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AGREEMENT BETWEEN PANORAMIC RADIOGRAPHY AND CBCT FOR THE DETECTION OF LOW BONE MINERAL DENSITY: A CROSS-SECTIONAL STUDY

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ABSTRACT

Objectives: To compare cone beam computed tomography (CBCT) and panoramic radiography in the detection of low bone mineral density patients.

Methods: This study was done on 46 patients obtained from the Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Ain Shams University. Patients were screened by DEXA, panoramic radiography, and CBCT. Radiographic quantitative and qualitative assessment for both right and left sides was performed. Radiographic analysis was compared with DEXA scan results.

Results: The panoramic mental and mandibular indices and the cone beam mandibular and inferior indices (MI, PMI, CTMI and CTI) were in good agreement with each other. While the panoramic and cone beam cortical indices (MCI and CTCI) were different to each other, in the detection of low bone mineral density patients.

Conclusions: For the radiographic detection of low bone mineral density, there is a good agreement between panoramic radiography and cone beam computed tomography regarding the mental and mandibular indices.

KEYWORDS: Osteoporosis; panoramic; cone beam computed tomography; bone mineral density; DEXA.

INTRODUCTION

Osteoporosis is a chronic long-lasting disease characterized by reduced bone mineral density (BMD). It often affects older individuals and gradually leads to an increased risk of bone fractures [1]. Osteoporosis progresses silently and can remain undetected until severe symptoms such as skeletal fractures emerge. Early diagnosis

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of osteoporosis is crucial as it can substantially improve the quality of life for affected individuals [2,3].

The diagnosis of oral signs of osteoporosis has gained increasing attention in recent times. Identifying osteoporosis, evaluating bone mass, and determining fracture risk are critical objectives during patient evaluations [4,5]. Dual-energy X-ray absorptiometry (DEXA) is the most widely used and reliable method for measuring bone mineral density (BMD). However, other techniques, such as quantitative computed tomography (QCT) and quantitative ultrasound (QUS), are also available [6,7].

Individuals with osteoporosis have alterations in the cortical thickness and morphology of maxillofacial bones, and there is evidence that panoramic radiography and Cone beam computed tomography (CBCT) imaging could be used for detection of low BMD [6-8]. CBCT produces high-quality structural images without any overlapping, magnification, or distortion, and enables three-dimensional visualization [8].

Several previous studies have compared panoramic radiography and CBCT for the radiographic diagnosis of osteoporosis with contradictory results [9-11]. Therefore, this study aimed to assess the agreement between panoramic readings and CBCT for osteoporosis detection.

MATERIALS AND METHODS

Subjects:

This study was conducted in the Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Ain Shams University. 46 CBCT scans were used. Patients were imaged for other dental purposes including implant placement. This study was approved by the Ethics Committee (FDASU-RecIM011965). All patients provided written informed consent. Individuals with a history of metabolic or hormonal bone diseases, renal disease, or current use of bone metabolism-altering medications were excluded from the study. Additionally, participants undergoing hormonal replacement therapy or receiving calcium and vitamin D supplements for at least six months were excluded. The selected patients were subjected to panoramic radiography and DEXA scanning.

Methods:

I- Cone beam computed tomography:

CBCT images were obtained by using I-CAT Next generation (Imaging sciences International, Hatfield, PA, USA). A voxel size of 0.2 mm and exposure parameters were set at 120 kV, 37.07 mA and 26.9 s acquisition time. A 16×20 cm FOV. Scans were viewed by I-CAT-Vision software (ver. 15.3.13@ imaging Sciences International).

Radiographic parameters were performed on the cross-sectional images in the region of the mental foramen as follows:

- Computed tomography mandibular index (CTMI) which is the thickness of the mandibular cortex below the mental foramen. **(Figure 1a).** [10]
- Computed tomography index (inferior) CTI (I) which is the ratio of the inferior cortical width to the distance from the inferior margin of the mental foramen to the inferior border of the mandible**. (Figure 1a).** [10]
- CT cortical index (CTCI) which is visual evaluation of the morphology of the different types of inferior cortex of the mandible **(Figure 2)**[10]. It was evaluated from cross sectional images visually bilaterally and classified according Klemetti's classification as follows: [12,13]

Class a: The endosteal margin of the inferior cortex is smooth and uniform **(Figure 2a).**

Class b: Semilunar defects or endosteal residues appear in the endosteal margin **(Figure 2b).**

Class c: The cortical layer is porous and there are several endosteal residues **(Figure 2c).**

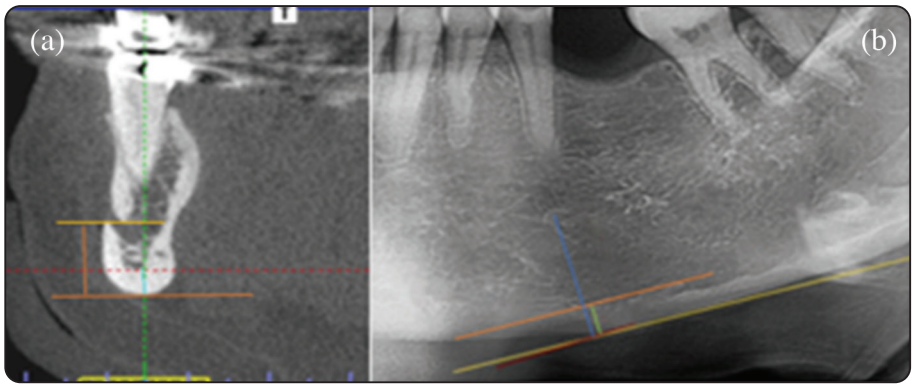

Fig. (1) Measurement of Mental index.(a) CBCT cross sectional image showing (CTMI, CTI). (b) cropped panoramic image showing (MI, PMI).

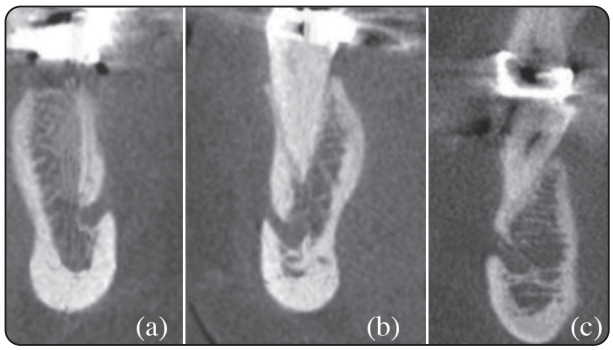

Fig. (2) CBCT cross sectional cuts showing the morphology of mandibular cortices (CTCI).

II. Panoramic radiography:

Panoramic radiographs were obtained using Vatech machine (Vatech digital X-ray imaging system, PCH-2500) with tube voltage of 90kvp, tube Current of 10mA and 10.4sec seconds scanning time. The images were analyzed by EzDent-I software program (EWOOSOFT Co., Ltd, ver.3.1.1.0). Radiographic parameters performed on panoramic images were as follows:

- Mental index (MI) which is thickness of mandibular cortex below the mental foramen (Figure 1b). [3]
- Panoramic mandibular index (PMI) which is the ratio of the inferior cortical width to the distance from the inferior margin of the mental foramen to the inferior border of the mandible (Figure 1b). [3]
- Mandibular cortical index (MCI). which is the appearance of the inferior mandibular cortical thickness. (Figure 3). According to Klemetti et al [12] the MCI was classified into three classes: C1, C2, and C3. C1 had even and sharp mandibular cortical bone, with no erosion, C2 was moderately eroded and there is some lacunar resorption and class C3 had several erosions and many porosities. [12]

III. Evaluation of the bone mineral density:

Bone mineral density at the femoral neck and lumbar spine (L1–L4) was determined using DEXA scanner (LUNAR Prodigy Primo machine, GE Lunar). Patients were classified as normal (T-score ≥ -1), osteopenia ($-1 \geq$ T-score ≤ -2.5), and osteoporosis (T-score ≥ -2.5) according to the WHO criteria [14].

VI. Data analysis:

Data were collected, processed in Excel sheet sheet, and then analyzed statistically using SPSS (v20). Graphical presentations were also created with Excel.

Quantitative variables were summarized using mean, standard deviation, range, standard error of the mean, and 95% confidence interval. Qualitative variables were described by frequency and percentage.

The agreement between the quantitative variables was assessed by Dahlberg Error, Relative Dahlberg

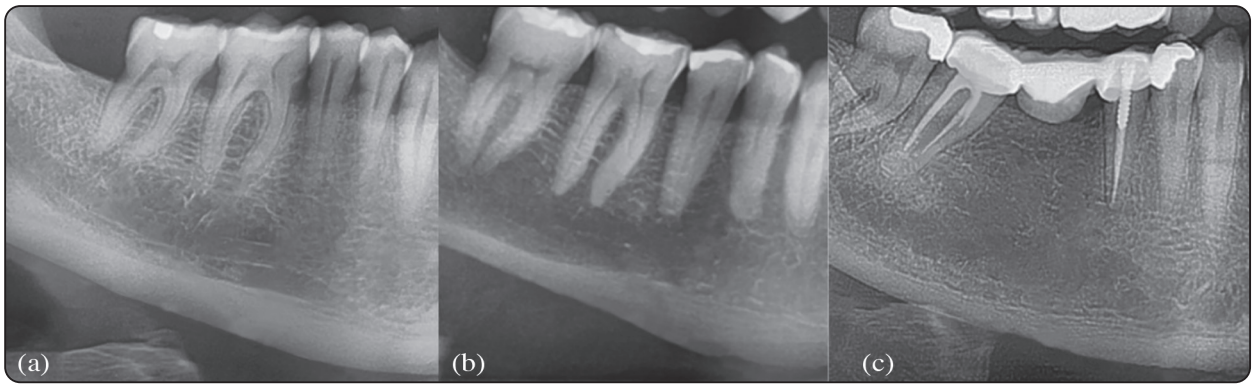

Fig. (3) Panoramic radiograph showing morphology of mandibular cortices (MCI).

Error, Bland and Altman limits of agreement and the Concordance Correlation Coefficient (ccc) with its 95% confidence limits. The agreement between the qualitative variables was assessed by percentage of agreement, Cohen Kappa and weighted Kappa with its 95% confidence limits.

RESULTS

Measurement of MI and CTMI: (Table 1, figure 4)

Regarding the agreement between MI and CTMI findings, Dahlberg error was 0.21 and the relative Dahlberg error (RDE) was 5.80%.

The mean MI and CTMI values measured on panoramic images and CBCT were 3.56±0.57 and 3.61±0.58 respectively. For comparison of MI and CTMI from panoramic images and CBCT in the Bland-Altman analysis, cross sectional images were considered the gold standard. The mean difference in MI, CTMI values from panoramic and CBCT images was 0.05 mm (95% CI -0.52 to 0.62 mm).

Regarding Concordance correlation coefficient, the agreement between MI and CTMI was good (CCC =0.886).

Measurement of PMI and CTI: (Table 1, figure 4)

Regarding the agreement between PMI and CTI, Dahlberg error was 0.0228 and the relative Dahlberg error (RDE) was 6.552 %.

The mean PMI and CTI values measured on panoramic images and CBCT were 0.34±0.05, 0.35±0.05 respectively. For comparison of PMI findings from panoramic images and CTI from CBCT in the Bland-Altman analysis, cross sectional images were considered the gold standard. The mean difference in PMI and CTCI values was -0.0146mm (95% CI -0.713 to 0.0422 mm).

TABLE (1) Assessment of agreement between panoramic and CBCT regarding mental index and mandibular index.

					Bland & Altman Limits of Agreement				Concordance Correlation		
	Mean	SD	DE	RDE	Mean	SD	95% confidence limits		CCC	95% confidence limits	
							Lower	Upper		Lower	Upper
MI	3.56	0.57	0.21	5.80%	0.05	0.29	-0.52	0.62	0.866	0.816	0.903
CTMI	3.61	0.58									
PMI	0.3409	0.0563	0.0228	6.552%	-0.0146	0.0289	-0.0713	0.0422	0.835	0.777	0.879
CTI	0.3554	0.0548									

DE: Dahlberg error, RDE: Relative Dahlberg Error, SD: standard deviation.

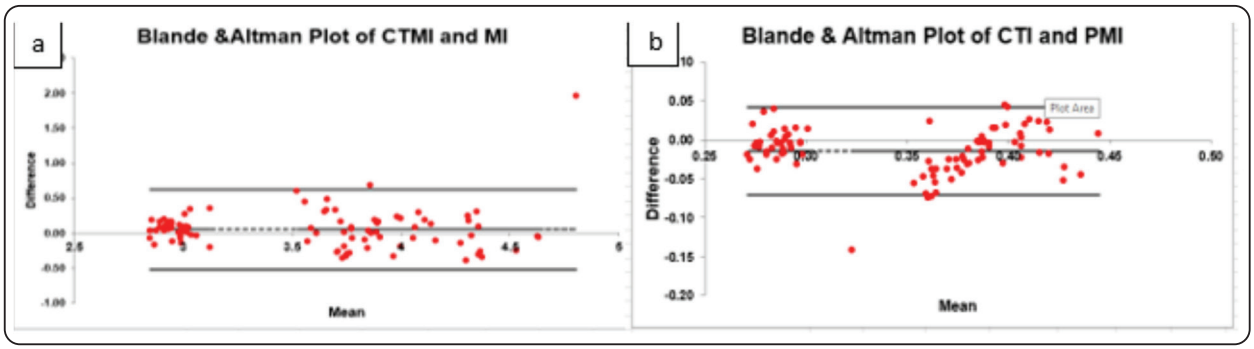

Fig. (4) a) Blande &Altman plot of CTMI and MI. b) Blande & Altman plot of CTI &PMI.

Regarding Concordance correlation coefficient, the agreement between PMI and CTI findings was good CCC = 0.835).

Assessment of MCI and CTCI: (Table 2)

The percentage of agreement between MCI and CTCI was 60.87% and weighted kappa was 0.335. That indicates weak or fair agreement.

TABLE (2): Assessment of agreement between MCI and CTCI.

		CTCI			Total
		C1	C2	C3	
MCI	C1	4	12	0	16
	C2	6	41	5	52
	C3	0	13	11	24
Total		10	66	16	92
Total agreement		4	41	11	56
Percentage of agreement			56/92		60.87%

DISCUSSION

Osteoporosis is a serious condition that significantly increases the risk of bone fractures. These fractures can be painful, debilitating, and even life-threatening [1]. Osteoporosis is a silent threat to the quality of bone, slowly decreasing bone strength. It disrupts the delicate balance between bone breakdown and formation, leading to porous, fragile bones [2].

Panoramic radiographs are a common imaging method in dentistry. Panoramic radiograph has been used to assess bone quality and detect osseous bone changes using MI, PMI, and MCI indices [15-18]. Despite being a widely used tool in dental diagnosis, panoramic radiography presents a challenging diagnostic tool due to its complex image formation, superimpositions, magnification, and potential for distortions, which can be further amplified by technical acquisition issues [19-21].

Dutra et al. previously investigated the validity of panoramic radiograph-based mandibular index (MI) values and the need for magnification correction[20]. Their study found that panoramic radiographs can provide accurate MI measurements. Secgin CK found that panoramic radiographs can provide accurate MI measurements, particularly when adjusted for magnification variations [10].

On the other hand, dentists widely request CBCT imaging nowadays for the bone assessment in patients, especially those seeking dental implants. CBCT provides high quality multiplanar images without magnification [9].

Many studies have used panoramic and CBCT imaging-based indices for bone quality assessment and detection of osteoporosis [8,9,10]. CBCT images have precise measurements of both vertical and buccolingual dimensions, revealing the true size and

shape of the mandible [22]. Koh and Kim validated mandibular indices of cortical lower jaws in CBCT in detection of low BMD using their results of DEXA as the gold standard [12].

In the present study, we have compared mandibular indices from panoramic images and CBCT scans to estimate the agreement between both techniques in the detection of osteoporosis using DEXA as a gold standard.

Regarding MI findings from panoramic images and CBCT scans. We found that the mean of MI and CTMI values were 3.56±0.57 and 3.61±0.58 respectively. Using statistical methods of agreement, there was a good agreement between MI and CTMI.

Our results were in concordance with Secgin CK et al [10]. They found, after magnification correction, the difference in MI and CTMI values was very small, and the agreement between the imaging modalities was good [10]. This was also in agreement with Gomes CC et al. [8]. Ozturk et al. also evaluated MI and CTMI on panoramic images and CBCT respectively. The results of both methods agreed with each other [11].

Regarding PMI and CTI, we found that the mean PMI and CTI values measured on panoramic images and CBCT were 0. 0.34 ± 0.05, 0.35 ± 0.05 respectively. Using statistical methods of agreement, there was a good agreement between PMI and CTI. our findings agreed with Secgin CK et al. [10] and Ozturk et al. [11].

Regarding mandibular cortex assessment in panoramic and CBCT scans, we found that the MCI and CTCI were in a fair agreement. The percentage of agreement of both indices was 60.87% and the weighted kappa was 0.335. Ozturk et al. reported that the weighted kappa coefficients indicated moderate and high correlations between MCI and CTCI scores[11]. Gomes et al.[8] compared reconstructed panoramic and cross-sectional images obtained from CBCT for determining the MCI in a group with a high risk for osteoporosis and found no differences in MCI findings between the two modalities. Secgin et al.[10] in another study, concluded that CBCT qualitative index provided better visibility especially in C3 cases than panoramic images. They contributed this to the overlapping of the buccal and lingual cortices in panoramic radiographs [10]. Moreover, Kato CN et al. [1] evaluated MCI determined by digital panoramic radiographs and reconstructed panorama of CBCT in the detection of low BMD. They found the reconstructed panorama of CBCT with 25 mm slice thickness was the most accurate.

To sum up, the panoramic mental and mandibular indices and the cone beam mandibular and inferior indices (MI, PMI, CTMI and CTI) were in good agreement with each other. While the panoramic and cone beam cortical indices (MCI and CTCI) were different to each other, in the detection of osteoporosis.

CONCLUSION

For the radiographic detection of osteoporosis, there is a good agreement between panoramic radiography and cone beam computed tomography regarding the mental and mandibular indices.

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