

Panoramic radiographs for detecting osteopenia: A pilot study

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Abstract

Osteoporosis characterized by low bone mass/osteopenia can be identified using radiomorphometric indices in routine panoramic radiographs. This study estimates the prevalence of osteopenia in 50-80 years age group, using panoramic mandibular index (PMI), mental index (MI) and mandibular cortical index (MCI). PMI, MI and MCI were applied on 36 panoramic radiographs; MI and MCI were compared with PMI. The prevalence of osteopenia was 11.1% with PMI and 44.4% with MCI. Using MI, the prevalence was 2.8% and 33.3% with 3mm and 4.77mm threshold respectively. The prevalence of osteopenia detected was highest using MCI (44.4%). Considering PMI as gold standard, MI with 4.77 mm threshold showed better agreement with PMI.

Introduction

Osteoporosis is a progressive systemic skeletal disease of the elderly, characterized by low bone mass (osteopenia) and micro-architectural deterioration of bone tissue, resulting in increased bone fragility and fracture risk.¹ Bone mass can be measured by various methods like dual energy xray absorptiometry (DEXA), quantitative ultrasound (QUS), quantitative computed tomography (QCT), digital X-ray radiogrammetry, radiographic absorptiometry, and other radiographic techniques.² Though DEXA is the most accepted method to assess bone mineral density (BMD), it's high cost and limited availability restricts routine use. Moreover, it is not recommended for regular screening;³ instead radiomorphometric indices applied on available panoramic radiographs have been suggested as useful screening tools for use by dentists.⁴ Various studies have reported mandibular indices to be good predictors of osteopenia/osteoporosis.⁴⁻⁸ Hence this institution-based pilot study was undertaken to estimate the prevalence of osteopenia in

elderly individuals using the indices, panoramic mandibular index (PMI), mental index (MI) and mandibular cortical index (MCI) on dental panoramic radiographs. Comparisons were also made among the indices in their ability to detect osteopenia; the highest percentage was detected by MCI and the least by MI.

Materials and Methods

Digital panoramic radiographs taken in the radiology department [using SIRONA ORTHOPHOS XG DS (Model No: D3352), with exposure parameters of 14.1 s, 64 kVp, 8 mA] from Sep 2014 to Sep 2015 along with the entered demographic data were evaluated by an oral radiologist with 15 years of experience. 36 radiographs of patients in the age group of 50-80 years, were selected at random, and divided into 3 age groups namely 50-59, 60-69 and 70-80 years. Equal number of males and females in each age group were included in the study. Clearly visible mental foramen and mandibular cortex were inclusion criteria. Those radiographs with bone destructive lesions, fractures and positioning errors which obscured the visualization of the region were excluded from the study.

The measurements of PMI and MI were made (Figure 1A) with reference to a perpendicular dropped from the midpoint of the mental foramen to a tangent (ST) drawn to the lower border of the mandible at the mental foramen region, as described by Ledgerton *et al.*⁹ Points P, Q and R were marked along this perpendicular (PR) in order to calculate PMI and MI. The point 'P' was marked on the line at the inferior rim of the mental foramen. The superior border of the lower cortex was marked as 'Q' and inferior border as 'R'.

MI was measured on the line PR, as the cortical width ('c' = QR) and any value less than 3 mm was considered as osteopenia.^{7,10-12} PMI was calculated as the ratio of c:b, as suggested by Benson *et al.* where 'c' denoted cortical width, QR; and 'b' the distance from the inferior border of mandible to the inferior rim of mental foramen, PR.⁵ PMI value less than 0.3 was considered as osteopenia.^{7,8,11} All analysis and measurements were made on the right side using SIDEXIS software for standardisation.

The radiographs were classified into C1, C2 and C3 types (MCI), based on the appearance of the lower border cortex of the mandible distal to the mental foramina (Figures 1A-C and 2).¹³ C1 type was considered as normal, C2 as osteopenia and C3 as osteoporosis.⁷ Since C3 (classified as osteoporosis) may be considered as

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advanced osteopenia, in our study, the total number of osteopenic individuals was considered to be the sum of C2 and C3.

For comparing the indices in their ability to detect osteopenia, PMI, being a ratio, was considered as the gold standard with which the other two indices were compared. SPSS software version 17.0 was used for the calculations. Weighted kappa coefficients were calculated to assess agreement of the findings of MI and MCI with PMI; and diagnostic accuracy values (sensitivity, specificity, false negative, false positive, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio, accuracy) were obtained for MI and MCI, based on gold standard PMI.

Results

Panoramic radiographs of 36 patients were studied using PMI, MCI and MI. The prevalence of osteopenia was 11.1% (n=4) when PMI was used, while it was 2.8% (n=1) using MI. The radiographs were categorized into C1, C2 and C3 types of MCI, and it was found that 55.6% (n=20) fell into C1 category, 38.9% (n=14) into C2 and

5.6% (n=2) into C3 category. The prevalence of osteopenia using MCI was 44.4% [n= 16 (C2 + C3)].

PMI, being a ratio, was adopted as the gold standard with which MI and MCI were compared. The results are given in Table 1. It was observed that kappa (κ) values were less than 0, suggesting poor agreement between the indices, PMI and MCI, and also PMI and MI (3 mm cortical width threshold). These results are statistically insignificant as P value was more than 0.05. A receiver operating characteristic (ROC) curve was generated with PMI as gold standard to determine the threshold value of MI with the highest diagnostic validity. A threshold of 4.77 mm was obtained with area under the curve being 0.914 (maximum value possible "1"), suggestive of good predictive power of MI. Using this threshold value of 4.77 mm, a comparison of MI with PMI gave significant results with fair agreement between the indices ($\kappa = 0.4$, $P < 0.05$) and better diagnostic accuracy values (Table 1).

Discussion

Screening for osteopenia or osteoporosis is performed to identify individuals at risk and those likely to benefit from treatment. The measurement of bone mass per unit volume or unit area, referred to as bone mineral density (BMD),² can be assessed quantitatively by techniques like DEXA, and semi-quantitatively or qualitatively by radiographs. Even though DEXA is the most accepted modality for estimating low BMD, its use is often limited due to high cost. Moreover, it is not recommended as a routine screening procedure.³

Early identification of osteopenia/osteoporosis by the general dental practitioner would be beneficial in referring such patients for preventing morbidities. Panoramic radiographs routinely taken in dental clinics have often been suggested as an economic means of detecting low bone mass. Various qualitative and quantitative mandibular indices including PMI, MI and MCI have been suggested for early identification of osteopenia or osteoporosis on panoramic radiographs.⁴⁻¹³

This study was undertaken as a pilot study to determine the prevalence of osteopenia in the elderly, using the three mandibular radiomorphometric indices, PMI, MI and MCI. Several authors have also studied about the detection of osteoporosis/osteopenia using these indices, in addition to modalities like DEXA and ultrasound.¹¹⁻¹⁶ A prevalence rate ranging from 46.6% to 62.7% has been reported using

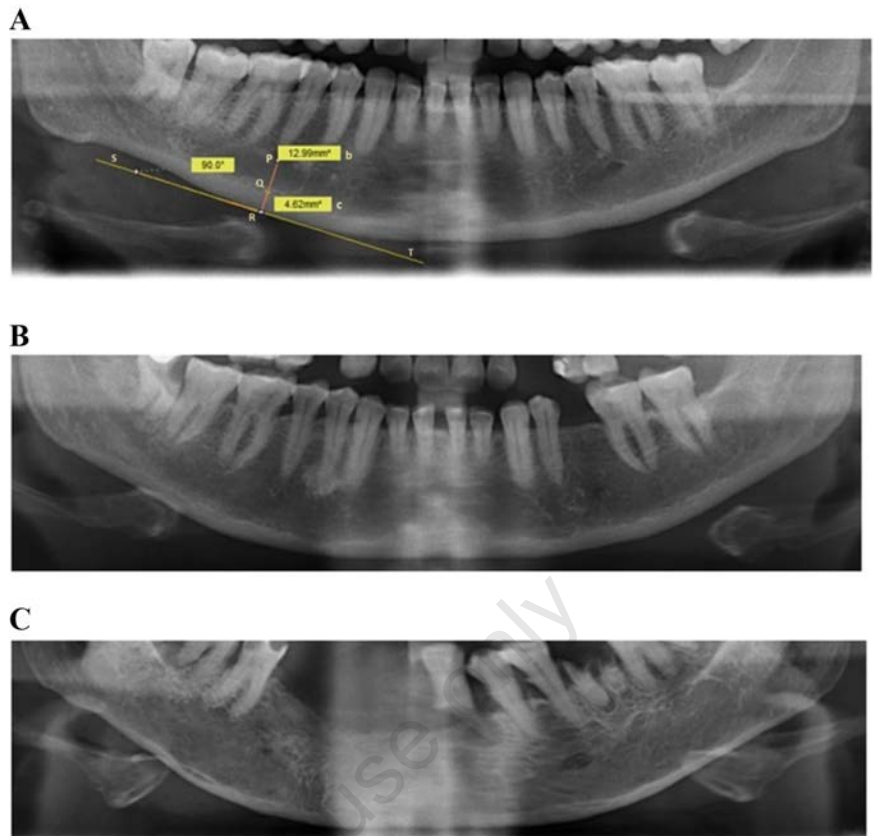


Figure 1. A) Measurement of PMI and MI on a cropped panoramic radiograph (MCI type C1) (c=4.62 mm; b=12.99 mm); B) MCI type C2 on a cropped panoramic radiograph; C) MCI type C3 on a cropped panoramic radiograph.

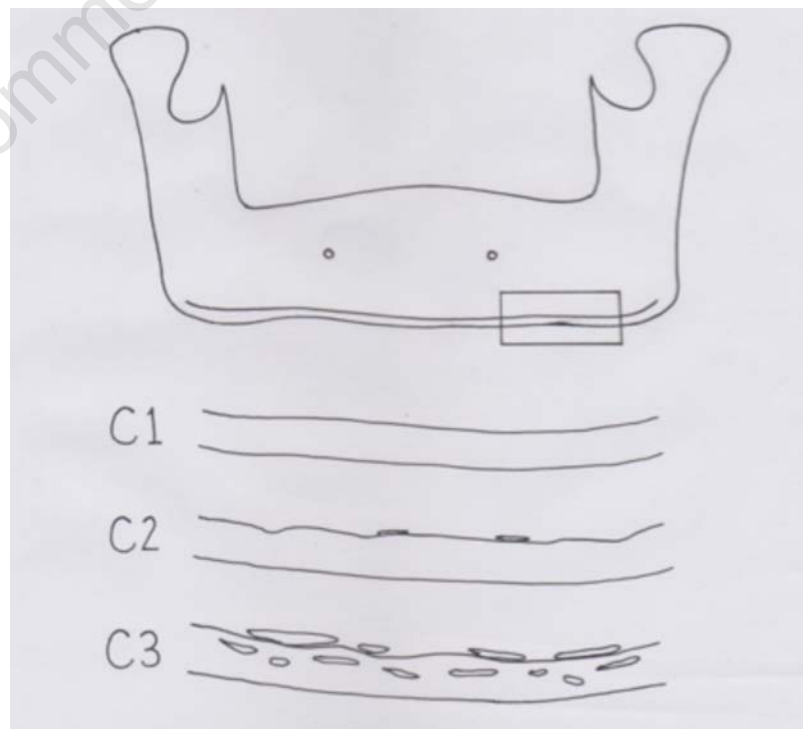


Figure 2. Diagrammatic representation of MCI types. Adapted from Klemetti E, Kolmakov S, Kroger H. Pantomography in assessment of osteoporosis risk group. *Scand J Dent Res* 1994; 102: 68-72.

DEXA,^{14,15} while the prevalence ranged from 20% to 87.5% with radiomorphometric indices.^{14,16}

Authors like Benson *et al.* and Ledgerton *et al.* suggested that PMI had a definite advantage over MI in that, being a ratio, PMI could compensate for image distortion and magnification inherent in panoramic imaging, thereby enabling direct comparisons of absolute values (of PMI) with other published studies.^{5,6} In a study by Drozdowska *et al.*, comparing the indices MCI, PMI and MR (mandibular ratio), with quantitative ultra sound (QUS) and BMD (mandible and hip) by DEXA, the best sensitivity, specificity, positive and negative predictive values were revealed by PMI.¹⁴ Hence in our study, PMI was adopted as the gold standard with which the results of MCI and MI were compared. The threshold of PMI used to assess osteoporotic status was 0.3, which was in accordance with other studies.^{7,8,11} In our study the prevalence of osteopenia using PMI was 11.1%, which was less than that reported by Drozdowska *et al.* (46.6%).¹⁴

When MCI was used to assess the prevalence of osteopenia/osteoporosis in the same population, a prevalence of 44.4% was observed. This value was similar to that reported by Taguchi (47.6%) and Khojastehpour (54.6%).^{17,18} Authors like Drozdowska *et al.* and Bhatnagar *et al.* observed a prevalence of 80% and 81% respectively when MCI was used as the evaluating tool.^{14,16} The role of MCI in detecting osteoporosis was studied by many authors, mostly by comparing with DEXA scan and MCI was found to be a useful indicator of osteoporosis.⁵ The prevalence rate

observed in our study was slightly lower when compared to a study by Wright *et al.* based on the National Health and Nutrition Examination Survey (NHANES2010), in which the prevalence of osteoporosis and low bone mass combined, in older adults in the United States was estimated to be about 54%. In their study, the prevalence of low bone mass alone was found to be 43.9%.¹⁹

Using MI with 3 mm cut-off, the prevalence of osteopenia was 2.8%, which was lower than that obtained using PMI (11.1%) and MCI (44.4%); however the prevalence rate increased to 33.3% with a 4.77 mm cut-off. This figure was higher than that observed by Drozdowska and Taguchi who reported prevalence rates of 20% using 4mm cut-off, and 25.1% using 3.45 mm cut-off respectively.^{14,17}

Among the 36 patients studied using MI, only 1 (2.8%) was found to be osteopenic by using a 3.0 mm cut-off. In contrast to PMI, there was no clear cut threshold value of MI for bone densitometry referral. 3.0 mm was used in majority of the studies,^{7,10-12} while 4 mm and mid 4 mm were suggested by others.^{4,20} Devlin *et al.*, in a collaborative multicentre study, 'The Osteodent project', compared MI and MCI with DEXA results of 671 females, and concluded that the mandibular cortical width (MCW) or mental index (MI) has better efficacy in detecting osteoporosis. They suggested that only those patients with MI ≤ 3 mm should be referred for further diagnostics.¹²

In the present study, the threshold of MI used for determining osteopenia was 3 mm. On comparing MI and MCI with gold standard PMI, agreement between the indices

was poor and the results were statistically insignificant. However, by using a threshold of 4.77 mm (obtained using an ROC curve) for MI, significant results were obtained with fair agreement between MI and PMI. In another study by Khojastehpour *et al.*, the correlation between DXA and two mandibular indices (MCI and MI) was evaluated in 119 postmenopausal women. A threshold of 4.29 was obtained for MI using ROC curve, which had a sensitivity of 81.4% and a specificity of 58.3%.¹⁸ Calciolari *et al.*, in 2015, by a systematic review and meta-analysis on panoramic measures for oral bone mass in detecting osteoporosis, demonstrated that an MCW value of 4 mm is more useful to exclude increased risk for low BMD.⁴ Studies have shown that though specificity was higher using 3mm, sensitivity was much higher using a threshold greater than 4 mm.¹² This was observed in the present study too, where sensitivities were 0 and 100% using 3 and 4.77 mm thresholds; and specificities were 96.9 and 75% respectively. When compared to 3 mm, a threshold value of 4.77 mm for MI had better agreement with PMI.

Conclusions

The prevalence of osteopenia was estimated in elderly males and females using three mandibular radiomorphometric indices, PMI, MI and MCI; the highest percentage of osteopenia was detected by MCI, and the least by MI. Cortical width threshold of 4.77 mm for MI had better agreement

Table 1. Diagnostic accuracy of MCI and MI (threshold set at 3 mm and 4.77 mm cortical width) in detecting osteopenia (PMI as gold standard).

PMI (Gold Standard) Total (n=36)	MCI		MI (threshold at 3 mm cortical width)		MI (threshold at 4.77 mm cortical width)	
	Osteopenia (n=16)	Normal (n=20)	Osteopenia (n=1)	Normal (n=35)	Osteopenia (n=12)	Normal (n=24)
Osteopenia (n=4)	1	3	0	4	4	0
Normal (n=32)	15	17	1	31	8	24
	$\kappa = -0.09, P=0.4$		$\kappa = -0.05, P=0.72$		$\kappa = 0.4, P<0.05$	
Sensitivity (%)	25		0		100	
Specificity (%)	53.1		96.9		75	
False negative (%)	75		100		0	
False positive (%)	46.9		3.1		25	
PPV (%)	6.3		0		33.3	
NPV (%)	85		88.6		100	
PLR (%)	0.5		0		4	
NLR (%)	1.4		1		0	
Accuracy (%)	50		86.1		77.8	

PPV, positive predictive value; NPV, negative predictive value; PLR, positive likelihood ratio; NLR, negative likelihood ratio.

with PMI, when compared to 3mm threshold. Use of larger sample size is recommended for further studies.

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