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Morphological Study of the Mental Foramen and the Accessory Mental Foramen in Dry Human Mandibles in Northeastern Brazil

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ABSTRACT

Introduction: introduction: The mentual foramen gives passage to the mentual nerves and vessels, while the accessory mentual foramen is an anatomical variation, giving passage to the accessory mentual nerve. Injuries to these nerves are frequent complications in surgical practice.

Objectives: the aim of this study is to morphologically analyze the mentual and accessory mentual foramen in a population in Northeast Brazil.

Methodology: the sample consisted of 91 mandibles from northeast Brazil. The mentual foramen was categorized into seven subtypes according to its topographical position. Linear measurements were performed in different points of the mandible, taking as reference the mentual and accessory mentual foramen. Laterality and dentition were taken into account.

Results: The position of the mentual foramen below the second premolar was the most frequent. Eleven mandibles (12.1%) had accessory mentual foramen. Differences were found in the distances from the mentual foramen to the lower margin of the dentate (0.031) and edentulous mandibles (p = 0.009) and from the mentual foramen to the posterior margin of the ramus of the mandibles (p = 0.0014). Comparing the dentate and edentulous mandibles, there was a difference in the distance from the mentual foramen to the alveolar crest, on both sides (p=0.0001).

Conclusion: the data obtained may be relevant for more effective surgical planning, especially in individuals from northeastern Brazil.

Keywords: Anatomy; Bone; Foramen Mental; Accessory Mentual Foramen.

Introduction

The mental foramen (MF) is an opening present on the external face of the mandible, usually below the apex of the roots of the second premolar teeth or, less frequently, below the first premolar teeth[1,2,3]. Although several studies indicate this location, there are frequent variations in this area, with no absolute anatomical landmarks for its identification[4].

This structure is an important element for face irrigation and innervation. The mental nerve, one of the main sensory nerves of the face, passes through this foramen after its origin in the mandibular canal as a terminal branch of the inferior alveolar nerve, which is responsible for the formation of the inferior dental plexus. It is responsible for the skin innervation of the lower lip and the labial gingiva[1,4]. The mental nerve damage can cause transient or permanent thermal and tactile changes in the mentioned innervation regions[2]. In addition to the mental nerve, the homonymous artery also passes through the mental foramen, whose main areas of irrigation are the muscles and skin on the chin region, together with the inferior labial and submental arteries in a network of anastomoses[1, 4].

Knowledge of MF anatomy, including the most common location and possible anatomical variations, is an important tool for a safe clinical and surgical practice by dentists, surgeons, and anesthetists, since the postoperative mental nerve palsy is the main complication in surgeries in this region[2]. To perform an anesthetic block in the lower premolar region, for example, it is essential to have a detailed understanding of the morphological presentation of this foramen and its relationship with other structures[3].

A common variation of high clinical importance is the accessory mental foramen (AMF). With variable frequency, it can reach 30% in some studies[5]. The AMF, when present, is located around the MF and gives passage to the accessory mental nerve, which innervates the skin and mucosa around the mouth commissure. One of the most common procedures involving the mental nerve during its passage through the MF is local anesthetic blocks for wound sutures or

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implants in the periapical region of the mandible, for example. This block may lose effectiveness due to the overlap of the two nerves, or there may be iatrogenic damage to the accessory mental nerve due to a lack of knowledge of this variation[2, 6].

In this perspective, this study aimed to analyze the morphological and morphometric characteristics of the MF, as well as the prevalence and position of the AMF in partially dentate and edentulous human mandibles in Northeast Brazil, given the surgical importance of this information for dental surgeons, traumatologists and anesthesiologists.

Materials and Methods

A total of 91 dry adult human mandibles (69 partially dentate and 22 edentulous) of undetermined age and gender (as they were not recorded at the time of acquisition) from Northeastern Brazil were analyzed, belonging to the Human Anatomy Laboratory of the Faculty Integradas of Patos (FIP) and Federal University of Ceara (UFC). Damaged mandibles, mandibles of children or affected by any pathology were excluded from the study. Mandibles with preserved teeth or alveolar processes were classified as partially dentate and the others without evidence of dental elements or alveolar processes as edentulous.

The position of the mental foramen was recorded as aligned with the longitudinal axis of the tooth or situated between two teeth according to the following scheme: If any part of the foramen is on a line drawn perpendicularly to the occlusal plane and passing along the longitudinal axis of a tooth, the foramen was assigned to that position. If any part is on a similar line passing through the contact area between the teeth, it has been assigned that position. If the foramen was too small to cross one line or too large to cross two lines, then it was assigned a more anterior position. The position of the mental foramen was expressed concerning the lower teeth, according to Tebo and Telford (1960)[7] (Figure 1).

Then, using a digital caliper with an accuracy of 0.01 mm (Absolute Digimatic Caliper, Mitutoyo, Aurora-IL, USA), the linear measurements were taken bilaterally from the center of the MF or the AMF to several anatomical landmarks, as shown in Figure 2 and 3. The laterality of the antimere, the number and the position of the AMF in relation to the homolateral MF were also analyzed.

The data were submitted to the Shapiro-Wilk Normality Test. The paired t-test was applied to evaluate the existence of statistical difference of the morphometric measurements between the right and left antimeres of each type of mandible, and the

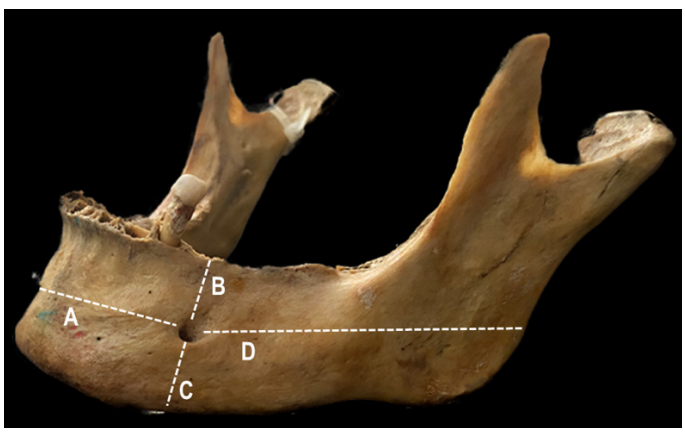

Figure 2. Linear measurements of mental foramen. (A) MF-MS: Distance of MF to mandibular symphysis; (B) MF-AC: Distance of MF to alveolar crest; (C) MF-LMM: Distance of MF to lower margin of the mandible; (D) MF-PMMB: Distance of MF to posterior margin of the mandible branch.

Figure 1. (A) A – Central incisor; B – Lateral incisor; C – Canine; D – First premolar; E – Second premolar; F – First molar; G – Second molar; H – Third molar. (B) Positions of mental foramen according to Tebo and Telford (1960)7. I – Between the canine and the first premolar; II – Beneath the first premolar; III – Between the first and second premolars; IV – Beneath the second premolar; V – Between the second premolar and first molar; VI – Beneath the mesial root of the first molar; VII – Position not determined.

Figure 3. Linear measurements of accessory mental foramen. (A) AMF-MF: Distance of AMF to mental foramen; (B) AMF-MS: Distance of AMF to mandibular symphysis; (C) AMF-AC: Distance of AMF to alveolar crest; (D) AMF-LMM: Distance of AMF to lower margin of the mandible.

unpaired t-test was applied to evaluate the comparisons between dentates and edentulous mandibles. The statistical analysis was carried out using GraphPad Prism® version 6.0 for Windows. Values of p≤0.05 were considered significant.

The present study was selected in accordance to the Brazilian Federal Law 8.501 (November 30, 1992) and an institutional approval was obtained.

Results

In our study, 91 mandibles were included, 69 dentate and 22 edentulous. On the right side, the most frequent position was type IV (80.77%), followed by type II (19.23%). On the left side, the most frequent position was type IV (73.08%), followed by type II (26.92%).

Table 1 presents the data referring to the linear measurements of the MF for dentate and edentulous mandibles. It was observed a difference in the distance from the mental foramen (MF) to the inferior margin of the mandible (LMM) between the right and left sides in both dentate (p=0.031) and edentulous (p=0.0098) mandibles. Moreover, a significant difference between the right and left antimeres of the MF-PMMB distance (p=0.0014) was observed in edentulous mandibles. When comparing dentate and edentulous mandibles, the distance between the MF to the alveolar crest was higher in dentate mandibles than edentulous, both in their right and left antimeres (p=0,0001).

Among the evaluated specimens, 11 mandibles with AMF were found (12.1%), being 8 dentate (8.8%) and 3 edentulous (3.3%), totaling 22 AMF. Among them, 5 mandibles had AMF bilaterally, being 4 dentate and 1 edentulous. A dentate mandible can also be highlighted, which had 2 AMF in the right antimere and 4 AMF in the left. Overall, 10 AMFs were found on the right side and 12 on the left. The AMF is located mainly anterior to the MF in both antimeres (right side - 44.44%; left side – 66.67%) in the dentate and edentulous mandibles, respectively.

The AMF was located at a lower average distance from the homolateral right MF (6.29 mm; SD = 5.86 mm) compared to the left side (10.64 mm; SD = 4.46 mm) (p =0.0173). No differences between antimeres were observed in the other AMF measurements analyzed (Table 2).

Table 2. Mean distance (mm) ± SD values of the morphometric analysis of accessory mental foramen in both sides (right and left) (N=91).

Measurements	Right	Left
AMF-MF*	6.29 ± 5.86	10.64 ± 4.46
AMF-MS	21.48 ± 10.84	18.30 ± 10.42
AMF-AC	9.77 ± 4.32	6.61 ± 3.49
AMF-LMM	13.30 ± 4.46	13.36 ± 4.58

Legend: AMF-MF: Distance of AMF to mental foramen; AMF-MS: Distance of AMF to mandibular symphysis; AMF-AC: Distance of AMF to alveolar crest; AMF-LMM: Distance of AMF to lower margin of the mandible. *p<0.05 between the antimeres analyzed.

Discussion

The mental foramen has become an important point of reference in surgical procedures on the mandible, especially in the minimally invasive surgical techniques of implantology and endodontics. The application of anesthetics in the foramen region is essential to perform these interventions. However, as it is an area with neurovascular bundles, proper management is essential to preserve the structures, avoiding lesions and, consequently, temporary or permanent changes in sensitivity. For this, the surgeon in his routine must have an understanding of the anatomy of the mental foramen, as well as his variations, such as the accessory mental foramen.

Table 1. Mean distance (mm) ± SD values of the morphometric analysis of mental foramen in both sides (right and left) of dentate and edentulous mandibles (N=91).

Measurements	Dentate mandible			Edentulous mandible			Dentate x Edentulous (p-value)	
	Right	Left	p-value	Right	Left	p-value	Right	Left
MF-MS	25.90 ± 2.5	26.15 ± 2.07	0.384	26.13 ± 1.72	26.42 ± 2.02	0.247	0.6767	0.5787
MF-AC	11.32 ± 3.26	11.35 ± 3.28	0.950	7.91 ± 2.33	8.05 ± 2.67	0.773	0.0001	0.0001
MF-LMM	12.66 ± 1.81	13.08 ± 1.55	0.031	12.73 ± 1.58	13.26 ± 1.76	0.0098	0.8640	0.6602
MF-PMMB	68.63 ± 4.82	68.67 ± 4.95	0.855	70.51 ± 5.27	68.11 ± 4.88	0.0014	0.1310	0.482

Legend: MF-MS: Distance of MF to mandibular symphysis; MF-AC: Distance of MF to alveolar crest; MF-LMM: Distance of MF to lower margin of the mandible; MF-PMMB: Distance of MF to posterior margin of the mandible branch.

Understanding the metric relationships of the mental foramen with the structures of the mandible allows the health professional to have a well-defined anatomical landmark to perform the correct procedures, avoiding damage to the neurovascular components. Morphometric analysis of the mental foramen in the present study observed metric data very close to the available studies in the literature (Table 3)[3,8,9,10,11,12]. Mental foramen seems to be an important reference point in the mandible to be used in invasive and non-invasive procedures, since it presents a well-recognized anatomy pattern in the literature. This similarity in the values could probably be due to the fact that most of the compared populations were Brazilian. In addition, the few studies[10,12] that worked with the morphometric analysis of the mental foramen did not discriminate the antimeres nor used the same measurements of the present study.

We found a significant difference in the MF-AC measurement between dentate and edentulous mandibles. The same was found in another Brazilian study[8]. This discrepancy and the persistence of similar values in the MF-LMM measurement between dentate and edentulous mandibles could let us infer that the absence of teeth implies greater bone wear, causing alterations in the alveolar crest. Thus, the presence of teeth would imply greater stimuli to the organism for bone deposition and, therefore, to preserve the mandible. Moreover, other factors such as age and eating habits could cause wear and directly interfere with its vertical reference[12].

Given this in consideration, the determination of the horizontal position of the mental foramen has been considered safer as opposed to the vertical position. This interferes with the relationship between the mental foramen and the alveolar crest, where there is a greater potential for bone damage, which reduces the vertical distance, implying possible failures in the procedures performed in the region in individuals who accumulate more factors that alter the lower dental arch. The horizontal distance does not undergo so many changes because it is not exposed to as many conditions that cause bone wear as the components that influence the vertical distance.

Understanding these findings made us use the classification established by Tebo and Telford (1960)[7], which is based on the location of the lower teeth, and consequently in the horizontal position. The most frequent position found in the present study was type IV, that is, beneath the second premolar, in the right and left antimeres. When compared with other studies available in the literature (Table 4), position IV is more common in populations from Saudi Arabia[13], India[2], North of Brazil[14], South of Brazil[15], and Southeast of Brazil[3]. However, there are still a large number of studies that present position III as the most

Table 3. Comparison of the morphometric analysis of the mental foramen in different populations (Values in mm)

Author			Present study	Li *et al*[11] (2017)	Oliveira *et al*[9] (2018)	Von Arx *et al*[10] (2013)	Kalender *et al*[12] (2011)	Lima *et al*[8] (2010)	Amorim *et al*[3] (2008)
Country			Brazil	China	Brazil	Switzerland	Turkey	Brazil	Brazil
MF-MS	Dentate mandible	Right	25.90 ± 2.5	-	-	-	-	29.15 ± 2.74	27.3 ± 0.42
		Left	26.15 ± 2.07	-	-	-	-	29.28 ± 2.77	27.2 ± 0.46
	Edentulous mandible	Right	26.13 ± 1.72	-	-	-	-	28.23 ± 2.68	26.90 ± 0.30
		Left	26.42 ± 2.02	-	-	-	-	28.63 ± 3.18	26.6 ± 0.44
MF-AC	Dentate mandible	Right	11.32 ± 3.26	-	11.35 ± 1.99	12.6 ± 6.90	-	11.01 ± 3.9	-
		Left	11.35 ± 3.28	-			-	11.76 ± 5.75	-
	Edentulous mandible	Right	7.91 ± 2.33	-	-		-	5.9 ± 3.23	-
		Left	8.05 ± 2.67	-	-		-	4.38 ± 2.36	-
MF-LMM	Dentate mandible	Right	12.66 ± 1.81	13.38 ± 1.80	12.31 ± 1.66	13.2 ± 3.5	12.3 ± 1.70	14.25 ± 1.89	-
		Left	13.08 ± 1.55	13.31 ± 1.74			12.6 ± 1.70	14.46 ± 1.82	-
	Edentulous mandible	Right	12.73 ± 1.58	-	-		-	13.65 ± 1.88	-
		Left	13.26 ± 1.76	-	-			13.53 ± 1.84	-
MF-PMMB	Dentate mandible	Right	68.63 ± 4.82	-	-	-	-	67.73 ± 5.95	-
		Left	68.67 ± 4.95	-	-	-	-	64.94 ± 6.08	-
	Edentulous mandible	Right	70.51 ± 5.27	-	-	-	-	65.24 ± 4.36	-
		Left	68.11 ± 4.88	-	-		-	62.49 ± 6.69	-

Legend: MF-MS: Distance of MF to mandibular symphysis; MF-AC: Distance of MF to alveolar crest; MF-LMM: Distance of MF to lower margin of the mandible; MF-PMMB: Distance of MF to posterior margin of the mandible branch.

Table 4. Comparison of the position of the mental foramen in different populations.

Study	Year	Country	Materials for study	Most common position of MF
Present study	**2022**	**Brazil (Northeast)**	**91**	**IV**
Zmyslowska-Polakowska *et al*[16]	2019	Poland	201	III
Oliveira *et al*[9]	2018	Brazil (Southeast)	104	III
Alam *et al*[13]	2017	Saudi Arabia	395	IV
Li *et al*[11]	2017	China	784	III
Kasat *et al*[2]	2016	India	100	IV
Saito et al[14]	2015	Brazil (North)	100	IV
von Arx *et al*[10]	2013	Switzerland	142	III
Kalender *et al*[12]	2011	Turkey	193	III
Guedes *et al*[17]	2011	Brazil (Midwest)	518	III
Lima *et al*[8]	2010	Brazil (Northeast)	130	R – III L – IV
Lopes *et al*[15]	2010	Brazil (South)	80	IV
Amorim *et al*[3].	2008	Brazil (Southeast)	170	IV

Legend: R: right side; L: left side.

prevalent, such as the populations of Poland[16], China[11], Switzerland[10] and Turkey[12].

This different location of the foramen between the populations around the world, could be related to specific ethnic characteristics shaped by eating habits, environmental influences, and biotype, among other factors, which influence the morphology of the mandible. Among those that presented different location types of the mental foramen, we still find Brazilian studies, such as Southeast Brazil[9] and Midwest of Brazil[17]. As it is a large country with a lot of ethnic diversity, there are differences in the location of the foramen, which should be a factor of attention during invasive interventions in different regions of Brazil. It is worth mentioning that to make the comparison with these studies the classification was adapted to fit the one adopted in our study. For this, the anatomical reference based on the lower dental arch was analyzed in the methodology of these studies and, subsequently, adapted to our classification. In general, all studies had the same anatomical references, but named differently, so there was only an adaptation to our description.

The accessory mental foramen, the main variation of the mental foramen which ramifications of the mental nerve pass and could interfere with the effectiveness of the anesthetic application, has also different morphological presentations. In our analysis (Table 5)[11,12,13,18,19], 11 mandibles (12%) were found with the presence of AMF, of which 6 (6.5%) had only one mandible foramen and 5 (5.5%) had it bilaterally. Compared to other studies, the value found is within the range of AMF's prevalence (12% - 13%) in a Turkish[12,18] and an Indian populations[19] studied. On the other hand, in a population from China[11], the AMF was found in only 2.5% of the mandibles evaluated and Saudi Arabia at just 7.2%. This discrepancy may be associated with the way of classifying the accessory mental foramen by differentiating it from other openings in the mandible

Table 5. Comparison of the prevalence of AMF in different populations.

Number of AMF	Present study n = 91	Aytugar et al[18] (2019) n=1005	Alam et al[13] (2017) n=395	Li et al[11] (2017) n=784	Kalender et al[12] (2011) n=193	Singh and Srivastav[19] (2010) n=100
0	80 (88%)	882 (87.8%)	385 (97.5%)	727 (92.7%)	170 (88%)	87 (87%)
1	6 (6.5%)	103 (10.2%)	9 (2.3%)	52 (6.6%)	19 (10%)	13 (13%)
2	5 (5.5%)	14 (1.4%)	1 (0.2%)	2 (0.2%)	4 (2%)	0
3	0	6 (0.6%)	0	2 (0.2%)	0	0
4	0	0	0	1 (0.1%)	0	0
Total of AMF	16	149	11	66	27	13
Total of mandibles with AMF	11 (12%)	123 (12.2%)	10 (2.5%)	57 (7.2%)	23 (12%)	13 (13%)

Legend: AMF: Accessory mental foramen.

such as the nutrient foramina, which do not have continuity with the mandibular canal[12].

Another interesting fact to be highlighted is that there is a tendency for the AMF to be located in the right antimere, with a higher prevalence being noted in all the analyzed studies. As for its position, it was identified that the AMF is more frequently located anterior to the MF, which is in agreement with other study[12], in which the AMF precedes the MF in 40.7% of cases.

In our study, we measured the distance of the accessory mental foramen to the mental foramen, the mandibular symphysis, the alveolar crest, and the inferior margin of the mandible. However, when looking at the literature, there are only measures referring the distance of AMF to MF and LMM (Table 6)[11,12]. Regarding the AMF-MF distance, the other works[11,12] presented average values for the right side (5.40mm to 5.55mm) and the left side (5.10 mm and 5.03mm) very close to what we found, except on the left side, which is possibly related to their superior sample size. Regarding the distance between the AMF and the LMM, there is a greater similarity in the measures of our work with the Chinese population[11], with a difference in the averages compared to Turkish population[12].

To our knowledge, this is the most complete study in relation to morphometric measurements of AMF and MF in a Brazilian population. A limitation of this study is that we didn't present all the anatomical components related to the foramina, such as vessels, nerves, nerve distribution patterns, etc., as it is a study in dry mandibles. In addition, it was not possible to classify the mandibles by age group, sex, biotype, eating habits and socioeconomic conditions, data that could influence and explain better the morphological findings in this study. However, the results presented in this study can be an important non-invasive methodology to acquire anatomical data to perform safer procedures, especially in Northeastern Brazil.

Conclusion

The mental foramen is of great importance as an anatomical reference point in surgical interventions. The morphometric analysis done in this study can be considered a reliable anatomical parameter for the health professionals. However, it is necessary to pay attention to bone wear in edentulous mandibles, considering that the lower teeth are protective factors for the mandibular surface, which can interfere with the vertical position of the foramen, making it more reliable to understand the horizontal position. In our study, the most frequent was type IV, in the line below the second premolar, however, there were differences in this location within the Brazilian territory and the global scenario.

Accessory mental foramen was present in about 12% of the population with a higher prevalence on the right side. The AMF measurements showed discrepancies when comparing the antimeres. Further studies are needed to compare and establish its localization patterns, especially in Northeastern Brazil.

Clarifying and disseminating this morphological information in the scientific community regarding the morphometry and variations of the mental foramen and accessory mental foramina are essential for safer invasive and non-invasive procedures in this region.

Table 6. Comparison of the morphometric analysis of the accessory mental foramen in different populations (Values in mm)

Measurements	Present study (2021) n = 91		Li *et al*[11] (2017) n = 784		Kalender *et al*[12] (2011) n =193	
	Right	Left	Right	Left	Right	Left
AMF-MF	6.29 ± 5.86	10.64 ± 4.46	5.40 ± 1.63	5.03 ± 1.26	5.55 ± 4.50	5.10 ± 4.40
AMF-MS	21.48 ± 10.84	18.30 ± 10.42	-	-	-	-
AMF-AC	9.77 ± 4.32	6.61 ± 3.49	-	-	-	-
AMF-LMM	13.30 ± 4.46	13.36 ± 4.58	13.48 ± 4.15	14.98 ± 3.40	10.50 ± 2.20	10.90 ± 2.40

Legend: AMF-MF: Distance of AMF to mental foramen; AMF-MS: Distance of AMF to mandibular symphysis; AMF-AC: Distance of AMF to alveolar crest; AMF-LMM: Distance of AMF to lower margin of the mandible.

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Mini Curriculum and Author's Contribution

1. Andressa Gabriella Duarte de Queiroz: discussion of the results and writing of the manuscript.

2. Marcílio Ferreira de Paiva Filho: discussion of the results and writing of the manuscript.

3. João Vitor Lopes de Medeiros Gonçalves: discussion of the results and writing of the manuscript.

4. Ítalo de Melo Câmara: discussion of the results and writing of the manuscript.
Débora Karoline de Araújo Deca: discussion of the results and writing of the manuscript.

5. Jalles Dantas de Lucena: discussion of the results and writing of the manuscript, conception and design of the study.

6. André de Sá Braga Oliveira: discussion of the results and writing of the manuscript, conception and design of the study.

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