El-Din *et al.*
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Relation between panoramic mandibular index and disease activity in patients with rheumatoid arthritis

Mounir Serage El-Din, Hesham Mohamed Farouk, Raghdaa Mohamed Teleb and Nashwa Ismail Hashaad*

Abstract

Background: DEXA scan could be unavailable at some health centers, and radiologic examination of the mandible and oral cavity is considered more commonly used radiologic test that can predict, diagnose, or even follow-up on any defect in bone mineralization. The aim of this study was to elucidate the ability of panoramic radiograph to detect osteoporosis in rheumatoid arthritis patients and correlate panoramic mandibular index with RA disease activity and severity parameters.

Results: The sensitivity of panoramic mandibular index for diagnosis of osteoporosis was 96% in group **I** (primary OP) and 70% in group **II** (RA patients). The positive predictive value of PMI was 67% in group **I** and 55% in group **II**. The negative predictive value of PMI was 34% in group **I** and was 46% in group **II**. The cutoff value of PMI for diagnosis of OP was ≤ 0.31 in group **I** and ≤ 0.17 in group **II**. In group I, there were significant correlations between panoramic mandibular index and patient's ages, weights, *T* score at L1-4, *T* score at femoral neck, and *T* score at forearm while there were insignificant correlations between PMI and patients' heights. In group **II**, there were significant correlations between PMI, patients' ages, weights, disease durations, SHARP score, ESR, RF, *T* score at L1-4, *T* score at femoral neck, and *T* score at forearm, while there were insignificant correlations between PMI and patients' heights, DAS, and CRP.

Conclusions: Panoramic radiography could have a potential usability in the diagnosis of osteoporosis in rheumatoid arthritis patients regardless of displaying insignificant correlation with disease activity.

Keywords: Panoramic mandibular index, Rheumatoid, Osteoporosis

Background

Osteoporosis is a common systemic skeletal disorder leading to decreased bone strength and increased susceptibility to osteofragility and fractures [1]. Primary osteoporosis refers to bone loss that occurs due to the normal aging process, while secondary osteoporosis results from specific clinical disorders [2]. Osteoporosis being a silent disease is usually discovered by its complications such as spontaneous fracture of the forearm, vertebrae, or femoral neck, so it should be discovered early [3]. Unfortunately, generalized osteoporosis is an extra-articular complication of rheumatoid arthritis (RA), and increased fracture susceptibility in patients with RA compared with patients without RA has been documented [4]. The standards for diagnosis of osteoporosis are the measurement of bone mineral density (BMD) by dual-energy X-ray absorptiometry (DEXA) defined through a *T* or *Z* score [5]. Despite X-ray examination detecting bone loss at >30%, DEXA is considered the most reliable diagnostic method and can detect loss of bone mass if at 1% [6]. Peripheral imaging techniques such as peripheral quantitative tomography, peripheral DEXA, quantitative ultrasound methods, and peripheral magnetic resonance imaging have also been used for patient monitoring [7]. Panoramic radiography is frequently performed before dental treatment, especially

*Correspondence: Zeinahashaad@yahoo.com

Rheumatology, Rehabilitation and Physical Medicine Department, Faculty of Medicine, Benha University, Benha 13115, Egypt

in older patients, to assess dental status and many studies suggested that incidental findings detected on these radiographs might be helpful to identify patients with low bone mineral density [8]. Mandibular cortical index (MCI), mandibular cortical width (MCW), and panoramic mandibular index (PMI) have been developed to assess and quantify the quality of mandibular bone mass and to observe signs of resorption on panoramic radiographs for identification of osteopenia [9]. The panoramic mandibular index is the ratio of the thickness of the mandibular cortex to the distance between the mental foremen and the inferior mandibular cortex [10].

Methods

Study design

This case control study was carried on thirty patients with primary OP patients (group I), thirty patients with rheumatoid arthritis and secondary OP (group II), and thirty apparently healthy volunteers' age and sex matched to other groups (group III) taken as a control group. RA patients fulfilled the 2010 American College of Rheumatology/European League against Rheumatism classification criteria for RA [11]. All patients and healthy controls were selected from the attendance of outpatient clinic and the inpatients of the Rheumatology, Physical Medicine, and Rehabilitation Department. Patients taking steroids for a long period, those with chronic renal disease, chronic liver disease, thyroid dysfunction, and hyperparathyroidism, smokers, with alcohol consumption, with other autoimmune diseases, and those with other metabolic bone disease were excluded from this study. A prior written consent was taken from each patient and control included in this study. The ethical committee of faculty of medicine in our university approved this study, and the committee's reference number was RC.2013.

Clinical assessment

All participants enrolled in this study were subjected to full history taking and thorough clinical examination. The medical records of the RA patients were reviewed. Demographic characteristics including age, gender, weight, and height were obtained from all participants. Clinical evaluation included 28 tender joint count (TJC) and swollen joint count (SJC) and joint pain assessment on 100 mm visual analog scale (VAS). RA activity was assessed using the disease activity score 28 (DAS28) [12].

Radiological investigations

Plain postero-anterior view of both hands, with assessment of radiological severity using the Sharp score, was done [13].

Determination of bone mineral density

For measurement of the BMD, the dual-energy X-ray absorptiometry (DEXA) scanning was done for all participants, using the GE Lunar Prodigy Primo Bone Densitometer, General Electric. All DEXA scans were performed by the same operator. The BMD values were presented as grams per square centimeter. Cutoffs of *T* score were determined based on the definitions of the World Health Organization [14].

Mandibular panorama

All dental panoramic radiographs were obtained during the DXA scan using a PM 2002 CC Proline unit by a single operator. Each patient underwent a panoramic radiographic examination using a cassette fitted with an aluminum step wedge. On the dental panoramic radiographs, measurements were made in millimeters separately on the right and left mandibular sides. The patient was positioned with his/her cephalic extremity rotated to the left and mouth wide open. In order to calculate PMI, the mental foramen was located, and a perpendicular line is drawn on the tangent at the lower margin of the mandible which passes through the mental foramen. Along this was the perpendicular distance between the lower margin of the mandible and the lower margin of the mental foramen, as well as the distance between the lower margin of the mandible and the upper margin of the mental foramen. PMI was obtained by calculating the ratio between these distances [15].

Statistical analysis

The data of this study was coded and entered using the statistical package SBSS version 12. The data was summarized using mean and standard deviation (SD) for the quantitative variables and percentage for qualitative variables. Comparisons between groups were done using the chi-square test for qualitative variable and non-parametric Mann-Whitney test for quantitative data. Correlations were done to show the relation between quantitative variables. *P*-value ≤ 0.05 was considered as statistically significant (Figs. 1 and 2).

Results

General characteristics of patients and controls

The patients of group I were 90.7% females and 9.3% males; their ages ranged between 50 and 73 years with a mean of 59.6 ± 10 years; their weight ranged between 65 and 120 kg with a mean of 82.62 ± 17.17 kg; and their height ranged between 148 and 175 cm with a mean of1162 ± 0.12 cm. Rheumatoid arthritis patients (group II) were 97% females and 3% males, and their ages ranged between 45 and 73 years with a mean of 47.2 ± 12 years;

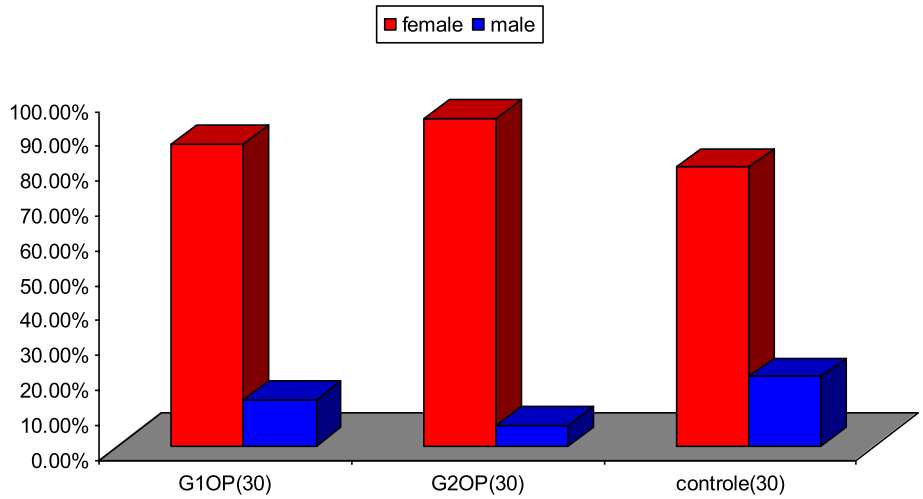

Fig. 1 Comparison between the patients and control groups as regards sex

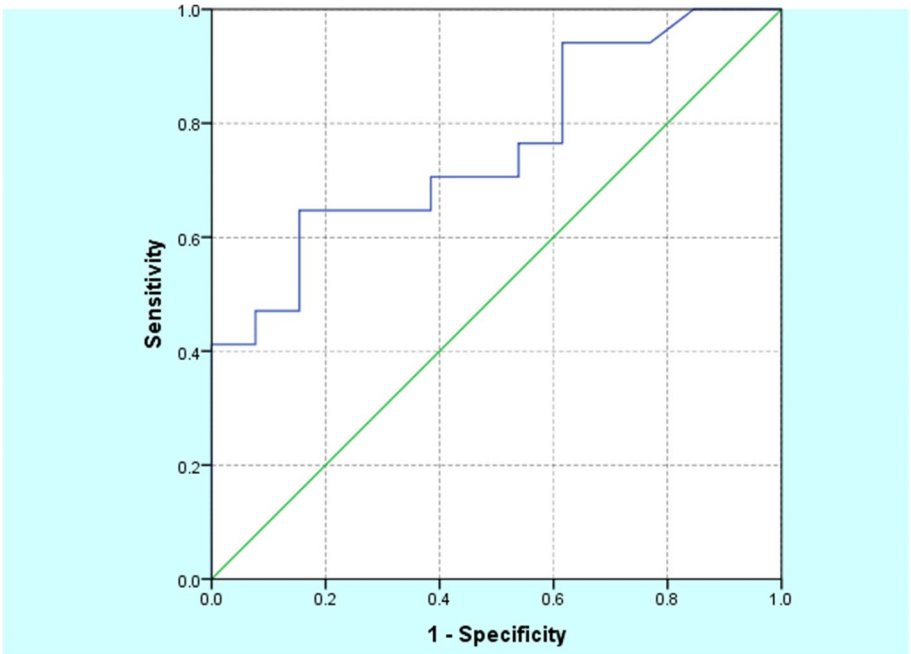

Fig. 2 Relation between PMI and reduced bone density (DEXA *T* score L1-4) using the ROC curve. Having area under the curve which is larger than 0.9 means that PMI is an excellent predictor for reduced bone density. This result is of statistically significant importance

their weight ranged between 65 and 120 kg with a mean of 82.62 ± 17.17 kg; their height ranged between 145 and 175 cm with a mean of 1162 ± 0.12 cm; their disease durations were between 1and 20 years with a mean of 7.5 ± 4.8 years; their DAS28 scores were with a mean of 5 ± 1.4; and their Sharp scores were with a mean of 5 ± 1. Their ESR 1st hour was with a mean of 40.8 ± 17.7 mm/h, C-RP was with a mean of 25.3 ± 12.2 mg/l, hemoglobin concentration was with a mean of 10.2 ± 1.4 gm/dl, WBCs was with a mean of 5.65 ± 1.56 ($\times 10^3$ cell/m^3), platelet count were with a mean of 3.29 ± 0.87 ($\times 10^3$ cell/m^3), ALT were with a mean of 32 ± 13.2 U/L, AST were with a mean of 28.3 ± 11.3 U/L, serum RF titer was with a mean of 40.7 ± 32.46 IU/ml, and serum anti-CCP titer was with a mean of 173.1 ± 30 ng/L. Group I and group III were age and sex matched with group II. (Fig. 1).

Table 1 Demographic and clinical findings of group I patients

Variable	Range	Mean ± SD
Age/year	50–73	59.6 ± 10 years
Weight/kg	65–120	82.62 ± 17.17
Height/cm	148–1755	162 ± 0.12

kg kilograms, *cm* centimeter

Table 2 Demographic and clinical findings of group II patients

Parameter	Range	Median	Mean ± SD
Age/year	24–73	46	47.2 ± 12
Weight/kg	65–120	78	82.62 ± 17.17
Height/cm	150–178	160	163 ± 0.09
Dis.duration/year	1–20	6.5	7.5 ± 4.8
DAS28	1.9–7	5.4	5 ± 1.4
SHARP score	67–410	145.5	176.63 ± 88

DAS disease activity score, *kg* kilogram, *cm* centimeter

Table 4 show that in group II, there were significant correlations between PMI and age ($P=0.015$), weight ($P=0.001$), disease duration ($P=-0.0539$), SHARP score ($P=0.034$), RF ($P=0.049$), ESR ($P=0.0287$), *T* score at L1-4 ($P=0.05$), at femoral neck ($P=0.01$), and at forearm ($P=0.003$), and there was insignificant correlation between PMI and DAS-28 ($P=0.279$) and CRP ($P=0.08$) (Tables 5 and 6).

Discussion

Our results showed highly statistically significant difference between primary osteoporotic patients (group I), osteoporotic RA patients (group II), and healthy controls (group III) regarding PMI which agreed with Balto et al. [16]. We revealed the specificity of PMI in diagnosis of OP was 50% in group I patients and 62% in group II, different with the results of Khojastehpour et al. [5] in his study when he found that the specificity of PMI was 88% in his osteoporotic patients. This gap may be due to the different sample size and different

Table 3 Comparison between the studied groups regarding *T* score of BMD and PMI

Parameter	Group I ($n=30$)		Group II ($n=30$)		Group III ($n=30$)		Mann-Whitney *U* test	*P*-value
	Median	Mean ± SD	Median	Mean ± SD	Median	Mean ± SD		
DXA *T* score F	−2.2	−2.3 ± 1	−1.2	−1.2 ± 1	−0.5	−0.42 ± 1.2	2.5	0.01*
DXA *T* score L1-4	−3.1	−3.4 ± 1.5	−2.1	−2.4 ± 1.7	−0.1	0.14 ± 1.4	5.6	0.001*
DXA *T* score Forearm	−3.4	−3.4 ± 1.5	−4.4	−4.6 ± 1.7	−1	−0.5 ± 1.3	2.4	0.03*
PMI	0.12	0.07 ± 0.06	0.16	0.17 ± 0.08	0.28	0.28 ± 0.1	4.1	0.007*

DEXA *T* score F, dual energy X-ray absorptiometry at the femur's neck; DEXA *T* score L1-4, dual-energy X-ray absorptiometry at the lumber spines of the first four lumber vertebrae, *PMI* panoramic mandibular index

Radiological findings in patients and controls

Table 1 shows that there was a significant difference between the three groups regarding *T* score at the femur neck ($P=0.01$), L4 ($P=0.001$), forearm ($P=0.03$), and PMI ($P=0.007$). Table 2 shows that the sensitivity of PMI was 96% for diagnosis of OP in group II (1ry OP) and 70% in group II (RA patients), the positive predictive value of PMI was 67% in group I and 55% in group II, the negative predictive value of PMI was 34% in group I and 46% in group, and the cutoff value of PMI for diagnosis of OP was ≤ 0.31 in group I and ≤0.17 in group II. (Fig. 2).

Relationships of PMI with clinical and laboratory findings in the studied groups

Table 3 shows that in group I, there were significant correlations between PMI and age ($P=0.019$), weight ($P=0.021$), ESR ($P=0.0377$), *T* score at L1-4 ($P=0.052$), at femoral neck ($P=0.041$), and at forearm ($P=0.03$), and there were insignificant correlations between PMI and both of CRP ($P=0.08$) and height ($P=0.312$).

Table 4 Specificity and sensitivity of PMI in the diagnosis of osteoporosis

Variable	Group I	Group II
AUC	0.907	0.758
***P*-value**	0.005*	0.01*
Cutoff	≤ 0.31	≤ 0.17
Sensitivity	96%	70%
Specificity	50%	62%
PPV	67%	55%
NPV	34%	46%

PPV positive predictive value, *NPV* negative predictive value

Symbol means significant

cutoff value. This work-documented sensitivity of PMI was 96% in group I and 70% in group II, similar to Bajoria et al. [17] who showed that the sensitivity of PMI in the diagnosis of OP was 100%. Our study found that the cutoff value for osteoporosis was 0.3 mm in agreement

Table 5 Correlations between PMI, clinical data, and laboratory findings in group I

Parameter	Group I	
	R	*P*-value
Age (year)	0.62	0.019*
Weight/kg	0.74	0.021*
Height/m	0.14	0.312
ESR (mm/h)	− 0.15	0.0377*
C-RP (mg/l)	0.51	0.08
DEXA *T* score LI-4	0.42	0.052*
DEXA *T* score femur	0.65	0.041*
DEXA *T* score forearm	0.87	0.03**

PMI panoramic mandibular index, *ESR* erythrocyte sedimentation rate, *C-RP* C-reactive protein, *DXA* dual-energy X-ray absorptiometry, *T score F*, at the femur's neck score, *L1-4* at the lumber spines of the first four lumber vertebrae

Table 6 Correlations between PMI, clinical data, and laboratory findings in group II

Parameter	Group II	
	R	*P*-value
Age (year)	0.71	0.015*
Disease duration	− 0.17	0.0539*
DAS28	0.204	0.279
Weight/kg	0.92	0.001*
Height/m	0.163	0.265
SHARP score	− 0.66	0.034*
ESR (mm/h)	− 0.19	0.0287*
C-RP (mg/l)	0.58	0.08
RF	− 0.17	0.049*
DEXA *T* score LI-4	0.48	0.05*
DEXA *T* score femur	0.72	0.01*
DEXA *T* score forearm	0.99	0.003**

DEXA dual-energy X-ray absorptiometry, *DAS28* disease activity score, *ESR* erythrocyte sedimentation rate, *CRP* C-reactive protein, *RF* rheumatoid factor, *T score F* at the femoral neck score, *L1-4* first four lumbar vertebrae

with Hastar et al. [18]. We demonstrated highly statistically significant correlations between *T* score at L1-4 and PMI in group I and in group II, consistent with Valerio et al. [8]. Furthermore, there was a statistically significant correlation between *T* score at the forearm and PMI in group I and group II in line with Nemati et al. [19]. Also, this study revealed a statistically significant correlation between *T* score at femoral head and PMI in group I and in group II in agreement with Pavicin et al. [20]. On the other hand, Drozdzowska et al. [21] 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 in their study. The previous conflict could be argued to his study-correlated PMI with BMD at the femur only; also, he depended on quantitative ultrasound measurement at the calcaneus. This study revealed a significant correlation between PMI and patient age in group I and in group II in agreement with Kwon et al. [22]. We found a significant relation between PMI and RF; also, Josphine et al. [23] found the same result by DEXA. Surprisingly, this study emphasized the significant correlation between *T* score at the femoral head and DAS-28 in group II in accordance with Gheita et al. [24], although Hafez et al. [25] found insignificant correlations between the DAS-28 and *T* score at the femoral head. This discrepancy could be explained by their selection of recent onset rheumatoid cases. Moreover, there was a significant correlation between the DAS-28 and *T* score at L1-4 and at the forearm in group II in similarity with Gauri et al. [26] despite us finding an insignificant correlation between DAS-28 and PMI. Regarding disease severity, we found significant correlations between the Sharp score and *T* score at the L1-4, femoral head, and forearm in group II, in accordance with Lodder et al. [27]. Noteworthy, we found significant correlations between the Sharp score and PMI. Some limitations were present in our study like the absence of bone turnover marker investigations and the small number of rheumatoid arthritis patients.

Conclusions

Panoramic radiography could have a potential usability in the diagnosis of osteoporosis in rheumatoid arthritis patients regardless of displaying insignificant correlation with disease activity.

Abbreviations

MCI: Mandibular cortical index; MCW: Mandibular cortical width; PMI: Panoramic mandibular index; DXA: Dual-energy X-ray absorptiometry; RA: Rheumatoid arthritis; SJC: Swollen joint count; TJC: Tender joint count; BMD: Bone mineral density; DAS28: Disease activity score 28.

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Authors' contributions

All authors have read and approved the manuscript. Idea suggestion, put the study design: MS and NH. Data collection and analysis: NH, HF, and RM. Manuscript writing and final revision: NH and RM. The content of the manuscript has not been published or submitted for publication elsewhere.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Done; the committee's reference number is as follows: RC.2013.
Written consents according to the Helsinki declaration were taken from all patients and control subjects prior to the participation in the study which was approved by the ethical committee of Faculty of Medicine, Benha University.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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