Original Article

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Analysis of anatomical landmarks of the mandibular interforaminal region using CBCT in a Brazilian population

Paloma Rodrigues Genú[1], Ricardo José de Holanda Vasconcellos[2], Bruna Paloma de Oliveira[3], Bruna Caroline Gonçalves de Vasconcelos[3], Nádia Cristina da Cruz Delgado[3]

[1]Universidade Federal de Pernambuco – UFPE, Faculty of Dentistry, Department of Social Medicine, Recife, PE, Brazil
[2]Universidade de Pernambuco - UPE, Faculty of Dentistry of Pernambuco, Department of Oral Medicine, Camaragibe, PE, Brazil
[3]Universidade Federal de Pernambuco – UFPE, Faculty of Dentistry, Department of Prosthetics and Oral and Facial Surgery, Recife, PE, Brazil

Abstract

Aim: To evaluate the position, presence, appearance and extent of various anatomical landmarks in the mandibular interforaminal region of Brazilian patients using cone-beam computed tomography (CBCT). **Methods:** A total of 142 CBCT examinations were analyzed to determine the most common location of the mental foramen (MF), the presence and extent of the anterior loop (AL) of the inferior alveolar nerve, and the appearance and length of the incisive canal (IC). The presence of sexual dimorphism and differences with relation to the left and right sides were also evaluated. **Results:** Most of the MF (45.5%) was located below the second premolar. The AL and the IC were observed in 18.9 and 96.5% of the images respectively. The average length of AL and IC was 3.14±1.25 mm and 13.68±5.94 mm respectively. No significant differences ($p>0.05$) between genders or left and right sides were observed for all evaluated parameters. **Conclusions:** The most common location of the MF, the high rate of visualization of the IC and the occasional presence of AL in the studied Brazilian population demonstrate the importance of using three-dimensional images of the mandibular anterior region, allowing proper surgical planning and preventing injury to the neurovascular bundle.

Keywords: mandible; cone-beam computed tomography; surgery, oral; mandibular nerve.

Introduction

One of the most frequent accidental complications that may occur during surgical procedures in the mandibular interforaminal region is a neurosensory disturbance in the chin and lower lip. This complication occurs when important structures such as the mental foramen (MF), the anterior loop (AL) of the inferior alveolar nerve and the incisive canal (IC) are not properly identified and protected[1].

During its path, the inferior alveolar nerve runs through the mandibular canal and it is divided into two segments near the MF: the mental, which emerges in this foramen innervating the mental region and the lower lip; and the incisive, which continues intraosseous and runs through the IC and innervates the anterior teeth. However, in some individuals, the terminal portion of the inferior alveolar nerve may extend, passing below the inferior border of the MF and after giving off the incisive nerve branches, the main branch curves back to the MF, which emerges as the mental nerve. This section of the nerve in front of the MF can be

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Corrrespondence to:
Bruna Paloma de Oliveira
Universidade Federal de Pernambuco
Departamento de Prótese e Cirurgia Buco-Facial
Pós-Graduação em Odontologia
Av. Prof. Moraes Rego, 1235
Cidade Universitária
CEP: 50670901, Recife, PE, Brasil
Phone: +55 81 92853170
E-mail: bruna_paloma@msn.com

described as the AL of the inferior alveolar nerve[2]. Additionally, the MF is presented as a structure that may have different anatomical variations in terms of size, shape and location[3].

The use of appropriate imaging techniques is therefore essential to enable the accurate identification and location of these vital structures, avoiding potential injuries when surgical procedures are performed in the mandibular interforaminal region, including insertion of dental implants, mentoplasty and rehabilitation after trauma[4]. Cone-beam computed tomography (CBCT) is a relatively new imaging modality that provides a detailed evaluation of important bony structures[5]. This technique has high resolution, a relatively low radiation dose and produces images that demonstrate on different planes the real size of anatomical structures of the interforaminal region[6-7].

In recent years, several studies have analyzed the characteristics of anatomical landmarks in the mandibular anterior region in various populations around the world[2,8-10]. Nevertheless, to date, few studies have evaluated by CBCT the characteristics of the mandibular interforaminal anatomy in populations from the Northeastern Brazil.

The objective of this study was to examine by means of CBCT the most common location of MF, the presence and extent of AL, and the appearance and length of IC in Brazilian patients, investigating the presence of sexual dimorphism and differences with respect to the left and right sides.

Material and methods

After local institutional research ethics committee approval (No. 67222), this retrospective study included a total of 143 CBCT scans of Brazilian patients, obtained between September and December 2012 from a radiology clinic located in Recife, PE, Brazil. The study population consisted of 43.4% male and 56.6% female patients with a mean age of 49.84 years (range 21-79 years).

The examinations were performed as part of the planning procedure for rehabilitation with dental implant placement. The selection criterion of the scans used in the research was: (i) bilateral presence of the first and second premolars, (ii) absence of pathology that could affect the position of MF, AL or IC.

The radiographic examinations were performed with a cone-beam volumetric tomography device, i-CAT (Imaging Sciences International, Hartsfield, PA, USA), adjusted at 120 kVp, 5 mA, voxel size of 0.25 mm, and field of view of 6 cm. The acquired images were reconstructed into multiple-plane views (axial, panoramic and cross-sectional) for evaluation of the following parameters:

1. **MF.** Location: (I) between canine and first premolar; (II) below the first premolar; (III) between first and second premolars; (IV) below the second premolar; (V) between second premolar and first molar; (VI) below the first molar.

2. **AL.** Presence and extent. Extent was measured by the distance between the anterior border of the MF and the anterior border of AL[7] (Figure 1).

3. **IC.** Appearance and length. Length was determined by the distance between the anterior border of the MF and the last mesial slice where the canal was definitely visible in cross-sectional images (Figure 2).

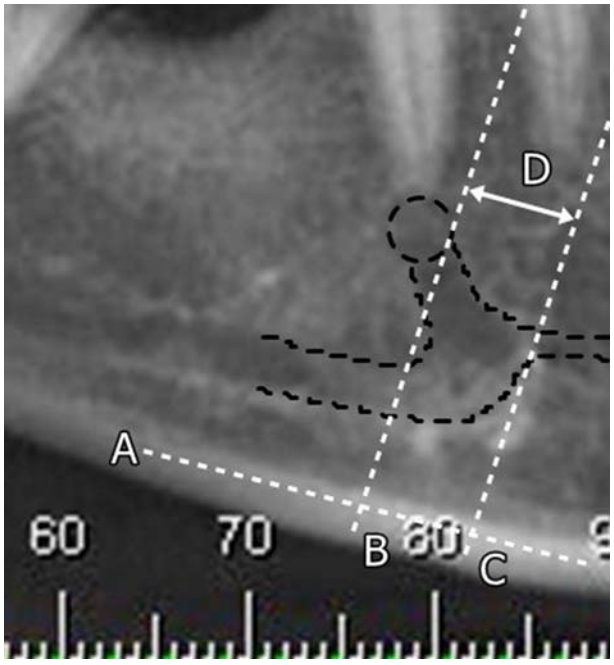

Fig. 1. Schematic presentation of measurement of anterior loop of the inferior alveolar nerve on a panoramic reconstruction image. (*A*) Line tangent to inferior border of mandible; (*B*) line perpendicular to *A* tangent to anterior border of mental foramen; (*C*) line perpendicular to *A* tangent to anterior border of the anterior loop; (*D*) anterior loop = shortest distance between *B* and *C*

In addition, differences with respect to the left and right sides and the presence of sexual dimorphism were also investigated. All measurements were performed by one of the authors with experience in the interpretation of CBCT and in oral and maxillofacial surgery. This researcher was blind to the gender of the patients.

The results were expressed in percentages and statistical measures: mean and standard deviation. Data were statistically analyzed using Fisher's exact test and McNemmar test in the categorical variables, and t-Student test with equal variances for numeric variables. Hypothesis verification of equal variances was performed using Levene's F test. A level of significance of 0.05 was adopted. The SPSS software (Statistical Package for the Social Sciences, version 17, Chicago, USA) was used.

Results

No significant differences ($p > 0.05$) between genders or right and left sides were observed for all parameters.

- *Mental Foramen*

One MF was found on each side in all patients. The most common location of the MF was below the second premolar (position IV), followed by a location between the first and second premolars (position III) (Table 1). Presence of MF in the region located between the canine and the first premolar (position I) was not observed.

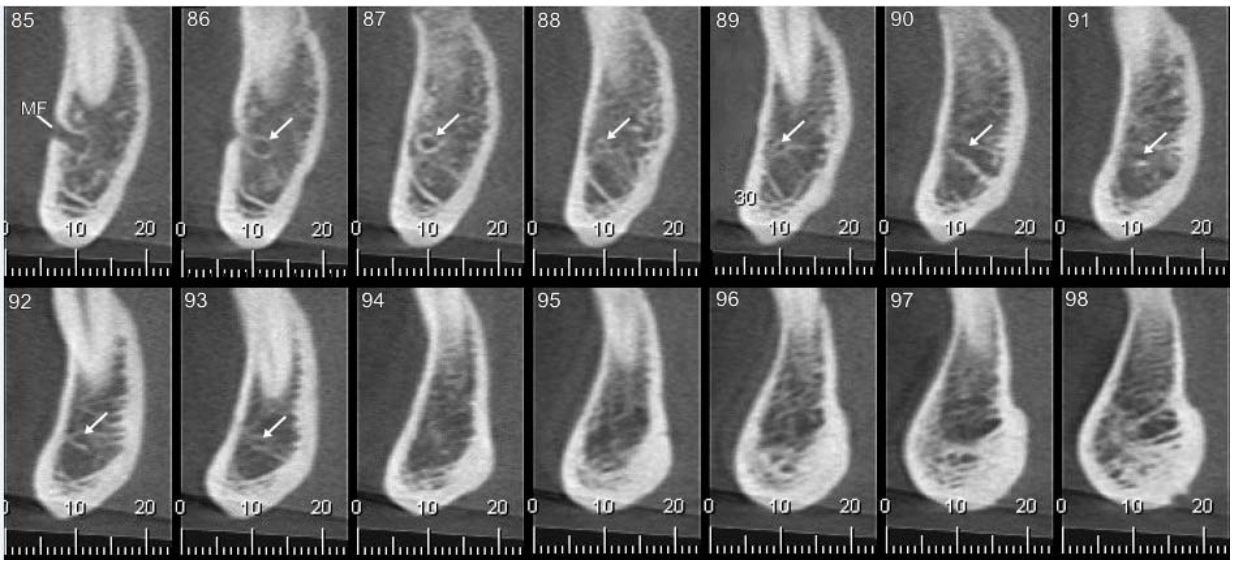

Fig. 2. In this example on cross-sectional reconstructions, the incisive canal could be seen on the images 86-93 (arrows). Since the step was 1 mm, the total visible length of the incisive canal was 8 mm

- *Anterior Loop of the Inferior Alveolar Nerve*

AL was visualized in 18.9% of the images (13 males and 14 females), most of them found unilaterally: 5.6% on the right side, 6.3% on the left side and 7% on both sides. The mean length of AL was 3.14 ± 1.25 mm. Table 2 describes the mean length of the AL according to gender and side.

- *Incisive canal*

In 96.5% of the images (61 males and 77 females) it was possible to identify the anterior extension of the IC, 91.6% bilaterally, 2.8% on the right side and 2.1% on the left side. The mean length of the IC was 13.68 ± 5.94 mm. The mean length of the IC according to the gender and side is described in Table 2.

Discussion

To avoid potential injury to the neurovascular bundle during surgical procedures in the mandibular anterior region, it is essential to define the exact location of the MF, as well as to determine the extent of the IC and consider the possibility of AL located mesially from the MF[11].

Table 1 - Gender distribution of the mental foramen position on the right and left sides

	Mental Foramen							
	Right			Left				
Position	Total n(%)	Female n n(%)	Male n (%)	Total n n(%)	Female n (%)	Male n (%)	*p* value[a] (%)	Total n (%)
I	0	0		0	0	0	p > 0.05	0
II	10 (7)	7 (8.6)	3 (4.8)	11 (7.7)	7 (8.6)	4 (6.5)	p > 0.05	21 (7.3)
III	47 (32.9)	26 (32.1)	21 (33.9)	49 (34.3)	26 (32.1)	23 (37.1)	p > 0.05	96 (33.6)
IV	67 (46.9)	37 (45.7)	30 (48.4)	63 (44.1)	33 (40.7)	30 (48.4)	p > 0.05	130 (45.5)
V	16 (11.2)	9 (11.1)	7 (11.3)	18 (12.6)	13 (16)	5 (8.1)	p > 0.05	34 (11.9)
VI	3 (2.1)	2 (2.5)	1 (1.6)	2 (1.4)	2 (2.5)	0	p > 0.05	5 (1.7)
Total	143 (100)	81(100)	62(100)	143 (100)	81 (100)	62(100)	p > 0.05	286 (100)

[a]Indicates statistical significance at level of p less than 0.05.

Table 2 - Mean and standard deviation of the length (mm) of the anterior loop and the incisive canal by side according to gender.

		Gender		
	Side	Male	Female	*p* value[a]
		Mean ± SD	Mean ± SD	
Length of the anterior loop	Right	3.31 ± 0.88	2.99 ± 1.50	p=0.608
	Left	3.25 ± 1.18	3.00 ± 1.51	p=0.699
Length of the incisive canal	Right	14.30 ± 6.11	13.28 ± 6.25	p=0.346
	Left	14.20 ± 5.76	13.15 ± 5.64	p=0.291

[a]Indicates statistical significance at level of p less than 0.05.

This radiographic study aimed to evaluate the most common location of the MF, as well as to analyze the presence and extent of AL, and the appearance and length of IC in a population from the Northeastern Brazil. Also investigated were dimorphism and differences with respect to the right and left sides.

Panoramic radiographs have been used to study anatomical landmarks of the mandibular interforaminal region[12-13]. However, CBCT is a modern imaging technique, providing a more precise three-dimensional evaluation, enabling the identification of anatomical variations[5]. In order to get a better visualization of anatomic structures and clinical applicability, the present study opted to use images of this type for examination.

According to the results of this study, the most frequent position of MF was below the apex of the second premolar (45.5%), followed by the position between the apex of the premolars (33.6%). This result is in agreement with the one reported by previous studies conducted in dry mandibles or panoramic radiographs of populations from the Southeastern and Northeastern Brazil[14-17], and in Malaysian[18], Turkish[19] and Indian[20] populations. However, Manhães Jr et al.[21] (2008), Amorim et al.[22] (2009), Almeida Filho et al.[23] (2011), and Guedes et al.[24] (2011) have shown by panoramic radiographs the position between the apex of the premolars as the most common for the MF in Brazilian populations from the Southeastern and Center-West regions. The same was observed in Nigerian[25], Jordanian[26] and Iranian[13] populations and on dry mandibles of the late Byzantine period[27].

When analyzing the position of MF in three different populations, Santini and Alayan[28] (2012) verified that among Chinese, the most common location was below the second premolar, whereas between Europeans and Indians, the MF was more frequently located between the first and second premolars.

The differences among populations from various countries or in the same country can be attributed to variations in the dietary habits, which may subsequently affect the development of the mandible[19]. In addition, it must be noted that in the majority of these studies both locations, between the apices of the premolars or along with the second premolar, are the first two main positions for the MF.

In the present study, no statistically significant differences were found between males and females, neither between right and left sides with respect to the position of the MF. This is in agreement with the results of previous studies[9,15,29].

Regarding the prevalence and extent of the AL of the inferior alveolar nerve, there is considerable disagreement among studies, because the radiographic visualization of this structure, especially in edentulous patients, may be adversely affected by poor bone qualities[30]. This information is of great importance to clinicians during the preoperative evaluation of the region. Additionally, patients with significant anterior extensions of the inferior alveolar nerve (larger than 2 mm) are more likely to suffer sensory disturbances or hemorrhagic complications when dental implants are installed in the most distal area of the interforaminal region[7].

In the present investigation, AL was verified in 18.9% of cases, a result lower than the one observed in the Filo et al.[2] (2014) study, which evaluated CBCT of a Swiss population and observed the occurrence of AL in 69.7% of patients; as well as that of Li et al.[31] (2013), which verified a prevalence of 83.1% of AL using spiral computed tomography scans of a Chinese population. However, Jacobs et al.[32] (2002) reported the presence of the AL in only 7% of the CT in Belgian patients. These differences in incidence may be related to geographic/ethnic differences, as well as to methodological discrepancies. According to de Oliveira-Santos et al.[7] (2012), different radiographic techniques, different methods of measurements and the inexistence of a specific definition of AL are recurrent in the literature.

Anterior loops ranging from 0 to 9.0 mm have been reported[7-8,30,33]. In our study, the mean value of the AL was 3.14 mm, coinciding with the values found by other authors also using CBCT[11]. However, in a study performed in Southeastern Brazil[34] was found a mean 2.41 mm length of AL in the analyzed CBCT scans.

As in other studies[2,35], the results of the present study showed no statistically significant differences related to gender or to the right and left sides. However, other investigations[8,10,31,33-34] have demonstrated that males have longer AL extensions.

IC was first described by Olivier[36] (1928), who defined it as a continuation of the inferior alveolar nerve, traveling through a canal or through vacuoles in spongy bone mesially from the MF. A relatively precise knowledge of the location of this anatomical structure is of extreme importance prior to any surgical procedure in the region in order to avoid potential neurovascular complications[4].

The results of our study demonstrated that visualization of the IC was possible in 96.5% of cases. These findings are in agreement with the results of Makris et al.[4] (2010) and Rosa et al.[34] (2013) that detected IC in 91% and 98.5% of cases respectively, using CBCT. According to Pires et al.[37] (2012), the ICs could not be identified in all of the CBCT images due to the small diameter of this structure.

The mean length of IC observed in this study was 13.68 mm, longer than the one found in the study by Rosa et al.[34] (2013) which found a mean length of 9.11 mm in patients from Southeastern Brazil. However, it was shorter than the one found by Makris et al.[4] (2010), who verified, also by using CBCT, an IC average length of 15.1 mm in Greeks. None of the previously cited studies observed significant differences in appearance or length of the IC with respect to gender or sides, confirming the results of the present research.

In conclusion, the variation in the location of MF, the high rate of IC and the occasional presence of AL in the Brazilian population discussed here, demonstrate the importance of using CBCT for assessment of bone morphology and anatomical dimensions of the mandibular anterior region, allowing proper surgical planning and preventing injury to the neurovascular bundle.

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