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Dentistry Section

Relationship Between Femur Bone Mineral Density, Body Mass Index and Dental Panoramic Mandibular Cortical Width in Diagnosis of Elderly Postmenopausal Women With Osteoporosis

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ABSTRACT

Objectives: To measure and determine mandibular cortical width (MCW) on the panoramic radiographs, to evaluate the usefulness of the method in identifying postmenopausal women with low femoral bone mineral densities (f- BMD) and to correlate the radiographic findings on panoramic radiographs with the f-BMD assessed by dual X-ray absorptiometry (DXA) to predict the efficacy of the radiographic method in diagnosing osteoporosis.

Materials and Methods: One hundred and twenty postmenopausal women (60 normal and 60 osteoporotic) in the age group of 50-75 y with f-BMD assessed by DXA had undergone panoramic radiographic examination. The patients were classified as normal (T-score ≥ -1.0) and osteoporotic (T-score ≤ -2.5). MCW on panoramic radiographs was measured bilaterally at the mental foramen region with a caliper and their mean was used as the exposure measure in the analysis.

Results: Student t-test showed that mean f-BMD, BMI and MCW was found be less in osteoporotic patients as compared to normal group with a statistically significant p-value < 0.001. Pearson correlation coefficient test revealed that MCW correlated positively with f-BMD and showed a significant decrease with age of the patient.

Conclusion: Postmenopausal women with low f-BMD had thinner mandibular cortex at the mental foramen region when compared to normal subjects and are more susceptible to femoral neck fractures. Mandibular inferior cortical width at the mental foramen region could be used to identify postmenopausal women with low f- BMD. Hence, dental panoramic radiographs serve as a useful screening tool for early diagnosis of osteoporotic fractures.

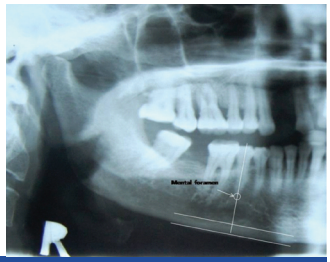
Keywords: Dual–energy absorptiometry, Mandibular cortical width, Menopause, Osteoporosis, Panoramic radiography

INTRODUCTION

Osteoporosis is a skeletal disorder characterized by low bone mass and micro architectural deterioration of bone tissue leading to enhanced bone fragility, with consequent increase in fracture risk [1]. It is one of the most prevalent conditions associated with aging and is thus a major public health problem [2]. It is known that after the age of 35 the bone mineral density (BMD) of men and women gradually decreases with increasing age. Women tend to lose BMD more rapidly than men, especially after the menopause. As a result osteoporosis is three times more common among women than men [3].

The World Health Organization (WHO) defines osteoporosis as a T-score at or below 2.5 (2.5 SDs below normal peak values for a young adult) [4]. It is also called as the silent epidemic, because the osteoporotic process continues for many years with no symptoms until the fracture occurs [5]. Common sites of fracture include the spine, hip, forearm and proximal humerus. Fractures at the hip incur the greatest morbidity and mortality, and give rise to the highest direct costs for health services. Since the disease is preventable, diagnostic techniques are of major importance [6].

BMD at specific sites can be measured using a variety of techniques, including quantitative ultrasound, single photon absorptiometry (SPA), dual photon absorptiometry (DPA), dual energy X-ray absorptiometry (DXA) and quantitative computed tomography (QCT) [7,8]. Self assessment tools such as Osteoporosis Self-Assessment Tool (OSTA), Osteoporosis Index of Risk (OSIRIS), Simple Calculated Osteoporosis Risk Estimation (SCORE), Osteoporosis Risk Assessment Instrument (ORAI), Female Osteoporosis Self-Assessment Tool for Asia (FOSTA) have been developed to identify low BMD elderly women [9]. It has been implicated that a large segment of postmenopausal women may not respond to the questionnaire if they have no knowledge about, and interested in, osteoporosis. Furthermore, it is likely that the selection cut-off point of questionnaire-based screening tools may vary among different populations [10]. A recent innovation in non-invasive bone mass measurement is DXA which offers a lower absorbed radiation dose, higher spatial resolution and greater scan speed [11]. There is also incontrovertible evidence that BMD as measured by DXA,



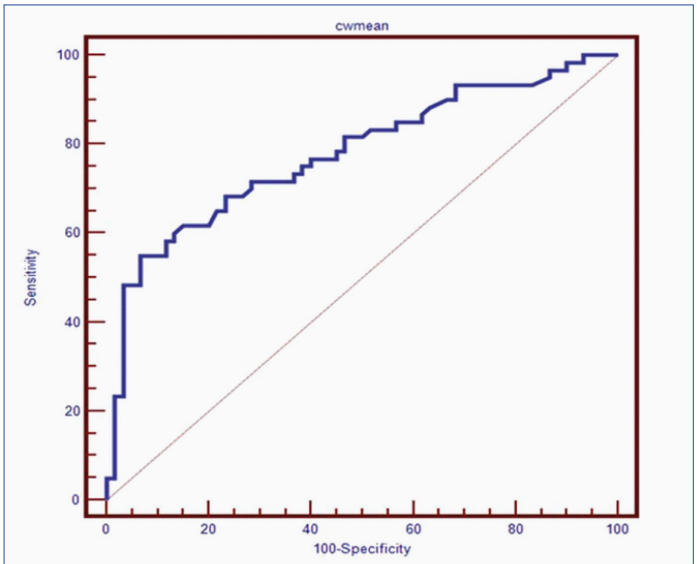
[Table/Fig-1]: Patient positioning on DXA for BMD assessment of hip (femoral neck) **[Table/Fig-2]:** A line parallel to the long axis of the mandible and tangential to the inferior border of the mandible was drawn. A line perpendicular to this tangent intersecting inferior border of the mental foramen, was constructed, along which mandibular cortical width (MCW) was measured. The distance between the two parallel lines is the MCW

Group	BMI (kg/m^2)		f-BMD(g/cm^2)		MCW(mm)		P value
	Mean + SD	Median (min- max)	Mean +SD	Median (min-max)	Mean +SD	Median (min-max)	
Osteo-porosis	23.732 +4.7425	22.9 (14.9-33.8)	0.5125 +0.0542	0.523 (0.345-0.573)	3.448 +0.9242	3.325 (1.63-5.63)	<0.001
Normal	28.910 +5.7365	27.9 (17.1-43.2)	0.8221 +0.0702	0.806 (0.734-1.015)	4.349 +0.7483	4.435 (1.79-5.83)	<0.001

[Table/Fig-3]: Comparison of body mass index (BMI), femoral bone mineral density (f-BMD), mandibular cortical width (MCW) values between the normal and osteoporosis groups

		Beta coeffi-cient	Std. Error	Wald statistic	Degrees of freedom	Sig.	Exp(B)
Step 1a	Age	-0.153	0.050	9.444	1	0.002	0.858
	BMI	0.176	0.056	10.038	1	0.002	1.192
	MCW mean	0.970	0.345	7.896	1	0.005	2.637
	Constant	1.322	4.384	0.091	1	0.763	3.750

[Table/Fig-4]: Binary logistic regression table to predict osteoporosis
Z = 1.322 - 0.153 (age) + 0.176 (BMI) + 0.970 (MCW mean)
Pv=1/ (1+e^z)



[Table-5]: Receiver operating characteristic curve (ROC) for mean MCW in identifying study groups

particularly at the proximal femur, is the main determinant of hip fracture risk [12].

However, BMD testing for all postmenopausal women is not practicable in many third world countries where bone assessment methods, especially DXA, are not widely available [13]. Moreover, most of the elderly have more opportunities to visit dental clinic for the treatment of dental caries and periodontal disease than to visit a medical office for diagnosis of osteoporosis prior to fracture. Hence, the panoramic radiographs takes a vital role in identifying postmenopausal women with undetected osteoporosis [13]. Various studies were conducted to evaluate the usefulness of width and morphology of the inferior cortex of mandible on panoramic radiographs in the diagnosis of postmenopausal osteoporosis and the results suggested that mandibular cortical width (MCW) on panoramic radiographs was thinner in osteoporotic subjects as compared to normal subjects [14-17]. It was also reported that a diagnostic threshold for MCW of 3mm or less is suggested as the most appropriate threshold for referral for bone densitometry in women [14,18]. The aim of this study was to investigate whether mandibular inferior CW on the panoramic radiographs is efficacious

Correlations					
Group			BMI (kg/m^2)	f-BMD (g/cm^2)	MCW (mm)
Normal	Age (Years)	Correlation	-0.179	-0.397	-0.205
		'p' value	0.170	0.002	0.116
		N	60	60	60
	BMI (kg/m^2)	Correlation		0.206	0.058
		'p' value		0.115	0.662
		N		60	60
	f-BMD (g/cm^2)	Correlation			0.218
		'p' value			0.095
					60
Osteop-orosis	Age (Years)	Correlation	-0.169	-0.145	-0.423
		'p' value	0.197	0.270	0.001
		N	60	60	60
	BMI (kg/m^2)	Correlation		0.243	-0.039
		'p' value		0.061	0.770
		N		60	60
	f-BMD (g/cm^2)	Correlation			0.032
		'p' value			0.808
		N			60

[Table/Fig-6]: Correlation between the variables for normal and osteoporosis groups
BMI, body mass index; f-BMD, femoral bone mineral density; MCW, mandibular cortical width

in identifying postmenopausal women with low femoral bone mineral density (f-BMD) diagnosed by using DXA.

MATERIALS AND METHODS

Study Sample

One hundred and twenty postmenopausal women (60 normal and 60 osteoporotic) in the age group of 50-75 y with f-BMD assessed by DXA in M. S. Ramaiah Memorial Hospital, Bangalore had undergone panoramic radiographic examination in M. S. Ramaiah Dental College and Hospital, Bangalore, India. Women who did not give informed consent for taking panoramic radiographs at f-BMD assessment were excluded from the study. Also, excluded from the study were postmenopausal women who had used tobacco or medication that affects bone metabolism, or who had metabolic bone diseases, diabetes, significant renal impairment, bone destructive lesions (osteomyelitis or malignant tumor) in the jaw, and osteoporotic fractures detected at BMD assessment. osteopenic patients were also excluded from our study. The ethical clearance for the present study was obtained from the ethical review committee of the institution. Informed consent was also obtained from all the study subjects explaining the aim and methodology of the study at the time of f- BMD assessment.

BMD assessment and Body Mass Index (BMI) measurement

BMD at the femoral neck was determined by DXA (Hologic, Discovery QDR series) [Table/Fig-1]. The BMD scores were given as the 'T' score according to WHO classification of osteoporosis. The patients were classified as normal (T score ≥ -1.0) and osteoporotic (T score ≤ -2.5). Height and weight was recorded at the time of BMD assessment. BMI was calculated from the measured height and weight of the patient by using weight/square of height (kg/m^2).

Dental panoramic Radiographic Examination

Panoramic radiographs were obtained at the time of DXA measurement with a PLANMECA 2002 cc Proline panoramic unit

at 10 mA and 18 s; the tube potential varied between 60 kVp and 75kVp depending on the age, sex and built of the patient. In order to achieve a standard, the panoramic radiographs were obtained by a single dentomaxillofacial radiologist and in full compliance with the reference points specified by the manufacturer of the device. MCW was measured made in millimeters with a digital caliper and plastic millimeter ruler by an intra-and inter observer with 10y of experience. The same viewing box, magnifier (x^2), caliper and ruler were used all in the measurements. When the mental foramen was visible, the measurements were done bilaterally by an intra- and inter observer and their mean was used as the exposure measure in the analysis [Table/Fig-2]. Intra-observer variation in cortical width measurement was 0.1mm, which was similar to the inter-observer variation.

STATISTICAL ANALYSIS

The Microsoft Excel and SPSS v 10.5 (SPSS Inc, Chicago) software packages were used for data entry and analysis. The student t-test was used to determine whether there was a statistical significant difference between the groups in the parameters measured. Pearson's Correlation Coefficient (r) was used to assess the direction and strength of the relationship between age, BMI, BMD and the MCW and correlation between the intra and inter-observer for measurement of MCW. A probability (Pv) equation for osteoporosis was calculated by applying binary logistic regression analysis to the age, BMI and MCW. To assess the optimal cutoff scores, receiver operating characteristic (ROC) curves was plotted for the MCW (Osteoporosis versus (vs.) Normal) to compare the sensitivity and specificity of measurement and area under the ROC curve (AUC) was also calculated. According to an arbitrary guideline [19], we distinguished between non-informative (AUC = 0.5), less accurate (0.5, AUC, 0.7), moderately accurate (0.7, AUC, 0.9), highly accurate (0.9, AUC , 1) and perfect tests (AUC= 1). p-values less than 0.05 were considered statistically significant.

RESULTS

A group of 120 post-menopausal women aged 50-75 years participated in the study. Out of 120, 60 postmenopausal women were used as controls with normal f-BMD. The mean age was 60.17 ± 5.548 y and 60 were osteoporotic with low f- BMD with mean age 67.15 ± 4.635 y. The mean DXA T-score (- 3.027 ± 0.492), BMI (23.732 ± 4.7425 kg/m^2), f- BMD (0.5125 ± 0.0542 g/ cm^2), MCW (3.448± 0.9242 mm) of osteoporotic patients showed a statistically significant decrease in relation to normal group with mean DXA T-score (- 0.240 ± 0.633), BMI (28.910 ± 5.7365 kg/m^2), f–BMD (0.8221±0.0702 g/cm^2), MCW (4.349 ± 0.7483 mm), p-value < 0.001 [Table/Fig-3].

Binary logistic regression analysis was used to measure the validity of age, BMI, MCW in the diagnosis of reduced f-BMD and osteoporosis. Osteoporosis was dependent variable and MCW, age and BMI were the covariates. Osteoporotic status was defined as 0 and non-osteoporotic status was defined as 1. Age (p =0.002), BMI (p = 0.002), were found to be important risk factors for osteoporosis and statistical significant difference was found for MCW (p =0.005) between groups with decrease in relation to osteoporosis group [Table/Fig-4].

ROC curve analysis [Table/Fig-5] showed that for mean MCW AUC for identifying normal and osteoporosis groups was 0.778 (95% confidence interval (CI),0.693 – 0.849) with a statistically significant p-value of 0.0001. The accuracy of AUC for identifying study groups by MCW was moderately accurate. In the present study, for identifying postmenopausal women with osteoporosis at femoral neck, MCW optimal cut off value was < 3.35mm with a low sensitivity (55.0%) but a very high specificity (93.3%) in the mental foramen region.

For osteoporotic patients, Pearson's correlation coefficient test demonstrated that MCW negatively correlated with age (r= -0.423, p=0.001), BMI (r= -0.039, p=0.770) and positively correlated with f-BMD (r=0.032, p=0.808). f-BMD was negatively correlated with age (r= -0.145, p=0.270), positively correlated with BMI (r=0.243, p=0.061). Pearson's correlation coefficient test for normal group showed that MCW was negatively correlated with age (r= - 0.205, p=0.116) and positive correlation was observed with f-BMD (r=0.218, p=0.095), BMI (r= 0.058, p=0.662). f-BMD was negatively correlated with age (r= -0.397, p=0.002) and positively correlated with BMI (r=0.206, p=0.115). Results showed that BMI of postmenopausal women decreased with age for osteoporotic (r= -0.169, p=0.197) and normal (r= -0.179, p= 0.170) [Table/Fig-6]. Pearson's correlation coefficient test showed positive correlation for the intraobserver (normal, r=0.999; osteoporosis, r=0.999) and interobserver readings (normal, r= 0.999; osteoporosis, r=0.999) for MCW on panoramic radiographs.

DISCUSSION

Osteoporosis, which is characterized by compromised bone strength, is frequently not detected until a fracture occurs [20]. Osteoporosis is very common among postmenopausal women, while women of high risk are often asymptomatic [11]. Therefore, the identification of low bone mass in postmenopausal women should be emphasized as subjects with low BMD are more susceptible to osteoporotic fractures [21]. Early interventions may maximize bone mass retention and enhancement and thus reduce the risk of fracture. A number of technologies can be used to assess bone density, including SPA, DPA, DXA, QCT, and radiographic absorptiometry (RA) [7,22]. Horner K et al used OSTEODENT software, based on radiographic data supplemented by some simple clinical information and established the relationship between the OSTEODENT index and hip fracture risk assessment using FRAX. Results demonstrated that OSTEODENT index significantly related to 10y probability of hip fracture derived from standard reference tool [23].

Although, the advantage of clinical information (age, weight, current hormone replacement therapy, and history of low fracture trauma) used in OSTEODENT is quick, easy to collect and has value in prediction of hip fracture risk [23] but in a study by Devlin H, a threshold value of the OSTEODENT index giving a false positive rate of 10% resulted in an ability to detect 69% of patients with osteoporosis [24]. Even though statistical techniques on large samples of patients show the methodology works quite well, there will always be those patients given a false diagnosis of osteoporosis who are unnecessarily worried by the "high risk" label. It has also been suggested many patients with undetected osteoporosis, may be unconcerned about osteoporosis [25]. In the present study, BMD assessment was done by DXA which is widely accepted as the "gold standard" method of clinical BMD in the proximal femur and it is generally considered to be the technique of choice for the assessment of BMD because of its high precision and high accuracy [7]. In the present study the mean f- BMD determined by DXA of the osteoporosis group was less than the normal group with statistically significant p-value< 0.001. The results were consistent with the study by S Dagistan and Bilge OM [26] who concluded that panoramic radiography can be used as an ancillary method in diagnosis of early osteoporosis.

Osteoporosis is also influenced by BMI of the women. Ravn et al., [27] found thinness (low BMI or low body weight) as a risk factor for low BMD or increased bone loss in postmenopausal women. BMI positively correlated with BMD in a study by Yasar et al., [6] and they also suggested that people with a BMI of 20–25 kg/m^2 have a higher rate of bone loss than those who are heavier. The mean BMI of the women included in their study was classified as overweight according to WHO criteria (mean BMI: 27.78; SD: 4.32). Their results were comparable with the present study in which mean BMI showed statistically significant decrease in relation to osteoporotic group (23.732 ± 4.7425 kg/m^2) as compared to normal group (28.910 ± 5.7365 kg/m^2) with p-value < 0.001 and the osteoporotic

patients were classified as normal weight according to WHO criteria. A positive correlation was obtained between the BMI and BMD for the normal and osteoporosis groups in our study.

Panoramic radiographs are widely used in dental clinics to assess oral health status and dental structures. Mental Index (MI) is the measurement of MCW at the mental foramen region as described by Ledgerton et al., [28]. Dutra et al., [29] showed that the measurement of MI is accurate in panoramic radiographs and representative of true bone status. The present study compares the MCW of postmenopausal women with osteoporosis and a normal group using panoramic radiography. It was observed that the mean MCW value was smaller in the osteoporosis group (3.448 ± 0.9242 mm) than the normal group (4.349 ± 0.9242 mm) with p-value <0.001 suggesting that MCW at the mental foramen region is thinner in the postmenopausal women with low f-BMD and was efficacious in differentiating patients affected by osteoporosis.

The cut off threshold of the MI at which patients should be referred to bone densitometry is not clear. Devlin and Horner reported that patients with thinnest mandibular cortices (< 3mm) should be referred for further osteoporosis investigation because it is this group that has the highest likelihood of osteoporosis [17]. In a study, Taguchi et al., [30] reported that the likelihood ratio for identifying women with low BMD was 13.90 for thin MCW (< 3.0mm) in the mental foramen region. The results were comparable to the present study in which MI cut off value by ROC analysis for identifying women with low f-BMD was < 3.35mm and the likelihood ratio for identifying women with low f-BMD was 8.25 for thin MCW (< 3.35) in the mental foramen region.

Age is a non – modifiable risk factor for osteoporosis. Human bones decrease in density and increase in porosity beginning at approximately the third decade of life. This decline in bone mass is accelerated in women after menopause and the rate of bone loss has been reported to vary from 0.5% to 1% per year. Thus menopause puts women at greater risk of osteoporosis. Therefore, increasing age is one of the important risk factor for osteoporosis and age related decrease in BMD is associated with increase in fracture prevalence [28,31]. In the present study MCW was also evaluated according to the age and it was observed that MCW below the mental foramen region correlated negatively with age for osteoporosis (r = - 0.423, p = 0.001) and normal groups (r = - 0.205, p = 0.116) region.

Osteoporosis is a systemic skeletal disease; it affects the bone density and structure of the jaw [20]. It has long been postulated that mandibular bone density may be indicative of systemic BMD [28]. Significant correlations have been demonstrated between the mandibular cortical analysis of panoramic radiographs and f-BMDs [14,32]. In the present study MCW at the mental foramen region correlated positively with f- BMD for normal and osteoporosis group.

CONCLUSION

Low f-BMD, age and low BMI are major risk factors for osteoporosis. Postmenopausal women with low f-BMD had thinner mandibular cortex at the mental foramen region when compared to normal subjects and are more susceptible to femoral neck fractures. Hence, mandibular inferior cortical width at the mental foramen region could be used for identifying postmenopausal women with low f- BMD establishing panoramic dental radiographs serve as useful screening tool for early diagnosis of osteoporosis. Further studies are needed to ascertain the value of panoramic radiology as an adjunct diagnostic tool in the screening of patients thought to be at high risk of osteoporosis.

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