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Evaluation of panoramic radiomorphometric indices in Indian population

Sumona Pal, MDS,[a] Sunita Amrutesh, MDS[b]

[a]Haldia Institute Of Dental Sciences And Research, India.
[b]Buddha institute of Dental Sciences and Hospital , Patna .India

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ABSTRACT

Objecitves: Radiomorphometric indices on dental radiographs can be used for screening of osteoporosis. However population-specific normative data is sparse. Aim was to establish radiomorphometric indices in Indian population and to determine role of age, gender and dentition on these indices.

Materials and Methods: Cross sectional study was undertaken from January 2010 to December 2010. OPGs of 80 samples were divided into four age groups. Mental index, panoramic mandibular index, mandibular cortical index, antegonial index were measured. Relationships with age and dentition were analysed using Statistical Package for the Social Sciences SPSS12.0. Student *t*-test, one way analysis of variance, Chi square test was used to find the statistical significance. P value < 0.05 was considered to be significant.

Results: In most of the study population endosteal margins of the mandibular cortex were even and sharp on both sides i.e.C1 appearance except in 60-69 years females who showed increased tendency of lacunar cortical defects i.e. C2 appearance. No correlation between dentition and mandibular cortical index (MCI), mental index (MI), panoramic mandibular index (PMI) & Antegonial index (AI) (p value 0.583, 0.059, 0.491 respectively). Population's mean of AI, MI, and PMI among males were 3.33, 3.97, 0.33 respectively and among females were 3.06, 3.64, and 0.32 respectively. (p value for AI, MI, PMI were 0.048, 0.028,0.037 respectively).

Conclusions: All indices negatively correlated with age. There was a general downward trend with age until sixth decade, when values declined sharply. No statistical significance was found between AI, MI, and PMI and dentition.

Keywords: Mandibular cortical index, mental index, osteoporosis, panoramic radiography, panoramic mandibular index.

INTRODUCTION

The silent epidemic of osteoporosis is crippling the society. Osteoporotic fractures are associated with substantial morbidity, incremental medical cost and high mortality risk. [1]

The use of oral radiographs has been proposed as screening tools. [2] Various studies show that the decreased bone mineral density (BMD) affects the morphometric, densitometric and architectural properties of mandibular bone in osteoporotic patients. Qualitative and quantitative indices, including mandibular cortical index (MCI), mental index (MI) or panoramic mandibular index (PMI) have also been used for panoramic radiographs to assess the bone quality and to observe signs of resorption and osteoporosis. WHO defines osteoporosis as a T score at or below 2.5 (2.5 SDs below normal peak values for a young adult).[3,4] It is not clear how to apply this diagnostic criterion to men and children, or across ethnic groups. The prevalence of osteoporosis and the incidence of fracture vary by sex, age and race/ethnicity.[3]Thus knowledge of ranges

Sumona Pal,
Dept. of Oral Medicine and Radiology,
Haldia Institute of Dental Sciences and Research
Purba Medinapur, West Bengal.
Pin: 721645, India
Tel: +91-9748095231
Fax: 03224-269058
e-mail: sumona_capri@yahoo.com

of mandibular radiomorphometric indices in the population studied is necessary to identify individuals whose mandibular radiomorphometric indices are abnormally low. Though many studies were conducted in developed countries with the use of dental radiographs for osteoporosis screening,[5-8] data from developing and underdeveloped countries is sparse.[4, 9]

The current study was conducted in a south Indian population, normal range of radiomorphometric indices were established and matched up to available data. Also the role of age, gender and dentition status on these indices was established.

MATERIALS AND METHODS

A cross sectional study was carried out from the period January 2010 to December 2010. 80 individuals requiring orthopantomogram (OPGs) for various dental diseases in the age range of 30 years to 69 years were selected from patients visiting oral radiology department at KLE Society's Institute Of Dental Sciences, Bangalore, India. An ethical clearance to conduct the study was obtained from the ethical committee of the institute prior to study. Written informed consent was obtained from each patient to use their radiographs for the study. Data was obtained regarding age, medical history and a thorough clinical examination of the oral cavity was done, dental status was established and recorded.

It is a known fact that the presence of posterior teeth influences the distribution of masticatory forces which influences bone remodeling especially alveolar bone. In order to be of diagnostic importance there should be no influence of teeth on these indices. Dentition status was classified according to the presence of mandibular molars. Those individuals having mandibular molars were classified as dentate, whereas those without mandibular molars but with other teeth present were categorized as partially dentate. Edentulous individuals were kept in a separate group. Root remnants were counted as teeth (except for root remnants totally imbedded in bone). According to this criterion 3 groups were created: 1—dentate; 2—partially dentate (missing all mandibular molars); 3—edentulous. After thorough clinical examination digital OPGs of these 80 individuals, in the age range of 30 years to 69 years were done using the same digital machine (Planmeca Promax, Helsinki, Finland).

The radiographs were assessed by subjective determination of patient positioning, head alignment, film density and contrast which were within the reviewer's standard range of quality.

The following patients were excluded from the study: radiographs with inadequate demonstration of mental foramina or the inferior cortex of mandible on either side, subjects with history of any metabolic bone disease or subjects taking any medications that affect bone metabolism such as estrogen.

The radiographs were grouped into four age groups as 30 – 39 years, 40 – 49 years, 50 – 59 years, and 60 – 69 years. All measurements were made using the software Dimax3 (Planmeca) (Figure 1). All radiographs were corrected for 20 % magnification. The following radiomorphometric indices were made:

1. Mandibular Cortical Index (MCI) – appearance of the inferior mandibular cortical thickness. MCI was assessed according to the criteria defined by Klemetti. [5]

C1 - Endosteal margin of the cortex is even and sharp on both sides.

C2 - Endosteal margin shows semilunar defects (lacunar resorption) and /or seems to form endosteal cortical residues on one or both sides.

C3 –The cortical layer forms endosteal cortical residues and is clearly porous.

Figure 1. All measurements done on OPG using software Dimax 3.

2. Antegonial Index (AI) – It is a measurement of cortical thickness in the region anterior to the gonion at a point. It was identified by extending a line of 'best fit' on the anterior border of ascending ramus down to the lower border of mandible (Figure 2). Where the anterior border of ramus was markedly curved, the line was drawn to fit closely as possible to the straighter, inferior, part of the bone margin above the third molar region.[10]

a- inferior border of the inferior mandibular cortex

b- superior border of the inferior mandibular cortex

I- Distance from inferior margin of mental foramen to the inferior border of mandible

S- Distance from superior margin of mental foramen to the inferior border of mandible

3. Mental Index (MI) – It is the cortical thickness at mental foramen. The mental foramen was identified and a line was traced which passed perpendicular to the tangent to the lower border of the mandible and through the center of the mental foramen. The cortical width was measured at this point, according to the technique described by Ledgerton et al. [11] (Figure 2).

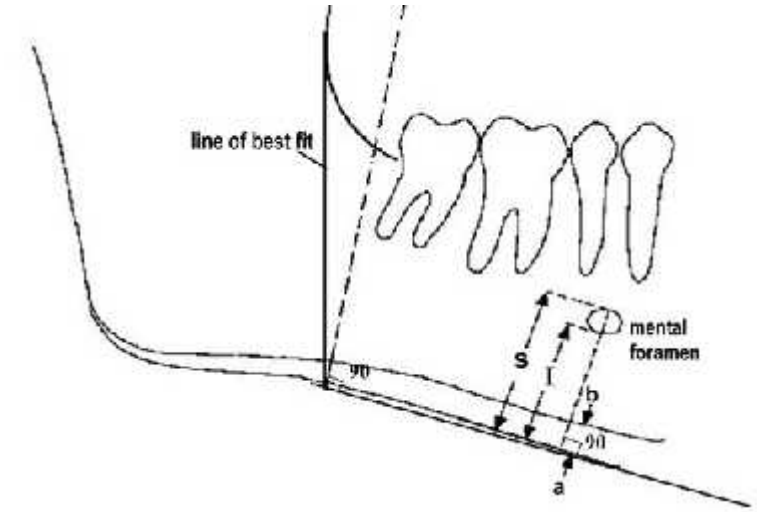

Figure 2. Sketch diagram of OPG showing measurements.

4. **Panoramic Mandibular Index (PMI)** – a line was drawn which passed perpendicular to the tangent to the lower border of mandible and through the center of the mental foramen. All measurements were done on this line[11] (Figure 2).

$$\text{Superior PMI} = \frac{C}{S}$$

$$\text{Inferior PMI} = \frac{C}{I}$$

PMI= Mean of superior and inferior PMI.
C=Thickness of cortex.

Reliability

Sixteen randomly selected radiographs were reanalyzed by the single observer after a period of 1 month to check for the intraexaminer reliability.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS 12.0) was used for the statistical analysis of the data. The following methods of statistical analysis have been used in this study. Student's t test was used to determine whether there was a statistical difference of radio morphometric indices between two groups for examples between males and females. One way analyses of variance were used to test the difference between more than two groups. Chi square test was used to determine the significance of difference in MCI values. In the above tests $p<0.05$ were taken to be statistically significant.

RESULTS

The study includes 80 individuals within the age range of 30 -69 years with 20 individuals in each group with equal number of males and females i.e. 10 males and 10 females in each group. There was high intra-observer reproducibility with no significant difference in first and second readings. The difference in linear measurements ranged between 0.017-0.260. MCI showed a good kappa agreement.

Distribution of MCI

The data regarding MCI distribution with age, gender and dentition is shown in table 1 and 2, respectively. Statistically significant difference in appearance of cortex ($p=0.013$ i.e <0.05) among women in various age groups was seen. There was sudden increase in C2 cortical appearance in women in the age group of 60-69 years with C2 cases seen in 60 % of women. No correlation was found between dentition status and the shape of mandibular cortex though most of the study population showed C1 cortical appearance. Only one patient showed C3 category.

AI, MI, PMI with age and gender

The data regarding AI, MI, and PMI distribution with age and gender is shown in tables 3 and 4. The population's mean value of AI among males and females was 3.33 (SD=0.56) and 3.06 (SD=0.62), respectively ($p=0.048$). The population's mean value of MI among males and females was 3.97 (SD=0.7) and 3.64 (SD=0.64) respectively ($p=0.028$). The population's mean value of PMI among males and females was 0.33 (SD=0.059) and 0.32 (SD=0.069) respectively ($p=0.037$). All indices were negatively correlated with age ($p<0.05$). There was a general downward trend with age until the sixth decade, when values began to fall sharply compared to the mean values for the population. The values AI, MI, PMI were significantly less in females than in males in the age group 60 -69 years.

Table 1. MCI with age & gender.

	Age	C1	C2	C3
Male	30-39	80%	20%	0%
	40-49	60%	40%	0%
	50-59	70%	30%	0%
	60-69	70%	30%	0%
Female	30-39	90%	10%	0%
	40-49	100%	0%	0%
	50-59	80%	20%	0%
	60-69	30%	60%	10%

Table 2. MCI with dentition.

AGE	Gr	C1	C2	C3
30-39	1	100%	0%	0%
	2	0%	0%	0%
	3	0%	0%	0%
40-49	1	75%	20%	0%
	2	5%	0%	0%
	3	0%	0%	0%
50-59	1	65%	15%	0%
	2	10%	10%	0%
	3	0%	0%	0%
60-69	1	30%	15%	0%
	2	5%	15%	0%
	3	15%	15%	15%

Table 3. Variation of AI, MI& PMI with age.

		Mean	SD	P
AI	30-39	3.24	0.51	
	40-49	3.20	0.63	
	50-59	3.02	0.56	
	60-69	2.85	0.65	0.041
MI	30-39	3.83	0.58	
	40-49	3.86	0.53	
	50-59	3.83	0.53	
	60-69	3.57	0.67	0.052
PMI	30-39	0.33	0.07	
	40-49	0.33	0.06	
	50-59	0.33	0.06	
	60-69	0.30	0.06	0.048

Table 4. Variation of AI, MI, and PMI with gender.

		Mean	SD	p
AI	Male	3.33	0.56	
	Female	3.06	0.62	0.048
MI	Male	3.97	0.70	
	Female	3.64	0.64	0.028
PMI	Male	0.33	0.059	
	Female	0.32	0.069	0.037

Table 5. Variation of AI, MI, and PMI with dentition.

	Gr	N	Mean	SD	p
AI	1	65	3.26	0.57	
	2	9	2.87	0.65	
	3	6	3.00	0.83	0.491
MI	1	65	3.89	0.64	
	2	9	3.00	0.67	
	3	6	3.86	0.77	0.583
PMI	1	65	0.33	0.06	
	2	9	0.29	0.06	
	3	6	0.29	0.06	0.059

AI, MI, PMI and dentition status

The mean AI in individuals without any tooth loss was 3.26, the mean AI in partially dentate individuals was 2.87, and the mean AI in completely edentulous individuals was 3.0. The mean MI in individuals without any tooth loss was 3.89, the mean MI in partially dentate individuals was 3.0, and the mean MI in completely edentulous individuals was 3.86.The mean PMI in individuals without any tooth loss was 0.33, the mean PMI in partially dentate individuals was 0.29, and the mean PMI in completely edentulous individuals was 0.29. When comparing AI, MI, and PMI with dentition status none of them showed any statistically significant difference with different dentition status (P value was 0.491, 0.583, 0.059 respectively). The data regarding AI, MI,

and PMI distribution with dentition status is shown in table 5.

DISCUSSION

BMD varies with races, ethnicity, age, gender [3], thus arises the need of population specific value ranges. Blacks have greater BMD than Caucasians. Hispanics are similar to Caucasians, Asians have the lowest BMD.[12] Values of BMD for men cannot be extrapolated from that of women; gender-specific reference databases must be used.[13] Recent reports propose a correlation between BMD of the axial skeleton and that of the jaw bone. [14] Radiographs remain the preferred method to assess BMD because of the high costs and limited access associated with other techniques.[15] Mandibular BMD assessed by DXA correlates significantly with BMD of other skeletal sites.[16]

Dentist can screen patients with unrecognized osteoporosis. The goal of such screening is to identify individuals at risk for osteoporosis and refer them appropriately.[17] Panoramic radiography could be reliable in screening for osteoporosis. [18]

Potential error introduced by positioning inaccuracies should be considered for measurements on OPGs. Nevertheless it has been shown that minor antero-posterior shift (+5 mm) and tilts ($+58^0$) were associated with variation of less than 2%.[19] In this study, radiographs with any marked positioning error were excluded. Digital measurements on OPGs are sufficiently accurate.[20] The intraobserver agreement was high & in conformity with other studies.[10,15,21] All measurements were made on any side with prominent mental foramen. No significant differences was found for measurements between left and right in British population.[10] Among British females, negative correlation was found for GI, MI and AI with age.[10] The present study demonstrated decrease of AI, MI, PMI in females at the age of 60 ($p<0.05$). Our study showed statistically significant difference for AI, MI between males and females ($p<0.05$). Lower values could be attributed to the constitutional differences between the sexes. In a previous study it was found that MI and AI decreased with age in females but increased in males. [21] In a further study, there was a general decrease in values of MI and AI in both genders until 75 years, and then both indices decreased sharply for females in contrast to males.[22]

Various investigators have studied the effect of dentition on radiomorphometric indices.[10, 21,23] A study reported no association of dental status and MI.[21] In one study edentulous individuals had lower AI.[10] Among 60-69 years, females showed a lower cortical thickness with no differences for dental status.[21] In our study, no correlation was found between dentition and MCI, AI, MI, PMI.

In this study, measurement of MI was complicated by changes in cortical morphology. It is suggested that patients with the thinnest mandibular cortices (≤3 mm) should be referred for further investigation as this group has the highest likelihood of osteoporosis.[6, 23] The relation of MCI with MI could not be assessed because of very few cases with C3. MCI has limitations in terms of intra- and inter-observer agreement.[24] Many investigators considered patients with C2, C1 to be normal and C3 to be osteopenic.[25] Few researchers demonstrated that mandibular cortical width (MCW) has better efficacy than the MCI .[6] A study found MI, MCI to be most accurate predictors of osteoporosis.[26] These indices are equally effective in males.[27] When comparing MCW, PMI and M/M ratio with BMD at lumbar spine and hip measured by DXA, MCW was more accurate than PMI and M/M ratio. However sensitivity and specificity was found to be low for both. [28] Among postmenopausal females it was noticed that a decrease in MCW by 1 mm increases the likelihood of osteopenia to

43%, and an increase by 1 unit in the number of teeth loss, increase the likelihood of cortical erosion to 6%. [29] Difficulty in identification of mental foramina due to multiple foramen, porous appearance of mandible creating radiolucencies, dense trabecular pattern, increased film density causes variation in PMI.[11] In this study none had multiple foramen and cases with ill-defined mental foramen were rejected. One major advantage of PMI over MI is that since it is a ratio its method of calculation takes account of differences in magnification associated with different panoramic equipments.[10] AI is a poor index for osteoporosis.[21] Problem of localization of the line that ‘‘best fits’’ the anterior border of ramus, interaction of dental status and AI, low correlation with MI in young, and lack of data relating this index to BMD discourages its use .[21] Based on the previous studies we suggest that a single index is not the ideal tool for screening , a combined analysis of MCI and MI is recommended as better predictors of osteoporosis.

In the present study, population mean of AI, MI, PMI among males were 3.33, 3.97, 0.33 respectively and among females were 3.06, 3.64, 0.32 respectively. Similar result was obtained in Brazilian postmenopausal women.[26] Population mean PMI is akin to another study[10] but differs from postmenopausal finnish females which reflects ethnic differences.[10,30] In the present study, PMI demonstrated a gradual reduction with age until sixth decade, then its mean value fell sharply, similar to a British research.[10] A contrasting report showed that in females, PMI demonstrated a gradual increase until the sixth decade and then decreased.[31]

In conclusion, all indices demonstrated a negative correlation with age and a significant difference between the younger and older age groups. Limitations of the study include small sample size and lack of correlation of the indices with DXA. Future studies, comparing DXA of hip and spine to these indices in known osteoporotic and normal people have to be undertaken to test the diagnostic validity of such a method and to establish appropriate diagnostic thresholds of abnormality for each index.

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