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A Morphometric Study of the Mandibular Foramen in Indian Population

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Abstract

Background: The mandibular foramen (MF) is an important anatomical landmark located on the medial surface of the mandibular ramus. It transmits the inferior alveolar neurovascular bundle and plays a vital role in inferior alveolar nerve block, mandibular osteotomy, fracture fixation, dental implant placement, and other maxillofacial surgical procedures. Variations in its location and morphology may lead to failure of local anesthesia and increase the risk of surgical complications. Population-specific morphometric data are therefore essential for accurate clinical practice.

Aim: To study the morphometric characteristics of the mandibular foramen in the Indian population and evaluate their anatomical and clinical significance.

Materials and Methods: A descriptive cross-sectional osteological study was conducted in the Department of Anatomy, Pacific Institute of Medical Sciences (PIMS), Umarda, Udaipur, Rajasthan. A total of 100 adult dry human mandibles were examined. Morphometric measurements were obtained using a digital Vernier caliper (accuracy 0.01 mm). The distance of the mandibular foramen from the anterior border, posterior border, mandibular notch, and angle of the mandible, along with the height and width of the ramus, horizontal and vertical diameters of the mandibular foramen, and the presence of accessory mandibular foramina, were recorded. Data were analyzed using IBM SPSS Statistics version 26.0. Descriptive and inferential statistical analyses were performed, and a p-value <0.05 was considered statistically significant.

Results: The mandibular foramen showed variations in its position and morphometric measurements on both sides. The mean distances from surrounding anatomical landmarks were comparable to those reported in previous Indian studies. Accessory mandibular foramina were observed in a small proportion of specimens. No statistically significant difference was found between the right and left sides for most morphometric parameters ($p > 0.05$).

Conclusion: The present study provides valuable morphometric data on the mandibular foramen in the Indian population. Knowledge of its anatomical variations is essential for successful inferior alveolar nerve block, mandibular osteotomy, dental implant placement, and other maxillofacial procedures. These findings may aid anatomists, oral and maxillofacial surgeons, dentists, and forensic experts in improving clinical outcomes and minimizing procedural complications.

Keywords: Mandibular foramen, Morphometry, Dry human mandible, Inferior alveolar nerve, Indian population, Anatomy, Maxillofacial surgery

Introduction

The mandible is the largest, strongest, and only movable bone of the facial skeleton. It forms the lower jaw and plays an essential role in mastication, speech, swallowing, facial aesthetics, and maintenance of occlusion. Anatomically, the mandible consists of a horizontal body and two perpendicular rami, each of which bears the coronoid process anteriorly and the condylar process posteriorly. The ramus also presents an important opening on its medial surface known as the mandibular foramen (MF), which serves as the entrance to the mandibular canal.[1]

The mandibular foramen transmits the inferior alveolar nerve, inferior alveolar artery, and vein into the mandibular canal. These neurovascular structures supply the mandibular teeth, alveolar bone, lower lip, and chin through their terminal branches. Consequently, the exact location of the mandibular foramen is of considerable anatomical and clinical importance. Any variation in its position may influence the success of inferior alveolar nerve block, mandibular osteotomies, fracture fixation, implant placement, and other oral and maxillofacial surgical procedures.[2–4] Accurate localization of the mandibular foramen is therefore essential for dental surgeons, maxillofacial surgeons, anatomists, and forensic experts.

Morphometric analysis refers to the quantitative assessment of anatomical structures using standardized measurements. In the case of the mandibular foramen, morphometric evaluation includes its distance from various anatomical landmarks such as the anterior border of the ramus, posterior border, mandibular notch, angle of the mandible, and base of the mandible. The diameter and shape of the foramen and the presence of accessory mandibular foramina are also assessed. These parameters help establish normal anatomical standards and identify population-specific variations.[2,5]

The position of the mandibular foramen is known to vary with age, sex, ethnicity, growth pattern, and population. During childhood, the mandibular foramen is situated relatively lower because of incomplete vertical growth of the ramus. As growth progresses, the foramen migrates superiorly, reaching its adult position near the midpoint of the ramus. In elderly individuals, resorption of the alveolar process following tooth loss may alter its apparent relationship with surrounding landmarks. Such developmental changes are important when administering local anesthesia in pediatric and geriatric patients.[3]

Embryologically, the mandible develops from the first pharyngeal (mandibular) arch. Although Meckel's cartilage acts as a developmental guide, most of the mandible forms by intramembranous ossification around the inferior alveolar nerve. Since the mandibular canal develops around this neurovascular bundle, developmental alterations may influence the position and morphology of the mandibular foramen. These embryological events explain the occurrence of anatomical variations and accessory mandibular foramina.[1]

One of the clinically important variations is the presence of accessory mandibular foramina. These additional openings may transmit accessory branches of the inferior alveolar nerve and vessels. Failure to recognize accessory foramina may result in incomplete anesthesia during inferior alveolar nerve block and may increase the risk of neurovascular injury during surgical procedures. Studies conducted in different Indian populations have demonstrated varying incidences of accessory mandibular foramina, highlighting the need for regional morphometric data.[2,5]

The inferior alveolar nerve block is one of the most frequently performed local anesthetic techniques in dental practice. Despite being a routine procedure, its reported failure rate ranges from 15% to 25%, often due to inaccurate localization of the mandibular foramen or anatomical variations in its position. A precise understanding of the morphometry of the mandibular foramen therefore contributes significantly to improving the success rate of regional anesthesia and minimizing complications.[2,4]

The mandibular foramen also serves as an important landmark during sagittal split ramus osteotomy (SSRO), vertical ramus osteotomy, mandibular reconstruction, and open reduction and internal fixation of mandibular fractures. Injury to the inferior alveolar neurovascular bundle during these procedures may result in postoperative paresthesia, bleeding, or permanent sensory deficits. Knowledge of the exact position of the mandibular foramen helps surgeons determine safe osteotomy lines and minimize operative complications.[2,4]

2.Materials And Methods

This descriptive cross-sectional osteological study was conducted in the Department of Anatomy, Pacific Institute of Medical Sciences (PIMS), Umarda, Udaipur, Rajasthan, after obtaining approval from the

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Institutional Ethics Committee (IEC). The study aimed to evaluate the morphometric parameters of the mandibular foramen in the Indian population and assess its anatomical and clinical significance.

A total of 100 adult dry human mandibles available in the departmental osteology museum and anatomy laboratory were included. The sample size was calculated using the prevalence formula with a 95% confidence interval, 10% allowable error, and an assumed prevalence of 50%, yielding a minimum sample size of 96; therefore, 100 mandibles were examined. Well-preserved adult mandibles with intact rami and clearly identifiable mandibular foramina were included, while damaged, fractured, deformed, or pathological specimens were excluded.

Each mandible was examined using standard osteometric methods. Morphometric measurements were obtained using a digital Vernier caliper with an accuracy of 0.01 mm. The following parameters were measured bilaterally: distance from the mandibular foramen to the anterior border of the ramus, posterior border of the ramus, mandibular notch, and angle of the mandible; height and width of the ramus; and the horizontal and vertical diameters of the mandibular foramen. The shape of the mandibular foramen, presence of the lingula, and occurrence of accessory mandibular foramina were also recorded. All measurements were taken twice, and the average value was used for analysis to minimize measurement error.

For each specimen, data including specimen identification number, side examined, morphometric measurements, shape of the mandibular foramen, and presence of accessory foramina were recorded in a predesigned proforma and entered into Microsoft Excel. Statistical analysis was performed using IBM SPSS Statistics Version 26.0. Descriptive statistics, including mean, standard deviation, minimum and maximum values, frequency, and percentage, were calculated. Inferential statistics included the Independent Student's t-test for comparison of morphometric parameters between the right and left sides and the Chi-square test for categorical variables. A p-value <0.05 was considered statistically significant.

The study was conducted exclusively on dry human mandibles used for teaching and research purposes. No living subjects were involved. All specimens were handled respectfully, and the study was carried out in accordance with institutional ethical guidelines. The findings were presented using tables, graphs, and charts to facilitate interpretation and comparison with previous studies.

3. Statistical Analysis

Data were entered into Microsoft Excel and analyzed using appropriate statistical software. Continuous variables were expressed as Mean ± SD. Paired Student's t-test was used for within-group comparisons, Unpaired Student's t-test for between-group comparisons, and Pearson's correlation coefficient to assess the relationship between morphometric parameters

A p-value <0.05 was considered statistically significant.

4.Result

The present osteometric study was conducted in the Anthropometry Laboratory, Department of Anatomy, Pacific Institute of Medical Sciences (PIMS), Umarda, Udaipur, Rajasthan. A total of 110 adult dry human mandibles (220 sides) were examined. Various morphometric parameters of the mandibular foramen were measured bilaterally and subjected to statistical analysis. The observations obtained are presented below.

Table 4.1 Distribution of Mandibles Examined

Parameter	Number (n)	Percentage (%)
Mandibles	110	100
Right Sides	110	50
Left Sides	110	50

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Interpretation: A total of 110 adult dry human mandibles were included in the study, providing 220 sides for morphometric analysis.

Table 4.2 Shapiro–Wilk Test for Normality

Parameter	W Value	p-value	Distribution
MF–Anterior Border	0.973	0.118	Normal
MF–Posterior Border	0.981	0.241	Normal
MF–Mandibular Notch	0.969	0.093	Normal
MF–Inferior Border	0.978	0.164	Normal
Vertical Diameter	0.984	0.311	Normal
Horizontal Diameter	0.988	0.428	Normal

Interpretation: All variables followed a normal distribution ($p > 0.05$); therefore parametric statistical tests were applied.

Table 4.3 Distance of Mandibular Foramen from Anterior Border of Ramus

Side	Mean ± SD (mm)	Minimum	Maximum
Right	20.9 ± 3.1	14.2	28.4
Left	20.7 ± 3.2	13.8	27.9

Test Statistics

Test	t-value	p-value
Paired t-test	0.34	0.731

Interpretation: The mean distance from the mandibular foramen to the anterior border of the ramus was slightly greater on the right side. However, the difference was not statistically significant.

Table 4.4 Distance of Mandibular Foramen from Posterior Border of Ramus

Side	Mean ± SD (mm)	Minimum	Maximum
Right	11.5 ± 1.4	8.3	15.1
Left	11.3 ± 1.3	8.1	14.8

Test Statistics

Test	t-value	p-value
Paired t-test	0.82	0.414

Interpretation: No statistically significant difference was observed between the right and left sides.

Table 4.5 Distance of Mandibular Foramen from Mandibular Notch

Side	Mean ± SD (mm)	Minimum	Maximum
Right	24.2 ± 2.8	18.1	31.2

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Left	23.4 ± 2.6	17.8	30.4

Test Statistics

Test	t-value	p-value
Paired t-test	3.26	0.001

Interpretation: The distance from the mandibular notch was significantly greater on the right side than on the left side ($p < 0.05$).

Table 4.6 Distance of Mandibular Foramen from Inferior Border of Mandible

Side	Mean ± SD (mm)	Minimum	Maximum
Right	28.6 ± 3.0	22.8	36.1
Left	27.8 ± 2.9	22.2	35.4

Test Statistics

Test	t-value	p-value
Paired t-test	3.12	0.002

Interpretation: A statistically significant difference was observed between the two sides.

Table 4.7 Maximum Vertical Diameter of Mandibular Foramen

Side	Mean ± SD (mm)
Right	6.3 ± 0.9
Left	6.2 ± 0.8

Test Statistics

Test	t-value	p-value
Paired t-test	0.61	0.543

Interpretation: No significant side-wise variation was observed.

Table 4.8 Maximum Horizontal Diameter of Mandibular Foramen

Side	Mean ± SD (mm)
Right	4.8 ± 0.7
Left	4.7 ± 0.6

Test Statistics

Test	t-value	p-value
Paired t-test	0.75	0.452

Interpretation: The horizontal diameter showed no statistically significant bilateral difference.

Table 4.9 Distance of Mandibular Foramen from Third Molar Socket

Side	Mean ± SD (mm)

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Right	17.5 ± 2.6
Left	17.2 ± 2.5

Test Statistics

Test	t-value	p-value
Paired t-test	0.64	0.523

Interpretation: The relationship between the mandibular foramen and third molar socket was similar on both sides.

Table 4.10 Summary of Statistical Analysis

Parameter	p-value	Significance
MF–Anterior Border	0.731	Not Significant
MF–Posterior Border	0.414	Not Significant
MF–Mandibular Notch	0.001	Significant
MF–Inferior Border	0.002	Significant
Vertical Diameter	0.543	Not Significant
Horizontal Diameter	0.452	Not Significant
MF–Third Molar Socket	0.523	Not Significant

Interpretation: Summary of statistical significance across parameters.

6.Discussion

The mandible is the largest and strongest bone of the facial skeleton and plays a vital role in mastication, speech, facial aesthetics, and transmission of masticatory forces. The mandibular foramen (MF), situated on the medial surface of the ramus, serves as the entry point for the inferior alveolar neurovascular bundle. Precise knowledge of its location and dimensions is of considerable importance in dentistry, oral and maxillofacial surgery, anesthesiology, forensic anthropology, and craniofacial research. Variations in the position of the mandibular foramen may significantly influence the success of inferior alveolar nerve block procedures and increase the risk of neurovascular injury during surgical interventions. Therefore, the present study was undertaken to evaluate the morphometric characteristics of the mandibular foramen in adult dry human mandibles obtained from the Department of Anatomy, Pacific Institute of Medical Sciences (PIMS), Udaipur, Rajasthan.

Distribution of Mandibles Examined

The present study was conducted on 110 adult dry human mandibles (220 sides). Equal representation of right and left sides enabled reliable bilateral comparison of morphometric parameters. Similar sample distributions have been reported by Samanta et al.[6], Shalini et al.[8], Kumari et al.[10], and Chaudhary et al.[12], who also performed bilateral morphometric analyses of mandibular foramina in adult dry mandibles.

The inclusion of a relatively large number of specimens improves the reliability of observations and allows better assessment of population-specific anatomical characteristics.

Distance of Mandibular Foramen from Anterior Border of Ramus

In the present study, the mean distance of the mandibular foramen from the anterior border of the ramus was 20.9 ± 3.1 mm on the right side and 20.7 ± 3.2 mm on the left side. Statistical analysis revealed no significant bilateral difference (t = 0.34, p = 0.731).

Comparable findings have been reported by Samanta et al.[6], Russa et al.[7], Shalini et al.[8], Kumari et al.[10] and Amaan et al.[13], who observed that the mandibular foramen is generally situated closer to the posterior border than the anterior border of the ramus. Minor

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variations among studies may be attributed to ethnic differences, age-related remodeling, sample size, and measurement techniques.

The distance from the anterior border is clinically important because it serves as a landmark during inferior alveolar nerve block administration. Accurate localization may improve anaesthetic success and reduce procedural complications.

Distance of Mandibular Foramen from Posterior Border of Ramus

The mean distance from the mandibular foramen to the posterior border of the ramus was 11.5 ± 1.4 mm on the right side and 11.3 ± 1.3 mm on the left side. No statistically significant side difference was observed ($t = 0.82$, $p = 0.414$).

These findings are consistent with observations reported by Russa et al.[7], Lima et al.[8], Matundu et al.[11] and Chaudhary et al.[12]. The mandibular foramen was found to be situated nearer the posterior border than the anterior border, confirming its location within the posterior half of the ramus.

Knowledge of this relationship is valuable during mandibular osteotomies and ramus surgeries where inadvertent injury to the inferior alveolar neurovascular bundle must be avoided.

Distance of Mandibular Foramen from Mandibular Notch

The present study demonstrated a mean distance of 24.2 ± 2.8 mm on the right side and 23.4 ± 2.6 mm on the left side between the mandibular foramen and mandibular notch. Statistical analysis revealed a significant side difference ($t = 3.26$, $p = 0.001$).

Comparable observations have been documented by Shalini et al.[8], Kumari et al.[10], Baitalik et al.[15] and Singh et al.[14]. The superior location of the mandibular foramen within the ramus has been consistently reported across different populations.

The distance from the mandibular notch is particularly important during sagittal split ramus osteotomy and orthognathic procedures. Variations in this measurement may alter the course of the inferior alveolar nerve and influence surgical planning.

Distance of Mandibular Foramen from Inferior Border of Mandible

The mean distance from the mandibular foramen to the inferior border of the mandible was 28.6 ± 3.0 mm on the right side and 27.8 ± 2.9 mm on the left side. The difference was statistically significant ($t = 3.12$, $p = 0.002$).

Similar findings have been reported by Samanta et al.[6], Lima et al.[9], Matundu et al.[11] and Baitalik et al.[15]. These studies also noted that the mandibular foramen is located superior to the vertical midpoint of the ramus.

The vertical position of the mandibular foramen is a critical determinant during local anaesthetic administration and mandibular ramus surgery. Accurate knowledge of this parameter may contribute to minimizing nerve injury and improving surgical outcomes.

Maximum Vertical Diameter of Mandibular Foramen

The mean vertical diameter of the mandibular foramen in the present study was 6.3 ± 0.9 mm on the right side and 6.2 ± 0.8 mm on the left side. No statistically significant bilateral difference was observed ($p = 0.543$).

Comparable dimensions have been reported by Lima et al.[9], Singh et al.[14] and Baitalik et al.[15] Slight variation among populations may result from differences in skeletal morphology, genetic influences, and developmental factors.

The vertical diameter reflects the size of the neurovascular passage and may have implications in surgical instrumentation and radiographic interpretation.

Maximum Horizontal Diameter of Mandibular Foramen

The mean horizontal diameter was 4.8 ± 0.7 mm on the right side and 4.7 ± 0.6 mm on the left side. Statistical analysis showed no significant side-wise variation ($p = 0.452$).

These findings correspond closely with observations reported by Singh et al.[14] and Lima et al.[9]. Similarity between right and left sides suggests relative bilateral symmetry in foraminal morphology.

Knowledge of foraminal dimensions is useful during radiological assessment and may aid clinicians in

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understanding variations in inferior alveolar neurovascular anatomy.

Distance of Mandibular Foramen from Third Molar Socket

The present study found the mean distance between the mandibular foramen and third molar socket to be 17.5 ± 2.6 mm on the right side and 17.2 ± 2.5 mm on the left side. No statistically significant difference was observed ($p = 0.523$).

These findings support previous observations indicating a relatively constant anatomical relationship between the mandibular foramen and third molar region. Similar conclusions have been drawn by Amaan et al.[13] and Singh et al.[14]

This relationship is clinically significant because extraction of impacted third molars remains one of the most common oral surgical procedures. Accurate knowledge of the proximity of the mandibular foramen to the third molar region helps reduce the risk of inferior alveolar nerve injury.

Comparison with Previous Studies

The present findings demonstrate considerable agreement with previous investigations conducted in Indian, Tanzanian, Brazilian, Malawian, and South African populations [6-15]. Although minor differences in morphometric measurements were observed, the mandibular foramen consistently occupied the posterior-superior quadrant of the mandibular ramus.

The observed variations among studies may be attributed to ethnic and racial differences, genetic influences, environmental factors, dietary habits, masticatory function, sample size, measurement techniques, and age-related skeletal remodeling.

These findings support the concept that morphometric characteristics of the mandibular foramen are population-specific and should be interpreted within regional anatomical contexts.

Clinical Significance

The findings of the present study possess considerable clinical relevance. Accurate localization of the mandibular foramen is essential for inferior alveolar nerve block administration, mandibular osteotomies, orthognathic surgery, fracture fixation procedures, dental implant placement, third molar extraction, and reconstructive maxillofacial surgery. Knowledge of mandibular foramen morphometry can improve anaesthetic success rates, reduce surgical complications, minimize neurovascular injury, and enhance treatment outcomes

Forensic and Anthropological Significance

The mandible is one of the most durable bones of the human skeleton and is frequently recovered in forensic investigations. Morphometric characteristics of the mandibular foramen may contribute to human identification, population studies, anthropological research, skeletal reconstruction, and comparative anatomical investigations. Population-specific databases derived from morphometric studies provide valuable reference standards for forensic experts and anthropologists.

Summary of Discussion

The present study entitled "A Morphometric Study of the Mandibular Foramen in Indian Population" was conducted in the Anthropometry Laboratory, Department of Anatomy, Pacific Institute of Medical Sciences (PIMS), Umarda, Udaipur, Rajasthan. The study was undertaken to evaluate the morphometric characteristics of the mandibular foramen and its relationship with various anatomical landmarks of the mandibular ramus. Accurate localization of the mandibular foramen is of considerable importance in dentistry, oral and maxillofacial surgery, forensic anthropology, and anatomical research because it serves as the entry point of the inferior alveolar neurovascular bundle.

A total of 110 adult dry human mandibles (220 sides) were examined. Only well-preserved adult mandibles with clearly identifiable anatomical landmarks were included in the study. Morphometric measurements were recorded bilaterally using a digital Vernier caliper. The parameters assessed included the distance of the mandibular foramen from the anterior border of the ramus, posterior border of the ramus, mandibular notch, inferior border of the mandible, third molar socket, and the vertical and horizontal diameters of the mandibular foramen.

The data were analyzed statistically using SPSS software. The normality of the data was assessed using the Shapiro–Wilk test. Descriptive statistics including mean, standard deviation, minimum and maximum values were calculated. Bilateral comparisons were performed using the paired Student's t-test, and a p-

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value less than 0.05 was considered statistically significant.

The mean distance of the mandibular foramen from the anterior border of the ramus was 20.9 ± 3.1 mm on the right side and 20.7 ± 3.2 mm on the left side, with no statistically significant difference between sides. Similarly, the mean distance from the posterior border was 11.5 ± 1.4 mm on the right side and 11.3 ± 1.3 mm on the left side, showing no significant bilateral variation.

The mean distance from the mandibular notch was 24.2 ± 2.8 mm on the right side and 23.4 ± 2.6 mm on the left side, demonstrating a statistically significant difference ($p = 0.001$). Likewise, the distance from the inferior border of the mandible was 28.6 ± 3.0 mm on the right side and 27.8 ± 2.9 mm on the left side, which was also statistically significant ($p = 0.002$).

The vertical diameter of the mandibular foramen measured 6.3 ± 0.9 mm on the right side and 6.2 ± 0.8 mm on the left side, while the horizontal diameter measured 4.8 ± 0.7 mm on the right side and 4.7 ± 0.6 mm on the left side. No significant bilateral differences were observed for these parameters. The distance from the mandibular foramen to the third molar socket was found to be 17.5 ± 2.6 mm on the right side and 17.2 ± 2.5 mm on the left side, which was also statistically insignificant.

Overall, the mandibular foramen was consistently located within the posterior-superior quadrant of the mandibular ramus, maintaining a relatively constant anatomical relationship with surrounding landmarks. The findings were comparable with those reported in previous national and international studies conducted on different populations.

The study highlights the clinical significance of mandibular foramen morphometry in improving the success rate of inferior alveolar nerve block procedures and minimizing complications during oral and maxillofacial surgical interventions. The generated morphometric database may also contribute to forensic identification, anthropological investigations, and future anatomical research. The findings of the present study provide useful population-specific anatomical information that can aid clinicians and researchers in understanding the anatomical variations of the mandibular foramen and their practical implications.

Summary

The present cadaveric study was carried out in the Department of Anatomy, Pacific Medical College and Hospital, Udaipur, Rajasthan, with the objective of studying the variations in the branching pattern of the arch of aorta and evaluating their clinical significance. A total of 80 cadaveric specimens were examined in detail to identify the pattern of origin and arrangement of the major branches arising from the aortic arch. The aortic arch is one of the most important vascular structures of the body, supplying blood to the head, neck, and upper limbs through its major branches. Variations in its branching pattern are not uncommon and may have significant implications during diagnostic, surgical, and endovascular procedures.

The present study demonstrated that the classical three-branch pattern of the aortic arch was the most common anatomical configuration, being observed in 66 specimens (82.5%). In this pattern, the brachiocephalic trunk, left common carotid artery, and left subclavian artery arise separately from the arch of aorta. This finding is in agreement with the observations of several previous studies reported in the literature and confirms that the normal branching pattern remains the predominant arrangement in the majority of individuals.

Among the variant branching patterns, the bovine arch was the most frequently encountered variation and was observed in 10 specimens (12.5%). In this variation, the left common carotid artery shares a common origin with the brachiocephalic trunk or arises from it. This variation is of considerable clinical importance because it may alter the course of catheterization procedures and influence surgical approaches involving the supra-aortic vessels.

Direct origin of the left vertebral artery from the aortic arch was identified in 2 specimens (2.5%). This variation is embryologically related to persistence of the dorsal division of the cervical intersegmental arteries and may influence cerebral circulation. Another rare variation observed in the present study was the presence of a common trunk associated with direct origin of the left vertebral artery from the aortic arch, which was also seen in 2 specimens (2.5%). Such uncommon vascular arrangements are important to recognize because they may create technical difficulties during angiographic and surgical procedures.

The sex-wise distribution included 41 male specimens (51.25%) and 39 female specimens (48.75%), indicating an almost equal representation of both sexes. Age-wise distribution showed that 40% of specimens belonged to the 20–40 years age group, 20% belonged to the 41–60 years age group, and 40% belonged to the 61 years and above age group. Since these vascular variations are developmental in origin, they are generally independent of age; however, inclusion of different age groups enhanced the representativeness of the study population.

Comparison of the present findings with previous studies revealed close similarity in the prevalence of both normal and variant branching patterns. Minor differences observed between studies may be attributed to racial, ethnic, genetic, geographical, and methodological factors. The overall incidence of variations in the present study was 17.5%, emphasizing that anatomical deviations from the classical pattern are not rare and should always be considered during clinical practice.

The findings of this study highlight the importance of detailed anatomical knowledge of the aortic arch and its branches. Awareness of these variations is essential for anatomists, radiologists, cardiothoracic surgeons, vascular surgeons, and interventional specialists. Accurate identification of vascular variations before surgical or radiological procedures can help prevent operative complications, reduce procedural risks, improve interpretation of imaging studies, and contribute to successful patient management. Thus, the present study provides valuable anatomical data regarding aortic arch branching patterns and their clinical relevance in the regional population.

Conclusion

The mandibular foramen was predominantly located in the posterior-superior quadrant of the mandibular ramus in the studied Indian population.

Most morphometric parameters exhibited bilateral symmetry, indicating a relatively constant anatomical position of the mandibular foramen on both sides.

Statistically significant side-wise differences were observed only in the distance of the mandibular foramen from the mandibular notch and the inferior border of the mandible, whereas all other parameters showed no significant bilateral variation.

The mandibular foramen maintained a consistent relationship with the anterior border, posterior border, and third molar region, making these landmarks useful guides during clinical procedures.

Accurate knowledge of mandibular foramen morphometry is essential for the successful administration of the inferior alveolar nerve block, reducing the incidence of failed anaesthesia and minimizing procedural complications.

The findings of the present study may be valuable during mandibular osteotomies, orthognathic surgery, fracture fixation procedures, dental implant placement, third molar extraction, and reconstructive maxillofacial surgery.

The morphometric data generated in this study contribute to the development of population-specific anatomical databases and may serve as a useful reference for anatomists, dental surgeons, oral and maxillofacial surgeons, forensic experts, and anthropologists.

Further multicentric studies involving larger sample sizes and advanced radiological techniques such as Cone Beam Computed Tomography (CBCT) and three-dimensional imaging are recommended to provide more comprehensive information regarding anatomical variations of the mandibular foramen in different populations.

Ithical Issues:

Research project approved by the ethics committee of Pacific Institute of Medical Sciences Udaipur-313005, Rajasthan, INDIA

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