Correlation between Dual-Energy X-Ray Absorptiometry and Panoramic Mandibular Indices in Prediction of Bone Mineral Density in Postmenopausal Females

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ABSTRACT

Background: Osteoporosis is a systemic disease of the bone that is characterized by reduced bone mass, which leads to increased bone fragility and fractureparticularly in postmenopausal women.The aims of study was toevaluate the relationship between mandibular radiomorphometric indices obtained on digital panoramic radiographswith the bone mineral densities of the lumbar spineevaluated using dual-energy X-ray absorptiometry (DXA) scan, in a population of osteoporotic and non-osteoporotic females.

Materials and methods: In panoramic images obtained from 60 female individuals divided equally into three groups: controls (20-30 years), non-osteoporotic post-menopausal aged 50 years and above and osteoporotic post-menopausal aged 50 years and above, the mean was calculated for mandibular cortical width (MCW), panoramic mandibular index (PMI), mandibular cortical index (MCI) and gonial angle index (GAI) values measured in the right and left sides of the mandible. Bone mineral density (BMD) values were measured by dual energy X-ray absorptiometry (DXA) scan.

Results: Significant positive correlation (r) was observed between bone mineral density of lumbar vertebrae and MCW (r=0.706) and PMI (r=0.668) of mandible, and a negative correlation was observed between MCI and BMD of lumbar vertebrae (r=-0.716). While GAI did not show any significant difference in relation to bone mineral density.

Conclusion: This study showed that MCW, PMI and MCI indices were useful for identifying females with low skeletal (BMD), while GAI was independable in detecting osteoporosis.

Key words: DXA scan, panoramic mandibular indices, post-menopausal females. (J Bagh Coll Dentistry 2016; 28(3):87-91).

INTRODUCTION

Osteoporosis is a disease characterized by low bone mass and micro-architectural deterioration of bone tissue, leading to bone fragility and enhanced susceptibility to fractures. Osteoporosis is predominantly a condition of theelderly[1]. It affects mostly women, especially after menopause as a result of estrogen withdrawal[2].A major obstacle to combating osteoporosis is the failure to identify individuals who have osteoporosis until the clinical consequences of osteoporosis have occurred (i.e., fractures form with little trauma to the bones)[3].

BMD evaluation by dual-energy X-ray absorptiometry (DXA) testing is considered the gold standard for fracture risk prediction[4]. However, in addition to not being recommended by the WHO as a triage screening tool for osteoporosis, it has a high financial cost[5]. Because the bones of the oral cavity are similar in structure and physiology to various other bones in the skeleton, several studies have been conducted with the object of detecting whether these skeletal changes in the mandible are specific to the osteoporotic stage[4,5].

Panoramic radiography has been an important component of dental diagnostic radiology for over 40 years [6].

Recent clinical studies have shown that panoramic radiography plays a critical role in the identification and evaluation of osteoporotic patients or those with low BMD by dentists[7].

Qualitative and quantitative indices which include the mandibular cortical index (MCI), mandibular cortical thickness (MCW), gonial angle index (GAI) or panoramic mandibular index (PMI) have been used for panoramic radiographs, to assess the bone quality and to observe signs of resorption and osteoporosis[6].

The present study focuses on obtaining a possible mean of early detection of osteoporosis by panoramic radiography.

MATERIALS AND METHODS

A cross-sectional study was conducted on 60 Iraqi femaleswho had been referred to bonedensitometer center for BMD evaluation by DXA technique at the X- Ray Institutein the Medical City in baghdad.

The patients were asked to participate in this clinical trial as volunteers, and they were thoroughly informed about the procedure.The sample was divided into three groups according to their age and osteoporotic status:

- **1st group:** 20 females with age 20-30 as control group (non- osteoporotic).
- **2nd group:** 20 postmenopausal non-osteoporotic females with age from 50 and above.

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- **3rd group:** 20 postmenopausal osteoporotic females with age from 50 and above.

Females with natural menopause (which occurrs after 12 months of amenorrhoea and for which there was no obvious pathologic cause) with no history of hysterectomy, were included in the study. Smoking, alcoholism and patients with any known systemic disease that would affect bone metabolism like hyperparathyroidism, hypoparathyroidism, hyperthyroidism, Paget's disease, osteomalacia, renal osteodystrophy, cancers with bone metastasis or significant renal impairment and patients who were on specific drugs (corticosteroids) which are known to have adverseeffects on bone metabolism wereexcluded from the study.

Dual–energy X–ray absorptiometry (DEXA) scan of thespinal vertebrae (L2–L4) was performed by using osteosys DEXXUM 3(Korea)machine. This procedure is the current gold standard for measuring bone mass and detecting osteoporosis[8].

Thereafter,The patients were then subjected to panoramic imaging in the Department of Oral Medicine, Diagnosis and Radiology at the College of Dentistry (Baghdad University), onDimax 3 Digital X-ray machine manufactured by Planmeca Oy, Helsinki, Finland. After that, the images were manipulated on the computer monitor of the x-ray machine to achieve best image quality,then converted to **JPG** (joint photographic experts group) files; so that linear and angular measurements werecalculated by AutoCAD software (2007).

The results of DXA scan were then compared with the results of the indices from the panoramic radiographs.

The following radiomorphometric indices were measured for each patient:

- **Mandibular cortical width (MCW),** which is the measurement of the cortical width at the mental foramen region[9].
- **Panoramic mandibular index (PMI)** is the ratio of the thickness of the mandibular cortex to the distance between the superior margin of mental foramen and the inferior mandibular cortex, presented by Benson *et al*.[10].
- **Mandibular cortical index (MCI)** refers to the mandibular cortical shapes on dental panoramic radiographs , and is categorized into one of the three groups according to the method of Klemetti *et al*., as follows: C1: Normal cortex, C2: Mild to moderately eroded cortex and C3: severely eroded cortex[11].
- **Gonial angle index (GAI),** which refers to the size of the gonial angle of mandible[12].

The WHO diagnostic criteria for osteoporosis defines osteoporosis in terms of a T-score which is below -2.5 and osteopaenia in terms of a T-score which is between -2.5 and -1[13].

RESULTS

The results showed that MCW and PMI mean value was the highest for the healthy young female group (group I).While, the MCW and PMI value of post-menopausal osteoporotic female group (group III) showed the lowest mean.The results showed that all the three groups were statistically highly significant in MCW and PMI as P-value<0.001.

The meanGAI value for group I was the lowest among the rest of the study groups. While the GAI ofgroup III showed the highest value.Theresults showed that all the three groups were statistically non-significant in GAI as p-value was 0.21 (Table 1).

Regarding MCI, it was found that group I has normal mandibular cortical index (C1). While group II shows lacunar resorption (C2) in 15% of the cases. And group III shows lacunar resorption (C2) in 45% and clear porosity (C3) in 40% of the cases.The difference between the 3 groups showed a high statistical significance as the p-value<0.001(Table 2).

The results showed a positive correlation between MCW, PMI and T-score as r pearson value was (0.706) and (0.668), respectively. And a strong negative correlation between MCI and T-scoreas r value was (-0.716).There is a weak negative correlation betweenGAIand T-scoreas r value (-0.224);(Table 3).

DISCUSSION

Panoramic radiography is a routine imaging method in dentistry and is part of many recallprogrammes.

Table1: Mean values of Mandibular cotical width, Panoramic mandibular index and Gonial angle index according to DEXA results.

Groups	MCW			PMI			GAI		
	Mean	SD	P-value	Mean	SD	P-value	Mean	SD	P-value
Normal young group	3.8	0.38		0.246	0.032		121.9	7.34	
Post-menopausal normal group	3.4	0.43	<0.001	0.207	0.032	<0.001	123.6	6.74	0.21 [NS]
Post-menopausal osteoporotic group	2.3	0.61		0.141	0.043		126	7.97	

Table2: Showing frequency and percentage of MCI in different study groups.

	Healthy young group		Postmenopausal non Osteoporotic group		Postmenopausal osteoporotic group	
MCI	N	%	N	%	N	%
C1	20	100.0	17	85.0	3	15.0
C2	0	0.0	3	15.0	9	45.0
C3	0	0.0	0	0.0	8	40.0
Total	20	100.0	20	100.0	20	100.0

Table3:Linearcorrelation coefficient of MCI, PMI, GAI, T-score and age of all three groups

	MCW	PMI	GAI	MCI
T-score	r=0.706 P<0.001	r=0.668 P<0.001	r=-0.224 P=0.17	r=-0.716 P<0.001

Several studies suggest that panoramic radiomorphometric indices may be useful for identifying patients with lowskeletal bone mineral density or osteoporosis [14,15]. Although some studies have found no relationship between skeletal and mandibular BMD [7,16].

Measurement of the thickness of the mandibular cortical width in panoramic radiographs has been suggested as a way to predict patients with low bone mineral density [17].

In the current study, the cortical bone in the mental region was significantly thinner in post-menopausal osteoporotic females if compared with post-menopausal non-osteoporotic females. This result was expected as it concurs with previous studies [18-,20].

Besides that, MCW was also significantly thinner in post-menopausal groups than the young healthy group, and this can be attributed to the fact that MCW is affected by hormonal changes likeestrogens which have an important role in the regulation of skeletal development and homeostasis; this is demonstrated by the dramatic loss of bone that occurs after menopause.(During estrogen deficiency there is prolongation of osteoclast life span due to inhibition of apoptosis) [21,22].This result was in agreement withTaguchi *et al*. and Khojastehpour *et al*.,who stated that age was shown to have a significant correlation with the MCW, as age increased, there was a decreasing rate in cortical width [15,23].

Panoramic mandibular index was first proposed by Benson *et al*.,as radiomorphometric index of adult cortical bone mass [10]. Predictably, in this study PMI demonstrated similar age-related correlations as those of MCW by showing a statistically significant difference among all the three groups; the result of this study agrees with that of Halling *et al*. and Kim *et al*. [24,25].

The results of this study is consistent with the results ofHorner and Devlin, in which the PMI values measured in females with osteoporosis on panoramic radiographs were compared with the mandibular bone values measured with DXA, and a significant relationship was found between the two. They concluded that PMI could be used as an indicator of mandibular bone density [18].Our results disagrees with the study done by Drozdzowska *et al*., which showed that there was no correlation between PMI and DEXA measurement and they suggested that it should not be used as an indicator of skeletal status [7].

Regarding the gonial angle, in thepresent study, the size of the gonial angle increases as age increases, but it did not show a statistical significant difference. Which agrees with the study conducted by Dutra *et al*., done onBritish population, where the correlation between age and gonial angle was statistically non-significant [26], also with Ceylan *et al*., wherethe gonial angle did not increase as age increases in theedentulous individuals; therefore, they stated that lack of correlation between the gonial angle and the age indicates that the angle does not change with increase of the individual's age [27].

The present study disagrees with that doneby Mahdi and Al-Nakib, which showed that older subjects had significantly larger gonial angle than younger ones [28].

One of the most commonly studied parameters of mandibular bone with respect to osteoporosis is the porosity of the mandibular cortical bone. In the present study, C1 shape of cortex was seen in younger females, but as age increased, the number of individuals who had C2 and C3 categories increased, presumably reflecting age related bone loss.

In the present study, C2 and C3 categories were predominantly seen in post-menopausal osteoporotic females, which were again supported by previous studies [29-31].

Klemetti *et al.* evaluated the MCI, which was also known by the author's name. Our results confirm the results achieved by Klemetti *et al.*, as they suggested that a thin or eroded inferior cortex of the mandible detected on dental panoramic radiographs, an indicator of alterations of the mandible, is useful for identifying post-menopausal females with undetected low skeletal BMD or osteoporosis[11].

Regarding T-score, we found that there is a positive correlation between MCW and T-score, this correlation was statistically highly significant, and this agrees with Hekmatin *et al.*,who found a significant correlation between BMD and MCW and positive correlation between MCW and T-score[32]. T-score was also correlated positively with the PMI, which statistically has highly significant difference that was repeated by Parlani [33]. T-score, in our study also correlates positively with the MCI, and this is agreed by Gulsahi*et al.* [30].

From this study, we can conclude that panoramic radiography gives sufficient information to makeanearly diagnosis regarding osteoporosis in post-menopausal females, and this may be helpful in the prevention of osteoporotic fractures in elderly females.

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