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ANATOMIC VARIATIONS

Unique air inclusions within the nasopalatine duct indicating its presence radiographically: a case presentation

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Abstract

The anterior maxilla is characterized by the nasopalatine canal that originates bilaterally from the anterior nasal floor, subsequently fuses, and terminates at the incisive foramen in the anterior palate. Embryologically, this structure forms within the primary palate, and contains the neurovascular bundle, but also continuous epithelialized bands. The latter, termed nasopalatine ducts, usually degenerate and/or obliterate before birth. However, in some individuals, the ducts may remain partially or completely patent. The present case report describes for the first time in the literature a rare finding of air inclusions within the anatomical area of the nasopalatine canal indicating the presence of a nasopalatine duct as visualized with cone beam computed tomography. The patient was asymptomatic and the radiographic findings were seen incidentally. An endoscopic inspection of the anterior nasal cavities confirmed the presence of the nasal openings of the partially patent nasopalatine ducts.

Keywords Anterior maxilla · Nasopalatine canal · Nasopalatine duct · Case report · Anterior nasal floor

Introduction

A characteristic anatomical structure of the anterior maxilla is the nasopalatine canal (NPC), also known as the incisive canal [16]. This canal originates bilaterally from the anterior nasal floor at either side of the nasal septum. It subsequently fuses in the central portion of the premaxilla and terminates at the incisive foramen in the anterior palate. Radiographically, the NPC presents as a radiolucent channel in the bone with a typical Y-shape configuration in the coronal plane [3].

The development of the NPC is complex and multifaceted [4]. Embryologically, the NPC is formed inside the primary palate, and not at the fusion site of the primary and secondary palate, as often erroneously shown in textbooks [11]. Therefore, all walls of the NPC are formed by bone originating from within the primary palate. The leading structures during formation of the NPC are the nasopalatine nerves. The nasopalatine arteries tend to be located lateral to anterolateral in the superior nasal segment of the NPC, but dorsal to dorsolateral in the inferior palatal segment of the NPC.

The bilateral nasopalatine duct (NPD), as a distinguished structure to the NPC, can only be found in fetuses that have developed a separation between their nasal and oral cavities, roughly after the 8th week of fetal development [11]. The NPD appears as a continuous epithelialized band around the 10th–12th fetal week, running separately and laterally from the nasopalatine nerves. The NPD connects the nasal and oral cavities. Around the 24th week, only some solitary epithelial remnants are left from the NPD [11]. Falci et al. [4] histologically evaluated fetuses from the 8th to 10th week and reported great morphological variations of the NPD: unilateral or bilateral occurrence, total or partial patency, or only islet forms. However, the NPD was consistently located within the NPC.

In many mammals the NPD is responsible for the conduction of pheromones from the mouth to the nasal cavity, thereby assisting in communication and breeding [4]. The vomeronasal organ (VNO) located at the bottom of

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the anterior nasal septum is considered the chemoreceptive structure of pheromones for signal forwarding to the central nervous system [12]. In humans, the existence and/or functionality of the VNO is called into question, although cadaveric histology has demonstrated the vestigial presence of VNO remnants [13, 18].

There is general consensus that the NPD degenerates and/or obliterates in humans before birth [17]. Based on embryology and phylogenetics, the NPD in humans is therefore thought to be a vestigial structure. In some individuals, the duct can remain patent and continuous, segmented, or occluded.

The present case report documents for the first time in the literature a rare finding of air inclusions within the anatomical area of the NPC indicating the presence of an NPD as visualized with cone beam computed tomography (CBCT) imaging.

Case presentation

A 45-year-old female patient was referred by her private dentist to the Department of Oral Surgery and Stomatology at the University of Bern to replace the right central incisor (FDI #11) with a dental implant. She was healthy and a non-smoker. Tooth 11 had been endodontically treated in adolescence, probably following dental trauma, and was later reconstructed with a porcelain-fused-to-metal crown. The patient reported occasional pain and tooth 11 presented an isolated periodontal pocket of 8 mm mesiobuccally. CBCT images exhibited a marked bone loss (triangular bone defect) at the mesiobuccal aspect of tooth 11 (Fig. 1). In addition, conspicuous air inclusions were noted in the region of the nasopalatine canal and incisive foramen (Fig. 2). The center of the nasal opening of the NPC was located about 15 mm posterior to the anterior nasal spine. The clinical examination of the anterior palate revealed a slightly inflamed incisive papilla of normal size, but no other findings such as openings, mucosal alterations or discharge.

Addressing the air inclusions observed on the CBCT images, the patient confirmed that she had noted a strange sensation in the anterior palate upon deep exhalation—she could literally feel the air intruding into the nasopalatine canals. To confirm a nasal opening of a persistently and partially patent NPD, an endoscopic inspection of the intranasal region of interest was carried out. On the right side, the nasal opening of the NPD was clearly visible whereas on the left side, an air bubble covered the opening (Fig. 3).

Discussion

The present case report appears to be the first CBCT documentation of air inclusion in the NPC suggestive of the presence of a nasally patent NPD. In fact, passage of air from the nose to the mouth was the second most frequently reported clinical sign in patients with complete patency of the NPD [17]. It was interesting in the present case to observe air bubbles radiographically (CBCT) as well as clinically (nasal endoscopy) at two different time points—the endoscopic inspection was carried out a few weeks after CBCT imaging. The rare finding of air bubbles within CBCT scans of the NPC should alert the clinician of NPD remnants. The region of the incisive papilla must be carefully inspected to rule out any palatal openings of a persistent NPD and to reassure the patient about this clinically harmless finding.

Three issues underline the clinical relevance of a persistent NPD: (1) mucosal openings adjacent to the incisive papilla may be erroneously interpreted as sinus tracts originating from the central incisor(s); such a wrong diagnosis may tempt the clinician to perform unnecessary endodontic treatment [10]; (2) the nose-blow-test after maxillary molar extraction may be false-positive because of air escaping via a patent NPD [15]; and (3) the development of the so-called

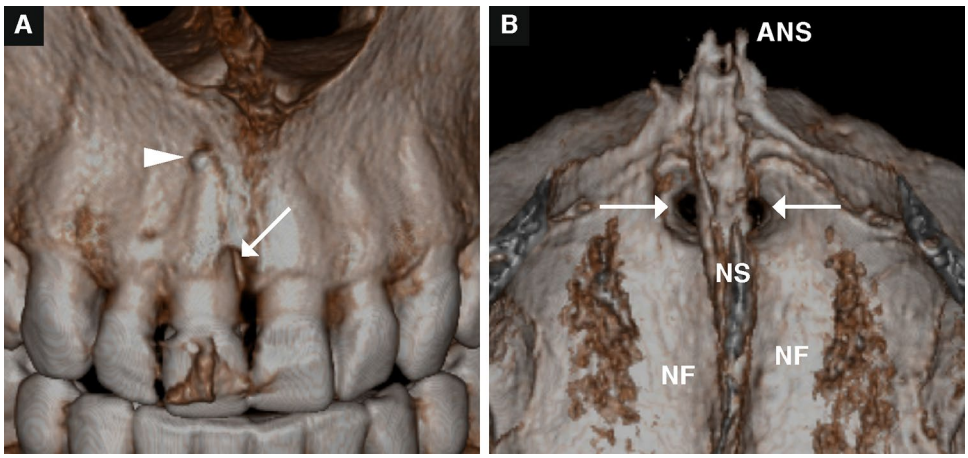

Fig. 1 Volume-rendered image of the anterior maxilla: **a** tooth 11 presents with a vertical bone defect at the mesiobuccal aspect (arrow) and the apical bone is fenestrated and overfilled root-filling material can be seen (arrowhead); **b** the bilateral nasal openings (arrows) of the NPC can be seen. *NF* nasal floor, *ANS* anterior nasal spine, *NS* nasal septum

Fig. 2 The CBCT images clearly show air inclusions (arrows) in the region of the NPC (**a** coronal view, **b** axial view, **c**, **d** sagittal views). Asterisks mark nasal openings of the presumed NPD

nasopalatine duct cyst has been associated with epithelial remnants of the NPD [1, 2, 9].

To the authors' knowledge, only a single clinical study has evaluated the presence and detection of the nasal openings in humans [5]. These authors endoscopically examined a total of 125 university community volunteers with a mean age of 23 years. The nasal opening of the NPD was detected in 94% of 221 unobstructed nostrils. The openings were located at a mean distance of 19 ± 0.2 mm posterior to the columella nasi and 2 ± 0.1 mm above the junction of the nasal floor and nasal septum. The nasal openings of the NPD were characterized by an easily detectable fossa in this location with an average fossa diameter of 3.6 ± 0.2 mm [5]. The authors had also noticed air bubbles and mucus trapped in the NPD fossae, similarly to the case presented in this paper. They speculated about a pooling mechanism of chemosignals in the area for increased absorption into the bloodstream. However, Jacob et al. did not perform any radiographic imaging of the study subjects. It would have been interesting to see if any air inclusions were found in the nasopalatine canal as in the present case report. Jacob et al. [5] also examined the excised nasal septa of eight cadavers. They found bilateral NPD fossae with openings in every specimen with identical locations to the cases from the clinical study. Furthermore, they could insert gutta-percha points into all nasal apertures to a depth ranging from 2 to 8 mm.

While many case reports have documented the insertion of gutta-percha points, wires or metallic probes into the palatal openings of the NPD with subsequent radiography, only few reports have proven the full patency of the NPD with an endoscopic examination of the anterior nasal floor [7, 17]. Knecht et al. [7] inserted a soft Teflon tube (diameter 0.8 mm) and von Arx et al. [17] inserted a gutta-percha point (#70). In both case presentations, the NPD could be easily probed from the palate and the device glided up into the respective nasal cavity without resistance, tissue injury or bleeding.

In humans, the NPD and VNO are considered a holdover in the evolutional chain of the homonymous structures found in animals [4]. Three different theories have been propagated about the formation of the NPD in the human prenatal phase: (1) the NPD develops between the primary and secondary palates; (2) the NPD forms within the primary palate; and (3) the NPD is a remnant of the primary oro-nasal communication [6]. The most recent histological study about fetal development of the NPC/NPD assessed serial sections of 26 heads of human fetuses of gestational ages 9–20 weeks [6].

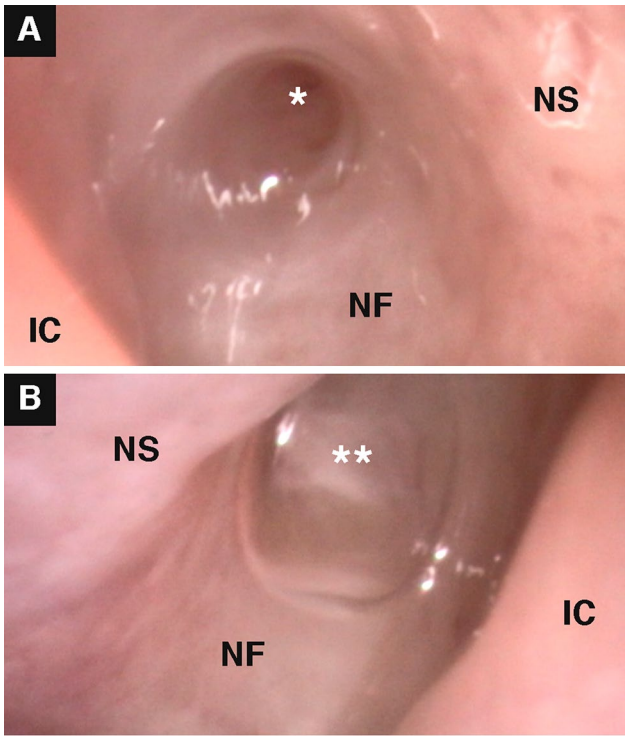

Fig. 3 Bilateral endoscopic inspection of the anterior nasal floor showing the nasal opening (single asterisk) of the NPD fossa on the right side (**a**) and an air bubble (double asterisks) located within the left NPD fossa hiding the nasal opening of the NPD on the left side (**b**). *IC* inferior nasal concha, *NF* nasal floor, *NS* nasal septum

The authors concluded that (1) the NPD, if present, passed through the NPC with the nasopalatine nerve and (2) the oro-nasal communication before secondary palate fusion was unlikely to be persistent as the duct. Conversely, because of the absence in earlier fetuses, the NPD was likely to be a variant or unusual phase of development temporally occurring after normal secondary palate fusion. The duct was not originated from the primitive oral epithelium but rather from the well-differentiated nasal epithelium [6]. The latter finding might explain that oral openings of human NPD have been reported rarely and usually in the context of pathology, whereas the nasal openings are common and relatively uniform in their morphologic characteristics and locations [5]. Indeed, the historically important description of the NPD by Leboucq in 1881 [8] highlighted the frequent obliteration of the palatal segments, but the persistence of the nasal segments of the NPD.

Phylogenetically, the NPD is related to the VNO. The VNO was originally discovered in 1809 in snakes by Frederik Ruysch, a Dutch anatomist. In 1811, Ludvig Jacobson, a Danish surgeon, described in detail the VNO in mammals, but also pointed out that the VNO appears to be vestigial in humans. The VNO comprises two tubular structures in a low and forward position on either side of the nasal septum, near the vomer bone [14]. The VNO develops in utero. Nerve fibers emerge from the developing organ and travel towards the brain. This is a crucial step in the development of the reproductive system. After this initial development, however, the vomeronasal organ regresses, leaving only a few vestiges in adults [14]. In some adults, the vomeronasal cavities can still be observed by endoscopy, but the VNO lack sensory neurons and nerve fibers. The vomeronasal sensory function is thus nonoperational in humans [14].

In conclusion, this case presentation including CBCT imaging documents the rare finding of air inclusions within the anatomical area of the NPC indicating the presence of an NPD. The clinician is advised to carefully inspect and examine the anterior palate, especially the region of the incisive papilla.

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Author contributions TA: project development; manuscript writing. MMB: manuscript editing. SFMJ: examination and treatment of case, manuscript editing.

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest related to this report.

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