Correlation between Radiomorphometric Indices and Edentulous Mandibular Arches to Diagnose Osteoporosis Using Orthopantomogram in West Bengal State in India

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ABSTRACT

Aim: To assess the influence of gender and age on different parameters of alveolar bone loss using orthopantomogram.

Materials and methods: Eighty subjects were enrolled in the study (20 dentulous and 60 completely edentulous), fulfilling the inclusion and exclusion criteria. Completely edentulous subjects were divided into four groups (15 males and 15 females above 60 years) and (15 males and 15 females below 60 years). Dentulous group comprised 20 subjects (10 males and 10 females) between 41 and 75 years. After taking panoramic radiographs, vertical as well as horizontal reference lines were drawn. The parameters used for evaluation included mandibular cortical index (MCI), inferior mandibular cortical width (MCW), panoramic mandibular index (PMI), alveolar bone loss (ABL), and height of bone at first premolar (Hp) and first molar (Hm) of the mandible.

Results: There was significant association between MCI and age for females with C2 and C3 categories being more common with advancing age. MCW was stable in all groups, except in females above 60 years of age. PMI and ABL were nonsignificant for age and gender. Although the average values of bone height (Hm and Hp) for males were higher than those of females, the results were statistically insignificant.

Conclusion: Panoramic radiographic measurements could provide much valuable information and could help in evaluating patients with a low bone mineral density (BMD) with a few limitations.

Clinical significance: Dental professionals could screen the patients through panoramic radiographs taken during routine clinical examination, which could help in identifying patients with a low BMD so that further treatment could be initiated early and thus to prevent a pathologic fracture.

Keywords: Bone mineral density, Edentulous patient, Osteoporosis, Panoramic radiograph.

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INTRODUCTION

Loss of alveolar bone from edentulous jaws is a common and serious clinical problem, especially among elderly. Retention, stability, and support are greatly compromised in conventional dentures, especially if mandibular ridge is greatly resorbed. This resorption causes great challenge in prosthetic rehabilitation by conventional dentures and leads to fabrication of new dentures, an up hill task.

Alveolar ridge resorption is a subtle combination of local and systemic factors but the exact process involved is poorly understood. Elderly people most regularly visit dentists and they are at high risk of osteoporosis and associated fractures. Dental radiographs are the most frequently used imaging modalities for screening dental patients.^{1,2} The Food and Drug Administration and American Dental Association recommend screening radiography for every newly edentulous patient because of the high prevalence of findings, such as root fragments and radiolucencies. Dentists regularly prescribe panoramic radiographs as a routine screening aid prior to treatment.

Osteoporotic fractures are health burden globally, resulting in decreased physical activity, leading to poor quality of life and high risk of mortality. Osteoporosis has multifactorial risk factors, the major contributor being a deficiency of serum estrogen level.² Since minimal symptoms appear prior to fracture, a major proportion of elderly people vulnerable to osteoporotic fractures still remain undiagnosed.³⁻⁵ Patients susceptible to osteoporosis exhibit thin and porous inferior mandibular cortex on panoramic radiographs and thus mandibular cortical index (MCI), inferior mandibular

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cortical width (MCW), and panoramic mandibular index (PMI) could be used as an indicator of bone mineral density (BMD); thus dental professionals have a chance of identifying this subclinical condition

through a routinely used panoramic radiographic investigation.^{6,7} Patients suspected of osteoporosis should be advised for a BMD assessment.

This study was done to correlate the loss of alveolar bone, radiomorphometric indices, and the duration of edentulism on orthopantomogram in completely edentulous patients, which could help in identifying patients with low BMD at an earlier stage without any extra cost, so that further treatment could be initiated as soon as possible.

MATERIALS AND METHODS

This study was done from 2010 to 2013 on subjects visiting the outpatient department of Dr. R. Ahmed Dental College and Hospital, Kolkata, India. The study was approved by the institutional ethical committee and the subjects were explained about the nature and the procedure of the study and an informed consent was obtained.

Study was conducted on 80 subjects and they were divided into two groups:

- **Dentulous group:** Comprised 20 subjects (10 males and 10 females) in between 41 and 75 years based on the inclusion criteria that they must have complement of at least 28 natural teeth with or without third molars, in Angle's class I occlusion. Dentulous subjects were incorporated because edentulous mandible lacks the landmarks for the first premolar and first molar on the diagnostic panoramic radiograph.
- **Completely edentulous group:** Sixty in number divided into four groups (15 males and 15 females above 60 years) and (15 males and 15 females below 60 years), fulfilling the inclusion criteria that all subjects were completely edentulous for more than 2 years and were chosen based on random sampling.

Exclusion Criteria

All subjects (dentulous and edentulous) must have no history of systemic diseases affecting bones, e.g., hypo or hyperthyroidism, etc., devoid of any physical abnormality or facial asymmetry and those on long-term steroid therapy or edentulous for less than 2 years were excluded from the study. All subjects had complete medical and oral examinations to fulfill the inclusion and exclusion criteria.

All radiographs were taken with the same digital panoramic apparatus (PANTOMEX 2000, USA) with an exposure parameter of 70 kVp, 15 mA to standardize the radiographic quality, and to minimize the technical errors all radiographs were taken by a single-trained operator. Radiographic images of anatomic landmarks, such as inferior and posterior borders of the mandible, and the mental foramen must be distinct and there must not be a gross distortion of the images of the jaws. After accurately tracing all the points and lines on the radiographs manually with a pencil and acetate tracing paper, the measurements were done with an electronic digital caliper (Asahi Precision Tools India) (accuracy 0.001 mm).

Reference Lines on the Panoramic Radiographs

- **Dentulous group:** In the mandible, a horizontal line was drawn tangential to the most inferior point of the mandibular angle and lower border of the mandibular body and another line parallel to the above-mentioned tangential line and 10 mm above the lower border of the mandible. The proportion of the horizontal mandibular length was determined by dividing the length of the mandibular body (from the midline to the posterior border of the ramus), by the length of the distal surface of the mandibular

first premolar from the midline and by the length of the distal surface of the mandibular first molar from the midline. Thus, the location of the first premolar and the first molar was placed on the edentulous mandible (Fig. 1).

- **Completely edentulous group:** In the mandible, vertical and horizontal lines were drawn and the following measurements were done (Fig. 2).

Mandibular Cortical Index

MCI is a classification of the morphological appearance of the mandibular inferior cortex distal to the mental foramen. It is classified into three groups by Klemetti et al.⁸ (Fig. 3).

C1—The endosteal cortical margin should be even and sharp on both sides of the mandible.

C2—The endosteal cortical margin has resorptive cavities with cortical residues one to three layers thick on one or both sides.

C3—The endosteal cortical margin is much porous with residues.

Fig. 1: Tracing of orthopantomogram on dentulous mandible to locate the site of first premolar and first molar

Fig. 2: Tracing of orthopantomogram of edentulous mandible showing vertical reference lines

Figs. 3A-C: Category of mandibular cortical index. (A) Normal cortex; (B) Mildly to moderately eroded cortex; (C) Severely eroded cortex

Fig. 4: Measurement of MCW at mental foramen

Fig. 5: Measurement of ABL and PMI

Mandibular Cortical Width

MCW is the width of the cortex at the mental foramen. A line parallel to the long axis of the mandible and tangential to the inferior border of the mandible was drawn. A line perpendicular to this tangent intersecting the inferior border of the mental foramen was constructed, and the distance between the two parallel lines is MCW^{9,10} (Fig. 4).

Panoramic Mandibular Index

The PMI is defined as the ratio of the MCW to the distance between the superior or the inferior margin of the mental foramen and the lower cortical margin of the mandible ($PMI = MCW/BBH$)^{7,11} (Fig. 5).

Alveolar Bone Loss

ABL is the ratio of the total bone height (TBH) to the basal bone height (BBH) (BBH is the height from the center of the mental foramen to the lower mandibular margin). $ABL = TBH/BBH$ (Fig. 5).

Bone Height at the First Premolar and Molar Area (Hp and Hm)

Bone height at first premolar (Hp), (Y2) and bone height at first molar (Hm), (Y3) regions were calculated according to the study by Guler et al.¹² i.e., by drawing a line tangential to the most inferior points at the mandibular angle and the lower border of the mandibular body. Horizontal lengths of the mandible were measured parallel to the tangent at 10mm above the lower border of the mandible. According to results from the dentulous subjects, the first premolar and the first molar were located approximately 35% and 55%, respectively, of the length of the mandibular body from the midline. The measurements Y1 (midline), Y2 (mandibular first premolar), and Y3 (mandibular first molar) were vertical distances from the interior border of the mandible to the alveolar crest (Fig. 6).

Statistical Analysis

Statistical analysis was performed with the help of Epi Info (TM) 3.5.3. Epi Info is a trademark of the Centers for Disease Control and Prevention. Descriptive statistical analysis was performed to calculate the mean with the corresponding standard deviations. Test of proportion was used to find the standard normal deviate (Z) to compare the difference in proportions and a Chi-square (χ^2)

Fig. 6: Measurement of bone height at first premolar (Hp) = Y2 and bone height at first molar (Hm) = Y1

test was performed to find the associations. One-way analysis of variance (ANOVA) followed by a Tukey test was performed to compare the means of more than two groups. Under Tukey test, the critical difference (CD) was calculated to compare pair-wise means. Mann–Whitney *U*-test was also used. A $p < 0.05$ was taken to be statistically significant.

RESULTS

Only C2 and C3 categories of MCI were found in this study and none of C1 was present. Chi-square test showed that the association between MCI and age-group was not statistically significant in males ($p > 0.05$). In females, the association between MCI and age-group was found to be statistically significant ($p < 0.01$). Females in the age-group < 60 years age-group were found to be more associated with C2, whereas females in the age-group > 60 years age-group were found to be more associated with C3. C3 increased with an increase in age in females, which reflected age-related bone loss in females (Table 1).

ANOVA showed that MCW was not affected by age and gender. Paired *t*-test showed that the mean did not change with an increase in age in males but decreased with an increase in age in females, thus it can be said that MCW was affected by age and gender (Table 2).

As per Mann–Whitney *U*-test, there was no significant difference between the medians of PMI ($p > 0.05$) (Table 3)

Table 4 showed that although the average bone height values for males were higher than those for females, statistically no

Table 1: Distribution (%) of MCI, classification (cat-C1 normal cortex, cat-C2 mild erosion, cat-3 severe erosions on endosteal margins of edentulous mandible) according to age and gender

Gender	Age	C1	C2 (in %)	C3 (in %)	χ^2	<i>p</i> value
Male	≤ 60	0	93%	7.1%	$\chi^2 = 1.15$	$p > 0.05$
	> 60	0	67%	33%		
Female	≤ 60	0	73%	26.7%	$\chi^2 = 10.10$	$p < 0.01$
	> 60	0	13%	87%		

Table 2: MCW of edentulous mandible in males and females

	Male		Female	
Age	≤ 60	> 60	≤ 60	> 60
Mean $\pm$ SD	4.86 ± 0.27	4.87 ± 0.18	4.62 ± 0.23	4.19 ± 0.15
<i>F</i>	$F_{1,28} = 0.0007; p > 0.05$		$F_{1,28} = 2.52; p > 0.05$	
CD ₅	1.48		1.25	
CD ₁	1.99		1.69	
Min	3.2	3.8	3.1	3.0
Max	6.8	6.3	6.1	5.1

Table 3: PMI in edentulous mandible in males and females

	Male		Female	
Age	≤ 60	> 60	≤ 60	> 60
Min	0.14	0.12	0.12	0.16
Max	0.53	0.49	0.55	0.49
Mann–Whitney <i>U</i> -values with <i>p</i> values	$U=24; p > 0.05$ (NS)		$U=33; p > 0.05$ (NS)	

Table 4: ABL in edentulous mandible in males and females

	Male		Female	
Age	≤ 60	> 60	≤ 60	> 60
Mean	1.88 ± 0.08	2.04 ± 0.14	1.85 ± 0.11	1.7 ± 0.12
<i>F</i>	$F_{1,28} = 2.00; p > 0.05$		$F_{1,28} = 0.90; p > 0.05$	
CD ₅	0.75		0.74	
CD ₁	1.01		1.99	
Min	1.2	1.1	1.1	1
Max	2.3	3.0	2.5	2.4

significant difference was observed between males and females with respect to ABL. The bone loss was more in females of age-group > 60 but as per the ANOVA followed by CDs no significant change had been observed between the mean values of males and females of both age-groups ($p > 0.05$).

Table 5 showed that the interaction of gender and age-group on height premolar and molar was not statistically significant ($p > 0.05$). Also, as per ANOVA followed by CDs, no significant change was observed between the mean values of males and females for Hp and Hm. This shows that gender and age-group individually influence the height of premolar and molar.

DISCUSSION

Relationship between osteoporosis and mandibular bone loss had been demonstrated by various studies. Most of these studies utilized methods, such as histology (microradiography), single photon absorptiometry, dual photon absorptiometry, quantitative computed tomography, and more recently, dual energy X-ray absorptiometry. These methods required expensive equipment and increased the treatment cost. Dental radiographs might be useful for screening patients for osteoporosis by studying alterations in the trabeculae.^{13–16} Despite the shortcomings of orthopantomogram, (like magnification and distortion of image), errors could be made negligible by comparing the proportion and not the actual measurement on orthopantomogram.

Mandibular Cortical Index

MCI was a simple index having fair reproducibility. From the data collected, it was found that MCI was not significantly associated in males, but was associated in females. C2 was more observed in females below or equal to 60 years and C3 was more evident in age-group above 60 years in females. These findings were in accordance with Ledgerton et al.,¹⁷ and Ziataric et al.¹⁸ Thus, it can be concluded that MCI can be used as a valuable indicator for BMD.

Mandibular Cortical Width

In the present study, the mean MCW was found to be statistically insignificant ($p > 0.05$), indicating that gender is not a significant factor influencing MCW. Mean MCW was almost stable and there was not much effect of age in males; however, it was less in females above 60 years of age. The findings were in concordance with the study of Dutra et al.,¹⁹ Yuzugullu et al.,²⁰ Ledgerton et al.,¹⁷ and Ziataric et al.^{18,21}

Panoramic Mandibular Index

Mann–Whitney *U*-test showed that *p* values were nonsignificant ($p > 0.05$) for both the gender and age-group. Benson et al.,⁷ Ledgerton et al.,¹⁷ and Klemetti et al.²² in their study on women

Table 5: Vertical bone height of edentulous mandible at first premolar and first molar regions in males and females

	Male				Female			
	Hp		Hm		Hp		Hm	
Age	≤60	>60	≤60	>60	≤60	>60	≤60	>60
Mean	27.47 ± 1.77	26.24 ± 1.15	23.26 ± 1.57	22.54 ± 0.57	23.04 ± 1.85	22.1 ± 1.23	19.86 ± 1.47	17.52 ± 1.76
F	$F_{1,28} = 0.34; p > 0.05$		$F_{1,28} = 0.19; p > 0.05$		$F_{1,28} = 0.18; p > 0.05$		$F_{1,28} = 1.03; p > 0.05$	
CD ₅	9.67		7.65		10.18		10.51	
CD ₁	13.02		10.31		13.70		14.15	

found higher PMI values than in the present study. Present study was similar to the findings of Yuzugullu et al.²⁰ Difference in ethnic origin could be the reason for the variation in PMI among different studies. Klemetti et al.^{22,23} concluded in their study that though a strong positive correlation between the PMI and the general mineral status could not be established, still PMI could be used as an indicator of bone mineral changes when there is a large deviation from the mean PMI.

Alveolar Bone Loss

ANOVA followed by CDs showed no significant difference between the means of ages ≤60 and >60 ($p > 0.05$) for both males and females which was in concurrence with the finding of previous studies.^{20,23} Some clinicians had observed that alveolar ridge reduction occurs quickly following the menopause and was accompanied by a more generalized skeletal osteoporosis. That may be due to the reason that in postmenopausal women, deficiency of estrogen hormone accelerates skeletal bone loss and may result in rapid alveolar bone resorption.

Bone Height at First Premolar and First Molar Region (Hp and Hm)

ANOVA and CD showed that there was no significant difference between the means of ages ≤60 and >60 ($p > 0.05$) for both males and females. Although the average values for vertical bone height of edentulous mandible at the first premolar (Hp) and first molar (Hm) area for males were higher than those for females, which was in agreement with Guler et al.¹² but statistically insignificant, Yuzugullu et al.²⁰ in their study found no difference in the heights in males and females. These differences could be due to remodeling in the mandibular cortex that takes place continuously and is affected by dental status, gender, and duration of edentulism, denture wearing habits, parafunctional activities, and use of medications affecting bones.

Since the age-related and gender-related changes occur in mandibular radiomorphometric indices, these support their potential use in identifying low BMD.²⁴ Despite all this, there were certain limitations in the study, including the small sample size of 60 subjects (edentulous), inclusion criteria of only edentulous individuals, and that it was a cross-sectional study. In the future, a long-term longitudinal study with improved subject strength would be required.

CONCLUSION

Without respect to gender, edentulous patients with C3 category and PMI <0.30 may be seen as high-risk patients for osteoporosis and therefore should be referred for further osteoporosis investigations. The present study suggested that panoramic radiography might provide valuable information and could help in screening patients with low BMD who could then be referred for further BMD investigations.

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