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Evaluation of radio-morphometric indices of mandible using digital panoramic radiography: a radiographic study

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Abstract

Background: Bone mineral density (BMD) varies with race, ethnicity, age, and gender. Thus arises the need for population-specific value ranges. Qualitative and quantitative indices of the mandible have also been used for panoramic radiographs to assess bone quality and to observe signs of resorption and osteoporosis.

Aim: To measure the radio-morphometric indices in a digital panoramic radiograph and to find the inter-relationship of the indices with the age and sex of the patients.

Materials and Methods: The study included 100 digital panoramic radiographic images of patients, and the samples were divided into four age groups. A panoramic radiograph of each patient was taken, and radio-morphometric indices were determined. Four indices, namely, cortical width at the gonion (GI) and below the mental foramen (MI), Mandibular cortical index (MCI) and Panoramic Mandibular Index (PMI), were measured bilaterally in all panoramic radiographs. All images were analyzed, and index values were calculated by applying linear measurements on the panoramic radiographs.

Results: Statistically significant differences were observed among the study population.

Conclusion: Radio-morphometric indices in a panoramic radiograph may possibly be used as a potential screening tool in identifying individuals with osteoporosis.

Keywords: Gonion index, Mental index, Panoramic radiography.

1. Introduction

The silent epidemic of osteoporosis is crippling society. Osteoporotic fractures are associated with substantial morbidity, incremental medical cost and high mortality risk. The use of oral radiographs has been proposed as a screening tool [1]. Qualitative and quantitative indices of mandibles have also been used for panoramic radiographs to assess bone quality and to observe signs of resorption and osteoporosis [2]. The prevalence of osteoporosis and the incidence of fracture vary by sex, age and race/ethnicity. Panoramic radiographs are economically feasible and result in low patient exposure to radiation [3]. In this study, the Mandibular cortical index (MCI), Panoramic Mandibular Index (PMI), Gonial index (GI) and Mental index (MI) are obtained on digital radiography to evaluate the mandibular bone density. Therefore, this study aimed to measure the radio-morphometric indices and to find the inter-relationship of the indices with the age and gender of the patients using digital panoramic radiography.

2. Materials and methods

The study included 100 digital panoramic radiographic images of patients, and the samples were divided into four age groups, namely 20-35yrs (Group 1), 36-50 years (Group 2), 51-65 years (Group 3), 65 years & above (Group 4). A panoramic radiograph of each patient was taken, and radio-morphometric indices were determined.

The study was carried out from the period January 2021 to October 2021. A total of 100 individuals requiring orthopantomogram (OPGs) for various dental diseases in the age range of 20 years to 65 years & above were selected from patients visiting the oral radiology department. An ethical clearance to conduct the study was obtained from the ethical committee of the institute prior to the study. Written informed consent was obtained from each patient to use their radiographs for the study. Data was obtained regarding age and medical history, and a thorough clinical examination of the oral cavity was done, dental status was established and recorded. The digital panoramic images were obtained using the software Digora Soredex 2.8. The following radio-morphometric indices were made:

Digital Panoramic images of patients with good quality, and images of patients aged 20 years and above were included in the study. Poor quality images resulting from patient positioning errors, images with inadequate demonstration of mental foramen and inferior cortex of mandible, images of the subjects with history of any diseases affecting the bone, and images with artifacts were excluded.

2.1 Mandibular Cortical Index (MCI) (Figure 1)

MCI was calculated based on the appearance of the cortical border of the mandible distal to the mental foramina. MCI was assessed according to the criteria defined by Klemetti.
C1 - The endosteal margin of the cortex is even and sharp on both sides.
C2 - The endosteal margin shows semilunar defects (lacunar resorption) and /or seems to form endosteal cortical residues on one or both sides.
C3 –The cortical layer forms endosteal cortical residues and is clearly porous.

2.2 Gonial Index (GI) (Figure 2)

Two lines were drawn: one tangential to the posterior edge of the mandibular angle and another tangential to the mandibular body. At the intersection of these two tangents, the angle was divided with a bisecting and parallel to that bisect, measurements were made of cortical of the mandibular angle (normal value of > 1.2 mm)

2.3 Mental index (MI) (Figure 3)

A tangent was drawn to the mandibular border and perpendicular to this, a tangent line intersecting the top edge of the foramen was drawn. In parallel to this line was measured cortical thickness (normal value > 3.1mm).

2.4. Panoramic Mandibular Index (PMI) (Figure 4)

A line was drawn, which passed perpendicular to the tangent to the lower border of mandible and through the center of the mental foramen. All measurements were done on this line (normal value > 0.3).

Superior PMI=C/S
Inferior PMI=C/I
PMI= Mean of superior and inferior PMI.
C=Thickness of cortex.

2.5 Statistical Analysis

The Statistical Package for the Social Sciences (SPSS 23) was used for the statistical analysis of the data. Kruskal-wallis test was used to determine gender, and whether there was a statistical difference of radio-morphometric indices between two groups, for example, between males and females. The Pearson correlation test was used to determine the correlation of indices between the right and left sides of the radiograph. The Mann-Whitney test was used to determine the statistical correlation between age and indices.

3. Results

The data obtained for all 100 panoramic radiographs analyzed are presented in Tables 1, 2 and 3. Patients from age group 1 showed the highest values for all indices, and group 4 presented the lowest values for all indices (Figures 5 - 10). Measurements of indices were made on both sides of the radiographs. Statistical analyses showed a significant difference between the results of each group analyzed in both male and female patients, using the Kruskal-Wallis test. Digital measurements on OPGs are sufficiently accurate. The present study demonstrated a decrease in MCI, GI, MI, and PMI in females at the age of 60 ($p<0.05$). Our study showed a statistically significant difference for GI, and MI between males and females ($p<0.05$). Among 60-69-year-olds, females showed a lower cortical thickness.

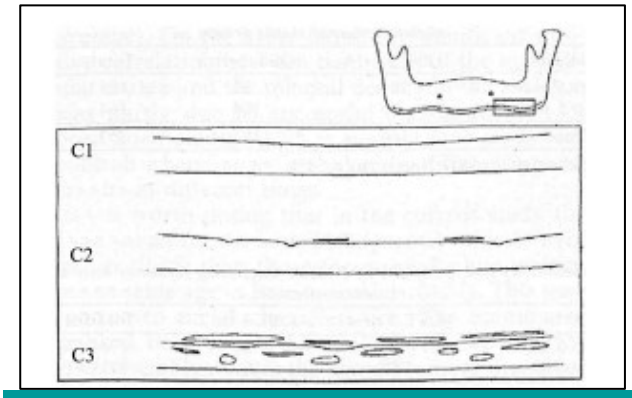
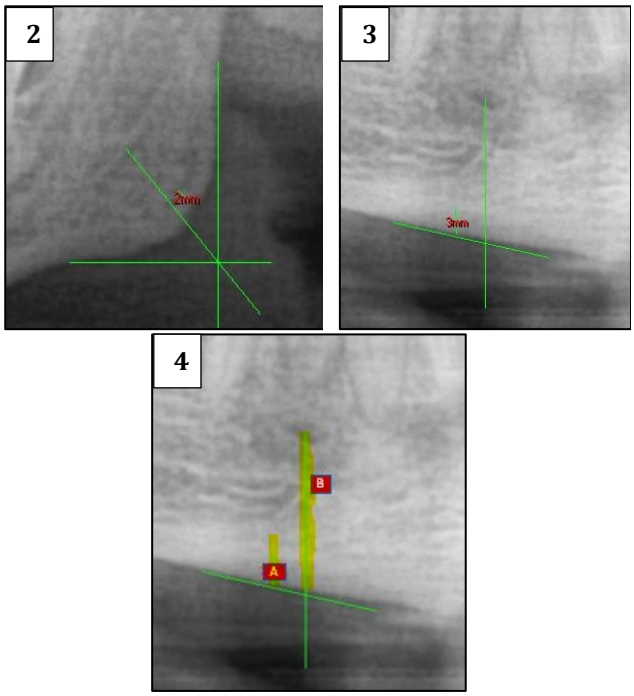


Figure 1. Mandibular Cortical Index (MCI)



Figures 2 - 4. Where, 2. Gonial Index (GI), 3. Mental index (MI), and 4. Panoramic Mandibular Index (PMI)

Table.1 MCI with age & gender

GENDER	AGE	C1	C2	C3
Male	20-35	80%	20%	0%
	36-50	60%	40%	0%
	51-65	70%	30%	0%
	65yrs & above	70%	30%	0%
Female	20-35	90%	10%	0%
	36-50	100%	0%	0%
	51-65	80%	20%	0%
	65yrs & above	30%	60%	10%

Table.2 Variation of GI, MI& PMI with age

Index	Age	Mean	SD*	P - value
GI	20-35	3.24	0.51	0.041
	36-50	3.20	0.63	
	51-65	3.02	0.56	
	65yrs & above	2.85	0.65	
MI	20-35	3.83	0.58	0.052
	36-50	3.86	0.53	
	51-65	3.83	0.53	
	65yrs & above	3.57	0.67	
PMI	20-35	0.33	0.07	0.048
	36-50	0.33	0.06	
	51-65	0.33	0.06	
	65yrs & above	0.30	0.06	

*SD – Standard deviation.

Table 3. Variation of GI, MI, and PMI with gender

Index	Gender	Mean	SD*	P-value
GI	Male	3.33	0.56	0.048
	Female	3.06	0.62	
MI	Male	3.97	0.70	0.028
	Female	3.64	0.64	
PMI	Male	0.33	0.059	0.037
	Female	0.32	0.069	

*SD – Standard deviation.

4. Discussion

Bone mineral density (BMD) varies with race, ethnicity, age, and gender, thus raising the need for population-specific value ranges. Radiographs remain the preferred method to assess BMD because of the high costs and limited access associated with other techniques. The present study demonstrated a decrease in MCI, GI, MI, and PMI in females at the age of 60 ($p<0.05$). Our study showed a statistically significant difference in GI, and MI between males and females ($p<0.05$). Lower values could be attributed to the constitutional differences between the genders. In a present study, it was found that MI and GI decreased with age in females but increased in males. In a further study, there was a general decrease in values of MI and GI in both genders until 65 years, and then both indices decreased sharply for females in contrast to males.

Researchers found out that MI is lower in women than in men and is lower among female patients with osteoporosis compared with healthy female individuals. Occlusal deformities could also lead to trabecular alteration and could have an impact on the density of bone. According to Horner and Devlin (2002) [1], measures of the inferior cortex of the mandible below 3 mm were considered as a parameter for diagnosis of low bone mineral density, there were minor or borderline measures to that found by Bras et al. (1982) [2], which held that a cortical thickness of less than 1mm in gonial angle is an indicator of metabolic bone loss. Above 65 years, females showed a lower cortical thickness.

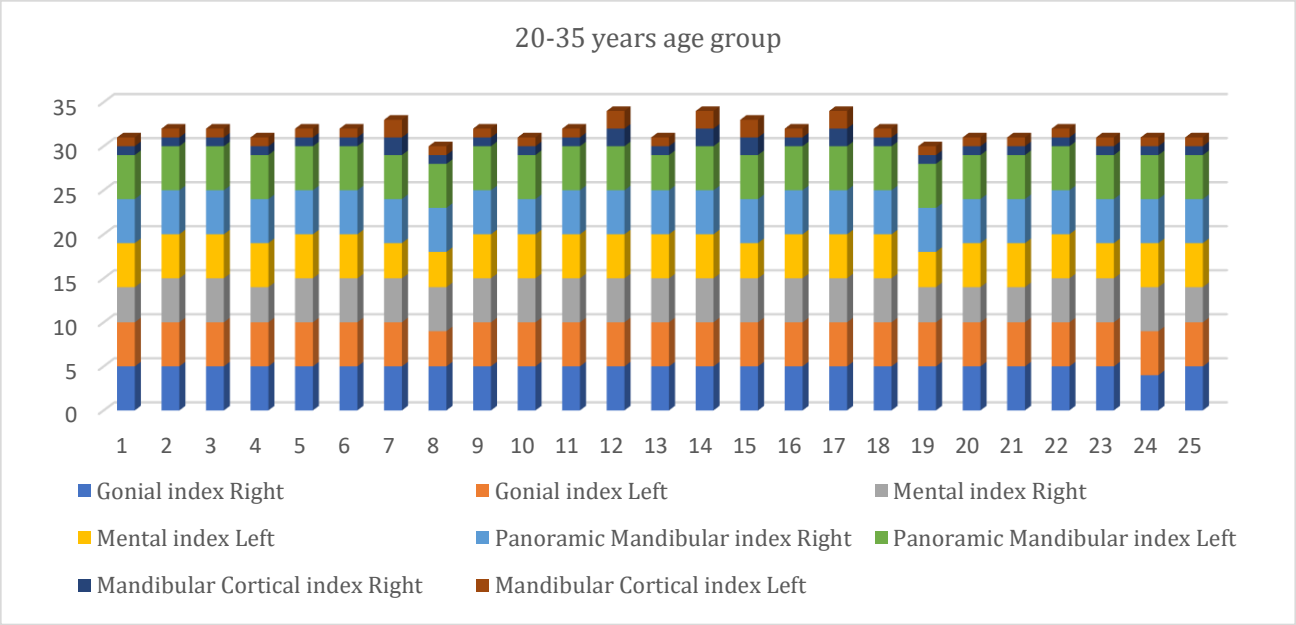


Figure 5. Age related variation of indices on both right & left side in age group 1

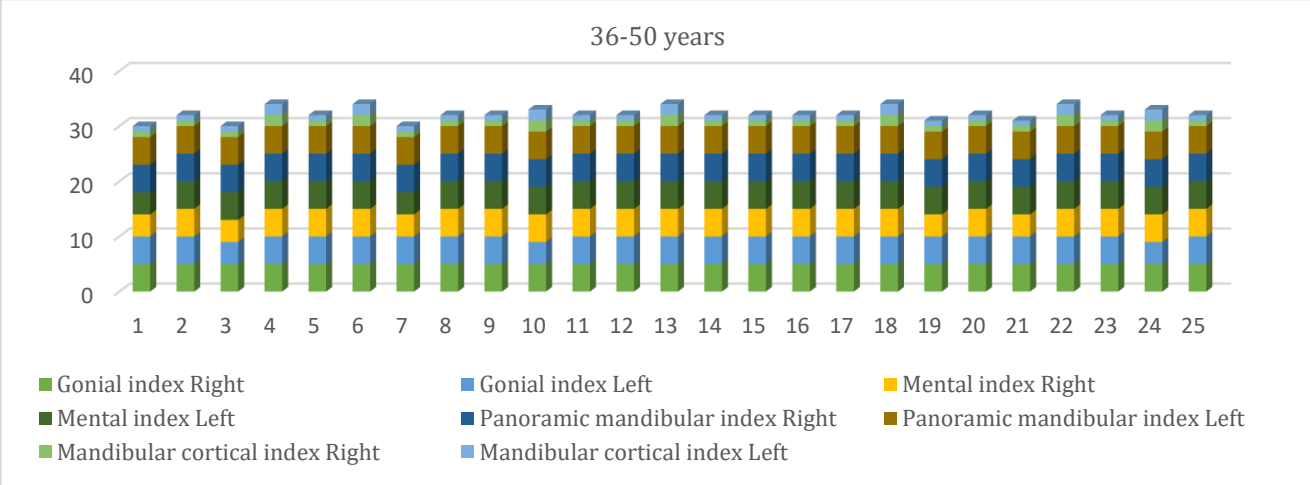


Figure 6. Age related variation of indices on both right & left side in age group 2

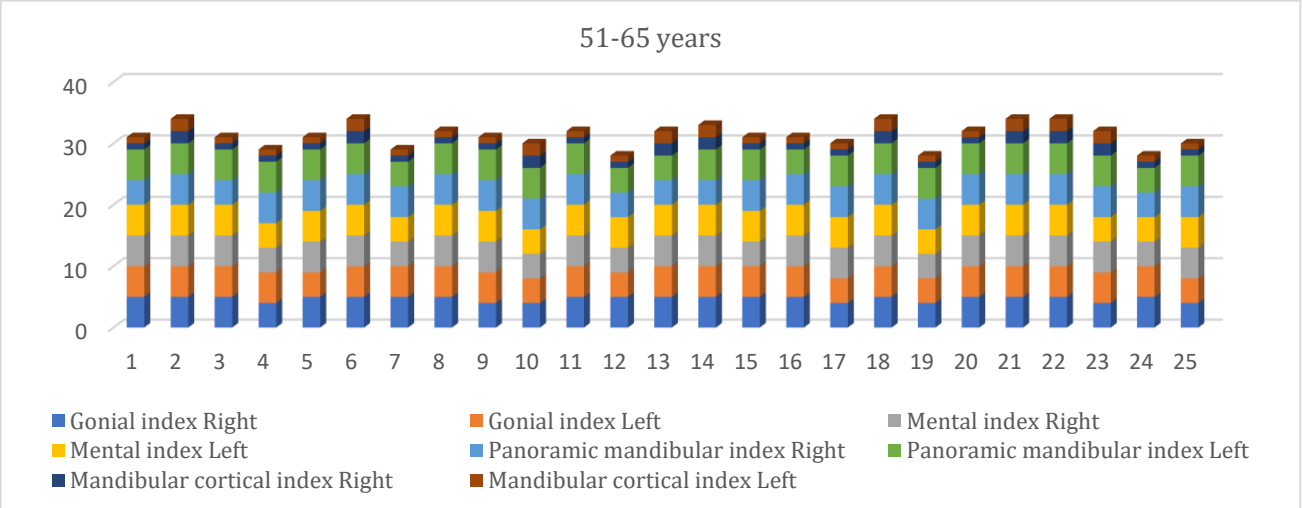


Figure 7. Age related variation of indices on both right & left side in age group 3

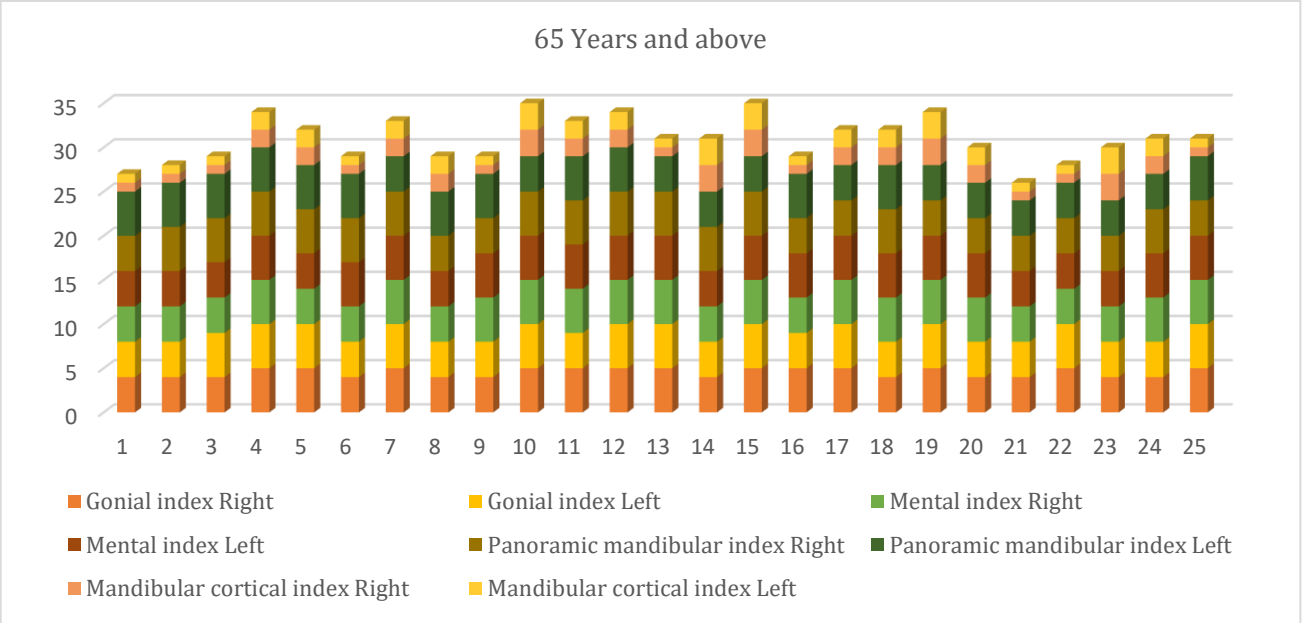


Figure 8. Age related variation of indices on both right & left side in age group 4

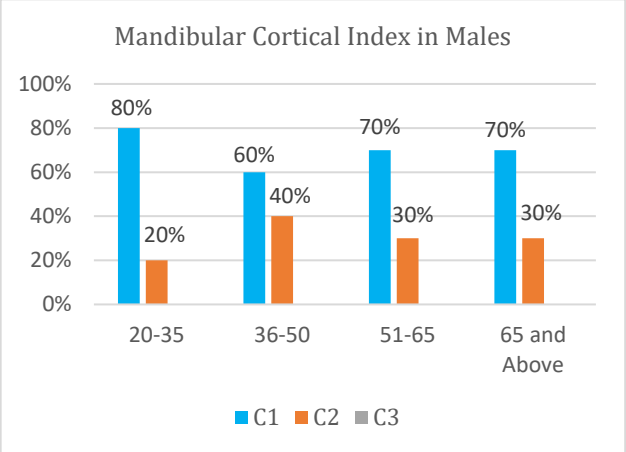


Figure 9. Mandibular Cortical Index values in Females

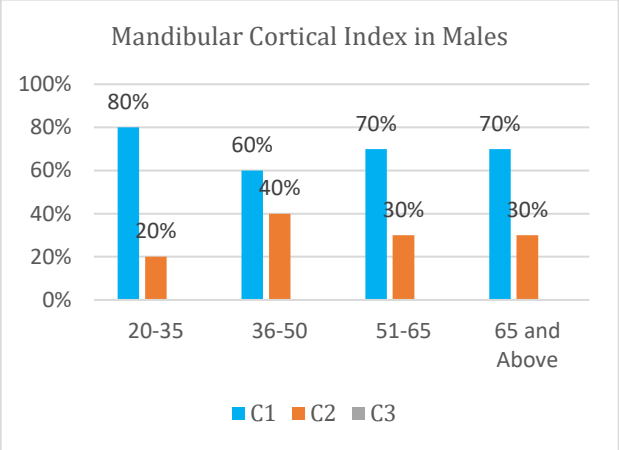


Figure 10. Mandibular Cortical Index values in Males

Many investigators considered patients with C2, and C1 to be normal and C3 to be osteopenic. In a study done by Gulsahi *et al.*, patients with C3 type of MCI should be considered as high-risk individuals for osteoporosis irrespective of age and gender [3]. Leite et al., considered MCI to be one of the accurate indices in assessing low BMD [4]. Kiswanjaya *et al.*, Dagistan *et al.*, and Hastar *et al.*, concluded that MCI could be used as one of the ancillary tools for assessing low skeletal bone mass [5-7]. The advantage of MCI is that it does not involve any measurements. It is an index of porosity, which is not affected by minor changes in magnification between x-ray machines [8,9]. Although the reliability of a two-dimensional radiograph; orthopantomography is very low because of its limitations such as overlapping of structure and artefacts, the density of bone considering the width and height can be well identified with the digital pantamographs.

Difficulty in the identification of mental foramina due to multiple foramina, porous appearance of mandible creating radiolucencies, dense trabecular pattern, and increased film density causes variation in PMI [10-12]. In this study, none had multiple foramen and cases with ill-defined mental foramen were rejected. One major advantage of PMI over MI is that since it is a ratio its method of calculation takes account of differences in magnification associated with different panoramic equipment.

In the present study, the population mean of GI, MI, and PMI among males were 3.33, 3.97,0.33, respectively and among females were 3.06, 3.64, 0.32, respectively. In the present study, PMI demonstrated a gradual reduction with age. A contrasting report showed that in females, PMI demonstrated a gradual increase until the sixth decade and then decreased. A significant difference was found between the younger and older age groups [13-14]. In the present study variation of GI, MI & PMI with age showed significant values of 0.041, 0.052, 0.048 and GI, MI & PMI with gender showed significant values of 0.048, 0.028, 0.037.

6. Conclusion

Bone mass and density are important factors contributing to bone strength. The elastic modulus of bone, a property of bone that is conceptually linked to its fragility, is proportional to the cube of its density. Therefore, small changes in bone density are associated with larger changes in bone strength. Osteoporosis is defined as "a disease characterized by low bone mass and micro-architectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk". Osteopenia can be identified by thinning of the cortex at the lower border of the mandible. Several mandibular cortical indices have been developed to allow the quantification of mandibular bone mass and the identification of osteopenia. Radio-morphometric indices i. e. MCI, PMI, GI and MI can be effectively measured on a panoramic radiograph and, hence could be used as a screening tool for determining osteoporosis. Using the MCI, patients with normal bone mass could be differentiated from those with reduced bone mass (osteopenia /osteoporosis). The present paper supports the importance of age & gender-related changes in mandibular radio-morphometric indices in identifying osteopenia and the role of osteoporosis in radio-morphometric index alterations, which can occur significantly and differently in male and female patients. Thus, radio-morphometric indices in a panoramic radiograph may be used as a potential screening tool in identifying individuals with osteoporosis.

Conflicts of interest: Authors declared no conflicts of interest.

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