



MAPPING THE MENTAL FORAMEN: MORPHOMETRIC VARIABILITY AND SURGICAL SIGNIFICANCE IN THE NORTH INDIAN POPULATION

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ABSTRACT

Background: The mental foramen (MF) is a key anatomical landmark that plays a vital role in various clinical and surgical procedures involving the mandible, including the administration of local anaesthesia and other invasive interventions. A clear understanding of its shape, position, and relationship to nearby structures is essential to reduce the risk of complications. This study aims to provide detailed anatomical insights into the location, morphological variations, and prevalence of both the mental foramen and any accessory mental foramina.

Materials and Methods: Fifty-five dry adult human mandibles of unknown sex were examined to determine the number, shape, and position of the mental foramina. Measurements were taken using digital vernier callipers, and the collected data were statistically analysed to calculate mean values and standard deviations (SD).

Results: All 55 mandibles showed bilateral presence of the mental foramen. Accessory mental foramina (AMF) were identified in 16 mandibles, representing a prevalence of 29.1%. The majority of the foramina (64.5%) had an oval shape. In most cases, the MF aligned with the long axis of the second premolar—62% on the right and 72% on the left. Bilateral measurements from standard anatomical landmarks were recorded, offering a comprehensive morphometric profile of the MF.

Conclusion: The MF demonstrates notable morphological and morphometric variations across populations. Knowledge of its exact position and dimensions is crucial for clinicians to ensure precise surgical planning, effective administration of anaesthesia, and the prevention of mental nerve injury.

Keywords: Mandible, Mental foramen, Anatomical variation, Accessory mental foramina, Morphometry

INTRODUCTION

The mental foramen (MF) is an important anatomical landmark on the front-side surface of the mandible. It serves as the exit point for the mental nerve and accompanying blood vessels that supply sensation and blood flow to the lower lip, chin, and nearby gingiva [1–3]. The MF can vary widely among individuals in terms of its size, shape, position, and the direction in which it opens. These variations may be influenced by factors such as sex, age, ethnicity, radiographic method, and the level of alveolar bone resorption, especially in people who are edentulous [4–5]. Because of this variability,

accurately identifying the location of the MF is essential to prevent nerve or blood vessel injury during surgical or anaesthetic procedures involving the mandible.

In addition to its positional variations, the mental foramen may sometimes be accompanied by accessory mental foramina (AMF)—additional openings in the mandible apart from the main MF [6–8]. These arise when branches of the mental nerve divide earlier than usual before exiting the bone [8]. Identifying these accessory foramina is clinically important, as failing to recognize them during procedures—such as periapical surgery, implant placement, or root canal treatment—may lead to sensory disturbances, inadequate anaesthesia, or other postoperative complications [9].

The size, shape, and positional differences of both the mental foramen and any accessory mental foramina have meaningful implications in a range of dental and maxillofacial procedures, including premolar curettage, endodontic treatments, restorative work, implant placement, and orthognathic surgeries [10]. Therefore, a detailed understanding of their morphology and measurements, especially in relation to nearby anatomical structures, is crucial for safe and effective clinical practice.

Given its clinical significance, the present study aims to assess the morphological and morphometric characteristics of the mental foramen, with special attention to its position relative to adjacent anatomical landmarks and the presence of accessory foramina. This knowledge supports improved surgical planning, reduces the risk of complications, and enhances precision in procedures involving the mandibular region.

MATERIALS AND METHODS

This study was carried out on fifty-five dry adult human mandibles of unknown sex, obtained from the Department of Anatomy at the University College of Medical Sciences, Delhi, India. The research focused on assessing the shape, size, position, and orientation of the mental foramen (MF), along with noting the presence of any accessory mental foramina.

The morphology of the mental foramen was carefully inspected with the help of a hand lens, which was also used to detect any accessory foramina. The size of the MF was measured by recording its transverse and vertical diameters (Figure 1).

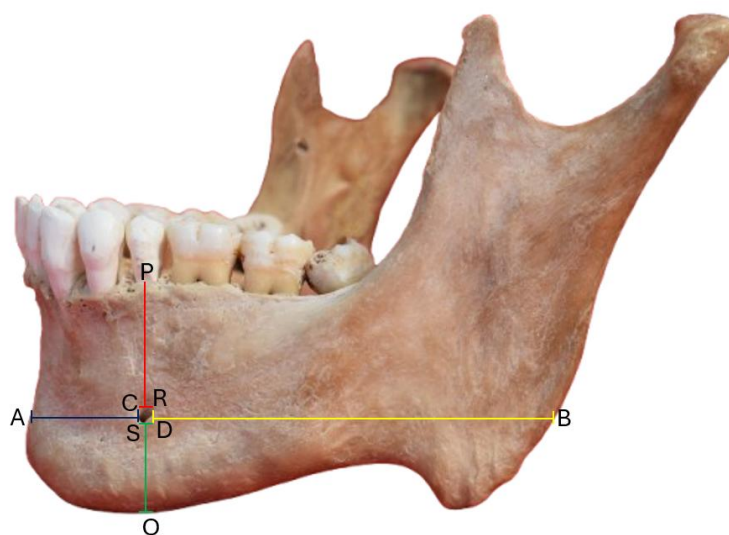


Figure 1: Relationship of the mental foramen to the body of the mandible

P: The point on the alveolar crest that lies directly in line (vertically) with the mental foramen.

Q: The point on the lower border of the mandible that is vertically aligned with the mental foramen.

R: The point marking the upper edge of the mental foramen.

S: The point marking the lower edge of the mental foramen.

A: The point on the symphysis menti that lies horizontally in line with the mental foramen.

B: The point on the posterior border of the ramus that lies horizontally aligned with the mental foramen.

C: The point located at the inner (medial) margin of the mental foramen.

D: The point located at the outer (lateral) margin of the mental foramen.

The transverse (side-to-side) measurements were taken using several key anatomical landmarks, including the symphysis menti, the back border of the mandible, the mandibular base, and the alveolar margins. The measurements included:

- **AB** – the distance from the symphysis menti to the posterior border of the mandible
- **AC** – the distance from the symphysis menti to the front edge of the mental foramen (MF)
- **DB** – the distance from the back edge of the MF to the posterior border of the mandible
- **CD** – the transverse diameter (TD) of the MF

Vertical measurements were recorded using the following parameters:

- **PQ** – the distance from the alveolar margin to the base of the mandible
- **PR** – the distance from the alveolar margin to the upper margin of the MF
- **SQ** – the distance from the lower margin of the MF to the base of the mandible
- **RS** – the vertical diameter (VD) of the MF

This approach allowed for precise measurement of the mental foramen (MF) in relation to nearby mandibular structures, supporting an accurate and detailed morphometric analysis.

Assessment of Mental Foramen Orientation, Accessory Foramina, and Position

To assess the orientation of the mental foramen (MF), an office pin was gently inserted laterally into the foramen, and the direction in which the pin pointed was observed visually. The presence of any accessory mental foramina (AMF) was also recorded, noting whether they appeared on the left or right side of the mandible and whether they were located anterior, posterior, superior, or inferior to the main MF.

Based on the direction indicated by the pin, the course of the mental foramen was classified into four groups:

- **D1:** Anterior
- **D2:** Antero-superior
- **D3:** Postero-superior
- **D4:** Horizontal

The position of the MF in relation to key mandibular landmarks—such as the symphysis menti, the posterior border of the mandibular ramus, the alveolar margin, and the base of the mandible—was determined using the method described by Voljevica et al. [11].

The transverse and vertical diameters of the MF were measured using a digital Vernier calliper with 0.01 mm accuracy. Finally, the location of the MF in relation to the mandibular teeth was categorized according to the classification proposed by Tebo and Telford [12] (Figure 2).

- **I:** Located between the canine and first premolar
- **II:** Aligned with the first premolar
- **III:** Situated between the first and second premolars
- **IV:** Aligned with the second premolar
- **V:** Located between the second premolar and first molar
- **VI:** Aligned with the first molar

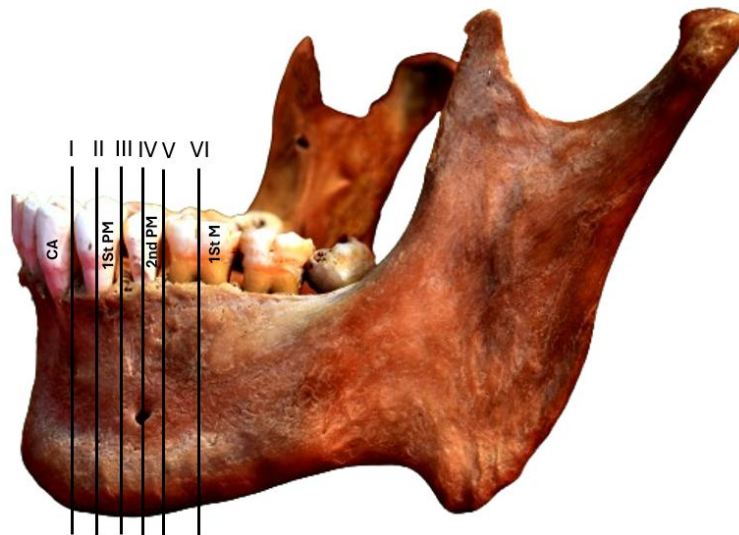


Figure 2: Illustration showing how the position of the mental foramen can vary in relation to the lower teeth, categorized as Positions I–VI.

Bilateral measurements and observations of the mandible were carefully recorded for each specimen. All data were then organized into structured tables and analyzed using SPSS software (version 16.0). The chi-square test was used to assess statistical significance, with a p-value of less than 0.05 considered meaningful. Finally, the findings were compared with results from earlier studies conducted in different ethnic populations.

RESULT

Shape of Mental Foramen

The shape of mental foramen was observed to be either round or oval (Figure 3).



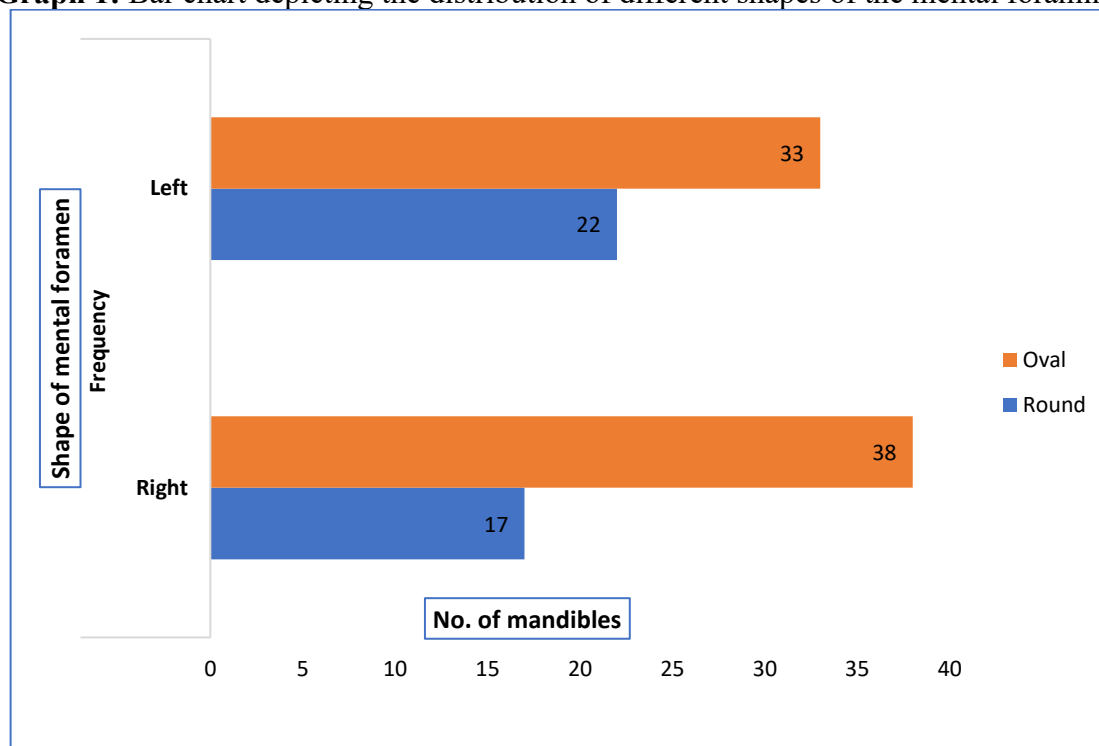
Figure 3: Shape of the mental foramen (A) Rounded, (B) Oval

Table 1 indicates that the mental foramen was most commonly oval in shape, appearing in 69.1% of specimens on the right side and 60% on the left. The round shape was less frequent, seen in 30.9% on the right and 40% on the left. Overall, the oval shape also appeared more often on both sides simultaneously, with 28 specimens showing bilateral oval foramina compared to 15 specimens with bilateral round ones.

Table 1: Distribution of the shape of the mental foramen on the right and left sides of the mandible.

Shape of Mental Foramen	Frequency		Percentage		Bilateral	Unilateral	
	Right	Left	Right	Left		Right	Left
Round	17	22	30.90%	40%	15	2	7
Oval	38	33	69.10%	60%	28	10	5
Total	55	55	100%	100%	43	12	12

The frequency of occurrence of the shape of mental foramen is shown in Graph 1. There was no statistically significant difference (p value > 0.05) in the shape of mental foramen on right and left sides.

Graph 1: Bar chart depicting the distribution of different shapes of the mental foramina.

Size of the Mental Foramen

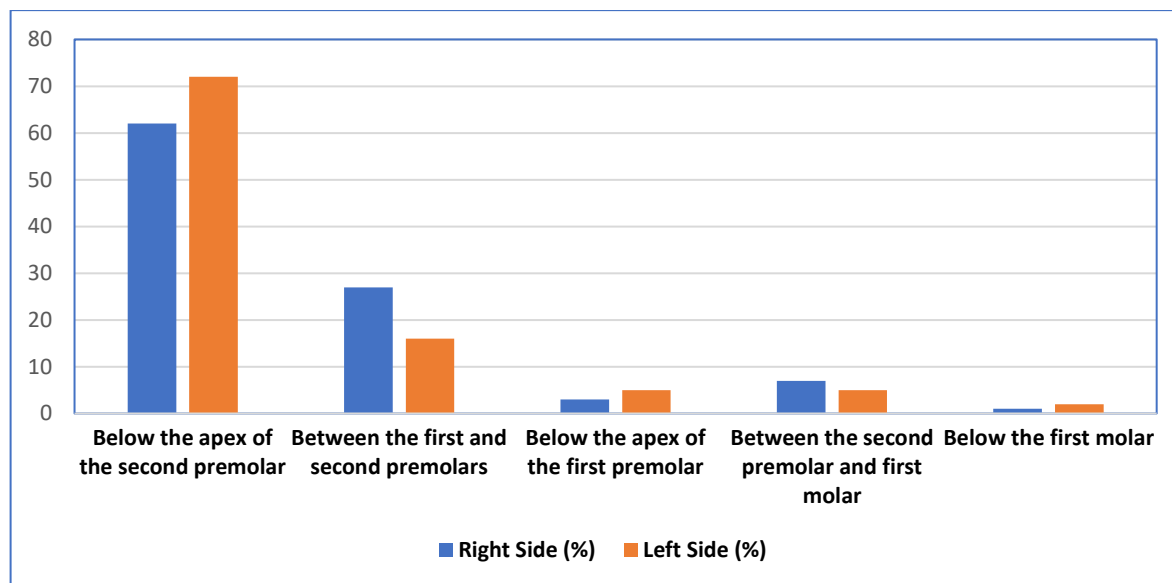
The mean transverse diameter of the mental foramen was slightly larger on the left side (3.43 mm) compared to the right side (3.27 mm), with an overall range of 1.03–5.13 mm. Analysis of bilateral measurements showed that the maximum transverse diameter was 3.26 ± 0.90 mm on the right and 3.41 ± 0.82 mm on the left, with the difference between sides being statistically significant ($P \leq 0.05$). For the vertical diameter, the mean measurements were 2.47 mm on the right side and 2.89 mm on the left, ranging from 0.99 to 4.03 mm. The maximum vertical diameters recorded were 2.45 ± 0.71 mm on the right and 2.60 ± 0.63 mm on the left. The distance from the mental foramen to the symphysis menti was similar on both sides, measuring 24.87 ± 6.07 mm on the right and 24.77 ± 6.07 mm on the left.

Distribution of Mental Foramen Position Relative to Teeth

In our study, the mental foramen (MF) was most commonly located along the vertical axis of the second premolar, appearing in 62% of cases on the right side and 72% on the left side. The next most frequent position was found between the first and second premolars. These findings are summarised in Table 2 and visually represented in Graph 2.

Table 2: Distribution of mental foramen positions relative to mandibular teeth on the right and left sides.

Position of Mental Foramen	Right Side (%)	Left Side (%)
Below the apex of the second premolar	62	72
Between the first and second premolars	27	16
Below the apex of the first premolar	3	5
Between the second premolar and first molar	7	5
Below the first molar	1	2

Graph 2: Depicts the location of the mental foramen relative to the mandibular teeth on both sides.

Incidence of Accessory Mental Foramen

An accessory mental foramen (AMF) was identified in 16 out of the 55 mandibles examined (Figure 4), resulting in an overall incidence of 29.1%. Of these, nine AMFs were found on the right side and seven on the left. Interestingly, three mandibles showed accessory mental foramina on both sides. The anatomical locations of these accessory foramina, in relation to the main mental foramen, were carefully analyzed across all 55 mandibles.

**Figure 4:** Accessory mental foramina observed: (A) two on the right side, (B) three on the left side.

In Table 3, the antero-inferior position of the accessory mental foramen (AMF) was the most commonly observed, seen in 9 cases (16.4%). This was followed by the antero-superior position,

which appeared in 4 cases (7.3%). The postero-superior and postero-inferior positions were much less frequent, occurring in only 2 cases (3.6%) and 1 case (1.8%), respectively.

Table 3: Position of the Accessory Mental Foramen Relative to the Mental Foramen

Position of AMF relative to Mental Foramen	Number of AMF	Percentage (%)
Antero-inferior	9	16.4%
Antero-superior	4	7.3%
Postero-superior	2	3.6%
Postero-inferior	1	1.8%

*Note: AMF = Accessory Mental Foramen.

Direction of the Mental Foramen

The orientation of the mental foramen was carefully assessed, and the frequency distribution is presented in Table 4. Comparative analysis showed no significant difference between the right and left sides ($p > 0.05$), suggesting a generally symmetrical pattern of mental foramen direction in the studied population.

Table 4 displays the directional orientation of the mental foramen in 55 adult mandibles. Bilateral occurrence was observed in 42% of cases, while unilateral presence accounted for 58%. The D3 orientation was the most common (47.3%), followed by D2 (32.7%), D4 (16.4%), and D1 (3.6%). The table also provides a side-specific breakdown of these orientations.

Table 4: Patterns of Mental Foramen Orientation on the Right and Left Sides of the Mandible

Direction	Frequency (n)	Percentage (%)	Right Side	Left Side	Bilateral
D1	2	3.6	1	1	0
D2	18	32.7	5	6	7
D3	26	47.3	9	5	12
D4	9	16.4	3	2	4
Total	55	100	18	14	23

Position of the Mental Foramen

In this study of 55 mandibles, the mental foramen was most commonly found in Position IV, as defined by the Tebo and Telford classification, occurring bilaterally in 51% of cases. Position III was the next most frequent, appearing bilaterally in 16% and unilaterally in 9% of mandibles. Positions II and V were observed less often, in approximately 5–7% and 15–20% of specimens, respectively, while Position VI was rare, seen in only 2–4% of mandibles. Notably, Position I was not detected in any specimen (Table 5).

Overall, the mental foramen showed a high degree of symmetry, with 80% of mandibles displaying the same position on both sides. Statistical analysis revealed no significant difference between the right and left sides ($p > 0.05$).

Table 5: Frequency distribution of mental foramen positions relative to mandibular teeth on the right and left sides of the mandible.

Classification	Right Side (n)	Left Side (n)	Right Side (%)	Left Side (%)	Bilateral (n)	Unilateral (n)
I	0	0	0%	0%	0	0
II	3	4	5%	7%	3	1
III	14	11	25%	20%	9	5
IV	28	28	51%	51%	28	0
V	8	11	15%	20%	6	5
VI	2	1	4%	2%	1	1

***Note:** Analysis of the mental foramen positions revealed a similar distribution on both the right and left sides of the mandible, with no statistically significant difference between them ($p > 0.05$).

DISCUSSION

Shape of the mental foramen

Several studies have reported on the shape of the mental foramen. The oval-shaped foramen was found to be the most common in the investigations by Mbajorgu et al. [13], Budhiraja et al. [14], and Oliveira et al. [15]. In contrast, a round-shaped foramen was more frequently observed in the studies conducted by Al-Khateeb et al. [16], Singh and Srivastav [9], and Ukoha et al. [17]. A comparative overview of the mental foramen shapes reported in previous studies is summarized in Table 6. The variation in the foramen's shape is thought to be influenced by the direction in which the mental vessels and nerves emerge [18].

Table 6: Variations in Mental Foramen Shapes: Insights from Different Populations

Authors	Oval (%)	Round (%)
Singh & Srivastav (2010) ^[9]	9.5	90.5
Mbajorgu et al. (1998) ^[13]	56.3	43.7
Budhiraja (2013) ^[14]	74.3	25.7
Oliveira et al. (2009) ^[15]	72.55	27.45
Al-Khateeb et al. (2007) ^[16]	Minority	Majority
Ukoha et al. (2013) ^[17]	24.24	75.76
Chandramohan et al. (2013) ^[19]	58	42
Present study (2024)	69.1	30.9

Size of the mental foramen

In the study by Ilayperuma I et al. [20], the mental foramen was reported to have a mean transverse diameter of 3.26 mm on the right side and 3.41 mm on the left, while the mean vertical diameter measured 2.45 mm on the right and 2.60 mm on the left. Similarly, Agrawal DR et al. [6] found that the mean transverse diameters were 3.33 mm on the right and 3.25 mm on the left, with vertical diameters of 2.15 mm and 2.13 mm, respectively. In the present study, we observed a mean transverse diameter of 3.27 mm on the right side and 3.43 mm on the left, and vertical diameters of 2.47 mm on the right and 2.89 mm on the left, which closely mirrors the findings reported by Dipti A. Nimje et al. [21]. Furthermore, the mental foramen most commonly opened in a posterosuperior direction in 65% of subjects, consistent with the observations made by Agrawal DR et al. [6].

Direction of the mental foramen

Understanding the direction in which the mental foramen opens is crucial for dental surgeons, as it determines the angle at which the needle should be inserted during a mental nerve block [15]. Studies have shown that the posterosuperior direction is the most common, including research by Agarwal and Gupta in South Gujarat [6], Mwaniki and Hassanali in Kenya [22], and Igbigbi and Lebona in Malawi [2]. Since the mental nerve typically exits the mental foramen in a posterolateral direction, it is not surprising that the posterosuperior opening is frequently observed [18].

Position of mental foramen

The anatomical position of the mental foramen is clinically important, particularly for performing mental and incisive nerve blocks, as well as for surgical procedures in the premolar region of the mandible [23]. Its location, however, shows notable variation among different ethnic populations [11]. For example, Igbigbi and Lebona [2] reported that in Malawian mandibles, and Mbajorgu [13] in Zimbabwean mandibles, position IV was the most common, followed by position V. In contrast, studies on British mandibles by Santini and Land [7] and on Chinese mandibles by Green [24] found position III to be the most frequent, with position IV occurring next. Research on Kenyan mandibles [22] indicated that position III predominates, followed by position II, whereas in Malay populations [25], position IV was the most prevalent, with position III as the second most common.

Our findings are in agreement with earlier studies conducted by Agarwal DR et al. [6] on the South Gujarat population, Voljevica A et al. [11] on the Bosnian population, and Budhiraja et al. [14] on the Indian population, supporting the idea that mental foramen location tends to be fairly consistent within a given ethnic group. Furthermore, the position of the mental foramen is also influenced by the morphology of the mandibular tooth roots [18]. A comparative overview of mental foramen positions across various populations is presented in Table 7.

Table 7: A Comparative Study of Mental Foramen Locations in Diverse Populations

Authors	Population	Most Frequent Position	Second Most Frequent Position
Budhiraja et al. (2013) ^[14]	Indians (Asia)	IV	III
Ukoha et al. (2013) ^[17]	South Eastern Nigerians	IV	V
Chandramohan et al. (2016) ^[19]	South Indians	IV	III
Gungor et al. (2006) ^[26]	Turkish (Europe)	III	IV
Moiseiwitsch (1998) ^[27]	North Americans	III	IV
Haghanifar & Rokouei (2009) ^[28]	Iranians (Middle East)	III	IV
Fabian (2007) ^[29]	Tanzanians (Africa)	IV	V
Olasoji et al. (2004) ^[30]	North Nigerians	III	IV
Present study (2024)	North Indians	IV	III

Incidence of accessory mental foramina (AMF)

The reported frequency of accessory mental foramina (AMF) varies across studies. For example, Singh and Srivastav [9] found AMF in 13% of mandibles, Gershenson et al. [5] observed double AMF in 4.3% and triple AMF in 0.7% of 525 mandibles, and Serman [31] reported an incidence of 2.7%. In our study, AMF was present in 16 out of 55 mandibles, representing 29.1%. These foramina arise when the mental nerve branches before emerging through the main foramen. Identifying their presence is important to avoid nerve injury during periapical procedures or surgical interventions.

CONCLUSION

Paralysis of the mental nerve is a significant complication that can occur during surgical procedures involving the mandibular canal and the mental foramen. For this reason, accurately identifying the mental foramen and understanding its morphometry is essential for dental surgeons, especially when performing nerve blocks or surgeries such as apical curettage of mandibular premolars and periodontal procedures. In this study, most mandibles showed oval-shaped foramina located at position IV. However, the position, shape, and size of the mental foramen can vary among different populations. Being aware of these anatomical differences is crucial for planning interventions in this area, both to reduce the risk of nerve injury and to ensure that mental nerve block anesthesia is effective.

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CONFLICTS OF INTEREST

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