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Panoramic radiographs and quantitative ultrasound of the radius and phalanx III to assess bone mineral status in postmenopausal women

Katarzyna Grocholewicz[1], Joanna Janiszewska-Olszowska[1*], Magda Aniko-Włodarczyk[2], Olga Preuss[2], Grzegorz Trybek[2], Ewa Sobolewska[3] and Mariusz Lipski[4]

Abstract

Background: Various mandibular indices have been developed to detect osteoporosis on panoramic radiographs. Quantitative ultrasound (QUS) is a low-cost, radiation-free method to assess bone status. The aim of this study was to compare mandibular morphometric analysis and QUS at the radius and proximal phalanx III finger.

Methods: The study involved 97 postmenopausal women, aged 48.5–71.5y (mean: 55.4). Mandibular morphometric analysis comprised: distance between upper and lower mandibular borders just behind the mental foramen (H), distance: mental foramen - inferior mandibular cortex (IM) and mandibular cortical width at the mental region (MCW). Then, ratios were calculated: MCW/IM = PMI (panoramic mandibular index), H/IM = MR (mandibular ratio). Mandibular cortical index (MCI) was used to classify the morphology of the mandibular cortex.
Bone mineral status assessed using QUS at the radius and proximal phalanx III finger was compared to population mean apical bone mass (T-score).
Linear regression analysis was used for correlations between continuous variables, Pearson's correlation coefficient r - for variables of normal distribution. Student's t-test was used to compare variables of normal distribution and for the latter - Mann-Whitney U-test. The level of significance was $p < 0.05$.

Results: Mandibular height was 13.42–34.42 mm. The mean mandibular cortical width was 3.31 mm. Mean values of PMI and MR were 0.33 and 2.57, respectively. Higher mean value of Ad-SoS was found in the radius than in the III finger. Phalanx T-score values were lower than those of the radius. T-score of the radius was < − 1.0 in 22 patients, indicating osteopenia. Basing on phalanx T-score, osteopenia was found in 39 patients. Category C1 of Mandibular Cortical Index was found in 48 women, C2 - in 37 women and C3 - in 12 women. Higher scores of Mandibular Cortical Index were recorded in older women. MCI significantly correlated with the skeletal status ($p = 0.01$) as well as with H, MCW and MR. Phalanx T-score was not correlated to PMI, MR or MCW.

Conclusions: 1. Mandibular Cortical Index can be used as a screening tool for detecting osteoporosis.
2. Quantitative ultrasound at the phalanx III constitutes a reliable way of assessing bone status.

Keywords: Osteoporosis, Quantitative ultrasound, Panoramic radiograph, Radiomorphometric indices

* Correspondence: jjo@pum.edu.pl
[1]Department of Interdisciplinary Dentistry, Pomeranian Medical University in Szczecin, Al. Powstancow Wlkp. 72, 70-111 Szczecin, Poland
Full list of author information is available at the end of the article

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Table 1 Distribution of radiomorphometric measurements and mandibular indices

Parameter	n	Mean	Median	Minimum	Maximum	SD
H (mm)	97	25.22	25.58	13.42	34.42	3.20
IM (mm)	97	9.96	9.85	6.42	15.23	1.61
MCW (mm)	97	3.31	3.38	1.69	5.38	0.67
PMI	97	0.33	0.33	0.05	0.52	0.07
MR	97	2.57	2.54	1.51	3.78	0.40

not only dental status but also the status of bones. Many studies suggested that incidental findings detected on these radiographs might be helpful to identify patients with low bone mineral density [13–17, 21]. This is the first study to compare measurements from panoramic radiographs and the radiation-free method of QUS of the phalanx and radius.

No correlations between MCW and phalanx as well as between Ad-SoS and phalanx T-score were found in the present study. Moreover, both PMI and MR proved to be ineffective in the screening of osteopenia/osteoporosis in women. These results are consistent with those by other authors, who emphasized poor utility of PMI and MR, but usefulness of MCI and MCW as screening tools for osteoporosis. Bhatnagar et al. [22] found a weak correlation between PMI and BMD. The same study showed that the degree of mandibular cortical shape erosion significantly correlated with BMD and concluded that the combined mandibular cortical findings (mandibular cortical shape erosion and mandibular cortical width) on panoramic radiographs were effective indicators of osseous changes in postmenopausal osteoporosis.

A similar evaluation was performed by Benson et al. [23], who used PMI to compensate for the vertical magnification that differs among various panoramic machines, but found a very weak correlation between the index and BMD in spite of the fact that PMI is inclusive of other variable i.e., half mandibular width. Therefore Benson et al. [23] used MCW, instead of PMI as an effective indicator. Klemetti et al. [23] also found that linear correlation of the panoramic mandibular index with all bone mineral density values was weak. Patients with reduced bone mass showed lower height of mandible and thereupon also MR.

Table 2 The skeletal status in examined women

Parameter	N	Mean	Median	Minimum	Maximum	SD
Phalanx Ad-SoS (m/s)	97	3941	3976	3337	4384	194
Phalanx T-score	97	−0.65	−0.4	−3.60	2.30	1.26
Radius Ad-SoS (m/s)	97	4152	4160	3853	4601	130
Radius T-score	97	−0.18	−0.2	−3.2	4.4	1.33

Table 3 Distribution of the study group according to T-score values

Parameter	T-score ≥ −1 n	T-score < −1 n	Total n
Phalanx	58	39	97
Radius	75	22	97

Stagraczynski et al. [24] showed that PMI and MR are not adequate radiological markers of vertebral bone loss in postmenopausal women. However, measurements of the distance between the inferior margin of the mental foramen and the inferior mandibular cortex did correlate with the degree of lumbar BMD deficiency.

Lee et al. [25] concluded that simple visual estimation of the mandibular inferior cortex width on panoramic radiographs might be useful for identifying postmenopausal women with low BMD. In similar studies Ohtsuki et al., [26] as well as Horner and Devlin [27] also found that mandibular cortical width significantly correlated with BMD,.

The lower specificity of cortical width in identifying low BMD, comparing to cortical shape was confirmed in the study by Khojastehpour et al. [28]. They demonstrated significant associations between BMD and MCW and MCI and concluded that postmenopausal women with thin or eroded mandibular inferior cortex may have an increased risk of low BMD or osteoporosis. Bollen et al. [29] observed that subjects with a self-reported history of osteoporotic fractures tend to have increased resorption and thinning of the mandibular lower cortex. In a study by Gulsahi et al. [30], it was stated that patients with C3 type of MCI should be considered as high-risk individuals for osteoporosis irrespective of age and gender. The usefulness of a visual estimation of the mandibular cortical bone integrity from panoramic radiographs for identifying postmenopausal women at high risk for osteoporosis has been confirmed by Geary et al. [31] as well as Alapati et al. [32].

Some authors emphasize that more lengthy training and experience in using the MCI would be needed for it to be effective as a diagnostic tool in general dental practice [33, 34].

In most studies, the diagnosis of osteoporosis is based on bone mineral density measured by dual-energy X-ray absorptiometry (DXA), but this technique is not a

Table 4 MCI categories according to the age

MCI	n	Age (years)				SD
		Mean	Median	Minimum	Maximum	
C1	48	54.8	54	48.5	67	4.3
C2	37	55.3	54	50	69	4.7
C3	12	58.5	55.5	50	71.5	7.9
Total	97	55.4	54	48.5	71.5	5.0