

THE ANATOMICAL VARIATIONS OF MANDIBULAR FORAMEN AND LINGULA REGARDING THE INFERIOR ALVEOLAR NERVE BLOCK – A LITERATURE REVIEW

Emilia Dîmbu¹, Cristina Popa^{2*}, Anca Sava³, Alexandra Lorina Stelea⁴,
M. Dîmbu⁵, Carmen Gabriela Stelea⁶

1,5. “St. Spiridon” Hospital Iasi, Romania

Department of Oral and Maxillofacial Surgery

“Grigore T. Popa” University of Medicine and Pharmacy Iasi

2. Faculty of Dental Medicine

Department of Oral Medicine

3. Faculty of Medicine

Department of Anatomy

4. Faculty of Medicine

Student

6. Faculty of Dental Medicine

Department of Dento-Alveolar Surgery

THE ANATOMICAL VARIATIONS OF MANDIBULAR FORAMEN AND LINGULA REGARDING THE INFERIOR ALVEOLAR NERVE BLOCK – A LITERATURE REVIEW (Abstract): In oral-maxillofacial surgery and, in general, in dentistry, providing a pain-free treatment is a very important part of the patient-doctor relationship and mandatory to provide high-quality health care. This review analyzes published research in English from 2000 to 2016, concerning the location and the particularities of the mandibular foramen and lingula. The aim of the article is to highlight the need for clinicians to have a solid understanding of the anatomy of the oral-maxillofacial territory. **Keywords:** MANDIBULAR FORAMEN, LINGULA, INFERIOR ALVEOLAR NERVE BLOCK, ANATOMY, MANDIBLE

INTRODUCTION

The inferior alveolar nerve block (IANB) is the second most frequently used (after infiltration) technique of local anesthesia, unluckily with a high rate of failure (31% to 81%) (1), caused mainly by the absence of bony landmarks and by the anatomical variations of the mandibular foramen and lingula (2). The literature presents the mandibular foramen to be found on the medial surface of the mandibular ramus, almost in its center and represents the entrance of the inferior alveolar vessels and nerve. The anterior limit of this opening is named lingula mandibulae, a sharp tongue-shaped bony projection, which gives attachment to the sphenomandibular ligament (3,4).

METHODS

The electronic journal search was limited to work published in English, from 2000 to 2016 and

included MEDLINE, ScienceDirect, Cochrane, EBSCO and Google Scholar databases. The search used a combination of the following keywords: “mandible”, “mandibular”, “foramen”, “lingula”, “inferior alveolar nerve block” and “anatomy”. Only full papers were included to obtain complete and complex data.

THE MANDIBULAR FORAMEN

The assessment of the mandibular foramen (MF) is a key step in the correct execution of the inferior alveolar nerve block or in oral-maxillofacial surgery planning (5). The main factor responsible for failure of IANB is the anatomical variation of its landmarks, which is directly associated with age, race and growth pattern. The MF cannot be palpated intraorally, so we need to evaluate different distances from MF to the IANB landmarks to obtain a better localization of it (6). Kilarkaje et al. (2005) (7)

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TABLE I

Mean values (in millimeters) for the distances between the mandibular foramen and anterior border of the ramus (MF-AB) and between the mandibular foramen and the posterior border of the ramus (MF-PB) reported for the Indian population

Authors	References	Side	MF - AB	MF-PB
Khan & Ansari (2016)	6	Right	16.06	12.02
		Left	16.13	11.10
Sandhya et al. (2016)	13	Right	16.00	10.21
		Left	16.27	10.28
Samanta & Kharb (2013)	14	Right	15.72	13.29
		Left	16.23	12.73
Hoque et al. (2013)	15	Right	16.34	14.14
		Left	16.27	14.04

found that age is an important factor when considering the anatomy of the mandibular foramen, because the distance between it and other landmarks increase with age. In the same study, they discovered that MF maintains bilateral symmetry and it is located within 25 mm of the anterior border of the ramus, mandibular notch, third molar or angle of mandible.

a) The anteroposterior position of the MF

According to several studies available in the literature, we can affirm that the distance from the anterior margin of the ramus to the MF ranged from 14.2 mm (edentulous Brazilian patients) (8) to 22.9 mm (adult Korean group) (9); the distance from the posterior border of the ramus to the MF averaged between 7.74 mm (primary dentition in Israeli children) (10) to 14.66 mm (Japanese adults with normal occlusion or edentulous Brazilian patients) (11,12). These differences can be explained by the racial discrepancies, craniofacial growth, anatomical variability, age or distinct methodologies used in these investigations. Some studies (9,10) sustain the idea that as dentition developed, the MF moves anteriorly, fact that could be explained by the bone apposition on the posterior border and bone remodeling in the anterior border.

Indian Studies

Regarding the Indian population, the values of the distance from the anterior border of the ramus to the MF ranged from 15.72 mm to 16.34 mm and from the posterior border to the MF ranged from 10.21 mm to 14.14 mm, as it is showed in the Table I. Khan & Ansari (2016)

(6) found for Indian population that MF lies on average at a distance of 16.06 mm on the right side and 16.13 mm on the left side from anterior border of ramus of the mandible and from the posterior border at 12.02 mm on the right side and at 11.10 mm on the left side. These information are more or less similar with other Indian studies (13,14,15). Sandhya et al. (2016) (13) noted that the mean distance from the MF to the anterior border was 16.0 mm on the right side and 16.27 mm on the left side, and from the posterior border 10.21 mm on the right side and 10.28 mm on the left side. According to Samanta & Kharb (2013) (14) the average distance of MF from anterior border was 15.7 mm (right side) and 16.23 mm (left side) and from posterior border was 13.29 mm (right side) and 12.73 mm (left side). Hoque et al. (2013) (15) found that MF was positioned at a mean distance of 16.34 mm and 16.27 mm on right side and left side respectively, from the anterior border of the ramus. In the same study, the distance from posterior border was 14.14 mm and 14.04 mm on right and left side, respectively.

Brazilian Studies

In the Tabel II are presented the studies that analyzed Brazilian population and their results showing that the distance from MF to anterior border of the ramus varied between 14.2 mm - 17.67 mm and to the posterior border ranged from 10.8 mm to 14.35 mm.

According to Ennes & Medeiros (2009) (8) the mean distance at Brazilian dry mandibles from anterior border of the ramus to the center of MF was 16.2 mm. In the same study, the

TABLE II
Mean values (in millimeters) for the distances between the mandibular foramen and anterior border of the ramus (MF-AB) and between the mandibular foramen and the posterior border of the ramus (MF-PB) reported for the Brazilian population

Authors	References		MF - AB	MF-PB
Ennes & Medeiros (2009)	8	Edentulous gr.	14.2	10.8
		1-10 teeth gr	14.6	12.8
		11-16 teeth gr	15.9	13.4
Monnazzi et al. (2012)	16		17.67	14.35
Valente et al. (2012)	12	Right	16.94	14.24
		Left	17.32	14.03

distance from anterior border to the anterior limit of the MF was 14.2 mm for the edentulous group, 14.6 mm for the 1-10 teeth group and 15.9 mm for the 11-16 teeth group and the distance from the posterior border of the ramus to the posterior limit of the MF was 10.8 mm in the edentulous group, 12.8 mm in the 1-10 teeth group and 13.4 mm in the 11-16 teeth group. Monnazzi et al. (2012) (16) found the mean value from the anterior border of the ramus to the anterior limit of the MF to be 17.67 mm and the distance from the posterior limit of the MF to the posterior border 14.35 mm. Valente et al. (2012) (12) observed in their study that the average value from anterior border of the ramus to the inferior limit of MF was 16.94 mm on the right side and 17.32 mm on the left side and from posterior border to the inferior limit of MF was 14.24 mm on the right side and 14.03 mm on the left side.

Korean Studies

Kang et al. (2013) (9) analyzed the MF using CT images from Korean patients aged 8-25 years and found that the mean distance from the anterior border of the ramus to the MF at the adult group (18-25 years) was 22.9 mm and 21.6 mm at the growth group (8-16 years). As we can see in the Table III, these findings are less similar to the findings of Park & Lee (2015) (17) who used CBCT images from Korean patients aged 18-31 years to measure the Ab-MF distance and concluded that it was on average 19.41 mm in the normal occlusion group, 19.01 mm in the skeletal class II malocclusion group and 19.85 mm in the skeletal class III malocclusion group.

France Study

Trost et al. (2010) (18) published a radio-anatomic study performed on panoramic radiographs of France patients and observed that mandibular foramen was found, in horizontal position, “around the midpoint of the anterior two-thirds and the posterior third of the ramus, preferentially in front of this point”.

The Width Of The Ramus

In our research, we found that the width of the ramus of the mandible ranges from 22.48 mm (in primary dentition in Israeli children) (10) to 37.70 mm (Korean adult group) (9). According to Kang et al. (2013) (9) the change of the width of the ramus regarding age was not statistically significant and the results suggested that the MF moves posteriorly with continued mandibular growth.

b) The superior-inferior position of MF

The Distance MF – Occlusal Plane

There are not many studies describing the distance from the mandibular foramen to the occlusal plane. Park & Lee (2015) (17) found that the vertical position of the MF at adult patients averaged -0.10 mm in the normal occlusion group, -0.03 mm in the skeletal class II malocclusion group and 2.79 mm in the skeletal class III malocclusion group, concluding that it was higher in the patients with skeletal class III malocclusion. Goda et al. (2015) (11) analyzed the same anatomical relationship at Japanese adult patients using CT images and discovered that the vertical position of the MF relative to the occlusal plane was 0.22 mm in the mandibular prognathism group and 1.6 mm

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TABLE III
Mean values (in millimeters) for the distances between the mandibular foramen and anterior border of the ramus (MF-AB) reported by other authors for the Korean population

<i>Authors</i>	<i>References</i>		<i>MF - AB</i>
<i>Kang et al. (2013)</i>	9	Adult group	22.9
		Growth group	21.6
<i>Park & Lee (2015)</i>	17	Normal occlusion group	19.41
		CI II malocclusion group	19.01
		CI III malocclusion group	19.85

in the normal occlusion group. Paryab & Ahmadyar (2015) (19) studied panoramic radiographs in children with mixed dentition and showed that the distance from MF to the occlusal plane was 3.69 mm in normal group occlusion and 4.01 mm in retrognathism group. These findings are similar with the study of Kang et al. (2013) (9), where the distance MF – occlusal plane was 3.8 mm in the adult group and 3.2 mm in the growth group.

The Distance MF - Third Molar

Some authors evaluated the location of MF relative to the third molar. Hoque et al. (2013) (15) found that the distance from the posterior edge of third molar socket to the MF was 16.7 mm on right side and 16.72 mm on left side. These findings are similar to the study of Sultana et al. (2016) (20) where the same distance was 17.9 mm on the right side and 17.6 mm on the left side. According to Shalini et al. (2016) (21) the distance from the midpoint of third molar tooth or socket to anterior margin of MF was 22.84 mm on the right side and 23.23 mm on the left side. The dissimilar values may be attributed to the different techniques of measurement.

The Distance MF – Mandibular Notch (Mn)

Even if the distance from mandibular notch to the MF does not represent an important landmark for the IANB, it is an important reference point for identifying the position of the mandibular foramen during orthognathic surgery. In our analyze we found that this distance ranges from 15.8 mm (in young Indian patients) (7) to 24.52 mm (4), with a mean value of 21.35 mm. In the study of Kilarkaje et al. (2005) (7), the distance from the center of the MF to the lowest point on the concavity of the mandibular notch was found to be on the right side 15.80 mm and 16.10 mm on the left side for the young

group, 21.60 mm for the adult group and 21.50 mm for the old group. Khan & Ansari (2016) (6) measured the distance from the superior border of the MF to the mandibular notch and found that the mean value for the right side was 18.79 mm and for the left side 18.71 mm. According to Park & Lee (2015) (17) the distance from the mandibular notch to the mandibular foramen was 21.59 mm in the normal occlusion group, 20.49 mm in the skeletal class II malocclusion group, and 18.77 mm in the skeletal class III malocclusion group. Ennes & Medeiros (2009) (8) measured the distance from the mandibular notch to the inferior limit of the MF and obtained the following results: 21.7 mm for the edentulous group, 24.3 mm for the 1 to 10 teeth group and 24.5 mm for the 11-16 teeth group.

The Distance MF – Mandibular Base (Mb)

The data collected for the distance between the MF and the mandibular base ranged from 19.1 mm (8) to 41.24 mm (12), with a mean value of 26.79 mm. The smallest values were found in the study of Ennes & Medeiros (2009) (8) on 99 Brazilian dry human mandibles, where the MF-MB distance was 19.1 mm for the edentulous group, 22.3 mm for the 1-10 teeth group, 21.7 mm for the 11-16 teeth group. These results are in contradiction with the study of Valente et al. (2012) (12), who analyzed Brazilian adult dry mandibles according to hemi-arch and concluded that the MF-MB distance was 39.15 mm for the edentulous group, 38.04 mm for the group with the presence of 1-4 dental alveoli and 41.2 mm for the group with the presence of 5-8 dental alveoli. Thangavelu et al. (2012) (5) found that the distance from the center of the MF to the MB in Indian population was 30.78 mm for the edentulous group both sides and for the dentulous group 27.62

TABLE IV
Comparison of different studies on location of lingula and its height

Authors	Reference	Population	Year	Dis- tance from anterior border of ramus (mm)	Distance from posterior border of ramus (mm)	Distance from mandibu- lar notch (mm)	Distance from mandibu- lar base (mm)	Height (mm)
Sekerci et al.	24	Turkish	2013	13.3	10.2	11.4	-	5.3
Samanta et al.	25	Indian	2013	20	15	15.4	-	5.2
Alves & Deana	26	Chilean	2015	17.76	15.28	17.29	33.30	8.29
Hosapatna et al.	4	Indian	2015	R 16.68 L 16.32	R 16.20 L 15.00	R 16.32 L 13.64	R 31.92 L 30.48	

Unreported measurements : (-) ; Right (R) ; Left (L)

mm on the right side and 27.30 mm on the left side. Even if the limits of the MF from where the measurements for edentulous groups were taken are different, this still does not explain the big differences, as studies showed that the diameter of the MF ranges from 2.38 mm (6) to 4.37 mm (21).

The Distance Mf – The Apex Of Retromolar Trigone

Shalini et al. (2016) (21) analyzed the relationship between the MF and the apex of the retromolar trigone in Indian population and found that the mean distance was 12.27 mm for the right side and 12.13 mm for the left side. These results are not similar with ones of Valente et al. (2012) (12) for the Brazilian population, where the same distance was 14.23 mm for the right side and 14.40 mm for the left side.

THE LINGULA (SPINE SPIX)

The “lingula” meaning “small tongue” in Latin, was described by Johannes-Baptist Spix in 1815 and was therefore named “Spis’s ossicle or spine”. It lies anteriorly to the mandibular foramen and it is used for identifying the site of IANB (22). Tuli et al. (2000) (22) classified the lingula by its shape into 4 types : triangular (lingula with wide base and narrow rounded or pointed apex), truncated (when the

top of the bony projection appeared quadrangular), nodular (when entire lingula except for its apex merged into the ramus) and assimilated (when lingula was completely incorporated into the ramus). Their study showed that in the Indian population the triangular form was found in 68.5% cases, truncated in 15.8%, nodular in 10.9% and assimilated in 4.8% cases.

These findings are more or less similar with the study of Shenoy et al. (2012) (23), where the most common form of lingula for Indian population was the nodular one. Their results were : on the right side : nodular 38%, truncated 34%, triangular 18%, assimilated 10% and on the left side : nodular 40%, triangular 28%, truncated 24%, assimilated 8%.

Sekerci et al. (2013) (24) analyzed the mandibular lingula in a Turkish pediatric population of 6- to 12-year-old children using cone-beam computed tomography imaging. The most common shape was the nodular type (48.3%), followed by truncated (23.4%), assimilated (14.4%) and triangular (13.7%). The results showed that the lingula was located at 13.3 mm from the anterior border of the ramus, 10.2 mm from the posterior border of the ramus, 11.4 mm from the mandibular notch, 2 mm from the occlusal plane and had the mean height 5.3 mm.

Samanta et al. (2013) (25) analyzed 60 Indian dry human mandibles and found that the

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lingula was located at 20 mm from the anterior border of the ramus, 15 mm from the posterior border of the ramus, 15.4 mm from the mandibular notch and had a mean height of 5.5 mm. These findings are not similar with other Indian studies (Tab. IV).

According to Alves & Deana (2015) (26), lingula was located at 17.76 mm from the anterior border of the ramus, 15.28 mm from the posterior border of the ramus, 17.29 mm from the mandibular notch, 33.30 mm from the mandibular base and had a mean height of 8.29 mm.

In the study of Hosapatna et al. (2015) (4) the measurements were taken from the tip of the lingula and the results were: on the right side the lingula was located at 16.68 mm from the anterior border, 16.20 mm from the posterior border, 16.32 mm from the mandibular notch, 31.92 mm from the mandibular base; on the left side lingula was located at 16.32 mm from the anterior border, 15.00 mm from the posterior border, 13.64 mm from the mandibular notch, 33.40 mm from the mandibular base.

CONCLUSIONS

The basic anatomy of the oral-maxillofacial territory is mandatory to be known by any clinician, in order to provide safe medical maneuvers. The inferior alveolar nerve block is one of the most used techniques of anesthesia, but in the same time one that can lead to failures caused by the anatomical variations. The mandibular foramen, usually situated at the posterior limit of the middle third of the ramus, is the key point where the needle of the syringe should be positioned to obtain an effective anesthesia. Panoramic radiograph represents a simple and inexpensive method to analyze pre-operative the bony landmarks of the IANB, but of course it is needed to be corroborated with a correct and complete extra and intra-oral examination. The main bony landmarks of the IANB are the anterior border of the ramus and the occlusal plane, but they are influenced by age, race and growth pattern. The literature is poor in data about the European studies of the mandibular foramen and lingula, so further research is needed.

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Corresponding author

Cristina Popa
e-mail: dr.cristinapopa@gmail.com