Relationship between Mandibular BMD and Bone Turnover Markers in Osteoporosis Diagnosis

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Abstract

Background: The purpose of the present study was to determine mandible bone mineral density and evaluate its correlation with central BMD and bone turnover.

Methods: Two hundred and seven postmenopausal women were enrolled in this cross-sectional study. After receiving the testimonials, questionnaires were completed and physical exams were done. For all participants central BMD was measured through DXA method. In each women periapical radiography performed in two regions of mandible. The plain x-ray films were scanned using a standard film digitizer and standardized in size and intensity using a calibration step wedge phantom. The phantom was placed upper site in film cover. After the film digitized, the developed Matlab software was used to image processing.

Results: Mean age and body mass index of participants were 54.6±6.3 years and 28.57±4.9 kg/m² respectively. Prevalence of osteoporosis and osteopenia in one of regions in central DXA were 17.4% and 48.2% respectively. There was strong correlation between mandible and total femur BMD (\(P=0.001\), \(r=0.80\)). In osteoporotic patients bone loss in mandible BMD was more than central DXA (\(P=0.02\)).

Conclusion: The main advantage of the proposed mandible BMD is to help clinicians make more accurate evaluation of Bone loss. Based on developed the suggested system a routine dental X-ray could be used to screen for bone loss.

Keywords: Mandible, BMD, Osteoporosis, Periapical, Image Processing

Introduction

Osteoporosis is described as a general skeletal disorder characterized by reduced bone mineral density. It can predispose us to bone fracture. Osteoporotic fractures are associated with high morbidity and mortality among various populations (1, 2).

Different Bone mineral densitometry instruments are used for measurement of the bone mineral density (BMD) and osteoporosis detection. In recent years competent systems such as quantitative computed tomography and dual X-ray absorptiometry (DXA) methods have been developed and widely employed (3).

Osteoporosis and periodontitis are two independent diseases though these diseases are related as both have damage bone tissue, share common risk factors, most prevalence in middle-aged and elderly women (4). Evidence indicated that mandibular bone loss occurs earlier than others. However application of above mentioned techniques for measuring bone density of jaws is not technically easy due to the shape of the bones (5).

Dentists have been investigating mandibular bone for a long time for detecting height of the alveolar ridge and mandibular osteoporosis which have serious consequences like edentulism (6). Also determination of mandibular bone density is of paramount importance for the diagnosis, treatment planning and management of dental procedures such as osseointegrated implants and grafting. Therefore radiographic assessment of bone quality has applications in implantology (1) and in research assessing the relationship between oral bone loss and osteoporosis (6).

Although photodensitometry via periapical and panoramic radiographs has been used to estimate mandibular bone mass, this method has low predictive value for skeletal osteopenia (7-9). A large number of quantitative and qualitative measurements of mandibular bone from radiographs have been devised for this purpose, including densitometry...

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Many of these require specialized facilities or are time-consuming and necessitate radiography of the highest standards. Advanced methods such as dual X-ray absorptiometry (DXA) and quantitative computed tomography (15, 16) have been applied in edentulous areas, and dual-photon absorptiometry (8). The correlation between the mandibular and other bone values was found to be as low as with photo densitometry. Digital image analysis techniques for quantisation of bone mass have been applied to oral digital or digitized radiographs. The use of gray-level values for detecting changes in alveolar bone density is under development (17, 18). These changes may also reproduce variation in other sites BMD (19). Mathematical methods for image-processing also are used to make the analysis of morphology easy (20). In this way, the structure of the trabecular architecture has been studied in vertebra (21), in the radius (22), and also on periapical radiographs (18, 23).

Radiographic measurements showed problems with inter observer variation, which suggests that careful training and calibration of observers would be important if they were to be used as an indicator of mandibular BMD (24). In vitro studies have used digital subtraction of oral radiographs (25, 26) to detect density changes in simulated osteoporosis. However, up until now, these new techniques have not been fully developed for use in clinical practice.

On the other hands, in spite of developing deliberate instruments and mentioned methods, still there is doubt in ability of fracture perdition depending only on BMD (27). Furthermore, Biochemical markers of bone turnover may be of value for prediction of individual bone loss and they may help in predicting risk of fracture in elderly women. Recent studies indicate that increased levels of biochemical markers of bone turnover are associated with greater bone loss. The purpose of the present study was to examine the diagnostic performance of dental periapical radiography and biochemical markers of bone turnover in relation to BMD in postmenopausal women.

### Material and Methods

#### Bone mineral densitometry

The subjects for the study were 207 postmenopausal women randomly selected from the participants of Iranian multicenter osteoporosis study (IMOS). All the subjects had undergone bone mineral density (BMD) measurements (T/Z scores) by dual energy X-ray absorptiometry (DEXA) at lumbar spine (vertebrae L2–L4) and hip (femur neck). The BMD (g/cm2) was measured by dual energy X-ray absorptiometry (Lunar-DPX, USA). The coefficient of variation for longitudinal BMD measurements in the DEXA machine averaged at 1.04%.

Normal bone mass was defined as BMD measurements at or above -1 standard deviation (S.D.) from the optimal peak bone density (T-score) of healthy young adult of the same sex.

BMD measurement at or below -2.5 S.D from the optimal peak bone density of healthy young adult of the same sex was osteoporotic and BMD measurement T score between -2.5 and -1 was osteopenia.

#### Periapical radiography

Periapical radiographs were obtained with a constant current of 8 mA, 70 kVp, and 3 s exposure times, always from the same distance. Holder was used for holding the film packet parallel to the teeth that also prevent bending of the packet. Images were recorded by use of standard radiographic film.

#### Step wedge phantom

Step wedge phantom was provided from hydroxyapatite composites. These composites contain hydroxyapatite nano powders. The step wedge phantom was composed of five steps of composite. It was designed by the authors, in cooperation with a related manufacturing company. Its segment densities were measured with DXA and corrected with chemical content estimations. During the exposure, the composite step wedge phantom was placed on the upper of the periapical film packet to provide a reference image on the radiograph. If it was superimposed on any bony structure, a new radiograph was taken after chang-
ing position of the phantom. Also for evaluating of Day-to-day variability in five patients radiography was performed five times over a period of 5 weeks with both phantoms.

**Image processing**

The plain x-ray films were scanned using a standard film digitizer and standardized in size and intensity using a calibration step wedge phantoms. The developed Matlab software was used to image processing. On the mandibular image, the mean grey levels were measured on the step wedge phantom and the regions of interest. The calibration curve was drawn, by plotting against the measured mean grey level values of each step on the step wedge phantom and those values of the measured densities on dual energy X-ray absorptiometry (figure 1). A multivariate stepwise linear regression algorithm was used to select a combination of mandibular measurements that correlates with hip and spine T-scores.

**Measurements**

Markers of bone formation included osteocalcin (OC). OC was measured by immunoassay (ELISA) using a Bioscience kit (Nortic Bioscience Diagnostic A/S, Denmark). The intra- and inter-assay CV were 2.6% and 4.7%, respectively. Another marker of bone resorption is the serum C-terminal telopeptides of type I collagen: serum crosslaps. Crosslaps were measured by ELISA using a Bioscience kit (Nortic Bioscience Diagnostic A/S, Denmark), with intra- and inter-assay CV of 5.1% and 6.6%, respectively.

**Statistical analysis**

Data were analyzed by means of a personal computer implemented with dedicated software (SPSS 11.5), to obtain mean±SD values, correlation matrix, Student’s t-test, analysis of variance and/or χ² tests, as appropriate. The level of significance was settled at <5%, as usual.

**Results**

In 207 postmenopausal women central BMD was measured through DXA method. The background characteristics of the study population are shown in Tables 1. Mean age and body mass index of participants were 54.6±6.3 yr and 28.57±4.9 kg/m² respectively. In each women periapical radiography performed in two regions of mandible. Inter and intra assay Coefficient of variance in mandibular BMD lower 2%.

ROC curves showed that the Mandibular BMD that was calibrated by Nano composite to diagnose osteoporosis with 85% specificity and sensitivity of 91%. The mean of BMD in hip and spine were 0.92±0.13 gram per cm² and 1.05±0.19 gram per cm² respectively (Table 1).

Prevalence of osteoporosis and osteopenia in one of regions in central DXA were 17.4% and 48.2% respectively. In osteoporotic patients bone loss in Mandibular BMD was more than central DXA (P= 0.02). There was strong correlation between mandible and total femur BMD that was shown in figure 2 (P= 0.001, r= 0.80). Also there was correlation between mandible and lumbar spine BMD (P= 0.01, r= 0.78). These correlation similar to correlation of spine BMD with hip BMD (r= 0.76, p=0.001) in this study. Mandibular BMD has a negative significant correlation with age (P= 0.01, r=0.79). Mandibular BMD negatively correlated with serum concentration of Osteocalcin (P=0.01, r=-0.17) but there was not significantly correlation between Mandibular BMD and serum concentration of Cross laps.

In logistic regression analysis Mandibular BMD independently of age and BMI predicted osteoporosis in all regions that evaluate by DEXA (P< 0.01).

**Table 1; Characteristics data of study population**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>mean ±SD</th>
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<tbody>
<tr>
<td>Age(years)</td>
<td>54.6±6.3</td>
</tr>
<tr>
<td>BMI(Kg/m²)</td>
<td>28.57±4.9</td>
</tr>
<tr>
<td>Menarche age(years)</td>
<td>13.04±1.57</td>
</tr>
<tr>
<td>Hip BMD(gr/cm²)</td>
<td>0.92±0.13</td>
</tr>
<tr>
<td>Spine BMD(gr/cm²)</td>
<td>1.10±0.19</td>
</tr>
<tr>
<td>Serum Cross laps (ng/mL)</td>
<td>0.29±0.11</td>
</tr>
<tr>
<td>Serum Osteocalcin (ng/mL)</td>
<td>12.09±3.18</td>
</tr>
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![Graph showing BMD vs Grayscale](image1)

**Fig. 1:** The calibration curve was drawn by plotting against the measured mean grayscale values of each step on the step wedge phantom and those values of the measured densities on DXA that reported as Mandibular BMD.

![Graph showing Linear Regression](image2)

**Fig. 2:** Linear regression with 95% mean prediction interval between bone mineral density in hip and periapical radiography grayscale.

**Discussion**

Bone densitometry assessment is used to diagnose osteoporosis, evaluate fracture risk and monitor for changes in bone mineral density. This study used DXA as a gold standard for in vivo measurement of bone mineral density. Whereas a consistent strong correlation exists between the amounts of bone mineral density (BMD) calculated in the spine, hip, and forearm, (28-30) conflicting results have been reported on the correlation between skeletal BMD and mandibular bone mass. In some studies no relationship has been
found (31, 32), in others only a moderate one (33-35). Diverse assessment techniques may be a possible explanation for the low correlation between skeletal BMD and mandibular bone mass. Our results demonstrated that mandibular BMD correlated with skeletal BMD. Other studies also have demonstrated a significant correlation between bone mineral density in the mandible or maxilla and the spine or hip (36). Jonasson et al showed that mandibular alveolar bone mass, assessed via the optical density of analog radiographs, was related to skeletal bone mineral density (37).

There is some indirect evidence consistent with our results, which have shown the common influence of systemic factors on oral bone loss and other bones. Postmenopausal women with fractures had a significantly higher number of teeth loss than those without fractures (38-42). Krall referred that osteoporosis may cause periodontal disease and tooth loss (43). It was suggested that tooth loss could be associated with spine fractures in osteoporotic females (44, 45). Several studies in Finland (46), Japan (47-50), the United States (51-53), Poland (54), and the United Kingdom (55, 56) offer contradictory outlook on the usefulness of mandibular evaluation in women.

Yang et al (57) showed a mandibular cortical bone thinning following ovariectomy due to serum estrogen drop. Estrogen deficiency following ovariectomy in rats has also been shown to affect alveolar bone as well as mandibular basal bone (58). Our results indicated that mandibular BMD negatively correlated with age. Previous studies have shown that mandibular cortical thickness has a significant negative correlation with age (59) and a significant positive correlation with BMD in other skeletal sites, for example, the forearm and iliac crest (60). The mandible may therefore undergo a similar age-related decline in BMD, as has been observed in other sites.

Our result revealed that mandibular BMD has a significant negative correlation with biochemical markers of bone turnover. It has been suggested that biochemical markers of bone turnover may be useful for identifying fast bone losers. Several cross-sectional studies indicated that bone turnover rate assessed by markers increases after the menopause and that high bone turnover is continued long after the menopause.

Lofman et al reported that the bone markers were correlated to the current bone mass and may predict future bone loss (61).

In conclusion, there is a relationship between mandibular and skeletal BMD. Although periapical radiographic findings and biochemical markers of skeletal turnover cannot replace bone density scanning for the diagnosis of osteoporosis, it is thought that they may help to more precise prediction of fracture risk and to determine sufficiency of osteoporosis therapy. Over all, periapical radiography could be useful as an available, low-priced and simple method in osteoporosis screening.

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References


