Content available at: https://www.ipinnovative.com/open-access-journals

IP International Journal of Maxillofacial Imaging

Journal homepage: https://www.ijmi.in/

Original Research Article

# Osteoporotic alterations of mandible in aged women using panoramic radiograph: A multicentric study

**Sowmya Gujjar Vishnurao[1]*, Roopa S Rao[2], Pradeep Kumar[3], Ashok L[4], Anitha Krishnan Pandarathodiyil[5]**

[1]*Dept. of Oral Medicine & Radiology, Institute of Dental Sciences, Bareilly, Uttar Pradesh, India*
[2]*Dept. of Oral & Maxillofacial Pathology, Faculty of Dental Sciences, Ramaiah University, Bangalore, Karnataka, India*
[3]*Dept. of Periodontics, Saveetha Dental College, Chennai, Tamil Nadu, India*
[4]*Dept. of Oral Medicine & Radiology, Bapuji Dental College & Hospital, Davangere, Karnataka, India*
[5]*Dept. of Oral Pathology & Oral Biology, Faculty of Dentistry, SEGi University and Colleges, Kota Damansara, Selangor, Malaysia*

ARTICLE INFO

*Article history:*
Received 02-08-2024
Accepted 28-08-2024
Available online 03-10-2024

*Keywords:*
Mandibular cortex index
Aged women
Osteoporosis
Panoramic radiography
Trabecular pattern

ABSTRACT

**Background:** Osteoporosis is a pandemic, chronic, silent skeletal condition that can cause bone fractures and possibly disability if left untreated. In clinical practice, it frequently goes unnoticed until a fracture develops. Therefore, the study aims to evaluate visually the diagnostic efficacy of panoramic-based mandibular cortex index and trabecular patterns in aged women.

**Materials and Methods:** Archival Panoramic radiographs of 800 aged women were examined and narrowed to controls (114) and study patients (116). Panoramic-based index i.e., mandibular cortical thickness, and trabecular patterns were visually evaluated.

**Results:** Dense homogeneous trabeculation and sparse trabeculation were found to be more sensitive and specific on the right side when evaluating Region of Interest 1, while Region of Interest 2 revealed sparse trabeculation. Mandibular Cortical Index in study patients revealed Osteoporotic MCI to be statistically significant when comparing the control. Overall, the control group had a statistically significantly higher Normal MCI (100%), Osteopenia MCI (76.5%), and dense homogeneous trabeculation (100%) score of the right mandibular cortex index than the study group.

**Conclusion:** Indicators from panoramic radiography may be helpful in triage screening procedures to detect osteoporosis.



## 1. Introduction

Osteoporosis is a worldwide disease with a global concern due to its high rates of morbidity and mortality in aging populations, particularly among women.[1,2] Aged women have a higher chance of getting osteoporosis than younger women due to decreased estrogen production and the associated decline in bone mineral mass.[3,4] As a result of the disorder's increased bone fragility, which raises the risk of fracture because the micro-architecture of the bone is compromised, the quality and strength of the bone are also affected.[5] As per the literature, there is a wide variation in prevalence across India which varied from 16.9% in the northern part to 21.8% in southern India. According to assessments from 2015, 20% of the 230 million Indian women over 50 years old will be estimated to have the disease. According to a recent study by Babhulkar S, et al., (2021), the prevalence of osteoporosis among aged women

* *Corresponding author.*
*E-mail address*: tamannamyangel@gmail.com (S. G. Vishnurao).

https://doi.org/10.18231/j.ijmi.2024.022

was 33.1% overall.[6]

Routine radiographs like intra-oral periapical radiographs and orthopantomograph (OPG) are procured in day-to-day dental practice, and among patients with osteoporosis, dentists are the first to notice the particular pattern of trabecular bone loss. This qualifies the dental radiographs for qualitative/quantitative bone mineral density (BMD) analysis.[7] The mandibular cortical index (MCI), panoramic mandibular index (PMI), mental index (MI), antegonial index (AI), and gonial index (GI), are some of the mandibular cortical indices that have been developed long ago to measure the mandibular bone mass and identified signs of jaw bone resorption on panoramic radiographs to diagnose osteopenia and osteoporosis.[5] Additional recent advanced techniques include dual-photon absorptiometry, single-photon absorptiometry, quantitative ultrasound/computed tomography, and dual-energy X-ray absorptiometry.[4] In addition to high-quality radiography, several of these investigations necessitate the use of expensive, time-consuming, or specialized equipment including trained personnel to use.[4,8]

The anatomical and functional makeup of the mandible is distinct. Regardless of age, trabecular volume and interconnectivity differ significantly between people, leading to varied trabecular bone patterns in the mandible.[9] With sensitivity ranging from 35.9% to 90.9% and specificity up to 93.9% for diagnosing osteoporosis, the MCI is one of the most popular osteoporosis risk indices.[10] Therefore, further supporting the numerous literary researches, dental radiographs were required for visual validation for reading jaw bone trabeculae on routine dental radiographs like OPG. With this context, the present study aimed to assess the diagnostic efficacy of visual assessment of panoramic-based mandibular indices in diagnosing and predicting osteoporotic alterations in aged women.

## 2. Materials and Methods

The OPG acquired for various diagnostic purposes between 2022 to 2023 from three primary dental care centers from both northern and southern parts of India like Institute of Dental Sciences, Bareilly, Bapuji Dental College & Hospital, Davangere, and Saveetha Dental College, Chennai, were pooled and examined. The study protocol was approved by the Institutional Ethics Committee (IHEC No.571) and agreed upon by another ethical committee of respective institutes. The committee waived the need for informed consent due to the retrospective nature of study.

Out of a total of 800 archival OPG acquired, the study group comprised of aged women ≥ 45 years with 116 patients and subjects between 18-45 years of age acting as controls with 114 patients. In male patients, ghost images, jaw pathologies/bone destructive lesions, OPGs with artifacts, complete edentulousness, and those with implants were excluded.

Before the study commenced, the examiner underwent standardization and calibration under the guidance of a consultant from the Department of Oral Medicine, Diagnosis, and Radiology. This process aimed to ensure consistent interpretations and uniform examinations, resulting in a kappa value of 1.00. All radiographs were captured using a digital Orthopantomograph (PM2002cc Proline) with exposure parameters set between 65-70kVp and 8mA, employing Kodak T-Mat, speed-E films. The radiographs underwent a subjective assessment to verify patient positioning, head alignment, film density, and contrast, all of which met the reviewer's established quality standards. Linear and angular measurements. The structures of interest were delineated on transparencies, which were affixed to the radiographs using a radiographic viewer. Subsequently, each image was cropped onto the right and left sides and labeled accordingly. The following radio morphometric indices were measured on each radiograph.

As per Lindh Index,[11] the trabecular pattern of jaws employed was P1 where dense homogeneous trabeculation showed many trabeculae connected with an impression of small/few marrow spaces, P2 where heterogeneous trabeculation with both dense and sparse trabeculation was found and P3 where sparse trabeculation with fewer trabeculae, larger marrow spaces, and an impression of more radiolucency was demonstrated. All these radiographic evaluations were accomplished at two regions of interest (ROI), firstly, at the mandibular ramus area, a region free of occlusal forces from dental elements,[2] and secondly at the mandibular angle, (posteriorly to the molar region, below the canal) a region free form interference of masticatory stress.[10] (Figures 1, 2 and 3)

**Figure 1:** Region of interest 1& 2 on right side of OPG

As per Mandibular Cortical Index/Klemetti Index,[12] which involved bilateral measurements at the inferior mandibular cortex, distal to mental foramina as Class I (Normal) with endosteal cortical margin even and sharp (Figures 1 and 4), secondly, Class II (Osteopenia) with mild to moderate erosion, as evidenced by semi-lunar defects along the margin (Figures 2 and 4) and cortical bone residues at one to three layers and finally, Class III (Osteoporosis) with severe erosion and cortical porosity

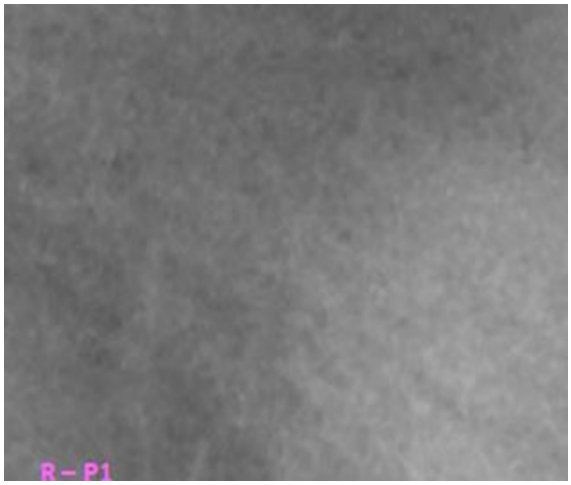


**Figure 2:** Region of interest 1 on right side of OPG showing Dense homogeneous trabeculation (P1)

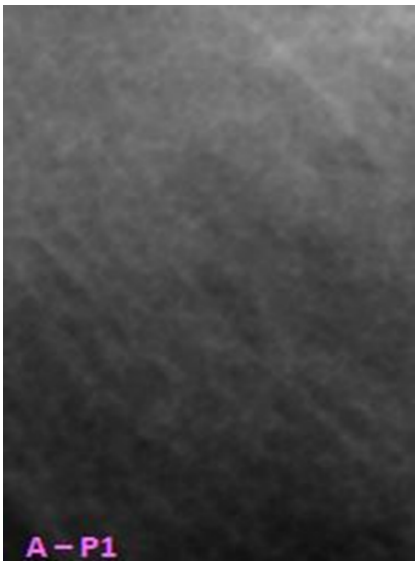


**Figure 3:** Region of interest 2 on right side of OPG represents Dense homogeneous trabeculation (P1)

(Figures 3 and 4)

### *2.1. Statistical analysis*

All the evaluation data was recorded into a spreadsheet program (Microsoft Excel 2021) and was imported into the Statistical Package for Social Sciences (SPSS) software, version 21.0 (SPSS Inc. Chicago, Illinois, USA). Mean and standard deviation, descriptive statistics, and Chi-square statistics were computed to determine group differences in mandibular measurements with the statistical significance set at $P<0.05$. Inter and intra-observer agreements were evaluated using weighted kappa statistics. The sensitivity and specificity of indices were calculated to identify bone mineral density loss.

**Figure 4:** Cropped OPG showing normal (C1) category of Klemmeti's Index

**Figure 5:** Cropped OPG showing moderate erosion (C2) category of Klemmeti's Index

## 3. Results

The mean+standard deviation of age in the study group was 58.11±5.93 years and 29.78±6.30 years in the control group. The descriptive information of visual trabecular bone assessment in the right mandibular ramus area, for dense homogeneous trabeculation, had the highest sensitivity at 64.9%, however, sparse trabeculation had good specificity at 50%. (Table 1) The descriptive information of

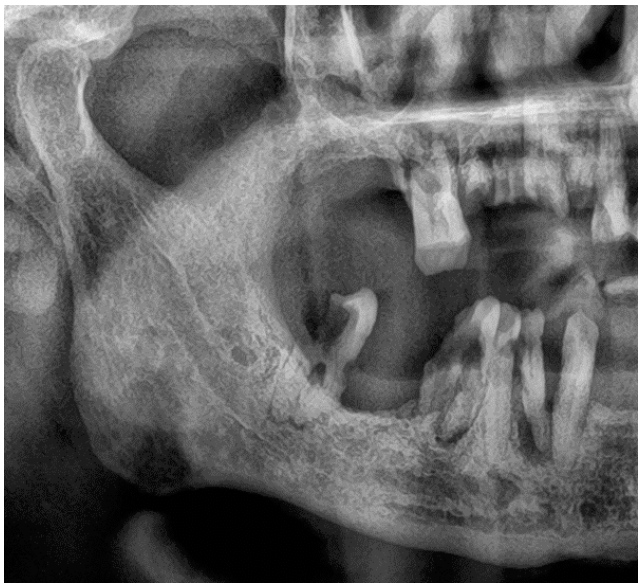

**Figure 6:** Cropped OPG showing severe erosion and cortical porosity (C3) category of Klemmeti's Index

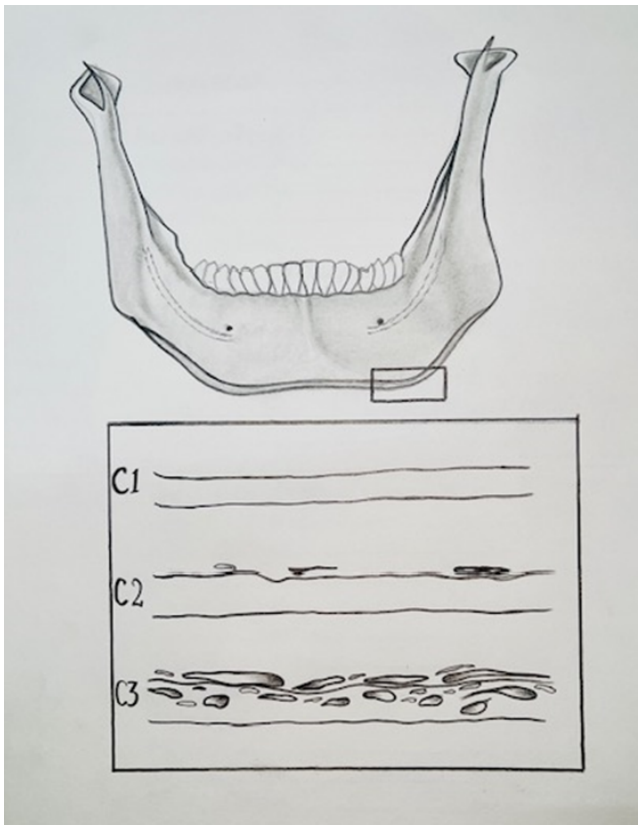


**Figure 7:** Diagram showing the MCI/Klenmetti's index classification. C1-endosteal margin of the cortex is even and sharp on both sides (normal cortex); C2-endosteal margin has semilunar defects (lacunar resorption) and/or endosteal cortical residues are present on one or both sides; C3 - heavy endosteal cortical residues and porosity are present in the cortical layer

visual trabecular bone assessment in the right mandibular angle, with 33.3% for heterogeneous trabeculation had the highest sensitivity, while sparse trabeculation had a high specificity of 75%. (Table 2) The description of the right mandibular cortical index showed sensitivity and specificity highest for Osteoporotic MCI at 66.7%, and 77.8% respectively. (Table 3) The descriptive information of visual trabecular bone assessment for the left mandibular ramus area (Table 4), mandibular angle (Table 5), and mandibular cortical index (Table 6) showed sparse trabeculation/Osteoporotic MCI with the highest sensitivity at 50%, 62.5%, and 71.4%, respectively. The Chi-square test showed no statistically significant difference in mandibular ramus area, mandibular angle, and mandibular cortical index between the right and left side within the study (Table 7) and control group (Table 8).

## 4. Discussion

The idea that low estrogen contributes to the pathogenesis of osteoporosis was first based on the observation that aged women, whose estrogen levels decreased, were more at risk for the disease process and fractures. Later, it was suggested that a calcium deficit and the aging of the bones were the main etiological causes of osteoporosis in women.[13] In fact, estrogen is more effective than testosterone at preventing bone resorption in men, and it helps men reach their maximal bone mass. The prevalence of osteoporosis is seen to be lower in males than in women, which is related to the fact that men have higher peak bone mass, less of a menopause-like process, and denser bones. Aged women were therefore taken into account in the current investigation to assess osteoporosis on the dental radiograph.[14]

Pietschmann G, et al., (2009) published one of the first studies on oral bone loss brought on by osteoporosis.[15] Early alterations are noticeable in the trabecular bone of jaws in women with involutional osteoporosis Type I who were older than 45 years, which aided in determining osteoporosis using OPG.[16] The present study was unique since it was the first of its kind to use the Lindh criterion[11] for assessing the visible trabecular bone on OPGs. On dental panoramic radiographs, cortical breadth and porosity are potentially helpful assessment techniques.[17,18] In 2011, Hastar E, et al., examined the effects of gender and dental status on the mandibular cortical index in older people with and without osteoporosis.Dental status was found to be strongly correlated with the MCI categories.[19] Whereas, Bajoria AA, et al., (2015)[20] concluded that MCI and other metrics may be assessed accurately on a panoramic radiograph, making them suitable as a screening tool for osteoporosis.

In the present study, the ROI chosen to evaluate trabecular pattern visually on OPG was as Lindh, et al., 2008 criteria[16] used in periapical radiographs of the premolar

**Table 1:** The descriptive information of visual trabecular bone assessmentin the right mandibular ramus area

| Right Mandibular Ramus Area | Cases | % | Cases | % | Cases | % | Sensitivity (%) | Specificity (%) |
|---|---|---|---|---|---|---|---|---|
| Dense Homogeneous Trabeculae | 24 | 64.9 | 29 | 69.0 | 22 | 62.9 | 64.9 | 45.8 |
| Heterogeneous Trabeculae | 11 | 29.7 | 11 | 26.2 | 13 | 37.1 | 26.2 | 43.6 |
| Sparse Trabeculae | 2 | 5.4 | 2 | 4.8 | 0 | 0 | 0.0 | 50.0 |
| Total | 37 | 100 | 42 | 100 | 35 | 100 | - | - |
| p-value | | | **0.001 (Significant)** | | | | | |

**Table 2:** The descriptive information of visual trabecular bone assessment in the right mandibular angle area

| Right Mandibular Angle Area | Cases | % | Cases | % | Cases | % | Sensitivity (%) | Specificity (%) |
|---|---|---|---|---|---|---|---|---|
| Dense Homogeneous Trabeculae | 3 | 4.2 | 5 | 13.5 | 1 | 16.7 | 4.2 | 13.9 |
| Heterogeneous Trabeculae | 16 | 22.5 | 9 | 24.3 | 3 | 50.0 | 24.3 | 15.2 |
| Sparse Trabeculae | 52 | 73.2 | 23 | 62.2 | 2 | 33.3 | 33.3 | 75.0 |
| Total | 71 | 100 | 37 | 100 | 6 | 100 | - | - |
| p-value | | | **0.001 (Significant)** | | | | | |

**Table 3:** The descriptive information of visual trabecular bone assessment in the right mandibular cortical index

| Right MCI | Cases | % | Cases | % | Cases | % | Sensitivity (%) | Specificity (%) |
|---|---|---|---|---|---|---|---|---|
| Normal | 1 | 1.4 | 0 | 0.0 | 0 | 0.0 | 1.4 | 12.7 |
| Osteopenic | 11 | 15.7 | 6 | 15.8 | 2 | 33.3 | 15.8 | 13.5 |
| Osteoporotic | 58 | 82.9 | 32 | 84.2 | 4 | 66.7 | 66.7 | 77.8 |
| Total | 70 | 100 | 38 | 100 | 6 | 100 | - | - |
| p-value | | | 0.001 (Significant) | | | | | |

**Table 4:** The descriptive information of visual trabecular bone assessment in the left mandibular ramus angle area

| Left Mandibular Ramus Area | Cases | % | Cases | % | Cases | % | Sensitivity (%) | Specificity (%) |
|---|---|---|---|---|---|---|---|---|
| **Dense Homogeneous Trabeculae** | 17 | 22.1 | 11 | 35.5 | 1 | 16.7 | 22.1 | 13 |
| **Heterogeneous Trabeculae** | 27 | 35.1 | 6 | 19.4 | 2 | 33.3 | 19.4 | 44.4 |
| **Sparse Trabeculae** | 33 | 42.9 | 14 | 45.2 | 3 | 50 | 50 | 88.5 |
| **Total** | 77 | 100 | 31 | 100 | 6 | 100 | - | - |
| **p-value** | | | **<0.001 (Significant)** | | | | | |

**Table 5:** The descriptive information of visual trabecular bone assessment in the left mandibular angle area

| Left Mandibular Angle Area | Cases | % | Cases | % | Cases | % | Sensitivity (%) | Specificity (%) |
|---|---|---|---|---|---|---|---|---|
| **Dense Homogeneous Trabeculae** | 4 | 5.7 | 4 | 11.1 | 1 | 12.5 | 5.7 | 15.4 |
| **Heterogeneous Trabeculae** | 19 | 27.1 | 7 | 19.4 | 2 | 25.0 | 19.4 | 23.7 |
| **Sparse Trabeculae** | 47 | 67.1 | 25 | 69.4 | 5 | 62.5 | 62.5 | 78.6 |
| **Total** | 70 | 100 | 36 | 100 | 8 | 100 | - | - |
| **p-value** | | | **<0.001 (Significant)** | | | | | |

**Table 6:** The descriptive information of visual trabecular bone assessment in left mandibular cortical index

| Left MCI | Cases | % | Cases | % | Cases | % | Sensitivity (%) | Specificity (%) |
|---|---|---|---|---|---|---|---|---|
| **Normal** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12.8 |
| **Osteopenic** | 5 | 7.4 | 5 | 12.8 | 2 | 28.6 | 12.8 | 12.8 |
| **Osteoporotic** | 63 | 92.6 | 34 | 87.2 | 5 | 71.4 | 71.4 | 71.4 |
| **Total** | 68 | 100 | 39 | 100 | 7 | 100 | - | - |
| **p-value** | | | **0.001** | **(Significant)** | | | | |

**Table 7:** The descriptive information of visual trabecular bone assessment in right & left mandibular ramus, angle, and mandibular cortical index among the study group

| Study Group | | Right | | Left | | p-value |
|---|---|---|---|---|---|---|
| | | Cases | % | Cases | % | |
| **Mandibular Ramus Area** | Dense Homogeneous Trabeculae | 37 | 56.1 | 29 | 43.9 | 0.124 |
| | Heterogeneous Trabeculae | 43 | 54.4 | 36 | 45.6 | |
| | Sparse Trabeculae | 36 | 41.4 | 51 | 58.6 | |
| **Mandibular Angle Area** | Dense Homogeneous Trabeculae | 9 | 50 | 9 | 50 | 0.988 |
| | Heterogeneous Trabeculae | 29 | 50.9 | 28 | 49.1 | |
| | Sparse Trabeculae | 78 | 49.7 | 79 | 50.3 | |
| **Mandibular Cortical Index** | Normal | 1 | 100 | 0 | 0 | 0.234 |
| | Osteopenic | 19 | 61.3 | 12 | 38.7 | |
| | Osteoporotic | 96 | 48 | 104 | 52 | |

**Table 8:** The descriptive information of visual trabecular bone assessment in right & left mandibular ramus, angle, and mandibular cortical index among the control group

| Control Group | | Right | | Left | | p-value |
|---|---|---|---|---|---|---|
| | | Cases | % | Cases | % | |
| **Mandibular Ramus Area** | Dense Homogeneous Trabeculae | 75 | 49.3 | 77 | 50.7 | 0.716 |
| | Heterogeneous Trabeculae | 35 | 53.0 | 31 | 47.0 | |
| | Sparse Trabeculae | 4 | 40.0 | 6 | 60.0 | |
| **Mandibular Angle Area** | Dense Homogeneous Trabeculae | 1 | 100.0 | 0 | 0.0 | 0.729 |
| | Heterogeneous Trabeculae | 70 | 50.0 | 70 | 50.0 | |
| | Sparse Trabeculae | 37 | 50.7 | 36 | 49.3 | |
| **Mandibular Cortical Index** | Normal | 6 | 42.9 | 8 | 57.1 | 0.234 |
| | Osteopenic | 70 | 51.1 | 67 | 48.9 | |
| | Osteoporotic | 38 | 49.4 | 39 | 50.6 | |

areas, which showed promise as a tool to identify women at risk for osteoporosis. Conferring to published research, the mental foramen near the base of the mandible has been chosen as the typical location. The findings for this study's assessment of the trabecular pattern in both ROI, however, were comparable and significant in both groups with little change between the right and left sides. MCI was regarded by Leite, et al., (2010) as one of the reliable indicators of poor BMD after assessing MCI by simple visual estimations in 351 aged women.[21] The evaluation of trabecular patterns on periapical radiographs and OPGs by Pham D, et al.,[9] found a strong correlation between the two, supported a study in which two calibrated observers at random, evaluated the interdental sites between the first molar and second premolar and between the two premolars on all the radiographs using a visual index. This, according to the present investigation was in agreement.

The mandibular alveolar bone mass (MABM) was quantified by photodensitometry by Jonasson G, et al.,[22] (2001) using periapical radiographs of 80 women and alveolar trabecular pattern. On casts, the interdental alveolar thickness and BMD of the forearm were evaluated by dual X-ray absorptiometry. Trabecular coarseness, MABM, and skeletal BMD were found to be significantly correlated. The authors concluded that as a clinical screening tool, trabecular pattern identification was superior to densitometric data which was in the consensus of the present study.

The most sensitive criteria on the right side of the mandibular ramus area for trabecular bone evaluation in the current study was found to be Dense Homogeneous Trabeculae with 64.9% sensitivity and sparse trabeculation

with 50% specificity with significance. However, the Mandibular Ramus on the left side revealed that sparse trabeculation had 50% sensitivity and 88.5% specificity with significance, making it more sensitive. Additionally, sparse trabeculation was discovered to be more sensitive and specific in Mandibular angles, with statistically significant values.

The MCI, designed by Klemetti E, et al., (1994),[12] allows for quick interpretation of the risk of osteoporosis, however, there is an interobserver bias when separating the cortical and spongiosa jawbones. Kiswanjaya B, et al., (2022)[23] found that healthy-aged people with Class 3 MCI had a significant association with lower BMD T-scores and were at higher risk of osteoporosis. Gaur B, et al., (2013)[24] found good sensitivity (100%) and specificity (88.88%) of MCI results. However, the present study, demonstrated greater sensitivity and specificity regarding Osteoporotic MCI criteria, with statistically significant values on both the right and left side.

The MCI with BMD was substantial for both groups in the current investigation, supporting Balcikonyte E, et al., (2004)[25] where the efficacy of two panoramic-based indices Mandibular Cortex Index and the height of mandibular inferior cortex (CI) were compared with a bone mineral density of lumbar area L2-L4 by dual-energy x-ray absorptiometry in 130 women as diagnostic key. Varied contrasting results were seen in the present study as different methodology was employed for its evaluation.

Gassama BC, et al., (2021)[26] used panoramic radiography in cross-sectional research of patients 40 years of age and older to assess the condition of the mandibular basilar cortex in both women with natural teeth and edentulous. A substantial statistical difference was seen in the relationship between MCI and dental status. This study demonstrates that age and oral health are important variables influencing the mandibular bone changes examined by the MCI. As a result of the different methodologies and criteria used in the current study, a variety of results were noted.

Alam T, et al., (2020)[27] assessed age, body mass index, mouth symptoms, and osteoporosis in aged women. Panoramic radiography was performed, followed by the acquisition of two direct digital intraoral periapical radiographs from the mandibular premolar-molar region. They concluded that MCI on panoramic radiographs are effective indicators of osseous changes in aged individuals, thereby determining early prediction of osteoporotic fracture risk and reducing its related morbidity.

## 5. Limitations

In this early investigation, two visual assessment techniques were compared to detect osteoporosis in aged women. Additionally, this was the first study to compare right and left sides with indices independently and within the groups. However, there was no significant result in the inspection of the jaw's sides. The symmetry of the jaw and uniform distribution of masticatory forces could be possible reasons.

## 6. Conclusion

With the use of radio morphometric indicators such as MCI and trabecular pattern, panoramic radiographs were effective screening methods for identifying osteoporosis. However, further investigations should be conducted worldwide to determine whether these indices are acceptable for triaging individuals with osteoporosis and referring them to medical professionals. Visual assessment, as a predictor of future fractures, may have some limitations for individuals of all ages and sexes and hence further Automated and Artificial Intelligence evaluation techniques may be developed and validated for its clinical uses.

## 7. Source of Funding

None.

## 8. Conflcit of Interest

None.

## References

1. Wowern N. General and oral aspects of osteoporosis: a review. *Clin Oral Investig*. 2001;5(2):71–82.
2. Watanabe PCA, Rodrigues GA, Azenha MR, Ribeiro MC. Bone Quality of the Dento-Maxillofacial Complex and Osteoporosis. Opportunistic Radiographic Interpretation. In: Rodrigo L, editor. Osteoporosis - Recent Advances, New Perspectives and Applications. Rijeka: IntechOpen; 2021.
3. Garnero P, Sornay-Rendu E, Chapuy MC, Delmas PD. Increased bone turnover in late aged women is a major determinant of osteoporosis. *J Bone Miner Res*. 1996;11(3):337–49.
4. Calciolari E, Donos N, Park JC, Petrie A, Mardas N. A systematic review on the correlation between skeletal and jawbone mineral density in osteoporotic subjects. *Clin Oral Implants Res*. 2016;27(4):33–42.
5. Cakur B, Şahin A, Dagistan S, Altun O, Çaglayan F, Miloglu Ö, et al. Dental panoramic radiography in the diagnosis of osteoporosis. *J Int Med Res*. 2008;36(4):792–801.
6. Babhulkar S, Seth S. Prevalence of osteoporosis in India: an observation of 31238 adults. *Int J Res Orthop*. 2021;7(2):362–8.
7. White SC, Rudolph DJ. Alterations of the trabecular pattern of the jaws in patients with osteoporosis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1999;88(5):628–35.
8. Lee BD, White SC. Age and trabecular features of alveolar bone associated with osteoporosis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2005;100(1):92–8.
9. Pham D, Jonasson G, Kiliaridis S. Assessment of trabecular pattern on periapical and panoramic radiographs: a pilot study. *Acta Odontol Scand*. 2010;68(2):91–7.
10. Tassoker M, Ozic MU, Yuce F. Prediction of osteoporosis through deep learning algorithms on panoramic radiographs. *Research Square*. 2022;(1):1–14.
11. Lindh C, Horner K, Jonasson G. The use of visual assessment of dental radiographs for identifying women at risk of having osteoporosis: the Osteodent project. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2008;106(2):285–93.

12. Klemetti E, Kolmakov S, Kröger H. Pantomography in assessment of the osteoporosis risk group. *Scand J Dent Res*. 1994;102(1):68–72.
13. DeVilliers TJ. Bone health and osteoporosis in aged women. *Best Pract Res Clin Obstet Gynaecol*. 2009;23(1):73–85.
14. Selvakumar R, Chandran A, Patil A, Harini TC, Dandekeri S, Verma D, et al. Osteoporosis risk group: Screening for osteoporosis in dental clinics using panoramic radiographs. *J Educ Health Promot*. 2022;11(1):271–7.
15. Pietschmann P, Rauner M, Sipos W, Kerschan-Schindl K. Osteoporosis: an age-related and gender-specific disease-a mini-review. *Gerontology*. 2009;55(1):3–12.
16. Stelt PVD, Geraets W. Automated Recognition Of Bone Structure In Osteoporotic Patients. In: and others, editor. Proceedings of SPIE, the International Society for Optical Engineering/Proceedings of SPIE. SPIE; 1989.
17. Thulkar J, Singh S. Overview of research studies on osteoporosis in aged women since the last decade. *J Midlife Health*. 2015;6(3):104–7.
18. Sela EI, Widyaningrum R. Osteoporosis detection using important shape-based features of the porous trabecular bone on the dental X-ray images. *Int J Adv Comput Sci Appl*. 2015;6:247–50.
19. Hastar E, Yilmaz HH, Orhan H. Evaluation of mental index, mandibular cortical index and panoramic mandibular index on dental panoramic radiographs in the elderly. *Eur J Dent*. 2011;5(1):60–7.
20. Bajoria A, Kamath G, Babshet M, Patil P, Sukhija P. Evaluation of radiomorphometric indices in panoramic radiograph-A screening tool. *Open Dent J*. 2015;9:303–10.
21. Leite AF, Figueiredo P, Guia CM, Melo NS, Paula A. Correlations between seven panoramic radiomorphometric indices and bone mineral density in postmenopausal women. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2010;109(3):449–56.
22. Jonasson G, Bankvall G, Kiliaridis S. Estimation of skeletal bone mineral density by means of the trabecular pattern of the alveolar bone, its interdental thickness, and the bone mass of the mandible. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2001;92(3):346–52.
23. Kiswanjaya B, Priaminiarti M, Bachtiar-Iskandar HH. Three panoramic indices for identification of healthy older people at a high risk of osteoporosis. *Saudi Dent J*. 2022;34(6):503–8.
24. Gaur B, Chaudhary A, Wanjari P, Sunil M, Basavaraj P. Evaluation of panoramic radiographs as a screening tool of osteoporosis in post menopausal women: a cross sectional study. *J Clin Diagnc Res*. 2013;7(9):2051–5.
25. Balcikonyte E, Balciuniene I, Alekna V. Panoramic radiographs in assessment of the bone mineral density. *Stomatologija*. 2004;6(1):17–9.
26. Gassama BC, Ndiaye ML, Lecor PA, Diop P, Toure S. Mandibular bone changes and dental status: A radiomorphometric study by the mandibular cortical index on a Senegalese female population aged 40 years and over. *Adv Oral Maxillofac Surg*. 2021;4:100200.
27. Alam TA, AlShahrani I, Assiri KI, Almoammar S, Togoo RA, Luqman M. Evaluation of Clinical and Radiographic Parameters as Dental Indicators for Postmenopausal Osteoporosis. *Oral Health Prev Dent*. 2020;18(3):499–504.

## Author biography

**Sowmya Gujjar Vishnurao,** Professor https://orcid.org/0000-0002-6441-0426

**Roopa S Rao,** Professor

**Pradeep Kumar,** Professor

**Ashok L,** Professor & Head

**Anitha Krishnan Pandarathodiyil,** Associate Professor

**Cite this article:** Vishnurao SG, Rao RS, Kumar P, Ashok L, Pandarathodiyil AK. Osteoporotic alterations of mandible in aged women using panoramic radiograph: A multicentric study. *IP Int J Maxillofac Imaging* 2024;10(3):100-107.