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Article

Cone Beam Computed Tomography Panoramic Mandibular Indices in the Screening of Postmenopausal Women with Low Bone Mass: Correlations with Bone Quantity and Quality

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Abstract: Objective. The present study examined the potential use of computed tomography panoramic mandibular indices on cone beam CT (CBCT) for the assessment of bone density in postmenopausal women with low bone mass. **Study design.** We enrolled 104 postmenopausal women who performed dual energy X-ray absorptiometry (DXA) using a DXA scanner and mental foramen region CBCT using NewTom VGi EVO Cone Beam 3D system. We assessed the relationship between DXA parameters: lumbar, femoral neck and total hip T score, bone mineral density (BMD), and lumbar trabecular bone score (TBS) and the panoramic mandibular indices: computed tomography mandibular index superior (CTI(S)), computed tomography mandibular index inferior (CTI(I)) and computed tomography mental index (CTMI). **Results.** We found important correlations between the CTI(I), CTI(S) and CTMI and bone mass, quantitative evaluated as BMD and T-score and also quality using TBS score. **Conclusion.** CBCT measured indices CTI(S), CTI(I), CTMI are useful in assessing patients with low bone mass.

Keywords: osteoporosis; menopause; cone beam computed tomography

1. Introduction

First defined in 1993, osteoporosis is a widespread bone condition marked by reduced bone density and structural weakening of bone tissue, leading to heightened bone fragility and an increased risk of fractures [1]. Although this condition can affect almost any person from any age group, postmenopausal women are a population “at-risk” to suffer from osteoporosis, mainly because of the changes in estrogen levels [2]. For the measurement of bone mineral density (BMD), the dual-energy-X-ray absorptiometry (DXA) is the gold standard for the diagnosis of osteoporosis [3], defined as follows, according to American Association Of Clinical Endocrinologists and American College Of Endocrinology (AACE/ACE) Clinical Practice Guidelines criteria: a. T-score – 2.5 or below in the lumbar spine, femoral neck, total, and/or 33% (one-third) radius; b. Low-trauma spine or hip fracture (regardless of BMD); c. Osteopenia or low bone mass (T-score between –1 and –2.5) with a fragility fracture of proximal humerus, pelvis, or possibly distal forearm; d. Low bone mass or osteopenia and high FRAX® fracture probability based on country-specific thresholds [4].

The threshold for diagnosing osteoporosis based on BMD is important for clinical assessment and treatment, but although it is the best tool to predict fracture risk, has several limitations that reduce its effectiveness in identifying patients who will eventually experience a fracture [1,5].

Knowing that there might be a significant correlation the BMD of the mandible and that in the femoral neck and lumbar spine measured in patients with osteoporosis [6,7], some tools like cone beam computed tomography (CBCT), which assesses jaw bone density and quality might be used to evaluate BMD in patients with low bone mass [8]. Barra et al [8] stated that radiomorphometric indices measured in specific centers from mental foramina are promising tools in CBCT of the

mandible for assessing the BMD in postmenopause, exhibiting significant differences among patients with normal BMD and the ones with osteopenia and/or osteoporosis. As well, Koh et al [7] reported that specific indices on CBCT axial, sagittal and coronal images are useful methods for osteoporosis screening. These panoramic quantitative indices are the most commonly used to evaluate the low bone mass in the mental foramina region.

We aimed to evaluate the correlations between panoramic mandibular and bone mass density in postmenopausal women, with regards to both quantity and quality.

2. Materials and Methods

This study was performed on postmenopausal women. Written informed consent was obtained from patients before the study. The study was approved by the Ethics Committee of “C. I. Parhon” National Institute of Endocrinology, Bucharest, Romania.

The inclusion criteria were: female sex; age greater than 50 years, DXA with TBS evaluation, biological evaluation, CBCT evaluation. Exclusion criteria were: presence of systemic diseases affecting bone metabolism, such as neoplasia, osteomalacia / history of rickets, endocrine disorders (hyperthyroidism, hyperparathyroidism, Cushing’s syndrome, or acromegaly), severe renal failure, liver failure, malabsorption disorders (Crohn disease, celiac disease); presence of rheumatologic diseases (rheumatoid arthritis, ankylosing spondylitis), history of oophorectomy; usage of medications interfering with bone turnover / density (glucocorticoids, aromatase inhibitors, selective serotonin reuptake inhibitors, medroxyprogesterone acetate, antiepileptic drugs, unfractionated heparin).

The included postmenopausal women had normal BMD, osteopenia or osteoporosis, with or without antiresorptive / anabolic treatment.

2.1. CBCT Measurements

According to the modified Ledgerton’s classification [9], we used the following panoramic mandibular indices: CTI(S), CTI(I), and CTMI, defined as follows:

- CTI(S): superior CT mandibular index (the ratio of the inferior cortical width to the distance from the superior margin of the mental foramen to the inferior mandibular border)
- CTI(I): inferior CT mandibular index (the ratio of the inferior cortical width to the distance from the inferior margin of the mental foramen to the inferior mandibular border)
- CTMI: CT mental index (the inferior mandibular cortical width)

Table 1. Indices and their significance.

Index	Value
CTI(S)	W/S
CTI(I)	W/I
CTMI	W
<i>*W-inferior cortical width of the mandible; S- distance from the superior margin of the mental foramen to the inferior mandibular border; I- distance from the inferior margin of the mental foramen to the inferior mandibular border</i>	

The measurements of S, I, and W indices were performed on coronal images. The W index represents the inferior cortical width of the mandible; the S index represents the distance from the superior margin of the mental foramen to the inferior mandibular border; the I index represents the distance from the inferior margin of the mental foramen to the inferior mandibular border. The measurements were performed by an experimented radiologist.

The CBCT images were obtained using NewTom VGi EVO Cone Beam 3D Imaging (CEFLA s.c. – Via Selice Provinciale 23/a IMOLA, Italy), at 110 kV, 7,5 mA, 3,5 s, pixel size 0,2 mm. The images were reconstructed using NewTom NNT (ISDP©10003:2020 compliant in accordance with EN ISO/IEC 17065:2012 certificate number 2019003109-2) with Viewer software.

2.2. Bone Mineral Density Measurements

BMD was measured at the lumbar spine (LS), femoral neck (FN), and total hip by DXA (General Electric Prodigy Lunar, Bedford, UK) using an enCore Software 10,50,086. BMD was expressed in grams per square centimeters (g/cm²), and by comparing the BMD with the peak bone mass of a young adult, a T-score was obtained, expressed in standard deviations (SD) and a Z-score for age-matched SD [15]. All measurements were done according to the International Society for Clinical Osteodensitometry [10]

TBS values were obtained by analyzing the L1–L4 vertebrae DXA images with an iNsight Software version 2.2.0.0 (Medimaps Group SA Headquarters, Switzerland).

All patients were scanned on the same DXA machine, yet by two different operators, thus allowing a user bias.

3. Statistical Analysis

We statistically analyzed the patients based on the value of the BMD (lumbar spine, femoral neck, total hip scores), T score (lumbar spine, femoral neck, total hip scores), respectively and TBS as continuous values, regardless of the osteoporosis diagnosis at the time of CBCT evaluation.

Alternatively, we used binary logistic analysis to divide the patients based on the osteoporosis diagnosis (according to AACE/ACE criteria) [4]. We also employed the regression analysis, the t-test, the Pearson’s correlation coefficient and Spearman’s rho, using IBM SPSS Statistics, version 25 (SPSS Inc, Chicago, IL, USA) for Mac OS.

4. Results

The characteristics of the patients included in the study are presented in the table below (Table 2). We included in the study 104 postmenopausal women, with mean age of 65.15 ± 9.12 years old. The mean age for menopause was 47.22 ± 5.3 years old, with a mean body mass index (BMI) of 26.58 ± 7.48. The mean lumbar BMD score was 0.944 g/cm³ (0.544, 1.437), with a mean T lumbar score of -1.95 SD (-5.3, 2.1). For femoral neck, the mean BMD score was 0.944 g/cm³ (0.554, 1.221), with a mean T score of -1.95 SD (-3.5, 1.3). The mean score for TBS was 1.284 g/cm³ ± 105.83 SD (1.062, 1,558).

Table 2. Patients distribution.

Parameter	T score ≤ -2.5*	T score ≥ -2.5*
Number	45	59
BMI (kg/m ²)	24.47 ± 4.91	27.66 ± 8.38
Age at menopause (years)	47.18 ± 4.49	47.43 ± 5.73
Femoral neck T score (SD)	-2.06 ± 0.66	-1.15 ± 0.85
Total hip T score (SD)	-1.67 ± 0.78	-0.6 ± 1.04
Lumbar T score (L1-L4) (SD)	-3.12 ± 0.69	-1.3 ± 0.92
Femoral neck BMD (g/cm ³)	0.727 ± 0.082	0.852 ± 0.11
Total hip BMD (L1-L4) (g/cm ³)	0.713 ± 0.366	0.941 ± 0.132
Lumbar BMD (g/cm ³)	0.805 ± 0.088	1.018 ± 0.012
TBS score (g/cm ³)	1207 ± 181	1313 ± 100.9
* the values are expressed in mean ± SD, did not include patients with osteoporosis based on other AACE criteria		

Table 3 lists the mean values of the CBCT parameters, depending on the bone quantity (assessed with lumbar and femoral neck T-scores), and bone quality (assessed with TBS). There were statistically significant differences based on bone quality and quantity, higher values of the studied CBCT parameters being observed in patients with higher T score and higher TBS (p < 0.0001).

Table 3. Mean values of the computed tomography parameters on cone beam computed tomography (CBCT) images.

CBCT parameter	Lumbar T score > -2.5 SD (n=62)	Lumbar T score ≤ -2.5 SD (n=42)	Low bone quality (TBS ≤1.23, n=21)	Intermediate bone quality (TBS >1.23 and <1.31, n=32)	Normal bone quality (TBS ≥ 1.31, n=33)	Femoral neck T score > -2.5 DS (n=85)	Femoral neck T score ≤ -2.5 DS (n=14)	P value
CTMI	2.74 ± 0.80	2.43 ± 0.83	2.12 ± 0.61	2.42 ± 0.84	3.04 ± 0.69	2.72 ± 0.74	1.84 ± 0.68	p < 0.0001

CTI(I)	0.24 ± 0.07	0.21 ± 0.07	0.20 ± 0.06	0.21 ± 0.07	0.26 ± 0.05	0.24 ± 0.06	0.17 ± 0.06	$p < 0.0001$
CTI(S)	0.18 ± 0.05	0.16 ± 0.05	0.14 ± 0.04	0.16 ± 0.05	0.20 ± 0.04	0.18 ± 0.05	0.13 ± 0.06	$p < 0.0001$
<i>TBS, trabecular bone score, expressed as g/cm³, SD, standard deviation, CBCT, cone-beam computer tomography, CTMI, computer tomography mental index, CTI-(I), inferior computer tomography mandibular index, CTI(S), superior computer tomography mandibular index</i>								

Statistically significant correlations were also observed between bone quantity, this time expressed as linear value using lumbar, femoral neck and total hip BMD, not only using T-score in the three mentioned regions. This emphasizes the importance of BMD in assessing bone quantity, more than just the T-score (Table 4). All CBCT parameters were moderately correlated (the highest correlation coefficient being 0.551 for CTMI with femoral neck T-score, see table 4). Using Pearson’s correlation coefficient and Spearman’s rho, we found the same moderate correlation between CBCT indices and bone mass (Table 5).

Table 4. Correlations between CBCT parameters and bone quantity and quality parameters.

Parameters for correlations [†]	CTMI	CTI(S)	CTI(I)
Lumbar T score*	0.429, $p < 0.0001$	0.387, $p < 0.0001$	0.364, $p < 0.0001$
Femoral neck T score*	0.551, $p < 0.0001$	0.465, $p < 0.0001$	0.481, $p < 0.0001$
Total hip T score*	0.470, $p < 0.0001$	0.440, $p < 0.0001$	0.451, $p < 0.0001$
TBS score*	0.431, $p < 0.0001$	0.421, $p < 0.0001$	0.351, $p < 0.0001$
TBS quality assessment***	0.454, $p < 0.0001$	0.379, $p < 0.0001$	0.423, $p < 0.001$
Lumbar BMD**	0.359, $p < 0.0001$	0.355, $p < 0.0001$	0.322, $p < 0.0001$
Femoral neck BMD**	0.522, $p < 0.0001$	0.443, $p < 0.0001$	0.446, $p < 0.0001$
Total hip BMD**	0.509, $p < 0.0001$	0.445, $p < 0.0001$	0.460, $p < 0.0001$
Osteoporosis defined as lumbar T score ≤ -2.5 SD	-0.387, $p < 0.0001$	-0.296, $p = 0.003$	-0.349, $p < 0.0001$
[†] Significant at the 0.05 level t-test (2-tailed)			
* expressed as standard deviations			
** bone mass density, expressed as g/cm ³			
*** trabecular bone score, expressed as low if TBS ≤ 1.23 g/cm ³ , intermediate if TBS > 1.23 and < 1.31 g/cm ³ and normal if TBS > 1.31 g/cm ³			
<i>TBS, trabecular bone score, expressed as g/cm³, SD, standard deviation, CBCT, cone-beam computer tomography, CTMI, computed tomography mental index, CTI-(I), inferior computer tomography mandibular index, CTI(S), superior computer tomography mandibular index</i>			

The study revealed moderate correlations between CBCT indices and BMD/TBS scores. Specifically:

- CTMI showed the highest correlation with femoral neck T-score ($r = 0.551$, $p < 0.0001$).
- CTI(S) and CTI(I) also displayed significant correlations with T-scores and BMD measurements across various sites (lumbar spine, femoral neck, and total hip), with correlation coefficients ranging from 0.322 to 0.522 ($p < 0.0001$).
- TBS scores were also moderately correlated with CBCT indices, with CTMI having a correlation coefficient of 0.431 ($p < 0.0001$).

Table 5. CBCT parameters and bone quantity and quality parameters by Pearson’s correlation coefficient and Spearman’s rho.

Pearson’s correlation [†]	CTMI, (n=104)	CTI(S), (n=104)	CTI(I), (n=103)
Lumbar T score*	0.429, $p < 0.0001$	0.387, $p < 0.0001$	0.364, $p < 0.0001$

Femoral neck T score*	0.551, p<0.0001	0.465, p<0.0001	0.481, p<0.0001
Total hip T score*	0.470, p<0.0001	0.440, p<0.0001	0.451, p<0.0001
TBS score*	0.431, p<0.0001	0.421, p<0.0001	0.351, p<0.001
TBS quality assessment***	0.454, p<0.0001	0.423, p<0.0001	0.379 p<0.0001
Lumbar BMD**	0.359, p<0.0001	0.355, p<0.0001	0.322, p<0.001
Femoral neck BMD**	0.522, p<0.0001	0.443, p<0.0001	0.523, p<0.0001
Total hip BMD**	0.509, p<0.0001	0.445, p<0.0001	0.481, p<0.0001
Osteoporosis defined as lumbar T score ≤ -2.5 SD	-0.185, p=0.06	-0.176, p=0.073	-0.675, p<0.0001
Osteoporosis defined as femoral neck T score ≤ -2.5 SD	-0.387, p<0.0001	-0.296, p<0.0001	-0.349, p<0.0001
Spearman's rho	CTMI	CTI-S	CTI-I
Lumbar T score*	0.439, p<0.0001	0.386, p<0.0001	0.380, p<0.0001
Femoral neck T score*	0.541, p<0.0001	0.439, p<0.0001	0.468, p<0.0001
Total hip T score*	0.476, p<0.0001	0.435, p<0.0001	0.449, p<0.0001
TBS score*	0.464, p<0.0001	0.460, p<0.0001	0.413, p<0.0001
TBS quality assessment***	0.456, p<0.0001	0.448, p<0.0001	0.419, p<0.0001
Lumbar BMD**	0.397, p<0.0001	0.371, p<0.0001	0.363, p<0.0001
Femoral neck BMD**	0.493, p<0.0001	0.393, p<0.0001	0.416, p<0.0001
Total hip BMD**	0.518, p<0.0001	0.450, p<0.0001	0.473, p<0.0001
Osteoporosis defined as lumbar T score ≤ -2.5 SD	-0.224, p=0.022	-0.212, p=0.031	-0.225, p=0.022
Osteoporosis defined as femoral neck T score ≤ -2.5 SD	-0.379, p<0.0001	-0.284, p<0.0001	-0.328, p<0.0001

† Correlation is significant at the 0.01 and 0.05 level (2-tailed)

* expressed as standard deviations
** bone mass density, expressed as g/cm³
*** trabecular bone score, expressed as low if TBS ≤1.23 g/cm³, intermediate if TBS >1.23 and <1.31 g/cm³ and normal if TBS >1.31 g/cm³
TBS, trabecular bone score, expressed as g/cm³, SD, standard deviation, CBCT, cone-beam computer tomography, CTMI, computer tomography mental index, CTI(I), inferior computer tomography mandibular index, CTI(S), superior computer tomography mandibular index

By using regression analysis (linear and logistic), we listed in Tables 6 and 7 the prediction power of the studied CBCT parameters for assessing the bone mass. We found that CTMI, CTI(I) and CTI(S) re effective in predicting bone quality and quantity (*p*<0.0001). In the logistic regression analysis, all models reached statistical significance (see Table 7).

Table 6. Predictions of osteoporosis and bone quality using regression analysis (linear regression).

Parameters	Variable	Regression value	Constant of the model	Model's sig.
Lumbar T score*	CTMI	0.70, p<0.0001	-3.76, p<0.0001	R ² =0.18, p<0.0001
Femoral neck T score*		0.46, p<0.0001	-3.26, p<0.0001	R ² =0.3, p<0.0001
Total hip T score*		0.336, p<0.0001	-2.99, p<0.0001	R ² =0.22, p<0.0001
TBS score*		0.00033, p<0.0001	-0.0167 p=0.09	R ² =0.18, p<0.0001
Lumbar T score*	CTI(S)	1.56, p<0.0001	-2.00, p<0.0001	R ² =0.15, p<0.001

Femoral neck T score*	2.61, p<0.0001	-2.09, p<0.0001	R2=0.21, p<0.0001
Total hip T score*	9.18, p<0.0001	-2.57, p<0.0001	R2=0.194, p<0.0001
TBS score*	0.0021, p<0.0001	-0.01, p=0.113	R2=0.177, p<0.0001
Lumbar T score*	6.97, p<0.0001	-3.52, p<0.0001	R2=0.13, p<0.0001
Femoral neck T score*	6.63, p<0.0001	-2.99, p<0.0001	R2=0.23, p<0.0001
Total hip T score*	7.3, p<0.0001	-2.67, p<0.0001	R2=0.20, p<0.0001
TBS score*	0.53, p=0.001	1.163 p<0.0001	R2=0.112, p<0.0001
* expressed as standard deviations			
** bone mass density, expressed as g/cm ³			

Table 7. Predictions of osteoporosis and bone quality using regression analysis (Logistic regression).

Parameters	Variable	Odds ratio	Model's sig.
TBS quality assessment***	CTMI	1.137, 95% CI (1.058, 1.222)	p<0.0001
Osteoporosis defined as lumbar T score ≤ -2.5 SD		0.953, 95% CI (0.906, 1.003)	p=0.063
Osteoporosis defined as femoral neck T score ≤ -2.5 SD		0.834, 95% CI (0.752, 0.924)	p<0.001
Osteoporosis based on AACE criteria**		0.891, 95% CI (0.837, 0.948)	p<0.0001
TBS quality assessment***	CTI(S)	1.20, 95% CI (1.081, 1.333)	p<0.0001
Osteoporosis defined as lumbar T score ≤ -2.5 SD		0.934, 95% CI (0.866-1.007)	p=0.076
Osteoporosis defined as femoral neck T score ≤ -2.5 SD		0.836, 95% CI (0.737, 0.949)	p=0.006
Osteoporosis based on AACE criteria**		0.868, 95% CI (0.796, 0.946)	p<0.001
TBS quality assessment***	CTI(I)	1.137, 95% CI (1.051, 1.230)	p<0.001
Osteoporosis defined as lumbar T score ≤ -2.5 SD		0.946, 95% CI (0.892, 1.003)	p=0.063
Osteoporosis defined as femoral neck T score ≤ -2.5 SD		0.847, 95% CI (0.765, 0.938)	p<0.0001
Osteoporosis based on AACE criteria**		0.906 95% CI (0.849, 0.967)	p<0.0001

5. Discussion

This study examined the use of computed tomography panoramic mandibular indices on CBCT images for the evaluation of BMD in postmenopausal women. The results demonstrated that CTMI, CTI(S) and CTI(I) are tools that can be used in mandibular CBCT for the assessment of bone mass in postmenopausal women, these indices exhibiting significant differences among this this category of patients, depending of the bone mass quantity and quality evaluated on DXA scan.

The study found significant correlations between the panoramic mandibular indices and lumbar T-scores. The computed tomography mental index (CTMI), computed tomography mandibular index superior (CTI(S)), and computed tomography mandibular index inferior (CTI(I)) showed the following Pearson correlation coefficients with lumbar T-scores: CTMI: r = 0.429, p < 0.0001; CTI(S): r = 0.387, p < 0.0001; CTI(I): r = 0.364, p < 0.0001. These results indicate a moderate positive correlation, suggesting that as the lumbar T-score increases, indicating higher bone density, the values of the

mandibular indices also tend to increase. The correlations with femoral neck T-scores were even stronger. The higher correlation coefficients reflect a stronger relationship between mandibular indices and femoral neck bone density compared to the lumbar spine. Similarly, total hip T-scores also showed significant correlations. Concerning TBS, the moderate correlations suggest that higher mandibular indices are associated with better trabecular bone quality.

Koh and colleagues [7,11] reported that specific CBCT indices could be effective for osteoporosis screening. Their findings align with the current study, which demonstrates moderate to strong correlations between CBCT indices and BMD/TBS measurements. Koh et al. also highlighted the usefulness of CBCT in assessing bone quality in postmenopausal women.

TBS is a relatively new metric derived from lumbar DXA scans. Unlike BMD, which measures bone mineral density, TBS provides an indirect assessment of trabecular microarchitecture. It is a valuable tool in evaluating bone quality and predicting fracture risk, as it reflects the structural integrity of trabecular bone, which is crucial in understanding bone strength and fragility. The current study explored the correlation between CBCT-derived mandibular indices and TBS. The key findings are: CTMI showed a moderate positive correlation with TBS ($r = 0.431$, $p < 0.0001$); CTI(S) had a similar moderate positive correlation with TBS ($r = 0.421$, $p < 0.0001$); CTI(I) also correlated with TBS, albeit slightly lower than the other two indices ($r = 0.351$, $p < 0.0001$). These correlations indicate that higher mandibular index values, as measured by CBCT, are associated with better trabecular bone quality as indicated by TBS scores. Diba SF et al [12] stated that the depletion of trabeculae bone structure is more obvious in osteoporotic postmenopausal women; thus, the initial bone quality assessment can be done using trabecular thickness parameters. However, in this study, they used dental radiographs as bone quality screening tool. This is the first study to correlate TBS with panoramic mandibular CBCT indices regarding the assessment of bone quality in postmenopausal women.

The consistent moderate to strong correlations across different T-scores and BMD measurements indicate that CBCT indices are reliable indicators of bone health. The highest correlation was observed between CTMI and femoral neck T-scores ($r = 0.551$), suggesting that mandibular indices might be particularly sensitive to changes in the bone density of the femoral neck. In a study by Munhoz et al. [13], significant correlations were found between mandibular cortical width and BMD. This study corroborates the present findings, particularly the strong correlation between CTMI and femoral neck BMD, reinforcing the potential of mandibular indices as indicators of overall bone health.

Barra et al. [14] also found significant differences in mandibular radiomorphometric indices among patients with normal BMD or low bone mass. Their study emphasized the potential of CBCT measurements in reflecting systemic bone density changes, similar to the findings in the present study.

While DXA remains the gold standard for diagnosing osteoporosis, this study highlights some limitations, such as the inability to predict fractures effectively. It has been cited in the literature that one of the limitations BMD measurement is that the majority of fragility fractures occur at non-osteoporotic BMD (T-scores > -2.5), compromising its role as a screening tool. Sornay-Rendu et al. [15] studied the radius bone microarchitecture with high-resolution peripheral computed tomography (HR-pQCT) in their OFELY study in postmenopausal women without low BMD. During a median of 15 years of follow-up, 46 women sustained incident fragility fractures, including 19 women with a major fragility fracture (clinical spine, forearm, proximal humerus, hip). Li et al. [16] investigated the fracture predictive value of QCT-based trabecular BMD of thoracic vertebrae derived from coronary artery calcium scan for hip fractures in a nationwide multi-center cohort (6814 subjects). Over a median follow-up of 17.4 years, in non-osteoporotic participants, 174 had radiographic moderate to severe compression vertebral fractures and 21 had hip fracture. CBCT offers an alternative by providing additional bone quality metrics through panoramic mandibular indices. The significant correlations between CBCT indices and DXA measurements support the recognition of CBCT as a bone mass predictor, especially taking into consideration the increased use for this tool in the general population.

Our findings suggest that recognizing the potential role of CBCT to assess bone mass could enhance early detection and management of osteoporosis in postmenopausal women. Since CBCT can be more accessible and less cumbersome than DXA, it offers a practical approach for widespread

osteoporosis screening in addition to the existing tools. This is particularly important given the increasing prevalence of osteoporosis among the aging populations.

6. Conclusions

The findings of this study suggest that CBCT-derived mandibular indices can be reliable indicators of low bone mass in postmenopausal women. These indices could potentially be integrated into routine dental assessments, providing an accessible screening tool for osteoporosis. Future research should aim to: validate these findings in larger, more diverse populations, explore the longitudinal predictive value of these indices for fracture risk, and investigate the cost-effectiveness and practical implementation of CBCT screenings in clinical practice.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org, Table 1: Indices and their significance, Table 2: Patients distribution, Table 3: Mean values of the computed tomography parameters on cone beam computed tomography (CBCT) images, Table 4: Correlations between CBCT parameters and bone quantity and quality parameters, Table 5: CBCT parameters and bone quantity and quality parameters by Pearson's correlation coefficient and Spearman's rho, Table 6: Predictions of osteoporosis and bone quality using regression analysis (linear regression), Table 7: Predictions of osteoporosis and bone quality using regression analysis (Logistic regression).

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References

- Schini M, Johansson H, Harvey NC, Lorentzon M, Kanis JA, McCloskey E V. An overview of the use of the fracture risk assessment tool (FRAX) in osteoporosis. *J Endocrinol Invest*. 2024 Mar;47(3):501–11.
- Bhatnagar A, Kekatpure AL. Postmenopausal Osteoporosis: A Literature Review. *Cureus*. 2022 Sep;14(9):e29367.
- on the Prevention WHOSG, of Osteoporosis (2000 : Geneva S. Prevention and management of osteoporosis : report of a WHO scientific group. World Health Organization; 2003. p. 192 p. (WHO technical report series ; 921).
- Camacho PM, Petak SM, Binkley N, et al. AMERICAN ASSOCIATION OF CLINICAL ENDOCRINOLOGISTS AND AMERICAN COLLEGE OF ENDOCRINOLOGY CLINICAL PRACTICE GUIDELINES FOR THE DIAGNOSIS AND TREATMENT OF POSTMENOPAUSAL OSTEOPOROSIS - 2016. *Endocr Pract Off J Am Coll Endocrinol Am Assoc Clin Endocrinol*. 2016 Sep;22(Suppl 4):1–42.
- Kanis JA. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis: synopsis of a WHO report. WHO Study Group. *Osteoporos Int a J Establ as result Coop between Eur Found Osteoporos Natl Osteoporos Found USA*. 1994 Nov;4(6):368–81.
- Taguchi A, Tsuda M, Ohtsuka M, et al. Use of dental panoramic radiographs in identifying younger postmenopausal women with osteoporosis. *Osteoporos Int a J Establ as result Coop between Eur Found Osteoporos Natl Osteoporos Found USA*. 2006;17(3):387–94.
- Koh KJ, Kim KA. Utility of the computed tomography indices on cone beam computed tomography images in the diagnosis of osteoporosis in women. *Imaging Sci Dent*. 2011 Sep;41(3):101–6.
- Barra SG, Gomes IP, Amaral TMP, Brasileiro CB, Abreu LG, Mesquita RA. New mandibular indices in cone beam computed tomography to identify low bone mineral density in postmenopausal women. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2021 Mar;131(3):347–55.
- Ledgerton D, Horner K, Devlin H, Worthington H. Panoramic mandibular index as a radiomorphometric tool: an assessment of precision. *Dentomaxillofac Radiol*. 1997 Mar;26(2):95–100.

10. Lewiecki EM, Binkley N, Morgan SL, et al. Best Practices for Dual-Energy X-ray Absorptiometry Measurement and Reporting: International Society for Clinical Densitometry Guidance. *J Clin Densitom* [Internet]. 2016;19(2):127–40. Available from: <https://www.sciencedirect.com/science/article/pii/S1094695016300038>
11. Koh KK, Tan JS, Nambiar P, Ibrahim N, Mutalik S, Khan Asif M. Age estimation from structural changes of teeth and buccal alveolar bone level. *J Forensic Leg Med*. 2017 May;48:15–21.
12. Diba SF, Gracea RS, Shantiningsih RR, Hidjah K. Analysis of mandible trabecular structure using digital periapical radiographs to assess low bone quality in postmenopausal women. *Saudi Dent J*. 2021 Dec;33(8):997–1003.
13. Munhoz L, Morita L, Nagai AY, Moreira J, Arita ES. Mandibular cortical index in the screening of postmenopausal at low mineral density risk: a systematic review. *Dentomaxillofac Radiol*. 2021 May;50(4):20200514.
14. Daly AF, Tichomirowa MA, Petrossians P, et al. Clinical characteristics and therapeutic responses in patients with germ-line AIP mutations and pituitary adenomas: an international collaborative study. *J Clin Endocrinol Metab*. 2010 Nov;95(11):E373–83.
15. Sornay-Rendu E, Duboeuf F, Chapurlat RD. Postmenopausal women with normal BMD who have fractures have deteriorated bone microarchitecture: A prospective analysis from The OFELY study. *Bone*. 2024 May;182:117072.
16. Li D, Mao SS, Budoff MJ. Trabecular bone mineral density as measured by thoracic vertebrae predicts incident hip and vertebral fractures: the multi-ethnic study of atherosclerosis. *Osteoporos Int a J Establ as result Coop between Eur Found Osteoporos Natl Osteoporos Found USA*. 2024 Jun;35(6):1061–8.

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