Gender Determination by Radiographic Analysis of Mental Foramen and Mandibular Canal using Cone-Beam Computed Tomography

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KEYWORDS

Gender

ABSTRACT

Introduction: Gender identification is crucial in forensic science, especially during mass disasters. It can be achieved through morphological

determination, Mental foramen, Mandibular canal, Cone-Beam Computed Tomography (CBCT)

examination of teeth, skull, and soft tissues, and molecular analysis. Radiographic analysis of the mental foramen and mandibular canal in the western population of Maharashtra is used to evaluate gender determination. **Aim:** The study aims to determine gender in the western population of Maharashtra through Cone-Beam Computed Tomography (CBCT) radiographic imaging of the mental foramen and mandibular canal. **Methodology:** The study used 260 CBCT images from the Department of Oral Medicine and radiology at KVVDU, Karad, and obtained ethical clearance from the Ethical committee. The images were analyzed using SPSS software and compared using an independent t-test, with a significance level of $p \leq 0.05$. **Results:** A study of 260 CBCT images revealed that males had higher R-SMC and R-IMC on the right side, while females had higher R-SMC and R-IMC on the left side. **Discussion:** The study uses CBCT technology to identify gender differences in growth trajectory and location of the mental foramen in forensic science, highlighting factors like hormones, endocrinal stimulus, and population. **Conclusion:** The study suggests that C-IMFrt and CBCT analysis of the mental foramen and mandibular canal can aid in gender determination in forensic analysis, though further research is needed.

INTRODUCTION

Identification of gender is one the most important aspects in forensic science. During mass disasters situations like tsunamis, earthquakes, bomb blasts, and road traffic accidents, forensic odontology becomes a major tool for identification of the individual which includes the age, gender, stature, and facial features [1]. Gender identification can be accomplished through either morphological examination of (teeth, skull and surrounding soft tissues) or molecular analysis, providing two distinct approaches for determining individual's gender [1]. Every individual has a unique set of dental characteristics like the number of teeth, decayed teeth and prosthesis which aid in identification of an individual. The use of metric and morphometric parameters of dental structures is a vital tool in forensic identification, enabling the investigators to accurately determine an individual identity [2].

When skull remains are limited, the mandibular structures play a critical role in facilitating identification, as they offer unique characteristics that can aid in determining an individual's identity [2]. Out of 28 bones of the skull, mandible or the lower jaw is the largest and the strongest bone. The shape and structure of mandible change across different age groups, sexes and racial populations, providing a unique set of characteristics for identification purposes [2]. It consists of a body which consists of alveolar process and a pair of rami to which muscles are attached which helps in mastication. As per reports after pelvic bone, mandible is the most durable structure that also helps in identification of gender of an individual [3].

Various radiographs such as intraoral periapical radiographs, orthopantomographs, computed tomography and CBCT can be used for radiological analysis to identify an individual. Conventional two dimensional (2D) cephalometric analysis are prone to errors due to challenges of identifying the precise measurement points, particularly when bony structures overlap [3]. CBCT provides three dimensional images of the dental and maxillofacial structures [4]. CBCT excels in depicting bone morphology compared to conventional imaging modalities as the visibility of these structures can fluctuate substantially, even within same individual [3]. Structures like the mental foramen and the mandibular canal can be visualized from all angles and exact dimensions with the help of CBCT.

Numerous studies have been carried out for gender determination using mental foramen and mandibular canal. As per our knowledge studies have not used anterior border of ramus of mandible and the mandibular canal in gender determination. Thus, the present study was aimed to evaluate gender determination by radiographic analysis of mental foramen and mandibular canal in western population of Maharashtra using CBCT.

Aim: The objective of the study is to assess gender determination using radiographic imaging of the mental foramen and mandibular canal in the western population of Maharashtra, employing Cone-Beam Computed Tomography (CBCT).

MATERIALS AND METHODS

Ethical approval

This study was conducted in accordance with the principles of the declaration of Helsinki. The Ethical clearance was obtained from the Ethical committee of Krishna Vishwa Vidyapeeth (KVV), Karad with Protocol number 210/2022-2023, dated on 17/01/2023.

Study design

This retrospective, observational study was carried out using the previously exposed CBCT images retrieved from the Department of Oral Medicine and radiology, School of Dental Sciences, KVVDU, Karad.

Sample size calculation

As per reference article entitled of "Determination sex by cone-beam computed tomography analysis of mental foramen in South Indian Population" [5].

$n=10.4975X2(1.68+1.22)^2/(13.44-11.80)^2$

Using this formula 260 CBCT images were retrieved. The images were grouped into two groups, Group A- 130 images of males, and Group B- 130 image of females.

The inclusion criteria include CBCT images of subjects aged between 20-45 years with presence of at least 28 teeth. The exclusion criteria include history of previous fractures in maxillofacial

region. History of pathological process like odontogneic cysts, odontogenic tumors, diseases affecting bone and CBCT images with artifcats.

Evaluation of measurements

The CBCT images were acquired using Carstream CBCT software model CS 9600 with field of view 16x10cm, kilovoltage of 120Kvp, a current of 5mA, slice thickness was 1.5mm,the image resolution was 0.1um.

All the CBCT images were subjected to following measurements in males and females:

1.R-SMCrt: Distance from the anterior border of the ramus of the mandible to the superior border of the mandibular canal on the right side.

2. R-SMClf: Distance from the anterior border of the ramus of the mandible to the superior border of the mandibular canal on the left side.

3. R-IMCrt: Distance from the anterior border of the ramus of the mandible to the inferior border of the mandibular canal on the right side.

4. R-IMClf: Distance from the anterior border of the ramus of the mandible to the inferior border of the mandibular canal on the left side.

5. C-SMFrt: Distance from the alveolar crest to the superior border of the mental foramen on the right side.

6. C-SMFlf: Distance from the alveolar crest to the superior border of the mental foramen on the left side.

7. C-IMFrt: Distance from the alveolar crest to the inferior border of the mental foramen on the right side.

8. C-IMFlf: Distance from the alveolar crest to the inferior border of the mental foramen on the left side.

Statistical Analysis

Data were analyzed using SPSS software version 20. Descriptive statistics, including mean, standard deviation of mean, and minimum and maximum values, were calculated for each variable. Inferential statistics were employed to examine the relationships between variables. An

independent t-test was used to compare mean values between male and female populations. In the present study, $p \leq 0.05$ was considered as the level of significance.

RESULTS

Out of total 260 CBCT images, 65 were females (130 images) and 65 (130 images) were males. The comparison of the mean measurements between right and left sides showed, R-SMC, R-IMC on the right side were higher than the left side in females, whereas in males R-SMC, R-IMC were greater on left side than the right side.

The mean measurements of R-SMClf, R-IMCrt, and R-IMClf were higher in males than females, although the differences were not statistically significant (Table 1). Conversely, the mean measurement of R-SMCrt was higher in females than males, with no statistically significant difference.

Table 1 represents the distribution of measurements from R-SMC and R-IMC on right and left sides in males and females.

	Females		Males			
Study Variables	Mean	SD	Mean	SD	Unpaired test	Pvalue
R-SMCrt	16.55	3.16	16.32	3.22	0.33	0.7394
R-SMClf	15.74	3.6	16.84	2.76	1.603	0.112
R-IMCrt	19.4	3.03	19.79	3.12	0.59	0.5539
R-IMClf	18.8	3.59	20.15	2.95	1.877	0.064

Figure 1 illustrates the saggittal sections measurements from anterior border of ramus of mandible to superior border of Mandibular canal.(R-SMC)

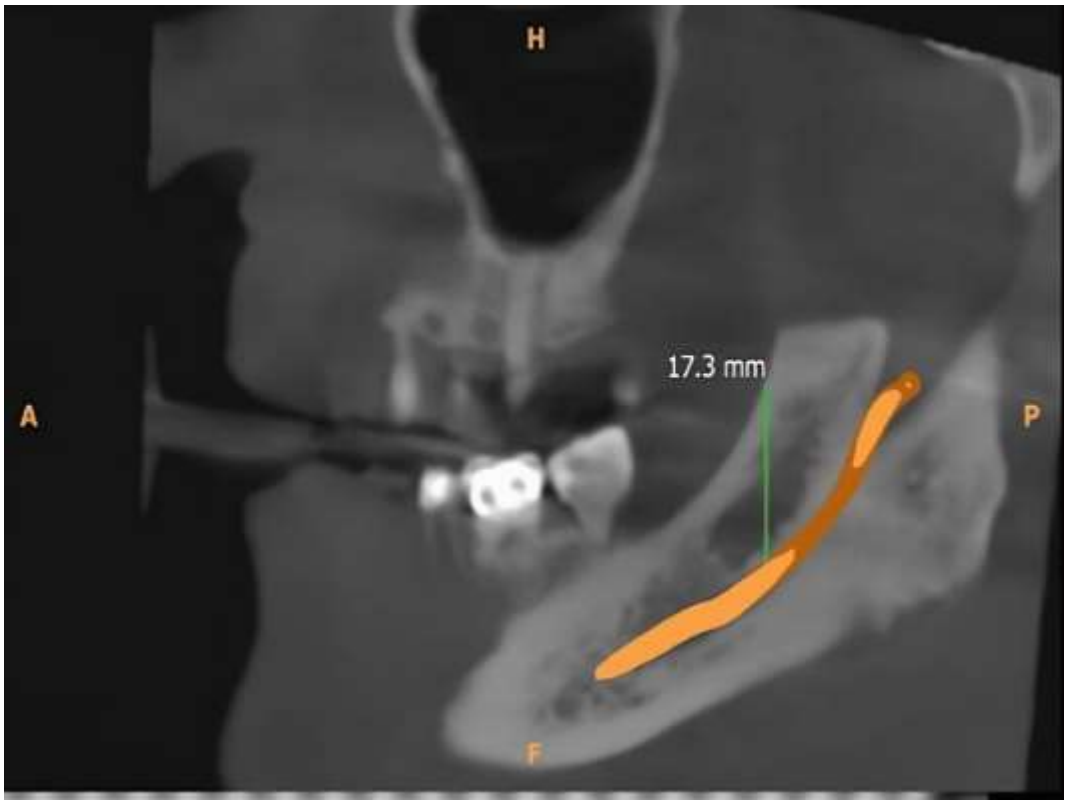
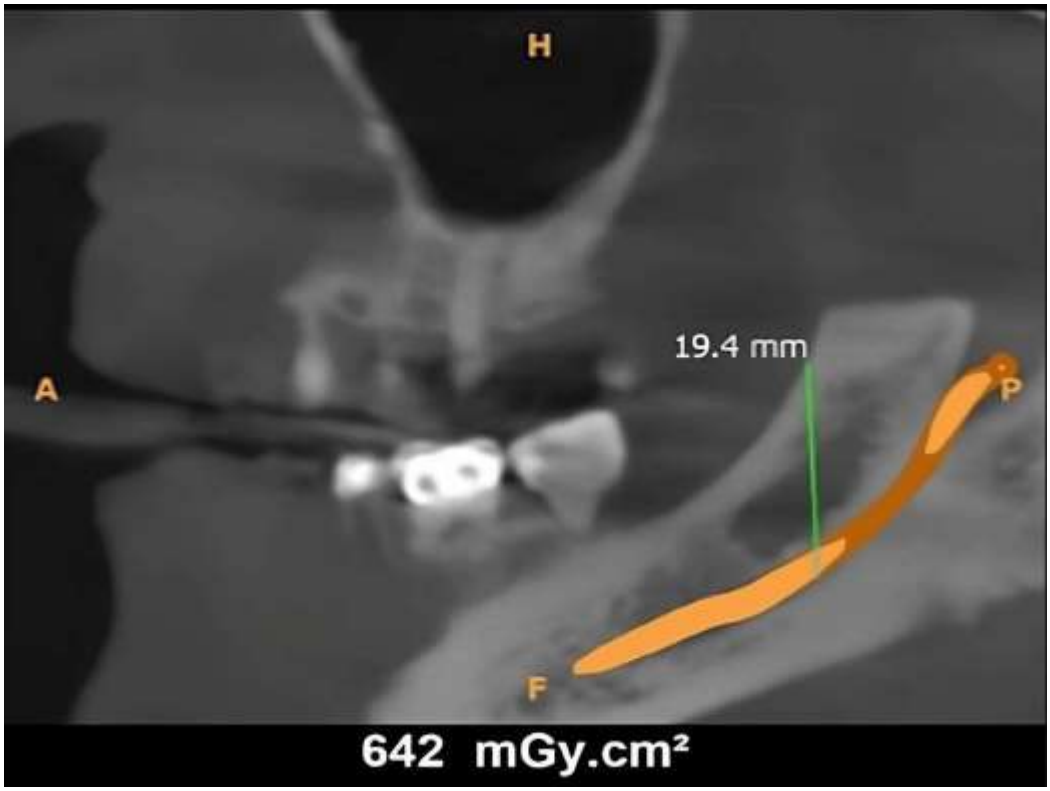


Figure 2 illustrates the saggittal sections measurements from anterior border of ramus of mandible to inferior border of Mandibular canal. (R-IMC)



The mean measurements of C-SMFrt, C-SMFlf, and C-IMFlf were higher in males than females, with no statistically significant differences (Table 2). However, the mean measurement of C-IMFrt showed a statistically significant difference between males and females (p=0.0047).

Table 2 represents the distribution of measurements from alveolar crest to superior border of mental foramen C-SMF and C-IMF on right and left sides in males and females.

	Females		Males			
Study Variables	Mean	SD	Mean	SD	Unpaired test	Pvalue
C-SMFrt	12.12	2.72	12.65	1.41	1.158	0.75
C-SMFlf	12.38	2.57	13.31	2.15	1.827	0.0712
C-IMFrt	15.05	2.61	16.36	1.5	2.897	0.0047
C-IMFlf	14.86	2.8	16.26	2.28	2.565	0.0121

Figure 3 illustrates the coronal sections measurements from alveolar crest to superior border of mental foramen (C-SMF).

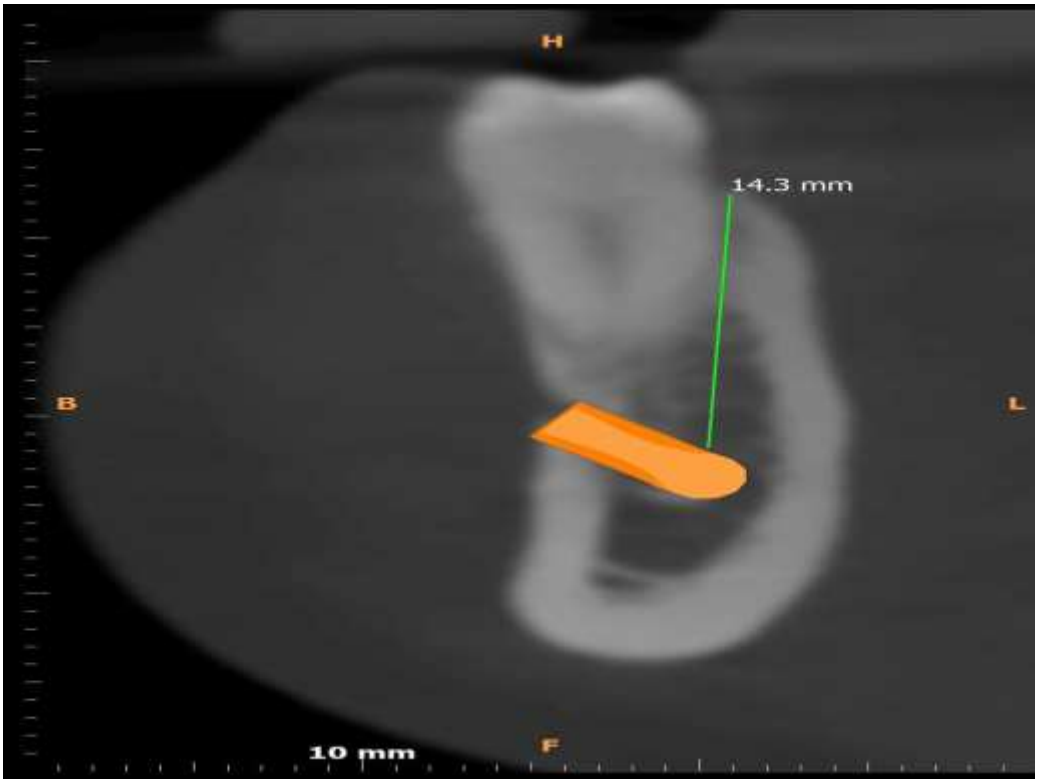
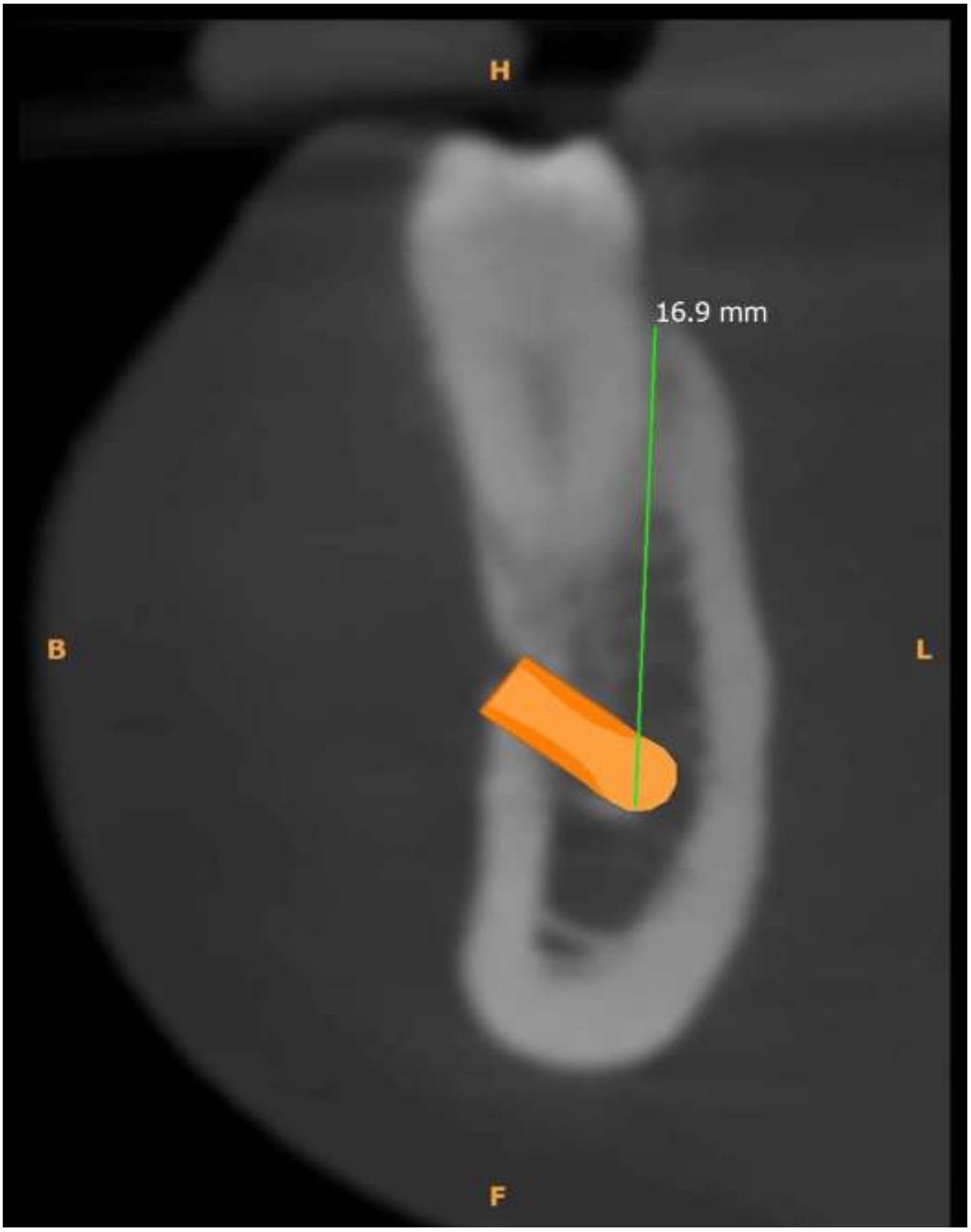


Figure 4 illustrates the coronal sections measurements from alveolar crest to inferior border of mental foramen (C-IMF)



DISCUSION

In forensic science for the identification of gender after pelvis, mandible is considered sexually dimorphic. The mandible is also considered one of the strongest bones in the human skeleton which makes it difficult to degrade. There is a significant difference in the growth trajectory in males and females due to the hormones and endocrinal stimulus. The population, culture and geographic status may also affect the gender differences.

Most studies have utilized panoramic radiographs for the determination of gender using the condyle, coronoid, gonial angle. The panoramic radiography is 2D radiographic technique in which we can visualize the maxilla, mandible, maxillary sinus in one plane which makes it not very accurate. With increasing use of 3D radiographic technique like CBCT, all the structures including the mandibular and mental foramen can be visualized in all different planes and more accurate dimensions can be retrieved. Hence, in this study we have utilized 120 CBCT images to determine the gender determination using the mental foramen and mandibular canal.

CBCT technology employs a unique cone-shaped X-ray beam to acquire a complete image in a single scan, offering a significant advantage over traditional slice-by-slice imaging methods. This allows for accurate and detailed 3D reconstruction of the complex maxillofacial region, facilitating enhanced diagnostic capabilities and treatment planning [6]. CBCT overcomes the shortcomings of panoramic radiography [7,8], including distortion, superimposition, and dimensional alterations, and also provides a more cost-effective and radiation-efficient alternative to conventional CT scans, delivering higher resolution images and enhanced diagnostic accuracy [9].

In our study the mean measurements of R-SMClf, R-IMCrt and R-IMClf were greater in males than in females. The results of our study were in accordance with S Padayachee, H Holmes, ME Parker studies [10].

The mean measurements of C-SMFrt, C-SMFlf and C-IMFlf were greater in males than in females with no statistically significant difference. Whereas the mean measurement of C-IMFrt were greater in males than in females with a statistically significant difference. In an in -vitro study conducted by Budhiraja V et al., the mean measurements on the right side were more than the left side [11].

According to the study by Asrani et al., males have higher values of crest to superior border of mental foramen which was in accordance with our study [12]. According to the study by R Rath the mean values of, SMeF (distance from point of maximum curvature of superior border of mental foramen to lingual alveolar crest ridge) measurements in males were higher than in females which is in accordance with our study [4].

Yousue and Brooks, Souaga et al., Freitas., Al-Khateeb et al., Amorim et al., [13] and Şahin et al., found that there was a significant difference in the location of the mental foramen according to gender and that the measurements were relatively higher in men, which was in agreement with the present study findings.

According to Thakur et al., the distance between the superior margins of the mental foramen to the inferior border of the mandible, the distance between the inferior margins of the mental foramen to the inferior border of the mandible (IM-IB), and the distance between the superior margin of the mental foramen to the alveolar crest (SM-AC) showed statistically significant values and helps in discriminating males from females which was in agreement with the present study findings [14].

Various other studies have utilized the distance from the canal and superior border of mental foramen till the alveolar crest ridge in age and gender determination [13,15,16,17] and some others have also taken the occlusal plane of the mandibular first molar/premolar as the most superior point [18].

Change CT studies in a Taiwanese population showed significant sex differences in the position of mandibular and mental foramina [19]. In a US cadaveric study, small but significant differences were found in the position of MF in the sexes as also verified by Amorim et al [13]. In contrast, a US study by Angel JS et al., using 165 CBCT images showed that the relative position of IAC remains fairly constant with age and sex [18]. Afsar et al., in a Canadian study found no correlation in the position of mandibular foramen with age or sex [7].

Limitations:

Study sample was less and the age group distribution of subjects was not done. The study was restricted to only western population of Maharashtra.

CONCLUSION

The study suggests that C-IMFrt can be used as a reliable parameter for gender determination.CBCT analysis of mental foramen and mandibular canal can aid in gender determination, particularly when combined with other forensic markers.The study's findings can contribute to developing population-specific standards for gender determination in forensic odontology.Further research is needed to confirm these findings and explore other potential parameters for gender determination. Gender determination plays an important role in forensic sciences. The mandible can be a valuable tool for determining gender due to its durability and resistance to damage and decomposition. Hence, the measurements of mental foramen and mandibular canal to crest using CBCT can be used for gender determination in forensic analysis.

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