

Characterization of the accessory mental foramen assessed by cone-beam computed tomography*

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ABSTRACT

Objective: To characterize the accessory mental foramen (AMF) using cone-beam computed tomography (CBCT). **Materials and methods:** A descriptive, cross-sectional, retrospective, observational study. A sample of 147 CBCT scans from 2023 was evaluated, selected from a total pool of 340 images from the Oral and Maxillofacial Radiology Service of Universidad Peruana Cayetano Heredia. Scans of adult patients of both sexes with optimal images and no artifacts in the area of interest were included. Cases presenting cystic, neoplastic, or traumatic lesions in the mandibular region were excluded. **Results:** AMF frequency was higher in the male group (9.68%) than in the female group (5.88%). The most frequent location was distoinferior (36.36%). Mean AMF diameter was greater on the left side ($1.89 \text{ mm} \pm 0.46 \text{ mm}$) compared with the right side ($1.15 \text{ mm} \pm 0.41 \text{ mm}$). The mean distance between the AMF and the alveolar ridge was $16.22 \text{ mm} \pm 4.81 \text{ mm}$, with no significant differences between sides. The mean distance between the AMF and the main mental foramen was $2.33 \text{ mm} \pm 1.41 \text{ mm}$, which was shorter on the left side ($1.74 \text{ mm} \pm 0.72 \text{ mm}$) compared with the right side ($2.67 \text{ mm} \pm 1.64 \text{ mm}$). The AMF was more prevalent on the right side, although without statistical significance. **Conclusions:** The AMF was found to have a frequency of 7.48%. It was more common in males, predominantly located in the distoinferior position, with a mean diameter of 1.42 mm, a distance to the alveolar ridge of 16.22 mm, and a distance to the mental foramen of 2.33 mm.

Keywords: mental foramen; anatomical variation; cone-beam computed tomography.

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INTRODUCTION

Mandibular development begins during the sixth week of embryonic development. It develops bilaterally within the mandibular processes of the first pharyngeal arch, each containing a cartilaginous core called Meckel's cartilage. Its development involves endochondral ossification, followed by replacement of this structure. At birth, the two halves of the mandible are separated by a fibrous joint known as the mandibular symphysis, which fuses toward the end of the first year of life (1).

The mandible is the only mobile bone of the skull. Its articulation with adjacent structures occurs through the temporomandibular joint (TMJ), a synovial joint that permits complex rotational and translational movements essential for functions such as mastication and phonation. In addition to supporting the teeth, the mandible allows nerves and blood vessels to pass through various specialized anatomical structures (1). The mental foramen (MF) is located on the anterolateral surface of the mandibular body. The mental nerve, a sensory branch of the inferior alveolar nerve, emerges through this foramen. Therefore, this structure plays an important role in procedures such as local anesthesia and surgical interventions in the region (2).

Anatomical variations may complicate procedures involving this region, including the presence of additional foramina (accessory mental foramen) or unilateral or bilateral absence of MF (see examples in Figures 1–4).

When the supernumerary foramen is double or multiple and smaller than the main foramen, it is referred to as an accessory mental foramen (AMF). Although uncommon, it is of considerable clinical and surgical importance due to its connection to a neurovascular bundle (3). Its prevalence ranges from 1.4% to 17.48% (4,5).

The inherent advantages of three-dimensional (3D) imaging have established cone-beam computed tomography (CBCT) as an essential diagnostic tool widely used in dental practice. In a study conducted in Saudi Arabia, Aljarbou et al. (6) evaluated the frequency and location of AMF in 603 CBCT scans and reported a prevalence of 9.95%, which was significantly higher in males than in females. The distance between MF and AMF ranged from 2.32 mm to 5 mm, with a posteroinferior position relative to the main foramen being the most common. In addition, only four cases of a second AMF were identified, all of which occurred in males.

Unlike two-dimensional (2D) modalities, such as periapical and panoramic radiography, CBCT provides valuable information about anatomical structures and their pathological changes, enabling more precise evaluation and, consequently, more accurate treatment planning. However, this method has certain limitations: it allows detailed visualization of calcified structures, such as teeth and bone, as well as the contours of some soft tissues when they are surrounded by structures with markedly different densities (7).

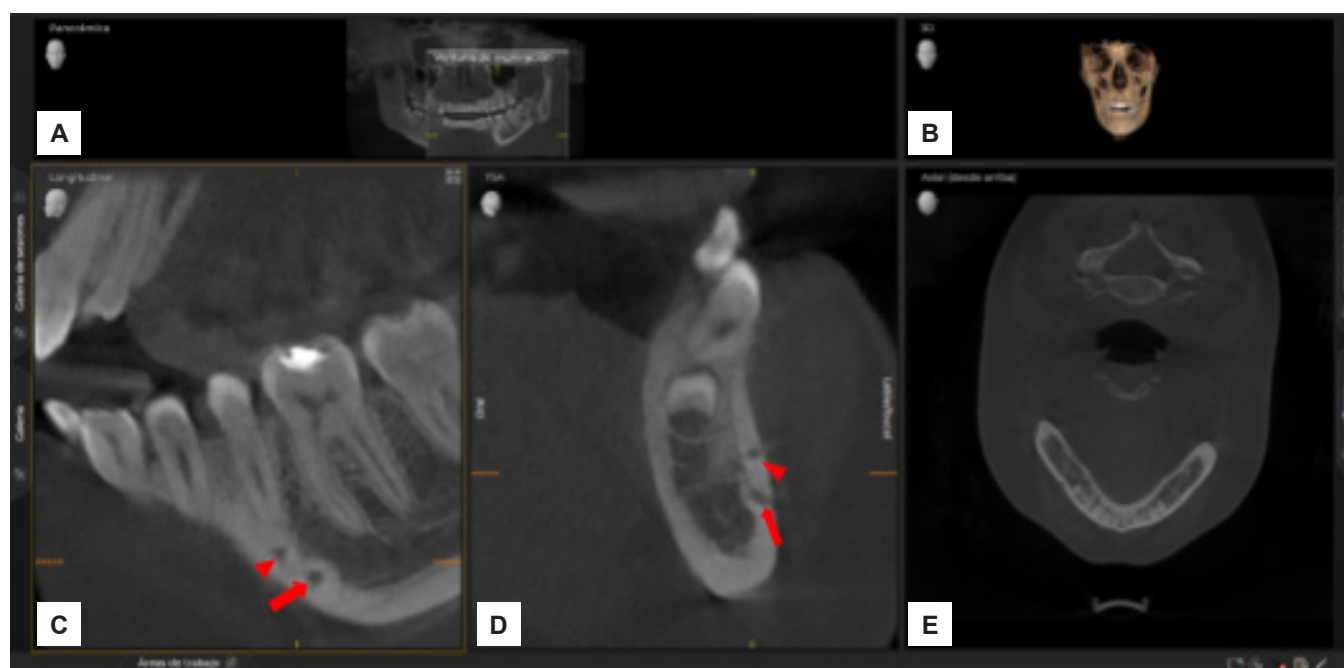


Figure 1. A) Panoramic reformation. B) Volume rendering. C) Longitudinal section showing the MF (arrow) and AMF (arrowhead). D) Transaxial section showing the MF (arrow) and AMF (arrowhead). E) Axial section.

Several CBCT-based studies have shown that AMF is a relatively common anatomical variation, with prevalence varying according to the population. Studies

conducted in Asia, Europe, and Oceania have reported frequencies ranging from 3.77% to 14% in countries such as Iran, China, Turkey, Bulgaria, Poland, and Australia

(8–16). In Latin America, reports are scarce; however, evidence from the Peruvian population has shown prevalence estimates ranging from 14% to 17%, indicating a frequency comparable to or even higher than that observed in other regions worldwide (17, 18). These findings underscore the need to accurately identify this anatomical variation using CBCT because of its clinical

implications for surgical and implant procedures in the mental region.

In this regard, this study aimed to characterize AMF using CBCT in patients treated at the Teaching Dental Center of Universidad Peruana Cayetano Heredia (CDD-UPCH) in 2023.

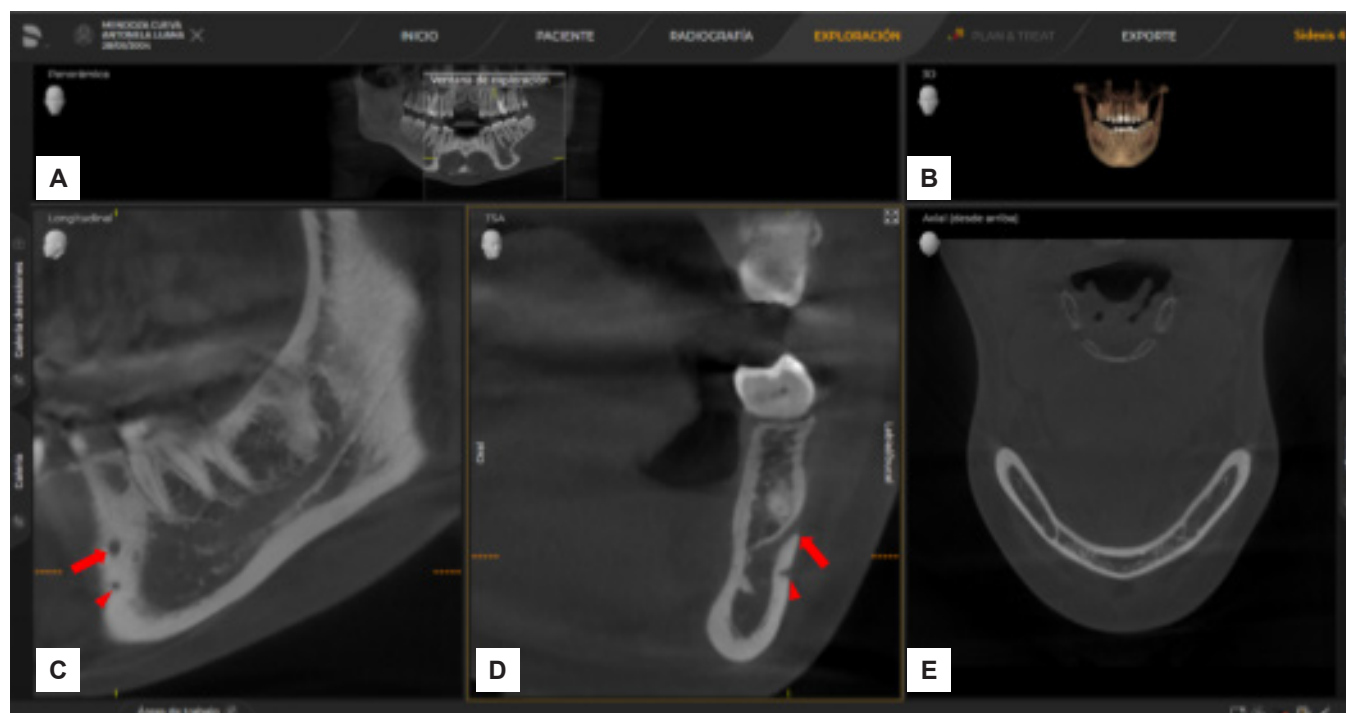


Figure 2. A) Panoramic reformation. B) Volume rendering. C) Longitudinal section showing the MF (arrow) and AMF (arrowhead). D) Transaxial section showing the MF (arrow) and AMF (arrowhead). E) Axial section.

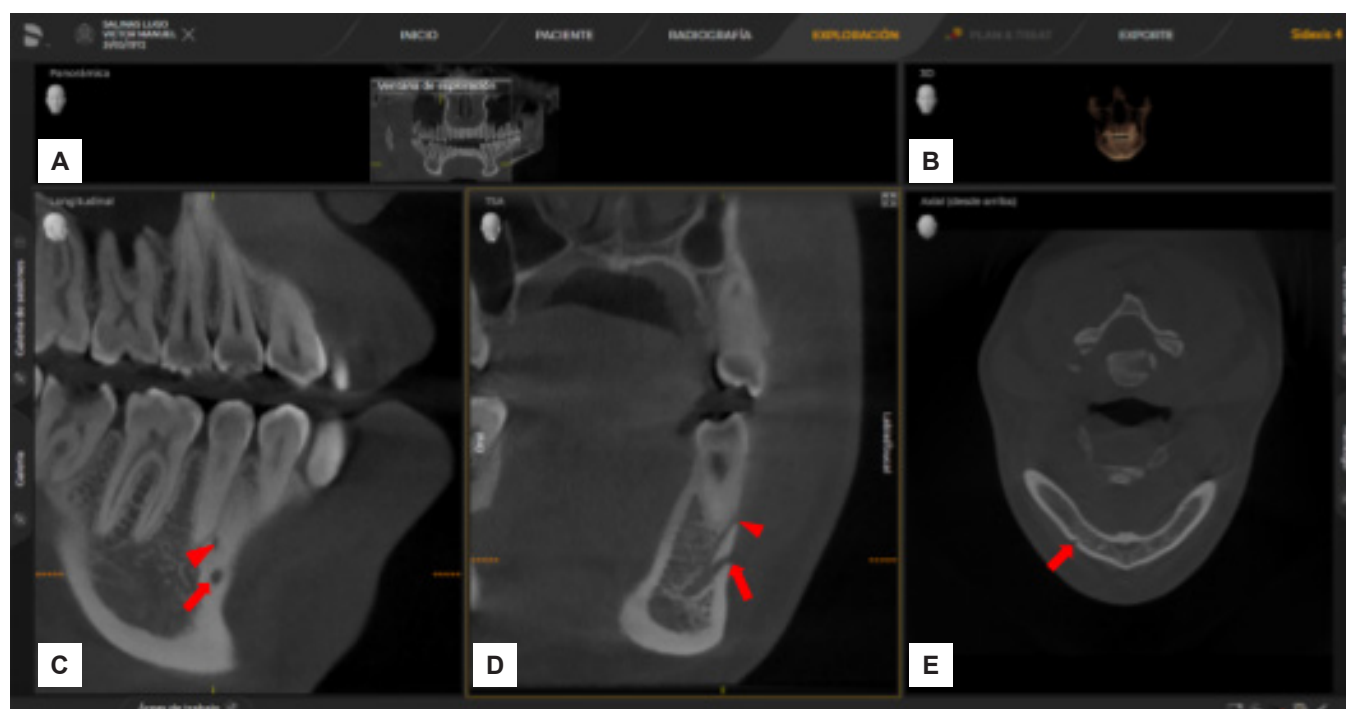


Figure 3. A) Panoramic reformation. B) Volume rendering. C) Longitudinal section showing the MF (arrow) and AMF (arrowhead). D) Transaxial section showing the MF (arrow) and AMF (arrowhead). E) Axial section showing the MF (arrow).

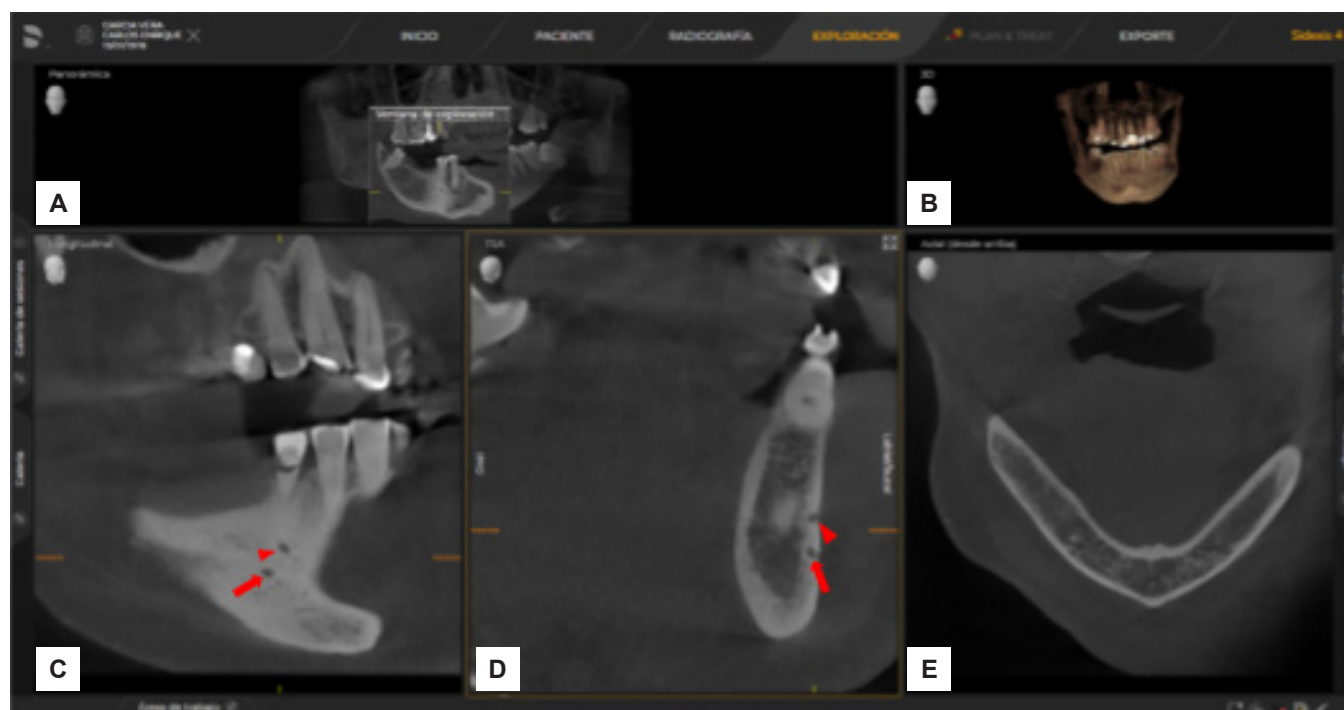


Figure 4. A) Panoramic reformation. B) Volume rendering. C) Longitudinal section showing the MF (arrow) and AMF (arrowhead). D) Transaxial section showing the MF (arrow) and AMF (arrowhead). E) Axial section.

MATERIALS AND METHODS

The study was descriptive, cross-sectional, retrospective, and observational. The study population consisted of CBCT volumes obtained from patients treated at the Teaching Dental Center of the Oral and Maxillofacial Radiology Department at Universidad Peruana Cayetano Heredia (UPCH), San Martín de Porres campus, during 2023, yielding a total of 340 volumes. A total of 340 CBCT volumes were available, from which a sample of 147 volumes was selected.

Nonprobability convenience sampling was used to select CBCT scans that met the inclusion criteria. These included CBCT scans of the full-field maxillofacial region from patients of either sex, aged 18–69 years, using an appropriate acquisition technique and without artifacts that could interfere with visualization of the mandibular canal. Conversely, CBCT scans showing evidence of cystic, neoplastic, or traumatic lesions in the region of interest were excluded.

To characterize AMF, demographic, anatomical, and morphometric variables were evaluated. The demographic variables included patient sex. In terms of anatomical variables, the presence or absence of AMF and its position relative to MF were recorded. The morphometric analysis included measurement of the largest AMF diameter, as well as the distances from the AMF to the alveolar ridge and to the MF. These measurements made it possible to describe the anatomical and dimensional characteristics of FMA using CBCT.

Procedures and techniques

Each CBCT scan was analyzed using a three-dimensional (3D) view in Sidexis 4® software and evaluated in three planes: axial, longitudinal, and transaxial. First, MF was identified to determine the presence of AMF on the buccal bone plate. When AMF was identified, the relevant variables, including its diameter and position, as well as its distances from the alveolar ridge and MF, were measured (Figures 1–4). To complement the analysis, the tools available in the imaging software were used, including brightness and contrast adjustment, zoom, and linear measurements, as well as adjustment of the longitudinal image axes according to the requirements of each case. The data obtained were recorded on a data collection form prepared for this purpose.

Calibration and pilot testing

To ensure the reliability of data collection, a theoretical training session was conducted under the guidance of a specialist holding a doctoral degree in Stomatology. In addition, for interobserver calibration, the principal investigators and the specialist independently evaluated 23 CBCT volumes that met the inclusion criteria. This procedure yielded a kappa coefficient of 0.85 and an intraclass correlation coefficient (ICC) of 0.9.

In a second session, conducted seven days later, intraobserver calibration was performed. During this phase, the principal investigators conducted a second analysis of the same volumes using the identical examination and

recording protocol, yielding kappa coefficients of 0.85 and an ICC of 0.9.

Selection of cone-beam computed tomography scans

Tomographic volumes were retrieved from the database of the Dental Teaching Center at Universidad Peruana Cayetano Heredia. The scans had been acquired using an Axeos system (Sirona®; Germany). This system operates with the following technical specifications: variable field of view, voxel size of 0.3 mm, focal spot size of 0.5 mm, and exposure parameters of 90 kV and 16 mA.

Data collection form

The tomographic volumes selected according to the inclusion criteria were recorded on a data collection form created in Microsoft Excel. Image assessment was performed on a Lenovo desktop computer with the following specifications was used: a 22-inch LCD monitor with a resolution of 1860 × 1050 pixels, an Intel Xeon® processor, 14 GB of RAM, and the Windows 11 operating system. Multiplanar analysis was performed using Sidexis 4® software by evaluating the axial, longitudinal, and transaxial sections (Figures 1–4). In addition, the examiner maintained a viewing distance of 50–75 cm from the monitor. To reduce eye strain, 30-second visual breaks were taken every 20 minutes, during which the operator focused on an object approximately 10 m away (19).

Analysis plan

IBM SPSS Statistics® version 25 was used with a 95% confidence level. Absolute and relative frequencies were calculated for categorical variables. Chi-square and Student's *t* tests were used to assess associations between variables.

Ethical considerations

The research protocol was registered in the Decentralized Research Information and Monitoring System (SIDISI), and it was reviewed and approved by the Institutional Research Ethics Committee (CIEI) of Universidad Peruana Cayetano Heredia, under approval certificate No. CIEI-274-25-24. Authorization was obtained from the university's Academic Department of Oral and Maxillofacial Medicine and Surgery (DAMCIBUM) to evaluate the CBCT scans obtained from the Oral and Maxillofacial Radiology Department of the Teaching Dental Center (CDD). To safeguard confidentiality, the tomographic volumes were assigned sequential identification numbers, thereby ensuring participant anonymity. Therefore, given the nature of the study, informed consent was not required.

ChatGPT was used as a support tool for grammar correction and language refinement in selected sections of the study, without modifying the scientific content or the interpretation of results.

RESULTS

A sample of 147 CBCT scans from 2023 obtained from the Oral and Maxillofacial Radiology Department of the Teaching Dental Center at Universidad Peruana Cayetano Heredia was evaluated. The sample comprised 62 male patients (42.18%) and 85 female patients (57.82%), all of whom were adults. Among the female patients, 5 of 85 (5.88%) presented with an AMF, whereas among the male patients, 6 of 62 (9.68%) presented with an AMF. Overall, 11 of the 147 patients (7.48%) presented with an AMF. The chi-square test was used to assess the association between sex and the presence of an AMF. Statistical analysis yielded a *p*-value of 0.388 (*p* > 0.05), indicating that the difference in AMF frequency between male and female patients was not statistically significant (Table 1).

Table 1. Frequency of accessory mental foramen (AMF) according to sex, assessed using cone-beam computed tomography (CBCT).

Sex	n	%	AMF				p-value
			Present		Absent		
			n	%	n	%	
Female	85	57.82	5	5.88	80	94.12	0.388*
Male	62	42.18	6	9.68	56	90.32	
Total	147	100.00	11	7.48	136	92.52	

*Chi-square test.

Regarding position, the most frequent was the distoinferior position (36.36%). On the left side, the most common position was distoinferior (50.0%), whereas

on the right side, the mesiosuperior, mesioinferior, and distoinferior positions predominated (28.57% each). No foramina were found in the inferior, mesial, or distal

positions. Analysis using the chi-square test yielded a p-value of 0.340 ($p > 0.05$), indicating that there was no statistically significant difference in the distribution

of foramen position according to side (left or right) (Table 2).

Table 2. Position of the accessory mental foramen (AMF) according to side.

Variable	n	%	Side				p-value
			Left		Right		
			n	%	n	%	
Position							
Superior	2	18.18	1	25.00	1	14.29	0.340*
Inferior	0	0.00	0	0.00	0	0.00	
Mesial	0	0.00	0	0.00	0	0.00	
Distal	0	0.00	0	0.00	0	0.00	
Mesiosuperior	2	18.18	0	0.00	2	28.57	
Mesioinferior	2	18.18	0	0.00	2	28.57	
Distosuperior	1	9.09	1	25.00	0	0.00	
Distoinferior	4	36.36	2	50.00	2	28.57	
Total	11	100.00	4	36.36	7	63.64	

*Chi-square test.

The mean diameter was 1.42 ± 0.55 mm. The diameter on the left side was greater (1.89 ± 0.46 mm) than that on the right side (1.15 ± 0.41 mm). Analysis using Student's t-test indicated a statistically significant difference ($p = 0.037$; $p < 0.05$), suggesting that AMF tends to have a greater diameter on the left side. In contrast, the mean distance between AMF and the alveolar ridge was 16.22 ± 4.81 mm ($p = 0.873$; $p > 0.05$), indicating that this variable did not differ significantly between the two sides (Table 3).

The mean distance between AMF and the main MF was 2.33 ± 1.41 mm. On the left side, the mean distance was 1.74 ± 0.72 mm, whereas on the right side, it was 2.67 ± 1.64 mm, with a p-value of 0.317 ($p > 0.05$), indicating no statistically significant difference in this distance between the two sides. Of the 11 cases in which AMF was identified, 4 (36.36%) were located on the left side and 7 (63.64%) on the right side. Thus, in the study sample, AMF was more frequently observed on the right side, although the difference was not statistically significant (Table 3).

Table 3. Diameter, distance to the alveolar ridge, and distance to the mental foramen (MF) of the accessory mental foramen (AMF), evaluated using cone-beam computed tomography (CBCT).

Variable	X	SD	Side				p-value
			Left		Right		
			X	SD	X	SD	
Diameter	1.42	0.55	1.89	0.46	1.15	0.41	0.037*
Distance to the alveolar ridge	16.22	4.81	16.52	4.15	16.04	5.46	0.873*
Distance to MF	2.33	1.41	1.74	0.72	2.67	1.64	0.317*
Total (n/%)	11	100.00	4	36.36	7	63.64	

X: mean; SD: standard deviation.

*Student's t-test.

DISCUSSION

The frequency of AMF observed in this study was 7.48%, confirming that this anatomical variant occurs with

relative frequency in the population studied. This result falls within the range previously reported in different populations evaluated using CBCT (10). However, the observed frequency was lower than that reported in some

studies conducted in Latin American populations (17) and in international studies (11). These differences may be attributable to ethnic and population-related factors, as well as variations in sample size, selection criteria, and methodologies used to identify AMF using CBCT.

Regarding sex, a higher frequency of AMF was observed in male patients than in female patients, a trend consistent with that reported in previous studies (6). Although the exact cause of this difference has not been established, it could be related to the morphological and dimensional characteristics of the male mandible, which generally exhibits greater bony robustness and a more complex distribution of neurovascular pathways. However, additional studies are needed to clarify the influence of sex on the presence of this anatomical variant.

In terms of anatomical location, AMF was most frequently found in the distoinferior position relative to the ipsilateral MF and predominantly on the right side, a pattern previously described in the literature (10). These results suggest some degree of anatomical consistency in the spatial arrangement of this structure. From a clinical perspective, knowledge of these locations is relevant for reducing the risk of neurovascular injury during surgical and implant procedures in the mandibular premolar region.

The mean AMF diameter was 1.42 ± 0.55 mm, with greater values observed on the left side. This finding is consistent with previously reported measurements (8). Identification of these dimensional variations is important because the diameter of the foramen may be related to the neurovascular contents passing through it and, consequently, to the potential risk of clinical complications.

Similarly, the mean distance from the AMF to the alveolar ridge was 16.22 ± 4.81 mm, a value comparable to that reported in other studies (8,10). On the other hand, the mean distance between AMF and MF was 2.33 ± 1.41 mm, showing similarity to some previous reports (6). However, greater distances have been reported in other studies (9). These discrepancies may be explained by interpopulation anatomical variation, as well as methodological differences related to image acquisition, measurement criteria, and sample size. Despite these differences, the available evidence consistently indicates that AMF may be located in proximity to the main MF.

One of the main limitations of the study was the partial availability of imaging data and the limited sample size. Logistical difficulties related to coordination also affected the rate at which the findings could be reviewed and validated. Nevertheless, the results obtained provide relevant information and serve as a basis for future research.

Future studies should include larger and more diverse samples, incorporating patients from different age groups, sexes, and geographic settings to obtain more representative data. Similarly, it is important to explore the implications of AMF in surgical practice to prevent potential clinical complications.

CONCLUSIONS

AMF was present in 7.48% of the cases evaluated. It was more frequently observed in male patients and in the distoinferior position relative to MF. The mean AMF diameter was 1.42 mm, the mean distance to the alveolar ridge was 16.22 mm, and the mean distance to MF was 2.33 mm.

Conflict of interest:

The authors declare no conflict of interest.

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Authorship contribution:

MNHC, AVVQ, LSYC: conceptualization, investigation, visualization, funding acquisition, writing of the original draft, writing - review & editing. **RALM:** data curation, formal analysis. **VERGC:** conceptualization, methodology, project administration, supervision, validation.

Statement on the use of artificial intelligence:

ChatGPT was used as a support tool for grammar correction and language refinement in selected sections of this manuscript, without modifying the scientific content or the interpretation of results. The authors reviewed and edited the resulting content and assume full responsibility for the integrity and accuracy of the manuscript.

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