ORIGINAL RESEARCH

Morphometric analysis of Mandibular Foramen in dry human skulls and its clinical implications in Indian perspective

[1]Dr. Pallavi Sharma, [2]Dr. Srikant Pandey, [3]Dr. Subodh Kumar, [4]Dr. Rashmi Prasad

[1]Tutor, Department of Anatomy, Nalanda Medical College, Patna, Bihar, India
[2]Senior Resident, Department of Paediatrics, Nalanda Medical College & Hospital, Patna, Bihar, India
[3]Associate Professor, Department of Anatomy, Nalanda Medical College, Patna, Bihar, India.
[4]Professor and HOD, Department of Anatomy, Nalanda Medical College, Patna, Bihar, India

Corresponding Author
Dr. Srikant Pandey
Senior Resident, Department of Paediatrics, Nalanda Medical College & Hospital, Patna, Bihar, India

Received: 26 November, 2023 Accepted: 15 January, 2024

ABSTRACT

Background& Objectives: Mandibular foramen lies on medial surface of mandibular ramus at the level of occlusal surface of the teeth and marks the opening of mandibular canal which runs obliquely downwards in the body of mandible and opens at the mental foramen. Idea about precise location of the MF is essential for performing mandibular surgeries like vertical ramus osteotomy, inverted L osteotomy and also aesthetic surgeries for dentofacial deformities. The inferior alveolar nerve is at a greater risk during these surgical procedures. Through the present study, we intended to study the number, shape, morphological variations and dimensions of the mandibular foramen in relation to different clinically important anatomical landmarks of Indian skull.**Methods:**This institution based descriptive was conducted at department of Anatomy, NMCH, Patna, Bihar, India over 3years from Jan 2019 to Dec 2021 involving skulls of known sex and approximate age at our Institute. The distance of mandibular foramen from anterior border of the ramus, posterior border of the ramus, mandibular notch, base of the mandible, third molar, and apex of retromolar trigone was measured with a vernier calliper and recorded.**Result:**28 dry human skulls or 56 sides (right + left) were studied in detail. The mean distance of mandibular foramen from the anterior border of ramus of mandible was 17.21±2.92 mm on the right side and 17.35±3.02mm on the left side, from posterior border was 10.64±2.34 mm on the right side and 9.88 ±2.33 mm on the left side, from mandibular notch was 21.07±2.83 mm on the right side and 21.42 ±3.03 mm on the left side, from the base of the ramus was 21.43±3.52 mm on right side and 22.31±3.65 mm on the left side. Single accessory mandibular foramen was found unilaterally in 3 mandibles (10.71%) and bilaterally in 2 mandibles (7.14%). Double accessory mandibular foramen was found unilaterally in 1 mandible (3.6%) and bilaterally in 0 mandibles (0.0%).**Conclusion:**Proper idea about morphometry of the mandibular foramen and the occurrence of accessory mandibular foramen provides valuable information to Surgeons and Anaesthetists for planning and conducting dental and maxillofacial surgeries.

Key words: Mandible, Mandibular foramen, Mandibular notch, Accessory Mandibular foramen, Inferior alveolar nerve block.

INTRODUCTION

Mandibular foramen (MF) lies on medial surface of mandibular ramus at the level of occlusal surface of the teeth. This marks the opening of mandibular canal which runs obliquely downwards in the body of mandible and opens at the mental foramen.[1] Anterior margin of the mandibular foramen is marked by a sharp tongue shaped projection called lingula which is directed towards mandibular condylar process. Inferior alveolar nerve is the larger terminal branch of the posterior division of the mandibular nerve which runs vertically downwards lateral to the medial pterygoid and to the sphenomandibular ligament to enter this mandibular foramen and runs in the mandibular canal. It is accompanied by inferior alveolar vessels. This neurovascular bundle divides into mental and incisive branches to supply the mandibular teeth and participates in the formation of the anterior loop.[2]

Studies have conclusively proved that there exist significant racial variations in the morphology of mandibular anatomy among the three major racial groups—Caucasoid, Mongoloid, and Negroid.[3] Sometimes, there can be an additional mandibular foramen which is defined as any opening in the mandible other than the MF, mental foramen, lingual

foramen, and sockets of teeth. The presence of accessory MF and additional branches of inferior alveolar nerve may lead to increased rates of failure of inferior alveolar nerve blocks as all the branches may not be anaesthetized.[4] The accessory MF has also been reported to be the site for the spread of tumours following radiotherapy in the lateral surface of mandible.[5] So the knowledge of accessory MF is imperative to radiotherapists when planning for radiation therapy in the lateral mandibular region.

Inferior alveolar nerve block (IANB) is a common procedure employed in dental and facial surgery such as removal of third molar tooth, dental pain, dentoalveolar trauma, dry socket, periapical abscess or painful surgeries on mandibular bone or lower lips/chin. This technique involves the insertion of a needle near the mandibular foramen in order to deposit a solution of local anaesthetic near to the nerve before it enters the foramen, a region where the inferior alveolar vein and artery are also present. The areas anesthetized are the mandibular teeth to the midline, body of the mandible, inferior portion of the ramus, buccal mucoperiosteum, mucous membrane anterior to the mandibular first molar, anterior two thirds of the tongue and the floor of the oral cavity, lingual soft tissues and periosteum. However, the failure rate of this technique is reported to be as high as 20%–25%.[6] The commonest cause for inferior alveolar nerve block failure is inaccurate localization of the MF. Main complications during this technique are haemorrhage, injury to the neurovascular bundle, fractures, and necrosis of mandibular ramus. Hence, thorough knowledge of the mandibular ramus including various landmarks is very essential. Based on this background, the present study was conducted to recognise specific location of the mandibular foramen with respect to clinically important anatomical landmarks.

2. Aim and Objectives

To study the number, shape, morphological variations and dimensions of the mandibular foramen in relation to different clinically important anatomical landmarks of Indian skull.

MATERIALS AND METHODS

Study Duration:three years from January 2019 to December 2021.

Study setting:deptt of Anatomy of Nalanda Medical College, Patna, Bihar, India.

Study design: institution based descriptive study.

Study technique: The study group comprised of skulls of known sex and approximate age from Anatomy and Forensic Medicine department of our Institute. Only those skulls with no significant gross pathology, deformity, or traumatic lesions were included in this study. Skulls showing damage in the mandibular region and those skulls with estimated age less than 18 years of age were excluded. Relevant parameters were measured in sagittal and transverse planes after stabilising the skull in Frankfurt horizontal plane. Dimensions were measured by a digital Vernier calliper with a precision of 0.1 mm. Each dimension was measured thrice and the mean figure recorded. The data collected was checked for errors prior to analysis. Measurements were taken using below mentioned bony landmarks on the mandible:

1) AB-MF: distance from the midpoint of anterior margin of Mandibular foramen to the nearest point on the anterior border of the ramus of mandible
2) PB-MF: distance from the midpoint of posterior margin of mandibular foramen to the nearest point on the posterior border of the ramus of mandible
3) AB-PB: breadth of the ramus from anterior to posterior border
4) MF-MN: distance from the lowest point of mandibular notch to the inferior limit of mandibular foramen
5) MF-MB: distance from inferior limit of Mandibular foramen to the base of the mandible
6) III Molar-MF: distance from the midpoint of third molar tooth or socket to anterior margin of Mandibular foramen
7) RT-MF: distance between the apex of the retromolar trigone and mandibular foramen
8)The angle of mandible was measured with a goniometer at the junction of inferior and posterior borders of the ramus of the mandible.

The mandibles were further observed for the presence of accessory mandibular foramen in and around mandibular foramen on the medial surface of mandibular ramus by means of a simple visual observation with the help of a magnifying lens and their prevalence rate was noted and analysed.

Statistical analysis: Information so collected was tabulated and entered in Microsoft excel sheet and further analysed by SPSS ver.20® software for Windows. Variables were expressed as mean, standard deviation, percentages, proportions or percentiles as appropriate. Pearson's chi-square test was used for comparison of categorical parameters and independent samples' t test for continuous parameters. P-value <0.05 was taken as significant.

RESULT

Over the 3-year study period, 28 dry human skulls or 56 sides (right + left) were studied in detail. Estimated age of these skulls ranged between 40-60 years. Of these, 16 (57.1%) were of male sex and the rest 12 (42.9%) were of female sex.

Distance of mandibular foramen from various landmarks on the right and left sides:

Table 1 below shows the minimum, maximum, mean and standard deviation values of the various parameters on either side of the mandible. There was no statistically significant difference between the values obtained on the right and left sides (P>0.05).

Table 1: Measurements on either side of the mandible

Measurement	Right side (mm)	Left side (mm)
AB-MF	17.21±2.92	17.35±3.02
PB-MF	10.64±2.34	9.88 ±2.33
AB-PB	30.87±3.92	31.09±3.99
Foramen-width	4.11 ±1.53	4.27±1.54
MF-MN	21.07±2.83	21.42 ±3.03
MF-MB	21.43±3.52	22.31±3.65
III Molar-MF	22.96±3.90	23.09±4.18
RT-MF	12.87±2.28	12.65± 2.39

(Values are presented as mean±SD.)

Angle of the mandible: The angle of the Mandible-Gonion was 118.87°±4.89° on the right side and 117.52°±5.08° on the left side. There was no statistically significant difference between the angles of the mandible on the right and left sides (P>0.05).

Localization of mandibular foramen in anteroposterior and superoinferior axis of the ramus of mandible: Percentile distribution of distance from anterior border of ramus to midpoint of mandibular foramen in relation to the distance from anterior to posterior border of ramus (AB-PB) on the right side was 54.08±3.62% and it was localized in the third quadrant in the anteroposterior axis. Similarly, on the left side it was 55.27±3.75% and it was also localized in the third quadrant in the anteroposterior axis of the mandibular ramus. The percentile of distance MF-MN in relation to MF-MN+MF-MB was 47.84±3.59% on the right side and it was localised at the junction of second and third quadrant in the superoinferior axis and 46.92±4.08% on the left side and it was also localised at the junction of second and third quadrant in the superoinferior axis of the mandibular ramus. There was no statistically significant difference in the location of mandibular foramen on the right and left sides (P>0.05) in both the anteroposterior axis and superoinferior axis.

Table 2: Location of MF wrt axis of mandibular ramus

Side	Anteroposterior localization (%)	Quadrant in anteroposterior axis	Superoinferior localization (%)	Quadrant in Superoinferior axis
Right	54.04±3.62	Third	47.84±3.59	Junction of second and third
Left	55.27±3.75	Third	46.921±4.08	Junction of second and third

Accessory mandibular foramen: Single accessory mandibular foramen was found unilaterally in 3 mandibles (10.71%) and bilaterally in 2 mandibles (7.14%). Double accessory mandibular foramen was found unilaterally in 1 mandible (3.6%) and bilaterally in 0 mandibles (0.0%). These accessory foramens were located at distance of less than 5 mm from the primary mandibular foramen and diameter of the accessory foramen was observed to be less than 2 mm. Unilateral single accessory mandibular foramen was found to be more common on the right side compared to the left side (P<0.05). But there was no statistically significant difference on the occurrence of double accessory mandibular foramen on the right and left sides (P>0.05).

DISCUSSION

Idea about precise location of the MF is essential for performing mandibular surgeries like vertical ramus osteotomy, inverted L osteotomy and also aesthetic surgeries for dentofacial deformities. The inferior alveolar nerve is at a greater risk during these surgical procedures. Daw et al. have reported great variability in the position of mandibular foramen from non-Asian hemi mandibles.[7] They have also emphasised that the knowledge of the location of the mandibular foramen would assist in performing a proper sagittal split of the mandibular ramus. During pterygomandibular technique of inferior alveolar nerve blockage long needles of size 33 mm and short needles of size 21.5 mm are used. If a long needle is used in a patient with small mandible, there is a risk of perforating the parotid gland capsule and injuring the branches of facial nerve. If a short needle is used in a patient with big sized mandible, there may be a fracture of the needle when it is completely introduced in the oral tissues.[8]

There exist significant differences in the morphometry of mandibular foramen in different ethnic groups as well as between different regions of the same country. Table 3 depicts the relevant findings about anatomy of MF in our study as well other study groups.

Table 3: Key findings of various studies

Author	Population	Right side AB-MF (mm)	Left side AB-MF (mm)	Right side PB-MF (mm)	Left side PB-MF (mm)	Right side MF-MN (mm)	Left side MF-MN (mm)
Oguz and Bozkir[9]	Turkey	16.9	16.78	14.09	14.37	22.37	22.17
Ennes and Medeiros[10]	Brazil	9.4±2.03	6.9±2.06	8.6±1.2	8.4±1.77	18.3±3.25	17.5±3.37
Prado et al.[11]	Brazil	19.2±3.6	18.8±3.8	14.2±2.4	13.9±2.6	23.6±3.1	23.1±3.0
Samanta and Kharb[12]	India	15.72±2.92	16.23±2.88	13.29±1.74	12.73±2.04	22.7±3.0	22.27±2.92
Raghavendra and Benjamin[13]	India	16.21± 2.12	16.67±2.34	11.08±2.34	11.11±2.34	21.38±3.91	20.95±3.39
Present study	India	17.21±2.92	17.35±3.02	10.64±2.34	9.88 ±2.33	21.07±2.83	21.42 ±3.03

(Values are presented as mean±SD.)

Ennes and Medeiros[10] have reported that the average gonial angle to be 125.6° with a standard deviation between 6.2° and 9.2°. Oguz and Bozkir[9] reported the angle of mandible to be 120.2°±4.7°. In the present study, it was 118.87°±4.89° on the right side and 117.52°±5.08° on the left side. The gonial angle is inversely proportional to the anteroposterior width of the mandibular ramus and the distance between mandibular foramen and base of the mandible (MF-MB). So, in individuals with wide gonial angle, inferior alveolar nerve blockage has to be performed at a site lower than the conventional site and with a short needle whereas in individuals with small gonial angle, the inferior alveolar nerve block has to be performed at a site higher than the conventional site and with a long needle.

Embryological basis for the occurrence of accessory mandibular foramen has been explained in literatures. Chávez-Lomeli et al.[14] have reported that, initially, 3 inferior alveolar nerves, innervating each of the 3 groups of mandibular teeth are formed in the embryo. Later, all the 3 nerves fuse and a single inferior alveolar nerve is formed. The incomplete fusion of the nerves leads to the formation of double mandibular canals. Usually, the main mandibular canal is found to have the entire inferior alveolar nerve passing through it and in some cases the nerves were found to be scattered. Pancer et al.[15] has reported the incidence of accessory mandibular foramen to vary from 0.88% to 10.66%. In the present study solitary accessory mandibular foramen was found unilaterally in 3 mandibles (10.71%) and bilaterally in 2 mandibles (7.14%). Double accessory mandibular foramen was found unilaterally in 1 mandible (3.6%) and bilaterally in 0 mandibles (0.0%). The range of distance between the accessory mandibular foramen and mandibular foramen is clinically important, because the spread of local anaesthetic affects the efficiency of the inferior alveolar nerve block. The spread of local anaesthetic in inferior alveolar nerve blocks, depends on the drug used, its concentration and the volume of drug injected. In the present study, the accessory foramens were located at a distance of less than 5 mm from the mandibular foramen, hence if a higher concentration and larger volume of local anaesthetic is used, the accessory nerves can also be completely anaesthetised.

CONCLUSION

Idea about morphometry of mandibular foramen is very important to achieve a successful inferior alveolar nerve block prior to dental surgeries and surgeries involving the lower jaw like osteotomy, orthognathic reconstruction surgeries of the mandible and dental implant procedures, and also to avoid injury to the neurovascular contents passing through it. Presence of accessory mandibular foramina may serve as a route for spread of infection and tumour cells. The present study on the morphometry of the mandibular foramen and the occurrence of accessory mandibular foramen will provide useful information to Surgeons and Anaesthetists for planning and conducting dental and maxillofacial surgeries.

7. Limitation: First limitation is that ours is a single centre study. Second limitation is relatively smaller number of specimens studied. Third limitation is related to non-utilisation of radiological tools for finer assessment.

8. Conflict of interest: None to declare

9. Source of funding: None.

REFERENCES

1. Collins P. Infratemporal and pterygopalatine fossae and temporomandibular joint. In: Standring S, editor. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40th ed. Edinburg: Churchill and Livingstone; 2008. pp. 530–532

2. Yu SK, Kim S, Kang SG, Kim JH, Lim KO, Hwang SI et al. Morphological assessment of the anterior loop of the mandibular canal in Koreans. Anat Cell Biol. 2015;48:75–80.
3. Komar D, Lathrop S. Frequencies of morphological characteristics in two contemporary forensic collections: implications for identification. J Forensic Sci. 2006;51:974–78.
4. Haas LF, Dutra K, Porporatti AL, Mezzomo LA, De Luca Canto G, Flores-Mir C, et al. Anatomical variations of mandibular canal detected by panoramic radiography and CT: a systematic review and meta-analysis. DentomaxillofacRadiol. 2016;45:20150310.
5. Fanibunda K, Matthews JN. Relationship between accessory foramina and tumour spread in the lateral mandibular surface. J Anat. 1999;195(2):185–90
6. Clarke J, Holmes G. Local anesthesia of the mandibular molar teeth a new technique. Dent Practit Dent Rec. 1959;36:321-26.
7. Daw JL Jr, de la Paz MG, Han H, Aitken ME, Patel PK. The mandibular foramen: an anatomic study and its relevance to the sagittal ramus osteotomy. J Craniofac Surg. 1999;10(6):475-79.
8. Hanihara T, Ishida H. Frequency variations of discrete cranial traits in major human populations. IV. Vessel and nerve related variations. J Anat. 2001;199:273–87.
9. Oguz O, Bozkir MG. Evaluation of location of mandibular and mental foramina in dry, young, adult human male, dentulous mandibles. West Indian Med J. 2002;51:14–16.
10. Ennes JP, Medeiros RM. Localization of mandibular foramen and clinical implications. Int J Morphol. 2009;27:1305–11
11. Prado FB, Groppo FC, Volpato MC, Caria PH. Morphological changes in the position of the mandibular foramen in dentate and edentate Brazilian subjects. Clin Anat. 2010;23:394–98.
12. Samanta PP, Kharb P. Morphometric analysis of mandibular foramen and incidence of accessory mandibular foramen in adult human mandibles of an Indian population. Rev Arg Anat Clin. 2013;5:60–66
13. Raghavendra VP, Benjamin W. Position of mandibular foramen and incidence of accessory mandibular foramen in dry mandibles. Int J Pharm Bio Sci. 2015;6:282–88.
14. Chávez-Lomeli ME, Mansilla Lory J, Pompa JA, Kjaer I. The human mandibular canal arises from three separate canals innervating different tooth groups. J Dent Res. 1996;75:1540–44.
15. Pancer B, Garaicoa-Pazmiño C, Bashutski JD. Accessory mandibular foramen during dental implant placement: case report and review of literature. Implant Dent. 2014;23:116–24.