Accessory Mental Foramen: A Review of the Literature and A Study in A Taiwanese Population

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Abstract: The inferior alveolar nerve and its branches are critical when performing oral surgical procedures in the posterior mandibular area. Any injury to the nerve bundles may lead to ineffectiveness of local anesthesia, paresthesia and numbness. The purposes of this study were to investigate the prevalence, location, and dimension of accessory mental foramen (AMF) in a Taiwanese population. Cone-beam computed tomography (CBCT) images of 100 patients were analyzed to identify AMFs. AMFs were observed in 6% of patients, including 3 males and 3 females (mean age: 55.0 ± 9.7 years). All AMFs were unilaterally located between the second premolar and the first molar. The mean diameter of the AMFs was 1.4 ± 0.2 mm. Therefore, clinicians should be aware of anatomical structures such as AMFs during surgical procedures over the posterior mandibular region. CBCT is a useful pre-surgical assessment tool for developing appropriate treatment plans and reducing neurovascular complications.

Introduction

The inferior alveolar nerve which is a branch of the mandibular division of the trigeminal nerve enters the mandibular foramen and extends forward in the mandibular canal. The inferior alveolar nerve is divided into the mental and incisive nerves. The mental nerve branches upward through the mental foramen (MF) and exist to the lateral mandible. Furthermore, the mental nerve is divided into several branches of nerves that supply the sensation to the skin of the mandible, the skin of the lower lip, and the gingiva[1]. However, the mandibular canal and MF might have anatomical variations, such as bifurcation[2,3,4] or multiple foramina[5,6]. Therefore, comprehensive pre-surgical radiographic examinations are indicated to avoid injury of the nerve during surgeries.

Regarding the term and definition of openings other than the MF, Sutton[7] described openings other than the MF in the lateral wall of the mandible as accessory mental foramina (AMFs). Naitoh et al.[8] defined AMF as the opening that is smaller than the MF in the cone-beam computed tomography (CBCT) images and shows continuity with the mandibular canal, whereas the buccal foramen that shows discontinuity with the mandibular canal is considered as a nutrient foramen. The definition of AMF proposed by Naitoh et al.[8] has been applied in a number of studies using CBCT[9–12] or dry mandibles[13] to analyze AMFs.

To assess the distributions of nerves and vessels in AMF, Iwanaga et al.[12] examined 63 mandibles with overlying soft tissue by using CBCT. A total of 20 AMFs were observed. The anatomy of these foramina was subsequently examined through dissection. The result revealed the existence of only nerves in 15 of the 20 AMFs, only vessels in 4 AMFs, and both nerves and vessels passing in 1 AMF. The nerves in AMFs derived from the angular branch, lateral labial branch, medial inferior labial branch, lateral inferior labial branch, and mental branch. The existence of AMFs increases the difficulty and risk of complications of oral surgeries[4,14–17]. Von Arx et al.[15] performed apical surgeries in 4 patients; these patients consented to biopsy of soft tissue bundles around the AMFs during the surgical process. These bundles were histologically examined and the results showed the existence of nerve tissues in the soft tissue bundles. One patient reported numbness in the lower lip and chin following surgery. The numbness had completely disappeared one year after surgery; however, a slight paresthesia was still noted over the buccal mucosa of the premolars. Concepcion and Rankow[14] performed apical surgery on the area adjacent to the AMF. The patient experienced mild tingling in the corner of the lower lip that persisted for 3 weeks after surgery. Complete recovery was observed 4 months after surgery.

Therefore, examinations before mandibular surgery should focus on not only the anatomy of the mandibular canal and MF, but also the existence of AMFs. To the best of our knowledge, there are no available reports to analyze the AMFs in a Taiwanese population. Moreover, CBCT can offer delicate three-dimensional (3D) images to evaluate the anatomic structures of the jaw bone. Therefore, the purposes of the present study were to assess AMFs using CBCT images in the Taiwanese population.

Materials and Methods

This study assessed images of Taiwanese patients who underwent CBCT examinations in Taipei Veterans General Hospital from April 2014 to October 2015. The exclusion criteria were as follows: (1) images of patients younger than 20 years old; (2) blurry images; and (3) presence of any pathological conditions in the area of the MF or AMF (i.e., cysts, tumors, or fractures). This study was approved by the Institutional Review Board of Taipei Veterans General Hospital (IRB No. 2017-06-011 CC).

The settings of CBCT (NewTom 5G, QR S.r.l., Verona, Italy) were as follows: 110 kV, 6.23 mA, and 0.15-mm-thick axial slices. SmartIris software (Taiwan Electronic Data Processing Co., New Taipei City, Taiwan) was adopted for analysis. Reconstructed 3D images of patients with more than one foramen in the mandibular area were selected (Figures 1A and 2A). AMF was defined, according to Naitoh et al.[8], as a buccal foramen other than the MF and had continuity with the mandibular canal. The differentiation between the MF and AMF was according to the diameters. The larger foramen was defined as the MF and the smaller one was represented as the AMF. All images were evaluated by a single periodontist (WC Lai).

Furthermore, NNTViewer software (QR S.r.l., Verona, Italy) was used to confirm the continuity of the foramina and mandibular canal from the axial, panoramic, sagittal, and cross-sectional images (Figures 1B and 2B). A section was selected from these images, and the suspect branch of the mandibular canal was traced with the marker tool of the NNTViewer software (Figures 1C and 2C). The marker could be reported simultaneously in other images. Therefore, we could confirm the branch of the mandibular canal passes through the mandibular lateral wall (Figures 1D and 2D)

The location of the AMF relative to the teeth was recorded. If the posterior teeth of the mandibular area were missing, a surgical stent was fabricated. The patient wore the surgical stent during CBCT scanning. The diagnostic wax-up of the stent was used as reference of the tooth position to evaluate the location of the AMF relative to the tooth. Subsequently, the location of the AMF relative to the MF was analyzed. Two horizontal lines which were parallel to the occlusal plane were drawn passing through the upper and lower edges of the MF on the reconstructed 3D image. Two vertical lines perpendicular to horizontal lines were drawn on the mesial and distal sides of the MF, with the MF as the center dividing the location of the AMF relative to the MF into eight regions: Anterosuperior, anterior, anteroinferior, superior, inferior, posterosuperior, posterior, and posteroinferior. The diameters of the AMF and the ipsilateral MF were determined by measuring the maximum dimensions using the axial and cross-sectional images.

The statistical software (SPSS v. 21.0, IBM Corporation, Armonk, NY, USA) was adopted for data analysis. Descriptive statistics, expressed as the mean ± standard deviation, were applied to describe age and the diameters of the AMF and the ipsilateral MF.

Results

This study selected images of 100

patients with 53 males and 47 females (mean age: 52.9 ± 13.8 years). Thirteen patients had additional foramina other than the MF in the buccal bony plate. Seven patients without discontinuity between the foramina and the mandibular canal were excluded. In total, 6 patients (3 males and 3 females) had AMF with a mean age of 55.0 ± 9.7 years. The prevalence of AMF was 6.0%. All cases had unilateral and single AMF. Four patients had AMFs on the right side and 2 patients had AMFs on the left side.

The mean diameters of the AMFs and the ipsilateral MF were 1.4 ± 0.2 mm and 2.2 ± 0.7 mm, respectively. AMFs were located in the apical area of the second premolar and the first molar. Regarding the locations of AMFs corresponding to the MFs, 3 AMFs were located superior to the MF, and 3 AMFs were located posteroinferior to the MF (Table 1).

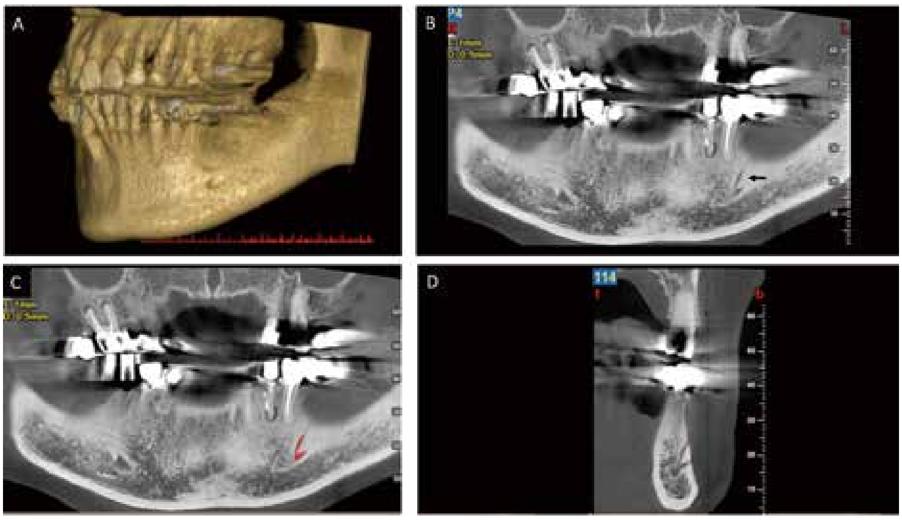

Figure 1. Cone-beam computed tomography analysis of Case 1

(A) Reconstructed 3D image showing 2 foramina at the apex of the first molar on the left side of the mandible. (B) Panoramic image revealing the branches of the mandibular canal (arrow). (C) Red line marking the branches of the mandibular canal on a panoramic image in the software analysis. (D) Cross-sectional image confirming the branches of the mandibular canal passing through the lateral wall of the mandible.

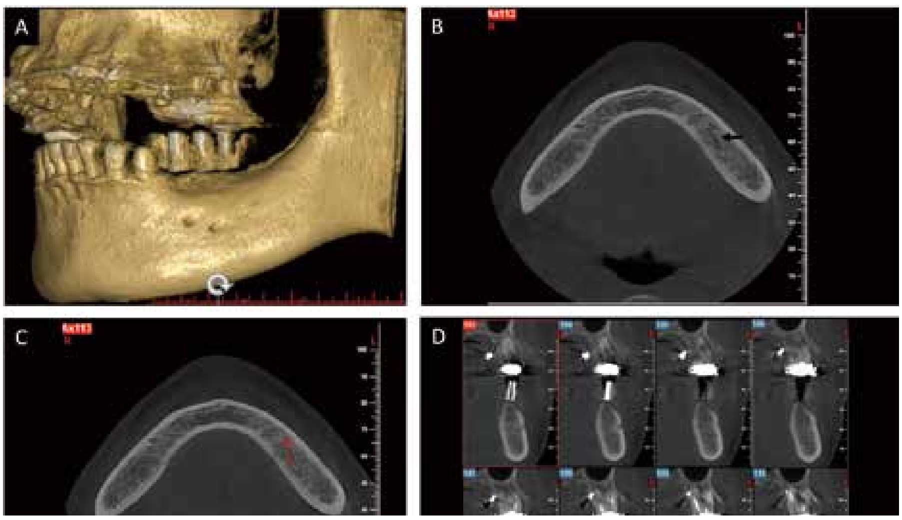

Figure 2. Cone-beam computed tomography analysis of Case 3

(A) Reconstructed 3D image showing 2 foramina at the apex of the first molar on the left side of the mandible. (B) Axial image revealing the branches of the mandibular canal (arrow). (C) Red line marking the branches of the mandibular canal on an axial image in the software analysis. (D) Cross-sectional image confirming the branches of the mandibular canal passing through the lateral wall of the mandible.

Discussion

The prevalence of AMF in this study was 6.0%, 3 males and 3 females. Two AMFs were on the left side and 4 AMFs were on the right side. Previous studies using CBCT analysis have reported the prevalence of AMF ranges between 3.0% to 13.1%[8–11,18–24] (Table 2). The prevalence of AMFs of some studies was not correlated to age[22], gender[8,11,21,24], and the side of the mandible[11,21]. Muinelo-Lorenzo et al.[21] examined CBCT images of 334 patients. AMFs were observed in 45 patients. Of patients with AMFs, 40.0% were males and 60.0% were females. In total, 48 AMFs were observed unilaterally, with 20 AMFs on the left side and 28 AMFs on the right side. Three patients had 2 AMFs. The existence of AMF was not significant difference related to gender or side of mandible. In contrast, some studies have found that there was statistically significant difference in prevalence of gender[22,23] and side of mandible [22]. Han et al.[23] examined 446 Korean patients and 39 AMF were observed in 36 patients. Among patients with AMFs, 71.8% were males and 28.2% were females. 13 patients had an AMF on the left side and 20 patients had an AMF on the right side. The prevalence of AMF in males was significantly higher than that in females. Li et al.[22] examined CBCT images of 784 Chinese patients. 66 AMFs were observed in 57 patients, 57.9% were males and 42.1% were females. The presence of AMFs was significantly higher in males

Table 1. The results of cone-beam computed tomography evaluation of the present study

Case	Gender	Age (years)	Side of mandible	Diameter of ipsilateral MF (mm)	AMF Diameter (mm)	AMF Location related to tooth	AMF Location related to MF
1	Male	72	Left	1.3	1.2	First molar	Superior
2	Female	45	Right	2.1	1.3	Second premolar	Postero-inferior
3	Male	54	Left	1.6	1.5	First molar	Postero-inferior
4	Female	46	Right	2.2	1.3	Second premolar	Superior
5	Female	57	Right	2.4	1.7	Second premolar	Postero-inferior
6	Male	56	Right	3.3	1.5	Second premolar	Superior
Mean ± SD		55.0 ± 9.7		2.2 ± 0.7	1.4 ± 0.2		

AMF: accessory mental foramen; MF: mental foramen

Table 2. Studies of cone-beam computed tomography evaluations of prevalence of accessory mental foramen

Authors	Country	Sample size (Male/Female)	Age (years)	AMF (%)	Left/Right (n)
Katakami 2008[9]	Japan	150	-	10.7	-
Naitoh 2009[8]	Japan	157 (48/109)	51.5 ± 14.9	7.0	6/9
Oliveira-Santos 2011[19]	Brazil	285 (133/152)	-	9.4	11/14
Naitoh 2011[18]	Japan	365 (130/235)	51.7 ± 15.1	7.7	-
Kalender 2012[11]	Turkey	193 (92/101)	38.6 ± 15.8	6.5	15/12
Imada 2014[10]	Brazil	100 (34/66)	40.9	3.0	2/2
Muinelo-Lorenzo 2015[21]	Spain	334 (139/205)	47.4 ± 15.5	13.1	20/28
Han 2016[23]	Korea	446 (217/229)	41.0	8.1	13/20
Zmyslowska-Polakowsk 2017[24]	Poland	200 (105/95)	54.5 ± 10.8	7.0	13/15
Li 2018[22]	China	784 (305/479)	34.0 ± 15.1	7.3	16/45
Present study	Taiwan	100 (53/47)	52.9 ± 13.8	6.0	2/4

AMF: accessory mental foramen

than females. The percentages of AMFs on the left and right sides were 26.2% and 73.8%, respectively.

Regarding ethnicity, Sawyer et al.[25] investigated the prevalence of AMFs in dry mandibles in different ethnic groups. The prevalence of AMFs was 5.7% of African Americans, 9.0% of Pre-Columbian Nazca Indians, 1.5% of Asian Indians, and 1.4% of American White. In studies of CBCT evaluations, the prevalence of AMFs was 7.3% in the Chinese population[22], 8.1% in the Korean population[23], 7% in the Polish population[24], and 6.5% in the Turkish population[11]. In the present study, the prevalence of AMF in the Taiwanese population was 6.0%.

In the present study, a total of 6 AMFs was observed on CBCT images. All of the patients have unilateral and single AMF. According to previous studies, most AMFs were unilateral; bilateral single AMF or unilateral multiple foramina were rare[8,22,23]. Naitoh et al.[8] observed bilateral AMFs in 2 of 11 patients. Out of 57 AMF patients, Li et al.[22] found 4 patients with bilateral AMFs and one with 2 ipsilateral AMFs. Han et al.[23] reported 36 patients with AMF and only 3 patients with bilateral AMF, accounting for 0.7% of the total number of AMFs observed.

The results of studies about the location of the AMF related to the MF were inconsistent. Some studies have analyzed the locations of AMFs anteriorly or posteriorly relative to the MF[24,26]. Zmyslowska-Polakowsk et al.[24] observed CBCT images of 200 patients. The results showed that 71.4% of AMFs were located anteriorly and 28.6% were posteriorly to the MF. Cantekin et al.[26] examined CBCT images of 265 Turkish children and 21 AMFs were found. 42.9% of AMFs were located anteriorly and 57.1% were posteriorly to the MF. Several studies[9,11,12,22,23] and the present study have divided the locations of AMFs relative to the MF into 8 regions: posterosuperior, posterior, posteroinferior, superior, inferior, anterosuperior, anterior, and anteroinferior. Regarding the most frequent location of an AMF relative to the MF, Katakami et al. reported that 59.0% of AMFs were posterior to the MF[9]; Kalender et al. found that 37.0% of AMFs were anteroinferior to the MF[11]; Han et al. found that 28.0% of AMFs were anterosuperior to the MF[23]; Li et al. found that 30.3% of AMFs were posteroinferior to the MF[22]; and Iwanaga et al. found that most of the AMFs (35.0%) were posterosuperior to the MF[12]. The present study showed that

Table 3. Studies of the locations of accessory mental foramina relative to the teeth and mental foramen

Authors	Location related to teeth	Most frequent location related to MF (%)
Katakami 2008[9]	Between first premolar and first molar	Posterior (59%)
Naitoh 2009[8]	-	Posteroinferior (60%)
Kalender 2012[11]	-	Anteroinferior (37.0%)
Sisman 2012[20]	-	Posteroinferior (35.8%)
Cantekin 2014[26]	-	Posterior (57.1%)
Imada 2014[10]	Between first and second premolars	Superior (50%)
Han 2016[23]	Between first and second premolars	Anterior (50%)
Zmyslowska-Polakowsk 20172[4]	-	Anterosuperior (28.8%)
Li 2018[22]	Between first and second premolars	Anterior (71.4%) Posterior (28.6%)
Iwanaga 2016[12]	Between first premolar distally and first molar mesially	Posteroinferior (30.3%)
Present study	Between second premolar and first molar	Superior (50%) Posteroinferior (50%)

MF: mental foramen

Table 4. Studies of the sizes of accessory mental foramina and the mental foramen

Authors	AMF (mm)	MF (mm)
Naitoh 2009[8]	1.9 ± 0.6	3.8 ± 0.9
Oliveira-Santos 2011[19]	1.95 ± 0.75	3.83 ± 0.65
Sisman 2012[20]	1.4 ± 0.4	-
Imada 2014[10]	0.93 ± 0.29	2.34 ± 0.4
Muinelo-Lorenzo 2015[21]	Long diameter: 1.80 ± 0.66 Short diameter: 1.12 ± 0.31	Long diameter: 4.01 ± 1.20 Short diameter: 2.66 ± 0.77
Han 2016[23]	H: 1.54 ± 1.41, V: 1.44 ± 0.41	-
Li 2018[22]	H: 1.38 ± 0.47, V: 1.23 ± 0.37	-
Katakami 2008[9]	H: 1.6, V: 1.2	H: 3.5, V: 2.6
Kalender 2012[11]	Male H: 1.5, V: 1.4 Female H: 1.5, V: 1.3	Male H: 2.8, V: 3.6 Female H: 3.5, V: 3.3
Present study	1.4 ± 0.2	2.2 ± 0.7

AMF: accessory mental foramen; MF: mental foramen; H: horizontal direction; V: vertical direction

50.0% of AMFs were superior to the MF and 50.0% of AMFs were posteroinferior to the MF.

By analyzing the location of AMFs relative to the teeth, the most frequent location was between premolars and first molars. The present study found 4 AMFs were located at the apex of the second premolar and 2 AMFs were located at the apex of the first molar. Imada et al.[10], Han et al.[23], and Li et al.[22] reported AMFs located between the premolars. Imada et al.[10] examined CBCT images of 100 patients, and reported 4 AMFs between the premolars. Han et al.[23] found 35.9% of AMFs were between the premolars. Li et al.[22] identified AMFs mostly in the apex of the first and second premolars. Katakami et al.[9] and Iwanaga et al.[12] found that AMFs were located between the first premolar and the first molar. (Table 3)

Regarding studies on the size of AMFs, Imada et al.[10] revealed that the mean AMF size was 0.93 mm and the mean ratio between the size of the AMF and the ipsilateral MF was 0.4. Oliveira-Santos et al.[19] examined AMFs on CBCT images, selecting only those greater than 1 mm as AMFs; the mean size of the AMF was 1.9 ± 0.7 mm and the ratios between the size of the AMF and the ipsilateral MF ranged between 0.24 and 0.99. Han et al.[23] and Li et al.[22] measured the sizes of AMFs in the horizontal and vertical directions. The results showed 1.54 ± 1.41[23] and 1.38 ± 0.47[22] mm in the horizontal direction and 1.44 ± 0.41[23] and 1.23 ± 0.37[22] mm in the vertical direction. Katakami et al.[9] reported the horizontal and vertical sizes of AMFs were 1.6 mm and 1.2 mm. The horizontal and vertical sizes of MF were 3.5 mm and 2.6 mm. When comparing MF with AMF, there was no significant correlation on the horizontal and vertical sizes. Zmyslowska-Polakowsk et al.[24] compared the vertical size of the MF on the sides with and without an AMF and found no significant difference regardless of the presence of AMFs. Conversely, Muinelo-Lorenzo et al.[21] measured the maximum and minimum sizes of AMFs, which were 1.80 ± 0.66 and 1.12 ± 0.31 mm, respectively, and the size of the MF on the side without an AMF was 4.47 ± 1.12 mm, which was significantly larger than the MF on the side with an AMF (4.01 ± 1.20 mm). Additionally, the size of the MF and the presence of an AMF were significantly correlated. Kalender et al.11 measured the horizontal and vertical sizes of AMFs and the MF. The results revealed that the size of the MF in males was significantly larger than that in females. However, no significant correlation was found between gender and the size of AMFs. In the present study, the mean maximum diameter of AMFs was 1.4 ± 0.2 mm, ranging between 1.2 and 1.7 mm, which is similar to that of previous studies[9,11,22,23]. The mean maximum diameter of the ipsilateral MF was 2.2 ± 0.7 mm. (Table 4)

Imada et al.[10] compared the prevalence of AMFs on CBCT and digital panoramic (PAN) images. They did not observe AMFs on PAN images, whereas AMFs were found on CBCT images (3.0%). Katakami et al.[9] observed 17 AMFs on CBCT images but not on PAN images. Naitoh et al.[18] compared the distribution of AMFs on PAN and CBCT images, observing 37 AMFs on the CBCT images and only 18 AMFs on PAN images (48.6% of CBCT). Muinelo-Lorenzo et al.[21] found that 45.83% of the AMFs and 83.87% of the MFs identified on CBCT were also visible on PAN images. The authors reported that factors influencing the observation of the MF on PAN images were MF diameter, shape, exit angle, and age. In the present study, the AMFs could not be detected on PAN images (data not shown) while 6 AMFs were observed on CBCT images. Therefore, the 3D CBCT images are more helpful to detect AMFs compared with 2D PAN images.

Conclusion

The present study demonstrated that the prevalence of AMFs was 6.0%, with considerable variations in the location of AMFs relative to the MF. AMFs were found between the apex of the second premolar and the first molar in the mandible. Therefore, CBCT offers delicate images to confirm the existence and anatomic structure of AMFs, which facilitates the establishment of appropriate treatment plans and reduces the possibility of postoperative complications.

中文摘要

下顎後牙手術如涉及下齒槽神經及其分支或解剖變異，可能會有局部麻醉效果不佳與顏面感覺異常、麻木等併發症。本研究的目的為觀察臺灣族群副頦孔的盛行率、分布的位置與孔洞的大小，共分析 100 位患者的錐狀射束電腦斷層影像，副頦孔盛行率為 6.0%，其中男性 3 人，女性 3 人，平均年齡為 55.0 ± 9.7 歲，皆發生於單側，且為單個副頦孔，分布於第二小臼齒至第一大臼齒間，副頦孔孔洞大小平均為 1.4 ± 0.2 毫米。因此，於下顎後牙手術應注意副頦孔等解剖構造，而錐狀射束電腦斷層影像為一良好的術前診斷工具，有助於訂定妥善的治療計畫與降低術後併發症的發生。

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