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Morphometric Analysis of The Mandibular Foramen in Dry Adult Human Mandibles: An Observational Study in The North Indian Population

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ABSTRACT

Background: The mandibular foramen (MF), located on the inner surface of the mandibular ramus, is a vital anatomical landmark. It transmits the inferior alveolar nerve and vessels, making its precise localization essential for procedures like nerve blocks, fracture repair, implant placement, and orthognathic surgeries.

Materials and Methods: The present study was conducted on 35 adult dry human mandibles in the Department of Anatomy, ESIC Dental College & Hospital, Rohini, Delhi. Ethical clearance was obtained prior to the study. The position of the mandibular foramen was measured using a digital caliper (accuracy 0.1 mm) and other standard tools, based on its distance from specific anatomical landmarks.

Results: The mean values of D1, D2, and D5 showed minimal variation between sides and were statistically insignificant ($p > 0.05$). In contrast, significant differences were observed for D3 and D4, with higher mean values on the right side ($p = 0.001$ and $p = 0.002$, respectively). The angle measurement (A) also demonstrated a statistically significant difference ($p = 0.02$), with a higher average angle recorded on the right side (125.1° ± 3.21°) compared to the left (115.4° ± 2.96°). These findings suggest asymmetry in certain morphometric parameters.

Conclusion: The present study highlights significant anatomical variations in the position of the mandibular foramen in adult dry mandibles. Precise morphometric data provide important insights for clinical procedures like inferior alveolar nerve blocks and contribute to anthropological and forensic research. These findings offer a valuable reference for surgical planning and future anatomical studies.

Keywords: *Anatomical variations, dry mandibles, inferior alveolar nerve block, mandibular foramen, mandibular ramus, mandibular base, mandibular foramen, gonial angle, vernier caliper*

1. INTRODUCTION

The mandibular foramen (MF), situated on the inner aspect of the mandibular ramus, represents a key anatomical structure with substantial clinical relevance. It serves as the conduit for the inferior alveolar nerve and its accompanying blood vessels, which innervate and vascularize the lower jaw, teeth, and surrounding soft tissues [1]. Accurate localization of the MF is critical in numerous dental and maxillofacial interventions, such as mandibular fracture management, implant surgeries, orthognathic procedures, and effective delivery of inferior alveolar nerve block anesthesia [2].

The anatomical position of the mandibular foramen holds significant clinical relevance, particularly in procedures involving local anesthesia and mandibular surgeries. However, its exact location is not uniform across individuals and is influenced by several factors, including sex, age, ethnic background, and regional or geographical differences [3]. Morphometric investigations across diverse populations have revealed considerable variability in the foramen's position. These findings highlight the necessity of having population-specific anatomical data, as relying on generalized anatomical landmarks may lead to reduced efficacy in nerve blocks and an increased risk of surgical complications. Therefore, understanding these variations is crucial for improving the accuracy of mandibular procedures and enhancing patient safety [3, 4].

Morphometric studies conducted within various regions of India have highlighted that the position of the mandibular foramen is not consistent across individuals, often exhibiting notable variation based on geographic origin. These findings underscore the necessity of region-specific anatomical data to enhance the precision and safety of clinical and surgical interventions involving the mandible. Furthermore, global research has indicated that ethnic and racial differences significantly influence the dimensions and anatomical positioning of mandibular landmarks. Such variability reinforces the importance of tailoring anatomical reference standards to diverse populations for improved outcomes in dental and maxillofacial procedures [4, 5, 6, 7].

The most accurate method for obtaining morphometric data without the interference of soft tissue remains the direct measurement of dry human mandibles. Despite advancements in imaging technologies—such as cone-beam computed tomography (CBCT)—which have enhanced in vivo anatomical visualization, direct osteometric assessment continues to be considered the gold standard due to its precision and reliability [2, 3, 8].

In this context, the present study undertook a comprehensive morphometric evaluation of the mandibular foramen using adult dry mandibles. This approach was chosen to establish dependable anatomical benchmarks that could contribute meaningfully to both academic anatomical literature and clinical applications. By documenting the precise dimensions and positional variations of the mandibular foramen, the study aimed to provide foundational data with implications for surgical planning, anesthesia administration, and forensic identification.

2. MATERIALS & METHODS

The present study was conducted on a total of 35 adult human mandibles of dry bone specimens. The research work took place in the Department of Anatomy, ESIC Dental College & Hospital, Rohini, Delhi. The samples were sourced from the anatomical collections of ESIC Dental College & Hospital Rohini, Delhi. Prior to the commencement of the study, ethical clearance was duly obtained from the institutional ethical committee to ensure compliance with research protocols.

Inclusion criteria: Adult individuals 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.

Measurement procedure: The location of the mandibular foramen was assessed by recording its distance from specific anatomical landmarks, utilizing a digital caliper with an accuracy of 0.1 mm, Protractor, Scale, Marker, Recording sheets. The following measurements were recorded exhibited in "Fig. / Graph 1".

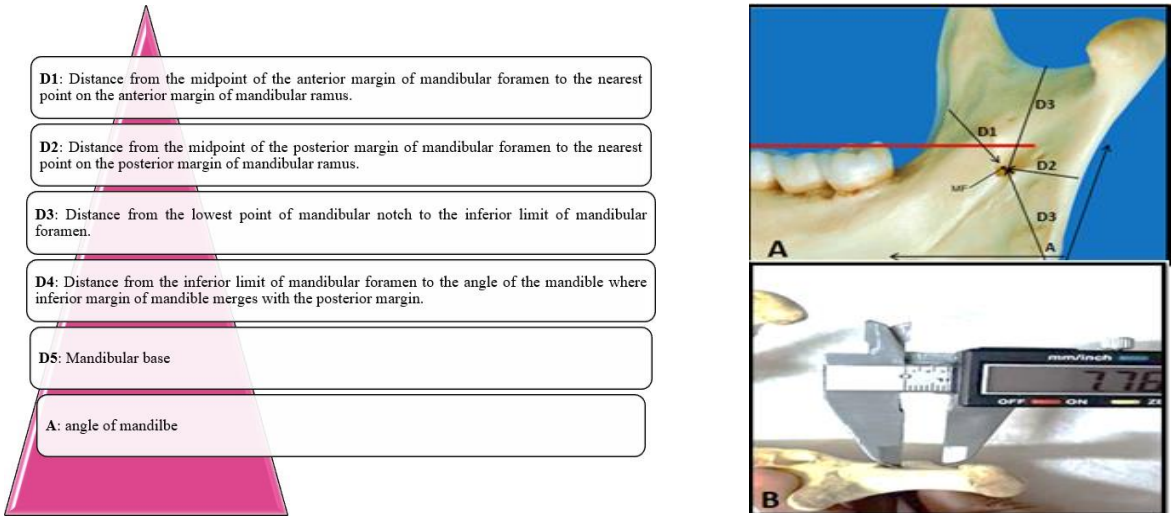

Fig. / Graph 1: Showing various measurements determine the distance (D) between the mandibular foramen and the posterior border of the mandibular ramus.

Statistical analysis: Statistical evaluation was carried out using SPSS software. 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.

3. RESULTS

Table 1 presents a comparative analysis of five linear distances (D1–D5) and one angular measurement (A) on both the right and left sides of the mandible. The mean values of D1, D2, and D5 showed minimal variation between sides and were statistically insignificant ($p > 0.05$). In contrast, significant differences were observed for D3 and D4, with higher mean values on the right side ($p = 0.001$ and $p = 0.002$, respectively). The angle measurement (A) also demonstrated a statistically significant difference ($p = 0.02$), with a higher average angle recorded on the right side (125.1° ± 3.21°) compared to the left (115.4° ± 2.96°). These findings suggest asymmetry in certain morphometric parameters, the detail measurements in shown in table 1.

Distances (D)	Right (mm)		Left (mm)		t-value
	Range (mm)	Mean ± SD	Range (mm)	Mean ± SD	
D1	12.1 – 25.1	18.94 ± 3.01	13.01 – 26.9	19.6 ± 2.28	0.05
D2	7.02 – 13.5	11 ± 1	8 – 13.1	11.08 ± 0.51	0.9
D3	16.9 – 30	23.48± 1.63	17.7 – 28.9	22.34 ± 1.81	0.001
D4	18.4 – 30.8	24.18 ± 3.04	2 – 29.9	22.98 ± 2	0.002
D5	23.1 – 35.1	27.18 ± 2	22.91 – 34.2	27.14 ± 1.91	0.1
Angle (A)	106º - 123º	125.1º ± 3.21º	111º - 135º	115.4º ± 2.96º	0.02

Table; 1: Comparative analysis of five linear distances (D1–D5) and one angular measurement (A) on both the right and left sides of the mandibular foramen (MF).

4. DISCUSSION

The present study offers comprehensive morphometric data concerning the precise location of the mandibular foramen (MF) in relation to various anatomical landmarks of the mandible. This anatomical insight is of significant clinical importance, as an accurate understanding of the spatial relationships between the MF and surrounding structures is essential for the successful execution of several maxillofacial procedures. These include the administration of inferior alveolar nerve blocks, which rely on precise localization to ensure effective anesthesia; mandibular osteotomies, where knowledge of MF positioning helps in avoiding neurovascular damage; and the surgical management of mandibular fractures, where the preservation of vital structures is crucial for optimal functional recovery [7].

Several studies across different populations have documented morphometric parameters (D1–D5, A) of mandibular anatomical landmarks. Mbajiorgu et al. (2000) [9] reported relatively high D3 and D4 values in a Zimbabwean population. Samanta & Kharb (2013) [10] observed slightly lower D1–D4 values in the Indian population, with minor right-left side variation. Russa & Fabian (2014) [11] found higher D1 and D4 measurements in Tanzanian individuals. Shalini et al. (2016) [12] provided additional data on angle (A) and D5, noting larger D5 values on the left side. Similarly, Lima et al. (2016) [13] reported symmetrical D1–D3 values in Brazilians, with slightly higher D5 on the right. Tshite et al. (2017) [14] observed consistent bilateral values in the South African sample. Matundu et al. (2021) [15] from Malawi recorded the highest D1 and D3 values among all populations, along with a notably consistent mandibular angle (A).

In the present study, the Indian population showed moderate D1–D5 values, with D1 (right: 18.9 mm, left: 19.6 mm) comparable to prior studies. The mandibular angle (A) was largest on the right (125.1°), exceeding values reported in previous research, suggesting potential regional variation in mandibular morphology.

Authors & Population	Side	D1	D2	D3	D4	D5	A
Mbajiorgu et al.,2000 (Zimbabwe) [9]		18.9±0.4	14.3±0.35	22.5± 0.5	28.4±0.65	-	-
Samanta & Kharb et al.,2013 (India) [10]	Right	15.7±2.9	13.3±1.7	22.7±3	21.5±2.9	-	-

	Left	16.2± 2.9	12.7±2	22.3±2.9	21.1±3.4	-	-
Russa & Fabian et al., 2014 (Tanzania) [11]	Right	19.9±3.16	12.7±2.2	21.5± 3	26.2± 3.9	-	-
	Left	20.19±2.6	12.6±2.6	20.7± 3	25.7± 4	-	-
Shalini et al., 2016 (India) [12]	Right	17.1±2.74	10.5± 2.1	21.8± 2.7	-	22.3± 3.3	117.4±4.9
	Left	17.4±3	9.7 ± 2	21.9± 3.3	-	25.3±4.5	117.5±5.9
Lima et al., 2016 (Brazil) [13]	Right	18.3±3.7	14.3±2.8	21.4±3.6	-	27.9±4.9	-
	Left	19±3.6	14.8±3.7	21.1±3.1	-	27.3±4.7	-
Tshite et al., 2017 (South Africa) [14]	Right	18.8± 2.4	13.7±2	20.1±3	22.9±3.7	-	-
	Left	18.9± 2.5	13.4±2	20± 3.1	22.7±3.7	-	-
Matundu et al., 2021 (Malawian) [15]	Right	20.8± 3.1	11.3±1.22	23.9±2.61	24.7±3.65	28.5±2.9	116.1±4.1
	Left	20.8±3.22	11.5± 1.4	23.5±2.65	24.2±2.8	27.8±2.99	115.8±4.2
Present study	Right	18.9±3.01	11±1	23.5±1.6	24.2 ±3	27.2±2	125.1º±3.2º
	Left	19.6±2.3	11.1±0.51	22.3±1.8	22.9±2	27.1±1.9	115.4º±2.96º

Table; 2: Comparison of mean distance of the mandibular foramen from various landmarks between the present study and other studies.

5. CONCLUSION

Present study underscores the considerable anatomical variations in the location of the mandibular foramen observed in adult dry human mandibles. Through precise morphometric measurements, the research offers valuable insights into mandibular morphology, contributing to both clinical and anthropological knowledge. The findings emphasize the critical importance of recognizing such variations during procedures like the inferior alveolar nerve block, where accuracy directly impacts therapeutic outcomes. Furthermore, the positional analysis of the mandibular foramen enhances our understanding of craniofacial structures, aligning with existing anthropological and forensic literature. By establishing a foundational reference, this work supports future studies on facial anatomy, with implications for surgical planning, forensic identification, and anthropological assessment.

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