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RESEARCH ARTICLE

PANORAMIC RADIOGRAPHIC INDEX AS A DIAGNOSTIC INDICATOR OF OSTEOPOROSIS – A DOUBLE BLINDED POPULATION BASED STUDY

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ABSTRACT

Introduction: Osteoporosis is a progressive disease of the bone causing micro architecturaldeterioration of bone tissue leading to enhanced bone fragility and consequent increase in fracture risk. It is essentially a preventable disease and panoramic radiographs can prove to be a novel and easy method for early detection of this otherwise debilitating disease.

Aim: The aim of the study was to evaluate the precision of panoramic mandibular index (PMI) and Body Mass Index (BMI) in detecting osteoporosis in post-menopausal women and their correlation with skeletal bone mineral density.

Materials and methods: The study was conducted in a dental college in India and included 71 women in their natural menopause. The Body Mass Index (BMI) and Panoramic Mandibular Index (PMI) were calculated. The Skeletal bone mineral density (BMD) was assessed and the T-score was obtained. Based on the T-scores obtained, the patients were divided into three study groups of Normal (n=24), Osteopenic (n=30) and Osteoporotic (n=17). All the readings of T-score, Body Mass Index, PMI were tabulated for statistical analysis which was done using the ANOVA, post-hoc Tukey HSD test and Pearson correlation coefficient test with the SPSS software version 18 (IBM, Chicago)

Results: A statistically significant difference in the mean scores of PMI among Normal, Osteopenic and Osteoporotic subjects was found ($p<0.00$). However, the difference in BMI was not significant. Also, less inter and intra investigator variability was found in our study. The PMI was significantly decreased in osteoporotic patients when compared to normal.

Conclusion: As dental panoramic radiographs are relatively inexpensive and regularly taken in a large fraction of the adult population, they represent an enormous potential as a screening tool for osteoporosis.

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INTRODUCTION

Osteoporosis is characterized as a significant age related deficiency in bone mass with a potential for structural failure leading to bone fragility and an increased risk of fracture (Peck, 1993). With advancing age, the human skeleton undergoes a continuous decrease in bone mass.

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One of the first symptoms of osteoporosis is fractures due to accelerated bone loss (Peck, 1993). In 1960, it was first reported that osteoporosis may cause oral bone loss which could also be one of the early signs of the disease (Groen, 1960). There has been a growing interest in oral signs of osteoporosis and various investigators have stated that the progressive loss of alveolar bone may be a manifestation of osteoporosis (Hirai, 1993; Klemetti, 1996; Kribbs, 1983). Diagnostic techniques which can predict osteoporosis are of major importance in the current clinical scenario. There have been growing number of researches in the past where it was

concluded that osteoporosis is diagnosable through oral radiographs by trabecular patterns (Lee, 2005 and Binte, 2007) and radiomorphometric indices (Dagistan, 2010; Mansour, 2013; Calciolari, 2015). Reproducibility of such indices is of paramount importance in using them as screening tools for osteoporosis. The present study focuses on reliability of a simple radiomorphometric index, the Panoramic Mandibular Index (PMI) in assessment of risk of osteoporosis. The aim of this study was to evaluate the usefulness of the Panoramic Mandibular Index (PMI) and Body Mass Index (BMI) for screening Osteoporosis and to determine whether they correlate with the bone mineral density (BMD) determined in the phalanges of the hand by Digital X-ray Radiogrammetry method.

MATERIALS AND METHODS

The present population based observational study was conducted in a dental hospital in Hyderabad in a total duration of 6 months. It consisted of 71 subjects, which was determined based on the prevelance of the disease as per the previous studies. All subjects were women, in natural menopause within the age range of 45 to 70, with no known systemicillness. The subjects who were indicated for panoramic radiographs for other dental complaints, were randomly chosen from the dental out-patient department of the hospital. Exclusion criteriaincluded subjects on medications such as Glucocorticoids, Anticonvulsants, Gonadotropin releasing hormone, excessive thyroxin doses, Lithium and Calcium supplements were excluded from the study. Four oral radiologists were recruited as volunteers and were assigned as two observers and two investigators in order to blind the study. After obtaining the institutional ethical clearance and patient consent, the age, height, weight, time elapsed since menopause and residential address with complete medical history was recorded by Observer I. The body mass index (weight/height^2) was calculated. The information about the subjects was blinded to both the investigators in order to eliminate information bias. Hand-wrist and Panoramic radiographs were taken. Standard patient positioning and imaging techniques were followed for taking all the radiographs. To avoid bias caused due to positioning errors a standardized patient positioning technique was followed. The radiographs were taken on PlanmecaProline EC 2002 machine by the same investigator each time. The panoramic image was standardized by correctly determining the patient position, head alignment and the same investigator took all the radiographs required for the study. Radiographs which were not in the standard range of quality with proper density and contrast were excluded from the study.

After exposure, the image processing and archiving was done using the *DURR* Vista Scan workstation and digital images were obtained.

Calculation of the Radiomorphometric Index (Panoramic Mandibular Index): The PMI was calculated on a digital scale as illustrated in the figure. [Figure 1]. This method of calculation was first proposed by Benson *et al*. (1991), as the ratio of the thickness of mandibular cortex to the distance between the mental foramen and the inferior mandibular cortex. The linear measurements were made on the digital images obtained by DurrDBSWIN vista software (version 3.2). The readings were recorded by two investigators, taken twice by each investigator, at two different times to avoid inter and intra observer variability. When the mental foramen was visible bilaterally, the measurements, as illustrated in the figure, were made bilaterally and their mean was used as the exposure measure in the analysis. When only one mental foramen was visible, the measurements were done only on that side.

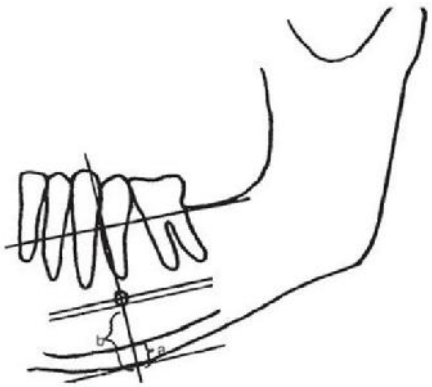

Figure 1. Figure showing measurement of Panoramic Mandibular Index (a/b)

Calculation of the Bone Mineral Density: Bone mineral density was calculated using the DXR (Digital X ray Radiogrammetry) methodand was expressed as T-score and Z-score.

The study subjects were divided based on the 1994 WHO report according to the t score values as follows: (WHO, 1994)

Normal: T score -1 and above

Osteopenic: T score < -1 and > -2.5

Osteoporotic: T score -2.5 or lower

The data thus collected was tabulated and statistical analysis was done using the ANOVA, post-hoc Tukey HSD test and Pearson correlation coefficient test with the SPSS software version 18 (IBM, Chicago). A correlation of all the indices was done with the study groups using the Pearson correlation coefficient analysis. All the values were in millimeters except for body mass index which is calculated in Kg/m^2

RESULTS

Based on the T-score obtained the patients were divided into three study groups of Normal (N=24), Osteopenic (N=30) and Osteoporotic (N=17). (Table 1) According to the WHO, (WHO, 1994), osteoporosis in women is defined as a BMD value at least -2.5 Standard deviation below the mean value of ayoung healthy population (T-score≤-2.5). Two sets of readings of Panoramic Mandibular Index obtained by two investigators were tabulated. A magnification factor of 20%, as specified by the manufacture of the Panoramic machine (PlanmeccaProline, 2002), was subtracted from the averages obtained. Statistical analysis was done using SPSS version 14. A p-value of <0.05 was set to be statistically significant. The results were tabulated and graphs obtained. Mean scores of PMI and BMI among the three groups of normal, osteopenic and osteoporotic were obtained and their standard deviations calculated. Comparison of means between all the groups was done using ANOVA followed by post-hoc Tukey HSD test.

Table 1. Comparison of mean PMI and BMI among the study groups

		N	Mean	SD	p-value	Post-hoc test
PMI	Normal	24	0.30	0.07	<0.001	1>2>3
	Osteopenic	30	0.25	0.05		
	Osteoporotic	17	0.17	0.06		
BMI	Normal	24	23.62	5.60	0.101	
	Osteopenic	30	23.44	4.35		
	Osteoporotic	17	20.74	3.30		

Table 2. Table showing correlation of PMI and BMI with study groups in which PMI was significant and BMI was not significant**

		PMI	BMI
Group	Pearson Correlation	.643(**)	0.218
	p value	.000	0.061
	N	71	71

Table 3: Correlation of BMI and PMI within each group showing that PMI was moderately correlating with T-score in osteoporotic patients (*Correlation significant with p=0.01), whereas BMI was not significant

			BMI	P value	PMI	P value
Normal	T score	Pearson Correlation	-.078	.719	.272	.199
		N	24		24	
Osteopenic	T score	Pearson Correlation	.255	.174	.343	.063
		N	30		30	
Osteoporotic	T score	Pearson Correlation	.352	.165	.560(*)	.019
		N	17		17	

Table 4. Intra and Inter observer reliability of PMI showed strong correlation between theexaminers; significance derived from r score

INTRA-OBSERVER				INTER-OBSERVER			
		I1R2	I2R2			I2R1	I2R2
I1R1	Pearson Correlation	.913(**)		I1R1	Pearson Correlation	.952(**)	.962(**)
	Sig. (2-tailed)	.000			Sig. (2-tailed)	.000	.000
	N	71			N	71	71
I2R1	Pearson Correlation		.978(**)	I1R2	Pearson Correlation	.917(**)	.918(**)
	Sig. (2-tailed)		.000		Sig. (2-tailed)	.000	.000
	N		71		N	71	71

** Significant correlation

The tests revealed that there was significant decrease in the mean scores of the PMI parameters among the three groups. Post hoc test revealed that Normal subjects had significantly higher PMI ($p<0.001$) than osteopenic and osteoporotic subjects and similarly osteopenic subjects had significantly higher PMI ($p<0.001$) than osteoporotic subjects. Whereas, there was no significant difference in the mean scores of the Body mass index among the three groups ($p = 0.101$) (Table 1) Corelation of PMI and BMI with the Bone Mineral Density scores was done with and within thestudy groupsusing the Pearson correlationcoefficient and it was found that there was a significant ($p=0.01$) moderate to strong correlation of PMI with the study groups while BMI was not significant. (Table 2) Within each group it was found that PMI was moderately correlating with T-score in osteoporotic patients ($p=0.05$), whereas BMI was not significant. Hence the results showed that as bone mineral density is increasing from osteoporotic to normal the radiographic measurements were also increasing. (Table 3). Inter and Intra investigator reliability was assessed using the Intra-class correlation coefficients for the PMI readings. In measuring the PMI, the intra investigator reliability ranged from 0.913 to 0.978 and the inter-examiner reliability ranged from 0.917 to 0.962. A strong correlation was seen in between the measurements of each investigator and the measurements of the two investigators (Table 4).

DISCUSSION

Osteoporosis, a metabolic bone disease, contributes to the increased risk of fractures due to low bone mass and enhanced bone fragility. Studies have shown that only one third of the patients surviving a hip fracture regain their original level of function (WHO, 1994). US National Osteoporosis Foundation (NOF) has proposed that there is increase bonedeterioration in women, especially post menopausal women, when compared to men (Dervis, 2005). Further, Women in their eighth decade have a ten times greater risk of being osteoporotic than women in their 5^{th} decades. In women, the risk of developing osteoporotic fractures after the age of 50 years is estimated to be 40 to 50 %, similar to that of coronary heart disease (Warburton, 2007). Many risk factors have been implicated for osteoporosis. They include menopause, low body weight, smoking habits, use of oral glucocorticoid therapy for more than three months, excessive thyroxine doses, low calcium intake, low physical activity and alcohol intake more than two times a day. Osteoporosis and its associated outcomes may play a major role in morbidity and mortality, thereby adversely affecting the cost of health care. Osteoporosis and its adverse outcomes are essentially preventable if diagnosed early. Studies have shown that women receiving anti-resorptive drugs obtain a 5-10% increase in bone mineral density which reduces the risk of osteoporotic fractures (Warburton, 2007).

Therefore, early diagnosis of this debilitating disease is of paramountimportance. Panoramic radiomorphometric indices may prove to be an effective strategy for early diagnosis of osteoporosis. Bone mineral density can be measured by various methods like Dual X-ray Absorptiometry (DXA and DEXA), Qualitative Ultrasound (QUS), Single Photon Absorptiometry (SPA), Dual Photon Absorptiometry (DPA), Quantitative Computed Tomography (QCT), Digital X-ray Radiogrammetry (DXR) and Single Energy X-ray Absorptiometry (SEXA) (Calciolari, 2015). DXR is a highly precise bone mineral density measures used. In DXR, the cortical thickness of the three middle metacarpal bones in the hand is measured in a digital X-ray image by a computer and is converted to the forearm bone density through a geometrical operation (Elliot, 2005). The BMD is corrected for porosity of the bone, estimated by a texture analysis performed on the cortical part of the bone. Because of its high precision, DXR is the technique of choice used to measure small changes in bone mineral density that occur over time, and hence more effective in monitoring changes that occur naturally on ageing.Since panoramic radiographs are the most commonly taken radiograph in the dental operatory, it will be very useful if this radiograph can hint in the possibility of the patient being Osteoporotic. Several studies in the past have suggested the use of panoramic radiographs as possible diagnostic indicators of osteoporosis (Calciolari, 2015; Valerio, 2013; Balcikonyte, 2004).

The present study focuses on the reproducibility of the Panoramic Mandibular Index and its correlation with the bone mineral density in osteoporotic patients. To curtail intrinsic errors and observer variability the present study involved two sets of readings calculated by two different investigators. Most authors concluded that there is variability in the scores assessed on a radiograph for indices, hence in the present study the Inter and Intra investigator reliability was calculated using the Intra-class correlation coefficients. A strong correlation was seen between the measurements of each investigator and the measurements of the two investigators. This was in agreement with the study conducted by Yasar F *et.al* in which a strong correlation was found in the intra-examiner measurements, however, inter-examiner reliability was not assessed for the same (Yasar, 2009). In the present study it was found that there was a statistically significant difference in the mean scores of PMI among Normal, Osteopenic and Osteoporotic subjects. Normal subjects had significantly higher PMI ($p<0.001$) than the Osteopenic ones and similarly the Osteopenic subjects had significantly higher PMI than the Osteoporotic subjects. This was in agreement with the study conducted by Dagistan *et al* who found that the MI(mandibular index) and PMI values in panoramic radiographs of male patients with osteoporosis were statistically significant when compared with the values of the control group; cortical bone thickness in these regions was also lower. He concluded that with advancing age and in patients with osteoporosis the PMI and cortical thickness significantly decreses (Dagistan, 2010). The precision of panoramic mandibular index in detection of osteoporosis was also determined in a study conducted by Khojastehpour L *et al*, the usefulness of PMI on panoramic radiographs in the detection of osteoporosis was evaluated and its correlation with BMD of the neck of femur and spine was determined. The mean PMI of nonmenopausal women was significantly different from those of menopausal and oophorectomized ones. There was a weak correlation between PMI and spinal BMD ($r=0.23$, $P<0.05$). The authors concluded that dental panoramic radiographs can be used in clinical practice to assist identifying individuals with low bone mass (Khojastehpour, 2009). This was in agreement with the present study resultsy. However, the authors in the above mentioned study had not considered the inter and/or intra investigator reliability leaving scope for information bias by the investigator which was eliminated in our study. In the present study, the body mass index was compared with the bone mineral density scores. It was found that out of 24 subjects showing normal bone mineral density, the body mass index ranged from 24.65 to 31.18 with a mean of 23.62. In 30 osteopenic subjects the body mass index ranged from 17.82 to 27.97 with a mean of 23.44. In the 17 osteoporotic subjects the body mass index ranged from 15.72 to 18.42 with a mean of 20.74.There was no significant difference in the mean scores of the Body mass index among the three groups ($p = 0.101$). This is in contrast with a study conducted by Espallargues M which reported that Body Mass Index significantly correlates with Bone Mineral Density and subjects with a Body Mass Index of 20-25 kg/m^{-2} have a high rate of bone loss than those who are heavier. However, it was also suggested that as the body mass index of a particular sex and age group may not have great variations, this parameter requires more studies on a larger sample size to be conclusive (Espallargues, 2001). Co-relational analysis in the present study showed that within each group PMI was moderately correlating with t score in osteoporotic patients ($p=0.05$). Hence, it was found that as bone mineral density is increasing from osteoporotic to normal the radiographic measurements were also increasing. This was in conjunction with the studies conducted by Balcikonyte E *et al* (2004) and Khojastehpour *et al.* (Khojastehpour, 2009).

Limitations

Although the present study has assessed an easier reproducible index to assess osteoporosis, it has certain limitations like taking only one radiomorhometric index, smaller sample size and may also have some intrinsic errors like visual perception of human eye and brain. Further studies on a wider scale would add momentum to the research in this area and draw better results with minimal bias.

Conclusion

With the aim to evaluate the efficacy of simple radiomorphometric indices as diagnosticindicators of osteoporosis, the study compared the values of Panoramic mandibular index and body mass index with that of bone mineral density. The authors concluded that there was a statistically significant decrease in the values of PMI with decrease in bone density. Since an orthopantomograph is the most commonly taken radiograph in a dental setting, PMI can prove to be a simple reproducible index to assess osteoporosis in its early stage. A predictor of osteoporosis could lead to early diagnosis and effective management of this debilitating disease thereby significantly decreasing the morbidity and improving the quality of life.

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