Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 22s (2025)
https://www.jneonatalsurg.com

From Foramina To Forensics: Mandibular Cbct Imaging In Gender Estimation

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Cite this paper as: Dr. Twinkal Patel, Dr. Bhavin Dudhia, Dr.Setu Kalaria, Dr. Parul Bhatia, Dr. Purv Patel, Dr Rinkal Virani, (2025). From Foramina to Forensics: Mandibular Cbct Imaging In Gender Estimation. *Journal of Neonatal Surgery*, 14 (22s), 371-378.

ABSTRACT

Background and objectives: This study uses CBCT to determine gender based on the mandible, focusing on key landmarks like the mandibular foramen, canal, and mental and lingual foramina.

Methods: Two hundred CBCT images of individuals aged 20-60 were analyzed for mandibular features using t-tests and logistic regression.

Results: Gender differences were found in the posterior mandibular foramen, mandibular canal, mental foramen, lingual canal, and lingual foramen distances ($p<0.05$).

Conclusion: This study underscores the relevance of CBCT in forensic odontology, providing nuanced insights into gender-related variations in mandibular anatomy.

Keyword: *Mandibular canal, Mental foramen, Cone-beam computed tomography, Gender identity, Forensic dentistry*

1. INTRODUCTION

Forensic odontology, a promising new area of forensic medicine, involves the application of dental sciences in identifying deceased individuals.[1] The mandible, being one of the most durable bones, remains intact longer than other bones and is frequently used by forensic experts to determine sex. [2] Radiographic morphometric methods including mandibular canal, mental foramen, anterior loop, lingual canal, and lingual foramen. [2,3,4,5,6]

2D Radiographs lack detail, while CBCT provides precise 3D anatomical documentation.[4]

This study aimed to determine gender based on measurements of the mandibular foramen, canal, mental foramen, and lingual structures on CBCT, and to assess the accuracy of these measurements for sex determination.

MATERIALS AND METHODS:

The study utilized a non-probability sampling method, specifically convenience sampling, where the selected CBCT data of either sex between the age group of 20-60 years from the radiological archives of the Oral Medicine and Radiology department of the institute were included in the study.

INCLUSIVE CRITERIA:

CBCT images were High-quality ideal images with full extension of mandible which cover mandibular foramen and ramus.

A complete set of fully erupted, periodontally healthy permanent teeth

EXCLUSION CRITERIA:

Deformities of mandible,

Pathologies involving mandible,

Surgical intervention,

Congenital anomalies or syndrome,

Foreign body

Selective sample size was calculated by following method where N=size per group; SD= Standard Deviation= 0.5, δ = mean difference = 5.55-4.3=1.25 $Z\alpha/2$= Z0.05/2= Z0.025 = 1.96 (From Z table at type I error of 5). $Z\beta$= Z0.20 = 0.842 (at 80% power) which gives 100 sample size for one arch.

$$N=2x\ [(Z\alpha/2 + Z\beta)^2 / (\delta 0)^2] \times SD^2$$

A total of 200 satisfied the inclusion criteria and were analyzed using multiplanar reformatted DICOM images, with all sections examined to identify foramina and canals which are mandibular foramina, mandibular canal, mental foramina, lingual foramina, and lingual canal. All the scan were examine using the Ez-3d-i simple viewer (Vatech) software for the reconstruction and for measurement by using a personal laptop (Asus Rog Strix G15 G512li-Hn279t Gaming Laptop: 10th Gen Core I7/16 Gb/512 Gb SSD/Win 10 Home/4gb Graph, 15.6 inch screen, 1920*1080 pixels, Antiglare, Taiwan). The measurements were made on different coronal and axial planes of the scan after selecting the 0.5mm slice thickness and 0.5mm interval between the sections according to different area of interest.

The data collection process included three independent observers. Each measurement was assessed by one observer three times, with the results averaged. This procedure was repeated by the other two observers, and their averaged results were subsequently compiled and recorded in the proforma.

To determine measurement of mandibular foramen, two measurements were taken in axial section showing the maximum width of the mandibular foramen. The distance from the most anterior point of the mandibular foramen to the most anterior part of the mandibular ramus was measured and labelled as the anterior mandibular foramen (AMAF). The distance from the most anterior point of the mandibular foramen to the most posterior part of the ramus was measured and recorded as the posterior mandibular foramen (PMAF). [Figure-1(A)].[1]

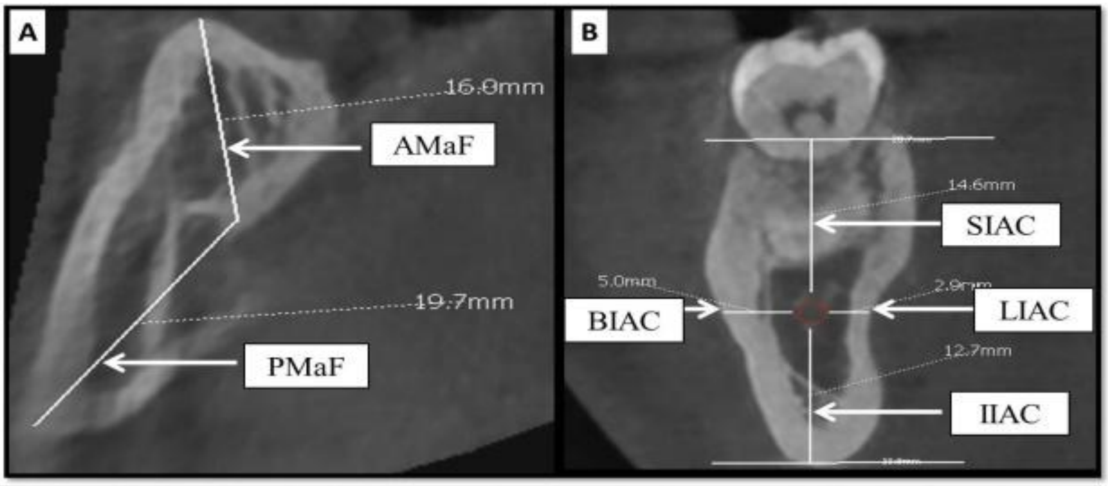

Figure 1: (A) Anterior mandibular foramen to Anterior mandibular ramus (AMaF) and to Posterior ramus (PMaF). (B) SIAC(Superior mandibular canal to alveolarridge midpoint); IIAC(Inferior canal to mandible's lowest border); LIAC(Lingual canal to lingual corticalplate); BIAC(Buccal canal to buccalcorticalplate).

To determine the mandibular canal measurement, four measurements were taken from CBCT coronal section at the first molar bifurcation. These included: 1) the distance from the highest point of the canal to the alveolar ridge crest (SIAC), 2) the distance from the lowest point of the canal to the mandible's inferior border (IIAC), 3) the distance from the most lingual point of the canal to the lingual cortical plate (LIAC), and 4) the distance from the most buccal point of the canal to the buccal cortical plate (BIAC). [Figure-1(B)][1]

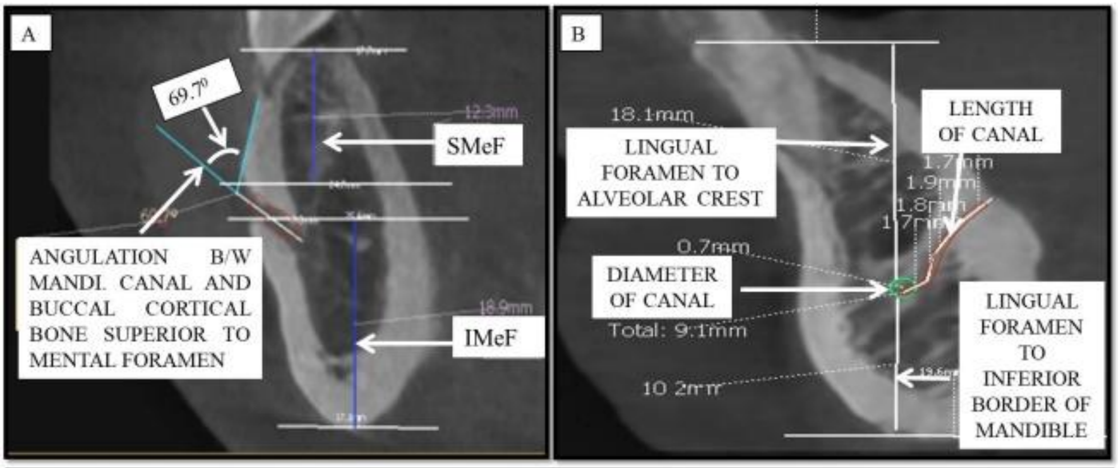

FIGURE 2(A) SMeF: Distance from the superior mental foramen to alveolar ridge crest. IMeF: Distance from the inferior mental foramen to mandible's lowest border.
FIGURE 2(B) : Identification and location of the lingual foramen and canal at the midline.

For the mental foramen, two measurements were taken from the coronal section where the mental foramen was widest. The first measurement: the distance from the most superior point of the mental foramen to the midpoint of the alveolar ridge crest, recorded as the superior mental foramen (SMeF). The second measurement: the distance from the most inferior point of the mental foramen to the lowest point of the inferior border of the mandible, termed the inferior mental foramen (IMeF). [1] The angle between the long axis of the mental canal (MeC) and the superior cortical bone was analyzed in each scan. [Figure-2(A)] Additionally, a sagittal view of mental foramen (MF), vertical (height, H) and horizontal (length, L) measurements were made between the cortical areas of the MF.[9]

Anterior cross-sections of the lingual canal and foramina were analysed the number of lingual foramina (LF) (0, 1, or more), the mean diameter of the LF, the mean length of the LF to the buccal cortical plate, the mean distance from the LF to the inferior border of the mandible and the alveolar crest, and the mean length of the lingual canals (LCs). [Figure-2(B)][6]

LEGENDS OF FIGURE:

Figure -1 (A,B)	(A) Anterior mandibular foramen to Anterior mandibular ramus (AMAF) and to Posterior ramus (PMAF). (B) SIAC(Superior mandibular canal to alveolarridge midpoint); IIAC(Inferior canal to mandible's lowest border); LIAC(Lingual canal to lingual corticalplate); BIAC(Buccal canal to buccalcorticalplate).
Figure-2 (A,B)	(A) SMeF: Distance from the superior mental foramen to alveolar ridge crest. IMeF: Distance from the inferior mental foramen to mandible's lowest border. (B) Identification and location of the lingual foramen and canal at the midline.

The study used **t-test** for mean comparison and **Logistic regression** for predictive analysis. The observations for all the subjects were recorded in Windows 10 Microsoft office 2016 and statistical analysis were done using SPSS software version 20.

RESULTS:

Based on the p-values and mean values, it can be concluded that there is a significant gender difference (p=0.01) in the left mandibular foramina measurement (PMAF-L), while there are no statistically significant gender differences in the other measurements (AMAF-R, AMAF-L and PMAF-R). Measurement for the IIAC [right (p=0.00) and left (p=0.00)] shows strong differences between males and females. For the SIAC left, while the differences are significant (p=0.03), they are less pronounced but still present for right and left sides. In contrast, measurements of the BIAC and LIAC do not exhibit significant differences between males and females, except for a potential difference in the LAIC on the left side, where the p value is not significant (Table-1).

TABLE: 1 MANDIBULAR CANAL AND FORAMEN			
PARAMETERS	MALE (MEAN VALUE) 112	FEMALE (MEAN VALUE) 88	P-VALUE
MANDIBULAR FORAMEN			
AMAF RIGHT	15.493	16.025	0.085
AMAF LEFT	15.836	15.736	0.782
PMAF RIGHT	16.540	16.144	0.303

PMAF LEFT	16.755	15.949	0.017
MANDIBULAR CANAL			
SIAC RIGHT	15.951	15.134	0.085
SIAC LEFT	15.521	14.574	0.037
IIAC RIGHT	8.217	7.047	O.OO0
IIAC LEFT	8.481	6.983	0.000
BIAC RIGHT	4.382	4.198	0.271
BIAC LEFT	4.416	4.076	0.072
LIAC RIGHT	2.908	2.666	0.165
LIAC LEFT	2.956	3.185	0.237
Footnote: AMAF - anterior mandibular foramen, PMAF - Posterior Mandibular Foramen, SIAC – Superior to Inferior Alveolar Canal, IIAC – Inferior to Inferior Alveolar Canal, BIAC - Buccal to Inferior Alveolar Canal, LIAC - Lingual to Inferior Alveolar Canal.			

Table 2 shows IMeF [right (p=0.00) and left side (p=0.00)], SMeF Left (p=0.03) and height of foramen (p=0.02) measurements which statistically significant gender differences, while others do not.

TABLE: 2 MENTAL FORAMEN			
PARAMETERS	MALE (MEAN VALUE) 112	FEMALE (MEAN VALUE) 88	P-VALUE
SMeF RIGHT	15.966	15.266	0.097
SMeF LEFT	15.489	14.556	0.037
IMeF RIGHT	10.082	8.581	0.000
IMeF LEFT	9.942	8.527	0.000
HEIGHT RIGHT	3.127	2.774	0.026
HEIGHT LEFT	3.264	2.951	0.028
LENGTH RIGHT	3.373	2.964	0.261
LENGTH LEFT	2.864	2.5	0.258
ANGLE RIGHT	42.924	44.743	0.292
ANGLE LEFT	44.181	46.469	0.205
Footnote: SMeF - Superior to Mental Foramen, IMeF - Inferior to Mental Foramen, HEIGHT - Height of the Mental Foramen, LENGTH - Length of the Mental Foramen, ANGLE - Angle of the Mental Foramen.			

Lingual canal length (p=0.03), lingual canal to buccal cortical measurement (p=0.00), lingual canal to alveolar crest (p=0.04) and inferior border of mandible (0.03) shows meaningful distinctions between males and females, while other aspects of lingual canal measurements do not exhibit statistically significant gender differences (Table-3).

TABLE: 3 LINGUAL FORAMEN AND CANAL

PARAMETER	MALE (MEAN VALUE) 112	FEMALE (MEAN VALUE) 88	P-VALUE (T-TEST)
NUMBER of canal	2.08	2.11	.677
Mean DIAMETER of canal	1.212	1.268	.492
Mean canal LENGTH	9.198	8.524	.031
Mean BUCCAL CORTICAL	4.269	3.816	.009
mean foramina to ALVEOLAR crest length	18.580	17.546	.048
Mean foramina to INFERIOR BORDER length	8.333	7.684	.032

The logistic regression equations for predicting the log-odds of Male are as follows: For IIAC Left, equation is Log-Odds (Male)=−2.238+0.317×IIAC Left. To convert the log-odds into a probability, Probability of Male (p)=1/1+1.373−Log-Odds (Male).

For IMeF Right, the equation is Log-Odds (Male)=−2.671+0.310×IMeF Right. To convert the log-odds into a probability, Probability of Male (p)=1/1+1.364−Log-Odds (Male).

For lingual canal to Buccal Cortical, the equation is Log-Odds (Male)=−1.297+0.369×Buccal Cortical. To convert the log-odds into a probability, Probability of Male (p)=1/1+1.447−Log-Odds (Male).

For all the equations, classify as Male if $p > 0.5$ and as Female if $p < 0.5$

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DISSCUSSION:

The non-uniform gender related distinctions in mandibular anatomy highlighted in this study offer valuable insights for both the field of dentistry and forensic anthropology. Concerning the mandibular foramen, De Oliveira Gambe et al.[10] observed that, in their study, the mean values for most measurements were generally higher in males, except for AMAF, where females had higher values. Additionally, studies by Gopal and Sundaram et al.[11], and Arwa et al.[1], identified statistically significant sex differences in their examination of an Indian sample, particularly in relation to PMAF. The variations between the results of these studies and the present study could be attributed to the different ethnic origins of the studied populations and the differences in standardization protocols for the measurements.[2]

In the context of mandibular canal measurements, it is noteworthy that the mean values for all assessed measurements were higher in male participants compared to their female counterparts, which aligns with the findings of Uppal et al. and Arwa et al. [1,2] This suggests that the higher mean values in males may be attributed to sex-based variations in adult bone growth.

Bone growth is controlled by several factors, including sex hormones and muscular tension. Sex hormones such as estrogen and progesterone can influence the speed of bone growth, contributing to the development of sex-based differences in the craniofacial morphology. Bone growth is more rapid in males, resulting in craniofacial dimensions that are larger than those in females.[2] Furthermore, Arwa et al.'s study also found statistically significant differences between sexes in the measurements of SIAC and IIAC, which mirrors the results of our study. In contrast, the measurements of BIAC and LIAC did not show statistically significant differences between males and females, which are consistent with current research findings. [10,11,12,13]

In context to mental foramen, according to the findings of Rudyard dos Santos Oliveira et al., their study revealed a significant difference in the IMeF and the height of the mental foramen, while no significant differences were observed in the other parameters analysed.[13,14,15]

Consistent with the research by Georges Aoun et al., the measurements of lingual foramen and lingual canal in their study were significantly higher in males than in females, which is in agreement with the results of the current study. Similarly, both studies found no significant difference in the number of canals, reflecting the same trend observed in Georges Aoun et al.'s findings.[6] According to the research by Yaseen Alqutaibi et al., significant differences were observed in several measurements of lingual canal, such as the length of the canal, the distance from the canal to the buccal cortical plate, the distance from the canal to the alveolar crest, and the distance from the canal to the inferior border of the mandible. These differences were reported as positive in their study. [7] The study conducted by Mesude Citir et al.[8] found no significant difference in the diameter or the number of canals when measuring the lingual foramen and canal. [6,9,16,17]

2. LIMITATION AND FUTURE PROSPECTIVES:

The study may focus on specific areas of the mandible, potentially overlooking other regions that could also exhibit gender-related differences. A more comprehensive examination of the mandible could provide a fuller understanding of anatomical variations.

Future research could expand to include more diverse populations across different age groups, ethnicities, and geographic regions. This would help in determining whether the findings are universally applicable or specific to certain demographics.

3. CONCLUSION:

In conclusion, the findings suggest that gender- related distinctions in mandibular anatomy are not uniform across all measurements and areas. Some measurements, such as IIAC, PMAF-L, IMeF and certain lingual canal measurements, shows significant differences between males and females, while others, including some mental foramen measurements, do not exhibit statistically significant gender differences. These findings provide valuable insights into the variations in mandibular anatomy and its potential gender-related differences.

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