Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(5), 1448-1454 | ISSN:2251-6727

# Metric Analysis of Mental Foramen Using Cone-Beam Computed Tomography in Sex Determination: A Retrospective Study

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***(Received: 16 July 2025 Revised: 20 August 2025 Accepted: 20 September 2025)***

**KEYWORDS**

Forensic odontology, Mental foramen, sex determination, sexual dimorphism

**ABSTRACT:**

**Introduction** Forensic odontology plays a pivotal role in human identification, particularly in scenarios where only skeletal remains are available. The mandible, being the most resilient craniofacial bone, is frequently utilized for sex determination. The mental foramen (MF) serves as a stable anatomical landmark, retaining its position throughout life, and may therefore be employed as a reliable indicator of sexual dimorphism.

**Objectives**: To evaluate sex-based differences in the dimensions and interforamen distances of the mental foramen using Cone-Beam Computed Tomography (CBCT), and to assess its applicability in forensic sex determination.

**Methods**: A retrospective study was conducted on 100 CBCT scans (50 males, 50 females) of individuals aged 18–50 years. Measurements included the height and width of the MF on both sides, as well as lateral and medial interforamen distances, using the lower first premolar as a reference. Data were analyzed statistically to assess sexual dimorphism.

**Results**: Males exhibited significantly greater MF height on the right side and width on the left side, while females showed greater MF height on the left side ($p < 0.05$). Both lateral and medial interforamen distances were consistently larger in males compared to females ($p < 0.001$).

**Conclusions**: The present study highlights evident sexual dimorphism in the morphometric characteristics of the mental foramen and interforamen distances. These parameters may serve as reliable adjuncts in forensic sex determination. Larger, population-based studies with advanced imaging tools are recommended to further validate these findings.

## 1.Introduction:

Forensic odontology is defined as a branch of dentistry, which deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings in the interest of the justice (1). Forensic anthropology, a closely related discipline, involves the application of biological and physical anthropology to legal investigations. The identification of human skeletal remains is the first and most crucial step in forensic examinations, as it forms the foundation for further analysis. Among the many challenges faced in this process, determining the sex of unidentified skeletal

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JCHR (2025) 15(5), 1448-1454 | ISSN:2251-6727

remains is of paramount importance, particularly in cases involving disfigured or decomposed remains resulting from mass disasters or criminal activity (2-4). Sex determination initiates the process of developing a biological profile, which is critical in forensic identification (1,5-7). he main parameters used are skeletal and anatomical features that differ between males and females (5). The pelvis and skull are considered the most reliable bones for sex estimation. However, when only partial remains are available, mandibular structures are often utilized due to their strength, resilience, and notable degree of sexual dimorphism (8,9). Several mandibular features—including the location of the mental foramen, bigonial breadth, bicondylar breadth, gonial angle, and mandibular height—have been reported to show significant gender-related variation (10–13).

The mental foramen (MF) is regarded as a dependable landmark in radiographic studies, as it maintains a consistent relationship with the inferior border of the mandible throughout life, even in cases of alveolar bone resorption. Owing to its stability, the MF has been widely recognized as an accurate indicator of sex (2,4,7,14,15).

Radiographic techniques have long supported forensic investigations, especially when adequate ante mortem records are available. With technological advances, Cone-Beam Computed Tomography (CBCT) now offers three-dimensional visualization and reconstruction, enabling precise and reproducible measurements of anatomical landmarks. CBCT images can be stored, reviewed, and shared, making them invaluable tools in forensic anthropology.

**2. Objectives:**

Given this context, the present study aimed to assess sex-based differences in the mental foramen using CBCT. The findings are expected to provide valuable data for forensic odontology and enhance the reliability of sex determination methods in diverse populations.

**3.Methods:**

This retrospective study was conducted on 100 CBCT scans, including 50 males and 50 females aged between 18 and 50 years. The scans were retrieved from the electronic records of the Department of Oral Medicine and Radiology, Saveetha Dental College and Hospital, Chennai, India, during the period of June 2023 to January 2024. All images had originally been obtained for various diagnostic and treatment purposes, such as periodontal, surgical, orthodontic, and other dental evaluations. Scans of individuals aged 18 years and above, with completed skeletal growth and good diagnostic quality, were included in the study. Exclusion criteria were a history of mandibular or orthognathic surgery, the presence of radiolucent or radiopaque lesions, malignancies involving the mandible or tongue, indeterminate or poorly visualized mental foramen, and congenital or developmental abnormalities of the mandible.

All CBCT scans were acquired using the CS 9300 Select CBCT unit, with parameters set at 120 kVp, 5 mA, and an exposure time of 24.01 seconds. Images were reconstructed and analysed using CS 3D Imaging Software. Measurements included the height and width of the mental foramen on both right and left sides (Figure 1, Figure 2), as well as lateral and medial interforamen distances (Figure3). The lower first premolar served as the reference point for all measurements. The collected data were tabulated and subjected to statistical analysis. Mean and standard deviation values were calculated, and independent sample *t*-tests were performed to compare male and female groups. A *p*-value of less than 0.05 was considered statistically significant.

**4.Results:**

The morphometric measurements of the mental foramen and interforamen distances were analysed based on gender, with a total of 100 samples (50

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males and 50 females). The results revealed notable differences between males and females across several parameters.

**Height of the Mental Foramen:** The mean height of the right mental foramen was significantly greater in males (3.46 ± 0.54 mm) than in females (2.70 ± 0.49 mm; $p = 0.0005$). In contrast, the left side exhibited higher values in females (3.40 ± 0.48 mm) than in males (2.99 ± 0.53 mm; $p = 0.0001$) (Figure 4,5)

**Width of the Mental Foramen:** The mean width of the right mental foramen showed no significant difference between males (3.47 ± 0.47 mm) and females (3.34 ± 0.46 mm; $p = 0.147$). On the left side, however, a significant difference was observed, with males demonstrating a wider foramen (3.53 ± 0.50 mm) compared to females (3.02 ± 0.44 mm; $p = 0.0005$).

**Interforamen Distances:** Both lateral and medial interforamen distances were significantly larger in males when compared to f emales. The mean lateral distance was 50.29 ± 2.01 mm in males and 44.75 ± 2.39 mm in females ($p = 0.0005$). Similarly, the mean medial distance was 50.71 ± 2.28 mm in males and 44.55 ± 2.01 mm in females ($p = 0.0005$).

These findings suggest that sexual dimorphism is evident in the dimensions of the mental foramen and interforamen distances, with males generally exhibiting larger measurements than females. This anatomical variation is critical for clinical applications such as local anaesthesia administration and surgical planning in the mandibular region.

## 5.Discussion

Sex determination is one of the most important aspects of forensic investigations, as it constitutes the first step in establishing a biological profile of unidentified skeletal remains. This step is particularly crucial in criminal cases, mass disasters, or when dealing with decomposed or disfigured bodies, where conventional identification methods may not be feasible (2,16). While morphological features of bones have traditionally been used for sex determination, they are often subject to errors and observer variability (16,17). Consequently, morphometric analyses of bones have gained prominence due to their reproducibility and reliability. Among skeletal elements, the mandible is especially valuable in forensic contexts because it is one of the strongest bones in the body, resistant to post-mortem changes, and demonstrates significant sexual dimorphism (18).

The mental foramen (MF) serves as a key mandibular landmark in forensic odontology. It is located on the buccal aspect of the mandible, usually near the apices of the premolars, although variations can occur, extending from the canine to the mesial root of the first molar (19). Its anatomical stability and consistent relation to the inferior border of the mandible make it a reliable parameter for morphometric analysis (2,5,7,15,16). In addition, the MF transmits vital neurovascular structures, making its assessment clinically relevant for local anaesthesia and surgical procedures.

In the present study, CBCT was employed to overcome limitations associated with two-dimensional imaging modalities such as panoramic radiography, which often suffer from magnification errors, superimposition, and distortion. CBCT provides high-resolution three-dimensional visualization and enables accurate linear measurements of anatomical landmarks, thereby increasing the reliability of morphometric data. This advantage has been highlighted in previous studies where CBCT was used for forensic and anthropological purposes (20).

Our findings revealed that the mean height of the right MF was significantly greater in males, while the left MF height was higher in females. This side-dependent variation is consistent with the study by Agthong et al., which demonstrated sex- and side-related differences in craniofacial foramina and recommended that both variables be considered when interpreting morphometric data (20). In terms of width, the right MF did not show a statistically significant difference between sexes, whereas the left MF was significantly wider in males. These results support the findings of earlier studies that reported sexual dimorphism in MF dimensions and emphasized their application in forensic identification (10–12).

The interforamen distances (both lateral and medial) were found to be significantly larger in males than in females. This is in agreement with the study by Vinay et al., who reported greater mandibular breadth measurements in males when compared to females in a South Indian population (11). However, the present study is among the first to specifically analyze lateral and medial interforamen distances using CBCT, providing new insights into mandibular dimorphism. The larger interforamen distances in males may be attributed to greater overall mandibular robustness and transverse dimensions, which are well-established markers of sexual dimorphism.

Although the findings strongly support the use of MF morphometry in sex determination, certain limitations must be acknowledged. The study was conducted on a relatively small and region-specific sample, which may not be representative of other populations. Additionally, inter-operator variability in landmark identification and measurement cannot be completely eliminated, despite the use of advanced imaging software.

Future studies should therefore focus on larger and more ethnically diverse populations to improve generalizability. Incorporating artificial intelligence, machine learning algorithms, and automated measurement tools may also enhance the efficiency, consistency, and reliability of such analyses.

Overall, this study reinforces the role of the mental foramen and interforamen distances as reliable markers of sexual dimorphism. The use of CBCT provides an additional advantage by enabling precise measurements, thereby strengthening the forensic applicability of these parameters in real-world scenarios.

## 6.Conclusion:

This study establishes the presence of sexual dimorphism in the morphometric characteristics of the mental foramen and interforamen distances using CBCT. The right mental foramen height and left mental foramen width were significantly greater in males, whereas the left mental foramen height was higher in females, and both lateral and medial interforamen distances were consistently larger in males. These findings reinforce the forensic value of the mental foramen as a reliable anatomical landmark for sex determination, while also highlighting the importance of considering side-dependent variations. Although the present study provides useful baseline data, its applicability is limited by the relatively small and region-specific sample. Future studies on larger, ethnically diverse populations, along with the integration of artificial intelligence and automated measurement tools, may further improve the accuracy, reproducibility, and forensic relevance of such analyses.

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JCHR (2025) 15(5), 1448-1454 | ISSN:2251-6727

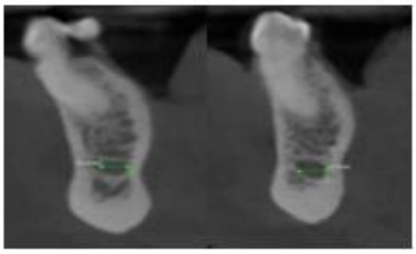

Figure 1 represents the width of mental foramen in right and left side

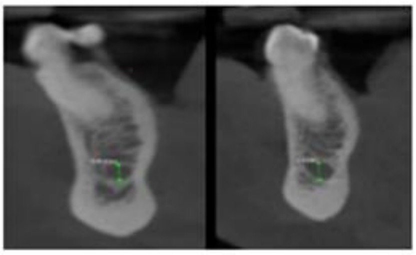

Figure 2 represents the height of the mental foramen in right and left side

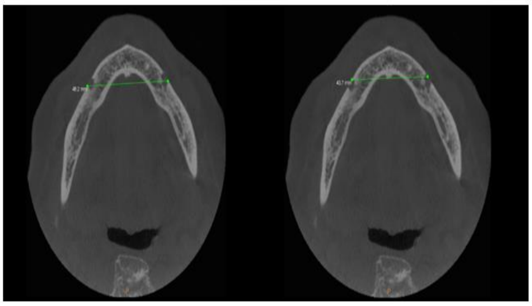

Figure 3 represents the Lateral Interforamen Distance and Medial Interforamen Distance were analyzed in axial section

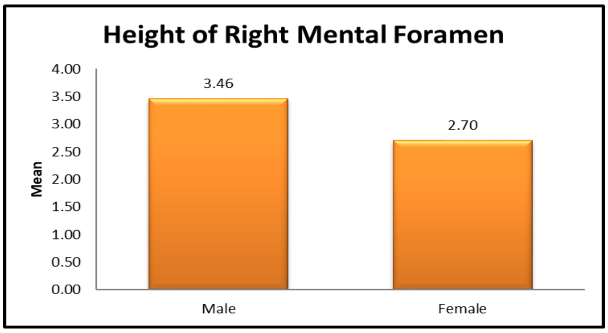


Figure 4 represents the height of right mental foramen in male and female

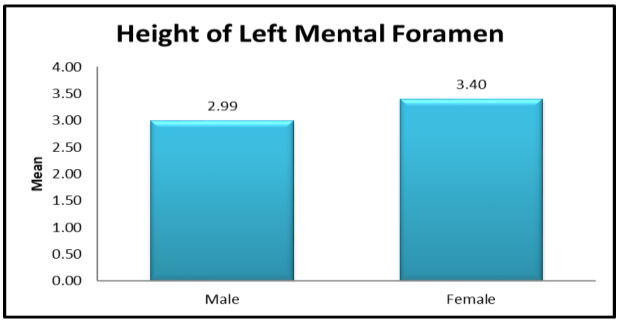


Figure 5 represents the height of left mental foramen in male and female

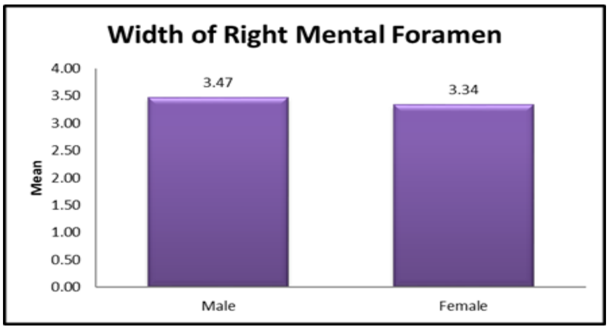


Figure 6 represents the width of right mental foramen in male and female

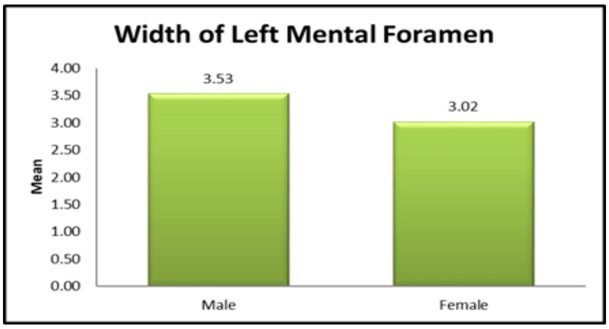


Figure 7 represents the width of left mental foramen in male and female

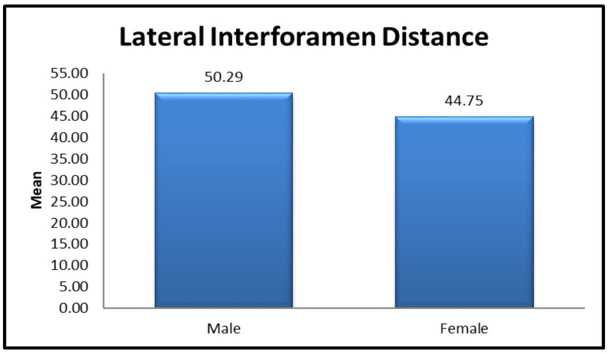


Figure 8 represents the lateral interforamen distance

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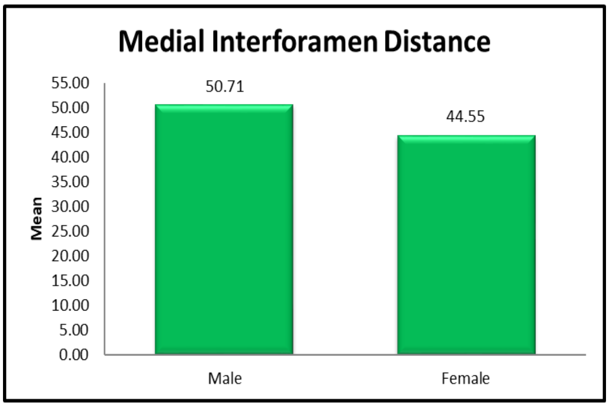


Figure 8 represents the medial interforamen distance

| Gender | | N | Mean | SD |
|---|---|---|---|---|
| Height Of Right Mental Foramen | Male | 50 | 3.46 | 0.54 |
| | Female | 50 | 2.70 | 0.49 |
| Height Of Left Mental Foramen | Male | 50 | 2.99 | 0.53 |
| | Female | 50 | 3.40 | 0.48 |
| Width Of Right Mental Foramen | Male | 50 | 3.47 | 0.47 |
| | Female | 50 | 3.34 | 0.46 |
| Width Of Left Mental Foramen | Male | 50 | 3.53 | 0.50 |
| | Female | 50 | 3.02 | 0.44 |
| Lateral Interforamen Distance | Male | 50 | 50.29 | 2.01 |
| | Female | 50 | 44.75 | 2.39 |
| Medial Interforamen Distance | Male | 50 | 50.71 | 2.28 |
| | Female | 50 | 44.55 | 2.01 |

Figure 9 represents descriptive statistics

**Independent Samples Test**

| | | Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Interval of the | |
| | | F | Sig. | t | df | p-value | Mean Difference | Std. Error Difference | Lower | Upper |
| Height Of Right Mental Foramen | Equal variances assumed | 1.518 | .221 | 7.376 | 98 | .0005 | .758020 | .102774 | .554069 | .961971 |
| Height Of Left Mental Foramen | Equal variances assumed | .043 | .836 | -4.055 | 98 | .0001 | -.411700 | .101522 | -.613166 | -.210234 |
| Width Of Right Mental Foramen | Equal variances assumed | .209 | .649 | 1.462 | 98 | .147 | .135300 | .092557 | -.048376 | .318976 |
| Width Of Left Mental Foramen | Equal variances assumed | .559 | .456 | 5.496 | 98 | .0005 | .517480 | .094157 | .330628 | .704332 |
| Lateral Interforamen Distance | Equal variances assumed | .329 | .568 | 12.548 | 98 | .0005 | 5.540040 | .441506 | 4.663886 | 6.416194 |
| Medial Interforamen Distance | Equal variances assumed | 1.773 | .186 | 14.331 | 98 | .0005 | 6.158380 | .429728 | 5.305599 | 7.011161 |

Figure 10 represents the significant difference between the bivariate samples in Independent groups using Independent sample t-test