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# Evaluation of the size and location of the mental foramen and anterior loop of the lower alveolar nerve in the Brazilian population using cone beam computed tomography

## Avaliação do tamanho e localização do forame mentual e da alça anterior do nervo alveolar inferior na população brasileira usando tomografia computadorizada cone beam

## Evaluación del tamaño y localización del foramen mentual y asa anterior del nervio alveolar inferior en la población brasileña mediante tomografía computarizada de haz cónico

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**Abstract**

Objective: The aim of this study was to evaluate the size, shape and location of the mental foramen (MF) and anterior loop (AL) in the Brazilian population through the analysis of cone beam computed tomography (CBCT) and panoramic radiography (PR). Method: We analyzed the location, shape and size of the MF, the distance between the upper wall of the MF and the alveolar crest (AC), the size of the AL and the presence of lingual anastomosis. Results: Fifty PR and CBCT exams were analyzed. In relation to the MF, the most common location was between premolars (56%), the most common shape was the oval shape (83%) and the average size in the PR was 3.63 mm and in the CBCT was3.66 mm. The average distance from the MF to the AC in the PR was 17.29 mm and in the CBCT was 11.48 mm. The average AL size was 3 mm, the smallest being 1 mm and the largest being 5 mm. Static analysis was performed to verify the relationship between the distance from the foramen to the AC with the values that were found in the PR and CBCT, which showed a statistically significant difference (p=<0.001) between them. Lingual anastomosis could be seen in 22% of the analyzed hemimandibles. Conclusion: CBCT is a reliable diagnostic test for planning rehabilitation near the MF. The distance between the implant and the foramen must be analyzed individually.
**Keywords:** Mental Foramen; Diagnosis oral; Dental implants.

**Resumo**

Objetivo: O objetivo deste estudo é avaliar o tamanho, formato e localização do forame mentual (FM) e da alça anterior (AA) na população brasileira por meio da da análise de tomografias computadorizadas cone beam (TCCB) e radiografia panorâmica (RP). Método: Foram feitas as análises de: localização, formato e tamanho do FM, distância entre a parede superior do forame mentual (FM) e a crista alveolar (CA), tamanho da AA e presença de anastomose lingual. Resultados: Foram analisados 50 exames de radiografia panorâmica e TCCB. Em relação ao FM a localização

mais comum foi entre os pré-molares (56%), o formato mais encontrado foi o oval (83%) e o tamanho médio na RP (3,63mm) e na TCCB (3,66 mm). A distância média do FM à CA na RP (17,29 mm) e na TCCB (11,48 mm). A média do tamanho da AA foi de 3 mm, sendo a menor 1 mm e a maior 5 mm. Foi feita a análise estatística para verificar a relação entre a distância do forame até a crista alveolar com os valores que foram encontrados na RP e na TCCB, que mostraram haver diferença estatisticamente significante (p=<0,001) entre eles. A anastomose lingual pode ser observada em 22% das hemimandíbulas analisadas. Conclusão: A TCCB é um exame de diagnóstico confiável para planejamento das reabilitações próximas ao FM. A distância entre o implante e o forame deve ser analisada individualmente.
**Palavras-chave:** Forame Mentual; Diagnóstico bucal; Implantes dentários.

**Resumen**

Objetivo: El objetivo de este estudio es evaluar el tamaño, forma y ubicación del foramen mentual (FM) y asa anterior (AA) en la población brasileña a través del análisis de tomografía computarizada de haz cónico (TCCB) y radiografía panorámica (RP). Método: Se analizaron: localización, forma y tamaño del FM, distancia entre la pared superior del foramen mentual (FM) y la cresta alveolar (CA), tamaño del AA y presencia de anastomosis lingual. Resultados: Se analizaron 50 exámenes de radiografía panorámica y TCCB. En relación a la FM, la localización más común fue entre premolares (56%), la forma más común fue la ovalada (83%) y el tamaño medio en PR (3,63 mm) y TCCB (3,66 mm). La distancia media de FM a AC en el RP (17,29 mm) y en el TCCB (11,48 mm). El tamaño medio de AA fue de 3 mm, el más pequeño de 1 mm y el más grande de 5 mm. Se realizó análisis estático para verificar la relación entre la distancia del foramen a la cresta alveolar con los valores que se encontraron en el RP y TCCB, los cuales mostraron una diferencia estadísticamente significativa (p=<0.001) entre ellos. La anastomosis lingual se observa en el 22% de los hemimandibles analizados. Conclusión: TCCB es una prueba de diagnóstico confiable para planificar la rehabilitación cerca de FM. La distancia entre el implante y el foramen debe analizarse individualmente.
**Palabras clave:** Foramen Mental; Diagnóstico bucal; Implantes dentales.

## 1. Introduction

Currently, osseointegrated implants are essential for dental practice in the oral rehabilitation of totally edentulous patients and patients with partial, multiple or single edentulism. Implants have high predictability of success, providing the patient with esthetics, function, phonetics and stabilization of the temporomandibular joint in a satisfactory manner. However, like any surgical technique, dental implants are also liable to complications (Ramalho-Ferreira et al., 2010).

One of the most common accidents associated with the installation of implants in the intraforaminal chin region are sensorineural disorders, because the diameter, location and shape of the mandibular canal and mental foramen (MF) are considered a structural and anatomical variation among individuals. Therefore, knowledge of anatomy and its variations becomes extremely important to avoid iatrogenic events (Apostolakis & Brown 2012; Morgado 2013).

In this context, after the loss of teeth, there is a continuous process of resorption of the alveolar bone, directly interfering with the bone availability in the region and consequently generating limitations in the installation of implants due to the presence of the vascular-nervous bundle (Greenstein & Tamow 2006).

The mandibular canal (MC), which is located in the mandible body, houses the inferior alveolar nerve (IANIAN), which innervates the premolars and molars. This nerve is divided into the mental nerve (MN) and the incisive nerve (IN). The MN emerges from the MF and is responsible for the sensitivity of the lip, chin and gums. The IN runs through the mandible, inside the mandibular incisor canal (MIC) and innervates the incisor and canine teeth (Brito 2014).

In this context, the anterior loop (AL) of the IAN is an anatomical variation of the intraforaminal region which occurs when the MN surpasses the MF anteriorly and returns to the foramen in a superior and posterior trajectory. Knowledge of this structure is important to delimitate a safe area in the intraforaminal region for implant placement (Brito 2014; Khein &Sheikhi 2017).

Among the diagnostic imaging methods, cone beam computed tomography (CBCT) has advantages when compared to two-dimensional techniques such as panoramic radiography (PR). The conventional techniques have limited capacity to accurately reveal the AL and their reliability is questioned. Through literature reviews, it was observed that the CBCT allows a

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better visualization of the aforementioned structures, ensuring more detailed studies of the intraforaminal region. The AL itself is not seen in imaging exams; however, the radiolucent or hypodense channel that contains this structure is referred to in the literature as its synonym (Brito 2014; do Carmo Oliveira et al., 2018).

The aim of this study was to evaluate the size, shape and localization of the MF and AL in the Brazilian population through CBCT and panoramic analysis to provide a greater scientific basis for the surgical practice of implant placement in the intraforaminal region.

## 2. Methodology

This is a retrospective, observational and cross-sectional study that analyzed the images of CBCT and panoramic x-rays taken in the period of 2013 to 2019 in the Radiology Center of the Araçatuba Dental School – UNESP.

CT scans were indicated for: evaluation of impacted teeth, pathology investigation, rehabilitation planning, or pre- or postoperatory facial trauma. The exams were performed with the Scanora 3D Soredex tomograph, and the panoramic device was Vateck Pax 400. The inclusion criteria were exams of patients who underwent CBCT and PR, and dentate adults. The exclusion criteria were presence of intraosseous pathology that could affect the position of the mandibular canal or MF, mandibular fractures, and partial posterior mandibular edentulism.

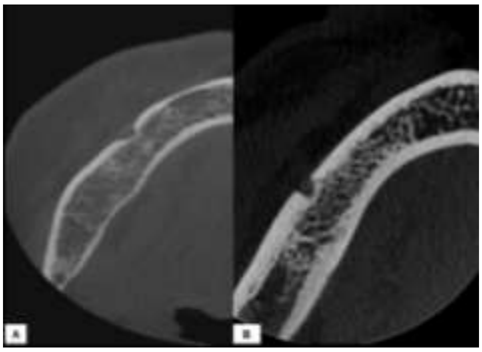
Two analyses were performed in the PR: visual and quantitative. In the visual analysis, it was possible to verify: (1) the position of the MF in relation to the teeth (first premolar, second premolar, between first and second premolar, between second premolar and first molar); (2) presence of the AL, classified as present or absent; and (3) visualization of the incisive nerve, classified into visible or not visible. The quantitative analysis was performed using the dental clinic system, developed in FOA-UNESP. The linear tool was used to perform the following measurements: (1) diameter of the MF: a line was made to measure the place with largest diameter of the foramen; (2) a vertical line was drawn from the height or the foramen to the alveolar crest (AC) (Figure 1).

**Figure 1.** Panoramic radiography. (A) Mental foramen diameter. (B) Alveolar ridge height.


Source: Personal source (2021).

The tomography analysis was performed using the OnDemand3D software, with 1 mm slices and 1 mm spacing, from the 3D visualization and selection of the foramen area for visualization of the axial and coronal slices. In the visual analysis, the following aspects were observed: (1) position of the foramen in relation to the teeth, using the same criteria of the PR; (2) in the axial slice, the exit position of the nerve in the foramen, which was classified as anterior or posterior (Figure 2); (3) foramen shape, classified as oval or round in the three-dimensional reconstruction (Figure 3); and (4) through coronal slices, the presence or absence of a lingual anastomosis (Figure 4).

**Figure 2.** CBCT in axial slice showing the (A) posterior and (B) anterior nerve exit.



Source: Personal source (2021).

**Figure 3.** Three-dimensional reconstruction of the CBCT demonstrating the (A) round and (B) oval shape of the mental foramen.

Source: Personal source (2021).

**Figure 4.** Cone Beam Computed Tomography in the coronal slice with visualization of the lingual anastomosis (arrow).

Source: Personal source (2021).

In the quantitative analysis, the following measurements were obtained in coronal slices: (1) size of the AL, through observation of the number of tomographic slices from the most anterior wall of the foramen to the first slice where the incisor canal was visualized. The incisive nerve was considered to be the first canal to appear on the CT scan with a dimension smaller than 3 mm in diameter. To determine the size of the AL, the number of cuts was multiplied by the thickness of each slice (1 mm) as demonstrated in the Figure 5; (2) AC distance (height of the ridge in the upper portion of the foramen to the bone crest), following the points determined: (A) the most superior portion of the foramen, (R) alveolar bone crest; (3) IR1 distance (height of the ridge in the upper portion of the incisor canal to the bone crest), following the points determined: (I) uppermost portion of the incisor canal, (R) alveolar bone crest; and (4) IR2 distance, (height of the ridge in the last cut where it is possible to view the upper portion of the incisor canal to the bone crest), following the points determined: (I) uppermost portion of the

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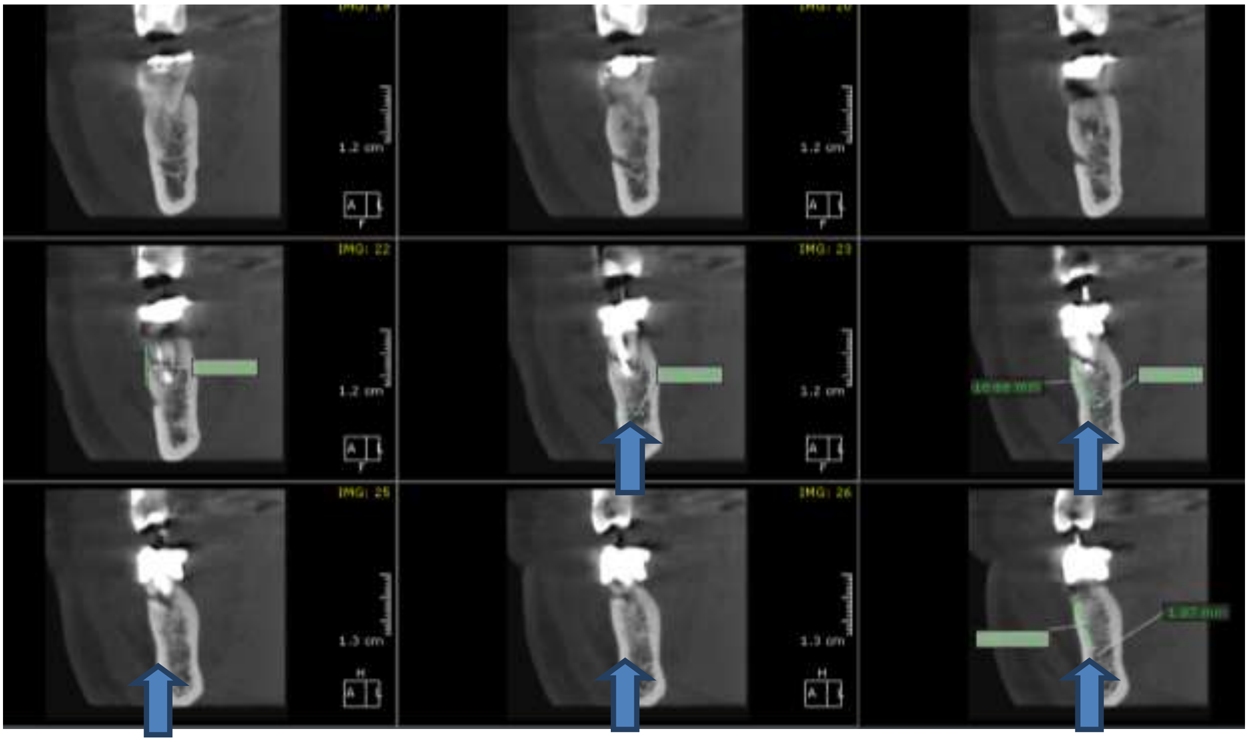
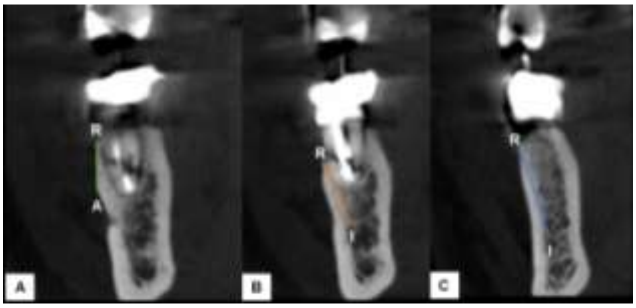
incisor canal, (R) alveolar bone crest (Apostolakis & Brown 2012; Tejada, 2016). In the Figure 6 is possible visualized the mark points described above.

**Figure 5.** CBCT in the coronal slice showing the measurement of the length of the AA, determined by counting the sequential number of slices until the incisor canal image disappears (sections 22 – 27), totaling 5 mm in length in this case.




Source: Personal source (2021).

**Figure 6.** CBCT in coronal slice. (A) AC distance; (B) IR1 distance; (C) IR2 distance.




Source: Personal source (2021).

The measurements obtained were tabulated in Excel® and the values found were submitted to percentage and statistical test. Data were submitted to statistical analysis using the Sigma Plot 2.0 software. All data were submitted to the Shapiro-Wilk normality test, showing non-parametric data. Then, Student's T test was applied to compare the relationship between the distance from the foramen to the AC and the relationship between the right and left sides in PR and CBCT.

## 3. Results

After examination of 837 CBCT and PR exams, 50 patients were selected. Of this sampling, 39 exams were from female patients and 11 from male patients, with a mean age of 41.4±14.4 years. Each side of the mandible was individually evaluated, corresponding with a final sampling of 100 hemimandibles. Two methods of evaluation of the CBCT and PR exams were used: visual and quantitative.

In the visual analysis of the PR, it was possible verify the presence of AL in just 18% of the cases, and the presence of IN in 20%. The most common shape of the foramen was the oval shape, observed in 83% of the mandibles analyzed. In the quantitative analysis, the mean size of the MF was 3.51 mm on the right side and 3.73 mm on the left side. The distance from the superior wall of the foramen to the AC was 17.43 mm on the right side and 17.16 mm on the left side.

In the CT scan, it was possible to observe through visual analysis that 37% of the MNs had an anterior exit, and 63% had a posterior exit. The most common shape was the oval shape (75%), while the round shape was found in 25% of the CBCT exams analyzed. Lingual anastomosis was present in 22% of the hemimandibles. In the quantitative analysis, the mean length of the AL was 3 mm; the mean diameter of the foramen was 3.76 mm on the right side and 3.57 mm on the left side.

The most common location of the MF, both in CBCT and in PR, was between the first and second premolars, and the least common was between the canine and first premolar (Table 1).

**Table 1.** Location of MF.

| Location of MF | Panoramic | | Tomography | |
|---|---|---|---|---|
| | Right % | Left % | Right % | Left % |
| Between C and 1° PM | 6 | 4 | 0 | 0 |
| 1° PM | 14 | 8 | 0 | 2 |
| Between 1° and 2° PM | 44 | 46 | 56 | 56 |
| 2° PM | 22 | 26 | 10 | 6 |
| Between 2° PM and 1° M | 14 | 16 | 34 | 36 |

Source: Personal source (2021).

Regarding the measurements of the distances from the MF and the IN to the AC, the values described in Tables 2 and 3 were found. Student's T statistical test was performed to verify the relationship between the distance from the foramen to the AC with the values found in PR and CBCT, which showed a statistically significant difference ($p=<0.001$) between them. When comparing the right and left sides, both in the PR ($p=0.279$) and in the CBCT ($p=0.895$), results showed no statistically significant difference (Table 3).

**Table 2.** Mean distance from the incisive canal (IC) to the alveolar crest (AC).

| Distance from IC to AC | Tomography | |
|---|---|---|
| | IR1 | IR2 |
| Right | 14,55 mm | 15 mm |
| Left | 14, 96 mm | 15,58 mm |

Source: Personal source (2021).

**Table 3.** Mean distance from the mental foramen (MF) to the alveolar crest (AC).

| Distance from MF to AC | Panoramic | Tomography |
|---|---|---|
| | Mm | mm |
| Right | 17,43 mmA | 11,53 mma |
| Left | 17,16 mmA | 11,60 mma |

The indication of upper and lower case letters shows statistical difference between groups (p <0,001). Source: Personal source (2021).

## 4. Discussion

The mandible is a moving bone, considered the largest and strongest bone in the face. It can be divided into two main parts: body and ramus. In the interior of the mandibular body is located the mandibular canal that houses the IAN, which is divided into MN and IN (Madeira 1995). The MN emerges from the MF, and is responsible for providing the sensibility of the lower lip, chin and vestibular gum of the lower anterior teeth. The IN follows its trajectory through the mandible in the interior of the incisor canal and is responsible for the innervation of the incisive and canine teeth. The AL is an anatomic variation that occurs in the intraforaminal area when the IAN makes an anterior ascending curve before leaving the MF (Brito 2014; Kheir & Sheikhi 2017). When this variation is not identified prior to implant placement, it can damage the AL and promote sensorineural alterations in the chin and lower lip regions (Velasco-Torres et al., 2017; Wismeijer et al., 1997).

The intraforaminal region is widely used for rehabilitation of patients who need dental implants. It offers, due to the anatomy of the mandible, more security to the dentist during implant placement, since in the posterior region of the mandible body, the chances of reaching the nervous vascular bundle increase and may cause further sensory alterations and hemorrhages (Alves et al., 2021; Apostolakis & Brown 2012; Madeira 1995; Morgado 2013).

With the intention of improving the biomechanics of the prosthesis, reducing the distance from the distal cantilever, in many cases, the implants are installed close to the mental foramen exit, not taking into account the presence of the AL (Prados-Frutos et al., 2017). Velasco-Torre et al. (2017) report in their study that 37% of the patients who had implants installed in the intraforaminal region had sensory changes, and 10 to 15% of these changes were permanent, justifying the relevance of studying the anatomical variations of this region (Wismeijer et al., 1997).

In this research, after analysis of 100 hemimadibles, the MF was found to be located between the premolars in 56 cases, being the region with the highest prevalence. Marimuthu et al, (2018) e do Carmo Oliveira et al. (2018) also observed in their studies that the most common position of the mental foramen is between the premolars, reinforcing the data found in this study.

The measurement of the length of the AL was performed by continuously counting of the transversal tomography slices, from the mesial edge of the MF to the most anterior portion of the IAN, with a mean size of 3 mm. The longest length reported by Neiva et al. (2004) was 11 mm, followed by 9 mm as reported by Uchida et al. (2009). The longest AL found in our study was 5 mm, and the shortest was 1 mm. Some authors indicate a safe distance of 1,5 – 2 mm mesial to the foramen for implant placement; however, as analyzed in this research, it is not ideal to have a predefined distance. Each patient must be analyzed individually, respecting their anatomic particularities (Bavitz et al., 1993; Greenstein & Tamow 2006).

Regarding the identification of the AL in the PR, although it is a radiograph exam that has been used in the last decades for planning implants, it offers a general overview of the area in which the dentist will work, in addition to being low cost, having a low dose of radiation and being easily available. However it has limitations such as magnification, distortion, lower sharpness and absence of 3D image when compared to CBCT (Brito 2014; Tejada 2016). The visualization of the AL was possible in 18% of the PR exams analyzed. Previous studies have shown similar values to those found by Marimuthu et al. (2018) (11,76%), and Tejada (2016) (13,6%), showing that neurovascular structures are more easily identified and visualized in CT scans, which makes this technique essential in the previous planning of rehabilitation with dental implants, reducing the risks of iatrogenic events on nervous structures (Bavitz et al., 1993).

The distance between the foramen and the AC is relevant data to assess the height that the implant can be installed without damaging the nerve. Kheir and Sheikhi (2017) indicate in their study an average length of 9 mm, but these types of results must be interpreted with caution, bearing in mind that each patient has its own anatomical characteristics. In PR, the mean value found was 17.29 mm, with the highest value being 21.51 mm and the lowest being 12.86 mm. In CBCT, the mean value found was 11.48 mm, with the highest value being 17.1 mm and the lowest being 6.65 mm. These data were submitted to the Student's T test, which showed a statistically significant difference between the types of analysis (p=<0.001) (Rácz et al., 1981).

Tejada (2016) and Marimuthu et al. (2018) found in their studies 2.48 mm and 2.79 mm, respectively, as the mean values for the mental foramen diameter. These values are very close to those found in this study (3.63 mm in the PR analysis and 3.66 mm for CBCT).

Another factor that cannot be ignored is the invasion of the implant in the incisor canal in dentate patients. The incisor canal should not be disregarded in pre-surgical planning, as it can lead to sensory disturbances such as paresthesia of teeth located anteriorly to the lesion if damaged by the implant. In this study, the incisor canal was shorter than the average length from the height of the foramen to the alveolar crest. The distance from the incisor canal was 14.75 mm, while from the mental foramen to the AC was 11.53 mm, data observed in the CBCT (Ernst & Inke 1962; Greenstein & Tarnow 2006). Alves et al. (2021) also also reinforce the importance of the tomographic study for the evaluation of the MF variations (Alves et al., 2021).

Anastomosis is the connection or junction of two blood vessels, two nerves or two muscle fibers. This was another anatomical variation observed in this study, which can be analyzed in CBCT. A 20% anastomosis was observed in the CBCT of the analyzed hemimandibles. In the study published by Ernest and Inke (1961), in which 30 dissected hemifaces were used, there were 22 cases of formation of anastomoses. The anastomosis may influence anesthesia failure, sensory alteration or abnormal bleeding during the surgical procedure (Bavitz et al., 1993). Malamed presents in his book a failure rate of 31 to 41% of the anesthetic technique for inferior alveolar nerve block, which may be related to this anatomical feature (Malamed 2013).

## 5. Conclusion

The CBCT is a reliable diagnostic test for planning rehabilitations close to the mental foramen, with mandatory individual evaluation of each patient to define the safe intraforaminal distance for implant placement in this region.

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