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Diagnosis of osteoporosis using cortex mandibular indices based on cortex thickness and morphology in comparison with visual assessment of the cortex

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ABSTRACT

Introduction: Osteoporosis is a common condition causing significant morbidity and mortality. There is some evidence of a correlation between bone mineral density of the mandible and that of the lumbar spine and hip. The ability to accurately detect osteoporosis based on routine dental imaging would allow early diagnosis. The aim of this study was to compare the diagnostic accuracy for low bone mineral density using mandibular radio morphometric indices versus simple visual inspection of the mandibular cortex.

Materials and Methods: Four independent investigators evaluated radio morphometric indices (mental index, antigonial index and morphology of the cortex) as well as assigning a rating of thin or normal cortex based on their initial impression on the panoramic radiographs of 49 post menopausal women with decreased bone mineral density and 42 unaffected controls. The sensitivity, specificity and positive predictive value for each index was evaluated.

Results: The mental and antegonial index had better sensitivity than specificity and positive predictive value. However the opposite was true for the morphology index and simple visual inspection of cortical thickness. External agreement was moderate to perfect (0.41 -0.93) for cortex morphology, and moderate to substantial (0.49-0.76) for simple visual inspection of cortical thickness but excellent for mandibular and antegonial index (> 0.8).

Conclusion: We found that the mandibular cortical thickness is affected in postmenopausal women with low bone mineral density when compared to controls. Furthermore radio morphometric indices and morphology are more accurate in the diagnosis of osteoporosis than simple visual assessment of cortical thickness.

Key words: Cortex, Mandible, Osteoporosis, Radiography.

Introduction

Osteoporosis is a common disease characterized by a reduction in bone mass accompanied by a compromise in the structural integrity of the bone with resultant increased vulnerability to fractures [1]. Although it affects both sexes it is seen more commonly in women than in men and globally it is estimated that approximately 200 million women are affected with increasing incidence with age [1]. There is significant morbidity

and mortality related to osteoporosis with 1 in 3 women and 1 in 5 men over 50 years of age sustaining an osteoporotic fracture [2-6].

Although the gold standard for measuring bone density is bone biopsy this is not practical and the most widely used test for the detection of osteoporosis is Dual-Energy X-ray Absorptiometry (DEXA). However DEXA is still culpable to errors that can be divided into several groups. The first group is object dependent errors including degenerative joint disorders, scoliosis, foreign body and other disease such as metastasis or fractures and positioning of the patient. The second group of errors is data analysis dependent including data entry and setting errors and the final group is the miscellaneous errors including calibrating and programming errors [7]. Despite these shortfalls DEXA is still the best in vivo method available for measurement of bone mineral density and gives a strong predictive value of hip fractures compared to methods using peripheral sites [8].

There is an accumulating pool of evidence in support of osteoporotic manifestation within the mandible raising the potential of routine dental radiographs in the form of orthopantomograms and periapical X-rays in performing the dual role of dental investigation as well as opportunistic screening for osteoporosis. Several methods have been studied including those requiring technical measurements to calculate radio morphometric indices (mandibular cortical thickness/width, panoramic mandibular index, mandibular index, gonial thickness and antegonial index), simple visual inspection [9] and mandibular densitometry [10].

There is evidence that all these methods with the exception of densitometry are correlated with skeletal bone mineral density and thus could potentially be used to screen for osteoporosis. Of importance is the evidence arising from the OSTEODENT study (a collaborative study of European centers investigating the role of dental x-rays in the diagnosis of osteoporosis) which found that OSIRIS, an index for calculating the risk of low bone mineral density, based on age, weight, hormone replacement therapy use and trauma from moderate contusions has greater validity than dental x-rays in predicting osteoporosis risk [11]. Thus the added radiation exposure of a dental x-ray for screening of osteoporosis is not warranted, however when routine dental x-rays are performed patients may also benefit from screening for osteoporosis.

Calculation of radio morphometric indices can be difficult and time consuming however visual inspection with the appropriate training may be more amendable for screening of routine dental X-rays. The aim of this study was to compare the diagnostic accuracy for osteoporosis using radio morphometric indices versus simple visual inspection of the mandibular cortex.

Material and Methods

This study approved by ethical committee of Qazvin University of Medical Sciences and There is no conflict with ethical considerations. A total of 91 postmenopausal women were recruited 49 affected by osteoporosis diagnosed by DEXA and 42 unaffected controls. All DEXA scans were performed using the medink osteodore bone densitomer (serial number 810,1999: France). Participants were classified as having normal bone mineral density if they had a T-score of >-1 and as having low bone mineral density if they had a T-score of <-1 at the lumbar spine.

All participants had undergone natural menopause and were not included in the study if they had any local or systemic disease affecting bone mineral density or were taking any medication that could affect bone mineral density. The panoramic radiographs were taken using the Praline model 2002cc panoramic machine (Helsinki, Finland) under the supervision of a single radiologist to exclude any radiographic distortions. Each radiograph was assessed independently by four radiologists with a special interest in maxillofacial and oral radiology for the Mental Index (MI), Antegonial Index (AI), Cortex Morphology and simple visual inspection. All examiners were blinded to the patients DEXA results. The continuous indices were calculated with the aid of calipers that digitally displayed the results (GUANGLU. Japan, Digimatic calipers; minimum unit displayed 0.01mm).

The methodology described by Legerton et al was utilized to measure the cortical width at the mental foramen. Using this method first the mental foramen was identified. Then a line was drawn passing through the centre of the mental foramen and perpendicular to the mandible, thus delineating the point for measurement of the cortical thickness (Fig. 1).

The Antegonial Index represents the cortical width just anterior to the gonion and was measured at the point on a line extended from the anterior border of the ascending ramus to the inferior border of the mandible (Fig. 2) [12]. The morphology of mandibular cortex (MCI) was divided by each observer into one of

three groups according to the classification described by kelemetti et al (Fig.3) [9] as follows:

C1: even sharp endosteal margins bilaterally

C2: endosteal margin with semilunar defects forming cortical residues,

AC3: heavy endosteal cortical residues and clearly porous cortex

Rating of the mandibular cortex by simple visual inspection was undertaken at an interval of two weeks from the radio morphometric indices and the examiners were blinded to their initial findings. The observers were asked to rate the mandibular cortex as either thin or normal based on gross visual inspection.

Data analysis was performed with using Statistical Package for the Social Science software (SPSS version: 15). The sensitivity, specificity and positive predictive value was calculated for all the parameters measured. Inter-observer agreement was assessed by calculation of the Cohon Kappa statistic for categorical indices. Interpretation of the Kappa statistic was based on the guidelines of Landis et al [13]: with less than 0.00 being poor agreement, 0.00-0.20 being slight agreement, 0.21-0.40 being fair agreement, 0.41-0.60 being moderate agreement, 0.61-0.80 being substantial agreement and 0.81-1.00 representing almost perfect agreement. The Pearson's correlation coefficient was used to assess inter-observer reliability for the continuous indices.

Result

The study population of 91 women had a mean age of 56.2 years (+/- 6.73) and based on DEXA of the lumbar spine 42 women were assessed as having normal bone mineral density defined for this study as a T-score >-1 and 49 women as having decreased bone mineral density if they had a T score of less <-1.

The sensitivity, specificity and positive predictive value based on precise measurements in the MI region was 83.7%, 35.7% and 60.3%. For the MCI the sensitivity, specificity and positive predictive value were 53.1%, 61.9% and 61.9% respectively. For the cortical status we found a sensitivity of 77.6%, specificity of 35.7% and positive predictive value 58.5%. Finally for simple visual assessment we found a sensitivity of 38.8%, specificity of 88.1% and positive predictive value of 79.2%. To assess for agreement between observers was used Kappa score. The kappa score for evaluation of MCI varied from moderate (0.41) to perfect (0.93) with a mean of moderate (0.46) and for simple visual assessment the kappa score varied from moderate (0.49) to substantial (0.76) with a mean of substantial (0.62). Inter observer agreement for continuous variables were excellent being 0.92 to 0.85 for MI and 0.87 to 0.82 for AI.

Fig 1. Mental index. A line passing through the middle of the mental foramen and perpendicular to the tangent to the mandibular lower border. The cortical width was measured along in this line.

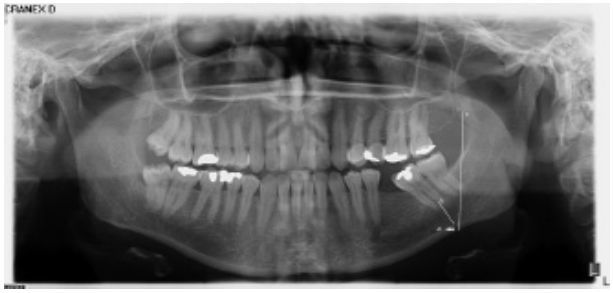

Fig 2. Antegonial index. Antegonial index is the measurement of the cortical width in the anterior region to the gonion at a point identified by extending a line of best fit on the anterior border of the ascending ramus down to the lower border of the mandible [14].

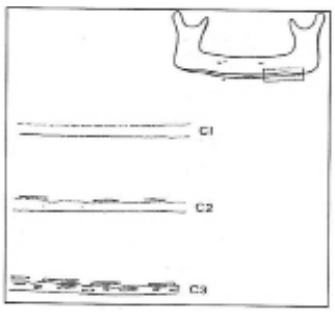

Fig 3. Category of morphology cortex (MCI). C1: the endosteal margin of the cortex is even and sharp on both sides, C2: the endosteal margin shows semilunar defects or appears to form endosteal cortical residues, C3: the cortical layer forms heavy endosteal cortical.

residues and is clearly porous.

Discussion

Maxillofacial radiography is a common diagnostic tool used in general and specialized dental practice. There is some evidence for the use of panoramic radiographs as an opportunistic screening tool for osteoporosis [14-17].

The aim of this study was comparison of the diagnostic accuracy of osteoporosis based on mandibular indices with visual assessment cortex. In this study we found the specificity and positive predictive value for simple visual assessment of the cortex to be high (88.1% and 79.2 % respectively), whereas the average sensitivity was low (38.8%). The low sensitivity means that more than half of the women with reduced bone mineral density were not identified on simple visual evaluation of cortical thickness. On the other hand the high specificity for this method means that approximately four out of five women with normal bone mineral density will be identified at such using this method.

Lee et al reported respectively 53%, 81.9% and 75.7% in the femoral area and respectively 56%, 81.9% and 72% in the spinal area to visual evaluation of mandibular cortex for sensitivity, specificity and positive predictive value [17], which is in agreement with the present study, so that the specificity and positive predictive value were high and sensitivity was low. However, its sensitivity was higher than the current study. The differences in sensitivity are between our study and that of Lee et al are difficult to reconcile but may be due to the older study population (mean age of 59.6) recruited by Lee et al compared to our study population which had a mean age of 56.2 years as increasing age has been shown to result in decreased cortical thickness [18]. On the MCI too, specificity and positive predictive value were higher than sensitivity, but that sensitivity value was more than variable of cortex visual evaluation. Gulsahi reported that sensitivity and specificity were 71.4% for the mandibular cortical index that compared to the current study, have a higher sensitivity and specificity [19]. Associated with differences in sensitivity obtained in tow study can be pointed out to high sample size and greater number of observer in the current study. Taguchi investigated the relationship of MCI with lumbar spine L2_L4 BMD, and in this study also obtained significantly difference between them [20]. Yasar reported that MCI index had a significant differences between two groups of patients with normal BMD and osteoporotic, and he introduced this variable as the best indicators in differentiation of osteoporotic patients from normal individuals with good repetition grade [18].

Drodzowska shown that the BMD status don't have a significant effect on MCI [21], probably due to the small sample size (n=30). In the present study, MI sensitivity and specificity in differentiating patients with decreased bone density was respectively 83.7% and 35.7% which is comparable with other studies. Based on the exact measuring in the MI and AI area, in both sensitivity were significantly higher than previous variable, where as was inverted in relation with the specificity. Thus, can conclude that accurate measuring is better and effective than visual evaluations of cortex in identify women with decreased skeletal density.

Devlin and Horner proposed that the MI has low to moderate accuracy in the diagnosis of patients with decreased bone density [22]. Ishii et al. found to similar results in MI, they proposed that with using of MI may be identified patients with decreased bone density [23]. Devlin et al. proposed that a 3mm width of cortex is a appropriate threshold for referral of patients (postmenopausal women) to densitometry tests [22], whereas White proposed that 4mm is more suitable [24]. In this study, cortex width was considered less than 5mm due to no exercise magnification coefficient [24]. According to the Gulsahi study, MI have moderate accurate in diagnosing patients with reduced density [19]. In his study threshold limit for MI was 3.5, that this is less than the current study. The point that caused the differentiation of threshold limit in these two studies is using of complete toothless patients in the Gulsahi study. So that Dutra proposed that loss of teeth can have a significant relationship with the cortex thick [25]. Qaraaty shown that a significant difference in MI between the two groups of people with normal and osteopenic BMD (P = 0.23) [18] that this is according to the Devlin [22], Dutra [25], Lee [17] and Taguchi reports [20]. But in the Drodzowska study, MI index did not shown significant difference between the two osteoporotic and non-osteoporotic groups [21], which this is probably due to small sample size (n = 30) in this study.

Taguchi evaluated association between lower mandibular cortex thickness and lumbar spine L2_L4 BMD that mandibular cortex thickness (MI) had significantly relationship with spine BMD [15]. In the present study the agreement between observers in the evaluation of visual cortex observed, Kappa rate was varied from 0.5 to 0.76. So that in the

current study, agreement rate in visual assessment was higher than Lee study that can be associated with high samples volume in the Lee study [17]. It should be mentioned that in the present study has been used of four radiologists with experience in this field, while in the Lee study used from the surgeon general dentists in addition to oral and maxillofacial radiologists. In the current study, agreement value was varied from 0.4 to 0.94 between observer in the evaluation of cortex morphology thickness that in comparison to other studies [26,18], this value was lower, which can be associated with higher number of observer compared with other studies.

Observer	*MI*	*AI*	*Number*
1	*4.43±0.95*	*3.56±0.82*	*91*
2	*4.32±0.95*	*3.53±0.72*	*91*
3	*4.29±1.90*	*3.263±0.86*	*91*
4	*4.47±0.90*	*3.53±0.95*	*91*

Table 1: Means, standard deviations for continuous variables in four observers.

Observer	*C1*	*C2*	*C3*
1	*49*	*39*	*3*
2	*46*	*42*	*3*
3	*34*	*51*	*7*
4	*32*	*56*	*3*

Table 2: Sample distribution by MCI category in four observers.

Observer	*Normal*	*Thin*	*Number*
1	*67*	*24*	*91*
2	*62*	*29*	*91*
3	*77*	*14*	*91*
4	*74*	*17*	*91*

Table 3: Sample distribution by visual assessment of cortex category in four observers.

Conclusion

In dental clinic usually not common application bone densitometry tests and routinely does not apply for patients. On the other hand, often is prescribed panoramic radiography for dental examination, especially before making prosthesis. Based on this study results, the highest sensitivity rate were reported in the precise measurements of cortex thickness variables. (MI and AI sensitivity were respectively 83.7% and 77.6 %). Therefore, can be suggested that these variables can be effective to diagnosis women with decreased BMD, of course, for definitive diagnosis is requires referral of patients to appropriate specialists for more accurate tests such as bone densitometry.

Also can be suggested that however using of mandibular cortex width is a simple screening tool to identify women with unknown reduced bone density, but its use is not feasible. Thus, can be expressing that inferior mandibular cortex morphology evaluation in panoramic radiography may be is useful for diagnosis of women with decreased BMD. Simply, use of MCI can be more applied and more comfortable. Based on this study results, visual observe variables is not effective in the diagnosis of patients with decreased BMD.

At the end can be expressed which cortex thickness precise measuring indices and inferior mandibular cortex morphology can act more effectively than cortex visual observe variable in diagnosis of patients with osteoporosis.

Conflict of Interest

There is no conflict of interest to declare.

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