Identifying risk groups for osteoporosis by digital panoramic radiography

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Abstract

Background: Osteoporosis is a disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to bone fragility, and enhanced susceptibility to fractures. Dental radiographs, especially panoramic images, have been used to predict bone mineral density. A number of indices, (mandibular cortical index [MCI], mandibular cortical width [MCW], and panoramic mandibular index [PMI]) have been developed to assess and quantify the quality of mandibular bone mass and to observe the signs of resorption. Objectives: The objectives of the study were to assess mental index (MI), MCW index, and PMI with bone density in identifying risk group for osteoporosis and also to investigate influence of age and gender on MI, MCI, and PMI. Materials and Methods: After obtaining consent, details regarding age, gender, systemic health status, and oral parafunctional habits were recorded in each patient. Then a digital panoramic radiograph was taken. The image thus obtained was subjected to calibrations and morphometric analysis using Digora version 2.7. The obtained values of indices were compared with the mean values of indices, to evaluate subjects whether they are prone to osteoporosis or not. The obtained information was subjected to statistical analysis for the significance of the parameters. Results: Data analysis showed that calibration indices were highly significant in the assessment of risk group for osteoporosis than noncalibration index. The subjects at a higher risk for development of osteoporosis were old-aged adults with higher prevalence being reported in women compared to male subjects. Conclusion: In conclusion, our results suggest that higher percentage of subjects with undetected decreased bone mineral density may be identified based on trained general dental practitioners analyses of their panoramic radiographs using simple screening analytical calibration MI and MCI.

Keywords: Bone mineral density, mandibular cortical index, mental index, osteoporosis, panoramic mandibular index

Introduction

Panoramic radiography has been an important component of dental diagnostic radiology for over 40 years. It is a technique that produces an image of the teeth and jaws on a single film. Nowadays there is a great tendency among researchers to use panoramic radiographs for detecting calcification of the branches of the external carotid artery and osteoporosis. Osteoporosis is a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue which lead to enhanced bone fragility and an increase in fracture risk. A major obstacle to combating osteoporosis is the failure to identify individuals who have the disease until the clinical consequences have occurred. Hence, early identification of such subjects is essential to prevent the risk of pathological fractures.

Dental professionals have a chance of identifying this subclinical condition through routinely used panoramic radiographic investigation. Previous research was aimed at correlating various panoramic indices and bone density in identifying the risk group of osteoporosis, but little research was done to identify the influence of age, gender.

Hence, our study intended to investigate in this regard with objectives to assess mental index (MI), mandibular cortical width (MCW), index and panoramic mandibular index (PMI) with bone density in identifying risk group for osteoporosis and to investigate influence of age and gender on MI, mandibular cortical index (MCI), and PMI.

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Materials and Methods

After the study protocol was approved by the institutional ethical review board, a total random sample of 400 completely dentate subjects with age ranging between 16 and 64 years, who were advised orthopantomograph (OPG) for dental diagnostic and treatment purposes were included in the study and subjects with any history of bone pathology and dystrophies, nontraumatic and traumatic fractures, diabetes mellitus, and any surgical treatment to mandible were excluded from the study. A specially designed proforma including demographic details of subjects and consent form was duly filled at the time of examination.

For each subject, a digital OPG was taken using OPG machine (Orthoralix) and photostimulable phosphor sensors (Digora), under standard exposure conditions as recommended by the manufacturer. The final images were obtained by accompanying software (Digora for Windows 2.7.103.437 network client, copy right© 1993–2010 Soredex) in Digital Imaging and Communications in Medicine format.

Calculation of mental, panoramic mandibular, mandibular cortical width indices

Panoramic mandibular index

PMI the ratio of the mandibular cortical thickness measured on the line perpendicular to the bottom of the mandible, at the middle of the mental foramen, by the distance between the inferior mandibular cortex and the bottom of the mandible (normal value: $\geq 0.3$).[2]

Mental index

MI mandibular cortical thickness measured on the line perpendicular to the bottom of the mandible at the middle of the mental foramen (normal value: $\geq 3.5$ mm). [2]

Mandibular cortical index

MCI is classification of the morphological appearance of mandibular inferior cortex distal to the mental foramen as:

- C1: The endosteal margin of the cortex is even and sharp on both sides of the mandible
- C2: The endosteal margin has semilunar defects (resorption cavities) with cortical residues one to three layers thick on one or both sides
- C3: The endosteal margin consists of thick cortical residues and is clearly porous.

To assess the interobserver error, a random sample of 50 OPGs were selected and reanalyzed by the second observer after necessary training, without the knowledge of age and gender. The degree of interobserver variability or more precisely the level of agreement or consistency between observers using the Kappa statistics given by Landis and Koch (1977). The values thus obtained were subjected to statistical analysis for testing significance of parameters.[2]

Results

Of the total study sample ($n = 400$), 53% ($n = 206$) were female subjects and 47% ($n = 194$) were male subjects. All subjects were randomly categorized into four age groups [Table 1].

The obtained mean MI, PMI, and MCI of 400 subjects on comparison with standard value showed statistical significance with a $P < 0.001$ denoted in [Table 2].

Influence of age on MI and PMI showed that the variance is significant with $P < 0.01$ in MI and nonsignificant for PMI values with a $P > 0.05$. Influence of gender on MI showed a statistical significance with $P < 0.001$ and PMI were not statistically significant with $P > 0.05$ [Table 3].

MCI evaluation showed that C2, C3 patterns predominantly found in 31.5% of female subjects on comparison to 13% of male subjects with a statistically significant $P < 0.001$ [Table 4]. Percentage of a C1 pattern of MCI was decreasing with increasing age, whereas the percentage of C2 and C3 pattern was increasing with advancing age [Table 5].

A nonparametric measure of statistical dependence between the calibration indices (PMI, MI) and noncalibration indices (MCI) showed a lack of association between MI, PMI, and MCI [Table 6].

From a set of randomly selected 50 subjects level of agreement between first and second observer showed k-value

Table 1: Demographic details of study sample

| Groups | Female n (%) | Male n (%) |
|--------|--------------|------------|
| 16-26 years | 61 (29.6) | 43 (22.4) |
| 27-36 years | 24 (11.7) | 46 (22.9) |
| 37-46 years | 46 (22.3) | 31 (16.1) |
| >47 years | 75 (36.4) | 74 (38.5) |

Table 2: Mean MI value of entire sample

| n | Mean | SD | P |
|---|------|----|---|
| MI | 400 | 4.7257 | 0.51818 | <0.001; significant |

SD: Standard deviation; MI: Mental index

Table 3: Influence of gender on mental index and panoramic mandibular index using one sample t-test

| Sex | n | Mean | SD | P |
|-----|---|------|----|---|
| MI Female | 207 | 4.64 | 0.54 | <0.001; significant |
| MI Male | 193 | 4.82 | 0.48 | |
| PMI Female | 207 | 0.36 | 0.07 | 0.163; NS |
| PMI Male | 193 | 0.35 | 0.07 | |

MI: Mental index; SD: Standard deviation; PMI: Panoramic mandibular index; NS: Not significant
of 1 for MI, 0.991 for PMI, and one for MCI denoting a perfect level of agreement between observers for the assessment of calibration and noncalibration indices [Tables 7 and 8].

**Discussion**

Osteoporosis is a term derived from Latin with “Osteo” meaning “bone,” “Porosis” meaning porus,” thus “Osteoporosis” means bones that are full of holes.[1] Global estimates revealed that by 2020 year, 14 million people having osteoporosis, and 47 million are expected to have osteopenia and number of hip fractures owing to osteoporosis is expected to double or triple by the year 2040[3] hence, our research was carried out in this regard to emphasize role of oral physician.

Most of research carried out on mandibular bone in assessment of osteoporosis revealed that there is a relationship between osteoporosis and bone loss in jaw bones evaluated by histology (microradiography), single photon absorptiometry, dual photon absorptiometry, quantitative computed tomography and more recently, dual-energy X-ray absorptiometry.[4]

Although, these measuring techniques are considered as gold standard or precise than simple visual analytical methods these methods possess certain drawbacks that they increase treatment cost and require expensive measurement equipment hence these methods cannot be applicable in the developing countries.[4]

A large number of dental panoramic radiographs approximately 10 million in Japan,[5] 17 million in the United States,[6] and 1.5 million in England and Wales[7] are taken yearly for examination of dental diseases such as periodontal disease. It would be economical and beneficial if panoramic radiographs could be used for identifying subjects with undetected osteoporosis so that we could refer subjects for confirmatory evaluation methods and further treatment which in turn can control the disease progression.[6]

In course of our study, the thickness of cortical bone was measured using digitized panoramic radiographic images, which facilitated the evaluation of trabecular to cortical bone thickness ratio in the mandible and precise determination of inner and outer margins of cortical bone together with vertical linear measurement analysis which is a prerequisite for calculation of panoramic radiomorphometric indices.[8] Conventional panoramic radiographs measurements were found to be associated with intrinsic errors and observer variability hence digital panoramic radiography was used in our study.[9]

| Table 5: Influence of age on mandibular cortical index using Chi-square test |
| --- |
| **Age n (%)** | **16-26 years** | **27-36 years** | **37-46 years** | **>47 years** | **P** |
| MCI | c1 (1) | 103 (99.0) | 63 (92.6) | 62 (80.5) | 79 (53.4) | <0.001; significant |
| | c2 (2) | 1 (1.0) | 5 (7.4) | 15 (19.5) | 65 (43.9) | |
| | c3 (3) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 4 (2.7) | |

**Table 6: Correlation between calibration indices (PMI, MI) and noncalibration index MCI**

| MI | PMI |
| --- | --- |
| Spearman’s correlation coefficient | 0.08 | 0.014 |
| P | 0.11; NS | 0.785; NS |
| n | 400 | 400 |

MCI: Mandibular cortical index; MI: Mental index; PMI: Panoramic mandibular index; NS: Not significant

| Table 7: Reliability between observers for calibration indices |
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| **MI_2** | **PMI_2** |
| Kappa statistics | 1.000** | 0.991** |
| P | <0.001 | <0.001 |
| n | 50 | 50 |

MI: Mental index; PMI: Panoramic mandibular index; **: Higher level of inter observer reliability for MI & PMI between observer 1 & 2

| Table 8: Reliability between observers for noncalibration indices |
| --- |
| **MCI_1** |
| c1 | c2 | c3 |
| --- | --- | --- |
| c1 (1) | 28 | 0 | 0 |
| c2 (2) | 0 | 21 | 0 |
| c3 (3) | 0 | 0 | 1 |

Kappa=1. MCI: Mandibular cortical index
Analyzing results of our study, it has been noted that mean PMI of our study population was 0.35 which was in accordance with study conducted among various ethnic groups who reported that mean value of PMI ranges between 0.31 and 0.38.[8]

Our study showed that there was a negative correlation of PMI with the age which matched with results of a study carried out by Beatriz et al.[9] implicating decreased influence of PMI in predicting risk group for osteoporosis among subjects of various age groups. Comparison of PMI score between females and males of different age groups in our study suggested a gradual decline in mean PMIs among those subjects aged above 47 years old due to higher chances of the prevalence of osteoporosis.[9]

Dagistan et al. investigated and found an association between MCI and osteoporosis which was in accordance with results of our study implicating the increased level of significance of MCI in identification of risk group.[8] Our study has shown that thickness and shape of mandibular cortex which includes C2 and C3 pattern associated with mandibular cortex in subjects with risk of developing osteoporosis reliably reflects systemic condition associated with bone mass loss which was in accordance with study conducted by Peycheva et al.[8]

Taguchi et al.[6] demonstrated an association between MCI and general skeletal BMD in men and women aged 40 years or younger, and inferred that adult men aged 40 years or younger with an undetected low BMD could be identified by the MCW measured on panoramic radiographs. While young adult women with an undetected low calcaneal BMD could not be detected, these findings are inconsistent with results of our study; this variability can be attributed due to the difference in ethnic origin of the populations. Osteoporosis risk assessment in men and women below 40 years in our study signified decreased chances of the risk of osteoporosis.

Muhit et al., Klementti et al., and Horner and Devlin focused on PMI[11-13] and found no distinct advantage of this index over MI as a tool for mandibular BMD measurement which was in accordance with results of our study due to comparatively lower level of significance between calibration indices (PMI and MI).

Othman et al.[14] did not find any difference in mean PMI between normal (0.38) and osteoporotic (0.37) females in 54–71 years age group, which was in accordance with results of study conducted by Drozdzowska et al.[15] and in accordance with the results of our study implying that PMI in women is not significantly correlated with bone density.

Reproducibility which indicate agreement between repeated measurements by observers showed a significant reproducibility between first and second observer for both calibration and noncalibration indices in our study which was in accordance with the results of study conducted by Watson et al., Kribbs et al., Klementti et al., Taguchi et al., and Bollen et al.[8,16] which was attributed to higher level of understanding of analysis pattern by first and second observers.

Our study did not assess the calcium and phosphorous levels and did not follow gender matching to a certain extent which are the limitations.

Conclusion

In conclusion, our results suggested that 23% of subjects with undetected decreased bone mineral density may be identified with routinely used dental panoramic radiographs. Trained Dentomaxillofacial radiologist can identify risk group for osteoporosis using simple screening analytical calibration (MI, PMI) and noncalibration (MCI) mandibular cortical indices.

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Conflicts of interest

There are no conflicts of interest.

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