

Panoramic Radiomorphometric Indices of the Mandible in an Iranian Population

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Abstract

Objectives: Radiomorphometric indices measured on simple radiographic images can be used for qualitative and quantitative assessment of bone. Panoramic radiographic imaging can therefore assist dentists in early detection of osteoporosis in patients. Considering the effect of ethnic and environmental factors on development of osteoporosis and absence of normal values of radiomorphometric indices for the Iranian population, which results in use of normal values of other ethnicities for determining the presence or absence of osteoporosis in patients, the present study was conducted to evaluate radiomorphometric indices in patients presenting to a private oral and maxillofacial radiology clinic in Rafsanjan, Iran.

Methods: The present cross-sectional study examined 385 eligible patients who met the inclusion criteria. Their demographic characteristics including age, gender and level of education were recorded. Their panoramic radiographic data, including radiomorphometric indices such as mandibular cortical index (MCI), antegonial index (AI), and gonial index (GI), were evaluated on each image. Multiple logistic regression was used to evaluate the effect of variables on mandibular bone radiomorphometric indices. P-value less than 0.05 was considered statistically significant.

Results: The mean AI and GI were 2.19 ± 0.56 and 0.87 ± 0.31 mm, respectively. In assessment of MCI, since none of the patients fell under the C3 category, all patients were categorized as C1 or C2. Assessment of demographic variables and radiomorphometric indices showed that age had a significant relationship with MCI and AI while gender had a significant relationship with GI.

Conclusion: Radiomorphometric indices can be used to assess the risk of osteoporosis in patients.

Key Words: Osteoporosis; Radiography, Panoramic; Mandible

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Introduction

Osteoporosis is a common systemic disease identified by the loss of bone mass and deterioration of the microscopic structure of bone and subsequently increased risk of bone fracture (1). At its early stages, osteoporosis is asymptomatic and is not often detected until a bone fracture injury occurs. Osteoporotic fractures are often complex and impose high medical costs on patients; moreover, they have a high risk of

mortality (2-3). Radiomorphometry is a simple inexpensive tool for diagnosis of osteoporosis, which is the use of bone radiomorphometric indices measured on a simple radiographic image (4). Since osteoporosis causes porosity and thinning of lower mandibular border, the MCI, AI, and GI as radiomorphometric indices are used to assess possible changes in these indices in comparison with the normal values and examine the presence/absence of osteoporosis (4).

Due to its acceptable quality, relatively low patient radiation dose and affordability, panoramic radiography is routinely used in dental treatment planning. On the other hand, radiomorphometric indices measured on radiographic images can be used for qualitative and quantitative assessment of bone and to detect early signs of bone loss and osteoporosis (5). Thus, dentists can play a major role in early detection of osteoporosis by thorough evaluation of radiographic images. Various demographic and epidemiologic factors (such as age, gender and level of education) have been documented to affect bone density directly or indirectly. For instance, it has been mentioned that level of education may affect bone density via direct and indirect effects on general knowledge, lifestyle, nutrition and economical status (6,7). Given the importance of prevention of osteoporosis and the effects of ethnicity, environment and lifestyle on this disease (8-10), the present study was conducted to assess radiomorphometric indices in patients admitted to a private maxillofacial radiology clinic in Rafsanjan.

Methods

This cross-sectional study assessed 385 patients admitted to a private oral and maxillofacial radiology clinic in Rafsanjan in 2014-2015, who required panoramic radiographs for their dental procedures. Sample size was determined according to a study by Maki *et al.*, (11) and using the sample size calculation formula assuming

the P, d and α values to be 0.1, 0.03 and 0.05, respectively. The inclusion criteria were as follows: Rafsanjan residents, age over 20 years (since calcification of cortical bones is going to be completed after the age of 18) (11), absence of diseases affecting bone metabolism (such as osteomalacia and hyperparathyroidism), not taking medications that affect bone metabolism (such as heparin and corticosteroids), having a proper panoramic radiographic image with no technical errors, and having no conditions or lesions in the mandible that could mask the lower mandibular border. Patients with edentulous mandible were excluded from the study. Radiographic imaging of patients was conducted using a panoramic digital system (Planmeca Promax, Helsinki, Finland). Patients' demographic information was recorded, including their age, gender and level of education. Their radiographic data, including the radiomorphometric indices of MCI, AI, and GI, were assessed on each image, and the results were recorded in a checklist.

MCI: Is the morphological classification of the lower mandibular cortex in the distal part of the mental foramen on panoramic radiographs (Figure 1), which includes the following categories (11):

C1: The cortical endosteal surface is smooth and uniform on both sides.

C2: The cortical endosteal surface shows semi-lunar areas or appears layered (with one to three layers) on one or both sides.

C3: The cortical layer is fully layered and clearly porous (on one or both sides).

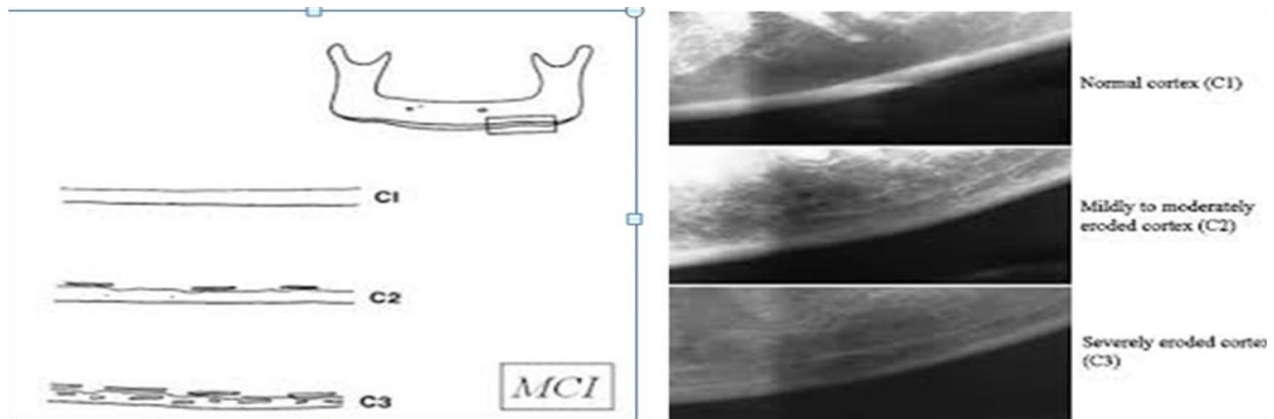


Figure 1- Classification of MCI (C1) The cortical endosteal surface is smooth and uniform on both sides; (C2) The cortical endosteal surface shows semi-lunar areas or appears layered (with one to three layers) on one or both sides; (C3) The cortical layer is fully layered and clearly porous (on one or both sides).

AI: To determine the mandibular cortex thickness in the antegonial area, a line is drawn parallel to the anterior border of the ramus and another line parallel to the lower border of the mandible. At the intersection of these lines, a line is drawn perpendicular to the lower mandibular cortex, and the thickness of the cortex in that area is then measured (Figure 2) (11).

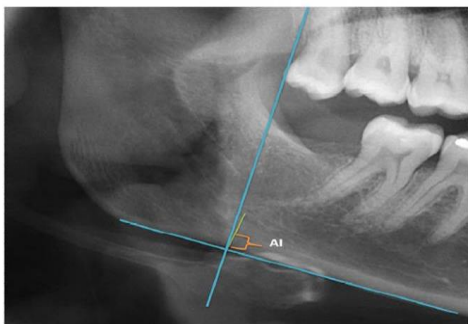


Figure 2- The AI measurement method on panoramic radiograph: To determine the mandibular cortex thickness in the antegonial area, a line is drawn parallel to the anterior border of the ramus and another line parallel to the lower border of the mandible.

GI: To determine the mandibular cortical thickness in the gonial area, a line is drawn parallel to the posterior border of the ramus and another line parallel to the lower border of the mandible. At the intersection of these lines, a bisector is drawn and the thickness

of the cortex is marked on the bisector and measured as GI (Figure 3) (11).

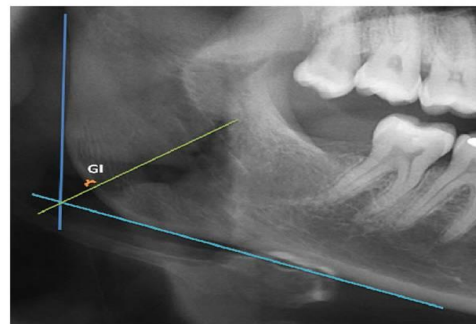


Figure 3- The GI measurement method on panoramic radiograph: To determine the mandibular cortical thickness in the gonial area, a line is drawn parallel to the posterior border of the ramus and another line parallel to the lower border of the mandible.

The linear measurements on digital panoramic images were carried out by a maxillofacial radiologist using Planmeca Romexis 3.6.0.R. Then, the obtained data were analyzed using SPSS 18.0 software (SPSS Inc., Chicago, IL, USA). To assess the relationship between radiomorphometric indices of the mandible (AI and GI) and age and level of education, one-way ANOVA was used. Also, to assess the relationship between radiomorphometric Indices of the mandible (AI and GI) and gender, independent two-sample t-test was used. In

order to analyze the relationship between radiomorphometric indices of the mandible (MCI) and gender, chi-square test was used. To evaluate the relationship of radiomorphometric indices with level of education, the Fisher's exact test was used. In order to determine the linear relationship among demographic variables including age, gender and level of education and AI and GI, ANCOVA was used and to evaluate the effect of these parameters on MCI, multiple logistic regression was applied; odds ratio (OR) and 95% confidence interval were reported and P-values less than 0.05 were considered statistically significant. Patients whose radiomorphometric indices showed a risk of osteoporosis were advised to visit a specialist for further examinations.

Results

The present study assessed 385 patients admitted to a private maxillofacial radiology

clinic in Rafsanjan in 2014. The patients had a minimum age of 27 years, maximum age of 78, and a mean age of 39.93 ± 8.95 years. Of the 385 patients studied, the MCI fell under the C1 category in 345 (89.6%) and under the C2 category in 40 (10.4%) patients. None of the patients fell under the C3 category. The minimum and maximum AI were 0.8 and 3.9mm, respectively. The mean AI was 2.19 ± 0.56 mm. The minimum and maximum GI were 0.2 and 2.0mm, respectively, and the mean GI was 0.87 ± 0.31 mm. One-way ANOVA showed significant effect of age on AI ($P < 0.001$); however, the level of education had no significant effect on AI. Moreover, independent t-test showed that gender had no significant effect on AI. One-way ANOVA showed that age and level of education had no significant effect on GI (Table 1).

Table 1- Comparison of AI and GI based on the demographic characteristics of patients

Variable	Number	AI	GI
		SD \pm Mean	SD \pm Mean
Age (years)			
35<	137	0.50 \pm 2.28	0.30 \pm 0.89
49-35	183	0.55 \pm 2.27	0.32 \pm 0.88
>50	65	0.54 \pm 1.77	0.30 \pm 0.79
P-value		0.001<	0.066
Gender			
Male	202	0.60 \pm 2.19	0.32 \pm 0.93
Female	183	0.52 \pm 2.18	0.29 \pm 0.80
P-value		0.888	0.001<
Level of education			
dropout High school	34	0.56 \pm 2.08	0.29 \pm 0.81
High school diploma	157	0.57 \pm 2.17	0.30 \pm 0.85
Associate diploma and bachelor's degree	151	0.56 \pm 2.22	0.32 \pm 0.89
Master's and higher	43	0.55 \pm 2.24	0.33 \pm 0.90
P-value		0.492	0.385

SD: Standard deviation

According to independent t-test, gender also significantly affected GI ($P < 0.001$). In

assessment of MCI, since none of the patients fell under the C3 category, this

category was eliminated from the tables altogether. The chi-square test showed that MCI was significantly affected by age ($P<0.001$, Table 2), but gender had no

significant relationship with MCI (neither C1 nor C2 category). Moreover, Fisher's exact test showed that the level of education had no significant effect on MCI (Table 2).

Table 2- Comparison of the frequency of MCI categories based on demographic characteristics of patients

variable	C1 Number (%)	C2 Number (%)	P-value
Age (years)			< 0.001
35<	132 (96.4)	5 (3.6)	
49-35	164 (89.6)	19 (10.4)	
50>	49 (75.4)	16 (24.6)	
Gender			0.318
Male	184 (91.1)	18 (8.9)	
Female	161 (88.0)	22 (12.0)	
Level of education			0.592
dropout High school	30 (88.2)	4 (11.8)	
High school diploma	137 (87.3)	20 (12.7)	
Associate diploma and bachelor's degree	138 (91.4)	13 (8.6)	
Master's and higher	40 (93.5)	3(7.0)	

The results of ANCOVA showed that of all the demographic variables including age, gender and level of education, only age affected AI (in mm) significantly ($P<0.001$), and that aging significantly decreased AI. The results of the ANCOVA showed that of all the demographic variables including age, gender and level of education, only gender significantly affected GI (in mm) ($P<0.009$), and that GI was significantly greater in men compared to women. The results of multiple logistic regression showed that of all the demographic variables including age, gender and level of education, only age significantly affected MCI (both C1 and C2 categories) ($P<0.001$), and patients in the age group of 35-49 years had higher odds of falling under the C2 category compared to those younger than 35 years ($P=0.017$, 95% CI: 1.26-9.994, OR=3.548). Moreover, patients aged 50 and older had higher odds of falling under the C2 category compared to those

younger than 35 years ($P<0.001$, 95% CI:3.548-36.001, OR=11.359).

Discussion

Osteoporosis is a systemic skeletal disease characterized by the loss of bone mass, microscopic deterioration of bone tissue and increased rate of bone fracture. Considerable efforts have been made to date to facilitate early diagnosis of this disease in patients, and many studies have discussed the importance of measuring radiomorphometric indices for prevention and early diagnosis of osteoporosis (12-14).

The present study assessed the relationship of radiomorphometric indices (MCI, AI and GI) with demographic variables. The mean AI was found to be 2.19 ± 0.56 mm (range 0.8mm to 3.9mm). In a study conducted by Dalili and Moghadam Quejeq (4), however, the mean AI was 3.54mm. In another study

conducted by Ledgerton *et al.*, (13) the mean AI was reported to be 3.29 ± 0.76 mm (range 0.9mm to 6mm). The disparity of findings might be due to the type of radiographic imaging device used, the radiologist's level of accuracy and skills and the study population in terms of ethnicity and race.

In the present study, AI significantly decreased with age, and the highest rate of decrease was observed in the over 50 years age group, which was expected given the reduced ossification and increased bone resorption in this age group. Similar to the present study, Dalili and Moghadam Qujeq (4), Maki *et al.*, (11) and Ledgerton *et al.*, (13) also found that AI decreased with age.

The present study showed the mean AI to be lower in women compared to men, but this difference was not significant while in other studies, this difference was significant (3, 11, 13). The mean AI was shown to increase with level of education, but this increase was not significant; further studies need to be conducted to clarify this relationship, which may be due to the effect of level of education on prevention of bone loss. The mean GI was 0.87mm in the present study, which was lower compared to the mean values found in studies by Sakhdari *et al.*, (6) (2.51mm), Ledgerton *et al.*, (13) (1.35mm), and Devlin and Horner (14) (1.67mm). The disparity of findings might be due to differences in patients' age, number and race, or even difference in radiography devices used according to Ledgerton *et al.*, (13). The mean GI decreased with age, although not significantly, and maximum reduction in GI occurred after the 5th decade of life. In studies conducted by Maki *et al.*, (11) and Tözüm and Taguchi (2), GI

significantly decreased with age. The mean GI was significantly lower in women than in men in our study, which was expected given the greater likelihood of development of osteoporosis in women. This finding was consistent with the findings of studies conducted by Tözüm and Taguchi (2), and Maki *et al.*, (11). Just like AI, the mean GI increased with level of education, although not significantly. This relationship requires further studies; however, the effect of education on preventing bone loss might still be at play. In a study conducted by Bosky *et al.*, (15) the mean AI and GI were 3.577 ± 0.81 and 1.431 ± 0.267 in a healthy population, 3.205 ± 0.781 and 1.012 ± 0.278 in a population with osteopenia, and 2.926 ± 0.716 and 0.93 ± 0.253 in a population with osteoporosis, respectively, which show that AI and GI decrease in people with osteoporosis. The mean AI and GI have not been recorded for healthy Iranian population and the data obtained from patients in the present study was therefore compared to the data reported by Bosky *et al.*, (15). Patients with greater likelihood of osteoporosis were referred to a specialist for further examinations. Assessing the relationship between MCI and age showed that the form of the lower mandibular cortex changes with age and approaches the C2 form as porosities develop, which was expected given the changes in ossification in older age, and was also consistent with the findings of Dalili and Moghadam Qujeq (4), Sakhdari *et al.*, (6) and Ledgerton *et al.*, (13). In assessing gender, 12% of women had C2 category compared to 8.9% of men. Unlike the results obtained by Maki *et al.*, (11) the present study found no significant

relationship between gender and MCI. No relationship was found between the level of education and prevalence of C2 category either; however, Janiszewska *et al.*, (6) and Hamid *et al.* (7) showed that the prevalence of osteoporosis decreased with an increase in level of education. They reported poor knowledge about menopause and hormone replacement therapy among the participants, and level of knowledge was associated with level of education. Bodade and Mody (16) reported that incidence of osteoporosis increased from group C1 to C2 to C3 and showed that individuals with C2 and C3 categories had higher risk of developing osteoporosis. In order to determine osteoporotic and normal values of radiomorphometric factors in the Iranian population, we recommend future studies on

various ethnicities and also on osteoporotic patients in Iran.

Conclusion

Considering the effects of gender and age on radiomorphometric indices, these indices can be used as a tool to assess the potential risk of developing osteoporosis in patients.

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Conflict of interest: "None Declared"

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