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ORIGINAL ARTICLE **OPEN ACCESS**

Assessment of Panoramic Radiomorphometric Indices in Preliminary Diagnosis of Osteoporosis in North Gujarat Population

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ABSTRACT
Bone with a normal regenerative capacity is essential for a successful outcome. It is important to know the quantity and quality of bone in the jaws when planning any surgical treatment. This study is done to evaluate osteoporosis using various panoramic radiomorphometric indices. To evaluate and correlate efficacy of panoramic radiomorphometric indices such as mental index (MI), panoramic mandibular index (PMI) & mandibular cortical index (MCI), quantative ultrasound in osteoporosis (QUS).A total of 200 individuals, 100 males and 100 females, between the age ranges of 20-70 years were selected and divided in to 5 age groups. Radiomorphometric indices like MI, PMI,MCI &QUS were assessed to evaluate bone mineral density. Mean, anova test, pearson's coefficient of correlation, chi-square independence test, post hoc tukey test were applied.The statistical analysis was done after 2 months of study completion. It was statistically non significant but mean MI, PMI values increased with age and the T-score increased & in MCI , C2 & C3 were more commonly found in osteopenic & osteoporotic patients compared to normal individuals.The study conclude that panoramic radiomorphometric indices can be used as inexpensive alternative screening method to assess the bone mineral density and identify individuals at risk for osteoporosis and fractures. A larger sample size with multicentre approach is required for establishing panoramic radiomorphometric indices as an effective tool for diagnosis and rapid screening of osteoporosis.
Keywords: *Bone Mineral Density, Osteopenia, Osteoporosis, Quantitative ultrasound, Radiomorphometric*

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INTRODUCTION

'Osteo' is a latin word for ''bones'', 'penia' stands for ''less'' and word 'pores' suggests ''holes''. Bone remodeling is a co-ordinated process of cellular activity that is responsible for the renewal and repair of damaged bone throughout adult life. [1]

Between 30-50 years of age, resorption of bone mass starts to decline (osteopenia). The process of decline occurs very rapidly in females after menospause due to oestrogen and bisphosphonates inhibit bone resorption by promoting osteoclast apoptosis.[1]

The World Health Organization (WHO) defines fragility fracture as "a fracture caused by injury that would be insufficient to fracture normal bone: the result of reduced compressive and/or torsional strength of bone." Clinically, a fragility fracture may be defined as one that occurs as a result of minimal trauma, such as a fall from a standing height or less, or no identifiable trauma.[2,3]

Recent technology have provided alternative methods, among which quantitative ultrasound (QUS) appears to be the most widely used. It is inexpensive, portable, ionizing-radiation-free and proven to predict hip fractures and all osteoporotic fractures in women and men.[3]

MATERIAL AND METHODS

A total of 200 individuals, 100 males and 100 females, between the age ranges of 20-70 years were selected for the present study based in the selection criteria. The proposal for study was approved by the Institutional Ethical Committee, NPDCH, Visnagar on 19/01/2017[CDSCO NO: ECR/600/Inst/GJ/2014/RR-20]. The procedure followed were by the ethical standards of Helsinki Declaration of 1964 and later versions. The selected individuals had their digital Panoramic radiograph and Bone mineral density analysis done using necessary radiation protection measures after taking their consent.

The sample size was calculated using the formula :N=z2[p(1-p)]2/ME2.. 200 subjects belonging to both sexes and all subjects were selected from Department of Oral Medicine and Radiology, NPDCH, Visnagar, Gujarat, India. visited for routine Panoramic radiographic examination.

Patients visiting oral medicine and radiology department for panoramic radiographic examination between 20-70 years of age of both gender without history of smoking, alcohol and tobacco habits without any systemic diseases were included., Females with menstrual irregularities (e.g .Pregnancy, lactation ,eumenorrheic, oligomenorrheic, amenorrheic) were not included.Patients with history of any metabolic bone disease (such as hyperparathyroidism, Paget's disease, osteomalacia, renal osteodystrophy or osteogenesisimperfecta), cancer with bone metastasis, significant renal impairment, and osteomyelitis were excluded.

The patients for the study were selected randomly from individuals reporting to the department after they fulfilled the inclusion and exclusion criteria. Thorough history taking andclinical evaluation were done. The selected individuals were explained the intention and procedures to be performed and subsequently consented for their participation in the study. Panoramic Radiograph was obtained for all these selected subjects employing Kodak 8000 C machine. All the linear measurements for radiomorphometric analysis (e.g., MCI, MI, PMI were obtained from these radiographs using Kodak Dental Imaging Software.

All measuements were done by the same operator. Subsequently Bone mineral density (BMD) was measured from right calcaneus of selected subjects using quantitative ultrasound machine (Osteosys SONOST-2000).Mean, anova test, pearson's coefficient of correlation, chi-square independence test, post hoc tukey test was applied for analyzing data. The following radiomorphometric indices were measured on each radiograph [Figure 1]

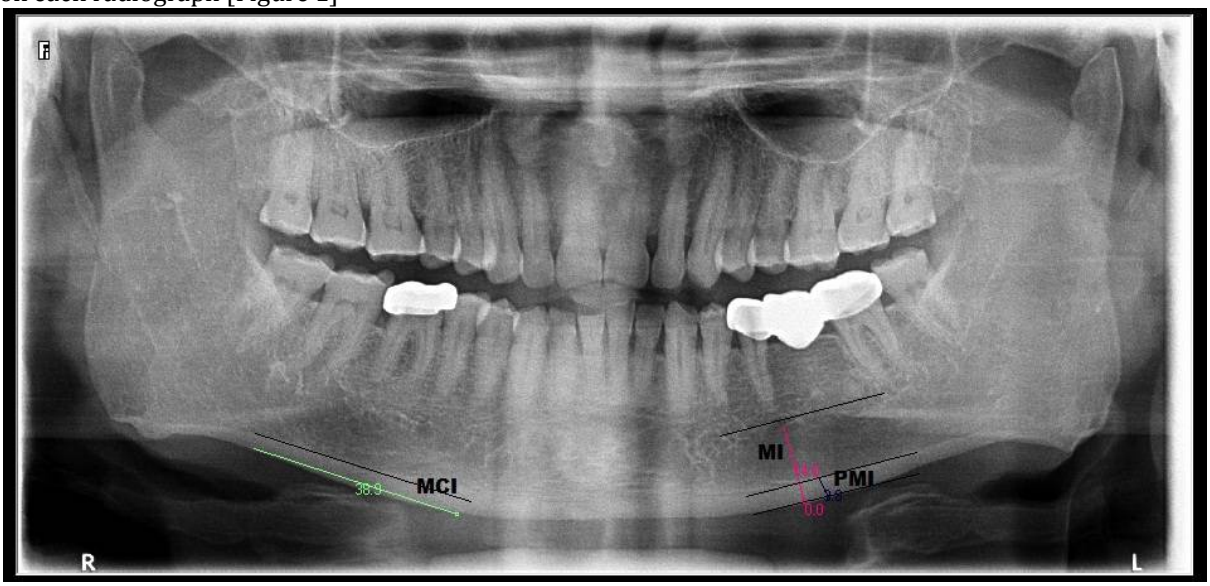

FIGURE 1: showing all the measurements on OPG has recorded a=MCI, b=MI, c=PMI

Mental Index (MI): Mandibular cortical thickness was measured on the line which was perpendicular to the bottom of the mandible at the middle of the mental foramen.

2. Panoramic Mandibular Index (PMI): The PMI is the ratio of the thickness of the mandibular cortex to the distance between the mental foramen and the inferior mandibular cortex.

3.Mandibular cortical index (MCI):The thinning of the inferior mandibular cortex was observed on both side of the mandible distal to the mental foramen. Classification of the appearance of the lower border of cortex of the mandible distal to the mental foramen, described by Klemetti et al.

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.

RESULTS

In the cases of PMI value in different age groups were statistically significant. Mean PMI was higher in more than 60 years of age group (0.38 ±0.08) followed by 51-60 years of age (0.37 ±0.07), 41-50 years of age group (0.34 ±0.08), 31-40 years of age (0.33 ± 0.07) and 20-30 years of age groups (0.34 ± 0.05) respectively. In the cases of MI value in different age groups were statistically not significant. Mean MI was high in patients of 31-40 years age group (10.95 ± 1.49mm) followed by 51-60 years of age group (10.77 ±1.62mm), more than 60 years age group (10.76 ±1.54mm), 41-50 years of age (10.65 ± 1.25mm) and 20-30 years of age (10.12 ± 1.53) respectively. In the cases of MCI value in different age groups were statistically significant. Out of 200 patients, 85 patients were having C1 mandibular cortical index followed by 83 patients were having C2, 32 patients were having C3 mandibular cortical index respectively. Majority of the study patients are having C2 score (52.9%) followed by C1 (41.4%) and C3 (5.7%) in age group of 31-40 years. Majority of the study patients are having C2 score (48.5%) followed by C3 (33.3%) and C1 (18.2%) in age group of 41-50 years. Majority of the study patients are having C2 score (60%) followed by C3 (22.9%) and C1 (17.1%) in age group of 51-60 years. Majority of the patients are having C2 score (50%) followed by C3 (38.9%) and C1 (11.1%) in more than 60 years of age.All the patients are having C1 score in age group of 20-30 years. (Table 2)

Table 1: Demographics of study

AGE	GROUPS	MALE n(%)	FEMALE n(%)
20-30	I	22 (52.4%)	20 (47.6%)
31-40	II	38 (54.3%)	32 (45.7%)
41-50	III	9 (27.3%)	24 (72.7%)
51-60	IV	19 (51.4%)	18 (48.6%)
>60	V	12 (66.7%)	6 (33.3%)
TOTAL=200		100	100

Table 2: Comparison of mean PM , MI, MCI value in different age groups.

AGE GROUPS(in years)	**MEAN PMI**			P VALUE
20-30	0.34 ± 0.05			0.007 S
31-40	0.33 ± 0.07			
41-50	0.34 ±0.08			
51-60	0.37 ±0.07			
>60	0.38 ±0.08			
AGE GROUPS(in years)	**MEAN MI(mm)**			
20-30	10.12 ± 1.53			0.080 NS
31-40	10.95 ± 1.49			
41-50	10.65 ± 1.25			
51-60	10.77 ±1.62			
>60	10.76 ±1.54			
GROUPS	**MCI**			0.000 S
	C1 (n=85)	C2 (n=83)	C3 (n=32)	
20-30	42 (100%)	0 (%)	0 (%)	
31-40	29(41.4%)	37 (52.9%)	4 (5.7%)	
41-50	6 (18.2%)	16 (48.5%)	11 (33.3%)	
51-60	6 (17.1%)	21 (60%)	10 (27%)	
>60	2 (11.1%)	9 (50%)	7 (38.9%)	

[Test used : (One way ANOVA),S= significant, NS=non significant, P value < 0.05 = S ,P > 0.05 = NS]

As the age increases patients with osteopenic are increases, also patients with osteoporosis are increases .In patients with more than 60 years age groups (77.8%) patients showed osteopenic bone mineral density followed by 51-60 years age group (73%) ,41-50 years age group (72.7%), 31-40 years age group (64.3%) & 20-30 years age group (54.8%).Osteoporosis found in (16.7%)>60 years age group patients followed by 15.2% patients of 41-50 years age group and 14.3% patients of 20-30year age group.(Table 3 & 4)

In the cases of comparison of MCI score with bone mineral density of patients**, m**ajority of the patients with C1- MCI score were having osteopenic bone mineral density (57.6%) followed by normal bone

mineral density (27.1%) and osteoporosis (15.3%) score. majority of the patients with C2 MCI score were having osteopenic bone mineral density (72.3%) followed by normal bone mineral density (15.7%) and osteoporosis (12%) bone mineral density. majority of the patients with C3 MCI score were having osteopenic bone mineral density (73.3%) followed by osteoporosis (16.7%) and normal bone mineral density(10%). Statistically non- significant difference was present between MCI and bone mineral density as p value was 0.161. (Table 5)

In the cases of comparison of mean MI and PMI in patients with various bone mineral density (QUS) were statistically non significant (p value was 0.790). Mean MI was high in osteoporosis group (10.821 ± 1.64mm) followed by osteopenic (10.684 ± 1.53mm) and normal patients (10.564 ± 1.35mm). Mean PMI was higher in osteoporosis group (0.355 ± 0.08) followed by osteopenic patients (0.350 ± 0.06) and normal patients (0.342 ± 0.07). Statistically non -significant difference was present among various types of PMI groups as p value was 0.743. (Table 6)

Table 3: Comparisison of bone mineral density in various age groups

AGE GROUPS	MEAN T-SCORE	P VALUE
20-30	-1.29 ± 0.80	0.217 NS
31-40	-1.46 ± 0.84	
41-50	-1.55 ± 0.79	
51-60	-1.59 ± 0.79	
>60	-1.78 ± 0.73	

[Test used : (One way ANOVA) S= significant, NS=non significant, P value < 0.05 = S , P > 0.05 = NS]

Table 4: Distribution of patients according to bone mineral density in various age groups

AGE GROUPS (in years)	Bone mineral density			p value
	Normal (n=39)	Ostopenic (n=133)	Osteoporosis (n=28)	
20-30	13 (31%)	23 (54.8%)	6 (14.3%)	0.385 NS
31-40	16 (22.9%)	45 (64.3%)	9 (12.9%)	
41-50	4 (12.1%)	24 (72.7%)	5 (15.2%)	
51-60	5 (13.5%)	27 (73%)	5 (13.5%)	
>60	1 (5.6%)	14 (77.8%)	3 (16.7%)	

[Test used : (Chi square test), S= significant, NS=non significant, P value < 0.05 = S , P > 0.05 = NS]

Table 5: Comparison of MCI Score with bone mineral density (QUS) of patients

MCI	**Normal (n =39)**	**Osteopenia (n =133)**	**Osteoporosis (n =28)**
C1	23 (27.1%)	49 (57.6%)	13 (15.3%)
C2	13 (15.7%)	60 (72.3%)	10 (12%)
C3	3 (10%)	24 (75%)	5 (16.7%)
P value	0.161 NS		

[Test used : (Chi square test) ,S= significant, NS=non significant, P value < 0.05 = S , P > 0.05 = NS, BMD=Bone mineral density]

Table : 6 Comparison of mean MI and PMI with bone mineral density (QUS)

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
MI	Normal	39	10.564mm	1.35	0.216	10.125	11.002
	Osteopenia	133	10.684mm	1.53	0.133	10.420	10.947
	Osteoporosis	28	10.821mm	1.64	0.311	10.182	11.460
	P Value	0.790					
PMI	Normal	39	0.342	0.07	0.011	0.319	0.364
	Osteopenia	133	0.350	0.06	0.006	0.338	0.362
	Osteoporosis	28	0.355	0.08	0.016	0.320	0.389
	P Value	0.743					

DISCUSSION

The jaw bones, like other bones in the body, it can be affected by systemic diseases or any medical treatment, as well as local bone disease which can result in total loss of teeth. Most of the research which has been carried out on mandibular bone, revealed that there was a relationship between osteoporosis

and oral bone loss, which was evaluated by means of radiographs, histology (microradiography), single photon absorptiometry (SPA), dual photon absorptiometry (DPA), quantitative CT (QCT) and more recently, dual energy X-ray absorptiometry (DXA),quantative ultrasound(QUS).[3-13]

The present study sought to assess BMD of the mandible by the use of panoramic radiography as a diagnostic method, primarily due to the fact that mandibular bone mineral density is a parameter closely associated with alveolar bone loss and early tooth loss. However, the patient with systemic diseases affecting bone metabolism is a subject of further studies and thus were not included in this study.

Our analysis suggests that determining BMD of the mandible (based on panoramic radiographs). As panoramic radiographic examinations are convenient and informative, and are common in odontological practice. For instance, our research findings indicate that the use of panoramic radiography for assessing bone mineral density of the mandible also allows for determining general skeletal bone mineral density loss in elderly female patients. These measurements, coupled with criteria such as other clinical risk factors and history of osteoporosis, could therefore prove to be a promising instrument in the assessment of risk for skeletal osteoporosis.

In our study PMI is a radiomorphometric method which was suggested that despite the alveolar bone resorption above the foramen, the distance from the foramen to the inferior border of the mandible remains relatively constant throughout life. Also, the selection of a ratio as the basis of the PMI represented an attempt which was made to compensate for image distortion and magnification which were inherent in panoramic imaging. The difference in mean PMIs between the age groups was statistically significant ($p = 0.007$), which showed a comparison between the different five age groups.

In this present study MI is not significant relation between the age groups ($p= 0.080$).MCI is a qualitative index of cortical morphology which is based on the appearance of the lower border of mandibular cortex is a simple classification based onthe panoramic radiograph. Contrary to MCI, the PMIand MI need to record some measurements onpanoramic radiographs and then require some calculations. In this study, MCI appearance was related to the T score of the patients suggesting thatlow bone mineral density may lead to changes in mandibular corticalmorphology. C1 was the most common in control group, C2 and C3 was more common in patients with osteoporosis and osteopenia than patients with normal BMD.

To the best of our knowledge this was the first study to correlate the calcaneal BMD with MCI was conducted, It was found in our study that MCI had a statistical significant negative correlation with T Score (skeletal bone mineral density), which suggests that as the T Score decreases from -1 to -2.5, the MCI score increases from 1 to 3. Although studies have been conducted to evaluate relationship between the MBMD and MCI effectively reflects the changes in the MBMD measured by methodology proposed by Horner et al. compare to patients with normal BMD, C2 and C3 score were more seen in patients with osteoporosis and osteopenia in present study. Poornima Govindraju, **et al**.[3] and Satish Alapati et al also observed that C2 and C3 categories of MCI increased as age advanced in females.[3-14]

Poornima Govindraju, et al. conducted a study on256 panoramic radiographs (128 digital and 128 analog) on subjects who were grouped into 8 age groups between 21 to 60 years with 5 year intervals between them and with equal sex distributions. The mandibular cortical index (MCI), mental index (MI) and panoramic mandibular index (PMI) were analyzed. They concluded thatMCI, MI and PMI indices are useful for identifying patients with low skeletal bone mineral densities (BMD) or osteoporosis. The results of the present study is in accordance with them where, MCI, MI and PMI indices were measured on the panoramic radiographs of patients and were found to indicate the loss of BMD and osteoporosis. Further, these indices also correlated significantly with the level of BMD loss i.e. it correlated significantly with the T-Score (obtained by QUS).[3,15-20]

Akshita et al.[21]MCI was a reliable index in identifying osteoporosis. ($P = 0.01$). The findings in our study reported postmenopausal women with distinctly thinner and porous mandibular cortices presented with lower BMDs which were in congruent with the study done by (Bras *et al.)*we observed a relatively high frequency of moderately eroded cortex on orthopantomograms (OPGs) of women aged between 50 years and 60 years. This finding was in accordance with our study.[21]

Sghaireen *et al*. showed that the MI was higher in younger age groups. This is consistent with the findings of previous studies that showed lower MI values in older age groups. PMI decreased as age increased in the present study. This is consistent with the findings of previous studies showing a reduction in the PMI with increased age. However, the findings of the present study demonstrated that the PMI was not significantly different between men and women. This is in contrast to previous literature that reported greater bone resorption and a thinner mandibular cortex in women than men. Which was similarly correlate with our study.[22]

Nasreen et al. revealed that the mean values of PMI decrease as the age of the subject increases and within groups the highest mean value [0.32] was observed in group II and the lowest value in Group I [0.24], also a highly statistically significant difference among both these groups were noted. This finding

was in accordance with our study. Mandibular cortical index (MCI) and the inferior mandibular cortex width was evaluated using the mental index (MI) in 64 female patients who had undergone dual energy X-ray absorptiometry assessment, and the authors concluded that there were significant differences between the normal and lower bone mineral density groups (osteopenia and osteoporosis) for MCI ($P <$ 0.01).[23]

LIMITATIONS

Limitations of our study could be the small sample size and if we could able to add the age with sex matched samples for the study for more consistent results but, due to limitation of words we could not express all details in the same article. Further, another limitation of the study could be manual calibration of radiographic indices that depends on the observer's skill.

SUMMARY

From the findings of present study we concluded that the indices which has been taken from OPG to evaluate bone mineral density in various age grouped patients were very effective and inexpensive alternative tool. In our study PMI and MI values were increased as age increased with statistically significant values and In MCI also increased as age increased but was not significant in our study.

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