may be candidates for DXA testing.^[19,20,33]

PMI is the ratio between the cortical width at the mental foramen region and the distance from the lower border to the inferior edge of the mental foramen (MI/h) [Figure 4].^[37] A few studies investigated the accuracy of PMI in detecting reduced BMD. These studies considered the threshold value of 0.3 and the estimated sensitivity and specificity was higher than 70%.^[8,20,38]



Figure 2: C2 category of MCI



Figure 3: C3 category of MCI

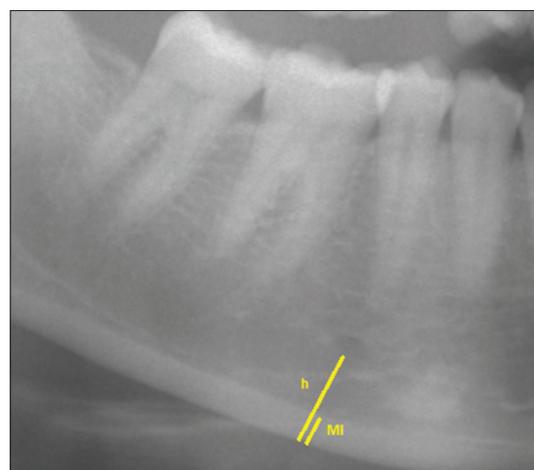


Figure 4: MI and PMI (MI/h)

Linear measurements on the panoramic radiographs have limitations because of unequal magnification and geometric distortion arising from exposure parameters or settings between different panoramic machines.^[23] Therefore, studies on standardized

panoramic radiographs would be more reliable in detecting osteoporosis. However, this is not a practical method in clinical situation.

Different studies revealed different intraobserver or interobserver agreement to detect osteoporosis using these panoramic indices.^[11,12,20,21,28-36,38] As none of these indices showed perfect intraobserver or interobserver agreement, it has been suggested to assess all of these indices.

Menopause is the major factor contributing to the rapid decrease in the BMD of the skeleton including the jaws in the elderly women. In the mandible, local factors such as the number of teeth and mastication influence the bone to some degree.

CONCLUSION

In conclusion, all three mandibular cortical indices (MCI, MI, and PMI) discussed in this review are useful tools to detect low BMD. Their limitations are mainly related to the panoramic radiographs or agreement between different observers. Postmenopausal women with C3 category, MI <3 mm, and PMI <0.3 may be considered for further osteoporosis investigation.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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