

Morphometric Analysis of Mandibular Foramina in Adult Nigerian Mandible

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ABSTRACT

Background and Objective: The mental neurovascular bundle emerges at the mandibular foramina (MF) a significant anatomical landmark on the anterolateral part of the jaw. Its morphological features, and precise location have important clinical implications for dental anesthesia, implant placement, and surgical procedures of the lower jaw. Population-dependent variations in the MF characteristics, however, are very common, and studies on Nigerian mandibles have been remarkably sparse. The present study was undertaken to provide crude morphometric data on the incidence, location, size, and accessory foramina of the MF in a Nigerian sample population.

Materials and Methods: The study entailed the analysis of sixty adult human mandibles (36 males and 24 females) stored in the Department of Anatomy, University of Ilorin. All specimens were complete and free of any deformity. Measurements were collected using a calibrated Vernier caliper, in a nominally modified version of the method of Alma et al. The positional relationship with the adjacent teeth was considered, and the occurrence of accessory mental foramina (AMF) was noted. Data were statistically processed using SPSS version 21.0, and it facilitated the generation of descriptive statistics.

Results: Bilateral MF were found in all mandibles studied. Circular patterns were more common than oval ones, appearing in 58.33% of cases on the left and 66.67% of cases on the right. With 48.33% on the right and 58.33% on the left, the foramen was most frequently observed in connection with the second premolar tooth. On average, the transverse size was 4.19 ± 1.18 mm on the left and 3.98 ± 1.17 mm on the right, while the vertical dimension was 3.06 ± 0.80 mm on the right and 3.19 ± 0.92 mm on the left. 8.33% of the left sides, and 11.67% of the right sides had accessory foramina.

Conclusion: The present findings support that the MF in Nigerian mandibles is predominantly circular and most frequently found at the level of the second premolar. The presence of accessory foramina in some specimens highlights the necessity for careful preoperative evaluation. These anatomical structures are not only important for dental, and maxillofacial surgeons, but also carry immense anthropological and forensic significance.

KEYWORDS: Accessory foramina, Mandible, morphometry, Premolar region, Nigerian population.

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INTRODUCTION

The Mental Foramina (MF) the last aperture of the mandibular canal through which the mental nerve and its accompanying arteries exit, is a significant anatomical landmark on the anterolateral portion of the jaw.^{1,3,8} The morphology, dimensions, and positional differences of the structure have been extensively studied in different populations due to the fact that these factors influence a large range of dental, surgical, and anesthetic procedures.^{2,4,7}

In the clinical environment, precise localization of the MF is essential to the successful administration of mental and incisive nerve blocks. Incomplete identification of the site may result in inadequate anesthesia, ongoing pain, or iatrogenic neurovascular bundle injury during implant placement, periapical surgery, and fracture repair.⁹ Alterations in the morphology of MF may also cause

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interference with the interpretation of radiographics and thus to misdiagnosis of periapical pathoses.^{5,6}

There is considerable inter-population variance in the MF's position in relation to the alveolar crest and the mandibular lower border.^{7,14} It is located on average 13–15 mm above



Figure 1: Positional measurements of the mental foramina.¹⁵

the mandibular base, although when referenced in relation to teeth, the most common location is either in the second premolar line or between premolars.^{15,17,18} All these are age, sex, ethnicity, and tooth loss dependent, and therefore the requirement of population-specific anatomical data.^{12,13,16}

Of clinical significance is the accessory MF (AMF), an additional mandibular opening present typically in the premolar-molar region.^{10,11} The incidence of AMF has been reported to range from 1.4% to 13%, depending on the population under study.^{11,12} Of surgical interest, detection of AMF is of critical importance since it may have additional branches of the mental nerve, leading to complications like inadequate anesthesia or accidental transection during surgery.¹⁰

Outside clinical practice, MF morphometry studies are relevant to anthropology and forensic anthropology. Since, mandibular form is genetically and environmentally determined, MF features can be used to identify population differences, reconstruct evolutionary trends, and assist in the identification of humans in forensic investigations.^{1,3}

Due to the lack of data on Nigerian populations, careful evaluation of the MF is of very high priority. Accordingly, this study examines the morphology, morphometry, and positional features of MF of adult Nigerian mandibles, offering baseline data for dental professionals, maxillofacial surgeons, anthropologists, and forensic scientists.

MATERIALS AND METHODS

Sample Collection

This descriptive osteological examination was carried out on a sample of sixty mandibles of adult human beings (36 males and 24 females) collected from the Anatomy Museum of the Department of Anatomy, University of Ilorin. Although the precise chronological ages of the specimens were not ascertained, they were all classified as adult bones due to the full eruption of the permanent dentition, well-defined alveolar margins, and fused symphy seal regions. Only mandibles that were free from gross deformities, fractures, or pathological lesions were utilized for this research. Bones with excessive resorption or arrested ossification were not included in the study.

Sex Determination

Sex determination of the mandibles was done on the basis of well-established morphological criteria. Mandibles with everted gonial angles, relatively coarser and larger texture of bone, and broad and square chin were deemed to be of male sex. Mandibles with obtuse gonial angles, smooth surface contours, and rounded mental regions were deemed to be of female sex. These criteria are routinely accepted in osteology and forensic anthropology to distinguish sexual dimorphism in skeletal remains.^{12,16}

Measurement Instruments

The measurements were recorded with a high-precision Vernier caliper to 0.01 mm precision and supplemented with a standard metric ruler, osteometric board, and identification markers. Each was measured three times and the mean reading recorded to minimize intra-observer variation.

Measurement Protocol

The morphometric examination of the MF (MF) was carried out using a modified version of the protocol of Alma *et al.*¹⁴ The mandible was fixed on a hard platform, and all measurements were recorded with a Vernier caliper to 0.01 mm. The vertical measurements comprised the total mandibular height (A1), it was determined to be the linear length between the mandibular lower border and the alveolar crest. The distances between the lower edge and the basal mandibular border (A3) and the alveolar crest and the top edge (A2) were used to determine the MF's location. The vertical MF length (A4) was then arrived at by mathematical subtraction of the sum of A2 and A3 from the value of A1.

In the anteroposterior measurements, the overall mandibular length (F1) was measured between the posterior border of the ramus to the mental symphysis midpoint. Anterior location of the foramen was measured as the symphysis to anterior border distance (F2). Direct caliper measurements were used to measure the true width of the foramen (F4), and the posterior border of the foramen to the ramus (F3) distance was obtained from $F1 - (F2 + F4)$.

Positional Classification: For the purpose of comparison, the position of the mandibular foramen (MF) was standardized based on its position relative to the neighboring dental structures. Six positional classifications were used for analytical precision, similar to previous studies.^{6,18} The first classification reported a foramen between first premolar and canine. The second classification reported its position at the level of the first premolar's crown. According to the third categorization, the foramen was situated in between the first and second premolars. The MF and the second premolar were positioned in a straight line in the fourth and most typical arrangement. The sixth categorization was for a foramen along the long axis of the first molar, and the

fifth, less frequent pattern, was between the first molar and the second premolar.

Accessory Foramina Assessment: The accessory mental foramina (AMF) were directly visualized. Their existence, number, and lateralization were noted. AMFs were discerned from nutrient foramina based on their comparatively larger sizes and clear aperture opening into the mandibular canal.^{10,11}

Statistical Analysis: All the collected data were keyed into Microsoft Excel and then analyzed using SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics of mean, SD, and range were calculated for all the parameters. Left versus right side measurements were compared and results were tabulated for better understanding. Results were cross-checked with values from previous published literature to highlight similarities and differences among different populations.

RESULTS

Location of the Mental Foramina

Interpretation (Table 1)

On the right side, average mandible height (A1) was approximately 30 mm, and the foramen-to-alveolar crest and mandibular base measurements were almost equal, approximately 13.5 mm. The foramen was vertical in size to almost 3 mm, and transverse in diameter to almost 4 mm. The overall length of the mandible (F1) was a mean of 92.7 mm, and the anterior border of the mandibular foramen was approximately 26.5 mm from the symphysis.

Interpretation (Table 2)

On the left, the results were rather similar to the right. The MF was located around halfway in the vertical direction (A2 ≈ 13.7 mm; A3 ≈ 13.4 mm). The vertical reach (A4) was slightly more than 3 mm on average. Transverse width (F4) was slightly broader on the left (4.19 mm) than on the right. The average mandible length was also similar, averaging 92.8 mm.

Table 1: Right-Side MF Location Metrics, table presents the mean, standard deviation, and observed range (in millimeters) of various parameters measured on the right side of the mandible.

Measurement	Mean	N	SD	Range
A1	30.33	60	3.40	23–38
A2	13.77	60	2.75	7–19
A3	13.51	60	1.62	10–18
A4	3.06	60	0.80	1–5
F1	92.68	60	5.21	78–107
F2	26.51	60	2.05	22–31
F3	62.21	60	4.58	50–72
F4	3.98	60	1.17	1–8

Positional Distribution of Mental Foramina

Interpretation (Table 3)

The most common place for the MF was behind the second premolar (Position IV) and accounted for approximately fifty percent of right-sided foramina and over fifty percent on the left side. The second most common place was between the first molar and second premolar (Position V). Places seen with less frequency were between the premolars (Position III) and along the first molar's axis (Position VI). No foramina were seen at Positions I or II in this population.

Morphological Variation

Interpretation (Table 4)

Round foramina were the most common type found, most often on the right side; however, many of the specimens possessed oval-shaped openings. Nearly half of the mandibles that we examined had bilaterally symmetrical round foramina.

Prevalence of Accessory Foramina

In all 60 mandibles, the principal MF was bilaterally present. AMF were found in 7 right-sided cases (11.7%), 5 left-sided cases (8.3%), and 2 mandibles (3.3%) that were bilateral. These additional openings were smaller than the principal MF, but clinically relevant since they may contain accessory branches of the mental nerve.

DISCUSSION

The present study evaluated the morphometric and positional characteristics of the MF (MF) within a sample of sixty Nigerian adult mandibles, thus providing new information specific to this group. The results confirm the existence of the MF bilaterally within each of the specimens under investigation, demonstrating significant differences in shape, size, and position compared to existing results from various ethnic groups.

Mandibular Height and Foramen Position The average mandibular height in this study was somewhat higher than the 28.79 mm found by Alma *et al.* (30.33 mm on the right side and 30.28 mm on the left). Such variations likely represent the influence of population-specific skeletal features and genetic factors. The mean separation between the alveolar

Table 2: Left-Side MF Location Metrics, table provides the mean, standard deviation, and range of measurements obtained on the left side.

Measurement	Mean	N	SD	Range
A1	30.28	60	3.29	23–40
A2	13.69	60	2.46	7–18
A3	13.39	60	1.48	10–18
A4	3.19	60	0.92	1–5
F1	92.77	60	5.18	78–107
F2	26.62	60	2.67	22–36
F3	61.96	60	4.47	53–72
F4	4.19	60	1.18	1–9

Table 3: MF Position Distribution, table illustrates the frequency distribution of MF positions relative to adjacent teeth.

Position	Right (n=60)	Left (n=60)	Bilateral
I	–	–	–
II	–	–	–
III	8 (13.3%)	13 (21.7%)	6 (10%)
IV	29 (48.3%)	35 (58.3%)	20 (33.3%)
V	22 (36.7%)	10 (16.7%)	7 (11.7%)
VI	1 (1.7%)	2 (3.3%)	–

crest and its superior margin in the measurement of the mandibular foramen's (MF) vertical position was 13.77 mm on the right side and 13.69 mm on the left. These measurements agree closely with the findings of Alma *et al.* (14.37 mm)¹⁴ and indicate that, in Nigerians, the MF is generally at a midpoint on the alveolar and basal aspects of the mandible. The distance from the inferior margin of the MF to the mandibular base (13.51 mm right; 13.39 mm left) also indicated congruence with the findings of Rahul *et al.*,¹⁶ although it was marginally greater than the figures given by Parmar *et al.*¹⁵ Such minor variations can be attributed to ethnic differences, nutritional factors, or variations in sample size.

Dimensions of the MF: The vertical dimension (A4) of the MF was a mean of 3.06 mm on the right and 3.19 mm on the left, which falls within the range of 3.5 mm. The transverse diameter (F4) was approximately 4 mm on both sides, which closely coincides with the values established by Rastogi *et al.*,¹⁷ being slightly lower in comparison with those in some Indian populations. These observations corroborate the evidence that the MF in the Nigerian population has moderate dimensions, a characteristic that remains of significant clinical significance for dental implant procedures and nerve block anesthesia.

Anteroposterior Position: The anteroposterior position of the MF relative to the posterior ramus boundary and symphysis was extremely consistent. The anterior margin of the MF was approximately 26.5 mm from the symphysis, conforming with Alma *et al.*¹⁴ The posterior margin of the MF to ramus was larger in this Nigerian series (62.21 mm right; 61.96 mm left) compared to Alma *et al.*,¹⁴ but comparable to Rahul *et al.*¹⁶ These results again demonstrate population-specific differences in mandibular proportions.

Foramen Shape and Position with Respect to Teeth: Morphologically, round foramina were the most frequent in this study (66.7% right; 58.3% left), although oval forms were also frequent. This agrees with Singh and Srivastav,^{12,13} who also reported a predominance of circular outlines, but with Parmar *et al.*,¹⁵ who reported oval foramina more characteristically. Such variations mean that shape of foramen may not necessarily be uniform even within regional populations

Table 4: MF Shape Distribution, table summarizes the observed shapes of the mental foramina.

Shape	Right (n=60)	Left (n=60)	Bilateral
Round	40 (66.7%)	35 (58.3%)	29 (48.3%)
Oval	20 (33.3%)	25 (41.7%)	14 (23.3%)

Position-wise, the MF was seen most frequently in position with the second premolar (Position IV), representing close to half of right-sided and over half of left-sided foramina. This finding is in agreement with Yesilyurt *et al.*,¹⁸ and bears testimony to the frequent usage of the second premolar area as a landmark for mental nerve block in clinical practice. The MF was less commonly seen between the second premolar and first molar (Position V) or between the premolars (Position III). Positions I, II, and VI were not found, or were found seldom, since extreme anterior or posterior positions are uncommon in Nigerians.

Accessory Mental Foramina: AMF occurred in 11.7% of right mandibles and 8.3% of left mandibles. These are comparable to Singh and Srivastav,^{12,13} who noted 13%, but are greater than Serman's 2.7%.¹⁹ AMF is of great clinical importance as undiagnosed foramina can be the cause of incomplete anesthesia, or neurovascular injury during surgery.^{10,11} These data emphasize the importance of meticulous radiographic, and surgical examination prior to dental extractions, implant placement, or orthognathic surgery.

Clinical and Anthropological Implications: In the clinical aspect, proper identification of the MF is necessary to avoid iatrogenic complications of periapical surgery, trauma management, and implant placement. Inadequate knowledge of accessory foramina could be the cause of the failure of mental nerve blocks, which is not uncommon in dentistry. Anthropologists and forensic experts may view the study of the MF as important markers to identify sex, ancestry, and population variation.^{1,3}

Together, the present findings highlight fine but important differences in the morphology of MF among Nigerian populations, and those previously studied. The common finding of the location of the second premolar region as that of the most frequent MF makes it a reliable landmark for health professionals. However, the relatively elevated frequency of accessory foramina necessitates individual evaluations by imaging methods, such as cone-beam computed tomography (CBCT), before performing surgical interventions.

CONCLUSION

It clarified, the morphological appearance and positional characteristics of the MF (MF) of adult Nigerians' mandibles. The foramen was present on both sides invariably, usually at the location of the second premolar, and was mostly circular in shape. Accessory foramina were also observed, and hence the significance of proper clinical examination.

Measures taken fall within ranges reported in previous research but show refined population-specific differences. The information is valuable reference material for Nigerian populations, enabling safer dental, and surgical interventions, and aiding anthropological and forensic science.

Recommendation

Results from this study can be used as a reference standard for studying the mental foramina morphology in Ilorin and the North Central region.

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Conflicts of Interest: None

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