

Unlocking the Mandibular Gateway: A Morphometric Insight into Demystifying the Anatomy of the Mandibular Foramen for Dental Procedures.

Naveen Kumar¹, Ravi Bhaskar², Anjana Shidaraddi², Shreyasi Mukherjee³, Ashwini Aithal P⁴

ABSTRACT

Objective

Detailed knowledge regarding the precise location of the mandibular foramen (MF) is essential to avoid iatrogenic injury to the inferior alveolar nerve and vessels during dental procedures. This study was designed to study the various morphometric measurements of the mandibular foramen and its relation to mandibular landmarks.

Materials and methods

MF from sixty dry adult mandibles were observed for variation in shape and location. The distance between the foramen and nearby bony landmarks of the ramus of the mandible was measured and analysed statistically.

Results

The mean vertical diameter of the MF on the right side was 3.31 ± 0.02 mm, and on the left side was 3.49 ± 0.01 mm, which was statistically significant ($p=0.007$). On the right side, the horizontal diameter was 2.95 ± 0.03 mm, and on the left, it was 3.03 ± 0.05 mm. The distance between the MF and the mandibular notch, anterior, posterior, and inferior border of the ramus of the mandible, showed slight variations on the right and left sides of the ramus. Statistically significant difference was observed in the measurement of MF and the anterior border of ramus between the right and left sides ($p=0.02$).

Conclusion

There were slight changes in the dimensions of MF and its distance to nearby mandibular landmarks between the right and left sides of the mandibular ramus. The precise localization of the MF is crucial for achieving a successful inferior alveolar nerve block and for avoiding injury to the neurovascular bundles passing through it during surgeries involving the lower jaw.

Keywords

Inferior alveolar nerve block; ramus of mandible; mandibular notch; morphometrics; maxillofacial surgery.

INTRODUCTION

Morphometric studies of the mandibular foramen (MF) in adult mandibles provide baseline measurements of position and dimensions of the foramen, which are essential for planning inferior alveolar nerve blocks for dental procedures and mandibular surgeries. The mandibular foramen (MF) is an opening on the medial surface of the ramus of the mandible, through which the inferior alveolar nerve and vessels enter the mandible¹. Precise localization of the MF and mandibular notch is crucial for effective administration of anesthesia and avoiding nerve injury during numerous dental and maxillofacial interventions, such as mandibular fracture management, implant surgeries, and orthognathic procedures².

Morphometrics of the MF show associations with demographic factors; however, the strength and direction of these relationships are typically modest and highly dependent on study design, landmarks, and imaging modality. Its exact location is not uniform across individuals and is

1. Ras Al Khaimah College of Medical Sciences. RAK Medical & Health Sciences University, Ras Al Khaimah, UAE.
2. Sri Siddhartha Medical College, Sri Siddhartha Academy of Higher Education, Tumakuru, Karnataka, India
3. Manipal College of Dental Sciences (Manipal), Manipal Academy of Higher Education, Manipal, Karnataka, India.
4. Manipal Academy of Higher Education, Manipal, Karnataka, India.

Correspondence

Dr. Ashwini Aithal P, Associate Professor, Division of Anatomy, Department of Basic Medical Sciences, Manipal Academy of Higher Education, Manipal 576104, Karnataka, India. Email: ashwini.anat@gmail.com

influenced by several factors, including sex, age, ethnic background, and regional or geographical differences. Morphometric investigations across diverse populations have revealed considerable variability in the position of the foramen, underscoring the value of population-specific baselines. These differences can be attributed to the landmarks used (e.g., coronoid notch vs. ramus borders) and the distinction between dry mandibles and radiographic data, which yield systematic differences in absolute values. Studies have also documented incidental accessory mandibular foramina, which may affect the reliability of nerve blocks. Understanding the position of MF helps predict the risk of accessory foramina, which may serve as routes for infection or tumor spread ³.

Morphometric studies, in addition, provide baseline anatomical data that aid clinicians and students in dental education, improving their technique for anesthesia and surgery, and are essential for tailoring clinical approaches to reduce the risk of complications ⁴. In this context, the present study undertook a comprehensive morphometric evaluation of the mandibular foramen using adult dry mandibles of South Indian origin to establish dependable anatomical benchmarks that could contribute to both academic literature and clinical applications.

MATERIALS AND METHODS

The present study was conducted on a total of 60 adult human dry mandibles.

Inclusion criteria: Adult mandibles of both sexes that were either fully or partially without teeth, yet remained structurally intact and well-preserved, were included in

the study.

Exclusion criteria: Mandibles exhibiting substantial bone loss, fractures, structural deformities, or any pathological conditions were excluded from the study.

Methodology: The location of the mandibular foramen was assessed by measuring its distance from specific anatomical landmarks using a digital caliper with an accuracy of 0.1 mm, a scale, and a marker. The measurements were recorded manually on pre-designed data collection sheets. Each measurement was repeated three times, and the average was documented to minimize any potential discrepancies and intra-observer variation (Figure 1).

The following measurements were recorded:

Vertical (VD) and horizontal diameters (HD) of the mandibular foramen.

Distance between mandibular foramen (MF) and mandibular notch (MN)

Distance between mandibular foramen (MF) and anterior border of ramus of mandible (ABR)

Distance between mandibular foramen (MF) and posterior border of ramus of mandible (PBR)

Distance between mandibular foramen (MF) and inferior border of ramus of mandible (IBR)

Statistical analysis was performed using SPSS software v 16.0. Descriptive statistics, including mean values, standard deviations, and Student's t-test, were applied to each parameter. The analysis focused on identifying variations in the location of the mandibular foramen across the examined specimens.



Figure 1: Morphometric measurement of the Mandibular foramen of a dried mandible using a Vernier caliper.

RESULTS

The statistical analysis of the morphometric measurements of the MF on the right side is shown in Table 1, and on the left side in Table 2. The mean vertical diameter of the MF on the right side was 3.31 ± 0.02 mm, while on the left side, it measured slightly higher (3.49 ± 0.01 mm). This difference was statistically significant ($p=0.007$). The same variation was observed in the horizontal diameter of the MF. On the right side, it measured 2.95 ± 0.03 mm, and on the left side, it measured 3.03 ± 0.05 mm, with no statistically significant difference.

In addition to measuring the dimensions of the MF, the study also aimed to localize the MF in relation to key anatomical landmarks. The distance between the MF and the mandibular notch, anterior, posterior, and inferior border of the ramus of the mandible, is shown in Tables 1 and 2. It was observed that there was a slight variation in the measurements between the right and left sides of the ramus. Statistically significant difference was observed in the measurement of MF_ABR between the right and left sides ($p=0.02$).

Table -1: Morphometric analysis data related to mandibular foramen on the Right side of the mandibular ramus.

Measurement	Mean $\pm$ SD (mm)
Vertical diameter (VD)	$3.31 \pm 0.02^*$
Horizontal diameter (HD)	2.95 ± 0.03
MF_MN	20.07 ± 0.14
MF_ABR	$16.59 \pm 0.16^*$
MF_PBR	12.62 ± 0.05
MF_IBR	24.68 ± 0.22

MF- Mandibular foramen, MN- Mandibular notch, ABR- Anterior border of ramus of mandible, PBR- Posterior border of ramus of mandible, IBR- Inferior border of ramus of mandible. * $p<0.05$ when compared to the corresponding measurement on the left side of mandibular ramus.

Table -2: Morphometric analysis data related to mandibular foramen on the Left side of the mandibular ramus.

Measurements	Mean $\pm$ SD (mm)
Vertical diameter (VD)	3.49 ± 0.01
Horizontal diameter (HD)	3.03 ± 0.05
MF_MN	19.57 ± 0.11
MF_ABR	17.36 ± 0.02
MF_PBR	12.43 ± 0.02
MF_IBR	24.94 ± 0.14

MF- Mandibular foramen, MN- Mandibular notch, ABR- Anterior border of ramus of mandible, PBR- Posterior border of ramus of mandible, IBR- Inferior border of ramus of mandible

DISCUSSION

Foramina are the focus of numerous research studies and are frequently the subject of morphometric studies⁵. MF is a key feature of the ramus of the mandible with paramount clinical importance. Although studies on CT scans are more accurate, studies dealing with dry bones are still acceptable and prevalent, as they provide a standard and more accessible mode of measurement⁶. Hence, the precise understanding and population-specific dataset of the MF in dry mandibles is very important to avoid the possibility of iatrogenic nerve injuries. The present study's measurements with respect to the distances from the MF to the anatomical landmarks are consistent with those of previous studies conducted across India and the world, with few variations^{4,7-9}.

MF size and location can show small but detectable differences between populations, likely reflecting genetic and environmental influences on craniofacial growth. However, most comparative studies report overlapping ranges across groups, which limits the clinical impact of individual procedures. In adults, age-related changes in MF morphometry are generally minimal beyond skeletal maturation; however, very small shifts related to remodelling or tooth eruption status may be observed in some radiographic analyses. Nevertheless, dental status, facial growth pattern, and overall mandibular size can confound apparent

demographic effects on MF measurements.

The distance between the MF–anterior border generally ranges between 15–20 mm, and the distance between the MF–posterior border ranges between 11–14 mm. This is consistent across Indian, UK/European, Sudanese, and South African populations, with regional variations¹⁰⁻¹². Significant morphometric and asymmetrical variation is observed both between regions (North vs. Central India) and between mandibular sides (left vs. right) within the samples^{13, 14}.

Knowledge of the mandibular foramen (MF) location from the anterior, posterior, and inferior borders of the mandibular ramus helps the dental surgeons to accurately locate the inferior alveolar nerve entry into the foramen during neurectomy surgeries and nerve block techniques¹⁵. The knowledge of distance of the MF from various landmarks would be helpful in innovating new techniques for using inferior alveolar nerve block. From our study, it was found that the variability of the distances from the given landmarks was not significant enough to produce failure of anaesthesia. For clinical planning, using population-specific normative data can improve localization accuracy, though the benefit is often modest for individual cases. Damage to the inferior alveolar nerve can be avoided in horizontal, vertical, and oblique osteotomies in the ramus⁴. Inferior alveolar artery is the principal artery of the lower jaw and thus, its location in MF is crucial for procedures such as dental extractions, particularly the removal of impacted third molars, dental implant surgery, cyst-tumor surgery, and procedures like orthognathic surgery¹⁶.

Sex differences in MF dimensions or localization are reported in some datasets but are usually small and not consistently significant after adjusting for overall mandible size or body stature. Age-related changes among adults are generally minimal for MF

morphometry; any changes tend to be subtle and are related to remodelling or dental status rather than large directional shifts¹⁷.

Limitations of the study:

The gender and exact age of each mandible could not be ascertained.

CONCLUSION

There were slight changes in the dimensions of MF and its distance to nearby mandibular landmarks, between right and left side of the mandibular ramus. The precise localization of the mandibular foramen is very important to achieve a successful inferior alveolar nerve block and to avoid injury to the neurovascular contents passing through it, prior to dental surgeries of the lower jaw like osteotomy, orthognathic reconstruction surgeries of the mandible, and dental implant procedures. The present study on the morphometry of the mandibular foramen will provide useful information to dental surgeons for planning and conducting dental and maxillofacial surgeries and assist radiologists and oncologists in localizing the mandibular foramen.

DECLARATION

Conflict of interest: NONE

Ethical clearance: Not applicable

Grants and Funding Information: Nil

Author Contributions

Conceptualization and methodology: NK, RB; Investigation: RB, AS; Formal analysis: SM, AAP; Visualization and writing – original draft: AAP; Writing– review and editing: AS, SM, NK; Supervision: NK, RB. All authors have read and agreed to the final version of the manuscript.

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