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REVIEW ARTICLE

INCIDENCE OF ACCESSORY MENTAL FORAMEN AND ITS CLINICAL SIGNIFICANCE – A REVIEW

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ABSTRACT

The accessory mental foramen (AMF) is a type of mandibular variation which transmits extra neurovascular branches, a fact with great importance in dental and surgical procedures. Its range and features do vary between populations, which is why broad based knowledge is required to which out to avoid issues like nerve injury or anesthesia failure. We did this review to look at the anatomical features, that is size and location of AMFs, their global prevalence, and what clinical use they have, and how they play a role in dental practice and forensics.
A systematic literature search was conducted using PubMed, Scopus, and Web of Science databases for studies published in the past five years. Keywords included: Accessory mental foramen (AMF), Bucal foramen, Mental foramen, Mandible, Dental surgery. The review was conducted in accordance with the PRISMA guidelines.
We did a thorough search of the literature looking at AMF prevalence, morphology and clinical implications across many populations. We looked at studies done on dry mandibles, radiographic reports and at what Cone-Beam Computerized Tomography (CBCT) shows. Also, we put together key studies which we looked at to present prevalence rates, types of variation in anatomy and diagnostic methods. AMF's range from 1% to 10% worldwide, we see higher rates in South Asian groups at 6 to 8.9% as compared to Iranian at 2 to 3% or Bosnian at 2.7%. AMFs are small, oval and are found near the first molar or second premolar. CBCT does a better job in detecting these as compared to panoramic x rays, also morphological studies give very precise measurements although may not see the smaller AMFs. The presence of AMFs reports anesthetization failure, nerve injury or bleed out during dental procedures and play a role in forensics and anthropology. AMFs are important anatomical variants that require attention in dental and surgical planning. CBCT is the best for accurate detection. By being aware of the AMF's prevalence and what they look like we see better results in care and less complications. Future research should standardize diagnostic criteria and explore demographic influences to improve clinical and forensic applications.

Keywords**:** Accessory mental foramen (AMF), Bucal foramen, Mental foramen, Mandible, Dental surgery

INTRODUCTION

1.1. Mental foramen and anatomical importance: The mental foramen, an important anatomical structure present on the anterior surface of the mandible, is the main pathway for the mental nerve and vessels, which furnish the innervation to the lower lip, labial mucosa, and chin skin [1]. Differences in the mental foramen's position, size, and shape have been widely described in various populations, underlining the necessity of a thorough knowledge of its anatomical features regarding surgical and diagnostic interventions [2]. Aside from the usual single mental foramen, accessory mental foramina can occur, which are additional openings that carry minor nerve branches and vessels [3].

1.2. Accessory mental foramen: although less common than its major counterpart, takes on significant

clinical importance owing to the ability of such structures to affect the success and safety of many dental and surgical procedures [3]. The prevalence of accessory mental foramina shows significant variation among different populations, highlighting the role of genetic andenvironmental determinants in their occurrence [2]. Its presence can result in neurosensory complications during operations, open reduction of mandibular fractures, or implant operations [4].

The precise identification and characterization of accessory mental foramina are important for avoiding iatrogenic damage to the mental nerve and related neurovascular structures and ensuring reduced postoperative morbidity and improved patient outcome [5]. This review is intended to present a broad overview of the AMF, including its anatomical features, prevalence, clinical relevance, and diagnostic options. Through review of available literature and emphasizing crucial considerations for clinical practice, this review hopes to raise dental professionals' awareness about the significance of identification and management of accessory mental foramina in respect of different clinical situations [3]. This article emphasizes the anatomical variations of the AMF, its clinical relevance in dental and surgical treatment, and proper imaging methods for its detection.

2. Anatomy of the Accessory Mental Foramen

2.1. Accessory Mental Foramen: It is described as an extra opening which occurs close to the main mental foramen, usually smaller in diameter, which carries accessory branches of the mental nerve and blood vessels.

The AMF is characterized as a foramen of an accessory bony canal with its origin in the mandibular canal [5]. Identification of an AMF is important during surgical planning to prevent nerve damage and facilitate effective anesthesia [3]. The dimensions, shape, and correct location of the mental foramen are variable [5]. The distance of the AMF from the mental foramen is between 0.67 and 6.3 mm, and the transverse diameter is between 0.81 and 3.9 mm [5].

2.2.Prevalence and anatomical variations: Prevalence of accessory mental foramina as reported in the literature varies greatly among studies and populations from 1% to 10% [5]. The reasons may lie in variations in sample size, study design, and population groups considered.

It is important to observe that genetic, environmental, and ethnic factors may be held accountable for the variation in location and frequency of the mental foramen and the accessory mental foramina in various populations. Accessory mental foramina can either be unilateral or bilateral and may be placed anterior, posterior, or below the main mental foramen. The size of accessory mental foramina is usually smaller than that of the primary mental foramen, measuring between less than 1 mm to a few millimeters. The location of the mental foramen in relation to the teeth is variable, with the most frequent location in line with the second premolar [6]. It can also be located between the first and second premolars, or even distal to the second premolar [7,8].

2.3. Neurovascular Supply:

Accessory mental foramina convey smaller branches of the mental nerve and vessels, which supply sensory innervation to the lower lip and labial mucosa [3].

These accessory nerve branches could overlap in their distribution with the main mental nerve, and hence there could be differences in sensory perception and efficacy of anesthesia.

The mental nerve arises from the inferior alveolar nerve, which is a branch of the mandibular nerve (V3), and leaves the mandible by passing through the mental foramen. The mental nerve provides sensory innervation to the lower lip, chin, and labial gingiva. The mental nerve also branches out further into finer nerves that pass out through the AMF. Accessory mental foramina can create a more variable and complex sensory innervation pattern in the anterior mandible.

3. Prevalence and Distribution

3.1. Global Prevalence: Reported prevalence of accessory mental foramina in various populations (e.g., South Indian, Mongoloid, Caucasian) varies between 1% and 10%. These differences may be due to variations in study designs, sample sizes, imaging modalities, and population genetics. Prevalence of accessory mental foramina also differs between various ethnic and geographical populations. Genetic ancestry, environmental factors, and diet may be among the contributing factors for these population-based variations. For example, research has proven that the prevalence of accessory mental foramina is increased in some populations, including African Americans and Native Americans, relative to Caucasians [9]. In particular, the frequency among French populations is approximately 2.6%, 1.4% among American Whites, 5.7% among American Blacks, 3.3% among Greeks, 1.5% among Russians, 3.0% among Hungarians, 9.7% among Melanesians, and 3.6% among Egyptians [10].

3.2. Age and Gender Factors: Limited evidence indicates that the frequency of accessory mental foramina is different with respect to age and sex. More research is required to determine the correlation between these demographics and the frequency of accessory mental foramina. The most frequent location of the mental foramen was observed to be along the long axis of the second premolar followed by between the second premolar and first molar [11].

Among Caucasians, the mental foramen is in front of the second premolar [2]. Among Mongoloids, the mental foramen is more anterior than in Caucasians [2]. There are gender variations in mental foramen location as well, with some of the studies reporting more anterior location in males as opposed to females. Based on very few studies with large samples, roughly one out of fifteen people possess AMF [12]. Moreover, males are slightly more likely to have AMF than females[12]. On the other hand, according to other research, there is no significant gender variation [12].

3.3. Bilateral and Unilateral Occurrence: Frequency of accessory mental foramina on right vs. left sides It has been observed that accessory mental foramina can occur unilaterally (on one side of the mandible) or bilaterally (on both sides). Most cases are unilateral, with bilateral cases being relatively rare. Understanding the frequency of unilateral versus bilateral occurrence is essential for surgical planning and diagnostic accuracy. Bilateral occurrence of AMF was noted in a single case [9]. A few studies did not reveal the presence of bilateral AMF [9]. Accessory mental foramina can be symmetrical or asymmetrical as regards size, shape, and location. Asymmetry can be more common because of developmental differences or environmental factors.

3.4. Demographic Factors: Impact of age, sex, and ethnicity on prevalence demographics like age, sex, and ethnicity can impact the prevalence and nature of accessory mental foramina. Genetic predisposition, environmental influence, and lifestyle behaviors might be responsible for differences in prevalence and form among populations. The most common location of the foramen, using the teeth as a landmark, was between the premolars in both males and females [13]. The shape of the foramen was oval with a slightly greater mean diameter in males than females. Accessory mental foramina are anomalies, and their occurrence has been established by cadaveric dissections, radiographs, and cone-beam computed tomography [9]. The incidence of AMF also differs significantly based on the population being examined. For instance, Balcioglu's 2011 research presents a 30-week-old fetus with MFA on the right side. Its incidence among the population differs based on ethnic and gender differences, ranging from 1% among the Russian people to 10% among the Arabic population [14]. AMFs are often unilateral, and they may also infrequently occur bilaterally [4,15].

4. Detection Methods

4.1. Morphological Examinations: Direct dry mandible measurement with Vernier calipers is a conventional approach to examining the morphology of accessory mental foramina. Direct measurement yields precise data on foramina size, shape, and position. Radiographic imaging such as panoramic radiographs and cone-beam computed tomography is crucial to use when detecting and describing accessory mental foramina in clinical practice [1]. Radiography enables visualization of foramina and their proximity to surrounding anatomical structures without the need for invasion. Traditional radiography provides minimal visualization of accessory mental foramina because of anatomical overlapping structures and low image resolution. Cone-beam computed tomography has higher accuracy and reliability in the detection of accessory mental foramina than traditional methods of imaging [1].

4.2. Cone Beam Computed Tomography: CBCT allows for detailed 3D visualization for the localization of accessory mental foramina. CBCT imaging enables accurate three-dimensional localization of accessory mental foramina, which helps in surgical planning and prevents neurovascular damage [16]. CBCT offers highly accurate images with little distortion, which helps in proper evaluation of the size, shape, and position of the foramina. The ability of CBCT to perform multiplanar reconstruction is vital, providing extensive visualization of these foramina in axial, coronal, and sagittal planes, critical to enhancing diagnostic accuracy and proper surgical preparation.

4.3. Identification Challenges: Clinical palpation and visualization are of limited use in identifying accessory mental foramina as they are small and can be variable in position. Accessory mental foramina may be hard to visualize clinically or to palpate on a routine dental examination, resulting in missed diagnoses. Misinterpretation of radiographs and anatomical variation may be issues in the precise identification of accessory mental foramina. Identification of accessory mental foramina from other anatomical structures or radiographic artifacts would require meticulous assessment and clinical correlation. Imaging modalities are invaluable in identifying these critical structures precisely[17]. The combination of panoramic radiography with higher-end imaging modalities like CBCT augments the accuracy in detecting the mental foramen location, setting the platform for automated segmentation procedures that enhance diagnostic ability [18].

5. Clinical Implications

5.1. Dental Anesthesia: Effect on inferior alveolar nerve block efficiency: Accessory mental foramina can affect the efficiency of inferior alveolar nerve blocks, causing incomplete anesthesia and failure of the procedure. Information regarding the exact location and anatomy of accessory mental foramina is vital to attain efficient nerve blockade in the region. Anesthesia failure in surgical procedures can occur because of a lack of knowledge about AMF [19]. The position of the mental foramen is a significant landmark in obtaining effective anesthesia [20]. Whereas if an AMF lies even more distally from the central

foramen, either anteriorly or posteriorly, an independent injection may be required to provide sufficient anesthesia [1].

5.2. Surgical Considerations: Surgical intervention of the mental area of the mandible, including implant placement or periapical surgery, risks intraosseous hemorrhage and nerve damage owing to the existence of accessory mental foramina[1]. Special preoperative planning through radiographic imaging is critical to prevent injury to the accessory mental nerve during surgery. Mental foramen positional variations may result in nerve injury during surgery, which would manifest as sensory alteration and neuropathic pain. Preoperative radiographic evaluation is significant in determining the

relationship between the tooth and inferior alveolar nerve [21]. Familiarity with the arterial supply and navigated implant placement of the mandibular symphysis can prevent these life-threatening emergencies [22]. Careful evaluation with CBCT is important for the prevention of possible nerve injury and complications [23]. Identification of variations in anatomy such as AMF is important for the prevention of neurovascular complications from dental procedures, including implantation surgery and nerve block. The accessory mental foramina seen approximately 3 to 5 percent and an average diameter of 0.3 mm [24]. Anatomical variation, such as AMF, seen in CBCT has a great impact in surgical planning [5]. CBCT images help determine a safe zone for bone harvesting and implantation by assessing the traits of intra bony nerve canals [25].

5.3. Forensic and Anthropological Applications:

Accessory mental foramina have racial differences regarding incidence and morphology, hence useful in racial determination and forensic investigation. Accessory mental foramina may be used as supplementary anatomical landmarks in forensic and anthropological investigations of skeletal remains. Changes in foraminal size and position can shed light on population affinities and evolutionary ties [5].
Research on accessory mental foramina helps us understand the diversity of the human skeleton and its implications in different domains.

6. Comparative Analysis Between Studies of Accessory Mental Foramen:
A systematic literature search was conducted using PubMed, Scopus, and Web of Science databases for studies published in the past five years. Keywords included: Accessory mental foramen (AMF), Bucal foramen, Mental foramen, Mandible, Dental surgery. The review was conducted in accordance with the PRISMA guidelines (figure 1).

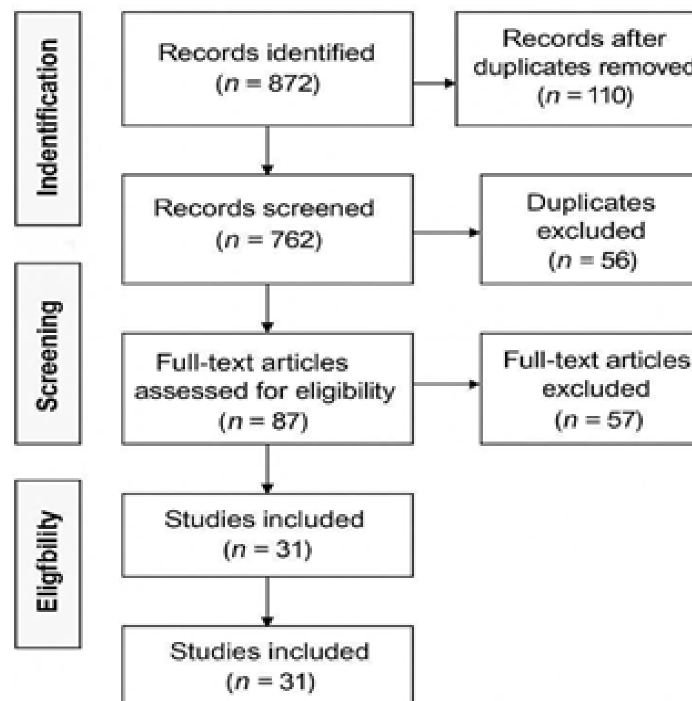

Figure 1. Bending, water sorption, and staining of custom-block, PM MA-disk and conventional PMMA [11].

The AMF is a clinically important mandible anatomical variation, possibly containing extra neurovascular structures that affect dental treatments. Several studies have investigated its prevalence and morphology across diverse populations. Voljevica et al. (2006) analyzed dry human mandibles in a Bosnian population, reporting an AMF prevalence of 2.7% bilaterally, with AMFs typically smaller and oval-shaped, located inferior or posterior to the primary mental foramen [26]. Sankar et al. (2011) studied 150 dry mandibles from South Andhra, India, and observed a greater AMF prevalence of 8.9%, frequently located close to the first molar, indicating regional differences [27]. Singh et al. (2010) described AMF prevalences of 5% on the right side and 8% on the left side in an Indian sample with variation in size and distance from the primary mental foramen [28]. Budhiraja et al. (2012) recorded 6.6% bilateral AMF frequency in mandibles of North Indians, with AMFs defined as minute, ovular apertures [29]. Patel et al. (2015) reported AMF frequencies of 6.45% on the right and 1.61% on the left side among a Gujarati population, noting asymmetry [30]. Udhaya et al. (2013) reported prevalences of 2.22% on the right side and 3.33% on the left side in Tamil Nadu, with the AMFs being mostly below the second premolar or first molar [31]. Zarei et al. (2014) found incidences of 2% on the right side and 3% on the left side in an Iranian population based on imaging methods [32]. Vimala et al. (2014) observed a 2.6% prevalence of bilateral AMF in North India [33], whereas Kadel et al. (2016) reported a 3% bilateral incidence among a Nepalese population [34]. Kasat et al. (2016) reported an incidence of 1.5% on the right side for AMF in an Indian population [35], and Katikireddi et al. (2016) observed a 2% incidence on the right side in South India [36].

Table 1. The prevalence and morphological findings of AMFs from these studies

Study	Population	Sample Size	AMF Prevalence on the right side	AMF Prevalence on the left side	Morphology and Location
Voljevica et al. (2006) [26]	Bosnian	Not specified	2.7% (bilateral)	2.7% (bilateral)	Small, oval, inferior/posterior to primary mental foramen
Sankar et al. (2011) [27]	South Andhra, India	150	8.9% (bilateral)	8.9% (bilateral)	Oval, near first molar
Singh et al. (2010) [28]	Indian	50	5%	8%	Variable size, near primary mental foramen
Budhiraja et al. (2012) [29]	North Indian	150	6.6% (bilateral)	6.6% (bilateral)	Small, oval openings
Patel et al. (2015) [30]	Gujarat, India	Not specified	6.45%	1.61%	Oval, asymmetric distribution
Udhaya et al. (2013) [31]	Tamil Nadu, India	Not specified	2.22%	3.33%	Oval, below second premolar or first molar
Zarei et al. (2014) [32]	Iranian	Not specified	2%	3%	Oval, near primary mental foramen
Vimala et al. (2014) [33]	North Indian	Not specified	2.6% (bilateral)	2.6% (bilateral)	Small, oval openings
Kadel et al. (2016) [34]	Nepalese	Not specified	3% (bilateral)	3% (bilateral)	Oval, near first molar
Kasat et al. (2016) [35]	Indian	Not specified	1.5%	Not reported	Small, oval, right sided
Katikireddi et al. (2016) [36]	South Indian	Not specified	2%	Not reported	Oval, near first molar

6.1. Methodological Variations: Study Design Variations

Prevalence and morphology of AMFs reported vary widely because of the differences in study design, such as sample size, method of detection, and study population. Sample sizes differed from 50 mandibles in Singh et al. (2010) to 150 in Sankar et al. (2011), Budhiraja et al. (2012), and the South Indian study [27–29]. Larger samples improve statistical validity but can be population-specific biases. Most of the studies employed dry mandible analysis using Vernier calipers for direct measurement (for example, Voljevica et al., 2006; Udhaya et al., 2013; South Indian study) [26,31], providing accuracy but possibly overlooking smaller AMFs because of dependence on naked-eye observation. Conversely, imaging studies, including Zarei et al. (2014), utilized cone-beam computed tomography (CBCT) or panoramic radiographs, which enhance the detection of tiny foramina but add variability because of variability in imaging resolution or slice thickness [32]. For instance, CBCT's greater sensitivity is likely responsible for higher AMF detection rates in some papers over dry mandible analysis. Population groups also varied, with studies examining ethnic groups (e.g., South Indian, Bosnian, Iranian, Nepalese), and possibly indicating genetic or craniofacial determination of AMF prevalence[26,27,31–34]. Diagnostic criteria for AMFs also varied; some needed evidence of a neurovascular bundle (e.g., Budhiraja et al., 2012) [29], whereas others identified AMFs by the presence of foramina only (e.g., Kadel et al., 2016) [34]. Such sample size, detection technique, and diagnostic criteria differences make direct comparisons problematic and suggest the necessity of standardized methods in AMF studies.

6.2. Consistency and Variability:

Despite methodological differences, there are a few consistent trends for AMF studies. The prevalence of AMF is consistently lower than that of the main mental foramen, between 1.5% and 8.9% [26]. South Indian cohorts among South Asian populations have been reported to have higher incidences of AMFs (6–8.9%) [27,31] than Nepalese (3%) [34] or Iranian (2–3%) populations [32], indicating possibly regional or genetic factors. Morphologically, the AMFs are invariably smaller and oval, found usually inferior or posterior to the main mental foramen, commonly adjacent to the first molar or second premolar [27–30]. Asymmetry is the common finding, and in studies such as Patel et al. (2015) (6.45% right vs. 1.61% left), Singh et al. (2010) (5% right vs. 8% left), and the South Indian study (6% right vs. 1.33% left), side-specific differences were reported [3,5,12], but the developmental or biomechanical reasons are unknown.

Prevalence and site discrepancies are significant. Sankar et al (2011) also reported the maximum AMF prevalence (8.9%) [27] well above Voljevica et al (2006) (2.7%) [26] and Kasat et al (2016) (1.5% right) [35]. These differences could be due to methodological variations, like analysis of mandible drying vs imaging, or anatomical characteristics specific to populations. South Indian populations, for example, could have greater AMF prevalence because of peculiar mandibular morphology [27]. Variability in location is also seen, whereas most of the studies place AMFs adjacent to the first molar or second premolar, Udhaya et al. (2013) observed variations with regards to distance from the primary mental foramen, perhaps due to variable measurement methods or anatomical definitions [31]. The clinical relevance of AMFs is repeatedly highlighted, with research indicating their effects on the efficacy of anesthesia (owing to extra nerve branches) and intraoperative hemorrhage risks during the implantation procedure [27,29].

Summary of major studies on AMF prevalence and morphology Prevalence rates of accessory mental foramina have been reported to vary from 1% to 10% of the population [37]. Differences in sample populations, imaging modalities, and diagnostic criteria are likely causes of such variations. The prevalence of double mental foramina was reported to be 4.2% by a CBCT scan study. Varying prevalence rates of AMF occur among different populations. Variables that influence these include genetics, ethnicity, and environmental factors.

7. Impact on Clinical Practice: Understanding the prevalence and nature of accessory mental foramina is crucial for evidence-based clinical decision-making. Clinicians need to consider the presence of accessory mental foramina when they plan surgical or anesthetic interventions in the mental area. This puts the imaging modalities in dental and surgical interventions into perspective. The existence of AMF can influence the success of local anesthesia, making the bleeding risk greater during surgical interventions [2]. Accessory mental foramina cannot be detected on radiographs and usually go undetected on clinical examination. Our research supports the value of knowledge about the anatomy of the mental foramen, including the possibility of having accessory mental foramina [2]. Accessory mental foramina are anatomical variations detectable by cone-beam computed tomography [37]. Knowledge about accessory mental foramina can assist dental clinicians in enhancing the outcome of treatments and minimizing complications during dental procedures. The size and number of accessory mental foramina differ from person to person [12]. Accessory mental foramina may be identified through cone-beam computed tomography to diagnose radiomorphometric and epidemiological parameters.

8. CONCLUSION

The accessory mental foramen is a widespread anatomical variation of the mandible that has an impact rate of 1% to 10% among various populations based on genetic, ethnic, and environmental conditions. This systematic review underscores the vital clinical significance of AMFs in dental and surgical interventions, especially in procuring proper anesthesia and avoiding neurovascular complications during such interventions as implant placement and mandibular surgery. The heterogeneity of AMF prevalence, morphology, and location, usually smaller, more oval, and located closer to the first molar or second premolar, emphasizes the need for accurate preoperative imaging, with CBCT becoming the gold standard due to its superior high-resolution, three-dimensional visualization. Despite methodological variations between studies, e.g., sample size, detection methods, and diagnostic criteria, recurrent patterns validate the clinical significance of AMFs and the necessity for uniform research protocols to maximize comparability. Identification of AMFs is crucial for dental professionals to enhance treatment results, reduce iatrogenic trauma, and increase patient safety. In addition, AMFs have the potential for applications in forensic and anthropological analyses, providing insights into population diversity and the identification of the skeleton. Future studies must address clarifying the demographic factors, including gender and age, as well as creating automated detection devices that can incorporate AMF identification into clinical practice easily, eventually promoting evidence-based dentistry.

DECLARATIONS

Ethical approval and consent to participate

Not Applicable

Availability of data and material

All data generated or analyzed during this study are included in the published article.

Competing interest

The authors declare that there are no competing interests.

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