ORIGINAL RESEARCH ARTICLE

Digital Radiography of Mental Foramen and Inferior Alveolar Canal – A Beacon for Gender Determination

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ABSTRACT

Introduction: The mandible is the strongest bone in the human body and persists in a well-preserved state longer than any other bone. One of the mandibular characteristics that can prove very helpful for age and gender determination is mental foramen and mandibular canal. **Aim:** The present study was aimed to determine and compare the radiographic position of mental foramen and shape of the inferior mandibular canal in males and females. **Materials and Methods:** One hundred and ninety-six panoramic radiographs were randomly selected for the analysis of mental foramen and inferior alveolar canal. The radiographs were digitalized and analyzed using the Statistical Package for the Social Sciences (21). $P < 0.05$ was considered to be statistically significant. **Results:** The average values of superior border of the mental foramen to the lower border of the mandible (LBM) and inferior border of mental foramen to the LBM were more in males as compared to females. *P*-value was significant for both the genders and for both the sides. In the present study, the most frequent position of the mental foramen was in the longitudinal axis of the second premolars and was located symmetrically. It was not significant for both males and females. The inter-mental foramen distance showed a mean of 32.15 mm for males and 27.8 mm for females, which was not significant for both males and females. Shapes of the inferior alveolar canal were not significant for both the genders. **Conclusion:** Based on the results of the present study, the distances from the mental foramen and inferior border of the mandible and the shape of the mandibular canal exhibit sexual dimorphism.

Key words: Anatomic position, mandibular canal, mental foramen, panoramic radiography

INTRODUCTION

Panoramic radiography (also called orthopantomography) is a radiographic technique that produces an image that includes both maxillary and mandibular dental arches and the surrounding structures as the maxillary sinus, nasal fossa, temporomandibular joints, styloid processes, and hyoid bone.[1] Although dentists might only concentrate on teeth and their supporting tissues when examining panoramic radiographs, they should also be able to identify all other structures that appear in the image.[2-4] Paeetero were the first to describe the principles of panoramic radiography.[5]

The word panoramic radiography was extracted from the panorama, which means an unimpeded view of an area in every required direction. They utilized to estimate the anatomical and structural relationship of the mandibular canal, the anterior loop of mental nerve, incisive canal, and mental foramen and other associated anatomical critical structures for implant surgery.[6-8]

Many anthropologists have studied the age systems, where age is often a primary organizing principle. Age systems include formal age classes of individuals of similar numerical age, age

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grades, or developmental stages based on social and biological development, and relative ages of individuals.[9] Different studies have well proved that mandible shows the gender dimorphism in many morphological features such as mandible height, gonial angle, bigonial width, and bicondylar width. The anatomical position of mental foramen used to differentiate between gender and such skeleton metric analysis done on radiographs is found to be of more accuracy.[10]

The most reliable and easily identifiable aspect of mental foramen is the distance between the superior border of foramen to lower border of mandible (SMF-LBM) apart from this the inferior border of the mental foramen (IMF) and LBM.[11] The inferior mandibular canal is an anatomical structure placed symmetrically in the mandibular bone. This canal hosts the inferior alveolar artery, vein, and nerve and is situated from the mandibular foramen in the ramus to the mental foramen.[12] The present study was aimed to determine and compare the radiographic position of mental foramen and shape of the inferior mandibular canal in males and females through Orthopantamogram (OPG) imaging.

Objectives of the Study

The objectives of the study were as follows:

- To evaluate and compare the SMF-LBM and the IMF-LBM values for gender differentiation
- To compare inter-mental foramen distance in both genders
- To compare the shape of the inferior alveolar canal in both the genders.

SUBJECTS AND METHODS

The study was performed using 196 digital OPGs that were collected from various private practitioners and diagnostic centers in Vellore, Tamil Nadu, India. The OPGs were of 98 male and 98 female patients who were native to Vellore district and aged between 15 and 55 years (33.7 ± 11.2 among males, 32.5 ± 10.5 among females). OPGs were taken as pre-treatment radiographs for orthodontic purposes.

The study population was divided into five age groups; 15–24 years, 25–34 years, 35–45 years, and 45–55 years. The chronologic age of an individual was calculated by subtracting the birth date from the date on which the radiographs were exposed for that particular individual. Decimal age was taken for simplicity of statistical calculation, and ages were estimated yearly, for example, 15 years 9 months as 15.75 years, and it was considered in 15 years age group.

Ethical Considerations

Confidentiality of cases records was maintained.

Inclusion Criteria

The following criteria were included in the study:

- High-quality radiographs with clearly seen mental foramen and the border of the mandible
- No abnormal dental condition, for example, impaction, transposition, and congenitally missing teeth
- No history of any systemic disease that might affect bone metabolism
- No history of orthodontic or maxillofacial surgery
- No history of trauma or disease to the head, face, and neck.

Exclusion Criteria

The following criteria were excluded from the study:

- Aplasia or other abnormal dental conditions
- Congenital anomalies
- Distortion of images, the presence of artifacts, or no visualization of the mental foramen
- History of prolonged illness, trauma, and disease of the head, face, and neck
- Orthodontic or maxillofacial surgery.

The Equipment Used

1. OPG machine: All radiographs were taken with a digital machine, SIRONA Orthophos XG 5 Ceph with the following parameters:
   - Kilovoltage of 62–73 kVp
   - Tube current 8–15 mA
   - Time for 15 s.
2. Films: Kodak 6 12
3. Scanner: Vista, 4000 U X-ray. The radiographic images were digitized using the scanner
4. Computer: The images were recorded in a computer file. Radiographic images were then processed using computer-aided program AutoCAD 2000.

OPG

The subject was asked to remove any piercing, hair accessories, jewelry, dentures, hair grips, eyeglasses, and metal objects from the head and neck that could interfere with the X-ray images.

Lead gowns were worn to protect the rest of the body.

OPG was taken with the patient in the standing position, with placing his chin on a chin rest and bite on a plastic piece with a disposable cover to hold the jaws in place so that all the teeth, especially the crowns, can be viewed individually. The subjects were instructed to follow all instructions and hold still once positioned, while the arm of the OPG machine rotates slowly around the head.

On OPG, the position of mental foramen (X) was fixed concerning three reference lines [Figure 1].

Mental foramen position parameters:

- SMF
- IMF
- LBM.

On both sides of the mandible, the following parameters were measured in millimeters, according to Mohamed *et al.* (2016) [Figure 1]:

- MF-ML: Distance from mental foramen (MF) to the midline (ML)
- ML-MF: Distance from the midline to the mental foramen.

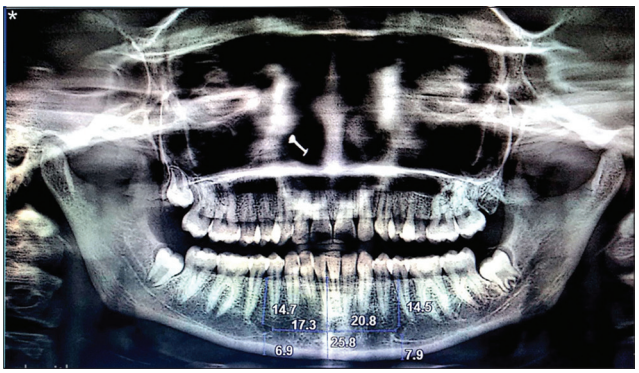


Figure 1: On orthopantomogram, the position of mental foramen was fixed using superior border of mental foramen, IMF, lower border of mandible, and on both sides of the mandible, mental foramen-midline (MF-ML): Distance from MF to the ML and ML-MF: Distance from the midline to the mental foramen was measured

Statistical Analysis

The data were subjected to statistical analysis using the Statistical Package for the Social Sciences (SPSS) (SPSS statistical package, version 21.0). Discriminate functional analysis was used to determine variables that discriminate between males and females and is increasingly utilized for sex diagnosis from skeletal measurements.

RESULTS

A total of 196 mental foramen and inferior alveolar canals were studied. Descriptive statistics of the male and female subjects are presented in the following tables. Depending on the demographic data of the subjects from the present study, the samples were grouped as shown in Table 1. The mean age and SD mean values study was 33.7 ± 11.2 for males and 32.5 ± 10.5 for females. The study showed that the confidence interval is 95%, and the level of significance is 5%.

Table 2 and Graph 1 represent the comparison of SMF-LBM and IMF-LBM. The results showed that distance between the SMF and the LBM in males is 16.25 mm on the right side as well as on the left side. The mean difference was 16.25 ± 0.05 on the right side, which was statistically significant ($P < 0.0001$ HS). The IMF and LBM in males showed 10.55 mm on the right side and 10.65 mm on the left side. The mean difference was 10.6 ± 0.07, which was statistically significant ($P < 0.0001$ HS). The distance between the SMF and the LBM on the right side showed 14.65 mm and 14.45 mm on the left side in females. The mean difference was 14.55 ± 0.11, which was statistically significant ($P < 0.0001$ HS). The IMF and LBM in females showed 6.85 mm on the right side and 7.85 mm on the left side. The mean

Table 1: *t*-test for age and gender distribution of cases

Chronological age (years)	Males (*n*=98)		Females (*n*=98)		Total (*n*=196)			
	Responses (*n*)	Frequency (%)	Responses (*n*)	Frequency (%)	Responses (*n*)	Frequency (%)	*t*	*P*-value
15–24.99	26	26.5	25	25.5	51	26.0	5.9	*P*<0.0001 HS
25–34.99	25	25.5	32	32.6	57	29.3		
35–44.99	26	26.5	24	24.4	50	25.5		
45–54.99	21	21.4	17	17.34	*38*	19.3		
Mean±SD	33.7±11.2		32.5±10.5					

Table 2: Comparison of SMF-LBM and IMF-LBM

Gender	Right (mm)	Left (mm)	Mean±SD	Z-value	*P*-value
Males					
Mean (SMF-LBM)	16.25	16.25	16.25±0.05	3595	*P*<0.0001 HS
Mean (IMF-LBM)	10.55	10.65	10.6±0.07	2648.57	*P*<0.0001 HS
Females					
Mean (SMF-LBM)	14.65	14.45	14.55±0.11	1649.54	*P*<0.0001 HS
Mean (IMF-LBM)	6.85	7.85	7.35±0.50	377.3	*P*<0.0001 HS

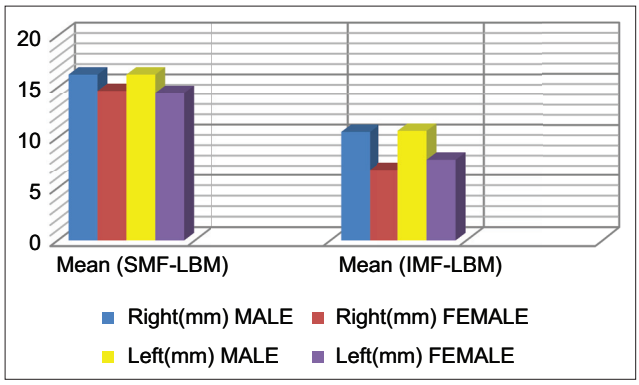
SMF: Superior border of mental foramen, LBM: Lower border of mandible, IMF: Inferior border of mental foramen, LBM: Lower border of mandible

difference was 7.35 ± 0.50, which was statistically significant ($P < 0.0001$ HS).

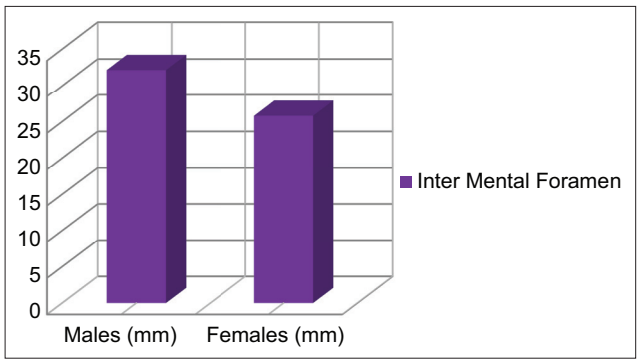
Table 3 and Graph 2 show that the distance between inter-mental foramen in males was 32.15 mm and for females, it is 25.78 mm. The mean difference was 28.95 ± 3.2, which was statistically significant ($P < 0.0001$ HS).

Table 4 shows that the location of mental foramen in males was observed maximum at the longitudinal axis of second premolar, 77.55% on the right side and 71.93% on the left side. The site for the location of mental foramen was observed minimum between the second premolar and first molar, 8.16 on the right side and 9.18 on the left side. In females, the location of mental foramen was observed maximum at the longitudinal axis of second premolar, 67.8% on the right side and 75.5% on the left side. The site for the location of mental foramen was observed minimum between the second premolar and first molar, 9.69% on the right side and 6.12% on the left side.

The shape of the inferior alveolar canal for males on the right side showed elliptical (83.1%), linear (4.6 %), turning (5.6%), and spoon (6.6%) and on the left side, elliptical (92.3%), linear (1.5%), turning (2.5%), and spoon (3.5%) [Table 5 and Graph 3]. The shape of the inferior alveolar canal for females on the right side showed elliptical (89.8 %), linear (1.5%), turning (3.5%), and spoon (5.10%) and on the left side, elliptical (84.2 %), linear (2.04), turning (5.6%), and spoon (8.16%) [Table 5 and Graph 4].



Graph 1: Comparison of superior border of mental foramen-lower border of mandible and inferior border of mental foramen-lower border of mandible



Graph 2: Comparison of inter-mental foramen distance among males and females

DISCUSSION

Pantomography is the frequently used radiographic technique in dentistry.[13] The word panoramic radiography is extracted from the panorama, which means an unimpeded view of an area in every required direction.[2] It is utilized to estimate the anatomical and structural relationship of the mandibular canal, the anterior loop of mental nerve, incisive canal, and mental foramen.[12]

Panoramic radiographs were used in the present study as they give a much better view. Panoramic radiographs have advantages such as bilateral visualization of anatomical structures, broader visualization of dense tissue areas, and the ability to visualize adjacent areas, thus allowing for a more standardized localization of mental foramen

Table 3: Comparison of the distance of inter-mental foramen (males and females) (*n*=196)

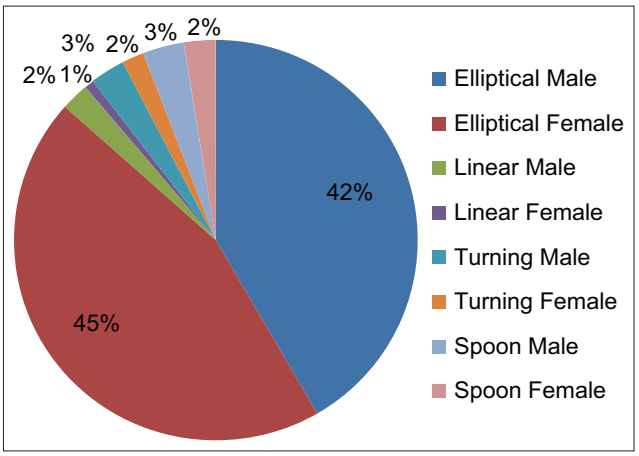
Inter-mental foramen	Males (mm)	Females (mm)	Total (mm)	Mean±SD	*t*	*P*-value
	32.15	25.78	5674.2	28.95±3.2	6.4	*P*<0.0001 HS

Table 4: Comparison of the location of mental foramen for males and females (Rt/Lt) % (*n*=196)

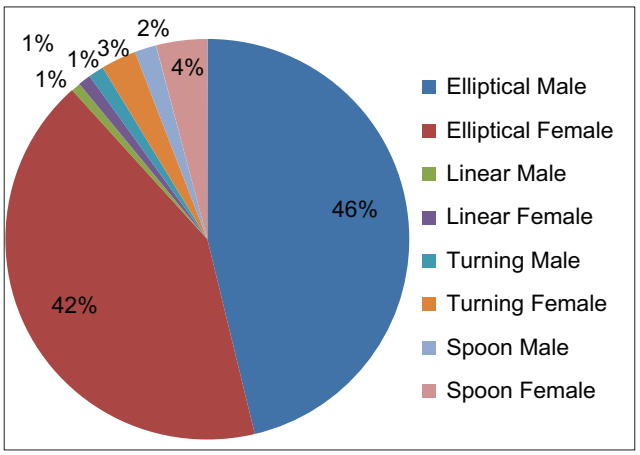
Location	Males		Females		Total	
					Males	Females
	Right % (*n*)	Left % (*n*)	Right % (*n*)	Left % (*n*)	Right% and Left%	
Second premolar	77.5 (*n*=151)	71.9 (*n*=141)	67.8 (*n*=133)	75.5 (*n*=148)	74.7	71.6
First and second premolar	14.8 (*n*=29)	18.8 (*n*=37)	22.4 (*n*=44)	18.3 (*n*=36)	16.7	20.4
Second premolar and first molar	8.16 (*n*=16)	9.18 (*n*=18)	9.7 (*n*=19)	6.12 (*n*=12)	20.4	7.9

Table 5: Percentage of shape of inferior alveolar canal in males and females (Rt/Lt) % (*n*=196)

Inferior alveolar canal	Elliptical		Linear		Turning		Spoon	
	Males	Females	Males	Females	Males	Females	Males	Females
Right	83.1 (*n*=163)	89.7 (*n*=176)	4.5 (*n*=9)	1.5 (*n*=3)	5.6 (*n*=11)	3.5 (*n*=7)	6.6 (*n*=13)	5.10 (*n*=10)
Left	92.3 (*n*=181)	84.1 (*n*=165)	1.5 (*n*=3)	2.04 (*n*=4)	2.5 (*n*=5)	5.6 (*n*=11)	3.5 (*n*=7)	8.16 (*n*=16)



Graph 3: Percentage of shape of inferior alveolar canal in males on the right side



Graph 4: Percentage of shape of inferior alveolar canal in females on the left side

and inferior alveolar canal. Comparative analysis between the right and left foramen is also tricky on other conventional radiographs. It is because of this reason panoramic radiographs were selected to study mental foramen.[13]

The mandibular canal is a canal that takes origin in mandibular foramen on the mesial aspect of the ascending mandibular ramus and slants forward and downward in the ramus, then progresses forwardly in the body until foramen mental which also carries inferior dental nerve.[14]

The mental foramen is more commonly located at the summit of the second mandibular bicuspid or in between the tips of the bicuspids. The mental foramen is a significant landmark during surgical procedures. The inferior dental nerve may be seen on the medial aspect of the mental foramen and passes far away from it as an anterior loop within the bone that should be considered to prevent injury to mental nerve before performing implant surgery.[13] The third branch (V3) of the V cranial nerve (trigeminal) invades the mandibular foramen. As the inferior dental nerve progresses

anteriorly in the mandibular canal, it traverses the lower jaw in linguobuccal direction. The mandibular nerve is halfway between the buccal and lingual cortical bone in the mandibular first molar region, where it bifurcates into the mental and incisive nerve.[15]

The present study was aimed to determine the radiographic position of mental foramen concerning anatomical structures and the shape of the inferior alveolar canal in different age groups in males and females. The age groups were determined according to different stages of growth and development as 15–54.99 years.

Wical and Swoope (1974) indicated that in spite of all the relative age changes that take place in the mandible, the distance between the MF (mental foramen) and the LBM remains unchanged.[16] According to the authors, Yosue and Brooks, the radiographic appearance of mental foramen classified as follows:[17]

- In the continuous type, the MF is uninterrupted with the mandibular canal
- In the separate type, the foramen is noticeably detached from the mandibular canal and with a distinct border
- In the diffuse type, the foramen has a vague boundary, while in the unidentified type, the MF is not visible.

Another classification for the position of mental foramen depending on its location of the tooth is as follows:[18]

- Location 1: MF situated anterior to the first premolar tooth
- Location 2: Situated in line with the long axis of the first premolar tooth
- Location 3: MF situated between the apices of the first and second premolar teeth
- Position 4: MF situated in line with the long axis of the second premolar tooth
- Position 5: MF situated between the apices of the second premolar and first molar teeth
- Position 6: MF situated in line with the long axis of the first molar tooth.

According to Mohamed *et al.* (2016), who studied the position of mental foramen in a sample of the Indian population, found that the distance between the mental foramen and each of the midline, the alveolar margin, and the base of mandible increases with age advances during childhood and then becomes relatively stable during adulthood. In the elderly group, the mean distance of the mental foramen position from the alveolar bone crest showed the least value when compared to other groups.[18]

In the present study, as regard to sex differences, males showed higher mean values than females in all measurements in all age groups. Singal and Sharma (2016) recorded the vertical measurements of mental foramen and correlated them to assess the sensitivity of these parameters in gender determination.[19] Rashid and Ali (2011) examined a total of 300 Iraqi subjects (150 males and 150 females), age ranging between 20 and 49 years old. Linear vertical measurements were performed on the radiographic images related to the vertical position of the mental foramen. The mean values were higher in males than females, and there was a high, statistically significant difference between genders.[20]

Thakur *et al.* (2014) signified the use of average measurements from the superior and the IMF to the LBM and to the alveolar crest on digital panoramic radiographs on the right side in determining the gender in a sample from Andhra Pradesh, India. The results of the study showed statistically significant differences in

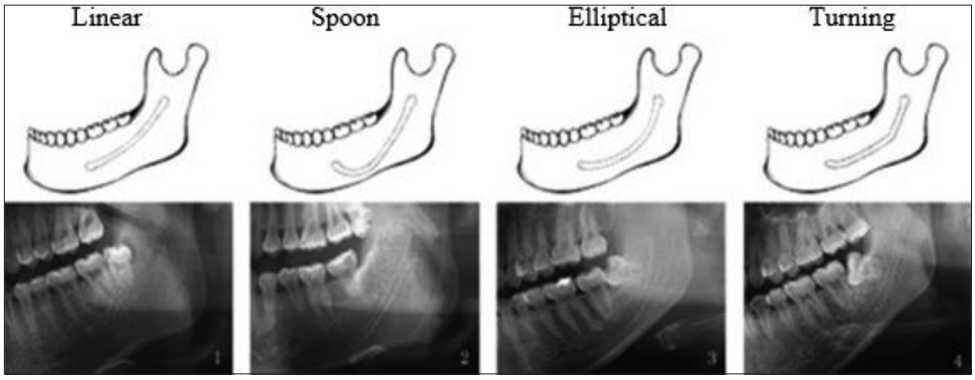


Figure 2: Shape of inferior alveolar canal. (Courtesy: Inferior alveolar canal course: A radiographic study; Liu *et al.*)[23]

males and females which were in concordance with the present study.[21]

Sahni *et al.* (2015) tested gender determination using mental foramen as a landmark on panoramic radiographs in selected North Gujarat population; 60 persons were selected. A digital caliper was used to measure the distance from the SMF-LBM and IMF-LBM. The analyzed data of the study showed that the mean values were significantly higher in males as compared to females who were in par with the present study.[22]

Liu *et al.* (2009) described linear, spoon, elliptical, and turning curve of the mandibular canal. The elliptical curve is the most common (48.50%), which was in concordance with the present study [Figure 2].[23] Jung and Cho (2014) showed that elliptical curves were most frequently observed, lowest among were the linear curves which were in concordance with the present study.[24] Rai *et al.* (2018) described the linear, spoon, elliptical, and turning curve of mandibular canal. Linear type of curve is the most common, which was not in concordance with the present study.[25] The present study showed elliptical type as the most common type among males and females.

CONCLUSION

The results of the present study indicate that the mental foramen position, shape of the inferior alveolar canal is not constant and changes as age advances. It is possible to predict age and gender in panoramic radiographs.

RECOMMENDATION

Further research and studies are required with a vast and large number of samples for accurate assessment of the position of mental foramen that would help in establishing its role in dental and forensic applications.

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