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A morphometric analysis of mandibular foramen in dry human mandibles of Indian population in Rajasthan State

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Abstract
Introduction: The Mandibular foramen (Mf) is an important anatomical landmark for the inferior alveolar nerve blocks, mandibular osteotomies & implant treatment. A thorough knowledge of the anatomy of the mandibular foramen is very essential hence this study aims to determine the position of Mf by studying dry human mandibles of Indian population in Rajasthan State.
Materials and Methods: The present study was conducted using 100 dried human mandibles out of which 79 were dentulous and 21 were edentulous.
Results: The average mean distance from the lowest point of mandibular notch (Mn) to the inferior limit of the Mf i.e. (Mn-Mf) was 22.65 ±4.33 mm (right side) and 22.94±3.46 mm (left side), from the midpoint of the anterior border of the Mf to the nearest point on the anterior border of the ramus (Ab) i.e. (Ab-Mf) was 15.72±2.57 mm (right side) and 16.02±2.28 mm (left side), from the midpoint of the posterior border of the Mf to the nearest point on the posterior border of the ramus (Pb) i.e. (Pb-Mf) is 11.39±1.87 mm (right side) and 11.58±1.93 mm (left side) and from the inferior limit of Mf to the furthest point on the angle of the mandible (Ag) i.e. (Mf-Ag) is 21.33±3.52 mm (right side) and 21.28±3.22 mm (left side).
Conclusion: The present study gives a fair knowledge of the position of Mf and provides useful information regarding the success rate of local anaesthesia, to the maxillofacial surgeons, radiologists and oncologists performing operations on the mandible to prevent complications and misinterpretations.

Keywords: mandible, mandibular foramen, morphometry, nerve block

Introduction

The mandible is the strongest and largest bone of the face which forms the lower jaw. It has a 'U' shaped anterior part, the body of the mandible, which bears the lower jaw teeth and a quadrilateral bony plate known as the ramus, which projects posterior and superior to the body. The ramus of the mandible has got anterior, posterior, superior and inferior borders and two surfaces, namely, the lateral and the medial surfaces [1].

The Mandibular foramen (Mf) is an irregular foramen which is located just above the centre of the medial surface of the ramus of the mandible[2]. The Mf curves downwards and forwards into the body of the mandible to form the mandibular canal which exit opens into mental foramen [1].

The Inferior Alveolar Nerve (IAN) and vessels pass through it which supplies the mandibular teeth, which runs further down in the mandibular canal to emerge out from the mental foramen [1].

The assessment of Mf is of a considerable importance for inferior alveolar nerve anesthesia, dento-alveolar surgery planning, endodontic treatments and lesions diagnosis. Incorrect estimations of its location might be the explanation to the unsuccessful anesthesia of IAN [3].

The most frequent technique failure in anesthesia of the IAN lies in the inappropriate setting of the needle, due to the inaccurate location of anatomic structure- that is Mf [4]. Anesthesia in the mandible may be associated with some difficulty. The success of this technique depends on the proximity between the anesthetic needle and the Mf [5]. Imperfections in the attainment of the anesthesia of the lower alveolar nerve must be generally due to the lack of observance of the localization of the Mf and also noticing its variations [6].

The Mf is an important anatomical landmark for surgical procedures like sagittal split osteotomies done to reposition the mandible in prognathism and retrognathia. The main complication encountered during this technique are haemorrhage, injury to the neurovascular bundle, undesired fractures and bone necrosis, hence a thorough knowledge of the mandibular ramus is very essential [7]. The risk of undesirable mandibular fractures might decrease when the Mf is taken as anatomic repairs in osteotomies performed for orthognathic purposes [8].

The mandibular and mental foramen are often chosen as reference points because of their stable relation with the base of the mandible, in paleoanthropological studies of the facial skeleton in different populations and for identification of the human remains [9, 10].

Therefore, the aim of the present study was to determine the precise location of the Mf from various landmarks such as anterior, posterior borders of the mandibular ramus, angle of mandible and from the mandibular notch in dry human mandibles of Indian population in Rajasthan State.

Materials and Methods

The present study was conducted on 100 human mandibles procured from the Department of Anatomy, Mahatma Gandhi Medical College & Hospital, Jaipur, the Department of Anatomy, SMS Medical College & Hospital, Jaipur, the Department of Anatomy, NIMS Medical College & Hospital,

Jaipur.

The human mandibles which had sockets for the second and third molar teeth were selected for the study and damaged mandibles were excluded.

The position of the Mf from various landmarks was recorded on both the mandibular rami.

All the measurements were taken with the help of a Vernier caliper having least count of 0.06 cm/ 0.6 mm (Fig. 1).

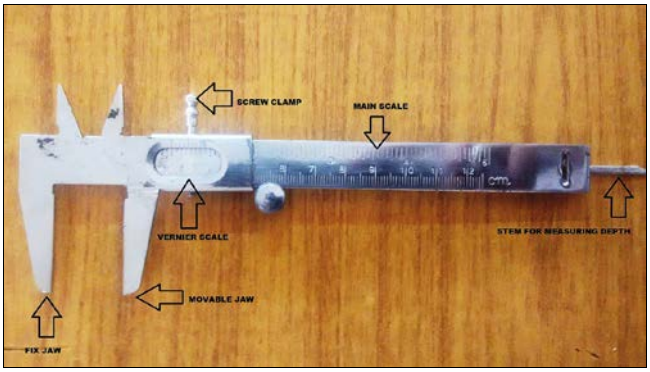

Fig 1: A Vernier Caliper

To locate precisely the Mf, the following parameters were studied (Fig. 2):-

1. Distance,
   A. From the lowest point of the mandibular notch (Mn) to the inferior limt of the Mf.
   B. From the midpoint of the anterior border of the Mf to the nearest point on the anterior border of the ramus (Ab) and from themidpoint of the posterior border of the Mf to the nearest point on the posterior border of the ramus (Pb).
   C. From the inferior limit of Mf to the furthest point on the angle of the mandible (Ag).
2. The data collected was tabulated, statistically analyzed to calculate the standard deviation (SD) and mean.

The results of this study were also compared with the previous findings of other authors.

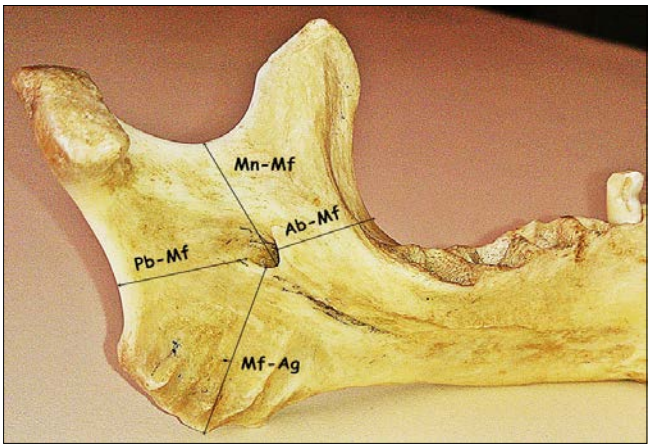

Fig 2: Picture showing measurements of Mandibular foramen (Mf) from various mandibular landmarks - a) lowest point of the andibular notch (Mn-Mf), b) anterior border (Ab-Mf), c) posterior border (Pb-Mf), d) angle of the mandible (Mf-Ag).

Results

The range, mean and standard deviation and P- values for each measurement of both sides of the studied mandibles, have been depicted in tabulated form in Table 1 and Table 2 whereas Figure 3 and Figure 4 shows the graphical representation of the observed data.

Table 1: Parameters to locate the Mandibular foramen (Mf) from various landmarks on the medial surface of the mandibular ramus (*Dentulous Mandibles)*

.Measurements	Side	Range (mm)	Mean (mm)	SD	P-Value
Mn-Mf	Right	16-35	22.91	3.877	.838
	Left	16-34	22.95	3.504	
Ab-Mf	Right	11-22	15.78	2.721	.244
	Left	11-20	16.09	2.299	
Pb-Mf	Right	8-17	11.29	1.988	.167
	Left	9-18	11.48	2.031	
Mf-Ag	Right	13-28	21.10	3.276	.751
	Left	13-29	21.18	2.960	

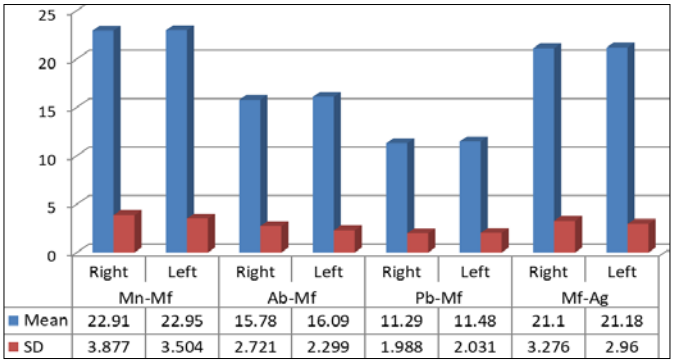

Fig 3: Bar diagram showing the mean distance & SD of various landmarks on the right and left sides of the dentulous mandibles.

Table 2: Parameters to locate the Mandibular foramen (Mf) from various landmarks on the medial surface of the mandibular ramus (*Edentulous Mandibles*).

Measurements	Side	Range (mm)	Mean (mm)	SD	P-Value
Mn-Mf	Right	17-28	22.76	3.239	.715
	Left	16-29	22.90	3.360	
Ab-Mf	Right	12-21	15.48	1.914	.284
	Left	13-22	15.76	2.234	
Pb-Mf	Right	10-14	11.76	1.300	.518
	Left	10-14	11.95	1.499	
Mf-Ag	Right	13-29	22.19	4.297	.142
	Left	13-30	21.67	4.297	

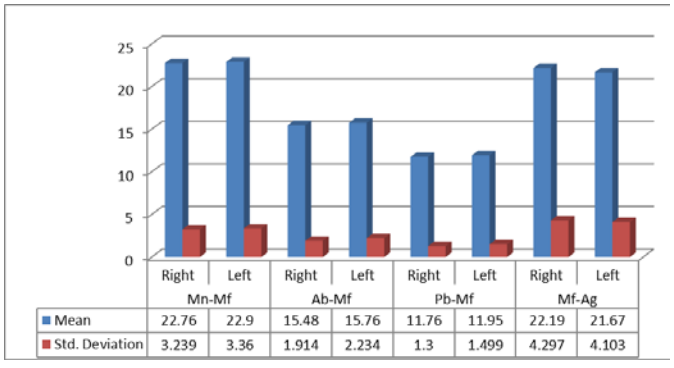

Fig 4: Bar diagram showing the mean distance & SD of various landmarks on the right and left sides of the edentulous mandibles.

After studying 100 mandibles (Dentulous + Edentulous), it was found that the average mean distance from the lowest point of mandibular notch (Mn) to the inferior limit of the Mf i.e. (Mn-Mf) was 22.65±4.33 mm (right side) and 22.94±3.46 mm (left side), from the midpoint of the anterior border of the Mf to the nearest point on the anterior border of the ramus (Ab) i.e. (Ab-Mf) was 15.72±2.57 mm (right side) and 16.02±2.28 mm (left side), from the midpoint of the posterior border of the Mf to the nearest point on the posterior border of the ramus (Pb) i.e. (Pb-Mf) was 11.39±1.87 mm (right side) and 11.58±1.93 mm (left side) and from the inferior limit of Mf to the furthest point on the angle of the mandible (Ag) i.e. (Mf-Ag) was 21.33±3.52 mm (right side) and 21.28±3.22 mm (left side).

Discussion

The position of Mf has been found to be variable which makes it difficult to anaesthetize the IAN. Various parameters have been used by different authors to locate the Mf as mentioned in Table 3.

Table 3: Comparison of studies on Mandibular foramen (Mf) by various authors.

Authors		Side	Ab-Mf (mm)	Pb-Mf (mm)	Mn-Mf (mm)	Mf-Ag (mm)
Oguz *et al* (2002) [11]		Right	16.90	14.09	22.37	-
		Left	16.78	14.37	22.17	-
Kilarkaje *et al* (2005) [12]		Right	18.5 ± 1.9	-	21.6 ± 3.1	25.1 ± 4.2
		Left	18.5 ± 2.0	-	21.6 ± 3.4	24.7 ± 4.4
Prado *et al* (2010) [13]		Right	19.2 ± 3.6	14.2 ± 2.4	23.6 ± 3.1	-
		Left	18.8 ± 3.8	13.9 ± 2.6	23.1 ± 3.0	-
Varsha Shenoy *et al* (2012) [14]		Right	16.1	11.7	23.6	-
		Left	16.3	11.3	23.6	-
Samanta P P *et al* (2013) [6]		Right	15.72 ± 2.92	13.29 ± 1.74	22.70 ± 3.0	21.54 ± 2.92
		Left	16.23 ± 2.88	12.73 ± 2.04	22.27 ± 2.92	21.13 ± 3.43
Present study (2015)	Dent.	Right	15.78 ± 2.72	11.29 ± 1.99	22.91 ± 3.88	21.10 ± 3.28
		Left	16.09 ± 2.30	11.48 ± 2.03	22.95 ± 3.50	21.18 ± 2.96
	Edent.	Right	15.48 ± 1.91	11.76 ± 1.30	22.76 ± 3.24	22.19 ± 4.28
		Left	15.76 ± 2.23	11.95 ± 1.50	22.90 ± 3.36	21.67 ± 4.10
	Dent. + Edent.	Right	15.72 ± 2.57	11.39 ± 1.87	22.65 ± 4.33	21.33 ± 3.52
		Left	16.02 ± 2.28	11.58 ± 1.93	22.94 ± 3.46	21.28 ± 3.22

According to a study conducted by *Oguz et al* (2002) [11] on West Indian mandibles, the Mf was positioned at 16.90 mm (right side) and 16.78 mm (left side) from the anterior border of mandibular ramus. *Kilarkaje et al* (2005) [12] in his study on Middle-east Asian mandibles, found that the Mf was located at a distance of 18.5 ± 1.9 mm (right side) and 18.5 ± 2.0 mm (left side) from the anterior border of the ramus of the mandible. Another study conducted by *Prado et al* (2010) [13] on Brazilian mandibles, reported the position of Mf at a distance of 19.2 ± 3.6 mm (right side) and 18.8 ± 3.8 mm (left side) from the anterior border of the mandibular ramus. *Varsha Shenoy et al* (2012) [14] in her study on mandibles of South Indian origin found that the Mf was located at a distance of 16.1 mm (right side) and 16.3 mm (left side) from the anterior border of the ramus of the mandible. Another study done by *Samanta P P et al* (2013) [6] on mandibles of Indian subcontinent, the Mf was positioned at 15.72 ± 2.92 mm (right side) and 16.23 ± 2.88 mm (left side) from the anterior border of mandibular ramus.

- In the present study, the distance of Mf from the anterior border of the mandibular ramus has been found to be 15.72 ± 2.57 mm (right side) and 16.02 ± 2.28 mm (left side) which is insignificant and thus is in conformity with the studies conducted by *Oguz et al* (2002) [11], *Varsha Shenoy et al* (2012) [14] and *Samanta P P et al* (2013) [6] but differs significantly from the studies conducted by *Kilarkaje et al* (2005) [12] and *Prado et al* (2010) [13].
  According to *Oguz et al* (2002) [11]'s study on West Indian mandibles, the Mf was positioned at 14.09 mm (right side) and 14.37 mm (left side) from the posterior border of mandibular ramus. *Prado et al* (2010) [13]'s study on Brazilian mandibles, reported the position of Mf at a distance of 14.2 ± 2.4 mm (right side) and 13.9 ± 2.6 mm (left side) from the posterior border of the mandibular ramus. *Varsha Shenoy et al (2012)* [14] in her study on mandibles of South Indian origin, found that the Mf was located at a distance of 11.7 mm (right side) and 11.3 mm (left side) from the posterior border of the ramus of the mandible. *Samanta P P et al* (2013) [6]'s study on mandibles of Indian subcontinent, the Mf was positioned at 13.29 ± 1.74 mm (right side) and 12.73 ± 2.04 mm (left side) from the posterior border of mandibular ramus.
- In the present study, the distance of Mf from the posterior border of the mandibular ramus has been found to be 11.39 ± 1.87 mm (right side) and 11.58 ± 1.93 mm (left side) which is insignificant and thus is in conformity with the studies conducted by *Varsha Shenoy et al* (2012) [14] but differs significantly from the studies conducted by *Oguz et al* (2002) [11], *Prado et al* (2010) [13] and *Samanta P P et al* (2013) [6].
  According to *Oguz et al (2002)* [11]'s study on West Indian mandibles, the Mf was positioned at 22.37 mm (right side) and 22.17 mm (left side) from the mandibular notch. *Kilarkaje et al* (2005) [12] in his study on Middle-east Asian mandibles, found that the Mf was located at a distance of 21.6 ± 3.1 mm (right side) and 21.6 ± 3.4 mm (left side) from the mandibular notch. *Prado et al* (2010) [13]'s study on Brazilian mandibles, reported the position of Mf at a distance of 23.6 ± 3.1 mm (right side) and 23.1 ± 3.0 mm (left side) from the mandibular notch. *Varsha Shenoy et al* (2012) [14] in her study on mandibles of South Indian origin, found that the Mf was located at a distance

of 23.6 mm (right side) and 23.6 mm (left side) from the mandibular notch. *Samanta P P et al* (2013) [6]'s study on mandibles of Indian subcontinent, the Mf was positioned at 22.70 ± 3.0 mm (right side) and 22.27 ± 2.92 mm (left side) from the mandibular notch.

- In the present study, the distance of Mf from the mandibular notch has been found to be 22.65 ± 4.33 mm (right side) and 22.94 ± 3.46 mm (left side) which is insignificant and thus is in conformity with the above studies.

  Kilarkaje et al (2005) [12] in his study on Middle-east Asian mandibles, found that the Mf was located at a distance of 25.1 ± 4.2 mm (right side) and 24.7 ± 4.4 mm (left side) from the angle of the mandible. *Samanta P P et al* (2013) [6]'s study on mandibles of Indian subcontinent, the Mf was positioned at 21.54 ± 2.92 mm (right side) and 21.13 ± 3.43 mm (left side) from the angle of the mandible.
- In the present study, the distance of Mf from the angle of the mandible has been found to be 21.33 ± 3.52 mm (right side) and 21.28 ± 3.22 mm (left side) which is insignificant and thus is in conformity with the study conducted by *Samanta P P et al* (2013) [6] but differs significantly from the study conducted by *Kilarkaje et al* (2005) [12].

  The reason for this difference in the position of Mf from various landmarks like anterior border, posterior border, mandibular notch and angle of the mandible might be due to factors like variations in the regional and geographical area, racial differences, age associated changes, sex, population, methodologies and eating habits of the people.

There is literature evidence stating that there are measurable significant differences between whites and blacks in the size and proportions of skeletal components. This could be due to racial variation in the mandibular anatomy. The literature contains conclusive evidence that significant metric and morphologic biological differences are present among the three major racial phenotypes, Caucasoid, Mongoloid and Negroid [5, 10, 15, 16, 17, 18].

The more posterior and higher position of Mf in Indians when compared with other races emphasizes a modification in the traditional IAN block technique to increase the success rate. Thus, the insertion of the needle for IAN block technique can precisely locate the Mf. The reason for this may be attributed to the ethnic and racial variations in the mandibular anatomy [19].

The developmental and age associated changes might be a reason for the variations in the mandibular anatomy. Secondary cartilages appear along anterior coronoid border (ossify soon and disappears before birth), nodules at symphysis mentii and a conical mass, the condylar cartilage, extends from the mandibular head downwards and forwards in the ramus, contributing to its growth in height and craniofacial growth. The mandible increases in size, bone is added at the posterior borders of the ramus and cornoid process, absorption occurring at their anterior borders. This remodeling is continuous until adult size, allowing alveolar parts to accommodate the permanent molar teeth [20].

The type of food consumed could be a reason for the variation in anatomy of the mandible, as the stimulation to the jaw growth could vary based on the consistency of food. The difference in values between vegetarians and non-vegetarians can be attributed to the type of food as the consistency of food between these two groups varies greatly. The amount of masticatory force exerted by a vegetarian would be much lesser as compares to non-vegetarian, thereby lesser stimulation for the growth of the mandible [19].

The anatomy of the mandible with regard to the position of Mf and its relation to the previously mentioned landmarks varied between vegetarians and non-vegetarians of South Indian population. These variations were found to be statistically significant with regard to the distance of Mf to posterior border. But, there was no statistical difference with regard to distance of Mf from the anterior border [19].

The ratio between Mf to anterior border and Mf to posterior border was higher in vegetarians (1.7:1) than in non-vegetarians (1.5:1) whereas the width of ramus was higher in non-vegetarians when compared with the vegetarians. This is because of the increase in the distance from Mf to posterior border in non vegetarians [19].

In the present study, the ratio between Ab-Mf mean distance & Pb-Mf mean distance was 1.4:1 that does not coincide with the above mentioned ratio which may be attributed due to non-categorization of samples.

Also, in the present study, there was no significant difference between the right and left sides, which favours and supports the studies conducted by *Hayward et al* (1977) [21], *Narayana et al* (2005) [22], *Ennes et al* (2009) [23].

Conclusion

The present study gives a fair knowledge of the position of Mf and provides useful information regarding the success rate of dental anaesthesia and to the maxillofacial surgeons, radiologists and oncologists performing operations on the mandible to prevent complications, misinterpretations and to plan and develop newer techniques for nerve blocks and mandibular surgeries. These data may also be useful in reconstructive surgery and anthropological assessments.

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