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ORIGINAL ARTICLE

Anatomy of the accessory mental foramen in a Saudi subpopulation: A multicenter CBCT study

Fahd Aljarbou [a,*], Abdullah M. Riyahi [a], Abdullah Altamimi [b], Abdullatif Alabdulsalam [b], Nasser Jabhan [c], Mazen Aldosimani [d], Hadi M. Alamri [e]

[a] *Department of Restorative Dental Sciences, Division of Endodontics, College of Dentistry, King Saud University, Riyadh 11545, Saudi Arabia*
[b] *Ministry of Health, Riyadh, Saudi Arabia*
[c] *Private Practice, Alkharj, Saudi Arabia*
[d] *Department of Oral Medicine and Diagnostic Sciences, Radiology Division, College of Dentistry, King Saud University, Riyadh 11545, Saudi Arabia*
[e] *Conservative Dental Sciences, College of Dentistry, Prince Sattam bin Abdulaziz University, Alkharj 11942, Saudi Arabia*

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Abstract *Aim:* The aim of this is to evaluate the prevalence and location of the accessory mental foramen (AMF) in a Saudi population using cone-beam computed tomography (CBCT).

Methodology: CBCT data were retrieved from two dental facilities at two universities located in two different cities and filtered over a period of four years. The scans were aligned when the AMF was noticed, and then the size of both the AMF and mental foramen (MF), its location, and the distance from the AMF to the MF were recorded. The AMF measurements were compared between males and females and between the two sides of the mandible.

Results: In total, 603 CBCT scans were investigated. The percentage of scans with an AMF was 9.95% ($n = 60$), and AMFs were almost equally distributed on both sides. Only four cases (0.66%) of a second AMF were detected among the scans. The MFs on both sides were significantly larger in males than in females ($P > 0.05$), but they showed no differences in the sizes of the AMFs. The AMFs were most commonly located inferior and posterior to the MF. The distance between the MF and AMF ranged from 2.32 to 5 mm.

* Corresponding author.
E-mail address: faljarbou@ksu.edu.sa (F. Aljarbou).

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Conclusions: The prevalence of the AMF in this Saudi population was 9.95%, and it was significantly more prevalent in males than in females. Its proximity to the MF makes it clinically important to conduct proper detailed planning prior to performing any procedure that might risk the vital structures.

1. Introduction

Adequate knowledge about vital anatomical structures is of the utmost importance in the field of endodontics due to their proximity to the root apices of the teeth (Direk et al., 2018). This proximity has a vital impact on diagnosis, particularly during radiographic evaluations (Di Lenarda et al., 2000), nonsurgical treatments (Knowles et al., 2003), and surgical endodontic treatment (Moiseiwitsch, 1995). One such structure is the mental foramen (MF).

The location of the MF has been thoroughly investigated in the literature. Alsoleihat et al. (2018) investigated a Jordanian population, and Direk et al. (2018) conducted an anatomical study and review of the literature on a Turkish population. Dos Santos Oliveira et al. (2018) analyzed the MF location along with other parameters in a Brazilian population, and Krishnan et al. (2018) examined data from Australia. Moiseiwitsch (1998) investigated the position of the MF in a North-American population.

Many studies have reported that the location of the MF is related to the apex of the mandibular second premolar (Phillips et al., 1990), but the exact location may differ based on several variables. Examples include race (Hollinshead, 1982), the methodologies used in the studies, which may include the use of dried skulls (Miller, 1953), panoramic radiographs (Halwani and Muteq, 2017), and cone-beam computed tomography (CBCT) (Alsoleihat et al., 2018; Direk et al., 2018; Dos Santos Oliveira et al., 2018; Krishnan et al., 2018; Li et al., 2018; Naitoh et al., 2009). These variables may lead to different findings. Hence, considering them in future studies and when interpreting the results in clinical practice is crucial. In a study conducted on a Saudi population using CBCT, more than 68% of the studied sample showed that the MF was closer to the apices of the mandibular second premolars than the mandibular first premolar (Aldosimani et al., 2019).

During the twelfth gestational week, as the inferior alveolar nerve and the mental nerve are formed, it has been suggested that accessory mental foramens (AMFs) may develop if the mental nerve ramifies prior to this stage (Robinson & Yoakum, 2020). Owing to advances in technology, particularly in imaging and magnification, there is emerging evidence and focus on the presence of an AMF (Goyushov et al., 2017; Krishnan et al., 2018; Naitoh et al., 2009), especially due to its importance during endodontic and periodontal procedures (Goyushov et al., 2017). Thus, the aim of the present study is to evaluate the prevalence and location of the AMF in a Saudi population using CBCT.

2. Materials and methods

Ethical approval for this study was obtained from the Institutional Review Board of Prince Sattam bin Abdulaziz University (IRB ID: PSAU2020020). CBCT data and patient information were retrieved from the databases of the Dental University Hospital of King Saud University (KSU) and the College of Dentistry in Prince Sattam bin Abdulaziz University (PSA) from 2016 to 2020. The study included all CBCT scans of patients aged 18 years and above that included the mandible. Patients who had diseases that might disrupt the shape or size of the mandible were excluded. The other exclusion criteria were non-Saudis, unclear visualization of the MF, patients younger than 18 years old, and invalid file numbers. The CBCT images had been taken for various indications, including impacted teeth assessment, endodontic treatment, implant site assessment, pathology, trauma, and temporomandibular joint assessment.

At KSU, the CBCT images were acquired using a Planmeca ProMax 3D Max (Planmeca, Helsinki, Finland) at a voltage of 90 kV, tube current of 11 mA, and isotropic voxel size of 0.02–0.04 mm. The images were reviewed using Planmeca Romexis 5.2 imaging software (Planmeca, Helsinki, Finland). At PSA, the images were acquired using a Carestream CS 9300 Select (Carestream Dent LLC, Atlanta, G, USA) at a voltage of 90 kV, tube current of 4 mA, and a voxel size of 0.09–0.5 µm. The images were analyzed using CS 3D imaging software (Carestream Dent LLC, Atlanta, G, USA).

Interruptions of the outer surface of the mandible near the main MF were assessed in the coronal section. Then, the axial and sagittal sections were used to explore and confirm the presence of an AMF along with their continuity with the mandibular canal. The size of the foramen was measured according to the method described by Naitoh et al. (2009) where the longest (a) and shortest (b) axes of each foramen were selected, determined manually, and then measured in the imaging software. The area was calculated using the following equation: $\text{area} = \pi a/2 \times b/2$.

The foramen with the greatest area was considered as the main MF, and the rest were considered accessories. The location of AMFs was determined manually, and then the distance of the AMF in relation to the MF was measured using the following equation: $\text{distance} = \text{root}(x^2 + y^2)$, as shown in Fig. 1. Sex and the sides of all measurements were correlated with the anatomical findings. The measurements were performed by three general practitioners and one maxillofacial radiologist after calibration using 20 pilot cases with one-week intervals between two readings.

Statistical analysis was performed using the software SPSS version 20.0 (SPSS, Inc., Chicago, IL, USA). A descriptive analysis was conducted, and an independent *t*-test was used to determine statistically significant differences between the measurements in relation to their categories. The chi-squared test was used to compare the presence of AMF based on sex. A P-value equal to or less than 0.05 was considered statistically significant.

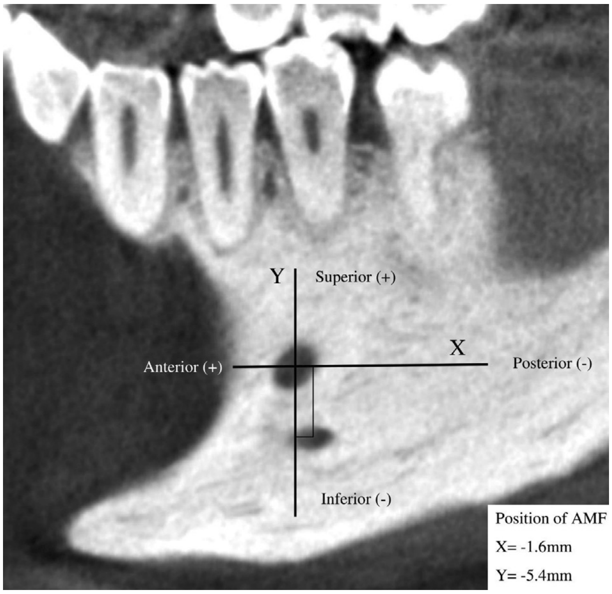

Fig. 1 Representation of the location and distance of the AMF in relation to the MF.

3. Results

In total, 603 CBCT scans from PSA (189 scans) and KSU (414 scans) were included in this study. Initially, 1739 scans were collected, but several of them were excluded due to the following reasons: non-Saudis (269 scans), unclear visualization of the MF (723 scans), patients younger than 18 years old (137 scans), and invalid file numbers (7 scans). The results of inter- and intra-examiner reliability were assessed using Cronbach's alpha test, which showed excellent reliability (ranging from 0.906 to 0.988).

The overall measurements of all the required variables are presented as the means and standard deviations (SDs) in Table 1. The prevalence of AMF was 9.95% ($n = 60$), which was distributed almost equally between the left and right sides. Additionally, only four cases of a second AMF (0.66%) were detected, which were also equally distributed between the two sides. The overall mean area of the MF was 11.35 ± 6.21 mm^2, and the mean area of the AMF was 1.24 ± 1.1 mm^2.

In terms of sex, males had significantly larger MFs than females on both sides (Table 2; $P < 0.05$). No statistically significant difference in the mean area of the AMF was observed between males and females on both the right and left sides. Second AMFs were detected in males only.

In total, 60 AMFs were found in the current study, including 39 in males and 21 in females. This difference was deemed statically significant ($P = 0.04$). The distance between the MF and AMF ranged from 2.32 to 5 mm, and the mean distance was 3.3 ± 0.55 mm. The most common locations for the AMF were inferior and posterior to the MF, and the least common positions were superior and anterior to the MF on both sides. The locations of all AMFs in this study are demonstrated in Fig. 2.

4. Discussion

To the best of our knowledge, this is the first anatomical study to investigate the prevalence and distribution of AMF using CBCT in a Saudi population. CBCT is a tool that provides a direct and noninvasive approach to study human anatomy (Krishnan et al., 2018; Naitoh et al., 2009). In addition, CBCT is useful for the detection and evaluation of the MF and its related anatomical structures in surgical cases prior to dental

Table 2 Areas of the MF on the right and left sides in males and females in mm^2.

Side	Variable	Sex	N	Mean	Standard deviation	P
Right	The area of MF	M	310	12.57 *	6.51	0.003
		F	293	9.54	5.23	
Left		M	310	12.68 *	7.07	0.002
		F	293	10.50	5.19	

Table 1 Descriptive representation of the measurements of the mental foramen (MF) and accessory mental foramen (AMF) on the left and right sides. All distances are in mm.

Side	Variable	N	Mean	SD
Right	MF- shortest axis	599	3.15	2.1
	MF- longest axis	599	4.44	2.72
	MF- area in mm^2	599	11.1	6.11
	AMF- shortest axis	33	1.01	0.45
	AMF- longest axis	33	1.49	0.54
	AMF- area in mm^2	33	1.28	1.03
	Distance between MF and AMF	33	3.2	0.44
Left	MF- shortest axis	600	3.16	0.92
	MF- longest axis	600	4.44	1.27
	MF- area in mm^2	600	11.6	6.31
	AMF- shortest axis	27	0.92	0.44
	AMF- longest axis	27	1.48	0.73
	AMF – area in mm^2	27	1.18	0.99
	Distance between MF and AMF	27	3.49	0.64

N, number of scans; SD, standard deviation.

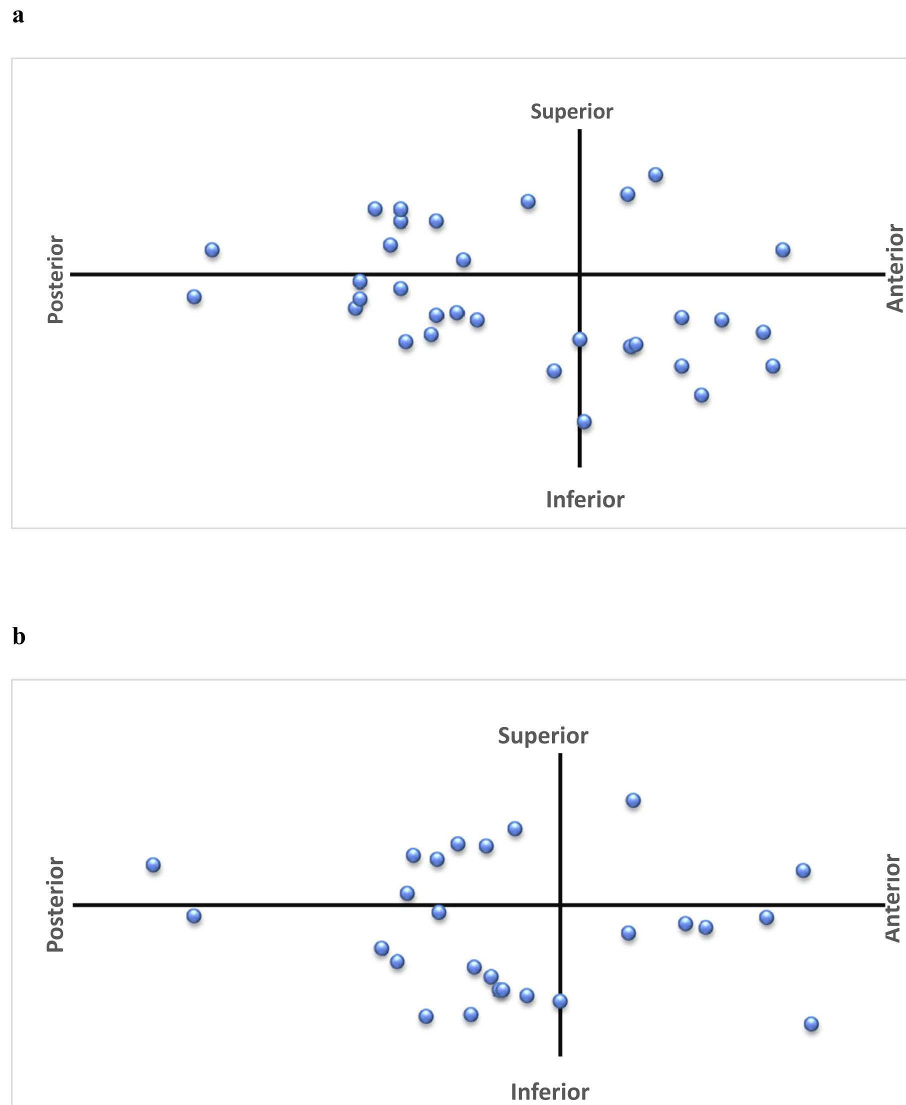

Fig. 2 The location of all the AMFs based on the values of the X and Y axes. The center of the figure represents the center of the MF. (**a**) Right AMFs and (**b**) left AMFs.

treatment because it can provide details that may aid in accurate planning and proper case management.

The mean area of the MF was significantly greater in males than females in the current study, which was in agreement with Muinelo-Lorenzo et al. (2015). They concluded that males had significantly larger MFs than females. They observed that the mean area in mm^2 of the MF in males was 11.71 ± 5.57, while that of females was 9.8 ± 4.46. This observation was noted in several other studies (Ritter et al., 2012) (Kalender et al., 2012). One study compared the distances between different landmarks within the skull and found that the distance between the MF and midline differs significantly between males and females, with the distance in males being greater (Agthong et al., 2005). This may indicate that male skulls are generally bigger than female skulls. Similarly, we assume that larger skulls would more likely have larger foramens compared to smaller skulls, which is presented in the current study, where the MF area was significantly larger in males than females.

The literature shows wide variation in the prevalence of AMF among different populations. A summary of the variations among different populations is presented in Table 3. These studies show prevalence ranging between 1.4% and 13.08%. In the current study, the prevalence of AMF was 9.95%, which is higher compared to other populations. Furthermore, it was significantly more frequent in males than females. This finding is in agreement with that of Han et al. (2016). Similar findings have been reported in other studies, but the differences were not statistically significant between males and females (Zmysłowska-Polakowska et al., 2017). On the other hand, one study reported no relation between sex and the prevalence of AMFs (Aytugar et al., 2019). The exact reason is unclear, but genetic predisposition might play a role in such variation.

AMFs can be found in different locations around the MF. Naitoh et al. (2009) reported that the majority of the AMFs were located inferior and posterior to the MF. This finding

Table 3 Variations in the AMF prevalence in accordance with the type of population.

Study	Prevalence of AMF in %	Population
Sawyer et al., 1998	1.4	American Whites
Sawyer et al., 1998	9	Nazca Indians
Paraskevas et al., 2015	4.17	Greek
Han et al., 2016	8.1	Korean
Wei et al., 2020	10.5	Southern Chinese
Aytugar et al., 2019	12.23	Turkish
Muinelo-Lorenzo et al., 2015	13.08	Spanish

was similar to the results of the present study, where the most frequent site for AMFs was inferior and posterior to the MF. Likewise, the mean area of the AMF in the current study was 1.24 ± 1.1 mm^2, which closely resembles the value of 1.7 ± 1.5 mm^2 reported by Naitoh et al. (2009).

The distance between the MF and AMF in the current study ranged from 2.32 to 5 mm, and the mean distance was 3.3 ± 0.55 mm. This is close to that reported by Goregen et al. (2013), who found a range of 1.6–4.9 mm. However, Naitoh et al. (2009) reported greater distances ranging from 4.5 to 9.6 mm with a mean distance of 6.3 ± 1.5 mm. however, this difference is considered minor and might not have clinical significance.

Despite the large sample obtained from two different cities in the current study, additional studies with wider regional distribution might yield results that better represent the Saudi population. Correlating the AMF position to the adjacent teeth might be advisable for greater clinical relevance. The age factor was not studied due to a lack of accurate age registration, and correlating this factor in future research could have great clinical impact.

The mandibular premolar region should be carefully examined prior to any dental procedure, especially if surgical intervention is planned (Von Arx et al., 2014). Potential lower-lip paresthesia can occur if these structures are violated during surgical procedures such as endodontic surgeries, placement of implants, and orthognathic surgeries (Rahpeyma and Khajehahmadi, 2018). In Saudis, the increased prevalence of the AMF and its proximity to the MF will necessitate greater care during surgical intervention, especially vertical release of the periodontal flaps, which are posterior to the MF. The use of preoperative CBCT can aid in the collection of valuable information before surgery and in the optimization of the surgical planning within the area.

5. Conclusions

The occurrence of the AMF in the Saudi population in the current study was 9.95%, and it was significantly more prevalent in males than in females. The AMF is in close proximity to the MF, and the most common locations were found to be inferior and posterior to the MF. Therefore, it is important to consider the use of CBCT imaging prior to surgical procedures in the mandibular premolar area.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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