Original Article

Panoramic mandibular index: Effect of age and gender related variations in the North-Indian population

Bathla S[1], Srivastava SK[2], Sharma RK[3], Chhabra S[4]

[1]*Dr Shilpa Bathla*
MBBS, MD
Assistant Professor, Anatomy

[2]*Dr SK Srivastava*
MBBS, MS
Ex-Senior Professor, Anatomy
sks_4848@rediffmail.com
[3]*Dr RK Sharma*
BDS, MDS
Professor, Periodontics
Pt. B.D. Sharma Post Graduate Institute of Dental Sciences Rohtak, Haryana, India
rksharmamds@yahoo.in
[4]*Dr Sudha Chhabra*
MBBS, MS
Senior Professor and Head, Anatomy
drsudhachhabra@gmail.com
[1,2,4]*Pt. B.D. Sharma Post Graduate Institute of Medical Sciences, Rohtak, Haryana, India*

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Correspondence to:
Dr Shilpa Bathla
+91-9729197065
drshilpa0810@gmail.com

ABSTRACT

Background: *Panoramic Mandibular Index (PMI) is a quantitative radiomorphometric index of the mandible. It is an important indicator of mandibular bone mineral density.*

Objectives: *To examine the age and gender related variations associated with the panoramic mandibular index and their effect in a group of North-Indian population of Haryana.*

Methods: *60 adult human orthopantomographs were evaluated and divided into six age groups (35-65 years) with equal number of males and females. Panoramic mandibular index was measured bilaterally on every radiograph. The measurements were analyzed for interactions with age and sex, using SPSS (Stastistical Package for Social Studies) software version no. 18. The tests employed were Kruskal-Wallis, Mann-Whitney and the unpaired T-test.*

Results: *The male mean panoramic mandibular index values ranged from 0.3 ± 0.025 to 0.381 ± 0.019, whereas the female mean panoramic mandibular values ranged from 0.286 ± 0.306 to 0.36 ± 0.007. Panoramic mandibular index showed significant negative correlation with age in both the sexes. Inter-age group comparisons showed statistically significant differences between the youngest and eldest age-groups in both the genders. Female values were lower than male values in all age groups, but sexual dimorphism was not observed.*

Conclusion: *Panoramic mandibular index was influenced significantly by the variations in age but minimally by the gender related variations.*

Key Words: *Panoramic mandibular index, mandibular inferior cortex, mental foramen, panoramic radiographs, radiomorphometric indices of mandible, sexual dimorphism*

Introduction

Osteoporosis, a systemic skeletal disease characterized by low bone mass predisposes to an increased risk of fracture. Bone mass is primarily determined by genetic factors, gender being the most important. The peak bone mass is observed around 30 years of age in both genders but is greater in males than in females. Bone loss occurring with age is a commonly observed phenomenon in humans. It affects both sexes but is increased in postmenopausal females.[1] Apart from age and gender, the multifactorial etiology of osteoporosis includes racial background, poor nutrition, reduced physical activity, smoking, excessive alcohol consumption, corticosteroid medication and other factors that affect bone remodeling rates.[2]

Previous work has established that mandibular bone mineral density is significantly correlated with that of skeletal sites important in assessment of osteoporosis (hip, lumbar spine).[3,4,5,6] In

the last few years, a variety of radiomorphometric indices for the mandible have been developed by various dental researchers all over the globe which are indicative of mandibular bone mineral density and have been successfully used in many studies for the correlation of altered mandibular morphology with skeletal osteoporosis. One of the frequently used radiomorphometric index is Panoramic Mandibular Index (PMI), a quantitative index based on the cortical width of inferior border of mandible.[7] In many studies conducted all over the world, panoramic mandibular index has presented the highest sensitivity among radiomorphometric indices in detection of osteoporosis and osteopenia and also the discretion to differentiate between the two conditions.[8,9] The potential use of this index in the screening of osteoporotic patients, augmented by its easy availability (since a large fraction of adult population undergoes radiographic examination as a part of their routine dental treatment), safety (minimal exposure to radiation) and cost-effectiveness; has made it an exciting avenue of research all over the globe.[10]

Numerous independent researchers have established the role of panoramic mandibular index in successful correlation of altered mandibular morphology with skeletal osteoporosis.[7,9,10] There is a continuous remodeling in the mandibular cortex associated with dental status and age, which presents differently in both the genders.[11] The correlations of panoramic mandibular index with age and gender have been reported by some authors, using mostly post-menopausal females and osteoporotic patients as the subjects of their respective studies.[9,12] However, there is scarcity of literature establishing the interaction of factors like age and gender with the panoramic mandibular index in a normal population, especially for men. The knowledge of such interactions is also important for successful dental treatments and implants. In addition to this, the comparisons of the panoramic mandibular index between different populations of the world involving various races and ethnic communities, which form an essential basis in the global standardization of any morphometric parameter, are very limited. Therefore, the present study was undertaken with the aim of measuring and studying the age and gender related variations in the panoramic mandibular index in the North-Indian population of Haryana (a state of India).

Materials and Methods

The study sample and design

This study was conducted in the department of Anatomy, Pt.B.D.Sharma Post Graduate Institute of Medical Sciences, Rohtak (Haryana, India) using 60 adult dental panoramic radiographs i.e. orthopantomographs; 30 males and 30 females, ranging from 35 to 65 years of age. The radiographs were obtained from department of Periodontology, of routine patients visiting dental clinics for various indications like periodontal diseases, implantations, cosmetic treatment etc. The radiographic machine used was Kodak 8000 (Kodak Eastman Company, France). Name, age and sex of the patient were recorded for each radiograph from the records of the radiography department. The following radiographs were excluded from the study:

- Poor quality images.
- Radiographs where the margins of mental foramen were not easily identified.

- Radiographs in which the inferior cortical borders of mandible were not clearly identified.
- Radiographs which showed any obvious gross distortion of the normal anatomical landmarks, for example, presence of a cyst, destructive lesions of mandible- which interfere with measurements.

The whole sample size of 60 orthopantomographs was divided into six age-groups of five-year age interval each as follows: group 1: 35-40 years, group 2: 41-45 years, group 3: 46-50 years, group 4: 51-55 years, group 5: 56-60 years, group 6: 61-65 years. Ten radiographs were used for each group with equal distribution of males and females.

Radiographic Measurements

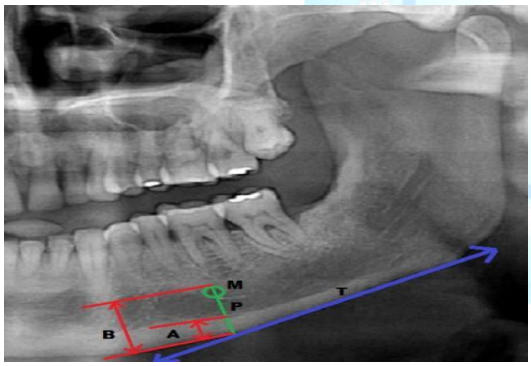

Fig. 1 Method of measuring Panoramic Mandibular Index (PMI): T- line tangent to the lower border of mandible, P- line perpendicular to T, passing through centre of mental foramen, A- mandibular cortical thickness on line P, B- distance from the superior margin of mental foramen to the lower border of mandible on the line P; PMI=A/B

The digitalized radiographs were printed on special photographic papers. The linear measurements were carried out using a vernier caliper. Panoramic mandibular index (PMI) was calculated according to the technique described by Benson et al.[12] It is the ratio of mandibular cortical thickness (measured on the line perpendicular to the tangent to the lower border of mandible and passing through centre of mental foramen) divided by the distance between the superior margin of mental foramen to the inferior border of the mandible; measured along the same perpendicular line mentioned earlier (Fig. 1). PMI was measured bilaterally on all radiographs and the mean of right-sided and left-sided measurements was calculated for every radiograph.

Statistical Analysis

Comparisons of the mean values of PMI were made between different age groups and also between both sexes. The data obtained from comparisons was subjected to statistical analysis using SPSS (Statistical package for social studies) software version no. 18. Kruskal-Wallis and Mann-Whitney tests were used for inter- and intra-age-group comparisons. Unpaired T-Test was used to ascertain the presence of sexual dimorphism.

Results

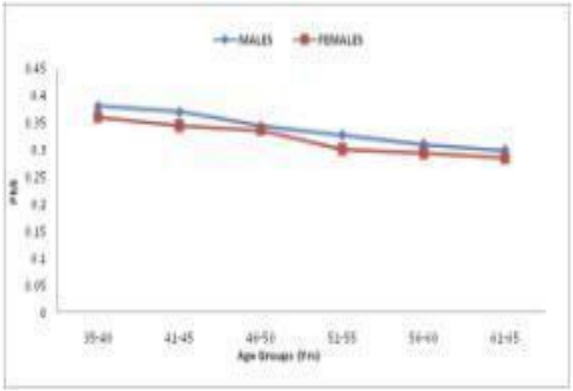

Fig. 2 Graph depicting the trend of mean Panoramic Mandibular Index (PMI) values with increasing age in males & females

Table 1: Panoramic Mandibular Index (PMI) values in Males in different age- groups

Age Group		No of Cases (n)	Males		Kruskal Wallis Test (p-value)
No	In yrs		Range	Mean PMI ± S.D.	
1	35-40	5	0.349-0.398	0.381 ± 0.019	p < 0.05
2	41-45	5	0.328-0.408	0.37 ± 0.029	
3	46-50	5	0.296-0.379	0.344 ± 0.033	
4	51-55	5	0.305-0.36	0.328 ± 0.025	
5	56-60	5	0.277-0.343	0.311 ± 0.028	
6	61-65	5	0.274-0.329	0.3 ± 0.025	

The range of panoramic mandibular index values recorded for males in the present study is shown in Table No.1. In males, the mean panoramic mandibular index values ranged from 0.3 ± 0.025 to 0.381 ± 0.019. There was a uniform trend of decrease in values of mean panoramic mandibular index with increase in age in males (Fig.2). The highest mean panoramic mandibular index value in males was reported in group 1 (35-40 years) and the lowest mean panoramic mandibular index value in males was seen in group 6 (61-65 years). The difference in the mean panoramic mandibular index values in the six different age-groups in males was found to be statistically significant by Kruskal-Wallis test ($p<0.05$) (Table No. 1).

Table 2: Panoramic Mandibular Index (PMI) values in Females in different age-groups

Age Group		No of Cases (n)	Females		Kruskal Wallis Test (p-value)
No	In yrs		Range	Mean PMI ± SD	
1	35-40	5	0.35-0.37	0.36 ± 0.007	p < 0.05
2	41-45	5	0.293-0.398	0.344 ± 0.05	
3	46-50	5	0.313-0.354	0.337 ± 0.016	
4	51-55	5	0.262-0.318	0.302 ± 0.023	
5	56-60	5	0.28-0.337	0.295 ± 0.024	
6	61-65	5	0.229-0.314	0.286 ± 0.036	

The range of panoramic mandibular index values recorded for females in the present study is shown in Table No.2. In females, the mean panoramic mandibular index values ranged from 0.286 ± 0.036 to 0.36 ± 0.007. A trend of decrease in panoramic mandibular index values was observed with increasing age in females and this decrease was the most prominent in group 4 (41-45 years) (Fig.2). The highest mean panoramic mandibular index value in females was seen in group 1 (35-40 years) while the lowest mean panoramic mandibular index value in females was recorded for group 6 (61-65 years). The difference in mean panoramic mandibular index values in six different age groups was found to be statistically significant by Kruskal-Wallis test ($p<0.05$) (Table No. 2); similar to males.

Significant negative correlations ($p<0.05$) between age and mean panoramic mandibular index were recorded for both males and females (Fig. 3). Value of the correlation coefficient was greater in males than in females.

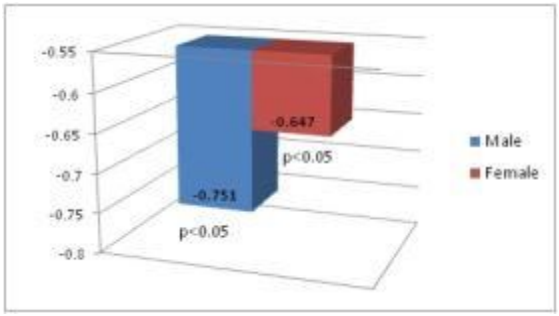

Fig. 3 Pearson's correlation-coefficient (r-values) between age and mean Panoramic Mandibular Index (PMI) in males and in females

The mean panoramic mandibular index values were compared separately for successive age groups for both males and females, using Mann-Whitney tests. These inter-age-group comparisons showed statistically significant differences only between groups 1 and 6, in both the sexes. (Table No. 3).

Table 3: Comparison of the mean Panoramic Mandibular Index (PMI) values between different age groups (Mann-Whitney Tests)

Age groups compared		Males	Females
Group No.	In yrs		
1&2	35-40 & 41-45	p>0.05	p>0.05
2&3	41-45 & 46-50	p>0.05	p>0.05
3&4	46-50 & 51-55	p>0.05	p>0.05
4&5	51-55 & 56-60	p>0.05	p>0.05
5&6	56-60 & 61-65	p>0.05	p>0.05
1&6	35-40 & 61-65	**p<0.05**	**p<0.05**

Table 4: Age-wise comparisons between male and female mean Panoramic Mandibular Index (PMI) values (Mann-Whitney tests)

Age Group No.	Age-group (Yrs)	Mean Male PMI ± S.D.	Mean Female PMI ± S.D.	p-value
1	35-40	0.381 ± 0.019	0.36 ± 0.007	p > 0.05
2	41-45	0.37 ± 0.029	0.344 ± 0.05	p > 0.05
3	46-50	0.344 ± 0.033	0.337 ± 0.016	p > 0.05
4	51-55	0.328 ± 0.025	0.302 ± 0.023	p > 0.05
5	56-60	0.311 ± 0.028	0.295 ± 0.024	p > 0.05
6	61-65	0.3 ± 0.025	0.286 ± 0.036	p > 0.05

Table 5: Mean Panoramic Mandibular Index (PMI) in Males vs. Females (Unpaired T-Test)

Radio morphometric Index	Cases compared		Mean PMI ± SD		p-value
	Male	Female	Male	Female	
PMI	30	30	0.339 ± 0.039	0.321 ± 0.039	p > 0.05

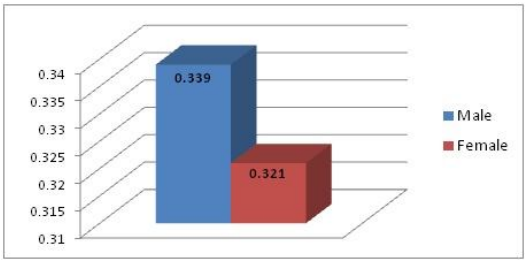

Fig. 4 Comparison of the mean Panoramic Mandibular Index between males and females

Even though the overall male mean GA value was greater than its female counterpart (Fig. 4), this difference was calculated as statistically insignificant ($p>0.05$) by the unpaired T- test (Table no. 5). Hence, there was no sexual dimorphism observed.

Female mean PMI values showed lower values than male mean PMI values in all age-groups (Table No. 4, Fig.2). But on statistical analysis, no significant differences were found in males and females of same age-groups in all six different age-groups (Table No. 4).

Discussion

Table 6: Comparison of the results of the present study with previous studies - I

AUTHOR	Population	Age-group	MALES		
			Range Of Mean Panoramic Mandibular Index	**Correlation Between Panoramic Mandibular Index And Age**	**Inter age-group comparisons**
Benson et al[19]	American	30-79 yrs	0.315 to 0.353	Increase with age	p>0.05
Raghdaa et al[13]	Egyptian	20-70 yrs	0.327 to 0.356	No uniform trend	-
Kalinowski et al[14]	Polish	20-95 yrs	0.12 to 0.51	-	-
Rao et al[15]	South Indian	30-60 yrs	0.267 ± 0.043 to 0.286 ± 0.007	Gradual decrease with age	-
Present Study	North Indian	35-65 yrs	0.3 ± 0.025 to 0.381 ± 0.019	Decrease with age, significant correlation	Groups 1&6: p<0.05

Table 7: Comparison of the results of the present study with previous studies - II

AUTHOR	Population	Age-group	FEMALES		
			Range Of Mean Panoramic Mandibular Index	Correlation Between Panoramic Mandibular Index And Age	Inter age-group comparisons
Benson et al[19]	American	30-79 yrs	0.266 to 0.352	Decrease with age, esp. after 50 yrs	p<0.05
Raghdaa et al[13]	Egyptian	20-70 yrs	0.330 to 0.365	No uniform trend	-
Kalinowski et al[14]	Polish	20-95 yrs	0.07 to 0.52	-	-
Rao et al[15]	South Indian	30-60 yrs	0.265 ± 0.037 to 0.286 ± 0.068	Decrease after 50 yrs	-
Present Study	North Indian	35-65 yrs	0.286 ± 0.306 to 0.36 ± 0.007	Decrease with age, significant correlation	Groups 1&6: p<0.05

Table 8: Comparison of the results of the present study with previous studies - III

AUTHOR	Population	Age-group	Sexual Dimorphism	Age - wise comparisons between Males and Females
Benson et al[19]	American	30-79 yrs	Absent	Males > Females
Raghdaa et al[13]	Egyptian	20-70 yrs	Absent	Females > Males
Kalinowski et al[14]	Polish	20-95 yrs	Present, Male > Female	Males > Females
Rao et al[15]	South Indian	30-60 yrs	Absent	Almost comparable
Present Study	North Indian	35-65 yrs	Absent	Males > Females

The observations made in the present study implied that age had a strong association with panoramic mandibular index as the difference in the mean panoramic mandibular index values in the six different age-groups in both sexes was found to be statistically significant.Whereas, the effect of sex on panoramic mandibular index was minimal and also statistically insignificant. A comparative study of the results of our study with those of previous authors is presented in Tables No. 6,7,8.

A highly significant negative correlation was observed between panoramic mandibular index and age in both the genders in our study. However, there is controversy in literature regarding the effect of age on panoramic mandibular index in both sexes as contrasting results have been reported by various authors. In our study, the mean panoramic mandibular index values in males showed a gradual decrease with increasing age and a significant negative correlation was calculated. Our results are supported by studies of Knezovic et al[16] (Croatian population) and Rao et al[15] (South-Indian population) (Tables No. 6&7). This is in accordance with the general consensus that bone mass decreases with age.[15] Bone tissue undergoes constant change caused by simultaneous processes of decay (resorption) by osteoclasts and formation (regeneration) by osteoblasts; termed as bone remodeling.[17] About the third decade of life, bone mass reaches its maximum, after which it starts to decrease owing to decreased osteoblastic activity. In sharp contrast to this, Benson et al[12] (American population) have reported an increase in panoramic mandibular index values with age in males. Interestingly, Raghdaa et al[13] in their study conducted on Egyptian population have reported that panoramic mandibular index values in males have shown an increase till age of 50 years, after which a steady decrease was noted (Table No. 6). These authors have quoted the theory of compensatory increase in cortical bone for atrophic mandibles as an explanation for the increase in values of this index with age.[18]

In females, the mean panoramic mandibular index values showed a decrease with increasing age and the decrease was the most prominent in group 4 (51-55 years). These results of our study were strongly supported by Benson et [12] and Rao et al[15] (Table No.7) who have also observed a sharp fall in mean panoramic mandibular index values after 50 years of age in females. This trend is attributed to the onset of postmenopausal osteoporosis. The onset of menopause (45 years onwards) leads to deficiency of estrogen hormone which augments osteoclastic activity leading to bone resorption. Estrogen deficiency also affects the active vitamin-D synthesis in renal tubules leading to reduced calcium absorption. Contrary to this, Mudda et al[19] have reported an increase in female mean mean panoramic mandibular index values with increasing age in South-Indian population.

The mean panoramic mandibular index values recorded in the present study for both the genders were similar to those reported by Raghdaa et al[13] and Benson et al12], but were larger than those reported by Rao et al15] (Tables No. 6&7). On the other hand, mean PMI values calculated by Kalinowski et al[14] in for both males and females were not at all comparable with our results. These differences in the values of the index reported by different authors are attributed to the racial or ethnic differences which exist in various populations of the world for any

morphometric measurement. Besides that, non-uniformity of the sample size could also be a contributory factor.

The inter-age-group comparisons done separately for males and females showed statistically significant differences between the youngest and the eldest age groups, in both the sexes. The study conducted by Benson et al[12] (Tables No. 6&7) recorded similar results in females but not in males.

In the present study, female mean panoramic mandibular values showed lower values than those of males in all age groups. But none of these differences were statistically significant. Similar observations were made by Benson et al[12] and Kalinowski et al[14] (Table No. 8). These observations can be explained by the fact that different mechanisms, specifically hormones, control bone remodeling in males and females and in general, bone mass and skeletal weight is heavier in males. In females, the onset of postmenopausal osteoporosis further contributes to this trend. In sharp contrast to this, Rao et al[15] and Raghdaa et al[13], respectively have reported comparable and higher values for females than males (Table No. 8). Explanation offered by the authors for this unusual finding was a probable lower distance between mental foramen and inferior cortex of mandible in females, owing to skeletal variations between the two sexes. Sexual dimorphism was not observed for panoramic mandibular index in the present study. Contrasting results have been reported in literature regarding this. Our result was supported by Benson et al[12], Raghdaa et al[13] and Rao et al[15] but contradicted by Kalinowski et al[14] who have reported sexual dimorphism for panoramic mandibular index (Table No. 8).

The present study concluded that the Panoramic Mandibular Index (PMI) had varied interactions with the factors of age and sex. PMI presented a significant negative correlation with age in both the sexes, but sexual dimorphism was not recorded. Therefore, while age of an individual had a profound effect on this index, it was affected minimally by the gender of the person.

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