

Osteometric Analysis of the Mandibular Foramen in Dry Human Mandibles

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ABSTRACT

Context (Background): Adequate anaesthesia is a prerequisite of most of the dental procedures. Effective pain control in dentistry may be achieved by the local anaesthetic techniques; the most common procedure which is followed being the inferior alveolar nerve block. The Traditional Halstead method is a direct technique in which the inferior alveolar nerve is approached by an intraoral access before it penetrates the mandibular canal. According to previous studies, the failure rate of this procedure was 20%, reaching to even higher percentages in the pulpal anaesthesia. The success of this technique highly depends on the proximity of the needle tip to the mandibular foramen at the time of the anaesthetic injection. For this reason, the technique must be based on the precise anatomical knowledge of the correct location of the mandibular foramen.

Aim: The aim of this study was to locate the mandibular foramen in relation to the borders of the mandibular ramus and also to locate the quadrant of the ramus in which the foramen was located in the vertical and horizontal directions.

Materials and Methods: 50 human mandibles were studied to determine,

A. The distance of the mandibular foramen to (a) the anterior border of the ramus (b) the posterior border of the ramus (c) the mandibular incisure (d) the lower border of the ramus.

B. The gonial angle and the correlation of the gonial angle to other parameters which were studied and

C. To categorize the lingula into various patterns depending on its shape and to measure the bi-lingular distance.

Results: This study revealed that the mandibular foramen was located on the third quadrant antero-posteriorly and at the junction of the second and third quadrant of the ramus supero-inferiorly. There was a negative correlation between the gonial angle and other linear parameters which were studied. The most common type of lingula which was found was of the nodular variety.

Conclusion: Localization of the mandibular foramen is a prerequisite prior to the inferior alveolar nerve block and during any surgical procedures on the mandibular ramus.

Key Words: Mandibular foramen, Lingula, Osteometry, Sagittal split osteotomy, Inferior alveolar nerve, Gonial angle

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 which is 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. The mandibular foramen (MF) is an irregular foramen on the medial surface of the ramus, which is located near the centre. The MF leads into the mandibular canal (MC), a canal which traverses the body of the mandible. The inferior alveolar (IA) nerve and the vessels, after passing through the MF, traverse the MC to supply the mandibular teeth. The lingula is a tongue shaped bony projection which is just medial to the MF [1]. Previous studies have classified the lingula into the truncated, triangular, nodular and the assimilated type, depending on its shape [2]. The IA nerve block is the commonest local anaesthetic technique which is used for anaesthetizing the lower jaw in dentistry. The success of this technique highly depends on the proximity of the needle tip to the MF at the time of the anaesthetic injection [3]. For this reason, this technique must be based on the precise anatomical knowledge of the MF.

The aim of the present study was to locate the MF in relation to the borders of the mandibular ramus and also to locate the quadrant of the ramus in which the foramen was located in the vertical and horizontal directions. It was also aimed to study the pattern of the lingula based on its shape.

MATERIALS AND METHODS

The following parameters were studied on both the sides of 50 human mandibles [Table/Fig -1]:

- 1) The smallest distance between the anterior border (Ab) of the mandibular ramus and the anterior limit of the MF (Ab-MF).
- 2) The smallest distance between the posterior limit of the MF and the posterior border (Pb) of the mandibular ramus (MF-Pb).
- 3) The smallest distance between the inferior limit of the MF and the mandibular base (MF-MB).
- 4) The smallest distance between the lowest point of the mandibular incisure (superior border) and the inferior limit of the MF (MI-MF).
- 5) The smallest antero-posterior measurement of the ramus which passes through the MF (Ab-Pb).

- 6) The gonial angle of the mandible (Go).
- 7) The types of lingula –Depending on its shape, the lingula was categorized into four types: truncated, triangular, nodular and the assimilated types.
- 8) Bi-lingular distance –Distance between the lingulae of both the sides.

All the linear distances (1-5 and 8) were measured by using a vernier caliper and Go was measured by using a goniometer. The distances from the MF to various landmarks and the lingular parameters were tabulated as an average of two measurements which were recorded independently by two people. The data were recorded separately for both the sides and they were expressed as average (Avg) and standard deviation (SD). The correlation between Go and the other distances was analyzed by the Pearson's linear correlation test.

The antero-posterior localization of the MF was obtained by identifying the distance between the Ab of the mandibular ramus and the mean point of the MF opening. This was calculated as follows: from Ab-Pb, the sum of Ab-MF and MF-Pb was subtracted. This gave the width of the MF. This was divided into halves to get the mean point of the MF opening and this was added to the distance, Ab-MF. Then, the percentage of the distance between Ab – the mean point of the MF with the Ab-Pb distance was calculated to locate MF antero-posteriorly.

The vertical localization of the MF was obtained by calculating how much MI-MF represented in the percentage of the addition of the MI-MF and the MF-MB distances.

RESULTS

The average, standard deviation and the minimum and maximum values of various parameters which were studied on either sides of the mandible are shown in [Table/Fig -2]. It was found that there was no significant difference in the values on the right and left sides. The correlation between Go and other distances were analyzed by the Pearson's linear correlation test. The coefficient could vary from -1 to +1. The positive scores indicated a direct proportional correlation, the negative scores indicated an inversely proportional correlation and zero indicated no correlation, the p value being ≤



[Table/Fig-1]: Photograph showing the various distances of mandibular foramen (MF) to borders of ramus Ab-MF: Smallest distance between the anterior border of mandibular ramus and the anterior limit of MF MF-Pb: Smallest distance between the posterior limit of MF and the posterior border of mandibular ramus MF-MB: Smallest distance between the inferior limit of MF and the mandibular base MI-MF: Smallest distance between the lowest point of the mandibular incisure and the inferior limit of MF

Mesurement	Side	Avg	SD	Min - Max
Ab-MF (cm)	Right	1.614	0.205049	1.0- 2.0
	Left	1.634	0.188019	1.2-2.1
MF- Pb (cm)	Right	1.168	0.216125	0.5 - 1.5
	Left	1.13	0.195093	0.8 - 1.5
MI- MF (cm)	Right	2.358	0.31239	1.8 – 3.5
	Left	2.356	0.31047	1.7 - 3.4
MF-MB (cm)	Right	2.352	0.28157	1.6 - 3.1
	Left	2.284	0.27357	1.6 - 3.1
Ab-Pb (cm)	Right	3.072	0.278509	2.5 - 3.6
	Left	3.072	0.278509	2.5 - 3.6
Go (degree)	Right	124.42	5.952499	109 - 140
	Left	124.14	6.147872	108 - 135

[Table/Fig-2]: Table showing Average (Avg), Standard Deviation(SD), minimum (min) and maximum (Max) values of various parameters studied.

	Side	Ab- MF	MF-Pb	MI- MF	MF- MB
Go	Right	-0.20891	-0.55725	-0.14946	-0.42364
Go	Left	-0.1119	-0.41364	-0.05444	-0.48037

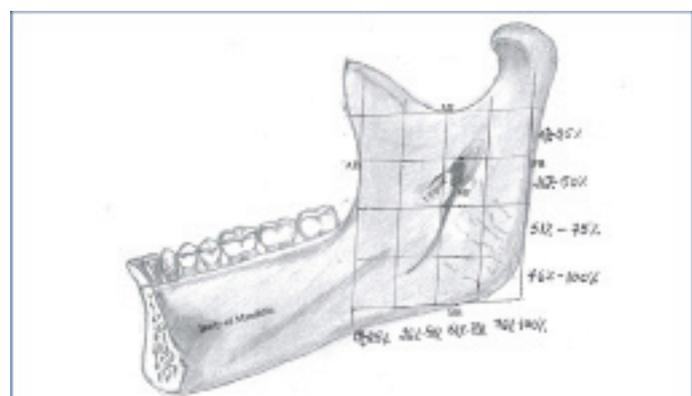
[Table/Fig-3]: Table showing correlation between linear distances of MF and Go.

Parameters	Avg
Ab- Pb (cm)	3.072
Ab- MF (cm)	1.624
MF- Pb (cm)	1.149
MI-MF (cm)	2.357
MF-MB (cm)	2.318
Go (degree)	124.28

[Table/Fig-4]: Table showing Avg measurement of various parameters studied.

AP Localisation	57.71%
SI Localisation	50.41%

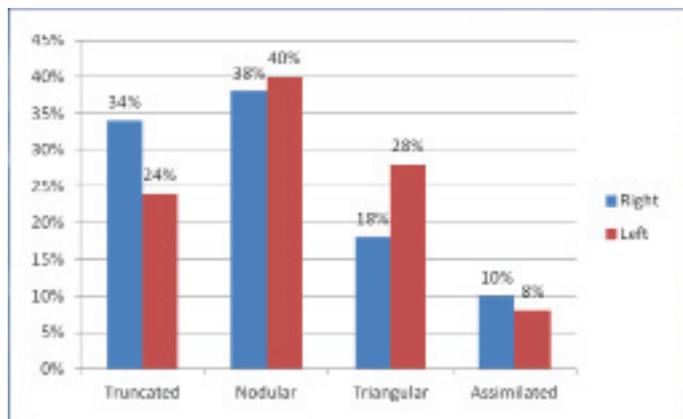
[Table/Fig-5]: Table showing antero-posterior and supero-inferior localisation of MF on ramus.



[Table/Fig-6]: Schematic diagram showing the antero-posterior and supero-inferior quadrants of ramus. Each quadrant is made up of 25% of the ramus surface. MF- Mandibular foramen, AB- Anterior border of ramus, PB- posterior border of ramus, MI- Mandibular incisure, MB- inferior border of ramus.

Type of lingula	Right	Left
Truncated	17 (34%)	12(24%)
Nodular	19(38%)	20(40%)
Triangular	9(18%)	14(28%)
Assimilated	5(10%)	4(8%)

[Table/Fig-7]: Table showing Lingular pattern on the right and left side.



[Table/Fig-8]: Bar diagram showing the distribution of lingular pattern on the right and left side.

	Avg	Min	Max	SD
Bi-lingular distance	7.184	6.1	8.3	0.444173

[Table/Fig-9]: TTable showing the Avg, Min, Max and SD of bi-lingular distance.

0.05. As has been described in [Table/ Fig -3], in the present study, the correlation of Go with other linear distances of the mandibular foramen were negative.

In [Table/ Fig -4], the average values of various parameters of both the sides have been illustrated. The Avg (average) measurement of the shortest antero-posterior distance (Ab- Pb) of the mandibular ramus which passed through the MF was found to be 3.07cm. The Avg of Ab-MF was 1.62 cm, that of MF- Pb was 1.15 cm, that of MI-MF was 2.36 cm and that of MF- MB was found to be 2.32 cm. The Avg measurement of Go of the mandible was found to be 124.28 degrees.

[Table/Fig-5] shows that the centre of the MF was located on a point which was 57.71% from the anterior border of the ramus on an antero-posterior (AP) plane.

If we divided the surface area of the ramus into four quadrants [Table/Fig -6], then this study could locate the MF centre to the third quadrant antero-posteriorly. At the same time, on a supero-inferior (SI) plane, the MF was found to be at 50.41% from the MI, thus indicating that it was located at the junction of the second and third quadrants on a SI plane.

This study found that the nodular variety of the lingula was the most common type which was found (39 out of 100 sides), which was followed by the truncated type (29 out of 100 sides), the triangular type (23 out of 100 sides) and the assimilated type (9 out of 100 side) respectively. [Table /Fig-7] and [Table/Fig-8] have shown the distribution of various types of the lingula on the right and left sides. [Table /Fig-9] describes the minimum, maximum, Avg and the SD of the bi-lingular distance which was measured on 50 mandibles.

DISCUSSION

The localization of the MF presented great variations, but in this study, there was no significant variation between the right and left sides, which was in accordance with the findings of previous studies [4-6].

A study on 34 adult Turkish mandibles showed that the Ab-MF was 16.9 mm and 16.78 mm on the right and left sides respectively. The MF-Pb was found to be 14.09 mm on the right side and 14.37 mm on the left side. The MI-MF was 22.37 mm on the right side and 22.17 mm on the left side. The MF- MB was 30.97 mm on the right side and 29.75 mm on the left side [7]. According to the present study, the Ab-MF was 1.61 cm on the right side and 1.63 cm on the left side, the MF-Pb was 1.17 cm on the right side and 1.13 cm on the left side, the MI-MF was 2.36 cm on both the right and left sides and the MF-MB was 2.35 cm on the right side and 2.28 cm on the left side.

The IA nerve block was the most frequently used local anaesthetic technique for restorative and surgical procedures on the mandible, with several million blocks being administered each year. According to previous studies, the traditional Halstead method had shown a 20% failure rate. The most common reason for the failure of the technique was the inappropriate location of the tip of the anaesthetic needle due to inappropriate localization of the MF [3,6,8]. There are some anaesthetic protocols which proclaim the utilization of long needles for the IA nerve blockage. On an average, the long needles are 33mm long and the short needles are 21.5mm long [6]. If the long needles are used in patients with small mandibles, the procedure can end in a technical failure, since there is a risk of perforating the parotid gland capsule where the infiltration of the anaesthetic solution may lead to the blockage of the facial nerve branches. On the other hand, the use of short needles in big-sized mandibles might lead to needle fracture [6]. In this study, the Avg distance between the Ab and the MF was found to be 1.6 cm [Table/Fig- 4], which was the ideal place for the anaesthetic infiltration. The maximum value for the same parameter was found to be 2.1 cm and the minimum was 1.0 cm. According to the values of the present study, the IA nerve block could probably be accomplished with short needles.

Bilateral sagittal split osteotomy (BSSO) and vertical ramus osteotomy (VRO) are the common procedures which are done for the correction of the mandibular prognathism, to reposition the mandible surgically. A thorough anatomical knowledge of the mandibular ramus is essential for these procedures, since they are technically difficult procedures and as they are also associated with a higher incidence of complications [9,10]. According to many studies, the posterior and the superior thirds of the ramus constitute a 'safety zone' where the MF is unlikely to be found. This area can be used in VRO with a low incidence of IA nerve damage [11]. In the present study also, the MF was found to be located in the third quadrant antero-posteriorly and at the junction of the second and third quadrants supero-inferiorly [Table/ Fig-5], which was in accordance with the findings of older studies [6,11]. Thus, familiarity with the described relationships of the MF will assist in the correct localization of the MF, which in turn, might reduce the chances of an undesired split as well as IA nerve morbidity. Thus, the correct localization of the MF will assist in performing proper and safe split osteotomy procedures on the mandible.

The average of Go was found to be 124.28 degrees in the present study, which was similar to the findings of Ennes and Medeiros [6] but to be different from that which was described by other studies [7]. It was worthwhile observing that the Go was related to the Ab-Pb width of the mandibular ramus and to the distance between the MF and the borders of the ramus in an inversely proportional relation [Table/Fig-3], as was also found in some other studies [6,12]. This meant that in individuals with a wide Go, it was possible to accomplish the IA nerve blockage with a puncture lower than the conventional one with short needles. In individuals with a smaller Go, it was possible to accomplish the IA nerve blockage with a puncture which was higher than the conventional one, with a lower probability of success with the use of short needles.

The lingula of the mandible is a sharp, tongue-shaped, bony projection on the medial aspect of the ramus. It is an important landmark on the medial side of the ramus as it is in close proximity to the MF. Hence, both the MF and the lingula are of clinical significance for the orodental surgeons. According to a study which was conducted on 165 mandibles, triangular lingulae were found in 226 sides, truncated ones were found in 52, nodular ones were found in 36 and assimilated ones in 16 sides [13]. Another study revealed that truncated lingulae were most commonly found (47%), which was followed by the nodular (23%), triangular (17%) and the assimilated shapes (13%) [14]. This study revealed that the nodular variety was the most common one which was found, followed by the truncated, triangular and the assimilated varieties [Table/ Fig -7 and 8].

CONCLUSION

Since some investigators [3] have stated that anaesthesia is essential for both the patients and the dentists, quoting that the opinion of the patients about their dentists was strictly based on their experience with local anaesthesia, it was preferred to infiltrate the anaesthetic solution in close proximity to the MF in the IA nerve block. Despite the great variation of the MF, it should be kept in mind that it is located in the third quadrant of the ramus antero-posteriorly and supero-inferiorly. It is also preferable to locate the MF by a CT scan prior to any surgical approach to the ramus, to prevent inadvertent injury to the IA nerve.

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FINANCIAL OR OTHER COMPETING INTERESTS:

None.

Date of Submission: **Dec 27, 2011**
Date of Peer Review: **Jan 27, 2012**
Date of Acceptance: **Mar 03, 2012**
Date of Publishing: **May 31, 2012**