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Original Research Article

Role of ortho-pantho-graphic X-ray in the diagnosis of osteoporosis

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ABSTRACT

Background: Osteoporosis affects people, especially old age, as postmenopausal women and remains unnoticeable until the patient presents with a fracture. Osteoporosis in human begins started with the loss of bone mass that increases with age, this is related to the decrease in bone density and an increase in porosity that will cause fractures in this osteoporotic bone. Objective was to assess the usefulness of orthopanthographic (OPG) in the early detection of osteoporosis.
Methods: This is an analytic across-sectional test validation study, was done in Hawari Hospital-Benghazi, Libya which considered a referral General Hospital affiliated with University of Benghazi. This study was done during a period from March 2022 to July 2023. Sixty women were selected, divided into osteoporotic and non osteoporotic groups depending on the clinical and laboratory investigations under the supervision of an orthopedic consultant in the outpatient clinic. Panoramic radiographic X-rays were taken for evaluation and estimation of the mandibular cortex on the basis of (Mental index, Klemetti index, and Panoramic mandibular index) as a diagnostic tool to differentiate normal from osteoporotic patient, all three indices correlated significantly with bone mineral density and used as useful indicators for detected the osteopenia and osteoporosis.
Results: We calculated values of the three indices (Mental index, Klemetti index, and Panoramic mandibular index) values were low especially in the osteoporotic group, as well the values of mental index and panoramic mandibular index were low compared with low bone mineral density of the patient and klemetti index with: C2, C3 categories (moderate and severe erosion) most common observed in the osteoporotic patient.
Conclusions: Orthopanthographic X-rays provide a valuable tool for early detection and assessment of osteoporosis (preclinical stage) especially when characterized by a decrease in bone mineral density.

Keywords: Osteoporosis, Low bone density, Mandibular radiomorphometric indices, MI, KI, PMI, Orthopanthographic X-ray

INTRODUCTION

Osteoporosis is a bone condition defined by loss of bone mass and fragility with increasing age, This is a universally observed phenomenon where the bone decreases in density and increases in porosity starting at about the third decade of life.[2] According to the National osteoporosis Foundation, osteoporosis affects more than two hundred million persons around the world.[22] Osteoporosis is a major health problem affecting one in three women over the age of fifty and may not be detected until fractures occur (silent condition).[9] These fractures most commonly occur in the vertebrae "compression fracture", distal radius, proximal humerus, distal femur, and around the hip joint. Since osteoporosis fractures are a health burden worldwide identifying subjects with a high risk of osteoporosis and preventing osteoporosis-related mortality

and morbidity is a significant health strategy. The diagnosis of osteoporosis is usually based initially on history, clinical examination, basic blood parameters, and bone mineral density measurement which is not a practical and economical technique for early detection.[15] Several investigators have demonstrated significant associations between dental panoramic radiographs and BMD of the skeleton generally, especially the spine and femur, The dentist will be able to identify osteoporosis in elderly individuals by using dental panoramic radiographs taken for the diagnosis of teeth and jaw bones without additional cost. thus referred the patients to the orthopedic surgeon for DEXA-scan and regular visits to improve lifestyle and start medical treatment.[7] Therefore, investigators are interested in the possibility of detecting osteoporosis from dental panoramic radiographs which can be represent the cortical situation of the mandible, These DPRs represented by three indices MI, KI, and PMI which are quantitative and qualitative indices calculated on oral DPRs.[17]

Aim and objectives

Aim and objective was to assess the usefulness of ortho-pantho-graphic (OPG) which was requested by the dentist in the detection of osteoporosis, thus referred the patients to the orthopedic surgeons for DEXA-scan and regular visits for improved lifestyles and the start of medical treatment.

METHODS

This is an analytic across-sectional test validation study, was done in Hawari Hospital-Benghazi, Libya which considered a referral General Hospital affiliated with University of Benghazi This study was done during a period from March 2022 to July 2023. All the patients gave their informed consent for inclusion before they participate in the study. All the information in this article was obtained according to academic and ethical rules of faculty of medicine of Benghazi University. Data was collected by purposive sampling technique through direct interviewing by using data collection pre-formed sheet (Table 1) and examining the patients that attending orthopedic surgery outpatient clinic of the hospital. Patients have been to divided into two groups: Group A: 30 patients who were diagnosed by the orthopedic consultant as osteoporotic patients. Group B: 30 patients who were diagnosed by the orthopedic consultant as non-osteoporotic patients.

Inclusion criteria

Women in the age of forty-five years or older with suspicious symptoms of osteoporosis (Table 1) were included.

Exclusion criteria

Patients with the following criteria were excluded: Undergoing hormonal replacement therapy, Taking calcitonin or biophosphonates, On corticosteroids, On chemotherapy or radiotherapy (cancer patients in general), Chronic kidney disease underwent renal replacement therapy and patient with the mandibular fracture or other parts of body fracture.

Orthopanthographic X-ray (OPG) was done in all patient groups, represented by mandibular radiomorphometric indices: Mental index (MI), Klemetti index: (C1, C2, and C3), and Panoramic mandibular index (PMI).

Table 1: Data collection pre-formed sheet.

Parameters
Serial number
Demographic characteristics
Name, Occupation, Telephone number, Age, Address, Marital status
Orthopedic surgery diagnosis
Conclusion of orthopedic consultant (cases: osteoporotic\non osteoporotic), Main complain, Any chronic illness, Low back pain, Fatigability, Arthralgia (small and large joint), History of previous fractures.
Investigations
Vitamin D3, calcium, po4, Alkaline phosphatase enzyme, Parathyroid hormone and thyroid hormones, conventional lumber sacral X-ray: AP and Lateral views and Dual-energy X-ray absorptiometry (DEXA) scan.
OPG parameters (mandibular radiomorphometric indices)
Mental index, Klemetti index: morphology of mandibular cortex: (C1, C2, C3) and Panoramic mandibular index.

Statistical analysis

Data was recorded, and statistical analysis was done by the SPSS program, version 26 software package. The statistical methods used were frequency and percentage for sorting the data figures (Bar chart, Pie chart), and the Chi-squared test used to detect any significant differences in category variables ($p<0.05$) was considered statistically significant for all statistical tests. Panoramic X-ray taken with radiographic apparatus. All panoramic images were made by using the panoramic machine (Figure 1) with standard world measurement of orthopanthographic X-ray under the supervision of an expert radiological technician who adjusted each image according to the patient position, head alignment and adjustment of a sensor to prevent radiographic errors (Figure 2). Panoramic radiographs (Figure 3) represent the quantitative and qualitative criteria of the mandibular cortical shape and width that can predict a possible loss of bone mineral density, assess bone quality, and observe signs of osteoporosis. These indices included mental index, mandibular cortical index (MCI) or (Klemetti index), and Digora software (DS 2.7) was used for support measurements of digital vernier caliper (Figure

4) (standard tool) used for measuring mental index and panoramic mandibular index.

Mental index or mandibular cortical width

It reflects the value of mandibular cortical thickness, measured by using the technique described by Ledgerton et al (Figure 5).

Figure 1: Digital OPG machine.

Figure 2: OPG X-ray: positioning of the patient.

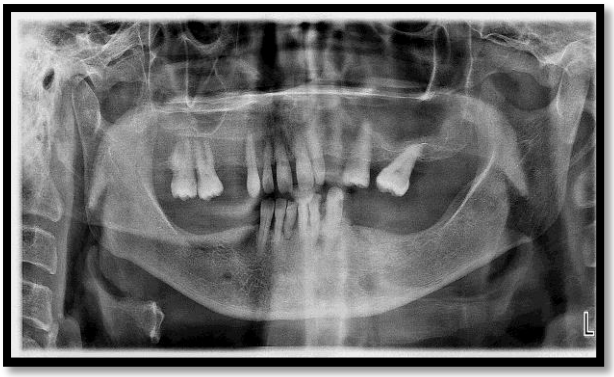

Figure 3: Orthopanthographic X-ray.

Second index: mandibular cortical index (Klemetti index)

for qualitative assessment of the inferior mandibular cortex, this index is classified into 3 categories (Figure 6).

Classification categories of Klemetti index

C1: The endosteal margin of the mandible cortex is even, regular, and sharp on both sides of mandible (Figure 6). C2: The endosteal margin appears to have semiluner defects or has resorptive cavities with cortical endosteal residues from one to three layers thick on one or both sides (Figure 7). C3: The endosteal margin consists of numerous thick cortical endosteal residues and is clearly porous (Figure 6).

Figure 4: Digital vernier calliper.

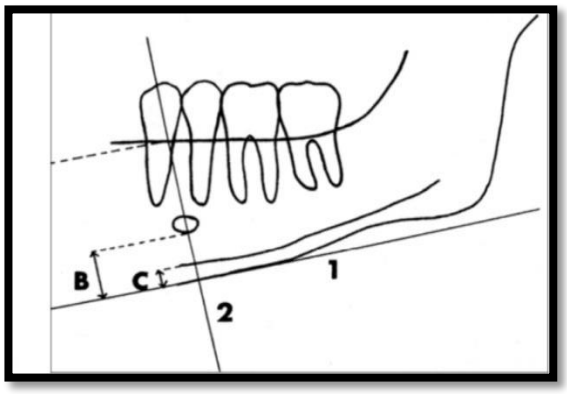

Figure 5: Measurements on the panoramic radiograph described by Wical, Swoope, Benson and Ledgerton techniques, inferior border of the mandible drawn by straight line 1 and line of Ledgerton-2 crosses mental foramen A-line, the mandibular cortical width describes by line-C and the distance between the inferior edge of mental foramen and the inferior edge of the mandible that describe by B line.

Panoramic mandibular index

It indicates the correlation of the residual ridge resorption with a mandibular height below the inferior edge of the mental foramen. Measurements of the panoramic mandibular index made according to the following criteria: 1-A line drawn which passed perpendicular to the tangential line to the lower border of the mandible and

through the center of the mental foramen. Measurements were made along this line of cortical width. The distance between the lower border of the mandible and inferior margin and superior margin of the mental foramen (Figure 7).

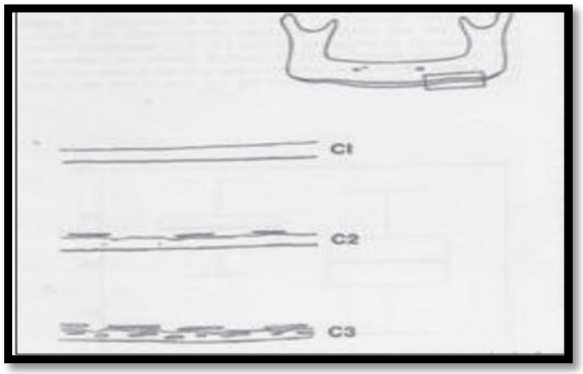

Figure 6: Categories classification (C1, C2, and C3) of Klemetti index.

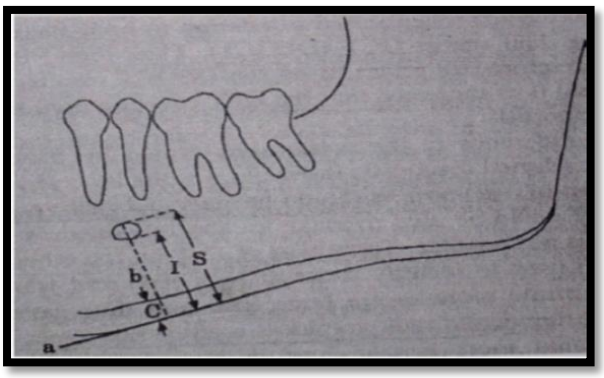

Figure 7: PMI measure a) is the tangential line to the inferior border, b) is the line passing through the center of the mental foramen along which measurements are made, c) is cortical width (CW), I and S is the distance from the lower and superior border of the mental foramen, PMI=CW/I.

Figure 8: OPG x-ray for osteoporotic patients showing the measurement of the distance from the inferior border of the mental foramen to the inferior border of the mandibular cortex about I=9.0 mm. Therefore PMI=MI/I (abnormal distance).

The superior panoramic mandibular index and the inferior panoramic mandibular index are calculated as: Superior panoramic mandibular index=Cortex thickness/distance from the superior margin of the mental foramen to the inferior border of the mandible. Inferior panoramic mandibular index=cortex thickness/distance from the inferior margin of the mental foramen to the inferior border of the mandible. Thus, panoramic mandibular index describes the thickness of the lower border of the mandible that tends to be reduced in a patient with osteoporosis (Figure 8).

RESULTS

Total cases were sixty women, aged from thirty-five years to eighty-two years with an average of fifty-five years. Sixty panoramic radiographs were obtained for Sixty women (thirty OPG rays for non-osteoporotic group and thirty OPG X-rays for the osteoporotic group).

Table 2: Common symptoms of the patients.

Symptoms	Yes, N (%)
Low back pain	16 (53.3)
Fatigability	16 (53.3)
Arthralgia (small and large joint)	15 (50.0)
Weak grip strength	17 (56.6)
Weak and brittle fingers nails	4 (13.3)
History of previous fractures	0 (0)

Fair and poor dental status were associated with increased age of the patient especially elderly postmenopausal women 28 women (osteoporotic group) and mild to moderated dental status with decreased age are 32 women (non-osteoporotic group). Calcium level: was found low in 14 of osteoporotic patients and normal in 16 of the osteoporotic patients. Vitamin D3 level: was found low in 6 patients, insufficient in 20 patients and normal in 4 patients of osteoporotic group. Alkaline phosphatase: if high in 21 and normal in 9 patients of the osteoporotic group. Parathyroid hormone (PTH) level: is high in only 3 patients of the osteoporotic group. Dual-energy x-ray absorption (Dexa-scan): was done only in 11 patients of osteoporotic group. Conventional X-ray lumbosacral spine showed: Decreased bone density in 14 cases (46.7%) of osteoporotic patients, Prominent thin cortex of the vertebrae in 14 cases (46.7%) of osteoporotic patients, Compression fractures not seen in our patients.

Statistical analysis of the 3 indices; Mental index (mandibular cortical width or thickness)

Abnormal mental index: OPG X-ray for a postmenopausal woman 63 years with a diagnosis of osteoporosis used (DEXA- scan) T-score at the neck of femoral about-2 and

T-score for the lumbar spine especially L4 about-3.4. According to World Health Organization criteria, the patient is osteoporotic, and the risk of pathological fracture were considered. The value of the mental index is about 1 millimeter (Figure 9).

Klemetti index (mandibular cortical index)

Three categories of Klemetti index C, C2, and C3, Klemetti index (C2 category): OPG X-rays (Figure 10) for 75-year- old menopausal woman with normal alkaline phosphatase, calcium (8.0), vitamin D3 (8), and PTH (77).

Figure 9: Abnormal mental index.

Panoramic mandibular index

OPG X-ray for (an osteoporotic patient of 68 years female) appears to measure the distance from the inferior border of the mental foramen (MF) to the inferior border of the mandibular cortex (MCB) about I= 8.53 mm (I abnormal reading (Figure 11).

Table 3: Thickness of the mandibular cortex.

Thickness of mandibular cortex		Osteoporosis	Not osteoporosis
Low <3 mm	**N**	21	0
	%	70.0	0
Normal >3 mm	**N**	9	30
	%	30.0	100

Relation of predictive values, sensitivity values, and specificity values with Mental index, Klemetti index, and panoramic mandibular index and their relation to the age of patients

Predictive, sensitivity, and specificity values of mental index in both groups: was found true positive in 21 pts. and false negative in osteoporotic group and was found true negative in non-osteoporotic group Sensitivity=A/(A+C)= 21/(21+9)=21/30=0.7, Specificity=D/(B+D)=30/(0+ 30)= 30/30=1, Positive predictive value=A/(A+B)=21/ (21+0)= 21/21=1, Negative predictive value=D/(C+D)=30/(9+ 30)=30/39=0.76.

The efficiency of MI for the diagnosis of the osteoporotic and non-osteoporotic patients is about 70%**.** Predictive, sensitivity, and specificity values of Klemetti index in both groups was found true positive in all patients of the osteoporotic group and true negative in 26 patients of the non-osteoporotic group. Sensitivity=A/(A+C)=30/(30+0) =30/30=1, Specificity=D /(B+D)=26/(4+26)=26/30=0.8, Positive predictive value=A/(A+B)=30/(30+4)=30/34= 0.8, Negative predictive value=D/(C+D)=26/(0+26)=26/ 26=1.

Figure 10: OPG x-ray showing Klemetti index with C2 category with High both T-score at the lumbar spine level in DEXA scan.

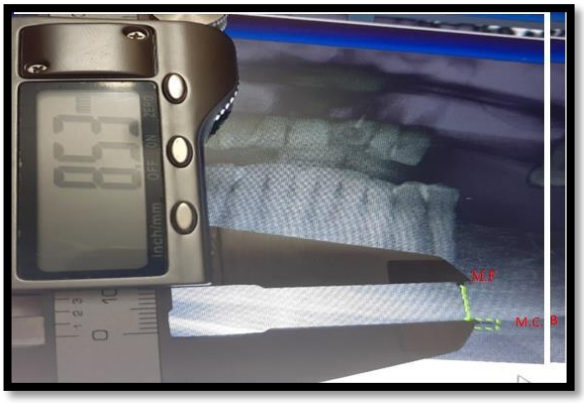

Figure 11: Abnormal panoramic mandibular index in patient with high T-score of DEXA scan at the level of lumbar spine (-3.1).

The efficiency of KI for the diagnosis of osteoporotic and non-osteoporotic patients is about 88.8%. Predictive, sensitivity, and specificity values of the panoramic mandibular index in both groups was found true positive in all patients of the osteoporotic group and false positive in all patients of the non-osteoporotic group. Sensitivity=A/(A+C)=30/(30+0)=30/30=1, Specificity= D /(B+D)=30/(0+30)=30/30=1, Positive predictive value=A/ (A+B)=30/(30+0)=30/30=1, Negative predictive value= D/(C+D)=30/(0+30)=30/30= 1. The efficiency of PMI for the diagnosis of osteoporotic and non-osteoporotic patients is about 100%.

DISCUSSION

Osteoporosis is a major health problem affecting one in three women over the age of fifty and may not be detected until fractures occur. Since osteoporosis fractures are a health burden worldwide identifying subjects with a high risk of osteoporosis and preventing osteoporosis-related mortality and morbidity is a significant health strategy. From our study, this is in agreement with Gulsahi.[15]

Table 4: Statistical correlation between the mental index and the age of the patients (non-osteoporotic group and osteoporotic group) by using (X^2 and p value).

Age group	Thickness of the mandibular cortex			Total	x^2	P value
		Low	Normal			
Less than50	N	0	15	15	10.769	0.001
	%	0	38.5	25		
Greater than 50	N	21	24	45		
	%	100	61.5	75		
Total	N	21	39	60		
	%	100	100	100		

Table 5: Statistical relationship between Klemetti index and the age of the patient of both groups depend on (X^2 and p value).

Age group (years)	Morphology of the mandibular cortex measure				Total	x^2	P value
		C1	C2	C3			
<50	N	13	2	0	15	17.069	0.000
	%	52.0	9.5	0.0	25.0		
>50	N	12	19	14	45		
	%	48.0	90.5	100.0	75.0		
Total	N	25	21	14	60		
	%	100	100	100	100		

Table 6: The statistical relationship between PMI and age of non-osteoporotic and osteoporotic groups depends on (X^2 and p value).

Age group (years)	Panoramic mandibular index			Total	x^2	P value
		Normal	Abnormal			
Less than 50	N	14	1	15	15.022	0.00
	%	46.7	3.3	25		
Greater than 50	N	16	29	45		
	%	53.3	96.7	75		
Total	N	30	30	60		
	%	100	100	100		

Osteoporosis sometimes has no symptoms (silent condition) until a fracture occurs, even our results showed no patient had a previous history of fracture which increases the risk of pathological fracture if the diagnosis missed, this is agreed with Kim et al.[9] As a general diagnostic guideline, we did the following: history for risk factors and symptoms, physical examination, and investigations: X-ray of lumbar and thoracic spine, blood tests (CBC, ESR, TFT) for all the patients to rule out other causes of bone weakness, Serum PTH, 25-0HD levels (vitamin D3), serum calcium and serum Alkaline phosphatase level for all patients. DEXA scan was not done for all of the patients due to the economic situation of most of our patients, the following investigation were not done: bone marrow biopsy after tetracycline labelling, Urinary free cortisol, measurement of serum and urine markers, and collagen breakdown products in the urine, e.g. N and C-telopeptides because these are costly expensive and some of them are not available locally this is agreed with other refrences.[3,24]

Dental status in our study showed clinical gingival recession and loss of teeth and loss of alveolar bone during OPG X-ray, these are the most common dental problems. Jaw fracture is the least problem in both groups of patients, We agree with Haster et al their results were statistically a significant difference for MI and PMI values according to dental status thus MI and PMI values of edentulous osteoporosis patients were lower, as well we agree with Mudda et al their results were showed generalized chronic periodontitis (Gingival recession, mobility of teeth and loss alveolar bone on dental X-ray) clinically with the

postmenopausal group and women after 44 years.[6,18] In our study, we found that calcium level is not a sensitive factor in the diagnosis of osteoporosis 14 cases (46.7%) of the osteoporotic group. As well we found that a low level of vitamin D3, 6 cases (20%) is observed in the osteoporotic group, and the level of parathyroid hormone is high only in 3 cases (10%) of the osteoporotic group, these variable values of blood parameters is inconsistent with the diagnosis of osteoporosis, this agrees with Rais et al.[21] In our study, statistical data (Bar chart, pie chart, and chi-squared test) showed significant differences in categorical variables, and there is a statistical significant correlation between MI and the age group of the patients (p=0.001) less than the standard value (0.05) this agreed with Kumar et al, Robert et al, Kristianti et al.[12,13,22] According to the results of our study, the mental index began to decrease sharply in women, especially postmenopausal women and reported that a cortical width of ≤3 millimeters is the most appropriate threshold for referring bone densitometry, as well has also proved that mental index values were smaller in older females group less than 3 mm in osteoporotic patients this is similar with results of other literature.[8,10,14] There is a significant relationship between the low value of the mental index, and low bone mineral density confirmed by the ideal standard measurements of the DEXA-scan test by Taguchi et al this agrees with our results in spite of the limited number of Dexa-scan of our patients.[24] In our results, the sensitivity and the specificity of the mental index in the diagnosis of osteoporosis group reported a sensitivity equal to 0.7, specificity equal to 1, and efficacy of mental index equal to 70%. This agrees with Klemetti et al.[11] The results of our study confirmed the statistically significant correlation between the Klemetti index and the age group of the patients (p=0.000) less than the standard value (p=0.05) this agrees with the study results by Banger et al.[4,5] According to the results of the study by Balcikonyte et.al enable of the Klemetti index to distinguish normal, osteopenia, and osteoporotic women, as well as correlations between mandibular cortex groups (C1, C2 and C3) and BMD were significant therefore the efficiency of the panoramic based Klemetti index in diagnosing osteopenia and osteoporosis is high, this is consistent with results of our study. The mandibular cortical index (KI) showed high sensitivity and high specificity and the patient with cortical shape index of C3 on nonstandardized panoramic radiographs have a higher risk of suffering systemic osteoporosis, This result is similar to studies of Al-Dam et al, Bhatnagar et al.[1,6] This agrees with our study sensitivity and specificity of Klemetti index in the diagnosis of osteoporosis group reported a sensitivity equal 1, specificity equal to 0.8, and efficacy of Klemetti index equal to 88.8%. This study confirms the statistically significant correlation between the panoramic mandibular index and the age group (p=0.00) less than the standard value (p=0.05), this is in accordance with the results of a study by Mudda et al.[18] The efficacy of the panoramic mandibular index in identifying postmenopausal women with low bone mineral densities especially in elderly women with a panoramic mandibular index smaller than 0.25 millimeter in panoramic radiographs should be referred for advanced osteoporosis investigation, Yashoda et al this agrees with our study that showed PMI values for an osteoporotic women sample was less than 0.3 mm.[26] In our study sensitivity and specificity of the panoramic mandibular index in the diagnosis of osteoporosis group reported a sensitivity equal 1, and specificity equal to 1 and efficacy of mental index equal 100%. This is in accordance with the results of a study by Passos et al.[20] According to the results of a study by Watanable et al atheroma (vascular calcification e.g.: carotid artery) in panoramic radiograph and its relation with systemic osteoporosis and osteopenia is observed in the patient, also related to the formation of atheroma in sample cases about fifty women under examination by DEXA-scan test for investigation LBMD, therefore, the atheroma was found in four patients, present correlation finding between osteoporosis and elongation of styloid process and atheroma on OPG X-ray, as well results in our study, we found one case from thirty cases of osteoporosis women demonstrated clear atheroma in OPG X-ray, this fact confirmed study of Watanable et al.[25]

Limitations

Our study was limited to dual-energy X-ray absorptiometery (DEXA-scan) test because the high cost of this test and socioeconomic status related to the low budget of the patients and replaced by another available investigation for bone densitometry. The sensitivities and specificities of (Mental index, Klemetti index, and Panoramic mandibular index) should be studied.

CONCLUSION

The dental panoramic radiographs (Orthopanthographic) proved to be more accurate in analyzing radiomorphometric indices (Mental index, Klemetti index, and Panoramic mandibular index), mental index and panoramic mandibular index were low values with increased age of the patient (advanced age/osteoporosis) especially women and klemetti index with C2, C3 categories records with elderly postmenopausal and osteoporosis women especially patient with T-score more than 2.5 in DEXA-scan test or high blood level of alkaline phosphatase enzyme, and high blood level of parathyroid hormone. Therefore, three indices (MI, KI, and PMI) were ancillary method used for the diagnosis of osteoporosis and important tools for assessment (low bone mineral density) on dental orthopanthographic x-ray, as the dental panoramic radiographs was low cost and available for all patients and benefit for detected osteoporosis.

Recommendations

According to our results necessary to recommend health education for all women especially age above 50 years and improve lifestyles for women under the age of 50 years to prevent start and developed osteoporosis disease. Early detection and diagnosis of osteoporosis by social health education centers in many counters this lead to help to

prevent later stages of disease (pathological fracture) because osteoporosis is considered a silent disease. Government support for the role of health awareness campaigns centers for education about osteoporosis disease and also support all health education work by achievement clinical studies and research. The role of a dentist can be to early detection of osteoporosis disease by using the dental panoramic radiograph a useful tool in screening osteoporosis and referring the patient to a specialist for further low bone mineral density investigation.

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