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# Anatomical Basis of the Palatal Injection Technique for Pulpal Anesthesia of Maxillary Teeth

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**Received:** 11 February 2025 | **Revised:** 17 March 2025 | **Accepted:** 26 March 2025

**Keywords:** canalis sinuosus | cone-beam computed tomography | local anesthesia | palatal alveolar foramina | palatal injection

## ABSTRACT

The aim of this study was to assess the effectiveness of palatal injection for managing the pulpal pain of unilateral maxillary teeth from central incisor to second premolar and to establish the anatomical basis for this technique. For this prospective observational study, 62 patients (aged 18–70 years) were included. They had been treated for carious dentine lesions, receiving prosthodontic, endodontic treatment, or extraction of any tooth/teeth in the region from central incisor to second premolar. A total of 100 teeth were treated. Cone-beam computed tomography (CBCT) scans were analyzed preoperatively to identify accessory canals (ACs) (≥ 0.5 mm in diameter) associated with canalis sinuosus (CS). The anesthetic was injected into the area of the target tooth or adjacent tooth next to the palatal openings of the AC(s) into the submucosa of the anterior hard palate. The effectiveness of anesthesia was confirmed by pulp tester readings and a survey using the Verbal descriptor and Likert scales before and during treatment. Pulpal anesthesia was successful in 100% of the treated vital teeth. In all cases, openings of ACs originating from the CS were identified on CBCT scans. Three patients underwent bilateral dental treatment under unilateral anesthesia. The bilateral communications of the CS in the midline of the upper jaw were identified in the CBCT scans of these patients. The authors have established the palatal alveolar foramen injection (PAFI) technique. Injection of an anesthetic solution into the area of the openings of CS on the palate (i.e., palatal alveolar foramina) induces pulpal anesthesia of adjacent target teeth with 100% efficiency. PAFI requires less of the anesthetic solution and is the ideal technique for restorative and prosthodontic treatment involving anterior teeth because it does not cause numbness of the lip and face.

## 1 | Introduction

The maxillary teeth are supplied by three superior alveolar nerves, which originate from the maxillary nerve (Nguyen and Duong 2023). The infraorbital nerve gives rise to the anterior and middle superior alveolar nerves, which, together with the posterior superior alveolar nerve (PSAN), contribute to the formation of the superior dental plexus (Standring 2015). This is located in the alveolar process of the maxilla, not under the mucous membrane of the maxillary sinus (Murakami et al. 1994).

According to von Arx and Lozanoff (2015), the anterior superior alveolar nerve (ASAN) begins from the lateral or inferior surface of the infraorbital nerve within the infraorbital canal. Robinson and Wormald (2005) identified different branching patterns of the ASAN from the infraorbital nerve. It emerged from the infraorbital nerve as a single trunk in 75% of cases and as a double trunk in the other 25%. Other authors have described the ASAN as comprising two to three fascicles (Murakami et al. 1994).

The ASAN traverses the anterior wall of the maxilla via a bony canal, the so-called canalis sinuosus (CS), first described by Jones (1939). Inside the CS, the ASAN innervates the maxillary central incisors, lateral incisors, canine, premolars, and surrounding soft tissue (Nguyen and Duong 2023). It not only innervates and nourishes the maxillary anterior teeth, the corresponding soft tissues, and the maxillary sinus mucosa, but also provides sensory innervation to the nasal septum, lateral nasal wall, and palatal mucosa (Sun et al. 2024). The terminal part of the CS often gives rise to accessory bony canals (ACs), which open via additional foramina in various anatomical locations, most commonly the anterior palate (Beckenstrater et al. 2024; de Oliveira-Santos et al. 2013). The diameters of such foramina range from 0.5 to 2.72 mm (Beckenstrater et al. 2024; Tomrukçu and Köse 2020). Many authors have focused on ACs with diameters over 1.0 mm. These ACs opened on the bony palate in 15%–36.9% of the population studied (de Oliveira-Santos et al. 2013; Shan et al. 2021).

According to Fitzgerald (1956) (cited in von Arx and Lozanoff 2015), the criteria for identifying a middle superior alveolar nerve (MSAN) are as follows: (1) it is intermediate in position between the ASAN and the PSAN; (2) it joins the premolar alveolar plexus; and (3) it is not a branch of the ASAN. The MSAN of the infraorbital nerve runs downward and forward in the wall of the maxillary sinus. It is responsible for providing additional sensory innervation to the sinus and the maxillary premolar teeth (Nguyen and Duong 2023). Anatomical studies have identified the MSAN in 23%–72% of individuals, and when it is absent, its targets are innervated from a plexus formed by the ASAN and PSAN (Robinson and Wormald 2005; Velasco and Soto 2012).

Our aim was to assess the effectiveness of palatal injection for managing pulpal pain in the ipsilateral maxillary teeth from central incisor to second premolar and to identify the anatomical basis for this technique.

## 2 | Materials and Methods

This prospective observational study was conducted as part of a research project registered by the State Organization "Belarusian Institute for System Analysis and Information Support in the Scientific and Technical Sphere" (#20231601). Ethical approval was obtained from the Ethics Committee of Belarusian State Medical University (protocol #3 of November 30, 2024), and patients volunteered to participate in the study by signing the written informed consent.

### 2.1 | Preparation of the Patients and Teeth

Maxillary teeth requiring treatment for carious dentine, prosthodontics, endodontics, or extraction, from the central incisor to the second premolar, were included in this study. Teeth with apical periodontitis, metal restorations, or incomplete root development were excluded. A total of 100 teeth were analyzed from 62 adult patients, 27 men and 35 women, average age 35 years (range 18–70 years), treated during the period November to December 2024. Seven teeth (7%) were extracted, two asymptomatic teeth (2%) underwent endodontic treatment for chronic pulpitis, and 91 vital teeth (91%) were treated for caries or prepared for prosthodontic restorations.

### 2.2 | Localization of the Palatal Foramina on Cone-Beam Computed Tomography (CBCT)

CBCT scans were analyzed preoperatively to identify ACs of the CS (Figures 1 and 2). All CBCT scans were obtained on Planmeca ProMax 3D Max (Planmeca, Helsinki, Finland) using the following settings: 96 kV; tube current: 12 mA; acquisition period: 12 s; 0.2 mm voxel. Reformatted sagittal and axial CBCT images were assessed using Planmeca Romexis viewer. Palatal openings (≥0.5 mm diameter) of the ACs of the CS, that is,

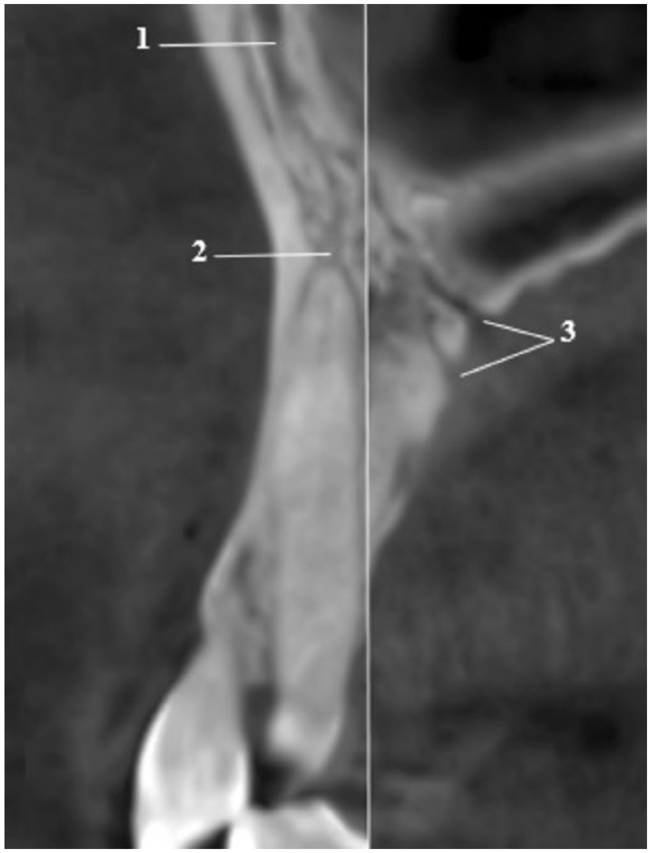


**FIGURE 1** | A 29-year-old male patient. CBCT, sagittal scans, showing branches of the canalis sinuosus (1) supplying the left upper canine (2) and reaching the palate posterior to the canine (3).

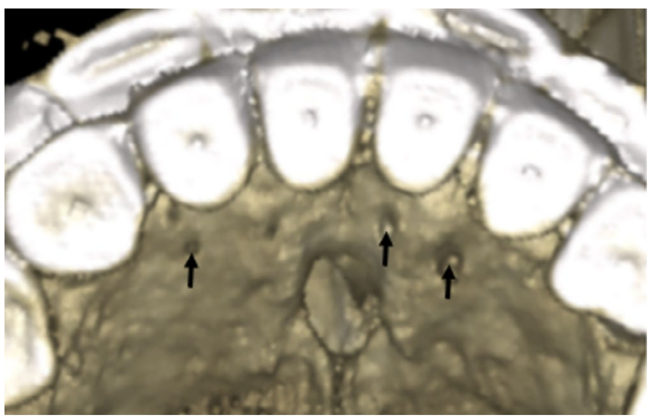

**FIGURE 2** | A 19-year-old female patient. CBCT volume rendering showing multiple palatial foramina of accessory canals of the canalis sinuosus with diameters greater than 0.5 mm.

palatal alveolar foramina (Iwanaga, Kabak et al. 2025a; Iwanaga Takeshita, et al. 2025), were detected in each patient. The number and locations of the foramina in relation to the teeth were recorded.

### 2.3 | Electric Pulp Test (EPT) and Anesthetic Injection

Before injection, an EPT was used to assess the vitality of the dental pulp. A patient's response below a 75–80-μA EPT reading was considered confirmation of vital pulp. The anesthetic was injected into the submucosa of the anterior palate, near the palatal openings of the AC(s), in the area of the target tooth or its adjacent tooth. Four percent articaine was used as an anesthetic depending on the individual characteristics of the palatal mucosa. After injection, the EPT was used to determine the effectiveness of pulpal anesthesia. The absence of a patient's response to a 75–80-μA EPT reading was considered confirmation of anesthesia. Anesthetic induction time, duration of pulpal anesthesia, and volume of anesthetic solution were recorded.

A Verbal Descriptor Scale was used to assess patients' pain during the procedure, the patients selecting the statement that best described their pain intensity: none, mild, moderate, severe, or unbearable. A five-point Likert scale was used to rate patients' satisfaction with the treatment (Table 1).

In this study, local anesthesia and clinical data were collected by an experienced dental practitioner. The CBCT data were analyzed with the participation of an expert oral and maxillofacial radiologist.

## 3 | Results

### 3.1 | CBCT Observation

In all 62 cases (a total of 323 foramina), the palatal openings of ACs originating from the CS were identified on CBCT scans (Table 2). The number of palatal openings with a diameter ≥0.5 mm ranged from one to five for each patient. The diameter of the ACs ranged from 0.5 to 1.56 mm (0.69 ± 0.17 mm) on the right side and from 0.5 to 1.21 mm (0.69 ± 0.15 mm) on the left. No significant relationships between AC foramina diameter and laterality were found ($p > 0.05$). The palatal foramina were most commonly located near the central incisors (25.1%), followed by the second premolars (22.3%) (Table 2).

**TABLE 1** | Scoring range of Likert scale.

| Likert scale description | Scale | Likert scale interval |
|---|---|---|
| Not at all satisfied | 1 | 1.0–1.80 |
| Partly satisfied | 2 | 1.81–2.60 |
| Satisfied | 3 | 2.61–3.40 |
| More than satisfied | 4 | 3.41–4.20 |
| Very satisfied | 5 | 4.21–5.00 |

### 3.2 | Pulpal Anesthesia

Among the 100 teeth selected for this study, 93 were vital (patient's response at 4–25 μA). Successful pulpal anesthesia was achieved in 100% of the treated vital teeth. On average, patients were highly satisfied with the dental treatment, that is, tooth extraction, endodontic treatment, or prosthodontic restoration ($M$ = 4.43, SD = 0.59). Local anesthetic was administered into the palate without significant pain. The anesthetic induction times ranged from 1 to 3 min, and the anesthesia began with a feeling of numbness in the nose. The volume of anesthetic solution injected varied between 0.5 and 0.8 mL.

All subjects obtained palatal soft tissue anesthesia and pulpal anesthesia of the target vital teeth (93 teeth). Three patients underwent bilateral dental treatment under unilateral anesthesia. The Verbal Descriptor Scale survey showed that all 62 patients (100%) experienced no pain during the procedure by reporting "none." Furthermore, no complications or side effects were observed or reported by patients either during or after the procedure.

## 4 | Discussion

Infiltration for pain management involves the deposition of local anesthetic solution at the level of the tooth apices so that it diffuses through the alveolar bone to bathe the periapical nerves (Baker 2015). Maxillary anterior teeth are commonly anesthetized by supraperiosteal infiltration into the mucobuccal fold close to the apices of the teeth. Accompanying numbness of soft tissues causes distortion of the lips (Friedman and Hochman 2001). This can be inconvenient for the patient with regard to speaking and eating, and it poses a risk of self-inflicted trauma (College et al. 2000).

However, multiple infiltrations are generally required to achieve anesthesia of more than one tooth (Velasco and Soto 2012), which increases both the injection discomfort and the volume of anesthetic solution applied (Corbett et al. 2010). The anterior and MSANs can be anesthetized by an infraorbital nerve block (IONB). However, several studies have shown that IONB is ineffective in providing profound pulpal anesthesia for the incisor teeth (Berberich et al. 2009; Karkut et al. 2010).

The palatal approach to the anterior and MSANs was described as AMSA nerve block by Friedman and Hochman (1998).

**TABLE 2** | Distribution of the palatal foramina of accessory canals of canalis sinuosus.

| Area | Number of foramina (%) |
|---|---|
| Second premolar | 72 (22.3) |
| First premolar | 44 (13.6) |
| Canine | 56 (17.3) |
| Lateral incisor | 70 (21.7) |
| Central incisor | 81 (25.1) |
| Total | 323 (100) |

Injection of anesthetic solution midpalatally allows it to penetrate through numerous bony foramina and access the anterior and MSANs and their plexuses. AMSA nerve block requires only one injection for an expected anesthesia duration of 45 min without accompanying unwanted numbness of the upper lip (Friedman and Hochman 2001). In the opinion of Friedman and Hochman, P-ASA nerve block produces anesthesia of the ASAN by deposition of anesthetic solution deep within the nasopalatine canal (Friedman and Hochman 1999). Iwanaga and Tubbs criticized their use of both the terms "AMSA block" and "P-ASA block" because the ASA and MSA branches of the infraorbital nerve were shown in their figure as if they coursed through the nasal septum, the ASA nerve ultimately reaching the incisive canal (Iwanaga and Tubbs 2018). However, there had been no anatomically convincing explanation for the success of palatal injection, although the reported AMSA block success rate ranged from 16.7% to 66% (Velasco and Soto 2012), until (Iwanaga Takeshita, et al. 2025b) identified new innervation of the maxillary teeth by the greater palatine and nasopalatine nerves through the palatal alveolar foramina. This can explain the outcomes of a palatal injection. The ACs of the CS could facilitate communication between the ASAN and alveolar branches of the greater palatine and nasopalatine nerves. The newly identified palatal innervation of the maxillary teeth strongly supports the findings of the present study. The teeth were anesthetized via both palatal and labial (buccal) pathways thanks to the ACs of the CS in the anterior region of the palate near the target teeth.

An essential factor concerning the potential diffusion and infiltration of anesthetic solution through the alveolar bone is the porosity of the cortical bone and the thickness of the palatal cortex. According to Cetkovic et al. (2018), despite the great thickness of the palatal cortex, other anatomical parameters of the palatal bone such as higher total porosity, open porosity, connectivity of the pores, and significantly more nutrient canals passing through the entire cortical thickness can ensure the diffusion of local anesthetics. Therefore, the anesthetic solution can easily reach the cancellous bone from the site of injection. The lower density of the palatal half of the cancellous bone (Ahad et al. 2020) would also facilitate diffusion up to the superior dental plexus.

In our opinion, another clinically significant cortical bone characteristic for anesthetic diffusion is the presence of the ACs—branches of the CS—reaching the palate near the teeth from the first incisor to the second premolar. Injection of an anesthetic solution into the area of the palatal openings of these canals induces pulpal anesthesia in adjacent teeth through the anterior and MSANs, and alveolar branches of the greater palatine and nasopalatine nerves (Iwanaga Takeshita et al. 2025b). This is the key point of the palatal injection we propose.

The CS is a distinct anatomical entity with reported prevalence ranging from 66.5% to 100% in different population groups (Beckenstrater et al. 2024). According to Ghandourah et al. (2017), at least one AC was registered in 67.6% of cases in German adults. The prevalence of ACs with diameter ≥1 mm was 27.4%. In a Chinese population, the prevalence of the ACs with at least 1.0-mm diameter was 36.9% (Shan et al. 2021). In one of the patients we observed, a CBCT examination revealed no AC openings on the palate. In this case, palatal injection was not effective.

Electric pulp testing is commonly used to determine pulp vitality (Chen and Abbott 2009). Some dentists also apply it to confirm the success of anesthesia and to provide complete pain control (Lin and Chandler 2008). The absence of a patient's response to an 80-μA reading EPT after administration is considered an assurance of anesthesia (Liew et al. 2021). In our study, vital teeth showed a 4–25-μA reading EPT before and a 75–80-μA reading EPT after injection of the anesthetic solution. During dental treatment, we monitored the presence or absence of a patient's subjective pain sensations using the Verbal Descriptor Scale. After treatment, overall patient satisfaction with anesthesia was 4.43 on a Likert scale, which corresponds to the description "very satisfied." The lower Likert scale scores by some patients can be explained by pain from depositing the anesthetic solution into the palatal soft tissues (Areenoo et al. 2022).

The palatal alveolar foramen injection (PAFI) technique was effective for all target teeth. In our study, three patients obtained bilateral anesthesia by unilateral injection of the anesthetic solution, as proved by pulpal anesthesia of the treated left and right upper teeth. We can explain this by bilateral communication through the CS in the midline of the upper jaw (Figure 3). The current scientific literature lacks information about such anatomical variations.

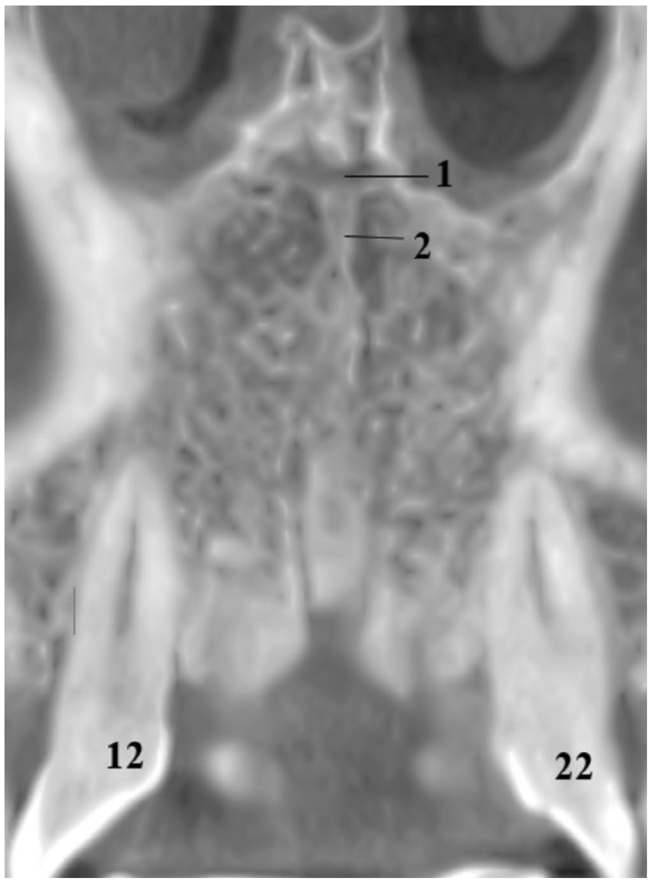


**FIGURE 3** | A 33-year-old male patient. CBCT, coronal scan, showing communication of left and right canalis sinuosus (1), which passes through the intermaxillary suture (2).

The PAFI is ideal for use in restorative and prosthodontic treatment involving anterior teeth, as it does not cause numbness of the lip and face.

## 5 | Conclusion

The authors have established the PAFI technique. Injection of an anesthetic solution into the area of the openings of CS on the palate (i.e., palatal alveolar foramina) induces a pulpal anesthesia of adjacent target teeth with 100% efficiency. PAFI requires less of the anesthetic solution, and it is an ideal technique for restorative and prosthodontic treatment involving anterior teeth because it does not cause numbness of the lip and face.

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