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Authors: H. A Marzook, A. A Elgendy, F. A Darweesh

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New accessory palatine canals and foramina in cone beam computed tomography
Running Head: New accessory palatine canals

H.A. Marzook¹, A.A. Elgendy², F.A. Darweesh³
¹Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Mansoura University, Mansoura, Egypt
²Endodontics, Head of Conservative Dentistry Department, Faculty of Dentistry, Zagazig University, Egypt
³Oral Biology Department, Faculty of Dentistry, Zagazig University, Egypt.

Address for correspondence: H.A. Marzook, Oral and Maxillofacial Department, Faculty of Dentistry, Mansoura university, 60 Elgomhoria Street, Mansoura, Postal code 35516, Egypt, tel: 00201274733334, fax: 0020502202835, e-mail: marzook_h@hotmail.com

ABSTRACT

Background: Palatal surgeries are associated with many complications. Accessory foramina may be a cause of concern. The aim of the present study was to assess the occurrence and to evaluate the anatomical features of accessory palatine foramina and their bony canals using cone beam computed tomography (CBCT).

Materials and methods: The incidence, location, and types of foramina on the palate were evaluated in 170 CBCT scans. Readings from coronal, sagittal, and axial planes were recorded using Planmeca Romexis Viewer 5.4.1.R. computer program. Data were tabulated and evaluated.

Results: Other than nasopalatine, greater and lesser palatine foramina, 278 foramina were observed in the palatal surface of the upper jaw in different locations. New accessory palatine foramina were found posteriorly in 14.71% of the studied scans with wide anatomical variations. Unusual foraminal canals were seen crossing the floor of the maxillary sinus laterally. The incidence of the anterior accessory palatine
foramina was 73.53%. Bilateral accessory palatine foramina were found in 43.53% of cases.

**Conclusions:** Accessory palatine foramina and their bony canals are frequently seen in CBCT with wide anatomical variations. New unusual connecting canals are found passing from palatine foramina to the lateral wall of the maxillary sinus through the sinus floor. These findings should be considered when planning for anesthesia and surgery in the palate.

**Key words:** cone beam computed tomography, anatomical landmarks, new palatine foramina, nasopalatine foramen, palate, canalis sinuosus

**INTRODUCTION**

Many complications are associated with surgical interventions in the palate. Complications include intraoperative bleeding, wound dehiscence, and nerve injury \([6, 8, 13, 33]\). To avoid these complications, total knowledge of bony neurovascular anatomical variations is recommended \([2, 38]\). Cone beam CT was found to play an important role in studying anatomical variations of the jaws \([27]\). The palatine foramina and canals are from the structures studied by many investigators \([21, 35]\).

The maxillary nerve is a purely sensory nerve supplying the upper dentition and gingiva, hard and soft palate mucosa, nose, upper lip, maxillary sinus, as well as many adjoining structures \([37]\). It innervates only the structures of the maxillary process in fetal life and further extends to include also the frontonasal process during embryological development \([37]\). The anatomical variations may cause anesthesia failure or surgical complications.

Many studies investigated neurovascular structures in the anterior maxilla which may show different variations. Greater palatine canal and Nasopalatine canal are from those structures \([21, 28, 34-37]\). Variants such as accessory canal of canalis spinuosus was studied by many investigators. It is typically visualized as a unilateral or bilateral radiolucent canal with a palatal foramen located opposite incisors or canines. Actually, blood vessels and nerves running through these canals often
considered as extensions of the infraorbital nerve and its branches. Accessory canals of canalis sinuosus were previously considered a rare anatomical variant but a high prevalence of these structures was found in many recent reports [32, 26, 41, 24, 22].

In the posterior region of the hard palate, the greater palatine and lesser palatine canals and foramina were studied for their anatomical features [18, 28, 34, 36]. The greater palatine nerve canal as an important maxillary anatomical landmark is located bilaterally. Its location, size, and shape have been studied by many investigators [10, 16]. Reports concerning anatomical variants such as accessory canals in the posterior palatal bone are lacking. CBCT analysis for accessory palatine foramina, however, has not been widely evaluated or used in clinical dentistry yet. Therefore, there is a need to establish a well-defined profile for the anatomical characteristics of accessory palatine canals and foramina in CBCT. The aim of this study was to assess the occurrence and to evaluate the anatomical features of accessory palatine foramina and their bony canals using cone beam computed tomography (CBCT).

**MATERIALS AND METHODS**

The study protocol was approved by the Ethical Committee of the Faculty of Dentistry, Mansoura University (code 03100918). Palatal bone was studied in 170 CBCT scans for any additional foramina and canals other than nasopalatine, greater palatine and lesser palatine. Readings from different slices were recorded using Planmeca Romexis Viewer 5.4.1.R. computer program (Planmeca, Italy). Of the 170 patients, 108 were female and 62 were male. The average age was 35.33 years. Scans showing large intraosseous lesions or fractures in the target area were excluded. The incidence, location, and direction of accessory canals were evaluated in coronal, sagittal, and axial planes by two investigators. These foramina were assigned into 2 main categories: anterior and posterior accessory palatal foramina. Anterior foramina are those located in front of upper first premolars; however, the others were considered posterior. The course and relations of additional canals were studied. Accessory foramina were considered branched from canalis sinuosus only after following the course of their bony canals. Recorded foramina were considered only when there is agreement between the 2 examiners. Data were collected for the
incidence, location and course of the anterior and posterior accessory palatine foramina and their canals, and evaluated.

RESULTS

A total of 278 additional foramina of the palate other than nasopalatine, greater palatine, and lesser palatine were recorded from coronal, sagittal, and axial planes of 170 CBCT scans. These foramina were assigned into 2 main categories anterior and posterior accessory palatine foramina (table 1). Nasopalatine foramen was found in the midline in all studied scans with different morphological variations. One hundred and thirty-three patients (78.24%) showed at least one more additional foramen.

A new type of palatine foramina was detected in the posterior region of the palate in 25 CBCT scans with abnormal directions of their associated bony canals (fig.1). These canals were found to extend upward to the medial wall of the maxillary sinus and nasal cavity and to follow a lateral course in the floor of the sinus. Posterior accessory palatine foraminal canals were found to exhibit multidirectional course in many cases (fig. 2). Different positions of posterior accessory palatine foramina in relation to alveolar ridge were found (fig. 3). More than one posterior accessory palatine canal was detected in twelve cases either unilateral or bilateral. Some posterior accessory foramina were found to be passing anteriorly and originating from canalis sinuosus (fig. 4).

There was a prevalence of the anterior accessory foramina, with significant variations of their locations and anatomical characteristics. Anterior accessory palatine foramina could be detected in different locations. Lateral incisor and canine region foramina could be observed. In most instances accessory foraminal canals were found to be connected to canalis sinuosus branch of infraorbital nerve (Fig. 5) and were directed upward anteriorly. Anterior accessory foramina originating from canalis sinuosus were found to be present in 125 patients (73.53%). Different locations of accessory palatine foramina in the anterior region were found. Many of the anterior accessory palatine canals were connected to nasopalatine canal and some were found to be related to the supply of upper anterior teeth (Fig. 6). Bilateral occurrence was found in 65 patients. More than two accessory palatine foramina could be detected in 88 patients either unilaterally or bilaterally (fig. 2). Accessory palatine foramina could not be related to canalis sinuosus in 26 scans (Fig. 3). Variations in size of accessory
palatine foramina could be seen in many cases (Fig. 4), and those were seen in coronal (Fig. 5), axial (Fig. 6), and sagittal planes (Fig. 7) according to their locations.

DISCUSSION

Complications related to surgical interventions in the palate had been reported. To avoid intraoperative and postoperative hemorrhage, neurosensory loss, the locations of neurovascular structures must be identified [6, 13, 33, 8, 2, 38, 7, 1]. Osseous neurovascular structures include the nasopalatine, greater and lesser palatine foramina and their canals [21, 10, 31]. In this study, these structures were found in all the studied scans (100%). These results are in agreement with many previous studies [31, 9]. In our sample of Egyptian adults, there was a relatively high incidence of accessory palatine foramina. There was a prevalence of the anterior accessory foramina, with significant variations of their locations and anatomical characteristics. In most instances accessory foraminal canals were found to be connected to canalis sinuosus. These results are in agreement with many previous studies [11, 17, 39, 40].

More studies are needed to investigate the abnormal lateral origin of the unusual new type of posterior palatine foramina. The possibility of being derived from the posterior superior alveolar nerve may result in a change of the common belief that greater palatine nerve block is sufficient for anesthesia of palatal gingiva opposing upper posterior teeth. This result may be supported by the findings of previous reports of occurrence of palatal anesthesia after a single buccal infiltration [3, 20, 5]. On the contrary, it may also put a question mark upon the accuracy of studies investigating the palatal effect of some local anesthetic solutions proposed to penetrate the alveolar bone after buccal infiltration [23, 25, 29]. To the best of our knowledge studies investigating the occurrence or the orientation of posterior accessory palatine foramina and canals are lacking. Failure of greater palatine anesthesia might be attributed to the presence of this extra abnormal innervation in some cases.

There is no other conclusive evidence in the literatures that multidirectional posterior accessory palatine foramina canals are present in humans. Most studies investigated the length and anatomic routes of the greater palatine canal or the opening direction, dimensions, and shape of the greater palatine foramen [34, 36, 37].
Multiple accessory palatine foramina were considered previously as double or triple greater or lesser palatine foramina [9, 4]. Our results disagree with these considerations as the lateral extensions of foraminal canals crosses the floor of the maxillary sinus laterally. This result may also support the recommendations of previous reports concerning the necessity of preoperative planning [15, 19].

The findings of the present study proved that there is a connection between many of the anterior accessory palatine canals and nasopalatine canal. Some of these canals were related to the supply of upper anterior teeth. These results are in accordance with some reports indicating this supply [15, 19]. The presence of anastomosis between different bony canals forming sometimes a network or a plexus of canals in the anterior region of the maxilla may add to the complexity of some periapical surgeries. This may also explain postoperative bleeding or sensory disturbances after endodontic surgery or palatal mucosal grafting in some cases [12].

In our study, cases showed variations of intra-bony canals. Of course, possibility of nutrient canals which was postulated by many researchers should be considered [30, 14]. Evidence-based recent studies do not clearly show this.

In this study, the accessory palatine foramina showed high incidence than previously considered for them [38, 32, 26]. A new type of accessory palatine foramina was discovered in the posterior region of the palate with abnormal extension of its canal to the floor of maxillary sinus. It is not safe to recommend any graft or implant surgery in this region of the palate without CBCT study of the region. In our Egyptian sample, there was a significant variability in the occurrence of palatine foramina and their bony canals anatomy and location. Considering narrow canals and using recent technology may be the cause of this high occurrence. Knowledge of the anatomical variations of neurovascular canals is necessary to preserve these structures during surgical procedures. To the best of our knowledge, this study was the first to investigate the radiographic anatomy of posterior palatal foramina in Egyptian population.

**CONCLUSIONS**

The results of this study showed that accessory palatine foramina and bony canals are frequently present in the palate with wide variations in CBCT. In the
anterior region of the palate, the incidence of foramina was the highest. Posterior accessory palatine foramina were also frequently seen with wide morphological variations. These findings should be considered in diagnosis and planning for surgery in the palatal region to prevent possible complications. A preoperative thorough investigation of the anterior and posterior palatal regions using CBCT is highly recommended when targeting surgical interventions in these areas. In this study, accessory palatine canals were evaluated only on CBCT images, and the contents of the canals were not confirmed. More cadaveric and clinical studies exploring the histological and anatomical contents are essential to validate the current findings.

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Table 1. Distribution of anterior and posterior accessory palatine foramina (APF) foramina along the studied CBCT scans.

<table>
<thead>
<tr>
<th>No</th>
<th>Studied Structure</th>
<th>Number of readings</th>
<th>Number of patients</th>
<th>Bilateral cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anterior APF</td>
<td>234</td>
<td>125</td>
<td>65</td>
<td>73.53%</td>
</tr>
<tr>
<td>2</td>
<td>Posterior APF</td>
<td>44</td>
<td>25</td>
<td>9</td>
<td>14.71%</td>
</tr>
</tbody>
</table>

Figure 1. New posterior accessory palatine foramen canal shown in coronal sections a) passing from palate to maxillary sinus, b) through sinus floor, c) to the middle of the floor, d) then to the lateral wall of the sinus, e) upward posteriorly, and f) in axial section with lateral, posterior, and upward direction.
**Figure 2.** Anatomical variations of the new posterior accessory palatine foramina and their canals shown in axial sections a) directed anteriorly first, or b) passing directly from palate to maxillary, and in coronal sections ascending upward, c) laterally to medial sinus wall, or d) directly through palate to nasal cavity.

**Figure 3.** Different positions of posterior accessory palatine foramina in relation to alveolar ridge in coronal sections: a) near the ridge in most of the cases, or b) away from ridge.

**Figure 4.** Posterior accessory foramina originating from canalis sinuosus.

**Figure 5.** Branching of canalis sinuosus in the upper jaw.

**Figure 6.** Different relations of accessory anterior palatine canals to nasopalatine canal: a) anterior, b) posterior, c) lateral, and d) opening into nasopalatine foramen.

**Figure 7.** Variation of branching of canalis sinuosus: a) labial and palatal bony plates branches, b) dental branches, c) high anterior accessory palatine branches, d) low anterior accessory palatine, e) wide or branched, and f) posterior palatine branching unilateral and bilateral.