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Original Research Article

Relationship between mandibular incisive canal and mental foramen using cone-beam computed tomography in a selected Brazilian Amazon population

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Abstract

Introduction: The mandibular canal is an anatomic structure that extends bilaterally from the mandibular foramen to the mental foramen. **Objective:** To identify the presence, extension, and length of the mandibular incisive canal with a cone-beam computed tomography, and to determine correlations with the positioning of the mental foramen and mandibular canal in a selected Brazilian Amazon population. **Material and methods:** The measurements of the incisive canal that ends at the mandible's lower buccal and lingual border, at its initial and terminal portions, were obtained from 95 odontological examinations using cone-beam computed tomography. These measurements were compared with the measurements of the distance between the mandibular canal ending at the same cortices in 2 distinct regions at the mental foramen region. Pearson's correlation test was used to establish a relationship between these measurements. **Results:** The mandibular incisive canal's bilateral identification mean age was of 44.29 ± 11.04 y and the mean length was 10.38 ± 4.01 mm. Moderate correlations were found between the measurements of the mandibular incisive canal, mental foramen, and mandibular canal. **Conclusion:** The mandibular incisive canal can reach the region of the median line, and it did not present differences between the genders or for the length and distance of the mandibular incisive canal to the cortices ending at the mandible base.

Introduction

The extension of the mandibular incisive canal (MIC) contains in its interior, neurovascular characteristics similar to those present in the mandibular canal, and is histologically similar to the inferior alveolar nerve present in the posterior mandibular region [11]. The mandibular canal (MC) is an anatomic structure that bilaterally extends from the mandibular foramen to the mental foramen (MF). Taking the radicular apex and the inferior edge of the mandible as reference points, this canal may present in 3 different positions: higher, with the mandibular canal closer to the dental radicular apex; lower and closer to the mandible's inferior edge; and in an intermediate position. Anatomically, the latero-lateral localization of the mandibular canal is usually in the center of the body of the mandible, and is initially closer to the lingual cortex and moves gradually towards the vestibular cortex until it reaches the region of the mental foramen, where it is externalized [4, 13]. The high incidence of MIC presented in anatomical studies shows that this canal may be considered a normal structure and not an anatomic variation of the inferior alveolar nerve [15]. The inferior alveolar nerve has its origin in the MF and ends at the level of the apex of the lateral incisor, and at other times, at the apex of the central incisor along its course it tends to position itself closer to the buccal plate or median line, with a tendency in the direction of the lingual vestibule [7]. The positioning of the MF may vary. It can be positioned mostly near the tip of the second premolar [17]. Others can be positioned are positioned near the tip of the first premolar [2].

The anterior mandible region is considered a donor area for grafts and is also in the installation protocol for overdenture-type prostheses. Many times in the past, it has been neglected in relation to anatomic repairs that may exist between the mental foramens, but like a surgical prerequisite, it is of fundamental importance that it is recognized as an anatomical structure and its variations present on the arc investigated [5, 7]. The use of 3-dimensional examinations, like cone-beam computed tomography (CBCT) are of great utility in the identification of the MIC, since panoramic radiography offers little definition of the region between the mental foramens because of the large overlap of images in this region [8]. However, the use of a reference to determine the localization of this structure in a 2-dimensional image is important in areas where CBCT is not regularly use.

A correct diagnostic and therapeutic plan should be executed for successful treatment. The MIC being the anterior region of the mandible, an area commonly used during rehabilitation procedures and as bone graft donor areas, this study proposes to evaluate the presence of the MIC and its relations with sex the path of the mandibular canal, and the positioning of the mental foramen from CBCT examinations in a selected Brazilian Amazon population, and thus, to determine a reference for the localization of this structure during surgeries in the region between the MFs.

Material and methods

The present research complies with the current ethical laws of the country in which it was performed: Ethical approval was given by the medical ethical commission of the "Comitê de Ética e Pesquisa do Hospital Ophir Lyola", Belém, Pará, Brazil, under the number 93.415.

The sample consisted of 95 CBCT examinations from the files of a dental clinic (32 men and 63 women; median age, 44.20 ± 11.04 y), and were acquired on an I-Cat® tomography machine (Imaging Sciences International, Pennsylvania, USA). Anatomical repairs were visualized by a single appraiser using the Xoran program (Imaging Sciences International, Pennsylvania, USA) from paraxial slices on a 17-inch LCD monitor with a screen resolution of 1280 × 1024 pixels that was previously calibrated for the preview of anatomical repairs of interest.

Patients with osseous lesions, primary dentition, absence of anterior teeth and first molar, presence of a bifid mandibular canal, and unerupted teeth were excluded from the study.

Initially, the observer evaluated the presence of the mandibular incisive canal and thereafter measured the length of this structure from the first image slice in which the structure manifested itself to the most mesial slice. The total length was given by the sum of the thickness of the paraxial slices presented in this interval. The extension of the incisive canal was determined by the region up to the apex of the tooth where the canal presented.

In 2 regions, we obtained measurements of the distance of the MIC to the external surfaces of the buccal cortices and from the lingual cortex to the mandibular base. The first was on the first slice in which the MIC presented, and the other in the last slice (figure 1, slices 31 and 38 respectively).

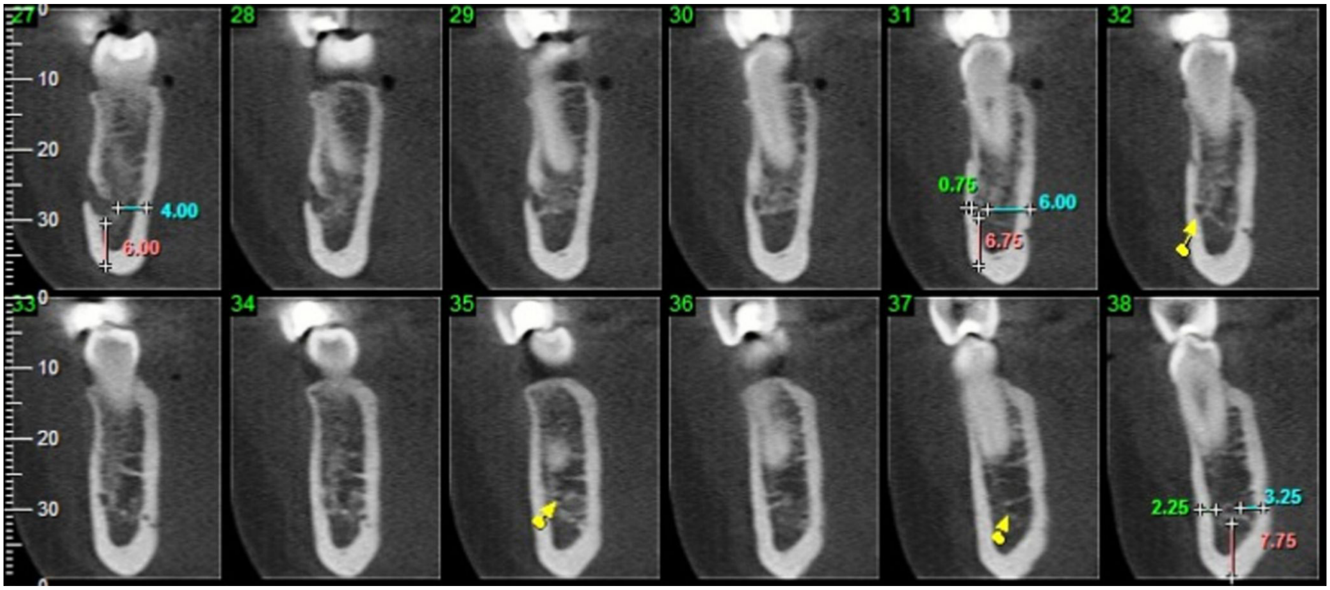

Figure 1 – The location of the MF, and measurements were obtained from the MF to the external surface of the lingual cortex and up to the mandibular base

The location of the MF was followed posteriorly, using the apex of the teeth as a reference, and measurements were obtained from the MF to the external surface of the lingual cortex and up to the mandibular base (figure 1, slice 27).

For the determination of mandibular canal positioning, we made measurements of the same from the external surface of the buccal cortex and lingual cortex to the mandibular base in 2 regions. The initial portion was determined from the slice in which the CM was first observed (after the FM) and from a more central slice to the apex of the first molar.

We used the Bioestat program 5.0 (Belém, Pará, Brazil) for statistical evaluation of parametric and non-parametric data. A *p*-value <0.05 was considered statistically significant. To evaluate if there were differences in the measurements between the first and the second region; those from the MIC, MC, and MF were evaluated using a *t*-test for matched samples, as they were divided into the right and left sides. Then, Wilcoxon's test was used to evaluate the difference between the right and left sides in relation to the extension of the MIC and the positioning of the MF. A linear Pearson's correlation was used to calculate the correlation between the positioning of the MIC with respect to the MF and MC in the evaluated regions.

Results

The average length of the MIC from the CBCT examinations was 10.33 ± 4.32 mm on the right side and 10.21 ± 4.01 mm on the left side. There were no differences between the sexes; however, the length of MIC was greater in men (table I).

Table I – Difference between the measurements of length of mandibular incisive canal in relation to the sex

	Men (*n* = 32)	Women (*n* = 63)	Total (*n* = 95)	*P*
Side	X^2 + SD	X^2 + SD	X^2 + SD	
Right	11,12 ± 4,07	10,11 ± 4,45	10,33 ± 4,32	0,1610
Left	10,98 ± 4,01	10,14 ± 4,05	10,21 ± 4,01	0.1981

X^2: mean; SD: standard deviation

The average and standard deviation of the distance of the MIC and the MC in relation to the buccal cortex, lingual cortex, and mandible base from the initial and terminal portions are presented in table II. From the results obtained, it was possible to observe statistically significant differences, except from the lingual cortex to the MIC ($p = 0.703$).

Table II – Difference between the mean distances of the mandibular incisive canal (MIC) and the mandibular canal (MC) for the buccal cortex, lingual and to the mandible base in the first and second region

Distance of MIC to the edges	**1st Region**		**2nd Region**		***P***
	Right side	**Left side**	**Right side**	**Left side**	
Buccal cortex	1,78±0,90	1,89±0,86	2,39±0,99	2,68±1,45	<0,0001**
Lingual cortex	3,87±1,53	3,65±1,49	3,81±3,63	3,63±1,49	0,703
Mandible base	7,52±1,67	7,53±1,81	7,00±1.98	6,87±2,34	<0,0001**
Distance of MC to the edges					
Buccal cortex	2,26±0,75	2,35±0,81	3,21±1,01	3,18±1,07	<0,0001**
Lingual cortex	2,42±0,96	2,55±0,95	1,84±0,89	1,91±0,69	<0,0001**
Mandible base	6,48±1,32	6,41±1,40	5,34±1,38	5,18±1,37	<0,0001**

Student t-Test. ***P<0,0001*

Table III presents the average and standard deviation of the distances of the MF with respect to the lingual cortex and the mandible base; most of it presented positioned on the apex of second premolar (40,52%).

Table III – Positioning of mental foramen (MF), mean and standard deviation of the distance of MF to the lingual cortex and mandible base in relation to the sex

Distance of MF to the corticals	**Men (n = 32)**		**Women (n = 63)**		**Total (n = 190)**
	Right side	**Left side**	**Right side**	**Left Side**	**Right side + Left side**
Lingual cortex	3,39±1,31	3,30±1,45	2,98±1,19	2,99±1,13	3,11±1,22
Mandible base	7,91±1,64	7,95±1,69	6,92±1,10	7,10±1,30	7,32±1,47
Localization of MF					**%**
1st premolar	3	4	5	3	7,91
Between the 1st and 2nd premolars	12	7	25	26	36,84
2nd premolar	13	15	25	24	40,52
Between the 1st molar and 2nd premolar	4	6	8	10	14,73

Table IV shows the correlations obtained for the distance of the MIC to the lingual cortex and the distance of the MF to the same, both in the first and the second regions and on both sides. In relation to the mandible base, we found a correlation between this measurement and the measurement to the mandible base in the region of the MF in the second region on the left side and correlations with this measurement on the right side.

Table IV – Correlation between the distances of mandible incisive canal (MIC), in initial portion (1) and in the terminal portion (2) and of mental foramen (MF) in relation to the lingual cortex and to the mandible base

Measures 1 and 2 of MIC with the MF	**Distance of MIC and the MF for the corticals**	**RIGHT SIDE**		**LEFT SIDE**	
		r	***P***	**r**	***P***
MIC 1 X MF	Lingual cortex	0,688	<0,0001**	0,676	<0,0001**
	Mandible base	0,662	<0,0001**	0,625	<0,0001**
MIC 2 X MF	Lingual cortex	0,525	<0,0001**	0,429	<0,0001**
	Mandible base	0,370	0,0002*	0,462	<0,0001**

* *P*<0,005

** *P*<0,0001 (strong correlation)

In relation to the MC, correlations were found with the MIC measurements in most of the evaluated regions. Correlations were not found between the region of the initial portion of the MIC and the region of the first molar for the MC, and between the terminal portion of the MIC and the region of first molar for the MC; the distance of both to the lingual cortex is shown in table V.

Table V – Correlation between the distances of mandible incisive canal (MIC) and the mandibular canal (MC) in two different regions (1 and 2) in relation to the buccal cortex, lingual cortex and the mandible base

Measurements 1 and 2 of MIC and the MC	**Distance of MIC and the MC to the cortical**	**RIGHT SIDE**		**LEFT SIDE**	
		r	***P***	**r**	***P***
	Buccal cortex	0.061	<0.0001**	0.202	0.049*
MIC_1 X MC_1	Lingual cortex	0.555	<0.0001**	0.485	<0.0001**
	Mandible base	0.517	<0.0001**	0.457	<0.0001**
	Buccal cortex	0.483	<0.0001**	0.201	0.050*
MIC_1 X MC_2	Lingual cortex	0.303	0.002*	0.153	0.138
	Mandible base	0.414	<0.0001**	0.327	0.001*

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Measurements 1 and 2 of MIC and the MC	Distance of MIC and the MC to the cortical	RIGHT SIDE		LEFT SIDE	
		r	*P*	r	*P*
MIC_2 X MC_1	Buccal cortex	0.484	<0.0001**	0.297	0.003*
	Lingual cortex	0.409	<0.0001**	0.377	0.0002*
	Mandible base	0.373	<0.0001**	0.376	<0.0001**
MIC_2 X MC_2	Buccal cortex	0.477	<0.0001**	0.321	0.001*
	Lingual cortex	0.247	0.015*	0.085	0.408
	Mandible base	0.33	0.0007*	0.187	0.068

* P<0.05

** P<0.0001 (strong correlation)

Discussion

The mandibular incisive nerve is a branch of inferior alveolar nerve with a medial intraosseous course, as well as the MF, that runs along the inside of the MIC, and more recently, these structures have been evaluated by radiography, tomography [1, 12, 13] and histology. It was identified that this canal contains the neurovascular bundle of the inferior alveolar nerve; therefore, injuries to this structure may signify the failure of surgeries in the region between the MFs [3] In our study, 95 cone-beam tomography examinations were evaluated, all with a voxel size of 0.25 and a slice thickness of 1 mm. The MIC was identified in all cases. Most studies report that the MIC is presented in more than 83% of the sample, and may vary according to the corticalization of the canal [9] and the voxel used during the evaluation of the images [7, 9, 12]. The morphology of the voxel is what determines the quality of the image.

Other studies about the existence of this anatomic structure in the region between the MFs and its clinical implications have been reported through the examination of normal and atrophic mandibles from cadavers, demonstrating that the MIC is present [1, 4, 10, 12]. The high identification frequency of this canal reinforces the idea that it may be considered a normal anatomical structure and is not merely an anatomic variation of the mandibular canal.

Studies such as those Kajan, Salari [9] and Rosa et al. [15], which estimated the length and the extension of the MIC in CBCT examinations have shown the longest length to be 20 mm and the shortest to be 3 mm. Relations were not found between the length of the MIC and sex or age, as well as in studies by Jacobs et al. [8]; however, the average length of the canal in men was always longer than in women, as reported in studies of the, However, the average length of the canal in men was always longer than in women, as reported in studies of Obradovic et al. [13] and Sassi et al. [16], because anatomically, the alveolar ridge presents as being thicker in men. Our study was based on tomography examinations of the Brazilian population, which has a large miscegenation, especially in the Amazon, and the quality of the image may have been influenced by the difference in length of the MIC in relation to other populations [1, 14, 15]. According to some studies, there are racial differences in the size and format of the mandible in the Brazilian population in relation to other populations, because the Brazilian population presents a longer mandible length and shorter symphysis than other populations [16].

We did not find correlations between the length and extension of the MIC and the localization of the MF. However, we may observe that the MIC may extend to the region of the central incisors without crossing the midline, and the longest lengths of this structure were found in examinations of patients that presented a more posterior localization of the MF. The most frequent localization of the MF was in the region of the apex of the second premolar (41.05%), followed by the region between the apexes of the first and second premolars (36.31%), the apex of first premolar (14.59%), and the apex of first molar (8.05%) (table III). Recent data show that the localization of MF is still controversial. Uploaded some authors as De Oliveira Santos et al. [5] report that a more frequent localization of this structure is the region between the premolars, while others confirm our results [6].

In our study, correlations between the positioning of the MF and MC with the positioning of MIC were found. In the first region, the MIC presented as more buccally inclined that the MC, which presented practically equidistant from the buccal cortex and lingual cortex. The average distance to the vestibular cortex from the initial and terminal portions of the MIC presented as statistically different, indicating that this structure initiates closer to the vestibular cortex and gets closer to the lingual cortex as it approaches the midline. When comparing the measurements of the vestibular cortex in the terminal portion of the MIC with the vestibular cortex of the MC in the region of first molar, it may be observed that these measurements presented differences because in the region of the first molar, the mandible canal approaches the lingual cortex while the MIC does not approach the lingual cortex, which increases the distance of this canal from the vestibular cortex.

The measurements of the distance of the MC to the vestibular cortex, lingual cortex, and the mandibular base in both the region anterior to the MF and in the region of the first molar presented lower values in relation to those found in the literature; however, the values were between the minimum and maximum found [18].

The average distance of the MIC to the lingual cortex in its initial portion and terminal portion did not present significant changes, but decreased in value, indicating that in its terminal portion, the MIC presents a tendency to approaching the lingual cortical. The mandibular canal presented as equidistant from the vestibular cortex and lingual cortex in the region of the MF. These measurements did not present statistically significant differences between themselves, approaching the lingual cortical the measurements that deviate from the MF.

When determining the distance of the MIC to the mandible base at the 2 evaluated regions, it may be observed that they present in the same way, with a descending tendency. These data are similar to studies that evaluated the distance of the MIC in relation to the mandible base, indicating that the MIC presents a descending trajectory on its approach to the midline [1, 8].

Correlations were observed between the distances of the MIC to the mandible base and to the MC, both in the initial and terminal portions of the incisive canal, indicating that this structure is always positioned above the MC, even when comparing it to the region before the MF and in the region of first molar. There was a correlation between the height of the MF and the MIC; they presented a similar distance, indicating the MIC may be localized at the same height as the MF and that the same may be used as a reference for the height of the anterior extension of the inferior alveolar nerve.

In relation to the distance of the MF from the lingual cortex, no relation was observed with the distance of the same to the MIC in its initial and terminal portions, which led us to believe that the trajectory of the MIC may be related to the opening direction of the MF and not to its actual depth.

It may be observed that the MIC may extend to the region of the central incisors, while it is more frequently identified extending to the region of the canines. When determining a structure that can serve as a parameter for the localization of the MIC, which is more reliable than using the height of the MF, we found that it presented at practically the same height as this structure, both in its initial and terminal portions. In future studies, we wish to evaluate the direction of the opening of the MF.

Conclusion

The mandibular incisive canal may reach the region of the median line, and it did not show differences between the sexes or for the length and distance of the mandibular incisive canal to the cortices ending at the mandible base.

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