Validity of Panoramic Indices to Evaluate the Association of Bone Mineral Density with Morphology of the Mandible in Osteoporotic Patients

[1]Masoume Hajipour [2]Yaser Safi [3]Mahdi Kadkhodazadeh [4]Mahdieh Mirakhori [*5]Reza Amid [6]Ali Dehghan

[1]General Practioner.
[2]Assistant Professor, Dept. of Oral & Maxillofacial Radioligy, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[3]Associate Professor, Dept. of Periodontics, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[4]Undergraduate student, Students Research Committee, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[*5]Associate Professor, Dept. of Periodontics, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran. E-mail: reza_amid@yahoo.com
[6]Assistant Professor, Dept. of Romatology, School of Medicine, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

Abstract

Objective: Osteoporosis is the most common metabolic disease of the bone decreasing bone mineral density (BMD) particularly in postmenopausal women. On the other hand, panoramic radiography has several applications in dentistry. It appears that by calculating some indices on panoramic radiographs, we may be able to predict the risk of osteoporosis in high-risk individuals. The present study was conducted to determine the correlation of skeletal pattern of bone and the morphology of the mandible in osteoporotic patients presenting to the Osteoporosis Clinic of Khatamolanbia Hospital and Imam Khomeini Dental Clinic in Yazd.

Methods: This descriptive, analytical, cross-sectional study was conducted on 70 women aged over 45 years, whom were selected from the above-mentioned centers. The gonialangle (GA), gonial index (GI), antegonial angle (AA), mental index (MI), antegonial index (AI) and antegonial depth (AD) were calculated on panoramic radiographs of patients and their BMD was measured in the lumbar area and femoral areas using dual X-ray absorptiometry (DXA). The correlation of panoramic indices with BMD was assessed using Spearman and Pearson's correlation tests. The difference in BMD values in different morphological patterns of the inferior cortex of the mandible was analyzed by Student t-test and in different thicknesses of the cortex using one-way ANOVA.

Results: The morphology of the inferior cortex was C1 in 62.9% and C2 in 37.1%. The cortex was thin in 24.3%, moderately thick in 32.9% and thick in 42.9%. Lumbar BMD was 0.92 (0.14) and 0.75 (0.15) g/cm^2, in C1 and C2, respectively ($p<0.001$). Femoral BMD was 0.81 (0.13) and 0.66 (0.09) g/cm^2 in C1 and C2, respectively ($p<0.001$). No significant association was found between GI, AI, GA, AA and AD (based on the estimates made on panoramic radiographs) with the BMD (based on DXA estimates).

Conclusion: Use of mandibular cortex indices on panoramic radiographs may be efficient for assessment of osteoporosis. However, further multicenter studies on larger sample sizes are required.

Key words: Bone mineral density, Gonial index, Mandibular index, Osteoporosis, Panoramic radiography.

Introduction:

Osteoporosis is a progressive systemic disease characterized by reduction in bone mass, mineral content and bone matrix and microstructural changes in bone. In this condition, the bones are

completely normal in terms of composition but undergo a reduction in the amount of bone mass. Osteopenia is the mild form of osteoporosis (1, 2). These changes increase the risk and rate of bone fractures (3).

Epidemiological studies on postmenopausal women have demonstrated that these individuals have fewer remaining teeth compared to women in the productive age. One possible explanation for such dental changes is the loss of jawbone density and volumein this group of patients. Moreover, it appears that osteoporosis enhances and aggravates alveolar bone loss (4).

Studies on the pace of bone loss following tooth extraction have revealed that osteoporosis accelerates the process of bone loss following tooth extraction via its effect on specific phases of bone resorption. On the other hand, a direct association exists between the calcium content and mandibular bone mineral dentistry (BMD) in osteoporotic women (4).

Considering the use of panoramic radiography in different fields of dentistry, it would be of great help if changes on panoramic radiographs could lead us to the detection of conditions associated with reduction in BMD. This would be abig step forward in screening for osteoporosis in susceptible individuals. If this hypothesis is correct, changes in BMD and risk of osteoporosis can be detected using dental radiographs resulting in earlyinitiation of necessary treatments for these patients.

To date, several indices have been assessed on panoramic radiographs and their association with BMD values has been evaluated (5). These indices include GA, MI, AI, AA, AD, mandible cortical index (MCI) and simple visual estimation (SVE). Some researchers have tried to assess the correlation of these indices with the mandibular BMD using DXA as the gold standard to predict the risk of fracture in the future (6).

BMD is the volume of bone mass in specific amounts of bone (7). Some researchers have reported that panoramic radiomorphometric indices have significant associations with mandibular BMD (8-10). However, this issue is in need of further investigation.

Considering the differences in correlations of the value of indices with the skeletal pattern, this study aimed to compare the validity of several panoramic indices in determining the correlation of skeletal pattern with morphology of the mandible in osteoporotic patients presenting to Khatamolanbia Hospital Osteoporosis Clinic and Imam Khomeini Dental Clinic in Yazd in 2013.

Methods:

This descriptive, analytical, cross-sectional study was conducted on women over 45 years presenting to the Osteoporosis Clinic of Khatamolanbia Hospital and Imam Khomeini Dental Clinic in Yazd in 2013, who had performed DXA for diagnosis of osteoporosis and signed informed consent forms for participation in this study.

Data were collected using a questionnaire. Indices were calculated on panoramic radiographs and the results of DXA were interpreted. All radiographs were obtained using Cranex D panoramic X ray unit (Soredex, Helsinki, Finland) by an experienced technician with over 10 years of clinical experience. All radiographic indices were evaluated by a senior dental student trained by a radiologist with over 10 years of clinical experience.

Patients did not have any systemic condition other than osteoporosis and were not taking any medications affecting bone metabolism such as heparin or corticosteroids. Based on the results of DXA regarding BMD, patients were divided into three groups of osteopenia ($-2.5 < \text{T-score} \leq -1$), osteoporosis (T-score < -2.5) and normal subjects (T-score > -1). Digital panoramic radiographs were obtained from patients and based on the morphology of the inferior cortex of the mandible, the subjects were divided   into

three groups as follows:

C1: The endosteal margin of the cortex was even and sharp

C2: The endosteal margin presented semilunar defects or appeared to form endosteal cortical residues (1-3 residues)

C3: The cortical layer formed heavy endosteal cortical residues and was clearly porous (in one or both sides).

Measurement of indices:

Antegonial index (cortical width in the region anterior to the gonion): In order to determine the mandibular cortex width at the antegonial region, a line parallel to the anterior border of the ramus and another line parallel to the inferior border of the mandible were drawn. A vertical line was drawn from the intersection of the afore-mentioned two lines to the inferior cortex of the mandible and the cortical width was measured at this area.

Mental index: Cortical width anterior to th�mental foramen

Antegonial depth: The distance from a vertical line to the inferior border of the mandible to the antegonial reference point

Gonial angle: The intersection of the line tangent to the inferior border of the mandible and posterior border of ramus

Antegonial angle: The angle between two parallel lines with the inferior border of the mandible at the antegonial point

Data were analyzed using SPSS version 18.0 and descriptive (mean, standard deviation, and frequency) and analytical (Student t-test, one-way ANOVA, Pearson's and Spearman's correlation coefficients and Dunnett's pairwise comparisons) statistics. $p \leq 0.05$ was considered statistically significant.

Results:

The mean age of understudy women was 54.67 (7.87) years and a mean of 12.22 (6.3) years had passed from their menopause. The mean (SD) of lumbar BMD was 0.86 (0.16) g/cm^2. This value was 0.76 (0.14) g/cm^2 for femoral BMD. The T-score in the lumbar, femoral and the total femoral areas was -1.56 (1.37), -1.09 (1.09) and -0.5 (0.65), respectively. The values for AA, MI, AI, AD and GA on panoramic radiographs were found to be 174.21 (9.9°), 12.72 (3.6) mm, 4.06 (1.37) mm, 1.47 (0.95) mm and 131.49 (9.56)°, respectively.

Based on SVE, 17 subjects (24.3%) had thin, 23 (32.9%) had moderate and 30 (42.9%) had thick inferior cortex. Moreover, the morphology of the inferior cortex of the mandible was C1 (the endosteal margin of the cortex was even and sharp) in 44 (62.9%) and C2 (the endosteal margin presented semilunar defects or appeared to form endosteal cortical residues) in 26 (37.1%) subjects.

Lumbar BMD in subjects with C1 morphology was 0.92 (0.14) g/cm^2. In subjects with C2 morphology, this value was 0.75 (0.15) g/cm^2. The results of student t-test revealed significant differences in BMD between C1 and C2 morphology of the inferior cortex of the mandible (mean difference of 0.17). BMD in C1 was significantly higher than that in C2 ($p < 0.001$).

One-way ANOVA was used to compare BMD in groups with different thicknesses of the inferior cortex of the mandible. Based on the results, significant differences were noted in this regard between different thicknesses of the inferior cortex of the mandible ($p < 0.01$). By an increase in thickness, BMD increased as well. Dunnett's post-hoc test was used for pairwise comparison of groups; which revealed significant differences in BMD in thin and moderate thicknesses of the inferior cortex of the mandible (with a difference of 0.149, $p=0.04$) and thin and thick cortexes (with a difference of 0.173, $p=0.007$). Pairwise comparison of moderate and thick cortexes revealed no significant difference in this regard.

Considering the normal distribution of MI, AI

and GA, their correlation with lumbar BMD and with one another was analyzed using Pearson's correlation test. The results showed a significant, positive correlation between MI and AI and a significant, negative correlation between MI and GA. No significant differences were noted between MI, AI and GA with lumbar BMD or with one another (Table 1).

Table 1- The correlation of MI, AI and GA with lumbar BMD in women over 45 years of age (Pearson's correlation test)

	Lumbar BMD	MI	AI
MI		–	–
Correlation coefficient	-0.211		
p-value	0.186		
AI			-
Correlation coefficient	0.141	0.275	
p-value	0.351	0.031	
GA			
Correlation coefficient	0.018	-0.599	-0.217
p-value	0.907	0.001	-0.072

Considering the non-normal distribution of AA and AD, their correlation with lumbar BMD was assessed using Spearman's correlation test; which indicated no significant association between different indices (Table 2).

Table 2- The correlation of AA and AD with lumbar BMD in women over 45 years (Spearman's correlation test)

	Lumbar BMD	AI
AA		–
Correlation coefficient	0.042	
p-value	0.78	
AD		
Correlation coefficient	-0.249	0.076
p-value	0.095	0.538

The results of Student t-test found significant associations between femoral BMD and C1 and

C2 morphology of the inferior cortex (mean difference of 0.159). BMD in C1 was significantly higher than that in C2 ($p<0.001$).

The femoral BMD in thin, moderate and thick cortexes based on SVE was 0.67 (0.12) g/cm^2, 0.76 (0.16) g/cm^2 and 0.79 (0.13) g/cm^2, respectively. One-way ANOVA was used to compare femoral BMD in different groups in terms of the thickness of the inferior border of the mandible. The results revealed significant differences in BMD in different groups ($p=0.04$). By an increase in thickness, femoral BMD increased as well.

Considering the normal distribution of MI, AI and GA, their correlation with femoral BMD and with one another was assessed using Pearson's correlation test. The results showed a significant positive association between MI and AI ($p=0.031$) and a significant negative correlation between MI and GA ($p<0.001$). No significant associations were noted between MI, AI, and GA with femoral BMD or with one another.

Considering the non-normal distribution of AA and AD, their correlation with lumbar BMD was assessed using Spearman's correlation test and no significant association was noted in this regard.

Based on the results, lumbar BMD according to the WHO estimate was found to be 0.85 (0.05) g/cm^2 in osteopenic patients, 1.02 (0.07) g/cm^2 in osteoporotic patients and 0.65 (0.08) g/cm^2 in healthy individuals. One-way ANOVA revealed significant differences in lumbar BMD among osteopenic, osteoporotic and healthy subjects. Lumbar BMD was the highest in healthy subjects and the lowest in osteoporotic patients ($p<0.001$). Multiple comparisons with Dunnett's test revealed significant differences in lumbar BMD between osteopenic and osteoporotic subjects (with a difference of 0.209, $p<0.001$) and also between healthy individuals and osteoporotic subjects (with a difference of 0.372, $p<0.001$). No significant difference was noted between healthy subjects and osteopenic

patients.

Based on the results, the femoral BMD according to the WHO criteria was 0.79 (0.15) g/cm^2, 0.96 (0.12) g/cm^2 and 0.72 (0.18) g/cm^2 in osteopenic, healthy subjects and osteoporotic subjects, respectively. One-way ANOVA showed significant differences in femoral BMD between osteopenic, osteoporotic and healthy subjects. BMD was the highest in healthy individuals and the lowest in osteoporotic subjects ($p<0.001$). Multiple comparisons by Dunnett's test revealed no significant differences in femoral BMD between osteopenic and osteoporotic and also between osteopenic and healthy individuals. However, BMD was significantly different between healthy individuals and osteoporotic subjects (with a difference of 0.242, $p=0.009$).

Discussion:

Early diagnosis of osteoporosis plays an important role in decreasing the risk of fracture and initiating appropriate treatment. On the other hand, panoramic radiography is commonly used in routine dental practice allowing the researchers to perform extensive assessments on the bone structure of the maxilla and mandible and the dentition. Recognizing the signs of osteoporosis on panoramic radiographs can play a fundamental role in diagnosis of this condition (11).

Based on SVE in the current study, the morphology of the inferior cortex of the mandible was C1 in 62.9% and C2 in 37.1% of women. C3 form was not seen in any women over 45 years presenting to the Osteoporosis Clinic of Khatamolanbia Hospital and Imam Khomeini Dental Clinic in Yazd during the one year study period. In a study by Dalili and Moghadam in 2003 on healthy women presenting to the oral and maxillofacial radiology clinics in Rasht city in the age range of 20-75 years, C1, C2 and C3 forms were noted

in 20.9%, 71.3% and 7.8% of subjects, respectively (12). Moreover, in a study by Imani Moghadam, *et al.* in 2006 on women presenting to the radiology department of Mashhad university of Medical Sciences, C1, C2 and C3 forms were seen in 29.9%, 65.7% and 4.4% of subjects, respectively (13). A recent investigation has reported the moderate or severe erosion of the lower cortex of the mandible up to 28% by taking age into consideration (14). Ledgerton, *et al.* (1999) reported the frequency of C2 cortex morphology to be 52% (15).

Differences reported in studies may be due to different age range of women, sample size, and ethnic differences related to nutrition and climate. Moreover, difference in the observer's vision may also affect these results. In general, C2 is closer to the normal state of the population. Moreover, with advanced age, the inferior cortex of the mandible also undergoes significant changes and by development of porosities, it approximates the C3 form. As the time elapses from the menopause, the effect of drop in sex hormones on bone loss is expedited. In the current study, conducted on women   over 45 years of age presenting to the above-mentioned centers, the AA, MI, AI, AD and GA on panoramic radiographs were 174.21 (9.9°), 12.72 (3.6) mm, 4.06 (1.37) mm, 1.47 (0.95) mm and 131.49 (9.56°), respectively (14). In a study by Ledgerton, *et al.* in 1999, this value was reported to be 4.46 mm (15) in a population of British women. This rate was reported to be 4.73mm by Devlin and Horner in 2002 (16). The values reported for MI in the above-mentioned studies were much lower than the value obtained in the current study, which may be due to the age range of participating women. Taguchi, *et al.* in 2006 evaluated postmenopausal women younger than 65 years and showed that MI in all cases was less than 3mm (17). Considering the mean age of menopause to be 51 years (15, 18), the drop in level of sex hormones at this time enhances the negative effect of age on reduction

of bone mass and results in a decrease in width of the cortex of the mandible.

Gulsahi, *et al.* in 2010 found no significant association between mandibular cortical indices, MI or mandibular panoramic indices with BMD at the alveolar ridges of the maxilla or mandible; these findings were in accord with the current study results (19); although, different bones were evaluated in the two studies.

Cakur, *et al*. (2009) found no association between the total femoral and lumbar vertebral BMD and the mandibular cortical index classification (20). Jagelavičiene, *et al*. (2010) evaluated the relationship of panoramic radiomorphometric indices of the mandible and calcaneus BMD (according to DXA estimate and laser) in postmenopausal women aged over 50 and found a significant association between MI and calcaneus BMD (21). Mansour, *et al*. (2013) also reported that panoramic indices (MI, mandibular panoramic and MCI) had a positive association with lumbar vertebral BMD in women; these results are in contrast to those of the current study (22).

In the current study, quantitative and qualitative radiomorphometric indices along with angular and linear calculations were used to estimate the validity of these indices for determining the risk of osteoporosis. Qualitative indices including MCI, and SVE are easier for use than quantitative indices and the femoral and lumbar BMDs were determined in different groups and compared.

Selection of the elderly, postmenopausal women in the current study was based on the fact that prevalence of osteoporosis is high in this group and these subjects are morelikely to show osteoporotic changes on their panoramic radiographs.

Although it has been reported that calculations made on panoramic radiographs may be beneficial for prediction of osteoporosis in postmenopausalwomen, such result was not observed in the current study. On the other hand, although one year was allocated to find adequate number of patients for this study, only 70 patients met the inclusion and exclusion criteria; which is limited for drawing a definite conclusion in this regard. Moreover, the current study did not include osteoporotic men.

Osteoporosis has a relatively high incidence among the Iranian women. According to the random model, the incidence rate of osteoporosis has reported to be 18.9% in the femur and vertebral column (confidence interval of 15%-22.7% in femur and 14.6%-23.2% in the vertebral column) (23). Considering the role of osteoporosis in increasing the risk of fracture of the hip, wrist, and the vertebral column, further multicenter studies are required to be performed on a larger sample size to assess the possible correlation of systemic osteoporosis and jawbone status on panoramic radiographs.

Conclusion:

Within the limitations of this study, although no significant difference was noted between the osteoporotic and control subjects in terms of MI, GI and AI, it appears that using MCI on panoramic radiographs may be beneficial for assessment of osteoporosis. However, future multicenter studies are required on larger sample sizes to better elucidate this topic.

Conflict of Interest: "None Declared"

References:

1. Andreoli TE, Carpenter CCJ, Griggs RC, Loscalzo J. Cecil Essentials of Medicine. 8th Ed. Philadelphia: W.B. Saunders Co. 2010; Chap 76: 802-811.
2. Wactawski-Wende J, Grossi SG, Trevisan M, Genco RJ, Tezal M, Dunford RG, *et al*. The role of

osteopenia in oral bone loss and periodontal disease. J Periodontol 1996; 67: 1076-1084.

3. Bozic M, Ihan Hren N. Osteoporosis and mandibles. Dentomaxillofac Radiol 2006; 35:178-184.

4. Lafzi A, Amid R, Kadkhodazadeh M, Ahrari F. Is there any association between systemic bone mineral density and clinical manifestations of periodontal disease? J Periodontol Implant Dent 2012; 4: 49-55.

5. Taguchi A, Suei Y, Ohtsuka M, Nakamoto T, Lee K, Sanada M, *et al*. Relationship between self-reported periodontal status and skeletal bone mineral density in Japanese postmenopausal women. Menopause 2005; 12: 144-148.

6. Horner K, Devlin H, Alsop CW, Hodgkinson IM, Adams JE. Mandibular bone mineral density as a predictor of skeletal osteoporosis. Br J Radiol 1996; 69: 1019-1025.

7. Celenk C, Celenk P. Relationship of mandibular and cervical vertebral bone density using computed tomography. Dentomaxillofac Radiol 2008; 37: 47-51.

8. Horner K, Devlin H. The relationship between mandibular bone mineral density and panoramic radiographic measurements. J Dent 1998; 26: 337-343.

9. Horner K, Devlin H. The relationships between two indices of mandibular bone quality and bone mineral density measured by dual energy X-ray absorptiometry. Dentomaxillofac Radiol 1998; 27: 17-21.

10. Drozdzowska B, Pluskiewicz W, Tarnawska B. Panoramic-based mandibular indices in relation to mandibular bone mineral density and skeletal status assessed by dual energy X-ray absorptiometry and quantitative ultrasound. Dentomaxillofac Radiol 2002; 31: 361-367.

11. Halling A, Persson GR, Berglund J, Johansson O, Renvert S. Comparison between the Klemetti index and heel DXA BMD measurements in the diagnosis of reduced skeletal bone mineral density in the elderly. Osteoporos Int 2005; 16: 999-1003.

12. Dalili Z, Moghadam Qujeq A. An investigation on mandibular radiometric indices in normal female population referred to maxillofacial radiology centers in Rasht. JDM 2003; 16: 14-21. [Persian]

13. Imani Moghadam M, Bagherpour A, Hatef MR, Ebrahimzadeh S. Evaluation of the relationship between skeletal status and radiomorphometric indices of the mandible observed in panoramic radiography in women. Journal of Mashhad Dental School 2006; 29: 145-152. [Persian]

14. Johari Khatoonabad M, Aghamohammadzade N, Taghilu H, Esmaeili F, Jabbari Khamnei H. Relationship among panoramic radiography findings, biochemical markers of bone turnover and hip BMD in the diagnosis of postmenopausal osteoporosis. Iran J Radiol 2011; 8: 23-28. [Persian]

15. Ledgerton D, Horner K, Devlin H, Worthington H. Radiomorphometric indices of the mandible in a British female population. Dentomaxillofac Radiol 1999; 28: 173-181.

16. Devlin H, Horner K. Mandibular radiomorphometric indices in the diagnosis of reduced skeletal bone mineral density, Osteoporos Int 2002; 13: 373-378.

17. Taguchi A, Tsuda M, Ohtsuka M, Kodma I, Sanada M, Nakamoto T, *et al*. Use of dental panoramic radiographs in indentifying younger postmenopausal women with osteoporosis. Osteoporos Int 2006; 17: 387-394.

18. Klemetti E, Kolmakov S, Heiskanen P, Vainio P, Lassila V. Panoramic mandibular index and bone mineral densities in postmenopausal women. Oral Surg Oral Med Oral Pathol 1993; 75: 774-779.

19. Gulsahi A, Paksoy CS, Ozden S, Kucuk NO, Cebeci AR, Genc Y. Assessment of bone mineral density in the jaws and its relationship to radiomorphometric indices. Dentomaxillofac Radiol 2010; 39: 284-289.

20. Cakur B, Dagistan S, Sahin A, Harorli A, Yilmaz A. Reliability of mandibular cortical index and mandibular bone mineral density in the detection of osteoporotic women. Dentomaxillofac Radiol 2009; 38: 255-261.
21. Jagelavičienė E, Kubilius R, Krasauskienė A. The relationship between panoramic radiomorphometric indices of the mandible and calcaneus bone mineral density. Medicina (Kaunas) 2010; 46: 95-103.
22. Mansour S, AlGhamdi AS, Javed F, Marzouk H, Khan EA. Panoramic radio-morphometric indices as reliable parameters in predicting osteoporosis. Am J Med Sci 2013; 346: 473-478.
23. Bagheri P, Haghdoost A, Dortaj Rabari E, Halimi L, Vafaei Z, Farhangnia M, *et al*. Ultra analysis of prevalence of osteoporosis in Iranian women "a systematic review and meta-analysis". Iranian Journal of Endocrinology and Metabolism (IJEM) 2011; 13: 315-325.