Evaluation of the Accessory Mental Foramen in a Pediatric Population Using Cone-Beam Computed Tomography

Cantekin K*/ Şekerci AE**

Objective: *The aim of the present study was to clarify the occurrence, diameter, and location of the accessory mental foramen (AMF) using cone-beam computed tomography (CBCT) images from a sample of Turkish children.* ***Study design:*** *This retrospective was carried out using a total of 275 CBCT images from child and adolescent patients were randomly selected from existing records in the Department of Oral and Maxillofacial Radiology at the University of Erciyes, Kayseri, Turkey. The mental foramen (MF) and AMF were assessed on axial, sagittal, and coronal CBCT slices.* ***Results:*** *The mean age was 10.51 ± 3.32 years, consisting of 139 males (mean age 10.64 ± 3.42) and 126 females (mean age 10.38 ± 3.18). Twenty-one AMFs were observed in 18 of 275 patients (6.5%, 10 boys and eight girls). There was no significant difference in gender in relation to the prevalence of AMF (p = 0.65). The mean area of the 21 AMFs and the MF on the side with the AMF were 0.7 mm^2 (SD ± 0.5) and 3.8 mm^2 (SD ± 2.2), respectively.* ***Conclusion:*** *It is important to stress that detecting the AMN using CBCT with 3D reconstructions may reduce the risk of paralysis, hemorrhage, and postoperative pain in this region. Our study presents the first report assessing the occurrence, diameter, and location of the AMF in the pediatric population using CBCT images. In this respect, not surprisingly, the mean size of the AMF of our population is smaller than other reports in the literature that involve adult populations.*

Key words: Accessory mental foramen, location, cone beam, anesthesia.

INTRODUCTION

The mental foramen (MF) allows one of the terminal branches of the inferior alveolar nerve to exit the mandibular body on each side. These innervate the lower lip, the mucous membrane, and gingiva as far posterior as the molar region.[1] The location and configuration of the MF and mandibular canal are important considerations in local anesthesia, endodontic treatments, and surgical procedures related to this region, such as genioplasty, mandibular rehabilitation after trauma, mandibular anterior segmented osteotomy, and dental implant application.[1]

From the Faculty of Dentistry. Erciyes University, Kayseri, Turkey.
*Kenan Cantekin, DDS, PhD, Assistant Professor, Department of Pediatric Dentistry.
**Ahmet Ercan Şekerci, DDS, PhD Assistant Professor, Department of Oral and Maxillofacial Radiology.

Send all correspendence to

Kenan Cantekin Department of Pediatric Dentistry, Faculty of Dentistry, Erciyes University, Kayseri, Turkey

Phone: +90.352 4374937-29254

Fax : + 90 352 438 06 57

E-mail: k_cantekin@hotmail.com

The locations of the MF and the mandibular canal are essential to performing effective nerve blocks. These anatomical landmarks and their surrounding structures must be identified preoperatively before root canal treatment of premolar and molar teeth and surgical procedures to avoid injuries, which could lead to undesirable events, such as paresthesia and hemorrhage.

However, the presence of foramina identified as the accessory mental foramen (AMF) in the surrounding area of the MF has been discovered.[2] The AMF is defined as smaller foramina, which show continuity with the mandibular canal. This possible supplementary innervation may explain the failure of inferior alveolar or mental injections to obtain deep anesthesia of the mandibular incisor in many instances.[3] Therefore, defining the AMF using cone-beam computed tomography (CBCT) images may reduce the rates of failure of inferior nerve injection, post-operative pain, paralyses, and hemorrhage in surgical procedures of mental and cheek regions in pediatric patients.

Conventional two-dimensional (2D) radiographs, such as periapical and panoramic, are the most common imaging modalities in dental practice, but they often fail to depict the AMF through the long axis, which is usually less than 1.5 mm. However, presurgical three-dimensional (3D) assessment with CBCT allows for accurate evaluation of the AMF and other anatomical structures in the maxillofacial region.[4-8-8]

Thus far, several reports have been presented to locate and measure the AMF using different radiological techniques in several adult populations, as visualized on panoramic[4,9-17] or CBCT images.[1,18,19] However, no studies have been found that describe the occurrence and characteristics of the AMF using CBCT or conventional 2D radiographs in the pediatric population. The aim of the present study was to clarify the occurrence, diameter, and location of the AMF using CBCT images from a sample of Turkish children.

MATERIALS AND METHOD

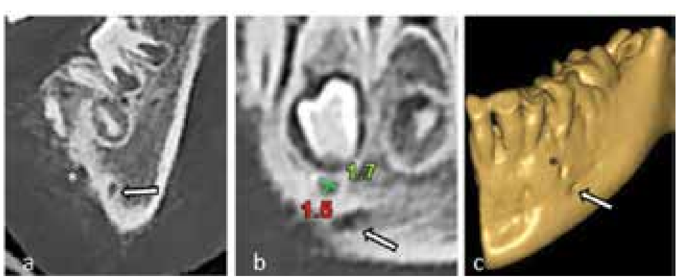
A sample of 312 CBCT images from child and adolescent patients were randomly selected from existing records in the Department of Oral and Maxillofacial Radiology at the University of Erciyes, Kayseri, Turkey.

Next, selected cases were independently reevaluated by the two examiners to diagnose and classify them into different abnormality subtypes, such as congenital changes, malignant and benign tumors, odontogenic lesions, bone-related lesions, traumatic lesions (bony fractures), and inflammatory lesions (mucosal thickening, retention cysts, opacities, sinus polyps, and antroliths). Data were gathered and disagreements between the examiners were solved by reaching a consensus.

The cone-beam images were acquired using a NewTom 5G flat panel CBCT machine (Quantitative Radiology, Verona, Italy). To establish a consistent orientation in the images, each patient was placed in a horizontal position, such that the Frankfort horizontal plane (the plane between the highest point of the external auditory canal's opening and the orbit's lowest point) was perpendicular to the table, with the head within the circular gantry housing the x-ray tube. The x-ray tube detector system performed a 360° rotation around each patient's head, with a scanning time of 36 seconds. The scanner operated with a maximum output of 110 KV and 15 mAs, a 0.16 mm voxel size and a typical exposure time of 5.4 seconds. The QR-NNT software version 2.21 (Quantitative Radiology) was used to analyze the images. Approval from the ethics committee was not required for this retrospective study. All images were scored by two well-trained dental specialists. Evaluated landmarks are denoted in Figure 1.

Selection criteria included the following: (1) Turkish children and adolescents aged between two and 15 years; and (2) high quality images (0.3 voxel protocol on CBCT). Exclusion criteria included the following: (1) subject of unknown age; (2) subject with some pathological and/or developmental conditions (i.e., tumors, cysts, or malformations); and (3) subject who had suffered significant head trauma, which potentially affected visualization of examined area.

Figure-1: Sagittal (**A**), coronal (**B**) and 3-D (**C**) CBCT view of a 5-year old boy patient depicting the accessory mental foramen(asterisk) and mental foramen (arrows). **Figure-1(B)** is also showing an example of vertical and horizontal measurements of the accessory mental foramen.



One film was excluded due to unknown chronological age, and 36 films were excluded for pathological conditions and trauma. The final sample, therefore, consisted of 275.

All 275 patients had been referred for CBCT diagnosis and treatment planning, and consisted of 29 impacted teeth patients, 178 orthodontic patients, 28 possible pathosis patients, 18 supernumerary teeth patients, and 22 temporomandibular joint (TMJ) disorder patients (Table 1).

The MF and AMF were assessed on axial, sagittal, and coronal CBCT slices (**Figure 1A, B and C**). The differentiation between the AMF and MF was based on their diameters; that is, the smallest represented the AMF, and the largest represented the corresponding MF. The distance between the center of the AMF and the MF was measured in the sagittal CT images (**Figure 1A**). In addition, the long (a) and short (b) axes of each AMF and MF were measured to calculate the elliptic area using the following formula (**Figure 1B**):

$$A = \frac{\pi . a . b}{4}$$

To assess reliability, 40 (15%) randomly selected radiographs were re-examined 7 days after the initial examination by the same observers to determine intra-observer agreement.

Statistical Analysis

All calculations were processed using the Statistical Package for the Social Sciences (SPSS) statistical software, version 16 (SPSS Inc., Chicago, Illinois). The Kolmogorov-Smirnov test was used to test the normality of distribution of the AMF. The chi-square test was used to determine the potential differences in the distribution of lesions as stratified by gender, and the Mann–Whitney U test was used to evaluate the relationship between the vertical size of the MF and the presence of AMFs. The kappa and paired *t*-test were also used to assess inter- and intra-examiner consistency, respectively; $p < 0.05$ was considered statistically significant for each test.

Table 1: Description of the 275 of subjects and their indications for cone beam CT (CBCT) referral

Age (years)	
Gender (n)	10.51 ± 3.32
Boy	167
Girl	145
Reason for Scan	**No of Subjects**
Impaction localization	19
Orthodontic records	178
Other possible pathosis	28
Supernumerary teeth localization	18
TMJ assessment	22

Table 2. Distribution of AMF and characteristics of AMF observed children.

Gender	Age			Localization		Side	
	Mean	SD	Range	Anterior	Posterior	Right	left
Boy (n=139)	10.64	3.42	3-15	6	5	7	4
Girl (n=126)	10.38	3.18	4-15	6	4	7	3
Sum (n=275)	10.51	3.32	3-15	12	9	14	7

Table 3. The area of AMF and the distances between the AMF and MF as well as AMF and MC.

		Range	Mean	SD
Distance	AMF-MF	1.1-3.8	1.86	0.80
	AMF-MC	1.1-5.8	2.84	**1.1**
Area	AMF	**0.3-2.4**	0.7	**0.5**
	MF	**1.7-5.6**	3.8	2.2

Table 4. Characteristics of AMF in the literature.

	Author (year)	Patients (N)	Number of sides	Gender (M/F)	Mean Age	AMF N	AMF %	Image
Adult populations	Katakami *et al*, 2008 [25]	150	300	–	–	17	5.7	CBCT
	Naitoh *et al*, 2009 [8]	84	168	27/57	52.1	7	8.3	CBCT
	Naitoh *et al*, 2009 [28]	157	314	48/109	51.5	11	7.0	CBCT
	Naitoh *et al*, 2011 [26]	365	730	130/235	51.7	37	7.7	CBCT+RPR*
	Kalender *et al*, 2011 [27]	193	386	92/101	38.6	32	6.5	CBCT
	Sisman *et al*, 2012 [1]	504	1008	307/197	39.73	14	2	CBCT
Pediatric population	Present study	275	550	139/126	10.51	21	6.5	CBCT

*RPR: rotational panoramic radiography.

RESULTS

The kappa statistics indicated excellent agreement for the observations of the anatomical landmarks as compared to the expert consensus statement. Kappa values were 0.99 and 0.10 for the AMF and MF, respectively. In addition, repeated scorings of a sub-sample of 40 radiographs indicated no significant intra-observer difference ($p > 0.05$). Intra-observer consistency was rated at 100%.

The mean age was 10.51 ± 3.32 years, consisting of 139 males (mean age 10.64 ± 3.42) and 126 females (mean age 10.38 ± 3.18). Twenty-one AMFs were observed in 18 of 275 patients (6.5%, 10 boys and eight girls). There was no significant difference in gender in relation to the prevalence of AMF ($p = 0.65$). Of the cases with AMF, six were bilateral and 15 were unilateral: 14 (66.6%) on the right and seven (33.3%) on the left (Table 2). Statistically significant differences were found between right- and left-sided AMF ($p < 0.01$).

There was no statistically significant difference in mean age between patients with AMF (10.54 ± 3.43 years) and those without (10.50 ± 3.19 years) ($p = 0.95$). Twelve AMFs (57.1%) were located in the anterior region, and nine (42.9%) in the posterior region. Nineteen of the AMFs were located in the inferior region and two AMFs were located in the superior region. Two AMFs had a connection with the anterior loop of the MF, and six AMFs had a direct connection with the mandibular canal at the posterior side of the MF.

The distance between the AMF and the MF ranged from 1.1 to 3.8 mm, with a mean of 1.86 mm (SD ± 0.8 mm). The distance between the AMF and the mental canal ranged from 1.1 to 5.8 mm, with a mean of 2.84 mm (SD ± 1.1 mm). The mean area of the 21 AMFs and the MF on the side with the AMF were 0.7 mm^2 (SD ± 0.5) and 3.8 mm^2 (SD ± 2.2), respectively (**Table 3**). Twelve and 9 of the AMFs were located in the distal and mesial region of the MF, respectively.

DISCUSSION

This is the first study to systematically evaluate the prevalence of AMF, as well as their diameter, distance to the MF, and location in relation to the MF in the teeth of a pediatric population using CBCT images.

Defining the anatomical characteristics of the MF region plays an important role in successful anesthesia and surgical procedures. An accessory foramen located in the region surrounding the MF and showing a connection with the mandibular canal is defined as the AMF and is believed to relate to the mental nerve.[1] In patients with an AMF, an accessory mental nerve (AMN) may be present as well; considered a branch of the inferior alveolar nerve, its presence can cause anesthetic and surgical failure. In addition, disturbances of the AMNs may occur as a result of surgical procedures, which can potentially lead to sensory complications in the mental and cheek regions.[19]

Several factors contribute to the reliability of landmark identification in children: the density and sharpness of images, the anatomic complexity and superimposition of hard and soft tissues, the definition of the landmark, and the training level or experience of the observers.[20,21] On the other hand, CBCT in dentistry has provided an imaging solution that has neither the projection errors associated with magnification nor the superimposition problems associated with traditional panoramic imaging.[22] In addition, CBCT has a wide range of tools, such as 3D reconstructions in any direction to permit accurate identification of landmarks. Studies have reported excellent accuracy with 3D computed tomography (CT).[23,24] Using CBCT (3D) in our study, identification of the AMF reflected a real clinical situation.

Previous studies have reported AMF frequency ranging from 2.0% to 8.3% based on CBCT images. [1,8,25-28] In the present study, a total of 21 AMFs were detected in 18 of the 275 patients, and the frequency rate was found to be 6.5%, which is similar to rates generally reported in previous studies (**Table 4**). In addition, there was no statistically significant difference between males and females in relation to the prevalence of AMF in the present and previously published studies ($p > 0.05$). Furthermore, we found no significant difference in mean age between patients with AMF and those without ($p > 0.05$).

The mean distance between the MF and AMF was found to be 5.0, 5.2, and 6.3 in different studies performed by Sisman *et al*,[1] Kalender *et al* ,[27] and Naitoh *et al*,[8] respectively. In the present study, the distance between the MF and AMF ranged from 1.1 to 3.8 mm, with a mean of 1.86 mm (SD: 0.8 mm), which is considerably lower than those reported in previous studies. The mean diameter of the AMF in the present study was 0.7 mm^2 (SD ± 0.5), lower than previous studies that reported the mean diameter of the AMF ranging from 0.9 to 1.7 mm^2 in different adult populations.[1,8,19,25,26]

The location of the AMF in relation to the MF was reported by Katakami *et al*,[25] Naitoh *et al* ,[8] and Sisman *et al* [1] The first two studies reported that the majority of AMFs were located in the distal region of the MF. Only one of 17 and three of 15 AMFs were located at the mesial region in those reports. On the contrary, Sisman *et al*[1] reported that the mesial-distal ratio (mesial: 6, distal: 8) in their study was close, which is similar to the rates in the present study. We found that nine of 21 AMFs were located in the mesial region of the MF. In addition, there is a total consensus between the present study and previous studies in regards to the location of the AMF in relation to the vertical position of the MF. The majority of AMFs were located in the inferior region in previous studies, as well as in the present study.[1,8,25]

On the other hand, although the radiation doses from CBCT are significantly lower than in medical CT, they are generally higher than conventional dental radiography.[29] Recently, the SEDENT-EXCT working group proposed provisional evidence-based selection criteria with clinical indications regarding when CBCT should be performed.[29] CBCT should only be used when the clinical question cannot be answered by conventional radiography, and the field of view (FOV) should be limited to the region of interest.[30] Ideally, CBCT equipment should be able to offer a choice of volume sizes to reduce patients' radiation exposure levels. A risk-benefit analysis must be performed on each individual patient when CBCT is being considered. In order to assess the risk of CBCT, the effective dose must first be calculated as well.

CONCLUSION

Although the presence and location of accessory buccal foramina and their neurovascular structures are important during surgical procedures involving the area surrounding the MF, the presence of AMFs in the mandible is frequently overlooked in clinical procedures. It is important to stress that detecting the AMN using CBCT with 3D reconstructions may reduce the risk of paralysis, hemorrhage, and postoperative pain in this region. In the present study, the frequency of AMFs is similar to rates generally reported in previous studies. Our study presents the first report assessing the occurrence, diameter, and location of the AMF in the pediatric population using CBCT images. In this respect, not surprisingly, the mean size of the AMF of our population is smaller than other reports in the literature that involve adult populations.

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